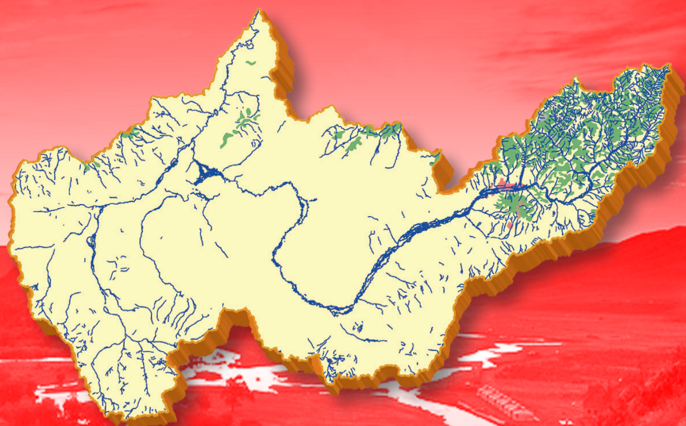
GOVERNMENT OF MONGOLIA

Kingdom of the Netherlands

TUUL RIVER BASIN

INTEGRATED WATER RESOURCES MANAGEMENT ASSESSMENT REPORT



GOVERNMENT OF MONGOLIA

MINISTRY OF ENVIRONMENT AND GREEN DEVELOPMENT

УСНЫ НЭГДСЭН МЕНЕЖМЕНТ

TUUL RIVER BASIN INTEGRATED WATER RESOURCES MANAGEMENT ASSESSMENT REPORT

Ulaanbaatar 2012

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This document was prepared within the framework of the "Strengthening Integrated Water Resources Management in Mongolia" project which was implemented at the Water Authority with support from the Government of The Kingdom of the Netherlands

**TUUL RIVER BASIN
INTEGRATED WATER RESOURCES MANAGEMENT
ASSESSMENT REPORT**

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Preface

Water resources are decreasing due to climate change, uncontrolled use of water sources and pollution. Also water demand is increasing following population growth and economic expansion. This has become an urgent issue worldwide. Nowadays countries set their goals to protect, increase and use national and international rivers using a basin approach integrated regulation based on millennium development goals. Countries pay much attention to implement it.

Mongolia also gives great importance to this issue. As mentioned in the "Law on Water", which approved by the Parliament in 2012, a nationwide "Integrated Water Resources Management Plan" will be approved and implemented by the Government and basin integrated water resources management plan will be approved and implemented by public administration central organizations responsible for environmental issues.

In order to implement major measures to use water resources wisely and protect our country's priceless wealth, a cooperation agreement for the inception phase of the "Strengthening Integrated Water Resources Management in Mongolia" project was signed by the Minister of Nature and Environment of Mongolia and Ambassador of the Kingdom of the Netherlands in Beijing in 2006 within the framework of the cooperation between the Governments of Mongolia and the Kingdom of the Netherlands. On completion of this phase this was followed by the signing of the cooperation agreement by Ministry of Nature and Environment of Mongolia[1] and Ministry of Development Cooperation of the Kingdom of the Netherlands in 2007 for the implementation of the Main phase of the "Strengthening Integrated Water Resources Management in Mongolia"

The project is implemented by the Water Authority, the former Government Implementing Agency for Water. Besides developing an "Integrated Water Resources Management Plan of Mongolia" the project document also refers to including two basin "model" plans. One of these is to develop an "Integrated Water Resources Management Plan of Tuul River Basin" and have it approved by the relevant authorities. By the order of the Minister of Nature, Environment and Tourism the Mongolian territory was delineated into 29 water basins in 2010. The country's capital is located in the Tuul River Basin and the population and industrial activity rapidly intensified during the past two decades. Water use increased and the adverse impacts on the environment are running out of control. The Basin suffers from severe degradation including water loss, resource scarcity and pollution.

The middle part of the Tuul River experiences the most pressure. For example: the Tuul river is always cut off near Ulaanbaatar city in spring time and its flow is infiltrating. In 2012, this phenomenon increased and the period without flow in the river as well as the length of river without flow increased compared to previous years.

This document was prepared for the development of the Tuul River Basin Integrated Water Resources Management Plan. The document is a compilation integrating reports written by the project team's international and national experts and consultants and covers the river basin's natural condition, land use, surface water and groundwater resources, regime, water quality and ecology, socio-economic development, water demand-use and its future perspectives.

This compilation is one of the main results of "Strengthening Integrated Water Resources Management in Mongolia" project. It provides all the basic data for the development of Tuul River Basin Integrated Water Resources Management Plan.

[1] Name of the Ministry was changed in 2012 to Ministry of Environment and Green Development

The compilation contains 7 parts. The first part covers the river basin location, climate, soil, plants, forest, land use and fauna. Part two deals with the river basin surface water resources, regime, impacts from climate change, computer models that estimates distribution of flow and water resources. The third part covers the basin's groundwater resources, geomorphology, geology and hydrogeology. Part four includes the basin's water quality and ecological issue assessment. The fifth part presents the demography, socio-economic development, water fee and tariff, assessment, fee issues and water sector investment in the river basin. In part six the basin's water supply, water demand-use (each sector by the year of 2008 and 2010), its future perspectives (by each sector in the level of 2015 and 2021), current condition of water constructions and recommendations of future measures are addressed. The seventh part is about river basin council, its formation, structures, legal environment, finances, human resources capacity, main directions of activities and recommendations for priority issues to be addressed in the near future.

I would like to note the importance of the contributions of the water sector researchers, project senior consultants, national and international consultants and project national team experts all of whom actively participated in the development of the research reports that are included in this compilation. I would like to express my gratitude to the Ministry of Environment and Green Development; Water Authority (former), relevant public organizations, entities and other administrative organizations that supported in terms of administration, organization and data for the project's implementation. On behalf of the Project team, I wish to express my gratitude to the Government of the Kingdom of the Netherlands; the Ministry of Development Cooperation and the Embassy of the Kingdom of the Netherlands in Beijing.

This compilation contains all the fundamental information for the development of the "Tuul River Basin Integrated Water Resources Management Plan". I do believe that it will be a handbook for water sector organizations, entity administration, experts, researchers of research organizations and students of universities and colleges.

Project National Director **Z.Batbayar (Ph.D)**

Abbreviations

ADB	Asian Development Bank
ALACGC	Administration of Land Affairs, Construction, Geodesy and Cartography
CSM	Centre of Standardization and Measurement
CWWTP	Central Waste Water Treatment Plant
GDP	Gross Domestic Production
GEI / IGE	Institute of Geo-Ecology
GIS	Geographical Information System
GoM	Government of Mongolia
GWP	Global Water Partnership
HADCM3	Climate model from Hadley Institute
HDI	Human Development Index
IG	Institute of Geography
IMH	Institute of Meteorology and Hydrology
IWRM	Integrated Water Resource Management
MAS	Mongolian Academy of Science
MDG	Millennium Development Goals
MECS	Ministry of Education, Culture and Science,
MF	Ministry of Finance
MFALI	Ministry of Food, Agriculture and Light Industry
MMRE	Ministry of Mineral Resources and Energy
MNET	Ministry of Nature, Environment and Tourism
MNS	Mongolian National Standard
MNT	Mongolian Tugrug
MoMo	German IWRM project
MRTCUD	Ministry of Roads, Transportation, Construction and Urban Development
MSUA	Mongolian State University of Agriculture
MUST	Mongolian University of Science and Tech
NAMHEM	National Agency for Meteorology, Hydrology, and Environmental Monitoring
NDIC	National Development and Innovation Committee
NEMO	Netherlands-Mongolia Trust Fund for Environmental Reform
NGIC	National Geo-Information Centre for Natural Resource Management
NGO	Non-governmental Organization
NSO	National Statistical Office
NUM	National University of Mongolia
OSNAAG	Housing and Communal Services Authority
PPP	Public Private Partnership
PUSO	Public Urban Services Organization

RB	River Basin
RBC	River Basin Council
SDUB	Statistical Department of Ulaanbaatar
SPC	State Property Committee
TRB	Tuul River Basin
UB	Ulaanbaatar
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Program
USUG	Water Supply and Sewerage Authority
WA	Water Authority
WB	World Bank
WHO	World Health Organization
WMO	World Meteorological Organisation
WPI	Water Poverty Index
WWF	World Wildlife Fund
WWTP	Waste Water Treatment Plant

Part 1.
NATURAL CONDITION AND LAND USE

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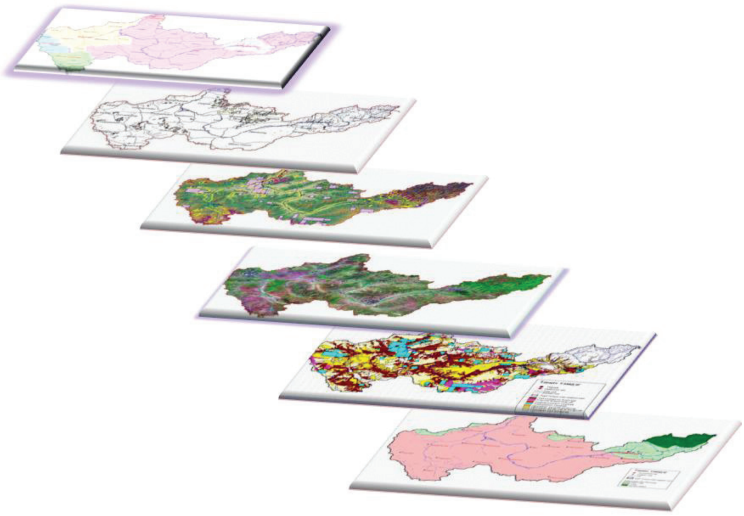
Kh.Tsogzolmaa[1]

Consultant: N.Chagnaa[1], Consultant engineer of Mongolia

[1] *"Strengthening Integrated Water Resources Management in Mongolia" project*



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1. Used information and materials

1.1. Information materials and their sources

The main information materials used in the land-use assessment are drawn from the following 3 sources:

- Base maps /1942-1986/
- Land use information /2002-2008/
- Satellite images /MODIS, Landsat, 1992-2008/

The base maps consist of topographic and thematic maps. In Mongolia work started to convert the topographic paper map into digital form by the end of the 1980s and continues until present. Initially the geographical projection and datum was not standardized and each entity or agency used a system of its own choice. However since 2009, by government resolution all maps are transferred to a common system (Transverse Mercator, WGS 1984, UTM Zones 45-50). The work to convert the base maps into digital form was executed mainly by the Information Center for Natural Environment of the Ministry of Nature Environment and Tourism, and by the Authority of Land Affairs. The Building and Geodesy Maps were converted by the Ministry of Roads, Transport, Construction and Urban Development, the Institute of Geography and by the Institute of Geo-Ecology of the Mongolian Academy of Sciences.

The thematic maps of soil, vegetation, ground water, and natural regions were converted to digital form by the Information Center of Natural Environment of the Ministry of Nature Environment and Tourism. Also the Institute of Geography and the Institute of Geo-Ecology of the Mongolian Academy of Sciences did some of that work.

The agricultural area, settlement areas, forest fund, water basin, as well as information on the road network are kept by the Authority of Land Affairs, Building, Geodesy Mapping of Ministry of Roads, Transport, Construction and Urban Development and the Institute of Geo-Ecology of the Mongolian Academy of Sciences which comprises the unified land database. Detailed information about pasture, hay-field and cultivated area is kept by the Information Center for Natural Environment of the Ministry of Nature, Environment and Tourism. Satellite information with different resolution and information of the elevation digital model are kept by the Information Center of Natural Environment of the Ministry of Nature, Environment and Tourism that is updated on a daily basis.

In the framework of the "National Geo-Information Center", a project implemented under the Information Center for Natural Environment of the Ministry of MNET, high resolution information and a database was compiled that was placed on the internet for public access and use (*geodata.mne-ngic.mn*).

Regarding aimags and soums within the Tuul River Basin there are 3 main sources of digital information:

- Census information on unified land
- Information on pastureland state and quality control confirmation
- Annual report on unified land
- Report on 'Economic and ecosystem evaluation in upper catchment of the Tuul River'', financed by the World Bank.

1.2. Maps, atlases and other resources

Several scientific works have been published like the Atlas of Climate and Surface Water Resources of the People's Republic of Mongolia (1985), the Scheme of Optimal Use and Protection of Selenge River Basin Resources (1986), the National Atlas of the People's Republic of Mongolia (1990) and the National Atlas of Mongolia (2009). The following maps have been used:

1. Land cover 2006 year	Scale 1:5,000,000
2. Unified Land	Scale 1:5,000,000
3. Natural regions	Scale 1:5,000,000
4. Special Protected Area	Scale 1:5,000,000
5. Hydrology network	Scale 1:5,000,000
6. Physical Geographical regionalization	Scale 1:5,000,000
7. Administrative Schedule	Scale 1:2,000,000
8. Pastureland typology	Scale 1:5,000,000

1.3. Methodology

In Mongolia, the land resources are divided into 6 main categories, making record that forms its information data. According to the Law on land approved in 1971 land was classified as:

1. Agricultural area,
2. Settlement area,
3. Land for special needs,
4. Forest reserves,
5. Water basin,
6. Reserved land

In 1998 the Law on land was renewed and approved by the Government of Mongolia. In this new law the category ''land for special needs'' was removed, while a new category ''road network'' was added. However, in 2004 through a revision of the law the category reserved land of the state was removed and the category land for special needs was re-introduced.

As it is specified in the law about land of Mongolia which is currently adhered to there are 6 classifications:

1. Agricultural area
2. Settlement area
3. Road network
4. Forest reserves
5. Water basin
6. Land for special needs

Satellite imagery was used to determine land use land cover, soils, vegetation, population densities, livestock densities and boundaries of river basin mapping the water drainage network in the Tuul River Basin. For the evaluation the distant aerial survey research methodology, geographical information system (GIS) and standard model methods were used.

2. Topography

The Tuul River is a tributary of the Orkhon River and joins the Orkhon River at Orkhontuul soum in Selenge aimag. The name of the Tuul River is taken from the confluence point of 2 rivers Nomin and Nergui which originate from the Khan Khentii mountains (2000 m above sea level) range of the Chisaalain aiguilles and the Shoroot mountain pass.

The highest point in the Tuul River basin is the top of Asralt Khairkhan at 2799.2 m above sea level; the lowest point is at 770 m where Tuul River flows into the Orkhon. The elevation ranges between 770-2800 m above sea level. Most part of the basin belongs to the Khentii mountainous region; many tributaries of the Tuul River originate from the Baga Khentii mountain. The Tuul River flows at the beginning through mountain taiga and forest steppe region, then down from Ulaanbaatar, the river flows through the steppe region which occupies 80% of the river basin area. The upper part of the river basin has steep rocks and plenty of forests with valleys between mountains of 1-3 km in width. The valley becomes wider downstream of Ulaanbaatar and it reaches a width of 8-10 km at Ulaanbaatar city.

The Tuul River Basin covers the territories of 7 districts of Ulaanbaatar city, 37 soums of 5 aimags and occupies a total area of 49774.3 km^2.

The Tuul River basin includes 65.5% of the Ulaanbaatar city area, 39.8% of Tuv aimag, 20.8% of Bulgan aimag, 6.0% of Uvurkhangai aimag, 4.4% of Arkhangai aimag, 2.2% of Selenge aimag (Figure 1 and Figure 2).

Figure 1. Location of the Tuul river basin

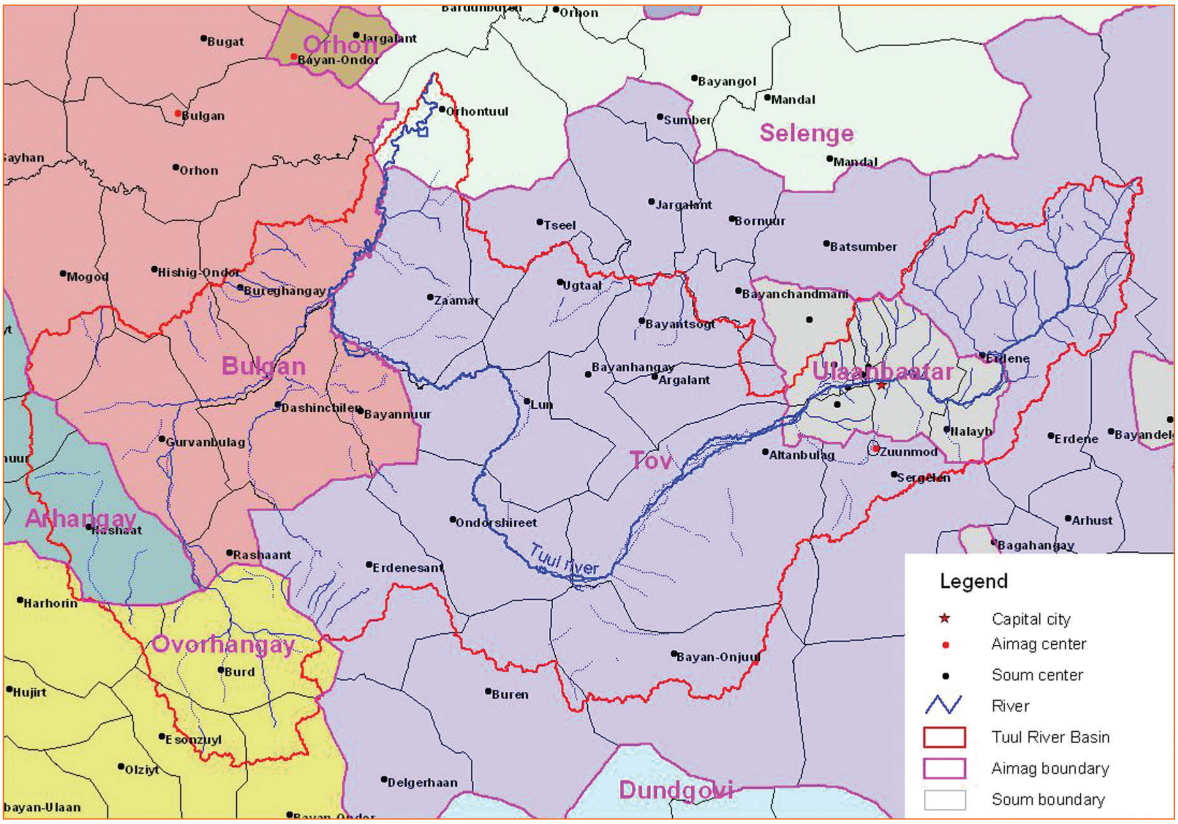

Figure 2. Administrative units in Tuul river basin

Three natural zones occur in the Tuul river basin: the steppe zone occupying 82.8%, the forest steppe zone occupying 11.8% and the high mountainous zone occupying 5.4% (Figure 3).

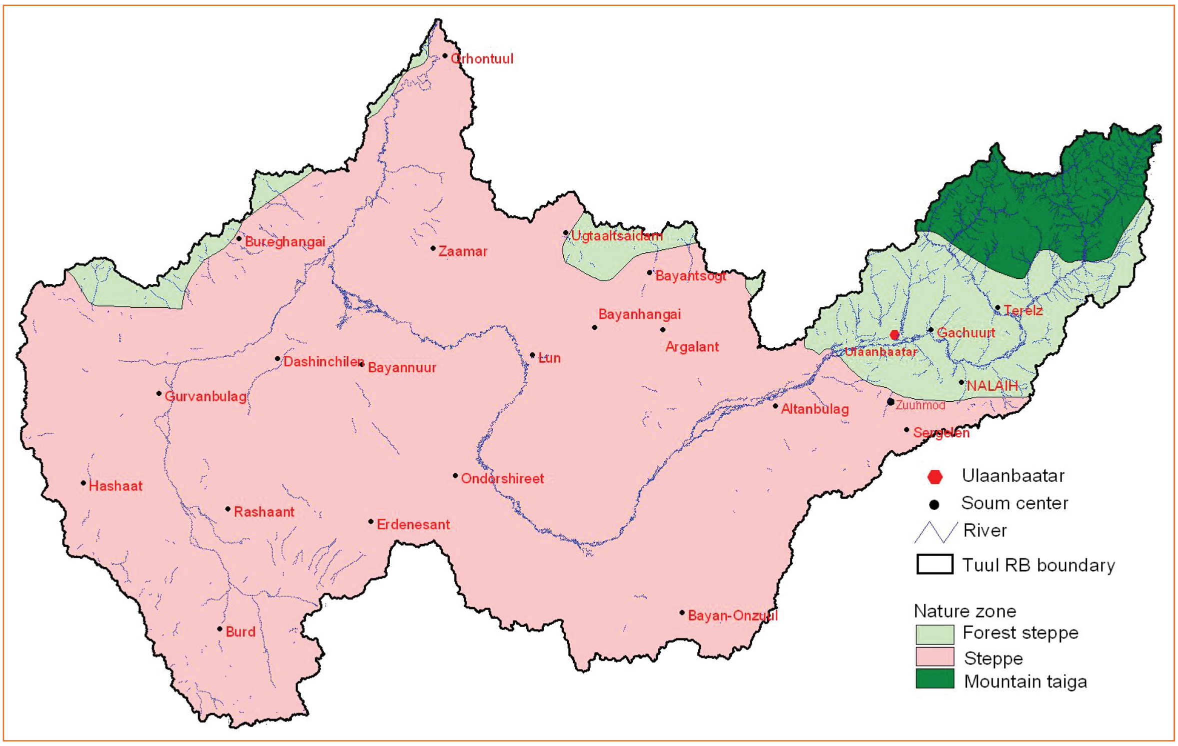

Figure 3. Natural zones in Tuul river basin

Table 1. Area of soums in Tuul river basin

No	ID	Aimag	Soum	Area in basin, *km²*	Total soum area, *km²*	Percentage (area in basin)	Percentage (of river basin area)
1	103	Ulaanbaatar	Bayangol	23.6	23.6	100.0	0.0
2	104		Bayanzurh	1228.9	1230.1	99.9	2.5
3	105		Nalayh	693.2	693.9	99.9	1.4
4	106		Han-Uul	510.0	510.0	100.0	1.0
5	107		Songinohayrhan	373.6	1205.1	31.0	0.8
6	108		Suhbaatar	207.4	207.6	99.9	0.4
7	109		Chingeltey	89.0	90.3	98.6	0.2
8	205	Arhangay	Ogiynuur	295.7	1683.9	17.6	0.6
9	206		Olziyt	0.3	1720.7	0.0	0.0
10	212		Hashaat	2175.6	2601.2	83.6	4.4
11	502	Bulgan	Bayannuur	1010.5	1010.5	100.0	2.0
12	505		Bureghangay	2019.5	3490.2	57.9	4.1
13	506		Gurvanbulag	2681.2	2681.2	100.0	5.4
14	507		Dashinchilen	2309.7	2309.7	100.0	4.6
15	508		Mogod	620.9	2823.7	22.0	1.2
16	510		Rashaant	612.9	612.9	100.0	1.2
17	515		Hishig-Ondor	960.8	2440.0	39.4	1.9
18	1405	Ovorhangay	Bayan-Ondor	508.1	3522.0	14.4	1.0
19	1407		Burd	2447.5	2641.1	92.7	4.9
20	1409		Esonzuyl	428.2	1966.6	21.8	0.9
21	1418		Harhorin	258.5	2305.3	11.2	0.5
22	1709	Selenge	Orhontuul	824.7	2941.7	28.0	1.7
23	1801	Tov	Altanbulag	5327.8	5665.7	94.0	10.7
24	1802		Argalant	974.1	1124.2	86.7	2.0
25	1804		Batsumber	9.6	2428.8	0.4	0.0
26	1806		Bayandelger	285.1	2171.3	13.1	0.6
27	1808		Bayan-Onjuul	2244.6	4794.9	46.8	4.5
28	1809		Bayanhangay	998.8	998.8	100.0	2.0
29	1811		Bayantsogt	1330.3	1474.1	90.2	2.7
30	1812		Bayanchandmani	34.5	610.8	5.6	0.1
31	1813		Bornuur	3.7	1144.8	0.3	0.0
32	1814		Buren	756.7	3752.7	20.2	1.5
33	1815		Delgerhaan	2.4	2168.0	0.1	0.0
34	1816		Jargalant	2.8	1850.1	0.2	0.0
35	1817		Zaamar	2802.1	2804.0	99.9	5.6
36	1818		Zuunmod	19.3	19.3	100.0	0.0
37	1819		Lun	2541.4	2541.4	100.0	5.1
38	1820		Mongonmorit	27.8	6696.6	0.4	0.1
39	1821		Ondorshireet	2623.5	2623.5	100.0	5.3
40	1822		Sergelen	1101.2	3795.7	29.0	2.2
41	1824		Ugtaal	1403.0	1551.7	90.4	2.8
42	1825		Tseel	385.8	1642.6	23.5	0.8
43	1826		Erdene	4109.6	8113.3	50.7	8.3
44	1827		Erdenesant	2510.3	3391.8	74.0	5.0
			Total	49774.4			100.0

Recent and previous research works in the Tuul river watershed use different watershed areas and river lengths (Table 2).

Table 2. Estimation of the Tuul river watershed area and river length

No	Name of the research works	Watershed area, km^2	River length, *km*
1	Surface water resources of the People's Republic of Mongolia, 1975	49840,0	704
2	Multiple use and preservation scheme of the Selenge river basin, 1986	49600,0	728
2	Murzaev E.M. People's Republic of Mongolia. M., 1952	49840,0	704
3	The Figures of the Tuul River Basin, 2008, MSA, Institute of Geoecology	49601,0	856
4	Myagmarjav.B,Davaa. G "Mongolian surface water", Ulaanbaatar, 1999	49840,0	819
5	Tuul river basin, Water Agency, IWRM project	49774,3	717
6	"Environmental Geo-information Center" project report, 2010	49840,0	704

The main reason for the differences in area and river length is the use of different methodologies in the estimation. In the previous research works (before 1990), watershed area and river length was estimated from the 1:100,000 scale topography maps on paper by hand way of planimeter, odometer and other scale methods. Nowadays, geographical information system programs (GIS) are used. As of river length, in some research works the point of the origin was derived from the farthest point till the river confluence, but in other works it may be that the point of the origin was taken from the confluence point of several small rivers which become named Tuul River.

Therefore, it is required to determine the estimation method of these hydrologic definitions.

The geographical coordinates of the point considered as the origin of the Tuul River are 108°13'20"E, 48°30'39"N, the coordinates of the river confluence point are 104°47'52", 48°56'55".

The coordinates of the extreme edges of the basin are:

West:	102.794078E
East:	108.308208E
North:	48.949525N
South:	46.662961N

3. Climate

3.1. Climate condition

The Tuul river basin is highly elevated, far from the sea, surrounded by mountains. So the climate condition is determined by height differences of day and night temperature, long winter, short summer and most precipitation falls in summer.

Summer is dominated by warm dry air and thunderstorms fall during the summer. At the end of August and the beginning of September a sudden cold is observed and in the autumn the precipitation decreases. At the beginning of November is coming winter.

The climate of the Tuul river basin area is represented by the observation data of Gurvanbulag, Erdenesant, Ugtaal, Zuunmod, Buyant-Ukhaa, Ulaanbaatar and Terelj meteorological stations. The location of these stations is shown in Figure 4.

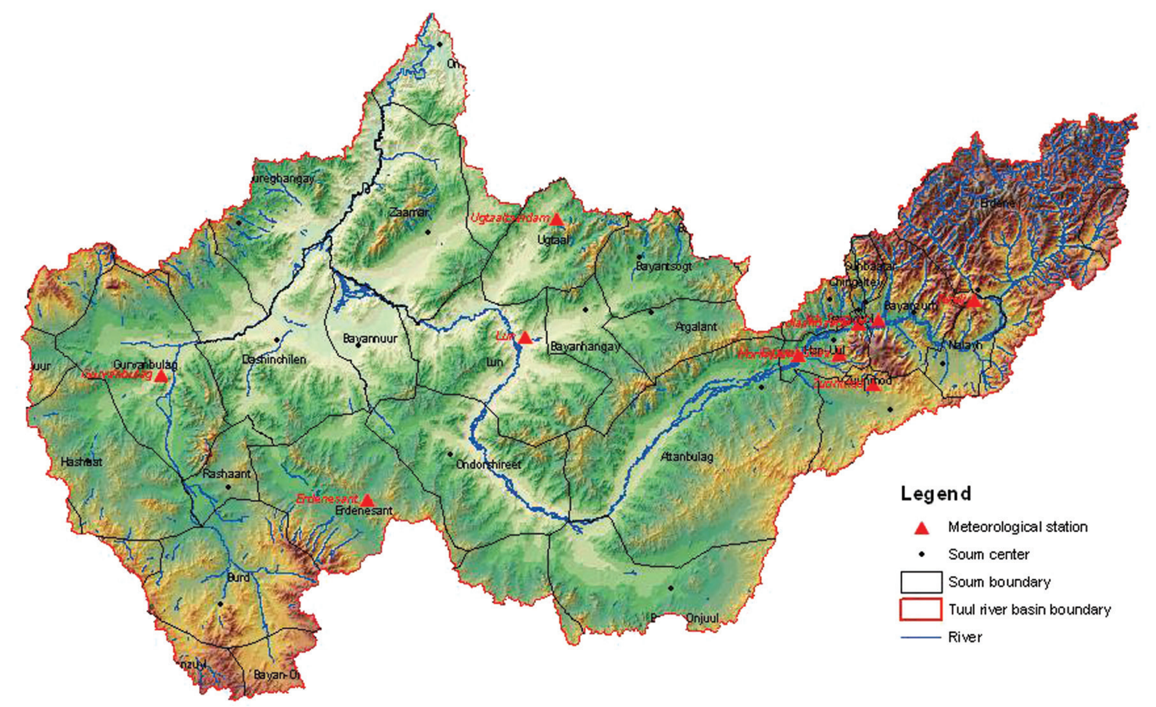

Figure 4. Location of the meteorological stations

The mean air temperature ranges from - 3.3˚C to - 0.4˚C from Terelj and Ulaanbaatar but from Ulaanbaatar to Orkhontuul - 0.4˚C -1.1˚C. January is the coldest month and in this period the development of the Asian anti-cyclon reaches it's peak. The monthly average air temperature is at Terelj and Ulaanbaatar -21.6˚C , at Buyant-Ukhaa -25.2˚C, at Lun -25.7˚C , at Erdenesant -17.8˚C, at Gurvanbulag -19.0˚C and at the confluence of the Tuul and Orkhon -24.8˚C. July is the warmest month. In this period the air temperature is at Terelj 13.0˚C, at Zuunmod 18.7˚C, at Erdenesant 17.5 ˚C, at Gurvanbulag -19.0˚C and at the confluence of the Tuul and Orkhon 19.3˚C .

Table 3 shows the monthly and annual air temperature at the meteostations.

Table 3. Air temperature, °C

Station name	Month												Average
	I	II	III	IY	Y	YI	YII	YIII	IX	X	XI	XII	
Zuunmod	-18.6	-16.3	-8.5	1.4	8.5	16.1	18.7	16.0	9.1	-0.4	-11.5	-18.7	-0.4
Buyant Ukhaa	-25.2	-19.8	-9.5	1.2	9.4	15.2	17.8	15.5	8.2	-0.9	-13.8	-22.5	-2.0
Ulaanbaatar	-21.6	-16.6	-7.8	2.0	10.0	15.6	18.0	16.0	9.2	0.7	-11.3	-19.1	-0.4
Terelj	-21.6	-18.6	-11.7	-1.6	5.8	11.0	13.0	11.3	5.6	-2.2	-11.9	-18.5	-3.3
Erdenesant	-17.8	-16.4	-6.8	2.4	10.3	15.6	17.5	15.7	9.5	1.1	-8.5	-15.5	0.6
Ugtaal	-23.8	-19.3	-8.6	2.3	10.3	15.3	19.7	15.5	9.5	0.4	-11.6	-20.5	-0.9
Gurvanbulag	-17.2	-13.3	-5.9	4.5	12.3	16.3	16.5	16.3	10.5	2.0	-8.9	-16.1	1.4
Lun	-25.7	-19.1	-6.8	4.7	12.1	18.0	18.2	17.8	11.3	1.1	-11.9	-22.4	-0.2
Mean	-21.6	-17.5	-8.4	2.0	9.8	15.4	17.4	15.5	9.0	0.1	-11.4	-19.3	-0.7

During the last 10 years the global warming impacts appeared in Mongolia and its future prediction could indicate that the annual average air temperature will increase by 3°C and 6°C in winter and summer respectively over Tuul river basin by 2070 [1].

The long term precipitation is at Ulaanbaatar 275 mm and at Gurvanbulag 242 mm. About 68-74% of precipitation falls as rain in summer. The daily maximum rain is observed during the rainstorm.

Table 4. Precipitation, mm

Station	Month												Sum
	I	II	III	IY	Y	YI	YII	YIII	IX	X	XI	XII	
1. Ugtaal	1.8	1.7	4.0	6.9	20.3	54.9	69.8	66.4	27.3	8.8	5.9	3.5	271.2
2. Zuunmod	2.7	2.5	3.7	8.0	17.7	48.5	70.5	74.6	29.0	8.8	6.3	3.1	275.3
3. Buyant Uhaa	1.7	2.1	2.7	6.9	18.2	39.9	65.7	67.4	32.5	7.7	4.9	3.1	252.9
4. Ulaanbaatar	2.7	2.6	3.7	9.5	18.3	50.0	65.3	72.4	32.3	8.1	6.1	4.0	275.0
5.Terelj	1.4	1.5	3.1	9.5	16.3	41.4	76.2	50.0	13.9	6.6	3.6	1.9	225.3
6. Erdenesant	1.9	2.4	4.3	8.5	18.6	47.6	76.1	63.5	26.4	7.5	5.2	3.4	265.2
7. Gurvanbulag	1.1	1.4	2.1	5.7	17.7	50.6	69.5	57.6	23.7	6.8	3.5	1.7	241.5
Mean	1.9	2.0	3.4	7.9	18.2	47.6	70.4	64.6	26.4	7.8	5.1	3.0	258.1

3.2. Climate change

Air temperature

Warming is increasing depending on the geographical location of Mongolia under the global warming pattern and especially there is high intensity value in the Tuul river basin. By observation data of meteorological stations in Tuul river basin, the mean annual air temperature increased by 2.0°C from the norm.

Due to global warming, the number of hot days are increasing. The maximum air temperature since 1940 was observed in the last few years in the Tuul River basin.

Precipitation

The Tuul river basin has a humid climate compared to other regions of the country. The total annual precipitation is around 200-400 mm. High mountain or runoff forming area precipitation is more than 350 mm per year. About 85-90% of the total precipitation falls in the vegetation period.

In the Tuul River Basin the total precipitation is changed not so much but the duration of rainfall during the summer season is decreased. Figure 5 shows the change in summer precipitation duration during the summer season at Ulaanbaatar station.

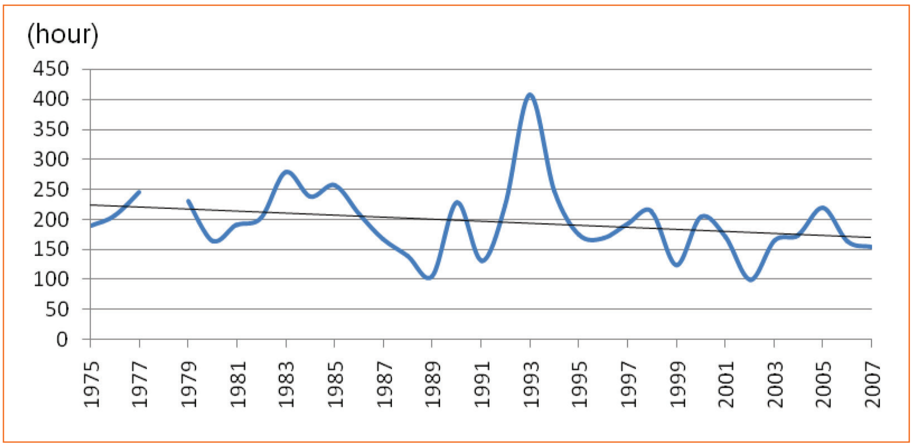

Figure 5. Precipitation duration during the summer

Figure 5 shows that the duration of the summer precipitation has been reduced by one third since 1975. Another change is that rain usually falls as thunderstorms during the summer.

Evaporation

The main reason of the aridity in the Tuul River basin generally is global warming. Nowadays the increasing evaporation (Eo) is causing aridity in the basin. The deficiency of the vegetation water supply affects the vegetation cover.

The difference in evaporation and precipitation (Eo-P) is becoming larger since 1990. In the period 1991-2008 compared with the period 1961-1990 mean values decreased by 30% in the runoff forming area of Tuul river basin.

4. Soil, vegetation, forest

4.1. Soil

The soil map of the Tuul river basin is created in the 1980s, by Mongolian Russian joint researches using aerophoto and satellite data based on 1:1,000,000 scale map. That map was digitized by Environmental Information Center of the National Agency Meteorology and Environmental Monitoring (NAMEM), during the project "Environmental Geoinformation Center".

Mountain soils occupy more than 50% of the Tuul River basin area, it is distributed evenly. The mountain soils include mountain dernotaiga, soddy taiga, forest dark, mountain meadow, and mountain dark chestnut soil classes. Along the river are distributed meadow swamp cryomorphic, meadow cryomorphic and meadow solonchak soil (Figure 6).

Table 5 and Table 6 and Figure 6 show soil type and classes, respectively their percentage.

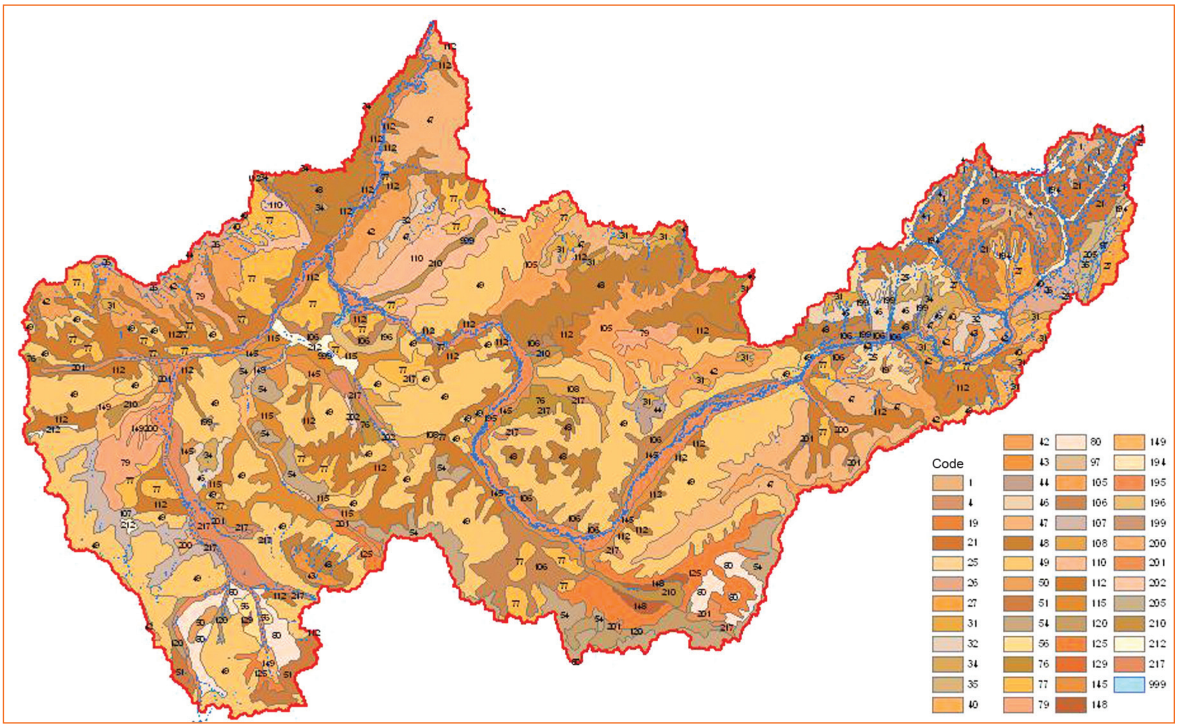

Figure 6. Soil types

Table 5. Soil type percentages

No	Soil type	Percentage
1	Mountain soil	56.3
2	Soil of steppe valley and depression	26.2
3	Low mountains and rolling hills soil	8.3
4	Soil of humid areas	6.6
5	Other soils and bare land /water, sand	1.4
6	Saline soil	1.1
7	Riparian soil	0.1
	Total	100

Table 6. Soil types

Code on map	Soil type	Soil name
1	Mountain soil	Sod mountain tundra
4	Mountain soil	Peaty-gleyed mountain tundra with mountain taiga - cryomorphic surfacely ferrimorphic
19	Mountain soil	Mountain cryomorphic-taiga surfacely ferriomorphic with mountain podzolic cryomorphic
21	Mountain soil	Mountain cryomorphic-taiga with mountain podzolic and mountain derno-taiga
25	Mountain soil	Mountain derno-taiga with mountain cryomorphic-taiga
26	Mountain soil	Mountain soddy-taiga with mountain forest dark colored
27	Mountain soil	Mountain soddy-taiga with mountain chernozem non calcareous
31	Mountain soil	Mountain forest dark colored with mountain meadow-forest
32	Mountain soil	Mountain forest dark colored with chernozem non calcareous
34	Mountain soil	Mountain forest dark colored with typical mountain chernozem
35	Mountain soil	Mountain chernozem non calcareous with mountain soddy-taiga
40	Mountain soil	Typical mountain chernozem with mountain forest dark colored
42	Mountain soil	Typical mountain chernozem with typical mountain dark chestnut
43	Mountain soil	Shallow mountain chernozem with mountain forest dark colored
44	Mountain soil	Shallow mountain chernozem with shallow mountain dark chestnut
46	Mountain soil	Mountain dark chestnut non calcareous with mountain forest dark colored
47	Mountain soil	Typical mountain dark chestnut with typical mountain chernozem
48	Mountain soil	Typical mountain dark chestnut with shallow mountain chernozem
49	Mountain soil	Typical mountain dark chestnut with shallow mountain dark chestnut
50	Mountain soil	Typical mountain dark chestnut with typical mountain chestnut
51	Mountain soil	Typical mountain dark chestnut with typical mountain chestnut and steppificated meadow chestnut
54	Mountain soil	Shallow typical mountain dark chestnut with typical mountain chestnut
56	Mountain soil	Typical mountain chestnut with shallow mountain chestnut
76	Low mountains and rolling hills soil	Dark chestnut non calcareous with friable sandy chestnut (division)
77	Low mountains and rolling hills soil	Typical dark-chestnut with shallow stony dark chestnut
79	Low mountains and rolling hills soil	Shallow stony dark chestnut with typical dark chestnut
80	Low mountains and rolling hills soil	Typical chestnut with shallow stony chestnut
97	Soil of steppe valley and depression	Chernozem non calcareous with meadow-chernozem
105	Soil of steppe valley and depression	Typical dark chestnut
106	Soil of steppe valley and depression	Typical dark chestnut with stony dark chestnut
107	Soil of steppe valley and depression	Typical dark chestnut with dark chestnut non calcareous and meadow solonchak
108	Soil of steppe valley and depression	Typical dark chestnut with dark chestnut weakly developed

Code on map	Soil type	Soil name
110	Soil of steppe valley and depression	Typical dark chestnut with dark chestnut solonetzic
112	Soil of steppe valley and depression	Typical dark chestnut with meadow chestnut
115	Soil of steppe valley and depression	Dark chestnut residually meadowish with meadow solonchak
120	Soil of steppe valley and depression	Typical chestnut with chestnut stony
125	Soil of steppe valley and depression	Residually meadowish chestnut with typical chestnut and meadow chestnut
129	Soil of steppe valley and depression	Stony chestnut with chestnut solonetzic and chestnut residually-meadowish
145	Soil of steppe valley and depression	Chestnut (non division) sandy
148	Soil of steppe valley and depression	Meadow chestnut with solonetz-solonchak complexes
149	Soil of steppe valley and depression	Meadow chestnut with meadow solonchak
194	Soil of humid areas	Meadow swamp cryomorphic with meadow cryomorphic
195	Soil of humid areas	Meadow swamp cryomorphic calcareous with meadow cryomorphic calcareous
196	Soil of humid areas	Meadow swamp cryomorphic solonetz with meadow cryomorphic solonchak
199	Soil of humid areas	Meadow cryomorphic with meadow swamp cryomorphic
200	Soil of humid areas	Meadow solonchak with solonetz-solonchak complex
201	Soil of humid areas	Meadow solonchak with solonchak meadow
202	Soil of humid areas	Meadow solonchak with weakly fixed sand
205	Riparian soil	Meadow alluvial with alluvial weakly developed and meadow swamp alluvial
210	Saline soil	Solonetz-solonchak complex
212	Saline soil	Solonchak with meadow chestnut solonchak
217	Other soils and bare land	Weakly fixed sands
999	Other soils and bare land	Water

As of soil-geography, the northern part of the river basin is included in the mountainous tundra (cryosols) and mountainous meadow soil (mollic cambisols) of the central part of the Khentii mountain range; the middle and farther of the northern part is in mountainous dark chestnut (mollic leptos ols) and steppe chestnut soil of the east and west of the Khentii range; and the southern part of the river basin is in mountain meadow chestnut soil (mollic leptos ols) of the dry steppe zone .

According to the research on soil cover classification, the soil was comprised in middle diluvium or soft mud, alluvial-dilluvial or sand-rock, middle alluvium or heavy mud moraine. And it is distributed as a meadow alluvial-dilluvial in part of the mountainous area, dilluvial, alluvial in steppe valley, alluvial moraine in large and small river basin meadow each separately.

The dominating soil formations are:

- High mountainous and mountainous taiga soil
- Middle and low mountainous chestnut soil,
- Steppe chestnut and dark chestnut soil,
- Meadow and river valley soil.

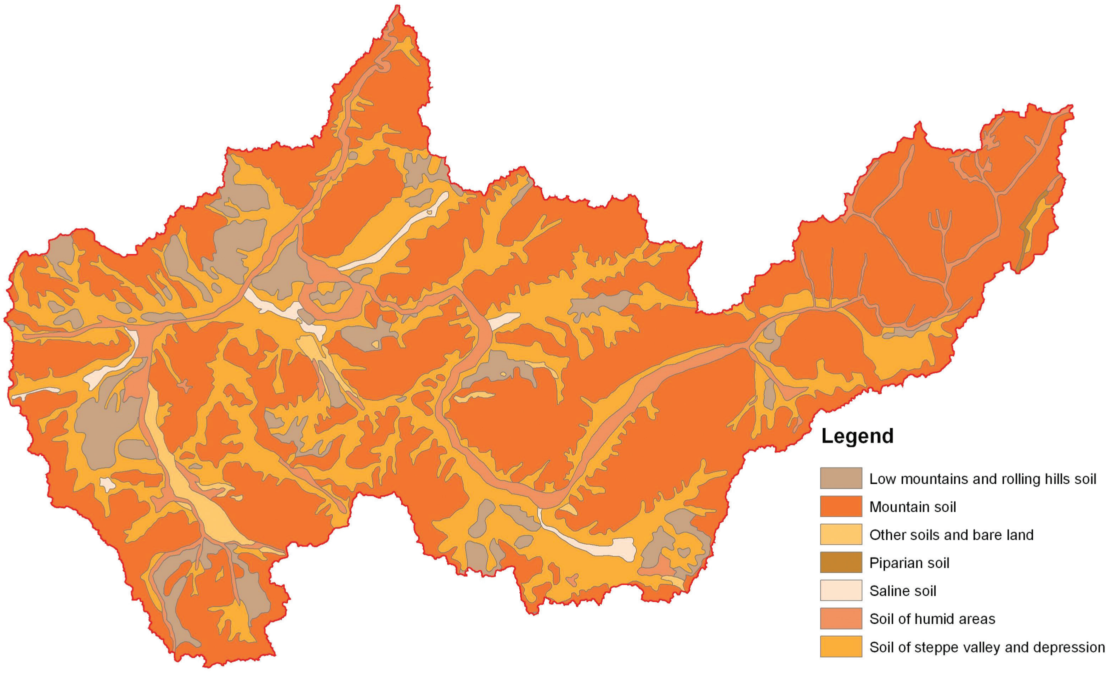

Figure 7. Soil classification

The meadow chestnut and steppe chestnut soil are considered as major resources in the river basin. Hayfield land soil is located on the mountainous taiga or mountainous forest soil and on the dark chestnut or meadow chestnut soil.

The majority of the area 89.3% is covered by normal soil, 4.14% by saline soil, 1.41% by solonetz soil, 2.1% by carbonated soil and the rest by light soil. And 67% of the soil cover is occupied by soft and middle mud soil, showing that utilization and restoration availability is relatively gentle. The soil classification is shown in Figure 7.

4.2. Vegetation

The vegetation is rich in the Khentii region, but poor in the steppe region because of the climate and elevation zones within the river basin area. The types of vegetation are changing from high mountain to low steppe.

Vegetation types are shown on Figure 8 and Table 8. The percentages of the main vegetation types are shown in Table 7.

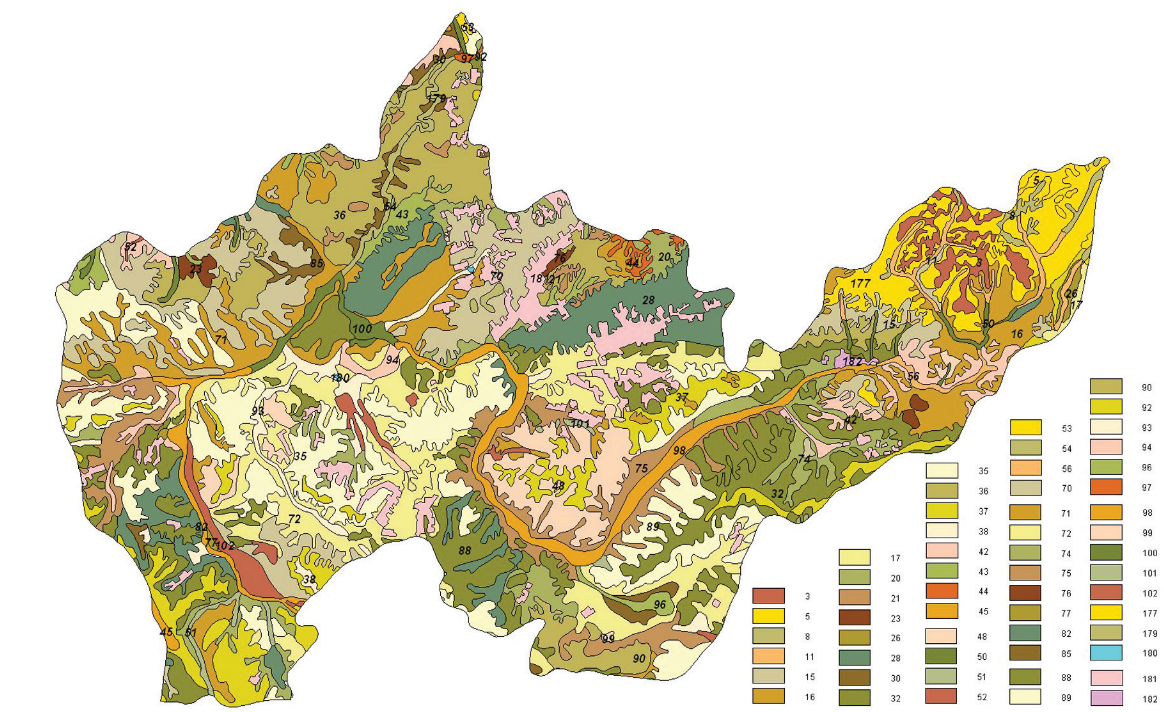

Figure 8. Vegetation types

Table 7. Vegetation type areas

no	Vegetation type	Area. *km²*	%
9	Steppe and dry steppe	10895.6	21.9
8	Non pasture	7723.8	15.5
7	Mountain taiga	128.4	0.3
6	Mountain steppe	3580.2	7.2
5	Mountain forest steppe	14677.8	29.5
4	Mountain desert steppe	926.0	1.9
3	High mountain	4932.0	9.9
2	Desert steppe	5670.6	11.4
1	Desert	1240.0	2.5
	Total	49774.3	100.0

Table 8. Vegetation types

Code	Vegetation name
3	Lichen-moss in light cembra-larch land with participation of yernik
5	Lichen-moss in combination with sedge on swampy meadow and moss-yernik
8	Shrubs, which are yernik-moss, yernik-sedge-kobresia, yernik-grass-kobresia with participation of solitary larch
11	Sedge-herb, sedge-kobresia, sedge with participation of yernik and larch
15	Herb-grass stand on larch and larch-birch forest in combination with larch forest on mountain tundra (10%)
16	Herb-grass stand on larch and larch-birch forest in combination with needlegrass-Filifolium-herb (20%) and fescue-herb (10%)
18	Herb-grass stand on pine-birch forest in combination with needlegrass-herb (20%) and herb-lymegrass (10%)
19	Herb-grass stand on birch-aspen forest in combination with Filifolium-herb-festuce (20%)
21	Lyemus-herb-needlegrass with participation of Armeniaca (larch in Khyangan0
25	Needlegrass-herb, needlegrass-sedge-herb with participation of Spiraea, peashrub
26	Bluegrass-herb, Poa-sedge-herb

Code	Vegetation name
27	Little soddygrass-herb with participation of Carex pediformis
29	Needlegrass-wheatgrass-herb in combination with stony herb-festuce (20%)
30	Needlegrass-herb in combination with stony herb-festuce-shrub (20%) (Cotoneaster, Spiraea, peashrub) and in herbaceous larch-birch forest (10%)
31	Festuce-herb in combination with stony little soddygrass-herb (20%) and with shrubs
34	Bluegrass-sedge-herb in combination with stony herb-festuce (20%) and in herbaceous larch-birch forest (10%)
35	Little soddygrass-herb in combination with sedge-bent on hollow (20%)
36	Needlegrass-herb combination with herb-big grass (20%) on hollow
37	Stony festuce-wormwood-herb, little soddygrass-wormwood-herb with Dasiphora, Spiraea, Armeniaca (in eastern), Bungei peashrub (in western)
39	Stony needlegrass-wormwood-herb with Armeniaca, peashrub, Spiraea (in east), Bungei peashrub (in west)
41	Sedge-rush-bent, bent-herb with participation of willow's grove
42	Sedge-grass-Iris in complex with alkaligrass-leymus-herb (20%) and Suaeda (10%)
43	Herb-lymegrass, herb-big grass with participation of willow, birch in complex with sedge-bent-herb (20%)
44	Grass-fabaceous-herb with predominance of brome, alfalfa, false wheat, melilot, vetchling
45	Grass and grass-herb with participation of elm, willow, in complex with sedge-herb (20%)
47	Herb-grass in combination with grove of willow (20%) and marshy sedge-bent-herb (20%), with participation of spruce along Tes River and Shishgid River
58	Needlegrass-fetuce-herb with participation of peashrub
59	Needlegrass-little soddygrass-lymegrass with participation of peashrub
60	Needlegrass-Cleistogenes, needlegrass-Cleistogenes-wormwood (with considerable abundance of peashrub in eastern part of country)
62	Needlegrass-lymegrass-herb
63	Low soddygrass-needlegrass-wormwood with participation of peashrub
64	Low soddygrass-pasture wormwood, low soddygrass-chinguefoil with participation of Bungei peabrush and Caragana pygmaea on degraded pasture
65	Lymegrass-needlegrass-wormwood and lymegrass-Cleistogenes-wormwood
69	Cleistogenes-needlegrass stand with Caragana microphylla (in eastern), and with Caragana bungei (in western)
72	Needlegrass-lymegrass-herb in complex with lymegrass-sedge (20%) and Achnatherum-lymegrass-Suaeda (10%)
75	Needlegrass-Cleistogenes-herb stand with Caragana microphylla and in combination needlegrass-festuce-herb on stony stand with participation of peashrub and almond
76	Stony needlegrass-wormwood-thyme with participation of peashrub and almond
77	Stony bluegrass-wormwood-herb with participation of shrubs (Spiraea, Cotoneaster, almond)
79	Alkaligrass-grass in achnatherum complex with lymegrass-sedge (20%) and with annual russianthistle (10%)
80	Lyme-sedge on achnatherum stand with herb-alkaligrass (30%) and with annual russianthistle (20%)
81	Blueflag-grass in complex with achnatherum-lymegrass (20%) (in western), and Suaeda-wormwood (10%)
83	Sedge-blueflag-grass in complex with lymegrass-achnatherum (20%) and grove of willow (10%)
84	Complex marsh: herb-grass (60%), lymegrass-sedge (20%), achnatherum's grove with grass-sedge (20%) in combination with willow bush (10%)
85	Complex marsh: Lymegrass-sedge (70%), grass-herb (20%), achnatherum's grove with russianthistle-herb (10%) in combination with willow-poplar grove (10%)
86	Grass-herb in complex with sedge-lymegrass-herb (20%)
87	Common reed-sedge with cane in combination with grass-herb (20%) and willow's grove (10%)
88	Solitary grass-herb on shrubs and light forest
89	Light willow forest with sandy wormwood
160	Unsuitables: sand, canyon, solonchak, dry riverbed with solitary bushes, dry circular salt marsh none vegetation, glacier, stony surface
161	Herb-grass stand on larch and larch-birch forest in combination with Filifolium-herb-festuce (20%) and festuce-herb (20%)
231	Festuce-herb-Stellera with participation of Carex pediformis on degraded pasture
311	Festuce-herb in combination with fescue-sedge-herb (20%) and in herbaceous larch-birch forest (20%)
998	Cropland
999	Water surface
1000	Urban
1591	Mountain taiga without importance of food meaning

Around 30% of the basin is occupied by mountainous and valley-steppe vegetation and 20% by steppe and dry steppe vegetation (Figure 9, Table 7).

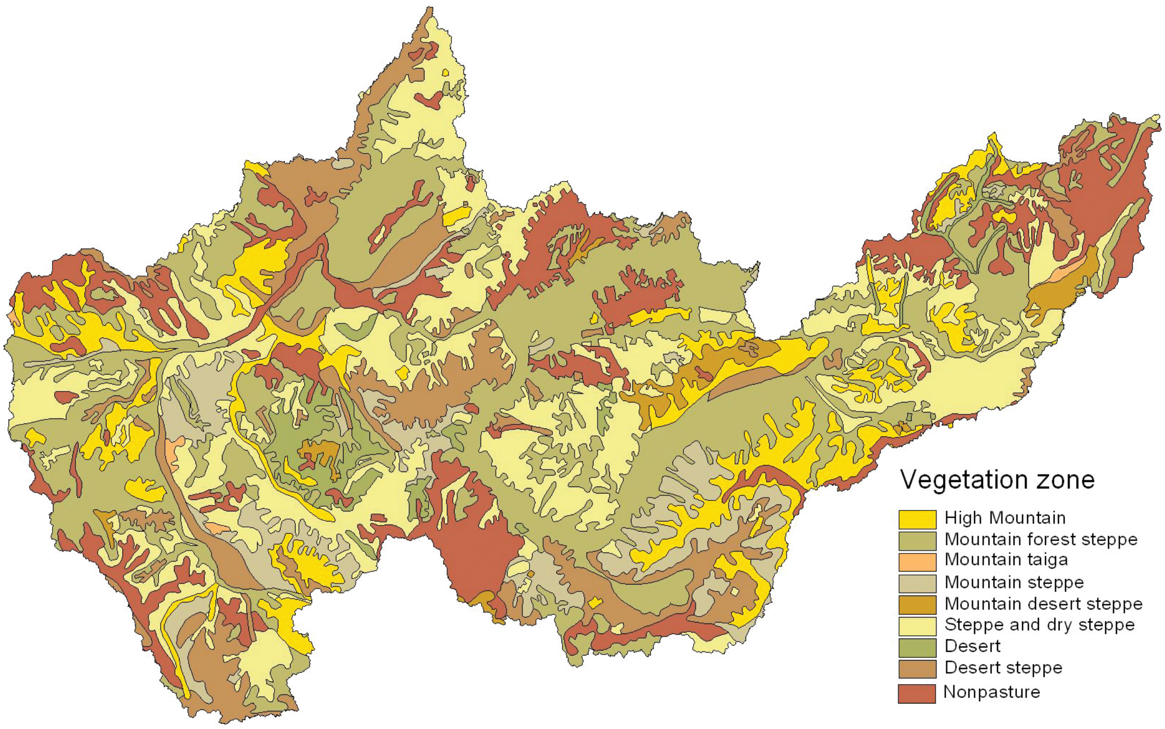

Figure 9. Main vegetation types

4.3. Forest

According to the Law on Land, forest resources include "forests, forest glades and logged areas, and forest strips, as well as land for growing forests and areas adjacent to forests to allow forest expansion".

Most of the forest fund of the Tuul River basin belongs to the Khan Khentii protected area and Gorkhi Terelj natural area, and to the Batkhaan and Khustai special protected area (Table 9). Originally there was around 5000 km^2 forest in the Tuul River basin. However, wood preparation works started since 1940 until now. Since then, the forest area is reduced approximately 100-200 thousand ha by entities or private people every year and the forest fund was reduced by 35%. Scientists (D.Enkhsaikhan, G.Davaa) believe that the natural influence of the forest fund to the river flow regulation is unbalanced as well as changing river How regine and reducing annual flow value. Hence, reforestation and forest cover issue are to be an inseparable component of the integrated Tuul river basin management.

Table 9. Forest in Protected areas

Name	Forest, *ha*
Khan Khentii SPA, Gorkhi-Terelj NP	208056.4
Batkhaan mountain NR	335.7
Bogd Khan mountain SPA	19940.1
Khustai mountain NP	1868.7
Khugnu Khan mountain NR	2365.2

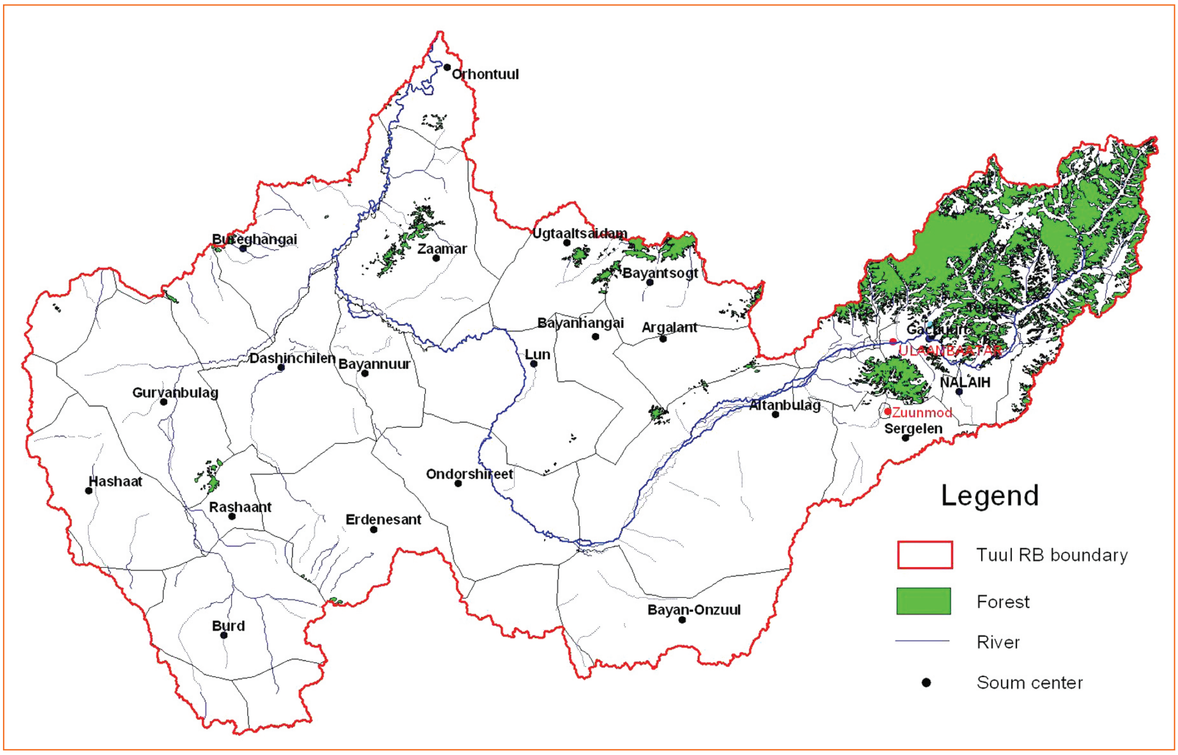

Figure 10. Forest area

5. Land use

5.1. Land cover

The digital elevation model of the Tuul river basin is shown in Figure 11.

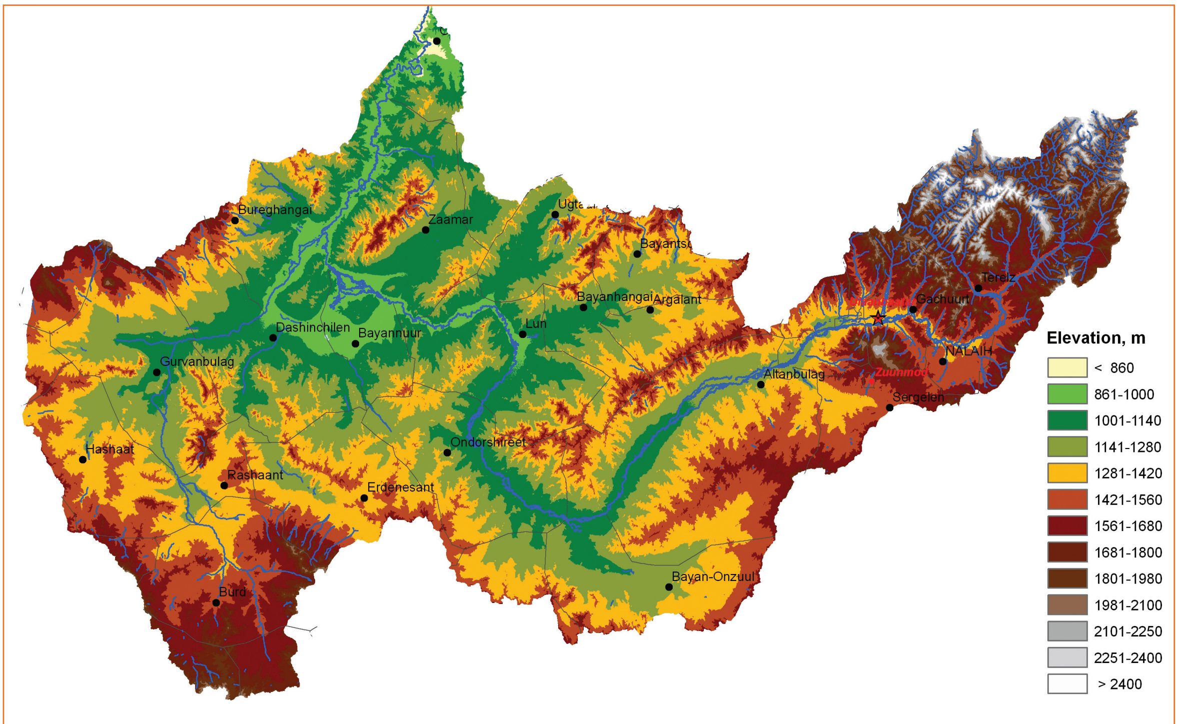

Figure 11. Digital elevation model of the Tuul river basin

It is interesting to evaluate the change in land cover by natural cause, climate change or human activities. MODIS satellite data on land cover from 1992 and 2002 shows considerable changes that can be attributed to these causes.

It shows that, 42% of the land is included in the desert-steppe classification that was originally included in the steppe field classification. It is the evidence that the desertification process is ongoing in Mongolia and pastureland degradation and desertification is indicated also by soil erosion not only by vegetation cover degradation. Researchers observed changes in pastureland crop, a drop in crop land classification number, unbalanced soil richness by soil erosion and compacted soil. Also, the ecological quality of the land was reduced [6].

Table 10, Figure 12 and Figure 13 show the changes of the land cover in Tuul River basin as of 1992 and 2002.

The forest and water land resources area have not changed significantly, but pastureland area was reduced by 2.7 times in 2008 compared to 1992 or 2002 and dry steppe and dessert-steppe was increased by 11-16 times. The land which was classified previously as pasture was transformed into dry steppe or dessert steppe land. It is a clear indication of the ongoing fast desertification process.

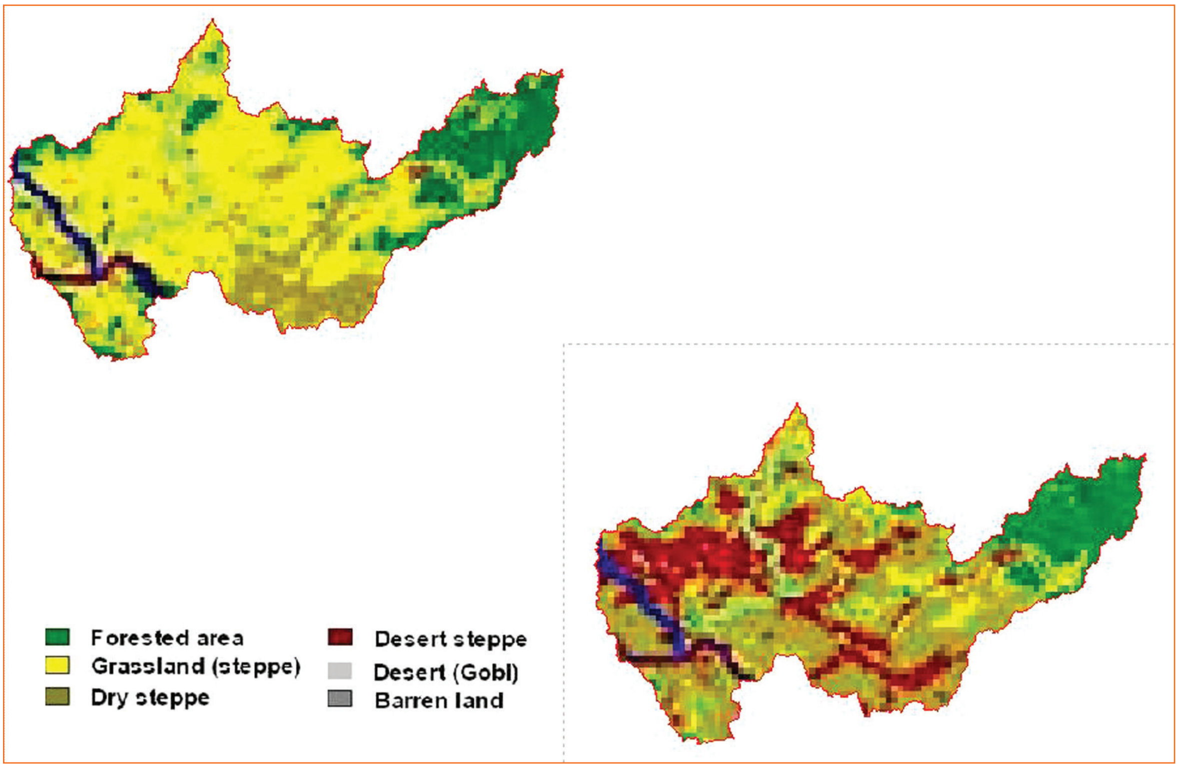

Figure 12. Land cover in 1992 and 2002

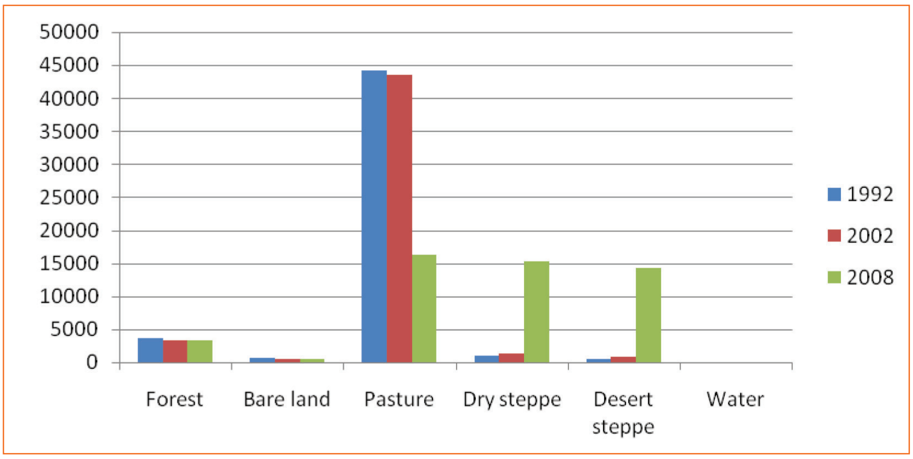

Figure 13. Changes of land cover (1992, 2002, 2008)

Table 10. Land cover changes

Class	Area, *km²*		
	1992	2002	2008
Pasture	44235	43551	16270
Forest	3579	3400	3386
Bare land	616	580	574
Dry steppe	920	1350	15270
Desert steppe	420	890	14271
Water	4	3	3

5.2. Land use

In the Tuul River basin agricultural land occupies 4560.9 thousand ha or 91.2%, forest 338.6 thousand ha or 6.8%, water 16.1 thousand ha or 0.3%, roads 15.2 thousand ha or 0.3%, urban and local settlement land 72.1 thousand ha or 1.4%. It was specified according to the unified land classification of the Mongolian Law on Land.

In this estimation, the classification of the land for special needs includes agricultural land, urban and local settlement area, roads, forests and water. Figure 14 shows the unified land classification.

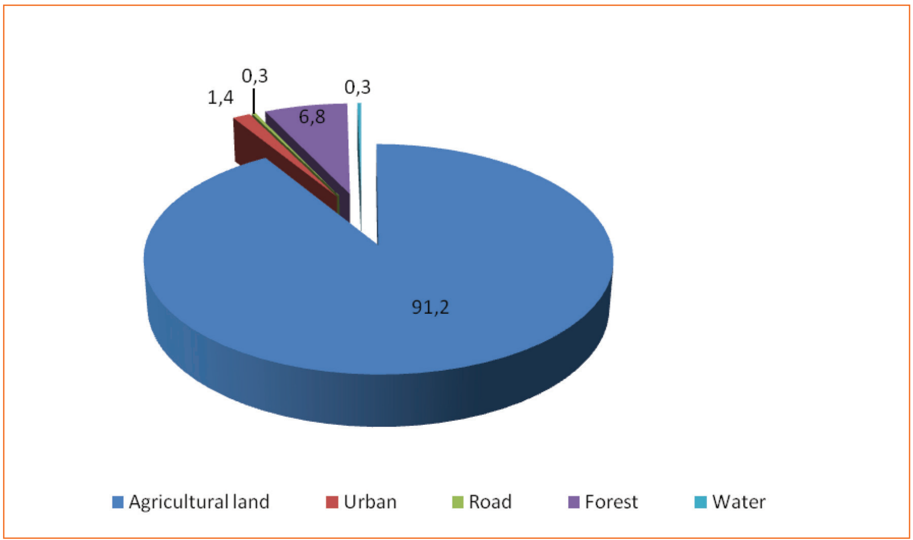

Figure 14. Unified land classification

The Tuul River Basin includes the Khan Khentii, Bogdkhaan strictly protected area, Gorkhi –Terelj nature park, Moltsog Els, Khustain Nuruu, Batkhan mountain range, Khogno Khan-mountain natural reserves. The total special protected areas occupy around 584.2 thousand ha of land which is 11.7% of the Tuul River basin (Figure 15).

Table 11. Protected areas

Protected area	Area, *km²*
Khan Khentii SPA	100561,6
Gorkhi-Terelj NP	289190,9
Bogd Khaan mountain SPA	41348,5
Moltsog els NR	487,9
Khustai mountain NR	48399,4
Batkhaan mountain NR	20111,5
Khugno Khaan mountain NR	84143,2
Total	584243.0

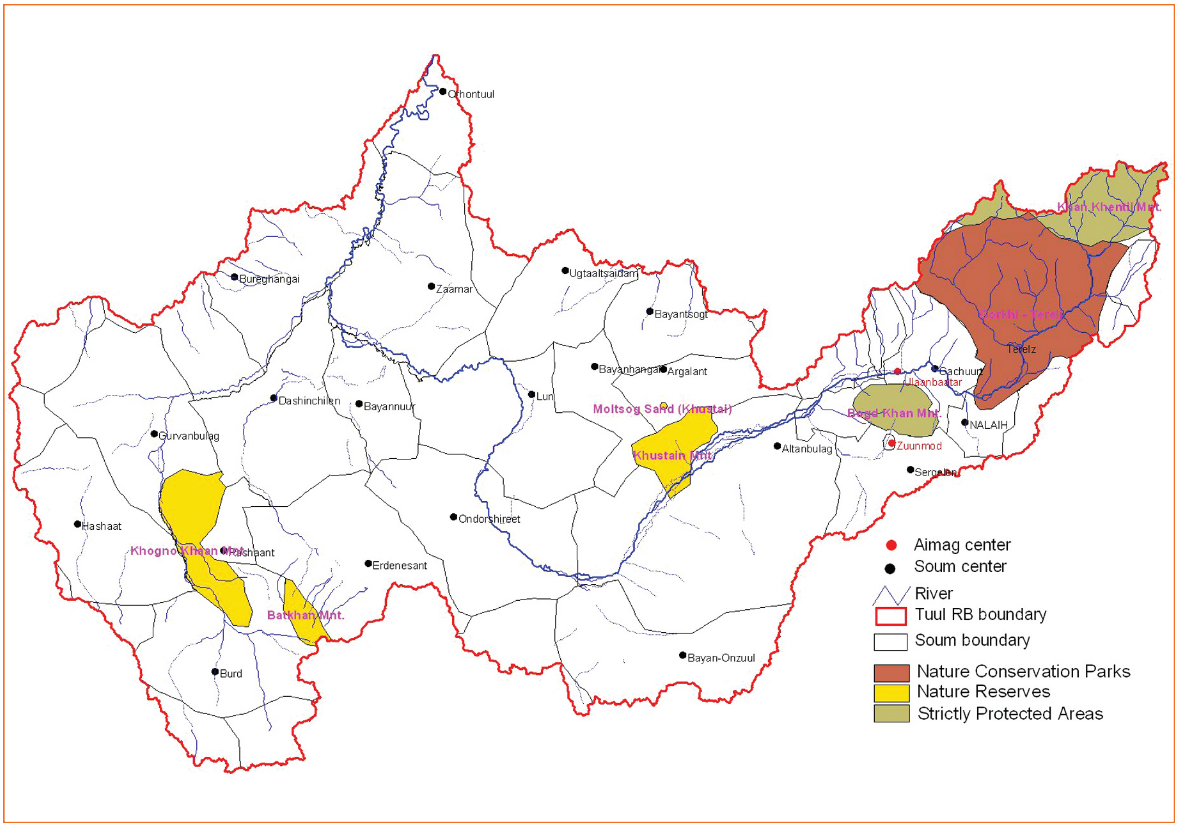

Figure 15. Location of the Protected Areas

Following developments in social needs and requirements as well as economic developments that have been taken place there is a noticeable change in land use. As of today land use in the Tuul River Basin includes the following 10 main types:

1. Pasture
2. Cultivation
3. Hay-field
4. Virgin land
5. Bare land (sand, rock cliff etc)
6. Settlement
7. Roads
8. Forest
9. Water
10. Manufacturing and mining

By land use type the largest area is occupied by pasture land in total of 42660.9 km^2 or 77.3% of total basin area. Crop land, settlement area, road and forest area varies between 0.1 – 6.8%. River and lake area occupy in total 16079 ha from which 13899 ha is occupied by rivers and 2180 ha by lakes. The land use map of the Tuul River Basin is given in Figure 16.

The table below shows areas and percentages of each land use type.

Table 12. Land use type

No	Land use type	Area, *km²*	%
1	Pasture	42660,9	85,7
2	Cropland	668,7	1,3
3	Hay	777,3	1,6
4	Abandoned land	1093,8	2,2
5	Sand	67,8	0,1
6	Urban	497,3	1,0
7	Industry/Mining	336,8	0,7
8	Road	151,2	0,3
9	Forest	3361,0	6,8
10	Water	159,6	0,3
	Total	49774,3	100,0

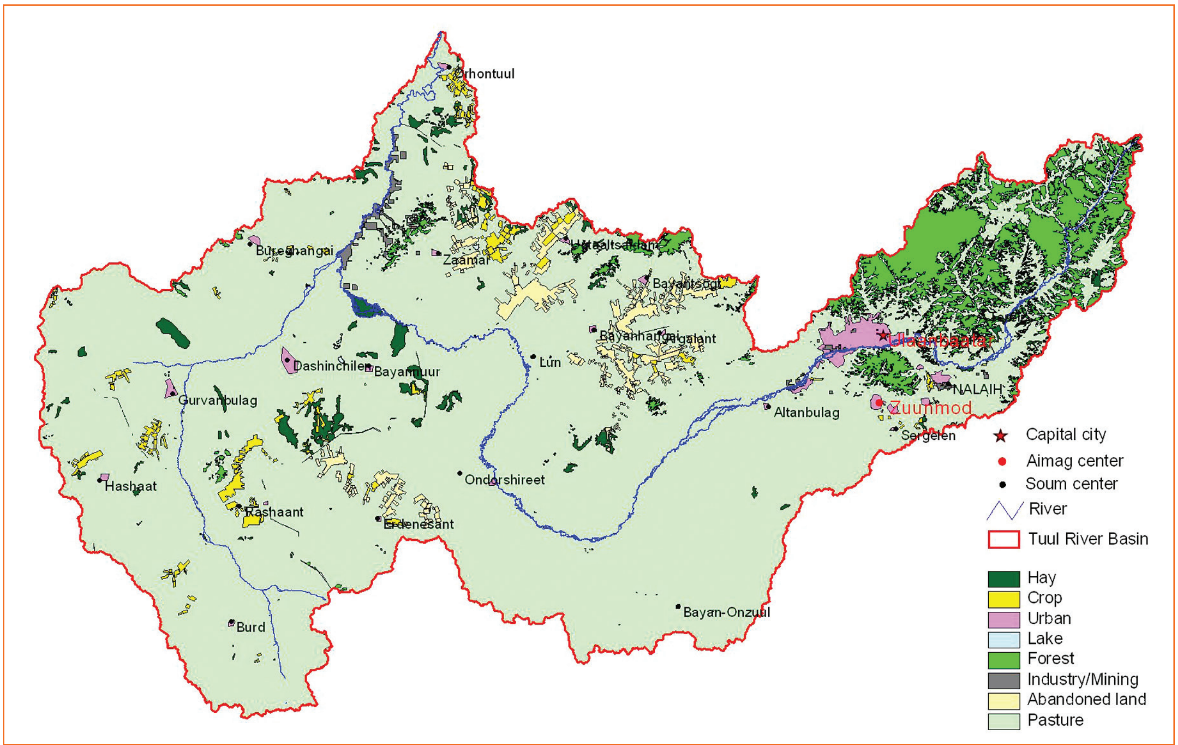

Figure 16. Land use map

The 2010 data of the unified land reports was used for the estimation of the Tuul River basin land use. However, the unified land reports are prepared annually and by each aimag and digital data is lacking to properly process the figure of river basin land use changes.

As mentioned in the unified land reports, urban and local land area is expanded and pasture land area is reduced due to the urbanization and infrastructure development. But there are no significant changes in hayfield land area despite the increase of the agricultural area due to ownership of the winter and spring quarter places. Also, the road network is increased by asphalt road constructions. Particularly, around 350 ha road area was increased by road construction work in Lun soum of Tuv aimag in 2010.

5.3. Current status of land relations

Following changes in the social conditions it became necessary to reform the legislation governing land issues in Mongolia. For this purpose a package law about land of Mongolia was approved. In the framework of this law, the main condition on land ownership, utilization or land protection is formed to regulate relations between citizens, entities, enterprises and state. At the same time a government policy on land issues is implemented that includes comprehensive organisational measures for the protection of land reserves, its pattern and quality; to keep its nature; to provide mapping making its registration and providing research study; to define land tariff, land fee and restoration of degraded lands.

In the Law on Land of Mongolia it is specified that the terminology of land relations should be used and understood as follows:

- To “own” land means to be in legitimate control of land with the right to dispose of this land;
- To “possess” land means to be in legitimate control of land in accordance with the purpose of its use and terms and conditions specified in respective contracts;
- To “use” land means to undertake a legitimate and concrete activity to make use of some of the land characteristics in accordance with contracts made with owners and /or possessors of land.

It is only since the year 2001 that citizens, entities or enterprises can own and use land with a legal right in Mongolia. By the end of each year information on land owners, land users and holders is submitted, as well as information about lands that are under land relations by aimags and in the whole country. By the end of 2008 about 5700 citizens own land in total of 41.2 km^2 areas in Tuul river basin.

Measures for land protection include restoration of destroyed land, destruction of rodents, forest cleaning, etc. To protect the land a centralized annual plan of land organizational structure is implemented by aimag and soum center. Since 2008 several protection measures covering an area over 3471 km^2 have been implemented such as pasture rotation in about 1500 km^2, extermination of rodents on 600 km^2. On other lands steps were taken to remove household waste; strip cultivation, enrichment with fertilizer and leveling of trenches and holes.

The report of land protection measures for 2008 reports that protective measures have been taken on damaged lands of 68.1%. However, holes and destroyed land caused by mining or private activities neither are nor reflected in the plan for rehabilitation work because they do not comply with legal specifications as stated in the report.

5.4. Land use approaches

The Tuul River basin is located strategically and in the most beneficent geopolitical position with a relatively favourable condition of nature and climate. It is the centre of Mongolian gravitation. Also, it comprises Zuun mod city as a key centre of the regional development concept. And it is a suitable territory which has well developed infrastructure and substantial market volume. Thanks to all these positive impacts, the social-economic sector of the Tuul River basin is sustainably developing in recent years.

Before 1990, Mongolian land use planning was directed to socially efficient land use. Nowadays, it is tried to regulate social activities on the bases of natural resources availability and to prevent land degradation, desertification, and deficiency of crop land, forest, and soil and water resources shortage. Hence this land planning, it was processed general plan of land organizational structure of each aimags in last many years. It was financed from local governments. A main objective of this general plan is focusing on land management policy which supporting current and further land utilization development with economically efficient and devoid of ecological adverse impacts.

It is right to include general plan of land organizational structure in processing of integrated water resources management plan of Tuul River basin.

Central regional mid-aimags reserve pasture land which named on ''Dashinchilen'' and ''Khukh del'' are included in state special needs land. Borderlines of this land are established according Mongolian government resolution # 64 which was approved on 17th Mar 2010. It comprised the whole territory of ''Dashinchilen'' (33740 ha) and half of ''Khukh del'' (14660 ha) reserve pastureland areas in the Tuul river basin. The Figure 17 shows the location of reserve pastureland areas in the Tuul river basin.

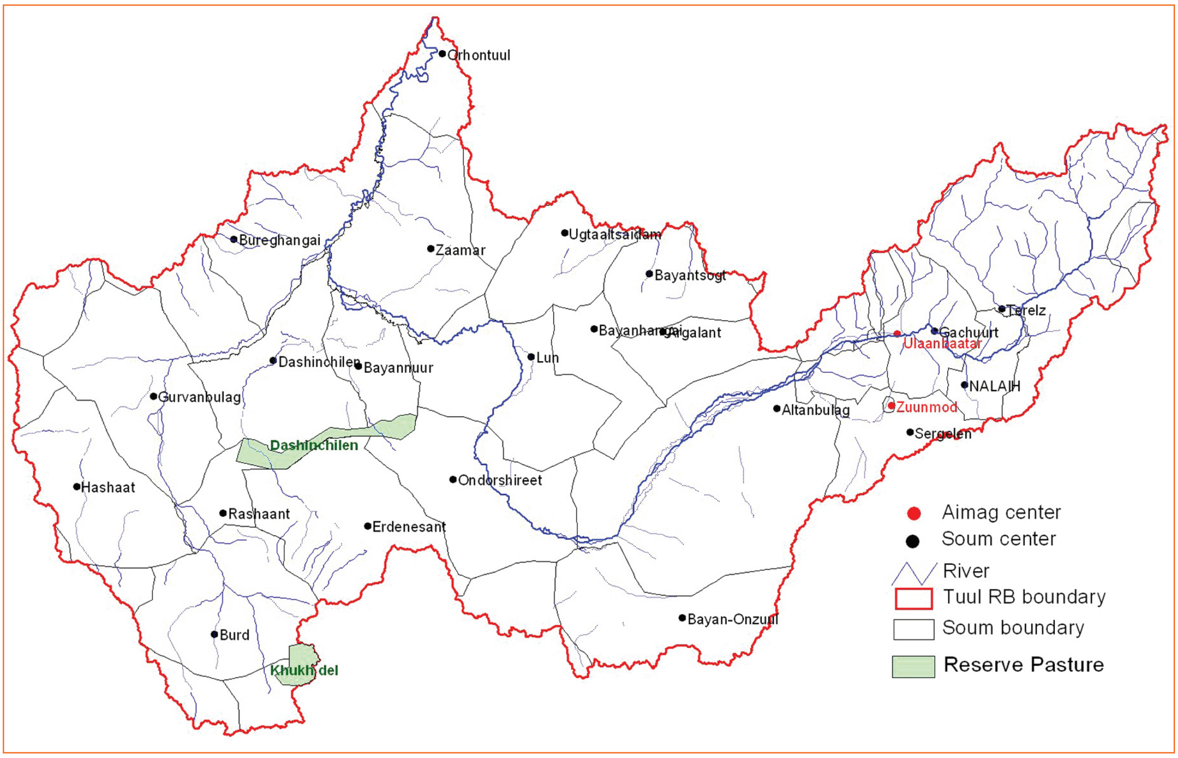

Figure 17. Reserve pastureland

5.5. Desertification and land degradation

Desertification

As defined by UNCCD (United Nations Convention to Combat Desertification) “the desertification is the land degradation in arid, semi-arid and dry sub-humid areas as resulting from various factors, including climatic variations and human activities". The researcher D.Dash [18] concluded in his research papers that, "the desertification is the inconvenient phenomena to reduce both natural and economic capacity of local area as results of the ecosystem productivity decreases in semi-arid area under natural factors and industrial impacts".

In 1996 Mongolia joined UNCCD (United Nations Convention to Combat Desertification) and in 2003 the Government of Mongolia developed and approved the "National Action Programme on Combat Desertification (NAPCD)". In this programme the current situation of desertification was analyzed and the policies were defined to combat desertification.

The desertification map made by the Institute of Geo-Ecology of the Mongolian Academy of Sciences shows that the desertification in Tuul River Basin covers a total area of almost 28877 km² of land or 57% of the total territory of the river basin. About 8.5% or 4293.2 km² is heavily degraded.

Table 13 shows the desertification status and desertification rate in the Tuul river basin and its spatial distribution is shown in Figure 18.

Table 13. Rate of desertification

Desertification rate	Area, *km²*	%
Slightly	13379.9	26.4
Moderately	11203.9	22.1
Severely	4293.2	8.5
Total	**28877.0**	**57.0**

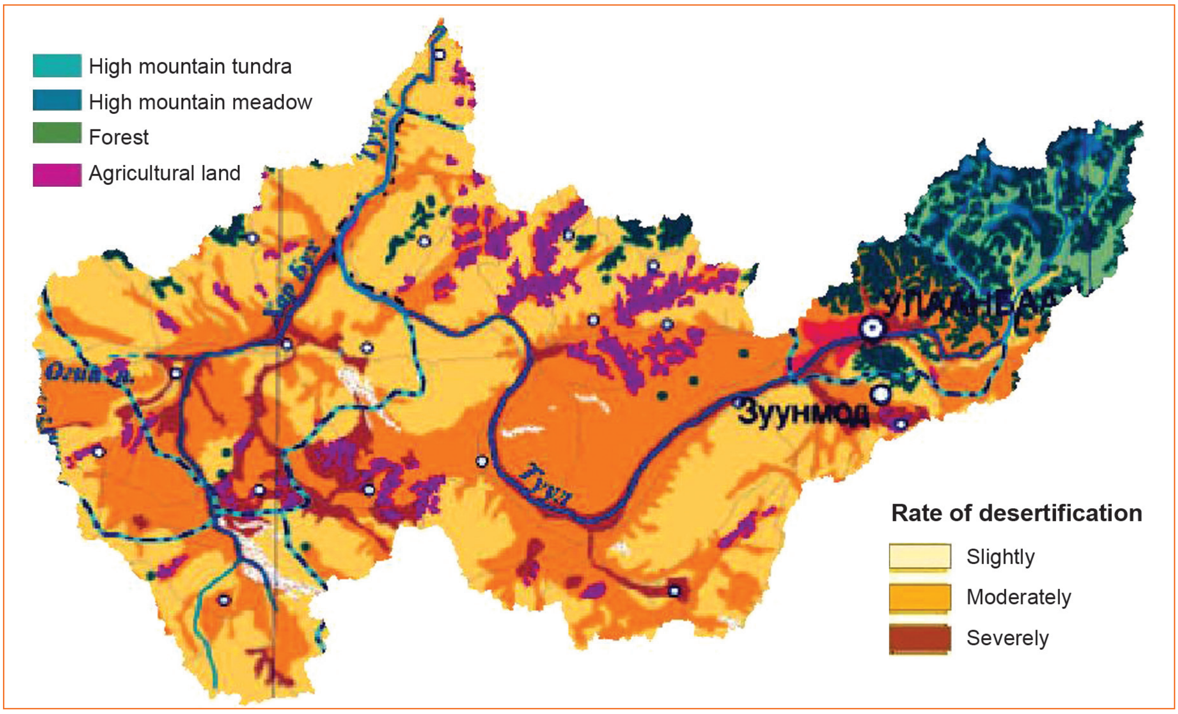

Figure 18. Desertification rate in Tuul river basin

Land degradation

Currently around 50% of the total population of Mongolia lives in the Tuul river basin. Figure 19 shows the population density of the river basin.

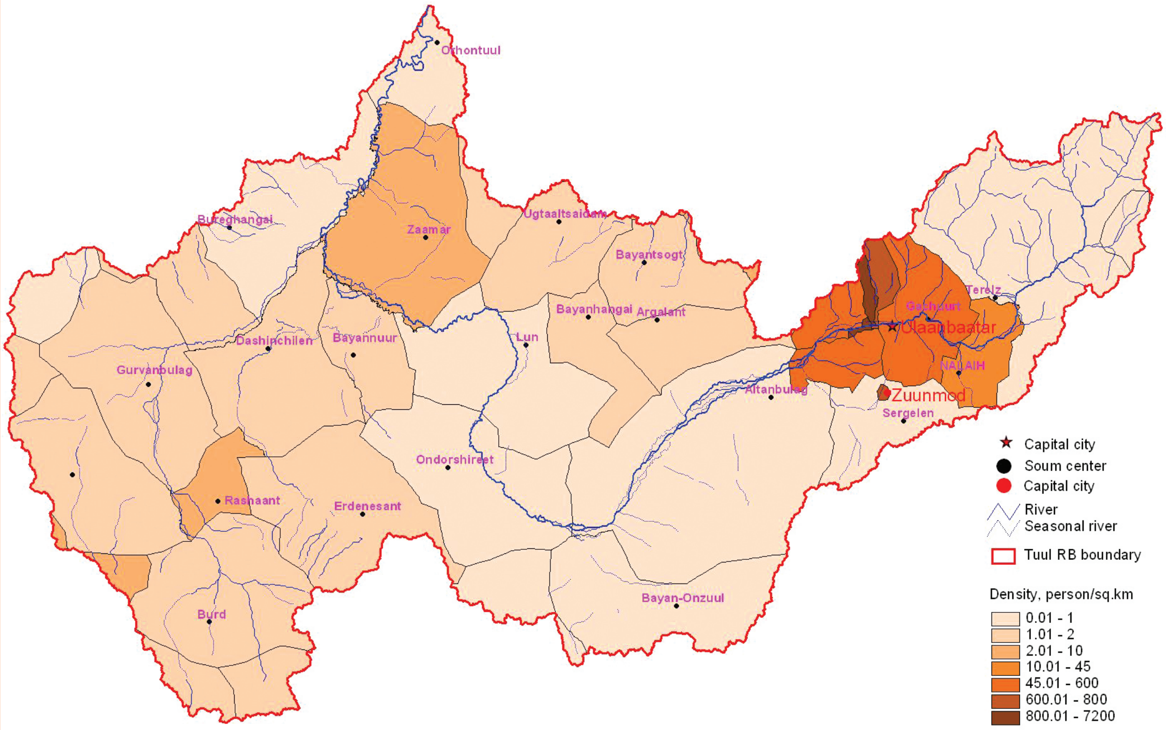

Figure 19. Population density in Tuul river basin

In recent years, the population centralization increased in the Tuul river basin. It is caused by increasing immigration by population from rural areas to urban areas. Also, the number of livestock head increased. This has caused pasture degradation to reach to 28.8%. Of the total land 3.7% was degraded by flaws and rodents. According to researchers, the main reasons of land degradation are:

- Pastureland is state property, but livestock is in private ownership
- Lack of land restoration activities
- Unevenly distributed pastureland use
- Change in seasonal tradition of pasture rotation (currently just 2 seasonal migrations in a reduced part of the pastureland area)
- Insufficient public ecological education
- Weakness of government involvement in control of pastureland regulation
- Herders initiative is poor in pastureland relation

Since 1990, the number of large cattle head was decreased but the small cattle head was increased in Mongolia. It is one of the main reasons of pastureland degradation. As of the livestock census result of 2010, it was counted 2856 thousand or 5.4% from the total national livestock in the Tuul river basin. Figure 20 shows livestock density in the Tuul river basin.

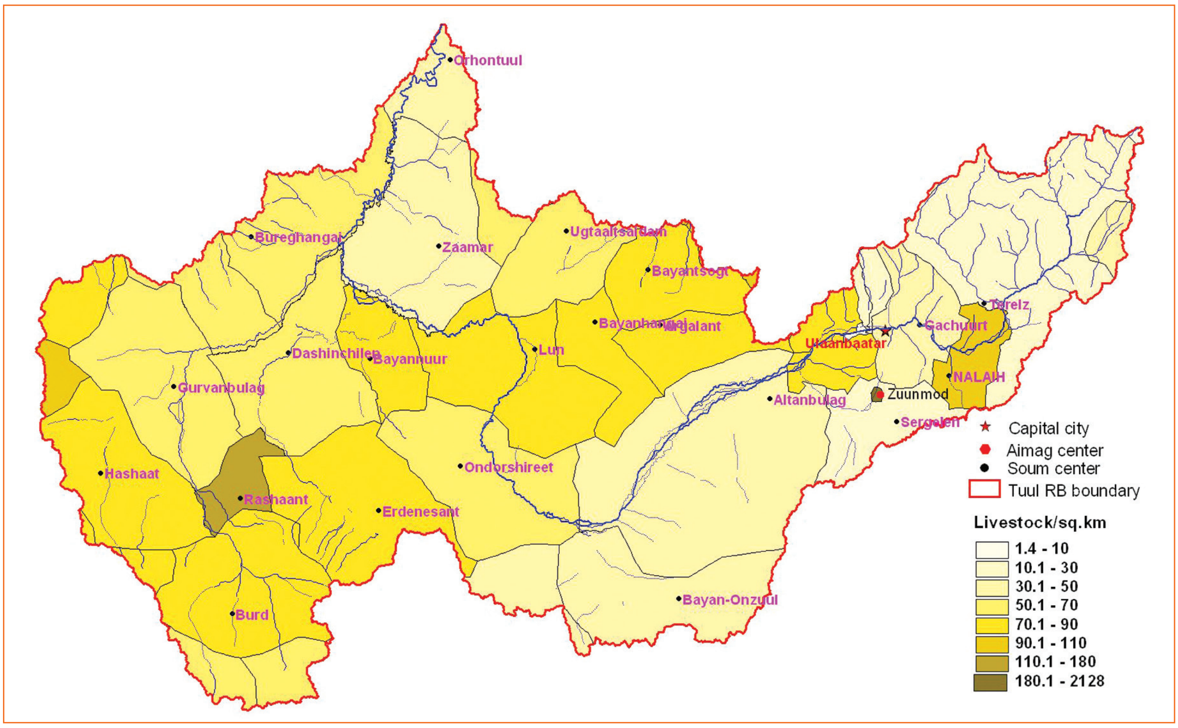

Figure 20. Livestock density

According to the Land Law of Mongolia, pastureland should be inspected on pattern and quality every 5 years. From the results of such inspections over the period of 2002-2008 the map presented in Figure 21 of overgrazed pastureland in Tuul River Basin has been prepared. From this figure, it can be concluded that overgrazing occurs mainly in the Tuul River valley which is overgrazed more than other areas.

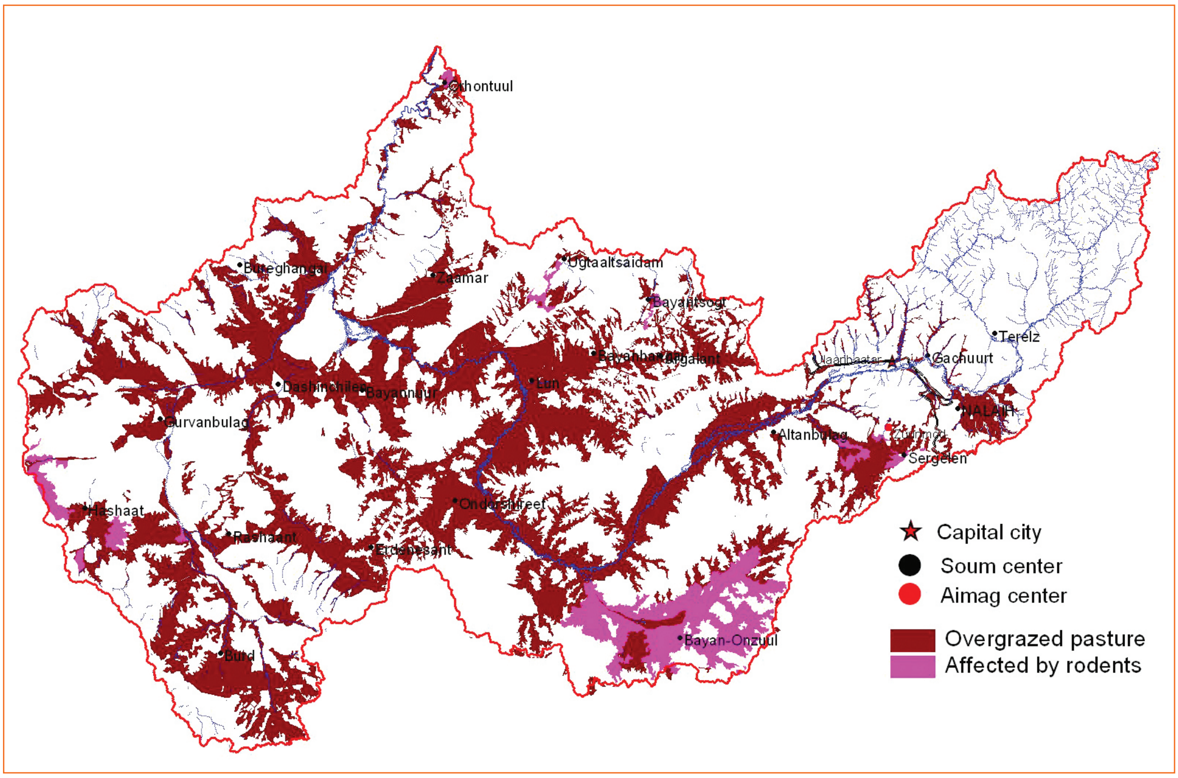

Figure 21. Overgrazing of pastureland

In the Tuul river basin, there is a broad range of mineral resources exploration and mining activity by citizens and entities. The explored area reached 4656.4 km^2 or 9.4% of the total basin area and around 0.7% areas are highly eroded by these mining explorations. As of report data of 2010 land fund, in total 1247 ha was eroded by mineral resources exploration. Figure 22 and Figure 23 show the location of the mineral resources exploration and mining areas of the Tuul river basin.

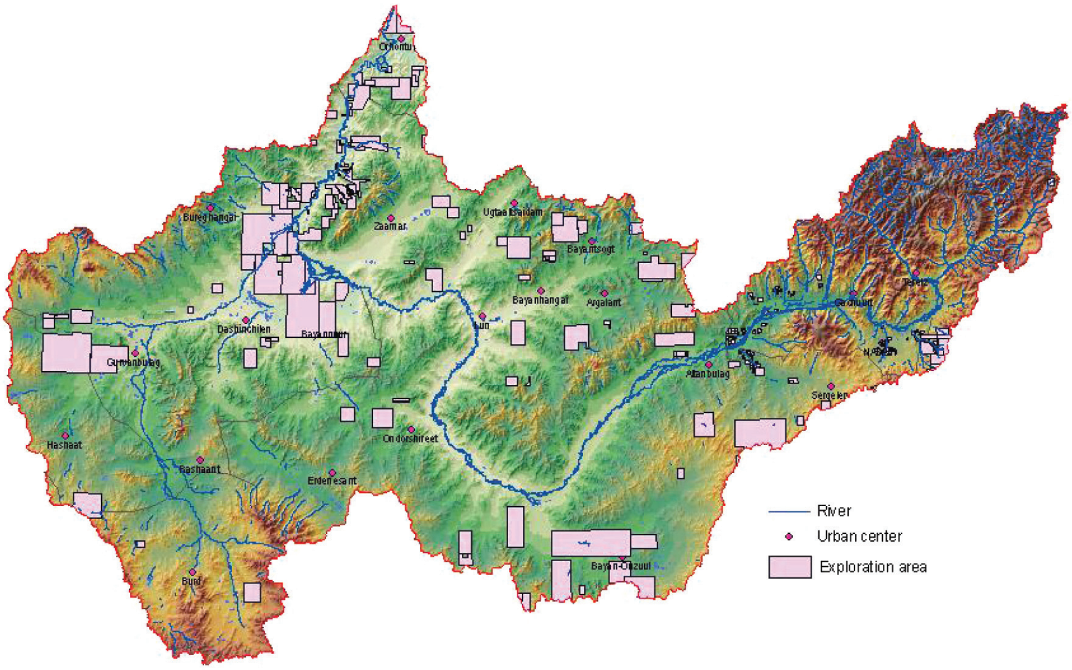

Figure 22. Exploration area in Tuul river basin

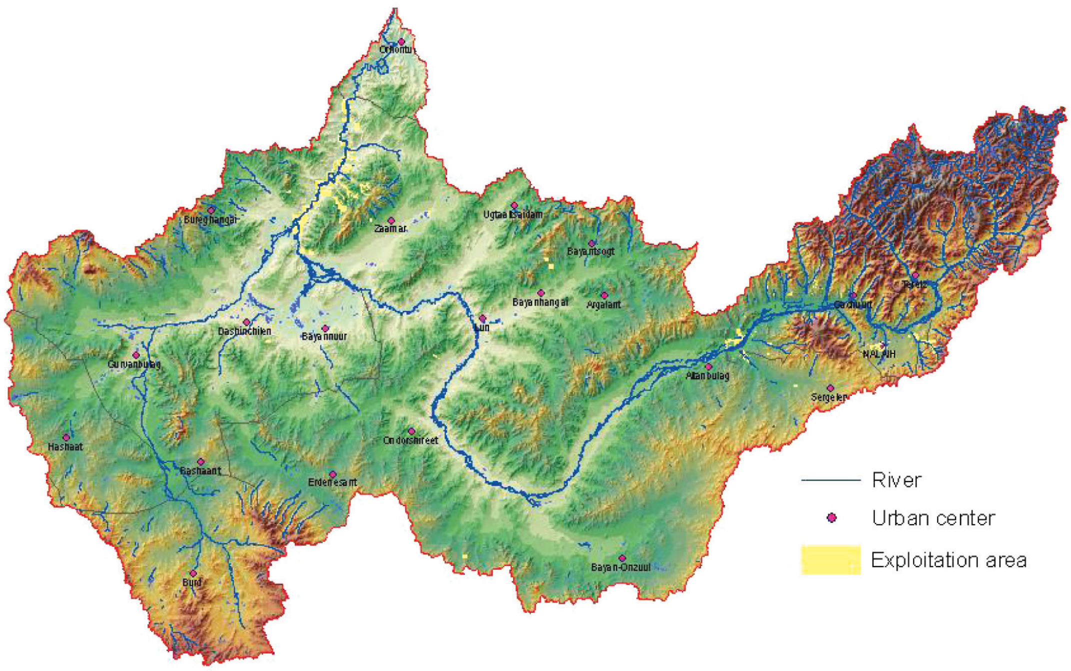

Figure 23. Exploitation area in Tuul river basin

In the frame of the Law on "Prohibition of Mineral Prospecting Exploration in Runoff forming Areas and Forest Areas" the Water Authority determined that the total area of the exploitation for mineral resources is 12.4% or 575.5km^2 from the total exploitation area of the Tuul River Basin. About 43.0% of the mining area or 145.9 km^2 is included in runoff forming and water protection zones (Figure 24).

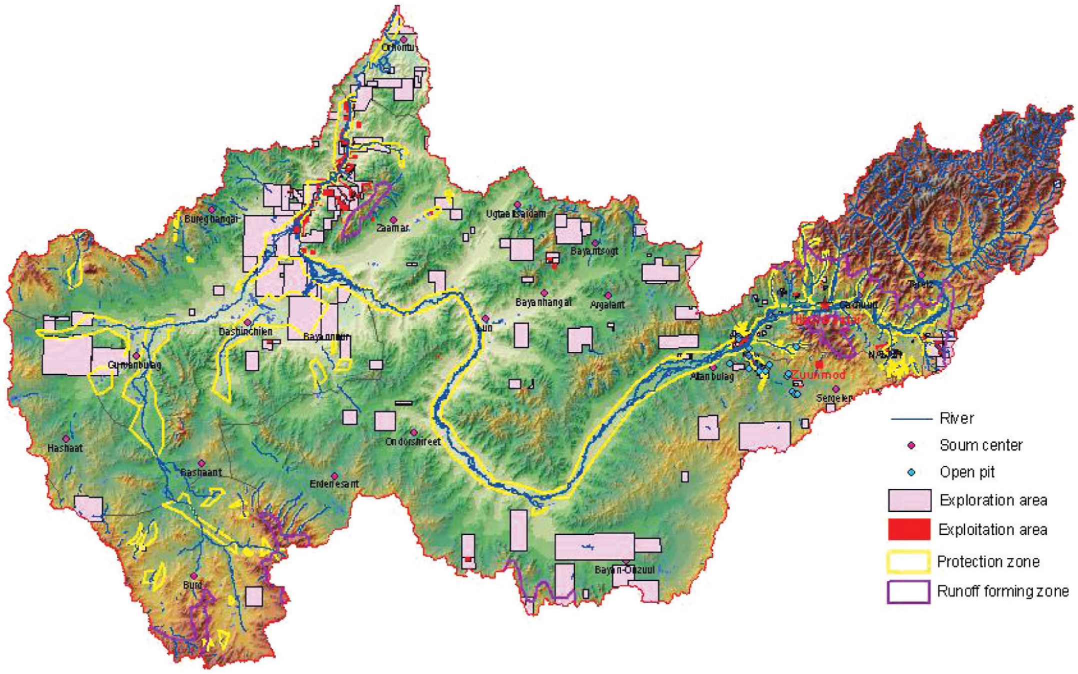

Figure 24. Exploration and exploitation area in protection and runoff forming zone

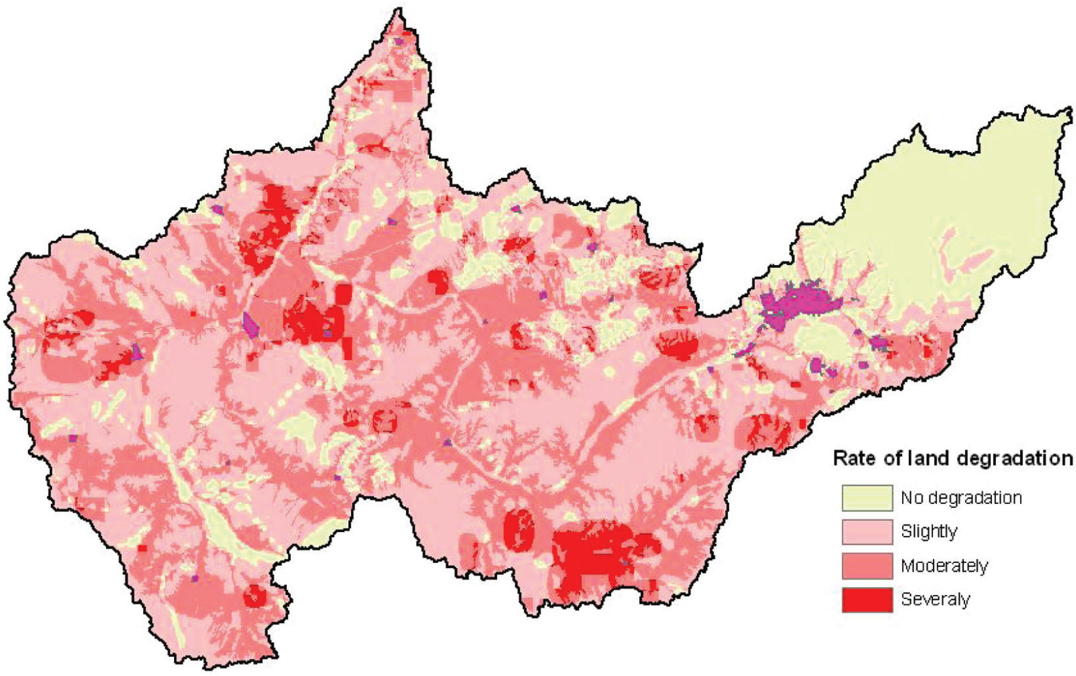

Figure 25. Land degradation rate

Figure 25 shows the land degradation categories of the Tuul river basin as determined by geographic information system. From this figure, it is clear that the land degradation category is higher in natural resources exploration areas and pasture areas. However, there might be other factors for land degradation.

One of the clear examples of land erosion by natural resource exploitation are the mining activities in Zaamar soum in Tuv aimag along the Tuul River.

When evaluating the current condition and changes of the land cover in Zaamar soum by using Landsat satellite image data of 1989, 2000 and 2005, there were clear changes around mountain forest area of the soum centre. All these changes are caused by mining effects which located along the Tuul River. Table 14 and Figure 26 show land cover changes and land erosion state along the Tuul river. The mining area was increased around 137 times in comparison to 1989 with 2000 and 212 times from 2000 till 2005. This number is only related to the Zaamar soum situation.

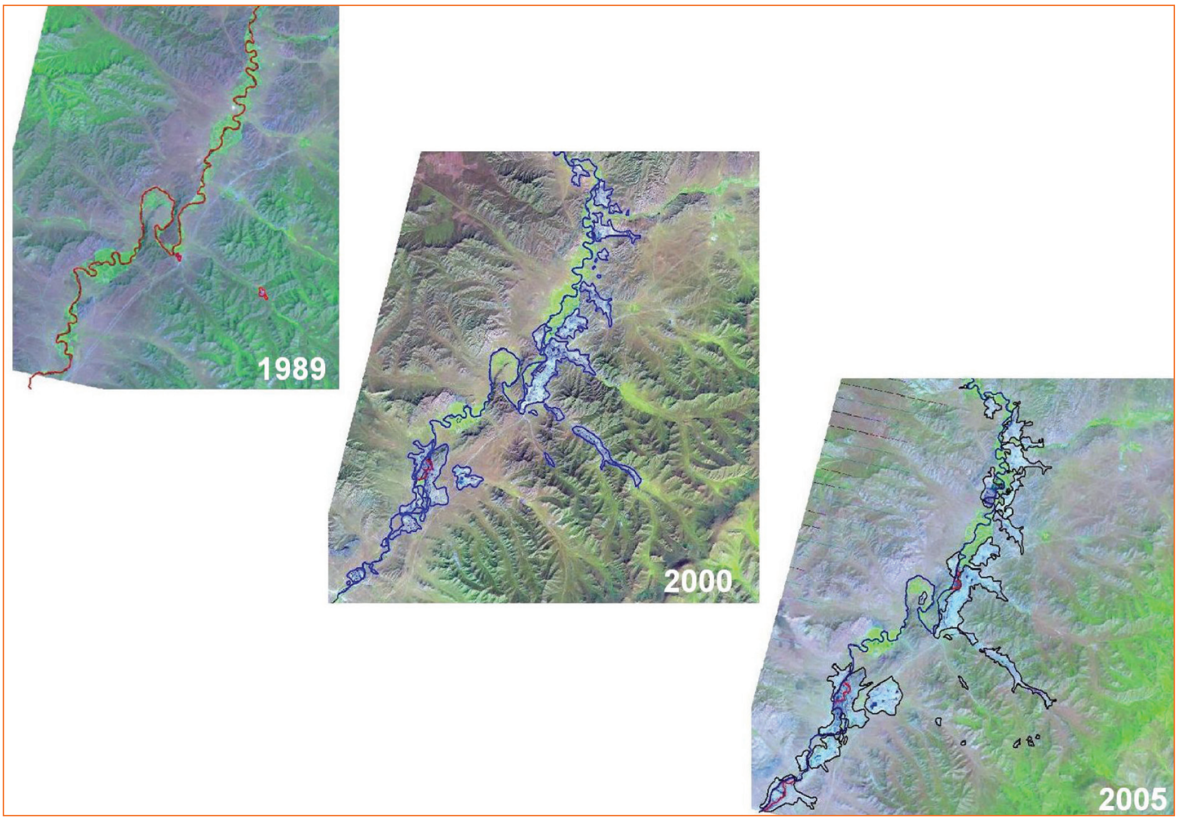

Figure 26. Landsat images of Zaamar (1989, 2000, 2005)

Table 14. Changes in Gold mining area (Zaamar)

Date	1989-08-21	2000-09-20	2005-08-17
Mining area, *ha*	21.6	2977.35	4592.41

5.6. Suggestions and conclusions on land use

- The Tuul river basin posseses many issues related to integrated river basin management, therefore it is necessary to urgently provide land organisation and management planing.

- It is essential to link foreign and domestic projects, programs, researches and scientific works which are implemented or which will be implemented in the Tuul River basin.
- Most parts of the Tuul river basin comprise the degraded pasture category. Therefore it is important to introduce an optimal pastureland management policy in this river basin area.
- It is neccesary to process all type of datas on a large scaled and use it for the development of the integrated water resources management plan of the Tuul river basin.

6. Wildlife

6.1. Introduction

There is no specific study on wildlife at Tuul River Basin level. However some studies have been carried out on biodiversity and fauna in Mongolia at different levels in total territories. Therefore, some data and results of study works which were previously done by scientists which may subject to the Tuul River Basin have been selected and included in this report. In order to determine distribution of animals in this basin, the basin is divided into 5 sub basins based on the following grounds:

- State of Tuul River and its tributaries being affected by human activities (low, medium and high)
- Natural zones (mountain taiga, forest steppe and steppe)
- Concentration of population and industries (low, medium and high density)
- Climate conditions and location of runoff observation point (Terelj, Zaisan, Altanbulag, Lun and Orkhon-Tuul)
- General formation of fauna distribution (Common feature of fauna in the natural zones)
- Parts that subject to balance use of water recourses in the Tuul River basin (upstream, midstream and downstream parts)

Sub basins as follows:

1. The 1st sub basin (From Tuul river upstream to Tuul-Terelj monitoring station)
2. The 2nd sub basin (From Tuul-Terelj station to Zaisan monitoring station)
3. The 3rd sub basin (From Tuul-Zaisan station to Altanbulag bridge)
4. The 4th sub basin (From Altanbulag bridge to Tuul-Lun monitoring station)
5. The 5th sub basin (From Tuul-Lun station to Orkhon-Tuul confluence)

The 1st sub basin overlaps with the upstream part of water recourses use balance. The 2nd and 3rd sub basins are included in the midstream part, and the 4th and 5th sub basins are included in downstream part.

Due to the Tuul river basin is located across mountain taiga, forest steppe and steppe, fauna in this basin keeps a general feature of fauna distribution in these natural zones. On the other hand, natural feature of fauna distribution needs to be precisely considered as it is changing to some extent. The steppe consist 82.8% of a total territory in the basin, forest steppe 11.8% and mountain taiga 5.4%, respectively. As the steppe animals which cover most part of the basin are different from others, they are subject to the 4th and 5th sub basins. There is a small change in fauna in the vicinity of Ulaanbaatar due to human activities and they are subject to the 2nd and 3rd sub basin.

Biodiversity database of Mongolia has been created and published online in 2006 by the Steppe Forward Program implemented under the National University of Mongolia /NUM/ in cooperation with professional organisations such as NUM, Academy of Science and Association of Ornithology, etc. It has been financed from the World Bank's NEMO project and contributed by UK Association of Zoology. By using this biodiversity database, the fauna in the upstream, midstream and downstream parts of the basin is precisely considered as mammal, fish, amphibians and reptile classes. Also bird species in the basin have been precisely determined based on the Mongolia's Red List of Birds published in 2011.

6.2. Fauna

There are 14 fish species, 50 mammal species and 2 amphibian/reptile species in the 1st sub basin, 8 fish species, 39 mammal species and 2 amphibian species in the 2nd sub basin. 9 fish species, 37 mammal species and 2 amphibian species in the 3rd sub basin, 9 fish species, 33 mammal species and 2 amphibian species in the 4th sub basin, and 13 fish species, 45 mammal species and 2 amphibian species in the 5th sub basin [28].

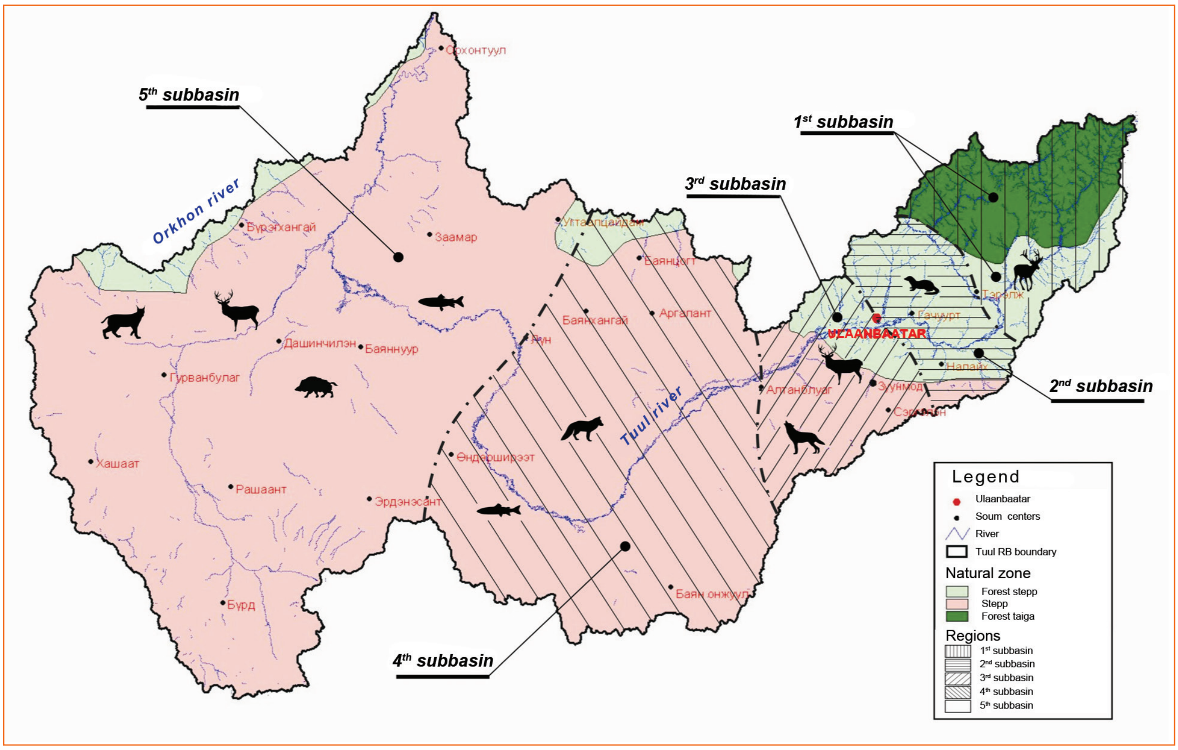

Figure 27. Overview of fauna zone, and rare and endangered animals in the Tuul River Basin

Fish. There are 16 fish species of 10 families in this river basin. Of these, 5 fish species such as Siberian sturgeon (asipenser baerii), ide (leuciscus idus), lenok (brachymystax lenok), taimen (hucho taimen) and arctic grayling (thymallus arcticus) might become rare or vulnerable. Also some fishes that reveal purity of water in the basin are included. Fish species of cyprinids including for perch, East Asian catfish (silurus asotus), Siberian spiny loach (cobitis melanoleuca), siberian stone loach (barbatula toni) and pike (esox lucius) have been observed in the Tuul River downstream of Ulaanbaatar at small number. But taimen (hucho taimen), fish of salmonids has not been found here according to study [24].

There are many factors which negatively affect aquatic animals in the Tuul River basin. For example, increase of mineralization, extreme fluctuation of a temperature, change in hydrogen content, lack of oxygen, detection of heavy metals, wastes, drawdown, etc negatively affect fishes and aquatic animals. Particularly, taimen (hucho taimen), lenok (brachymystax lenok) and grayling (thymallus) which are semi-migratory fishes, and ephemeroptera, plecoptera and trichoptera which are weather indicating insects are vulnerable in these changes. Therefore, it is obviously important issue to conserve fishes and other aquatic animals and to provide natural restoration and development of vegetation as well as normal ecological conditions [25].

Amphibians and reptiles. There is a few variety of reptile and amphibian species in the basin and is distributed along areas with a convenient habitat condition on a limited scale. One species of amphibian Mongolian toad (Bufo raddei) and one species of reptile steppes rat snake (elephe dione) have been reported in the Mongolian Red List of Amphibian and Reptiles [22].

Mongolian toad (Bufo raddei). This is one of the most widespread species in Mongolia. It essentially relies on wetlands such as river, lakes, springs and oasis in Gobi desert, steppe and forest zones [22], [23].

There is a probability that its population might become rare recently due to degradation of its habitats, water pollution, mining of natural resources, and drought of rivers and lakes. But Mongolian toad is unlikely to reach critical level of scarcity.

Steppes rat snake (elephe dione). The steppes rat snake is inhabited in a wide area covered from desert region to north taiga in various natural zones elevated at 600-3000 m above sea level, except mountain zone [22].

This species is widespread in areas with a variety of biotope and obviously there are many causes of becoming rare. Main natural factor to negatively affect this species is a malnutrition related to winter cold weather, drought and crop reduction as well as threat to become a prey of wild animals such as fox, corsac fox and bird of prey. Another main factor to decline distribution of this species, degrade habitat quality and reduce its population is a degradation of its habitat due to establishment of infrastructure such as urban settlement, paved road, hydropower station etc and various human activities such as exploration and mining of natural recourses [22]

Mammals. There are ‘Endemic’ 128 mammal species, ‘Invasive’ 4 mammal species and totally 132 mammal species in Mongolia. Of these, approximately 60 mammal species of 18 families of 7 orders are in the Tuul River basin. These include 7 insectivore species, 23 species of simple toothed rodents, 4 species of double toothed rodents, 7 species of wing handed animals, 14 carnivore species and 5 artiodactyla orders.

Some 20% of a total 60 mammal species which inhabited in the Tuul River basin were included in the Mongolia’s Red List of Mammals as rare and near threatened classes. Also these mammals were registered in the Mongolian Red Book and in Mongolian Law on Fauna as rare and very rare animals. Some representatives of these rare mammals as follows:

Eurasian otter (lutra lutra). It is found in the upstream part of the basin from Tuul-Bosgo Bridge monitoring station to Terelj monitoring station.

Since 1930 it has been prohibited to hunt the Eurasian otter and included in the Red List as very rare according to the Mongolian Law on Hunting in 1995. It was registered in two editions of the Mongolian Red Book as rare and very rare.

It is written in the Mongolian Red List of Mammals that main cause of Eurasian otter becoming rare is related to pollution of its habitat (water) ecosystem due to illegal hunting and mining activities [20]

Eurasian elk (alces alces). It is mainly found in Khentii and Khuvsgul taiga, and Onon, Kherlen, Tuul, Kharaa, Eruu and Minj River basins. This species included in the Mongolia’s Red List of Mammals as ‘endangered’ as it was considered that its population decreased by 50% due to scarcity and pollution of its habitat and uncontrolled hunting.

Also it was included in two editions of the Mongolian Red Book as 'very rare'. In addition, this species is forcefully pushed into lack of habitat due to water pollution caused by mining activities (mining of gold and minerals).

Birds. Approximately 171 bird species have been reported in the Tuul River basin. Of these, some 37 bird species are non-migratory birds, 134 species are migratory birds and totally 142 species lay their eggs in the basin. Also some 8 bird species such as bean goose (anser albifrons), mandarin duck (aix galericulata), smew (mergus albellus) and pallid harrier (circus macrourus) summer here. Vice versa, 5 species such as mallard (anas formaosa), gold crester wren (regulus regulus), siskin (cardullis spinus), yellow bunting (emberiza citrenilla) and snow bunting (plectrophenax nivalis) winter here [26].

The reason of why 134 bird species or 78.36% of overall birds in the basin are migratory birds is the main migration way for migratory birds migrate to/from Mongolia is passed by this basin.

There are 12 rare bird species and 1 very rare species which is a white-naped crane (grus vipio) in the basin. As we see from above, some 9.12% of all the birds found in this basin are subject to rare and very rare bird species.

Wild animals at Bogd Khan Mountain National Park

This national park is totally included in the Tuul River basin. Diversity of fauna is distributed in this park. This is one of the oldest national parks in the world (considered that its protection status started from the 13th century). As biodiversity has been originally conserved in this national park for the centuries, it is highly important not only at national level, but the global level. There are 54 mammal species such as marmot, squirrel, hedgehog, palla's cat, martin, lynx, deer, Siberian roe deer, wild sheep and Siberian ibex, and 205 fish species of 36 families of 14 orders, and 1660 insect species of 174 families of 16 orders, 259 mezofauna species of 13 families, 93 microorganism species of 14 orders, 2 amphibian species of 2 families, 4 reptile species of 4 families, 612 vascular plant species of 70 families, 163 moss species of 33 families, and 160 lichen species of 16 families in the Bogd Khan Mountain. Of these, 13 mammal species, 10 bird species, 5 species insects, 23 vascular plant species, 4 moss species, 6 lichen species are considered as rare at level of Bogd Khan Mountain. Of these species, 2 mammal species, 4 bird species, 1 butterfly species and 1 vascular plant species were registered in CITES. Also 3 mammal species, 5 bird species, 5 insect species, 4 vascular plant species and 6 lichen species were registered in the Mongolian Red Book published in 1997 [27].

As the Bogd Khan Mountain belongs to very southern branch mountain of Khentii taiga, it becomes a south boundary of fauna distribution in taiga and forest zones. There are some rare biological formations such as distribution of spruce across mountain ranges. The spruce is a rare tree species in Mongolia.

6.3. Conclusions on wildlife

1. There are 16 fish species of 10 families, 2 species of amphibians and reptiles, approximately 60 mammal species of 18 families of 7 orders, 171 bird species at the Tuul River basin level. Of these, 5 bird species and 11 mammal species are included in near threatened class, 12 bird species and 1 mammal species 1 bird species in rare class, 1 mammal species in very rare class:
   - Of fishes, mammals, amphibians and reptiles included in the 1st sub basin, 1 fish species and 2 mammal species are endangered, 2 fish species and 5 mammal species are near threatened, and 1 fish species and 1 mammal species are

vulnerable. Also moose elk (alces alces), Eurasian otter (lutra lutra) and sable (martes zibellina) are found only in this sub basin. Compare to other sub basins, relatively high number of animals have been registered here. This is due to low impact from human activities in this sub basin.

- Of fishes, mammals, amphibians and reptiles included in the 2nd sub basin between Tuul -Terelj monitoring station and Tuul-Zaisan monitoring station, some 3 mammal species are endangered, 1 fish species and 1 mammal species are vulnerable.
- Of fishes, mammals, amphibians and reptiles included in the 3rd sub basin between Tuul-Zaisan station and Altanbulag Bridge station, 1 fish species, 2 mammal species are endangered and 2 fish species are vulnerable.
- Of fishes, mammals, amphibians and reptiles included in the 4th sub basin between Altanbulag Bridge station and Tuul-Lun station, 2 mammal species are endangered, 1 fish species and 5 mammal species are near threatened and 1 fish species is vulnerable.
- Of fishes, mammals, amphibians and reptiles included in the 5th sub basin between Tuul-Lun station and Orkhon-Tuul confluence, 1 fish species and 2 mammal species are endangered, 2 fish species and 6 mammal species are near threatened and 1 fish species is vulnerable.

2. As we can see from fauna distribution in these 5 sub basins, the biggest number of fauna registered in the 1st sub basin in which human impact on environment is lower than others. But variety of fauna decreased in the 2nd and 3rd sub basins in the vicinity of Ulaanbaatar. While the distribution is the least and animals and birds which tolerant to environmental pollution are dominated in the 4th sub basin. This is due to lack of habitats for animals and birds caused by urbanization, industrialization and environmental pollution. Variety of fauna is tended to increase in the 5th sub basin between Lun monitoring station and Orkhon-Tuul confluence and it shows that habitat and conditions for wild animals are better than other sub basins.
3. For variety of fish species, lenok (brachymystax lenok) and arctic grayling (thymallus arcticus), etc inhabited in a relatively fresh and stream water are found in the 1st and 5th sub basins. There are cyprinids and non-hunting fishes which tolerant to environmental change and inhabited in warm water are dominated in the 2nd, 3rd and 4th sub basins.
4. City of Ulaanbaatar, Zuunmod, state-owned large factories, economic entities, organizations are located in the Tuul River basin and some 44.8% of a total population is based in this basin. Also majority of the basin population is concentrated in the city Ulaanbaatar. In this connection, most of water use, consumption and water resource population are occurred in the midstream part of the Tuul river basin, too. This bad situation triggers pollution of air, water and soil and degradation of plant cover and leads these animals to migrate to other areas and change their life habits.
5. As there is a rapid change in population of wild animal, birds, fishes and aquatic microorganisms as well as their life habits, it is necessary to carry out the detailed study on their location, population, species and life habits and possibility to verify them and to make further actions clear to take in the future.
6. It needs to improve living conditions of rare and endangered wild animals, birds and fishes, etc and breed them and to organize framework.

7. When organizing any industrial activities in any part of the basin, it is important to specifically focus on a complete conservation of living conditions for animals, birds and fishes, etc then make planning and performance.

8. It is considered that it would be essential to carry out the detailed study on animals and birds, and to plan protection of them based on a regional assessment shown in Table 15-18.

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ANNEX. Fauna distribution in the Tuul River basin

The Tuul River basin is divided in 5 sub basins according to a specific standard and the variety of fauna and their regional status is presented in this Annex. A table of regional status has been developed by the Steppe Forward Program implemented under the National University of Mongolia (NUM) in cooperation with Ministry of Nature, Environment and Tourism of Mongolia, NUM, Academy of Science and Association of Ornithology, etc. This programme has been financed from the World Bank's NEMO project and contributed by UK Association of Zoology. This regional status data is the most recent one in the result of number of discussion and meetings with both national and international professionals of above organisations according to the assessment method that meets the international standard.

The 1st sub basin from Tuul-Bosgo bridge to Tuul-Terelj monitoring station (Tuul River upstream part) Fauna species

Table 15. Tuul River upstream (Fish diversity and their regional status):

No	Common name	Order	Family	Regional status
1	Siberian sturgeon	Acipenseriformes	Acipenseridae	Critically endangered
2	Siberian stone loach	Cypriniformes	Balitoridae	Least concern
3	Siberian spiny loach	Cypriniformes	Cobitidae	Least concern
4	Ide	Cypriniformes	Cyprinidae	Near threatened
5	Common minnow	Cypriniformes	Cyprinidae	Least concern
6	Pseudorasbora	Cypriniformes	Cyprinidae	Data deficient
7	Roach	Cypriniformes	Cyprinidae	Least concern
8	Pike	Esociformes	Esocidae	Least concern
9	Burbot	Gadiformes	Lotidae	Data deficient
10	Perch	Perciformes	Odontobutidae	Least concern
11	Lenok	Salmoniformes	Salmonidae	Vulnerable
12	Arctic grayling	Salmoniformes	Thymallidae	Near threatened
13	East Asian catfish	Siluriformes	Siluridae	Least concern

Table 16. Tuul River upstream (Mammal species and their regional status):

No	Common name	Order	Family	Regional status
1	Siberian roe deer	Artiodactyla	Cervidae	Least concern
2	Elk	Artiodactyla	Cervidae	Endangered
3	Red deer	Artiodactyla	Cervidae	Critically endangered
4	Wild boar	Artiodactyla	Suidae	Near threatened
5	Grey wolf	Carnivora	Canidae	Near threatened
6	Red fox	Carnivora	Canidae	Near threatened
7	Eurasian lynx	Carnivora	Felidae	Near threatened
8	Wolverine	Carnivora	Mustelidae	Least concern
9	Eurasian otter	Carnivora	Mustelidae	Data deficient
10	Sable	Carnivora	Mustelidae	Vulnerable
11	Eurasian badger	Carnivora	Mustelidae	Least concern
12	Alpine weasel	Carnivora	Mustelidae	Least concern
13	Ermine	Carnivora	Mustelidae	Least concern
14	Least weasel	Carnivora	Mustelidae	Least concern
15	Siberian weasel	Carnivora	Mustelidae	Least concern
16	Northern bat	Chiroptera	Vespertilionidae	Least concern
17	Brandt's bat	Chiroptera	Vespertilionidae	Data deficient

No	Common name	Order	Family	Regional status
18	Daubenton's bat	Chiroptera	Vespertilionidae	Least concern
19	Whiskered bat	Chiroptera	Vespertilionidae	Least concern
20	Brown big eared bat	Chiroptera	Vespertilionidae	Least concern
21	Particoloured bat	Chiroptera	Vespertilionidae	Least concern
22	Daurian hedgehog	Erinaceomorpha	Erinaceidae	Least concern
23	Arctic hare	Lagomorpha	Leporidae	Least concern
24	Tolai hare	Lagomorpha	Leporidae	Least concern
25	Daurian pika	Lagomorpha	Ochtonidae	Least concern
26	Northern pika	Lagomorpha	Ochtonidae	Least concern
27	Siberian jerboa	Rodentia	Dipodidae	Least concern
28	Mongolian silver vole	Rodentia	Arvicolidae	Least concern
29	Korean field mouse	Rodentia	Muridae	Least concern
30	Grey red-backed vole	Rodentia	Arvicolidae	Least concern
31	Striped dwarf hamster	Rodentia	Cricetidae	Least concern
32	Long tailed dwarf hamster	Rodentia	Cricetidae	Least concern
33	Eurasian harvest mouse	Rodentia	Muridae	Data deficient
34	Reed vole	Rodentia	Arvicolidae	Data deficient
35	Narrow headed vole	Rodentia	Arvicolidae	Least concern
36	Maximowic's vole	Rodentia	Arvicolidae	Data deficient
37	Wood lemming	Rodentia	Arvicolidae	Data deficient
38	False zokor	Rodentia	Spalacidae	Data deficient
39	Eurasian red squirrel	Rodentia	Sciuridae	Near threatened
40	Root vole	Rodentia	Arvicolidae	Least concern
41	Long tailed ground sqiurrel	Rodentia	Sciuridae	Least concern
42	Siberian chipmunk	Rodentia	Sciuridae	Least concern
43	Siberian shrew	Soricomorpha	Soricidae	Data deficient
44	Eurasian water shrew	Soricomorpha	Soricidae	Least concern
45	Laxmann's shrew	Soricomorpha	Soricidae	Least concern
46	Large toothed Siberian shrew	Soricomorpha	Soricidae	Least concern
47	Least shrew	Soricomorpha	Soricidae	Data deficient
48	Tundra shrew	Soricomorpha	Soricidae	Data deficient
49	Even toothed shrew	Soricomorpha	Soricidae	Data deficient
50	Mongolian vole	Rodentia	Arvicolidae	Least concern

Table 17. Tuul River upstream (amphibian and reptile diversity and their regional status):

No	Common name	Order	Family	Regional status
1	Steppes rat snake	Serpentes	Colubridae	Least concern
2	Mongolian toad	Anura	Bufonidae	Least concern

The 2nd sub basin from Tuul-Terelj to Tuul-Zaisan monitoring station (beginning of midstream part) Fauna species

Table 18. Fish diversity and their regional status in the beginning of midstream part:

No	Common name	Order	Family	Regional status
1	Siberian stone loach	Cypriniformes	Balitoridae	Least concern
2	Siberian spiny loach	Cypriniformes	Cobitidae	Least concern
3	Common minnow	Cypriniformes	Cyprinidae	Least concern
4	Pseudorasbora	Cypriniformes	Cyprinidae	Data deficient
5	Pike	Esociformes	Esocidae	Least concern
6	Burbot	Gadiformes	Lotidae	Data deficient
7	Perch	Perciformes	Odontobutidae	Least concern
8	Lenok	Salmoniformes	Salmonidae	Vulnerable

Table 19. Mammal diversity and their regional status in the beginning of midstream part:

No	Common name	Order	Family	Regional status
1	Mongolian gazelle	Artiodactyla	Bovidae	Endangered
2	Red deer	Artiodactyla	Cervidae	Critically endangered
3	Grey wolf	Carnivora	Canidae	Near threatened
4	Corsac fox	Carnivora	Canidae	Near threatened
5	Red fox	Carnivora	Canidae	Near threatened
6	Pallas's cat	Carnivora	Felidae	Near threatened
7	Eurasian lynx	Carnivora	Felidae	Near threatened
8	Sable	Carnivora	Mustelidae	Vulnerable
9	Eurasian badger	Carnivora	Mustelidae	Least concern
10	Alpine weasel	Carnivora	Mustelidae	Least concern
11	Ermine	Carnivora	Mustelidae	Least concern
12	Least weasel	Carnivora	Mustelidae	Least concern
13	Siberian weasel	Carnivora	Mustelidae	Least concern
14	Northern bat	Chiroptera	Vespertilionidae	Least concern
15	Brandt's bat	Chiroptera	Vespertilionidae	Data deficient
16	Daubenton's bat	Chiroptera	Vespertilionidae	Least concern
17	Whiskered bat	Chiroptera	Vespertilionidae	Least concern
18	Brown big eared bat	Chiroptera	Vespertilionidae	Least concern
19	Particoloured bat	Chiroptera	Vespertilionidae	Least concern
20	Daurian hedgehog	Erinaceomorpha	Erinaceidae	Least concern
21	Tolai hare	Lagomorpha	Leporidae	Least concern
22	Daurian pike	Lagomorpha	Arvicolidae	Least concern
23	Sibirean jerboa	Rodentia	Dipodidae	Least concern
24	Mongolian silver vole	Rodentia	Arvicolidae	Least concern
25	Grey red backed vole	Rodentia	Arvicolidae	Least concern
26	Striped dwarf hamster	Rodentia	Cricetidae	Least concern
27	Long tailed dwarf hamster	Rodentia	Cricetidae	Least concern
28	Brandt's vole	Rodentia	Arvicolidae	Least concern
29	Mongolian jird	Rodentia	Gerbillidae	Least concern
30	Narrow headed vole	Rodentia	Arvicolidae	Least concern
31	Campbell's hamster	Rodentia	Cricetidae	Least concern
32	Mongolian marmot	Rodentia	Sciuridae	Endangered
33	Long tailed ground squirrel	Rodentia	Sciuridae	Least concern
34	Daurian ground squirrel	Rodentia	Sciuridae	Data deficient
35	Siberian shrew	Soricomorpha	Soricidae	Data deficient
36	Laxmann's shrew	Soricomorpha	Soricidae	Least concern

No	Common name	Order	Family	Regional status
37	Large toothed Siberian shrew	Soricomorpha	Soricidae	Least concern
38	Least shrew	Soricomorpha	Soricidae	Data deficient
39	Even toothed shrew	Soricomorpha	Soricidae	Data deficient

Table 20. Amphibian diversity and their regional status in 2nd sub basin:

No	Common name	Order	Family	Regional status
1	Steppes rat snake	Serpentes	Colubridae	Least concern
2	Mongolian toad	Anura	Bufonidae	Least concern

The 3rd sub basin from Tuul-Zaisan station to Tuul-Altanbulag bridge (midstream part) Fauna species

Table 21. Fish diversity and their regional status in midstream part:

No	Common name	Order	Family	Regional status
1	Siberian stone loach	Cypriniformes	Balitoridae	Least concern
2	Siberian spiny loach	Cypriniformes	Cobitidae	Least concern
3	Common minnow	Cypriniformes	Cyprinidae	Least concern
4	Pseudorasbora	Cypriniformes	Cyprinidae	Data deficient
5	Pike	Esociformes	Esocidae	Least concern
6	Burbot	Gadiformes	Lotidae	Data deficient
7	Perch	Perciformes	Odontobutidae	Least concern
8	Lenok	Salmoniformes	Salmonidae	Vulnerable
9	Taimen	Salmoniformes	Salmonidae	Endangered

Table 22. Mammal diversity and their regional status in midstream part:

No	Common name	Order	Family	Regional status
1	Monglian gazelle	Artiodactyla	Bovidae	Endangered
2	Red deer	Artiodactyla	Cervidae	Critically endangered
3	Grey wolf	Carnivora	Canidae	Near threatened
4	Corsac fox	Carnivora	Canidae	Near threatened
5	Red fox	Carnivora	Canidae	Near threatened
6	Pallas's cat	Carnivora	Felidae	Near threatened
7	Eurasian lynx	Carnivora	Felidae	Near threatened
8	Eurasian badger	Carnivora	Mustelidae	Least concern
9	Alpine weasel	Carnivora	Mustelidae	Least concern
10	Ermine	Carnivora	Mustelidae	Least concern
11	Steppe polecat	Carnivora	Mustelidae	Least concern
12	Least weasel	Carnivora	Mustelidae	Least concern
13	Siberian weasel	Carnivora	Mustelidae	Least concern
14	Northern bat	Chiroptera	Vespertilionidae	Least concern
15	Brandt's bat	Chiroptera	Vespertilionidae	Data deficient
16	Daubenton's bat	Chiroptera	Vespertilionidae	Least concern
17	Whiskered bat	Chiroptera	Vespertilionidae	Least concern
18	Particoloured bat	Chiroptera	Vespertilionidae	Least concern
19	Daurian hedgehog	Erinaceomorpha	Erinaceidae	Least concern
20	Tolai hare	Lagomorpha	Leporidae	Least concern
21	Daurian pika	Lagomorpha	Arvicolidae	Least concern
22	Siberian jerboa	Rodentia	Dipodidae	Least concern
23	Mongolian silver vole	Rodentia	Arvicolidae	Least concern
24	Grey red-backed vole	Rodentia	Arvicolidae	Least concern
25	Striped dwarf hamster	Rodentia	Cricetidae	Least concern

No	Common name	Order	Family	Regional status
26	Long tailed dwarf hamster	Rodentia	Cricetidae	Least concern
27	Brandt's vole	Rodentia	Arvicolidae	Least concern
28	Mongolian jird	Rodentia	Gerbillidae	Least concern
29	Narrow headed vole	Rodentia	Arvicolidae	Least concern
30	Campbell's hamster	Rodentia	Cricetidae	Least concern
31	Long tailed ground squirrel	Rodentia	Sciuridae	Least concern
32	Daurian ground squirrel	Rodentia	Sciuridae	Data deficient
33	Siberian shrew	Soricomorpha	Soricidae	Data deficient
34	Laxmann's shrew	Soricomorpha	Soricidae	Least concern
35	Large toothed Siberian shrew	Soricomorpha	Soricidae	Least concern
36	Least shrew	Soricomorpha	Soricidae	Least concern
37	Even toothed shrew	Soricomorpha	Soricidae	Data deficient

Table 23. Amphibian diversity and their regional status in midstream part:

No	Common name	Order	Family	Regional status
1	Steppes rat snake	Serpentes	Colubridae	Least concern
2	Mongolian toad	Anura	Bufonidae	Least concern

The 4th sub-zone from Tuul-Altanbulag station to Tuul-Lun station (the beginning of downstream part) Fauna species

Table 24. Fish diversity and their regional status in downstream part:

No	Common name	Order	Family	Regional status
1	Siberian stone loach	Cypriniformes	Balitoridae	Least concern
2	Siberian spiny loach	Cypriniformes	Cobitidae	Least concern
3	Common minnow	Cypriniformes	Cyprinidae	Least concern
4	Pike	Esociformes	Esocidae	Least concern
5	Burbot	Gadiformes	Lotidae	Data deficient
6	Perch	Perciformes	Odontobutidae	Least concern
7	Lenok	Salmoniformes	Salmonidae	Vulnerable
8	Arctic grayling	Salmoniformes	Thymallidae	Near threatened
9	Siberian dace	Cypriniformes	Cyprinidae	Least concern

Table 25. Mammal diversity and their regional status in downstream part:

No	Common name	Order	Family	Regional status
1	Mongolian gazelle	Artiodactyla	Bovidae	Endangered
2	Grey wolf	Carnivora	Canidae	Near threatened
3	Corsac fox	Carnivora	Canidae	Near threatened
4	Red fox	Carnivora	Canidae	Near threatened
5	Pallas's cat	Carnivora	Felidae	Near threatened
6	Eurasian lynx	Carnivora	Felidae	Near threatened
7	Eurasian badger	Carnivora	Mustelidae	Least concern
8	Alpine weasel	Carnivora	Mustelidae	Least concern
9	Ermine	Carnivora	Mustelidae	Least concern
10	Steppe polecat	Carnivora	Mustelidae	Least concern
11	Least weasel	Carnivora	Mustelidae	Least concern
12	Northern bat	Chiroptera	Vespertilionidae	Least concern
13	Daubenton's bat	Chiroptera	Vespertilionidae	Least concern
14	Whiskered bat	Chiroptera	Vespertilionidae	Least concern
15	Particoloured bat	Chiroptera	Vespertilionidae	Least concern
16	Daurian hedgehog	Erinaceomorpha	Erinaceidae	Least concern

No	Common name	Order	Family	Regional status
17	Tolai hare	Lagomorpha	Leporidae	Least concern
18	Daurian pika	Lagomorpha	Arvicolidae	Least concern
19	Siberian jerboa	Rodentia	Dipodidae	Least concern
20	Mongolian silver vole	Rodentia	Arvicolidae	Least concern
21	Striped dwarf hamster	Rodentia	Cricetidae	Least concern
22	Long tailed dwarf hamster	Rodentia	Cricetidae	Least concern
23	Brandt's vole	Rodentia	Arvicolidae	Least concern
24	Mongolian jird	Rodentia	Gerbillidae	Least concern
25	Narrow headed vole	Rodentia	Arvicolidae	Least concern
26	Campbell's hamster	Rodentia	Cricetidae	Least concern
27	Mongolian marmot	Rodentia	Sciuridae	Endangered
28	Long tailed ground squirrel	Rodentia	Sciuridae	Least concern
29	Daurian ground squirrel	Rodentia	Sciuridae	Data deficient
30	Siberian shrew	Soricomorpha	Soricidae	Data deficient
31	Laxmann's shrew	Soricomorpha	Soricidae	Least concern
32	Large toothed Siberian shrew	Soricomorpha	Soricidae	Least concern
33	Least shrew	Soricomorpha	Soricidae	Data deficient

Table 26. Amphibian diversity and their regional status downstream part:

No	Common name	Order	Family	Regional status
1	Steppes rat snake	Serpentes	Colubridae	Least concern
2	Mongolian toad	Anura	Bufonidae	Least concern

The 5th sub basin from Tuul-Lun station to Tuul-Orkhon Tuul confluence (downstream part) Fauna species

Table 27. Fish diversity and their regional status in downstream part:

No	Common name	Order	Family	Regional status
1	Siberian stone loach	Cypriniformes	Balitoridae	Least concern
2	Siberian spiny loach	Cypriniformes	Cobitidae	Least concern
3	Ide	Cypriniformes	Cyprinidae	Near threatened
4	Common minnow	Cypriniformes	Cyprinidae	Least concern
7	Roach	Cypriniformes	Cyprinidae	Least concern
8	Pike	Esociformes	Esocidae	Least concern
5	Burbot	Gadiformes	Lotidae	Data deficient
6	Perch	Perciformes	Odontobutidae	Least concern
7	Lenok	Salmoniformes	Salmonidae	Vulnerable
8	Arctic grayling	Salmoniformes	Thymallidae	Near threatened
9	Taimen	Salmoniformes	Salmonidae	Endangered
9	Siberian dace	Cypriniformes	Cyprinidae	Least concern
13	Lake minnow	Cypriniformes	Cyprinidae	Data deficient

Table 28. Mammal diversity and their regional status in downstream part:

No	Common name	Order	Family	Regional status
1	Siberian roe deer	Artiodactyla	Bovidae	Least concern
2	Red deer	Artiodactyla	Bovidae	Critically endagered
3	Wild boar	Artiodactyla	Suidae	Near threatened
4	Grey wolf	Carnivora	Canidae	Near threatened
5	Corsac fox	Carnivora	Canidae	Near threatened
6	Red fox	Carnivora	Canidae	Near threatened
7	Pallas's cat	Carnivora	Felidae	Near threatened
8	Eurasian lynx	Carnivora	Felidae	Near threatened
9	Wolverine	Carnivora	Mustelidae	Least concern
10	Eurasian badger	Carnivora	Mustelidae	Least concern
11	Alpine weasel	Carnivora	Mustelidae	Least concern
12	Ermine	Carnivora	Mustelidae	Least concern
13	Steppe polecat	Carnivora	Mustelidae	Least concern
14	Least weasel	Carnivora	Mustelidae	Least concern
15	Siberian weasel	Carnivora	Mustelidae	Least concern
16	Northern bat	Chiroptera	Vespertilionidae	Least concern
17	Greater tube nosed bat	Chiroptera	Vespertilionidae	Least concern
18	Brandt's bat	Chiroptera	Vespertilionidae	Data deficient
19	Daubenton's bat	Chiroptera	Vespertilionidae	Least concern
20	Whiskered bat	Chiroptera	Vespertilionidae	Least concern
21	Brown big eared bat	Chiroptera	Vespertilionidae	Least concern
22	Particoloured bat	Chiroptera	Vespertilionidae	Least concern
23	Daurian hedgehog	Erinaceomorpha	Erinaceidae	Least concern
24	Arctic hare	Lagomorpha	Leporidae	Least concern
25	Tolai hare	Lagomorpha	Leporidae	Least concern
26	Daurian pika	Lagomorpha	Arvicolidae	Least concern
27	Siberian jerboa	Rodentia	Dipodidae	Least concern
28	Mongolian silver vole	Rodentia	Arvicolidae	Least concern
29	Korean field mouse	Rodentia	Muridae	Least concern
30	Grey red backed vole	Rodentia	Arvicolidae	Least concern
31	Northern red-backed vole	Rodentia	Arvicolidae	Least concern
32	Striped dwarf hamster	Rodentia	Cricetidae	Least concern
33	Long tailed dwarf	Rodentia	Cricetidae	Least concern
34	Brandt's vole	Rodentia	Arvicolidae	Least concern
35	Mongolian jird	Rodentia	Gerbillidae	Least concern
36	Narrow headed vole	Rodentia	Arvicolidae	Least concern
37	Root vole	Rodentia	Arvicolidae	Least concern
38	Campbell's hamster	Rodentia	Cricetidae	Least concern
39	Mongolian marmot	Rodentia	Sciuridae	Endangered
40	Long tailed ground squirrel	Rodentia	Sciuridae	Least concern
41	Eurasian water shrew	Soricomorpha	Soricidae	Least concern
42	Laxmann's shrew	Soricomorpha	Soricidae	Least concern
43	Large toothed Siberian shrew	Soricomorpha	Soricidae	Least concern
44	Least shrew	Soricomorpha	Soricidae	Data deficient
45	Tundra shrew	Soricomorpha	Soricidae	Data deficient

Table 29. Amphibian diversity and their regional status in downstream:

No	Common name	Order	Family	Regional status
1	Steppes rat snake	Serpentes	Colubridae	Least concern
2	Mongolian toad	Anura	Bufonidae	Least concern

The diversity of fauna in the Tuul River basin

Table 30. Diversity of fishes and their regional status in the Tuul River basin:

No	Common name	Distribution (by sub zones)	Regional status
1	Siberian sturgeon	1	Critically endangered
2	Siberian stone loach	1-5	Least concern
3	Siberian spiny loach	1-5	Least concern
4	Ide	1;5	Near threatened
5	Common minnow	1-5	Least concern
6	Pseudorasbora	1-3	Data deficient
7	Roach	1;5	Least concern
8	Pike	1-5	Least concern
9	Burbot	1-5	Data deficient
10	Perch	1-5	Least concern
11	Lenok	1-5	Vulnerable
12	Arctic grayling	1;4;5	Near threatened
13	East asian catfish	1	Least concern
14	Taimen	2;4	Endangered
15	Siberian dace	4;5	Least concern
16	Lake minnow	5	Data deficient

Remark:

1- Distributed in the 1st sub basin from Tuul River upstream part to Tuul-Terelj station (upstream part)
2- Distributed in the 2nd sub basin from Tuul-Terelj station to Tuul-Zaisan station (midstream part)
3- Distributed in the 3rd sub basin from Tuul-Zaisan station to Altanbulag bridge (midstream part)
4- Distributed in the 4th sub basin from Altanbulag bridge to Tuul-Lun station (downstream part)
5-Distributed in the 5th sub basin from Tuul-Lun station to Orkhon-Tuul confluence (downstream part)

Table 31. Diversity of mammals and their regional status in the Tuul River basin:

No	Common name	Distribution (sub basin)	Regional status
1	Siberian roe deer	1;5	Least concern
2	Mongolian gazelle	2-4	Endangered
3	Elk	1	Endangered
4	Red deer	1-3;5	Critically endangered
5	Wild boar	1;5	Near threatened
6	Grey wolf	1-5	Near threatened
7	Corsac fox	2-4	Near threatened
8	Red fox	1-5	Near threatened
9	Pallas's cat	2-5	Near threatened
10	Eurasian lynx	1-5	Near threatened
11	Wolverine	1;5	Least concern
12	Eurasian otter	1	Data deficient
13	Sable	1;2	Vulnerable
14	Eurasian badger	1-5	Least concern
15	Alpine weasel	1-5	Least concern
16	Ermine	1-5	Least concern
17	Steppe polecat	3-5	Least concern
18	Least weasel	1-5	Least concern
19	Siberian weasel	1-3;5	Least concern
20	Northern bat	1-5	Least concern
21	Greater tube-nosed bat	5	Data deficient
22	Brandt's bat	1-3;5	Data deficient
23	Daubenton's bat	1-5	Least concern

No	Common name	Distribution (sub basin)	Regional status
24	Whiskered bat	1-5	Least concern
25	Brown big eared bat	1;2;5	Least concern
26	Particoloured bat	1-5	Least concern
27	Daurian hedgehog	1-5	Least concern
28	Arctic hare	1;5	Least concern
29	Tolai hare	1-5	Least concern
30	Daurian pika	1-5	Least concern
31	Northern pika	1	Least concern
32	Siberian jerboa	1-5	Least concern
33	Mongolian silver vole	1-5	Least concern
34	Korean field mouse	1;5	Least concern
35	Grey red backed vole	1-3;5	Least concern
36	Northern red-backed vole	5	Least concern
37	Striped dwarf hamster	1-5	Least concern
38	Long tailed dwarf hamster	1-5	Least concern
39	Eurasian harvest mouse	1	Data deficient
40	Reed vole	1	Data deficient
41	Brandt's vole	2-5	Least concern
42	Mongolian jird	2-5	Least concern
43	Narrow headed vole	1-5	Least concern
44	Maximovic's vole	1	Data deficient
45	Wood lemming	1	Data deficient
46	False zokor	1	Data deficient
47	Eurasian red squirrel	1	Near threatened
48	Root vole	1;5	Least concern
49	Campbell's hamster	2-5	Least concern
50	Mongolian marmot	2;4;5	Endangered
51	Long tailed ground squirrel	1-5	Least concern
52	Daurian ground squirrel	2-4	Data deficient
53	Siberian chipmunk	1	Least concern
54	Siberian shrew	1-4	Data deficient
55	Eurasian water shrew	1;5	Least concern
56	Laxmann's shrew	1-5	Least concern
57	Large toothed Siberian shrew	1-5	Least concern
58	Least shrew	1-5	Data deficient
59	Tundra shrew	1;5	Data deficient
60	Even toothed shrew	1-3	Data deficient
61	Mongolian vole	1	Least concern

Table 32. Diversity of amphibians and their regional status in Tuul River basin:

No	Common name	Distribution (by sub zone)	Regional status
1	Steppes rat snake	1-5	Least concern
2	Mongolian toad	1-5	Least concern

Remark:
The second column's meaning is explained in the remark of Table 30.

Table 33. Diversity of birds and their regional status in the Tuul River basin

№	Scientific name	English name	Regional status	Distribution	Habitat
1	Bonasia bonasia	Hazel Hen	LC	Tuul River basin	Resident breeder, laying egg
2	Lyrurus tetrix	Black Grouse	LC	Bogd mountain	Resident breeder, laying egg
3	Tetrao parvirostris	Spotted Capercaillie	LC	Tuul River basin	Resident breeder, laying egg
4	Lagopus muta	Rock Ptarmigan	LC	Recorded at 45km north of Ulaanbaatar city	Resident breeder, laying egg
5	Coturnix japonica	Japanese Quail	LC	Tuul River valley	Breeding visitor, laying egg and wintering species.
6	Anser cygnoides	Swan Goose	NT	Tuul River	Breeding visitor and laying egg
7	Anser fabalis	Bean Goose	LC	Upper Tuul River	Passage migrant and summer visitor
8	Anser albifrons	White –fronted goose	NT	Upper Tuul River	Rare passage migrant
9	Anser Indicus	Bar headed goose	LC	Tuul River	Breeding visitor and laying egg
10	Cygnus cygnus	Whooper swan	LC	Lower Tuul river	Common breeding visitor, laying egg
11	Cygnus columbianus	Tundra swan	LC	Lower Tuul river	Passage migrant
12	Tadorna ferruginea	Ruddy shelduck	LC	Tuul River (more than 500 individuals each year) near Ulaanbaatar	Common breeding visitor and laying egg
13	Tadorna tadorna	Common shelduck	LC	Tuul River basin	Fairly common breeding visitor and laying egg
14	Aix galericulata	Mandarin duck	NA	Two males were recorded in waste water pond near Ulaanbaatar on 8 may, 2010.	Summer visitor and rare species
15	Anas falcata	Falcated duck	NT	Tuul River basin	Rare breeding visitor and laying egg
16	Anas penelope	Eurasian wigeon	LC	Tuul and Terelj Rivers	Breeding visitor and laying egg
17	Anas platyrhynchos	Mallard	LC	Tuul and Terelj Rivers	Breeding visitor, laying egg and wintering species
18	Anas formosa	Baikal teal	VU	Steppe lake west of Lun soum of Tov province in June, 2000 (a male).	Rare passage migrant
19	Aythya fuligula	Tufted duck or tufted pochard	LC	Tuul River valley	Breeding visitorand laying egg
20	Mergus albellus	Smew	LC	Tuul River	Summer visitor and passage migrant
21	Mergus merganser	Goosander	LC	Tuul River	Breeding visitor, laying egg and wintering species
22	Okyura leucocephala	White headed duck	EN	Three females and a male were seen in Tsegeen lake of Lun soum of Tov province on 28 May, 2010.	Breeding visitor, laying egg and rare species
23	Gavia arctica	Arctic loon	LC	Tuul River	Breeding visitor and laying egg
24	Podiceps cristatus	Great crested grebe	LC	Tuul and Terelj river valley	Breeding visitor and laying egg
25	Podiceps auritus	Slavonian grebe	LC	Tuul River valley	Breeding visitor and laying egg
26	Podiceps nigricollis	Black necked grebe	LC	Tuul and Terelj river valley	Common breeding visitor laying egg
27	Ciconia nigra	Black stork	LC	Tuul River basin	Breeding visitor and lying egg
28	Ardea cinerea	Grey heron	LC	Tuul River	Breeding visitor and laying egg
29	Falco vespertinus	Red footed falcon	NA	Hustai Nuruu National park	Vagrant
30	Falco amurencis	Amur falcon	LC	Tuul River valley	Breeding visitor and laying egg

№	Scientific name	English name	Regional status	Distribution	Habitat
31	Falco subbuteo	Northern hobby	LC	Upper Tuul river	Common breeding visitor and laying egg
32	Pandion haliaetus	Osprey	LC	Tuul and Terelj river valley	Breeding visitor and laying egg
33	Pernis ptilorhynehus	Oriental honey-buzzard	LC	Tuul River valley	Passage migrant, laying egg and possibly a breeding visitor
34	Mulvis migrans	Black kite	LC	It migrates throughout Mongolia.	Common breeding visitor and laying egg
35	Halia eetus leucoryphus	Pallas sea eagle	EN	Tuul River basin	Rare breeding visitor and laying egg
36	Haliaeetus albicilla	White tealed sea eagle	NT	Tuul and Terelj river valley	Breeding visitor and laying egg
37	Gypaetus barbatus	Bearded vulture	VU	One breeding pair has annually nested at Erdenesant mountain of Tov province from 1997 to 2004.	Resident species and laying egg
38	Circaetus gallicus	Short toed eagle	EN	Tuul River valley	Breeding visitor and laying egg
39	Circus macrourus	Pallid harrier	DD	Tuul River valley	Summer visitor and passage migrant
40	Circus melanoleucos	Pied harrier	DD	P.Ganhuyag photographed one nest with two eggs in reed beds at Zezeg lake, 145 km SE of Ulaanbaatar city on 4 June, 2010.	Rare breeding visitor and laying egg
41	Accipter gularis	Japanese sparrow hawk	LC	Tuul River valley	Rare breeding visitor and laying egg
42	Buteo rufinus	Long legged buzzard	LC	Tuul River valley	Breeding visitor and laying egg
43	Aquila clanga	Greater spotted eagle	EN	One individual was recorded near Terelj River in May, 1986.	Very rare breeding visitor, laying egg and passage migrant
44	Hieraactus pennatus	Booted eagle	LC	Two breeding pairs were observed at Uvur Zaisan of Bogd Mountain near Ulaanbaatar.	Breeding visitor and laying egg
45	Nisaetus nipalensis	Hodgson’s hawk eagle	NA	Tuul River valley of the Songino uul, Ulaanbaatar.	Vagrant
46	Chlamydotis undulata	Houbara bustard	VU	10 km away from Lun soum of Tov province	Breeding visitor, laying egg and rare species
47	Porzana pussila	Baillon’s crake	LC	Upper Tuul River	Breeding visitor and laying egg
48	Fulica atra	Common coot	LC	Tuul River valley	Common breeder and laying egg
49	Grus vipio	White naped crane	VU	Seven birds at Kharbukh river of Tuul River basin in June, 2006.	Breeding visitor
50	Charadrius dubius	Little ringed plover	LC	Tuul and Terelj river valley	Breeding visitor and laying egg
51	Charadrius alexandrinus	Kentish plover	LC	Tuul River valley	Breeding visitor and laying egg
52	Charadrius veredus	Oriental plover	LC	Tuul River valley	Breeding visitor and laying egg
53	Scolopax rusticola	Woodcock	LC	Tuul and Terelj river valley	Breeding visitor and laying egg
54	Gallinigo megala	Chinese snipe	LC	Tuul and Terelj river valley	Breeding visitor and laying egg
55	Gallinago gallinago	Common snipe or snipe	LC	Tuul and Terelj river valley	Breeding visitor and laying egg
56	Numenius minutus	Little curlew	LC	Tuul River valley	Passage migrant
57	Numenius arquata	Western curlew	LC	Tuul River valley	Breeding visitor, laying egg and passage migrant

№	Scientific name	English name	Regional status	Distribution	Habitat
58	Numenius madagascariensis	Eastern curlew	LC	Tuul River valley	Passage migrant
59	Tringa totanus	Redshank	LC	Tuul River	Breeding visitor and laying egg
60	Tringa stagnatilis	Marsh sandpiper	LC	Pools with reed beds and marshes SW of Tsegeen lake, Lun soum of Tov province.	Breeding visitor and laying egg
61	Tringa ochropus	Greensandpiper	LC	Upper Tuul and Terelj Rivers	Breeding visitor and laying egg
62	Tringa glareola	Wood sandpiper	LC	Tuul and Terelj river valley	Breeding visitor and laying egg
63	Actitis hypoleucos	Common sandpiper	LC	Tuul and Terelj river valley	Common breeding visitor and laying egg
64	Arenaria interpres	Turnstone	LC	Tuul River valley	Passage migrant
65	Calidris minuta	Little stint	LC	Tuul River valley	Passage migrant
66	Calidris ruficollis	Rufous –necked stint	LC	Tuul River valley	Passage migrant
67	Calidris temminckii	Temminck's stint	LC	Tuul River basin	Passage migrant
68	Calidris subminuta	Long toed stint	LC	Tuul River valley	Passage migrant
69	Calidris acuminata	Sharp tailed sandpiper	LC	Туул голын хөндий	Passage migrant
70	Limicola falcinellus	Broad billed sandpiper	LC	Tuul River basin	Passage migrant
71	Philomachus pugnax	Ruff	LC	Upper Tuul River	Breeding visitor and laying egg
72	Larus canus	Mew gull	LC	Tuul River	Breeding visitor and laying egg
73	Larus ridibundus	Common black headed gull	LC	Tuul River	Breeding visitor and laying egg
74	Larus minutus	Little gull	LC	Tuul River basin	Breeding visitor and laying egg
75	Sterna caspia	Caspian tern	LC	Tuul River	Breeding visitor and laying egg
76	Sterna hirundo	Common tern	LC	Tuul River	Breeding visitor and laying egg
77	Chlidonias leucopterus	White winged tern	LC	Lower Tuul River	Breeding visitor and laying egg
78	Chlidonias niger	Black tern	LC	Upper Tuul River	Breeding visitor and laying egg
79	Columba oenas	Stock pigeon	LC	Hustai Nuruu National park in June, 2007.	Breeding visitor and laying egg
80	Columba palumbus	Wood pigeon	DD	Hustai Nuruu National park	Breeding visitor and laying egg
81	Streptopelia orientalis	Rufous turtle dove	LC	Tuul and Terelj river valley	Breeding visitor and laying egg
82	Streptopelia decaocto	Collared turtle dove	LC	Two birds were observed at Tuul River in Hustai NP of Altanbulag soum in Tov province on 7 October, 2001.	Resident breeder, laying egg and passage migrant
83	Cuculus canorus	Cuckoo	LC	Tuul and Terelj river valley	Breeding visitor and laying egg
84	Cuculus saturatus	Oriental cuckoo	LC	Tuul and Terelj river valley	Breeding visitor and laying egg
85	Otus scops	Eurasian scops owl	LC	Tuul and Terelj river valley	Breeding visitor and laying egg
86	Bubo bubo	Northern Eurasian eagle owl	LC	Tuul River basin	Resident breeder
87	Asia otus	Long eared owl	LC	Upper Tuul and Terelj rivers	Breeding visitor, laying egg and partial migrant
88	Caprimulgus indicus	Highland night jar	LC	Tuul River valley	Breeding visitor and laying egg
89	Apus pacificus	Pacific swift	LC	Upper Tuul and Terelj rivers	Breeding visitor and laying egg
90	Alcedo atthis	River kingfisher	LC	Tuul and Terelj river valley	Breeding visitor and laying egg

№	Scientific name	English name	Regional status	Distribution	Habitat
91	Upupa epops	Hoopoe	LC	Tuul River basin	Breeding visitor and laying egg
92	Jynx torquilla	Wryneck	LC	Tuul and Terelj river valley	Breeding visitor and laying egg
93	Dendrocopos minor	Lesser spotted woodpecker	LC	Tuul and Terelj river valley	Resident breeder and laying egg
94	Dendrocopos hyperyhtrus	Rufous bellied woodpecker	NA	Tuul River valley and near Uubulan	Vagrant
95	Dendrocopos leucotos	White backed woodpecker	LC	Tuul and Terelj river valley	Resident breeder and laying egg
96	Dendrocopos major	Great spotted wood pecker	LC	Tuul and Terelj river valley	Resident breeder and laying egg
97	Picoides tridactylus	Eurasian three toed wood pecker	LC	Tuul and Terelj river valley	Resident breeder and laying egg
98	Dryocopus martius	Black woodpecker	LC	Tuul and Terelj river valley	Resident breeder and laying egg
99	Oriolus oriolus	Golden oriole	DD	Hustai Nuruu NP	Breeding visitor, laying egg and passage migrant
100	Piresoreus infaustus	Siberian jay	LC	Bogd mountain	Resident breeder and laying egg
101	Cyanopica cyanus	Azure winged magpie	LC	Tuul and Terelj river valley	Resident breeder and laying egg
102	Pica pica	Black billed magpie	LC	Tuul and Terelj river valley	Resident breeder and laying egg
103	Nucifraga caryo catactes	Eurasian nutcracker	LC	Tuul and Terelj river valley	Resident breeder and laying egg
104	Corvus dauuricus	Daurian jackdaw	LC	Tuul and Terelj river valley	Breeding visitor, laying egg and partial migrant
105	Parus major	Great tit	LC	Tuul and Terelj river valley	Resident breeder and laying egg
106	Parus palustris	Marsh tit	LC	Upper Tuul River	Resident breeder and laying egg
107	Parus montanus	Willow tit	LC	Tuul and Terelj river valley	Resident breeder and laying egg
108	Parus cinctus	Siberian tit	LC	Terelj River	Resident breeder and laying egg
109	Parus ater	Coal tit	LC	Tuul and Terelj river valley	Resident breeder, egg
110	Remiz coronatus	Penduline tit	LC	Tuul and Terelj river valley	Breeding visitor, laying egg and partial migrant
111	Riparia riparia	Bank swallow	LC	Tuul and Terelj river valley	Breeding visitor and laying egg
112	Hirundo rustica	Barn swallow	LC	Tuul and Terelj river valley	Breeding visitor and laying egg
113	Hirundo daurica	Red rumped swallow	LC	Tuul River basin	Breeding visitor and laying egg
114	Delichon urbicum	House martin	LC	Tuul and Terelj river valley	Breeding visitor and laying egg
115	Melanocorypha mongolica	Mongolian lark	LC	Tuul River basin	Resident breeder and laying egg
116	Calandrella brachydactyla	Greater short toed lark	LC	Tuul River basin	Breeding visitor, laying egg and a partial migrant
117	Calandrella chelecnsis	Asian short toed lark	LC	Tuul River basin	Breeding visitor, laying egg and partial migrant
118	Galerida cristata	Crested lark	LC	Tuul River valley	Resident breeder, laying egg and partial migrant
119	Eremophila alpestris	Shore lark	LC	Tuul River basin	Resident breeder and laying egg
120	Bradypterus tacsanowskius	Chinese bush warbler	LC	Tuul and Terelj river valley	Breeding visitor, laying egg and passage migrant
121	Locustella certhiola	Pallas's grasshopper warbler	LC	Tuul and Terelj river valley	Breeding visitor, laying egg and partial migrant

№	Scientific name	English name	Regional status	Distribution	Habitat
122	Acrocephalus orientalis	Oriental reed warbler	LC	Tuul River basin	Breeding visitor, laying egg and passage migrant
123	Acrocephalus aedon	Thick billed reed warbler	LC	Tuul River	Breeding visitor and laying egg
124	Phylloscopus collybita	Siberian chiffchaff	LC	Tuul and Terelj river valley	Breeding visitor and laying egg
125	Phylloscopus fuscatus	Dusky leaf warbler	LC	Tuul and Terelj river valley	Breeding visitor and passage migrant
126	Phylloscopus schwarzi	Radde's leaf warbler	LC	Tuul and Terelj river valley	Passage migrant
127	Phylloscopus proregulus	Yellow rumped warbler	LC	Tuul and Terelj river valley	Breeding visitor, laying egg and passage migrant
128	Phylloscopus inornatus	Yellow browed leaf warbler	LC	Tuul and Terelj river valley	Breeding visitor, laying egg and passage migrant
129	Phylloscopus humei	Hume's leaf warbler	LC	Tuul and Terelj river valley	Breeding visitor and laying egg
130	Sylvia communis	Common white throat	LC	Bogd Khaan mountain and Tuul River valley	Breeding visitor, laying egg and passage migrant
131	Panurus biarmicus	Reedling	LC	Tuul River basin	Resident breeder and laying egg
132	Sitta europaea	Wood nuthatch	LC	Tuul River basin	Resident breeder and laying egg
133	Regulus regulus	Gold crester wren	LC	Tuul and Terelj river valley	Breeding visitor, laying egg, passage migrant and winter visitor
134	Certhia familiaris	Common treecreeper	LC	Upper Tuul River	Resident breeder and laying egg
135	Sturnia sturninus	Daurian starling	LC	Upper Tuul River	Breeding visitor, laying egg and passage migrant
136	Sturnus cineraceus	Grey starling	LC	Tuul and Terelj river valley	Breeding visitor, laying egg and passage migrant
137	Turdus merula	Blackbird	NA	This species has been recorded at Davaany zurlug, 10 km west of Ulaanbaatar on 10 September, 1989.	Vagrant
138	Turdus naumanni	Red tailed thrush	LC	Tuul and Terelj river valley	Breeding visitor, laying egg and passage migrant
139	Turdus pilaris	Fieldfare thrush	LC	Upper Tuul and Terelj rivers	Breeding visitor, laying egg and passage migrant
140	Tarsiger cyanurus	Red flanked blue tail	LC	Upper Tuul and Terelj rivers	Breeding visitor and passage migrant, egg
141	Phoenicurus phoenicurus	White fronted red start	LC	Tuul and Terelj river valley	Breeding visitor, laying egg and passage migrant
142	Phoenucurus auroreus	Daurian redstart	LC	Tuul and Terelj river valley	Breeding species and laying egg
143	Saxicola torquatus	European stonechat	LC	Tuul and Terelj river valley	Breeding visitor, laying egg and passage migrant
144	Oenanthe pleschanka	Common pied wheatear	LC	Upper Tuul and Terelj rivers	Breeding visitor and laying egg
145	Oenanthe isabellina	Isabelline chat	LC	Tuul and Terelj river basins	Breeding species and laying egg
146	Muscicapa grisiesticta	Spot breasted flycatcher	NA	A single bird was recorded at Davaany Zurlug(10 km west of UB) of Tov province on 11 June, 1990.	Vagrant
147	Muscicapa sibirica	Sooty flycatcher	LC	Tuul and Terelj river valley	Breeding visitor, laying egg and passage migrant

№	Scientific name	English name	Regional status	Distribution	Habitat
148	Muscicapa dauurica	Greay breasted flycatcher	LC	Tuul and Terelj river valley	Breeding visitor and laying egg
149	Fecidula zanthopygia	Korean flycatcher	LC	Upper Tuul and Terelj rivers	Breeding visitor and laying egg
150	Ficedula albicalla	Taiga flycatcher	LC	Tuul and Terelj river valley	Breeding visitor and laying egg
151	Cinclus cinclus	White billed dipper	LC	Tuul and Terelj river valley	Resident breeder and laying egg
152	Passer domestricus	House sparrow	LC	Ulaanbaatar city	Resident breeder and laying egg
153	Passer montanus	Tree sparrow	LC	Ulaanbaatar city	Resident breeder and laying egg
154	Motacilla citreola	Citrine wagtail	LC	Tuul and Terelj river valley	Breeding visitor and laying egg
155	Anthus richardi	Richard's pipit	LC	Tuul and Terelj river valley	Breeding visitor and laying egg
156	Anthus godlewskii	Godlewski's pipit	LC	Tuul and Terelj river valley	Breeding visitor and laying egg
157	Carduelis spinus	Siskin	LC	From 3 to 13 individuals were founded in Terelj, Bogd Mountain and Hustai NP in December, 2009 and January, 2010.	Breeding visitor, passage migrant and winter visitor
158	Bucanetes mongolicus	Mongolian trumpeter	LC	Tuul River valley	Resident breeder and laying egg
159	Uragus sibiricus	Long tailed rosefinch	LC	Tuul and Terelj river valley	Resident breeder and laying egg
160	Carpodacus erythrinus	Scarlet rosefinch	LC	Tuul and Terelj river valley	Breeding visitor and laying egg
161	Carpodacus rhodochlamus	Red mantled rosefinch	LC	Tuul and Terelj river valley	Resident breeder and laying egg
162	Pinicola enucleator	Pine grosbeak	LC	Tuul and Terelj river valley	Resident breeder and laying egg
163	Pyrrhula pyrrhula	Bullfinch	LC	Tuul and Terelj river valley	Resident breeder and laying egg
164	Coccothraustes coccothraustes	Eurasian hawfinch	LC	Tuul and Terelj river valley	Resident breeder, laying egg and partial migrant
165	Emberiza citrinella	Yellow bunting	LC	Tuul and Terelj river valley	Breeding visitor and possibly wintering species
166	Emberiza leucocephalos	Pine bunting	LC	Tuul and Terelj river valley	Breeding visitor, laying egg and passage migrant
167	Emberiza cioides	Siberian meadow bunting	LC	Tuul River basin	Resident breeder , laying egg and partial migrant
168	Emberiza rustica	Rustic bunting	LC	Tuul and Terelj river valley	Passage migrant
169	Emberiza rutila	Chestnut bunting	LC	Tuul River	Breeding visitor and laying egg
170	Emberiza schoeniclus	Common reed bunting	LC	Tuul River valley	Breeding visitor and laying egg
171	Plectrophenax nivalis	Snow bunting	LC	Tuul River valley	Winter visitor

Explanation:

LC- Least concern
NT- Near threatened
DD- Data deficient
NA- Not applicable
VU- Vulnerable
CR- Critically endangered
EN- Endangered

PART 2.
SURFACE WATER RESOURCES

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Introduction

This technical report presents the results of the studies which were conducted in the scope of the “Strengthening Integrated Water Resources Management in Mongolia” project which is funded by the Government of the Netherlands and implemented at the Water Authority of Mongolia.

The Tuul River basin is located in the central part of the country and drains to the Arctic Ocean basin. It originates in the Natural Reserve in the Khentii Mountain arrange, and runs through the southern part of the Mongolian capital Ulaanbaatar.

The Tuul River basin has the highest population in the country and the growing density of population and livestock and the development of the gold mining industry have significant influence on the water regime and the quality of this river.

The text of chapters 1-5 is based on studies conducted by the Hydrology section of the Institute of Meteorology and Hydrology (IMH) under supervision of Doctor G.Davaa. The Annexes were prepared by the project experts.

1. Used data and information

1.1. Sources of observed long term data and information

The main data sources of the studies are the long term observations at the hydrological gauging stations in the Tuul River basin. The hydrological stations and data belong to the National Agency for Meteorology, Hydrology and Environment Monitoring. The Hydrology section of the Agency is responsible for operation and maintenance of the network, data processing, analysis and management.

The data collection on water resources and flow regime of the Tuul River began from 1945 by establishing a hydrological gauging station at Ulaanbaatar. The hydrological gauging station network of the Tuul river basin consists of 8 gauging stations along the Tuul River at Bosgo, Ulaanbaatar, Altanbulag, Lun and along some tributaries Selbe-Sanzai, Selbe-Dambadarjaa, Terelj and Uliastai.

1.2. Data and information from field trips and expeditions

Different research and professional organizations have done hydrological and water resources related studies in the Tuul River basin in different periods. For example, field trips and measurements were conducted by the Institute of Meteorology and Hydrology (1966, 1982, 1998, 2002), by Joint-Russian Mongolia expeditions (1970th), by Joint Mongolian-Japanese studies (1993-1994), by the Institute of Geography and Institute of Geo-ecology, etc.

1.3. Map, atlas and other sources

Several maps and catalogues have been produced on the water resources and flow regime of the Tuul such as the Map of Climate and Surface Water of Mongolia (1985) and the National Atlas of Mongolia (1990) and (2009).

Some research results related to the water resources and flow regime of the Tuul River were produced by scientific-technological national projects such as "Development of methods and technologies on Prediction and climate related natural disaster" (1998-2000), "Computerized technology and methods for weather and hydrological forecasting" (2001-2003), "Elaboration of methods and technologies on Prediction of regional climate change and climate related disaster, extremes", (2004-2006), "Assessment and prediction of surface water resources and flow regime of Mongolia" (2007-2009) etc.

2. Methodologies

Common hydrological methods have been used to conduct the studies and this report: Statistical methods, flood frequency analysis, altitudinal dependence of hydrological parameters, runoff components, empirical equations, and mathematical models including flood routing, rainfall-runoff, Horton's law, remote sensing and GIS.

The RIBASIM model [34] was used to study the water balance of the Tuul River and to study the effect of a dam on the flow regime of the Tuul River. The model is a water allocation model enabling to compare the water use with the available surface water and groundwater resources.

3. Tuul River basin description

3.1. Morphometry of the river basin

The total river basin area of the Tuul River is 49774.3 km^2. The total length of all rivers in the Tuul River basin is 11046.5 km, the river network density is 0.23 km/km^2 and the mean basin elevation is 1300 m. According to Horton's law, the Tuul River is 6^{th} order (Figure 1).

3.2. Drainage network of the river basin

The Tuul River takes its origin at Chisaalai peak at an elevation of 2000 m and from the confluence point of Namya and Nergui Rvers located at Shorootyn hill is named as Tuul River. Galtai, Khag, Khongor, Zuunbayan, Kholiin, Zuunbayan, Uliastai, Selbe and Kharbukh are main tributaries of the Tuul River. The valley of the Tuul River becomes more wide after Ulaanbaatar city and begins to loose runoff along the river from around Altanbulag. The long term mean annual runoff of the Tuul River is 26.6, 25.8 and 24.1 m^3/sec at Ulaanbaatar, Songino and Undurshireet, respectively (the latter two stations are not permanent).

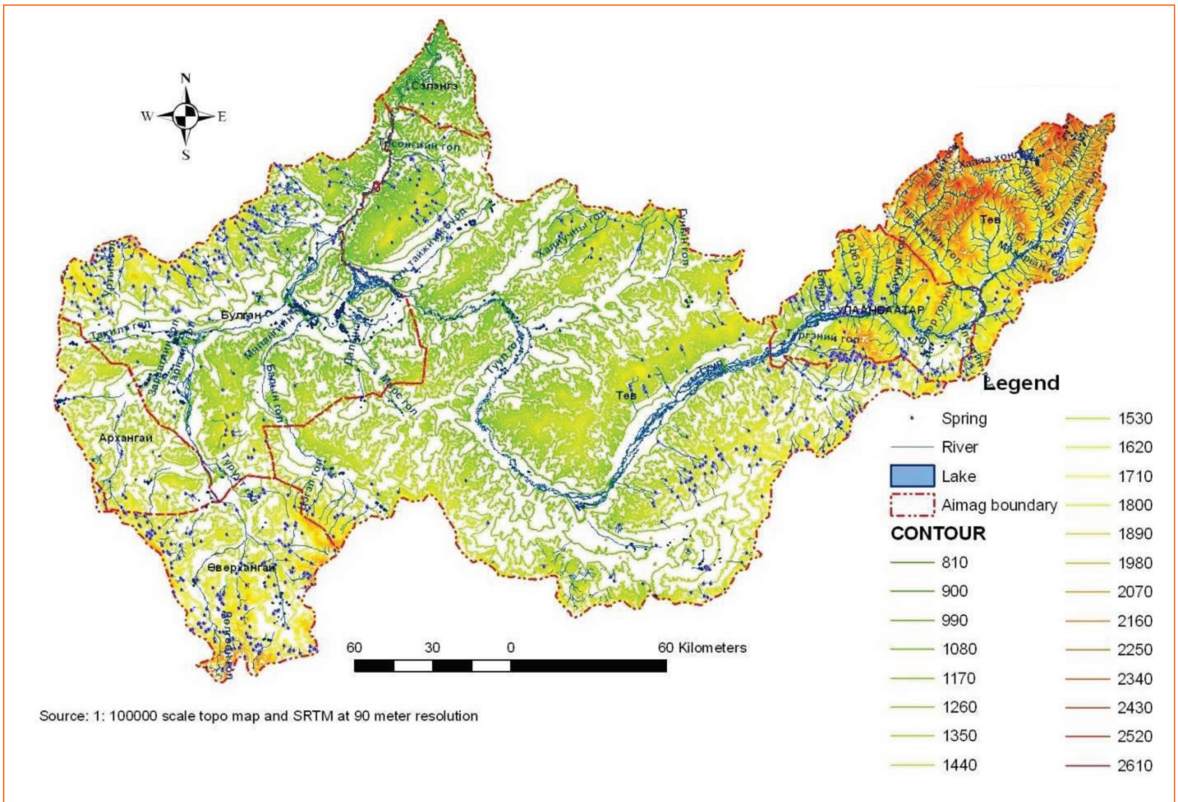


Figure 1. River network of the Tuul River basin

Historically some big floods have occurred along the Tuul River and for example, flood water reached the Zaisan and Gandan hills in 1915. Such big floods also occurred in 1934, 1959, 1966 and 1967.

3.3. Hydrological monitoring network in the Tuul River basin

IWRM requires an adequate monitoring network for the collection of comprehensive data and information on water resources while better data and information will enable better management, more accurate assessment of water resources and wiser decisions on water resources protection and appropriate use.

The first hydrological station was established on the Tuul River at Ulaanbaatar in 1942 and since 67 years continuous data have been collected at this site. Today, there are 8 hydrological gauging stations operating in the Tuul River basin including Tuul-Bosgo, Ulaanbaatar, Altanbulag, Lun and at Selbe-Sanzai and Dambadarjaa, Terelj-Terelj, Uliastai-Uliastai (Table 1). These stations belong to the National Agency for Meteorology, Hydrology and Environment Monitoring.

Table 1. Description of hydrological gauging stations in the Tuul River basin

No.	River	Station	Coordinates		Period of observation	
			Lat.	Long.	Open	Closed
1	Tuul	Bosgo bridge	48.03333	107.73333	1985.X.22	
2	Tuul	Ulaanbaatar	47.88333	106.93333	1975.IV.14	H
3	Tuul	Altanbulag	47.945	106.54056	1997.VI.01	
4	Tuul	Lun	47.88861	105.27222	1997.V.27	
5	Terelj	Terelj	47.96667	107.46667	1969.IX.01	
6	Uliastai	Uliastai	47.96667	107.33333	1992.X.01	
7	Selbe	Sanzai	48.13333	106.88333	1993.VI.01	
8	Selbe	Dambadarjaa	47.98000	106.92000	1984.I.01	T

The National Agency for Meteorology, Hydrology and Environment Monitoring wishes to increase the density of gauging stations in terms of space and time and to improve the equipment of stations to allow continuous measurements for the water resources and flow regime in the Tuul River basin. The highest priority is to consider the possibility to extend the hydrological network in the river basin.

According to WMO standards, mountain and forest regions should have 1 hydrological gauging site for every 700 km^2 of area and steppe and Gobi desert regions, 2000 and 12000 km^2, respectively. Such a spatial density allows to estimate and monitor surface water resources and regime in appropriate accurate way. Considering Tuul River's different geographical regions from forest-mountain to steppe, at least 25-30 hydrological gauging stations for surface water are needed in order to meet accuracy of estimation and monitoring for surface water resource and regime.

The following extension and strengthening of the hydrological monitoring network in the Tuul River basin is proposed:

Extension of the network in space or installation of new hydrological gauging station: Tuul-Zaamar

Strengthening and improving key stations: Tuul-Bosgo, Tuul-Ulaanbaatar (cable way, iron boat, modern current meter, automatic water level sensor etc).

Increasing measurement time density: automatic water level sensors, operational data transmission devices at Selbe and Upper Tuul.

4. River runoff and flow regime

4.1. Water balance of the river

The water balance of the river basin expresses according to the following equation.

$$Q = P - ET \pm \Delta S$$

Where: Q – river runoff, P - precipitation, ET – evapotranspiration (soil moisture evaporation), ± ΔS – change in basin storage with given time of period Δt.

Basin average precipitation: the precipitation in the Tuul River basin is represented by the Takhilt-Ulaanbaatar meteorological station's long term data presented in the Table 2.

Table 2. Long term mean monthly sum of precipitation in the river basin, mm

	Months												Annual
	1	2	3	4	5	6	7	8	9	10	11	12	
Precipitation, mm	2.2	1.6	3.7	7.3	14.7	54.6	57.9	75.9	23.4	9.7	4.2	3.2	258.4

The long term mean of annual sum of precipitation in the Tuul River basin is estimated at 248.5 mm with 90% of the precipitation falling within the April-September months. The warm period sum of the rainfall in the Tuul River basin is 233.8 mm. The daily maximum rainfall was 74.9 mm and it was observed in 1967. The estimated maximum daily rainfall with 1% of probability of occurrence in the Tuul River basin is 120 mm and the heaviest rainfall event occurred in 1982 with an intensity of 44 mm in 20 minutes.

Finally, the long term water balance of the Tuul River is as follows:

$$Q\ (130\ mm) = P\ (248\ mm) - ET(118\ mm)$$

4.2. Spatial and temporal distribution of river runoff, flow regime and analysis of runoff coefficient

One of the specific characteristics of the runoff sources of the Tuul River is the relatively low portion of groundwater contribution. It was estimated that about 69% of the annual runoff forms from rainfall, 6% from snow melting and 25% from groundwater sources. This shows that according to the flow regime classification the Tuul River belongs to the rivers with spring snow melting and rainfall floods.

The spring flood is observed at the end of April and beginning of May and the duration and magnitude of the spring flood runoff is usually less than that of the rainfall flood. After the spring flood a short warm season low flow follows. During July to September the rainfall flood is observed with several peaks. The maximum discharge of the rainfall flood exceeds the spring flood by about 1.5-2 times.

After the rainfall flood, water levels continue to drop until the beginning of the ice phenomena. Ice phenomena begin from the end of October and by the middle of November a stable ice cover is formed. Ice phenomena continue for about 150 days up to the end of April (Figure 2).

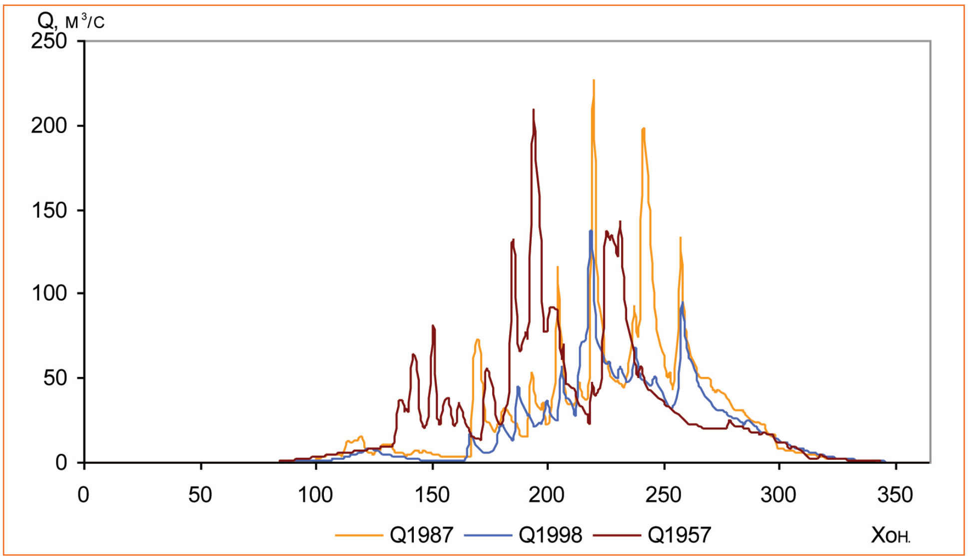


Figure 2. Typical annual hydrograph of the Tuul River (Tuul-Ulaanbaatar station)

Annual distribution of runoff: Depending on flow conditions, 62-64% of the annual runoff forms within the VI-VIII months. Runoff of the Tuul River recedes, freezing up to the river bed in the winter season limiting water use (Table 3).

Table 3. Annual runoff distribution (percentage from annual mean)

River-station	Months											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Tuul-Ulaanbaatar	0.02	0.03	0.16	2.06	9.95	14.6	24.8	25.3	16.0	5.42	1.34	0.15
Tuul –Gachuurt	0.02	0.03	0.16	2.07	9.97	14.6	24.8	25.3	16.1	5.43	1.34	0.15
Tuul –Terelj	0.02	0.03	0.16	2.06	9.95	14.6	24.8	25.3	16.0	5.42	1.34	0.15
Tuul –Bosgo bridge	0.07	0.06	0.18	2.45	10.1	15.2	23.1	25.0	16.3	7.40	1.73	0.31
Terelj-Terelj	0.01	0.01	0.12	2.38	9.96	15.0	23.0	24.8	16.2	7.31	1.67	0.25

***Studies on runoff losses along the Tuul River*:** natural runoff losses along the Tuul River begin at around Altanbulag after Ulaanbaatar city where the valley of the river becomes wider. Maximum induced runoff losses are observed in the reach between Terelj Bridge and Zaisan Bridge. During winter and spring seasons, this reach may shift up to the confluence of the Tuul and Terelj.

Several field measurements have been done along the Tuul River by different organizations, projects and joint researchers in different periods. For example: Russia-Mongolian expeditions in 1978, JICA in 1993-1994, IMH in 1998, 2002 etc.

The runoff loss or groundwater recharge rate increases near the Ulaanbaatar water supply well fields along the Tuul River and the runoff loss zone has a tendency to extend upstream along the Tuul River until the confluence point of the Terelj and Tuul Rivers (Figure 3).

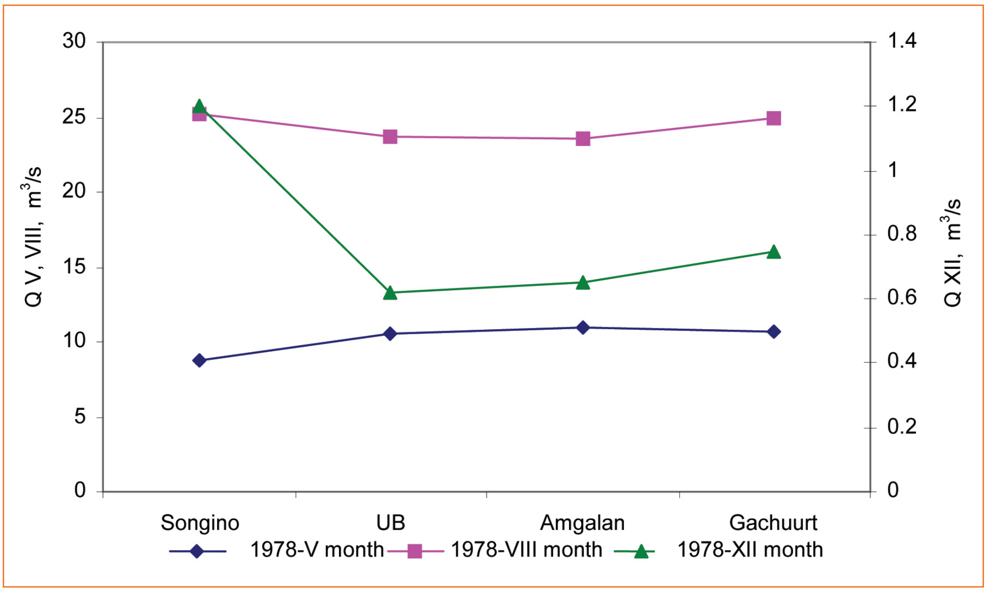


Figure 3. Longitudinal distribution of runoff of the Tuul River in different flow periods

During the rainfall flood in the warm period the runoff of the Tuul River increases in downstream direction. This is because the rainfall flood runoff from the tributaries of the Tuul River exceeds the runoff loss by infiltration through the riverbed (Figure 4).

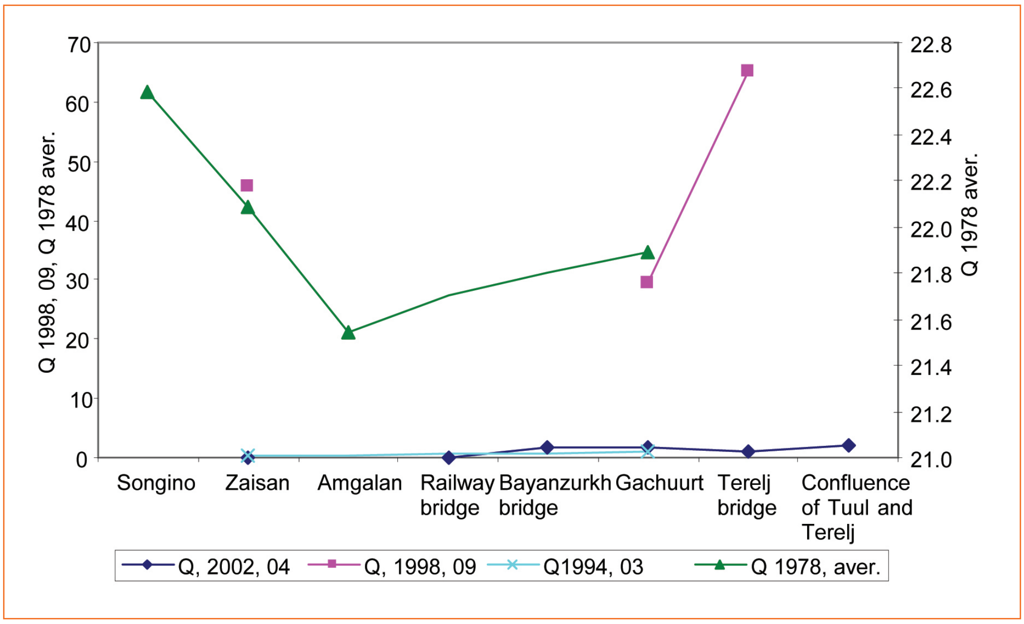


Figure 4. Runoff losses along the Tuul River

The low flow of the Tuul River increases in downstream direction and therefore the alluvial deposits of the Tuul River at Zaamar area contain more water in the winter season.

Runoff coefficient: the variation of the runoff coefficient is a clear indicator of the change of the natural factors of the runoff formation in the river basin. The coefficient is the ratio between basin runoff and basin precipitation. If the river basin is covered by forest or dense vegetation with an unchanged soil cover then generally the runoff coefficient is less and most of the precipitation is spent for evapotranspiration, soil infiltration and groundwater recharge. In case of a paved surface, the runoff coefficient is close to one. The value of the runoff coefficient increases in river basins where desertification takes place. The studies show that the runoff coefficient has increased in the last 60 years in the Tuul River basin (Figure 5).

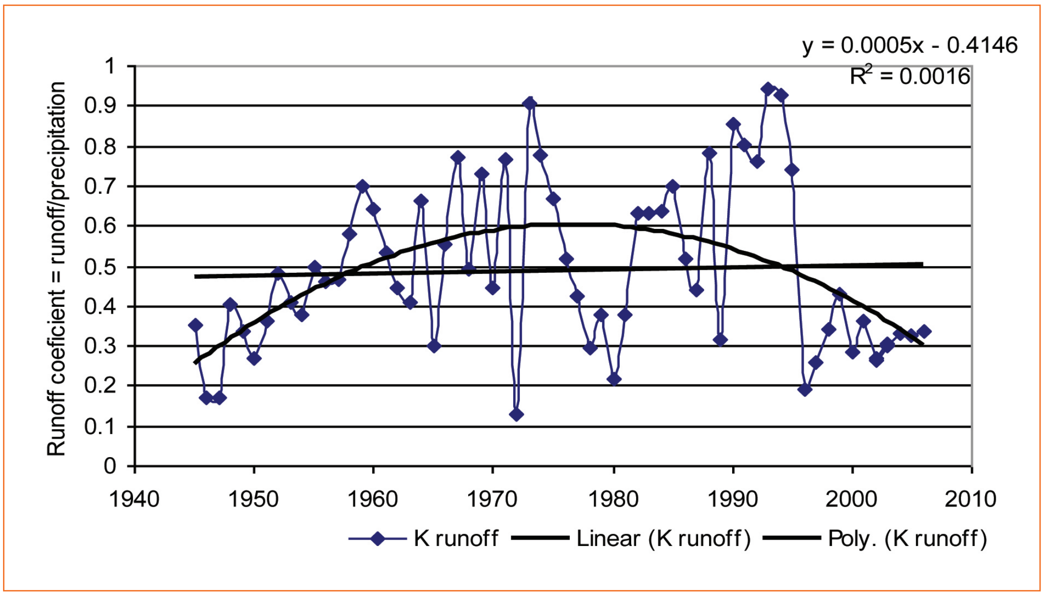


Figure 5. Runoff coefficient changes in the Tuul River basin

The mean runoff coefficient in the Tuul River was around 0.49-0.50 before 1974 and these values have increased till 0.53 since 1974. As a result of these changes, direct runoff of Tuul River has increased by 4 mm and at the same time groundwater resources of the basin have a tendency to decrease (Table 4).

Table 4. Changes of water balance components and runoff coefficient

River-station	Period of estimation	P, *mm*	Q, *mm*	R	ET, *mm*
Tuul-Ulaanbaatar	1945-1975	248.0	128	0.51	119.7
	1976-2006	250.1	132.6	0.53	117.5

4.3. Long term mean runoff, floods and low flows

Long term mean runoff: the long term mean runoff of the Tuul River at Ulaanbaatar station is 26.1 m^3/sec. During high flow years, the mean runoff with 5% of probability of occurrence can reach 56.4 m^3 /sec and in case of low flow years with 97% of probability of occurrence, the mean runoff of the Tuul River can reach 6.0 m^3/sec (Table 5).

The long term mean runoff estimated by different statistical methods for different probabilities of occurrence is presented in Figure 6. The catchment areas of the long term mean runoff estimation sites are 6300, 5520, 2158 and 1220 km^2 at Tuul-Ulaanbaatar, Tuul-Gachuurt, Tuul-Bosgo and Terelj-Terelj respectively.

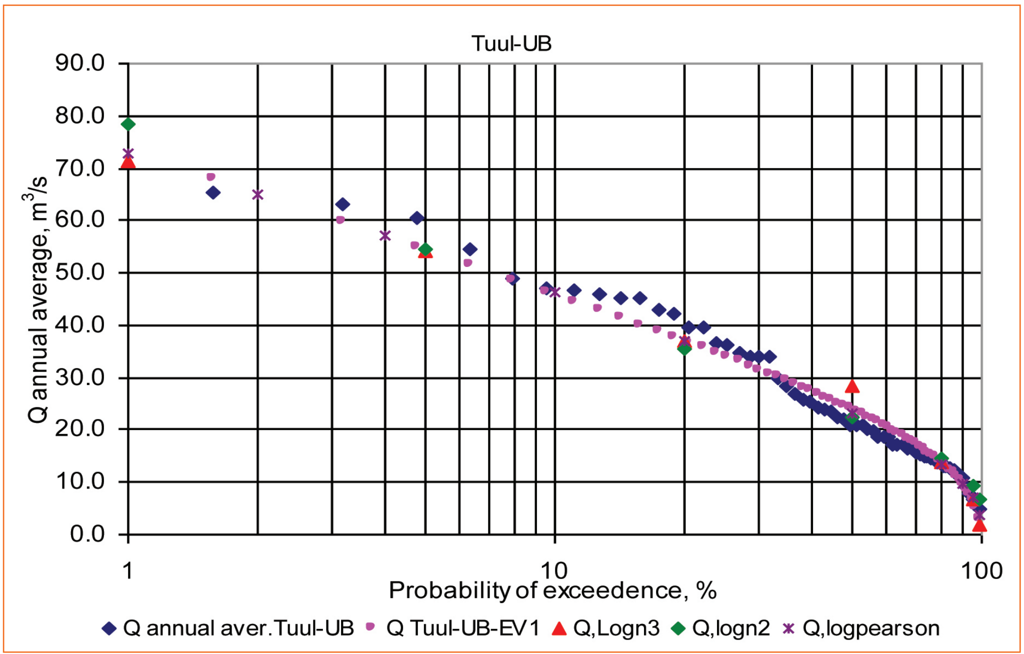


Figure 6. Probability of occurrence curve of the long term mean runoff of the Tuul River (Tuul –Ulaanbaatar station)

The estimation of the long term mean runoff at the sites with a short period of observation such as Tuul-Gachuurt, Tuul-Bosgo and Tuul-Terelj was done by extending the short records using the simultaneous observation data of the long records of Tuul-Ulaanbaatar and Terelj-Terelj.

Table 5. Long term mean runoff with different probability of occurrence

River-station	P, %								
	1	5	10	25	50	75	90	95	97
Tuul-Ulaanbaatar	70.4	59.1	47.8	34.0	21.6	15.0	10.0	7.7	6.0
Tuul -Gachuurt	62.7	52.6	42.6	30.3	19.2	13.3	8.9	6.9	5.3
Tuul -Terelj	31.0	26.0	21.0	15.0	9.49	6.58	4.40	3.39	2.64
Tuul –Bosgo bridge	22.8	17.1	14.5	10.9	8.23	6.66	5.36	4.32	3.75
Terelj-Terelj	19.8	14.8	12.5	9.43	7.09	5.73	4.60	3.70	3.20

The estimated long term mean runoff of the Tuul River at Ulaanbaatar station is 25.8 m^3/sec and at Gachuurt- 23.2 m^3/sec, near Tuul-Terelj-12.8 m^3/sec, and at Bosgo bridge 9.12 m^3/sec. As for Terelj River the mean long term runoff is 7.8 m^3/sec at the Terelj site (Table 6).

Table 6. Long term mean runoff in the Tuul River basin

No.	River-station	Period of coverage	Basin		Long term mean Runoff			Cv	Cs
			Area	Mean elevation	Q, *m^3/s*	q, *l/sec km^2*	h, *mm*		
1	Terelj-Terelj	1971-2008	1220	2067	7.8	6.4	202.3	0.4	0.8
2	Selbe-Sanzai	1994-2008	34.2	1620	0.1	3.8	120.0	0.7	1.4
3	Selbe-Dambadarjaa	1985-2008	188	1510	0.4	2.2	70.5	0.6	1.3
4	Uliastai-Uliastai	1990-2008	317	1400	0.6	1.8	56.7	0.8	1.6
5	Tuul-Ulaanbaatar	1945-2008	6300	1852	25.8	4.1	129.2	0.6	1.2

No.	River-station	Period of coverage	Basin		Long term mean Runoff			Cv	Cs
			Area	Mean elevation	Q, m^3/s	q, *l/sec km²*	h, *mm*		
6	Tuul-Undurshireet	1983-94	18427	1563	21,1	1,14	36	0,26	0,52
7	Tuul-Lun	1998	23850	-	-	-	-	-	-
8	Tuul-Zaamar	-	47850	1248*	22.2	0.70	22.1		-

Remark: data series from Tuul-Altanbulag and Tuul-Lun too short to calculate meaningful mean

The mean runoff of the Tuul River was estimated at the downstream sites of Undurshireet and Zaamar using observed data from Undurshireet and Lun and using field measurements at Zaamar (1989). The estimation shows that the long term mean runoff at Undurshireet and Zaamar is 20.6 and 17.9 m^3/sec, respectively.

Maximum flow: the maximum flow of the Tuul River is observed during the summer rainfall floods. Usually the maximum discharge is observed at Ulaanbaatar and due to the flood routing, there will be attenuation of the flood peak along the Tuul River after Ulaanbaatar. The magnitude of the spring flood maximum due to snow and ice melting is less compared to the maximum of the rainfall flood.

For example the estimated maximum discharge with 1% of probability of occurrence of the spring flood at Tuul-Ulaanbaatar is 480 m^3/sec and at Terelj-Terelj is 140 m^3/sec. The maximum discharge of the rainfall flood with 1% of probability of occurrence reaches 1850 m^3/sec at Tuul-Ulaanbaatar and at Terelj-Terelj is around 822 m^3/sec (Table 7).

Table 7. Maximum discharge of rainfall flood

No	River-station		Runoff with different probability of occurrence Discharge Q, specific runoff q and runoff depth h					
			0.1	1	2	5	10	25
1	Tuul-Ulaanbaatar	Q (m^3/s)	3076	1850	1480	1120	800	500
		q (l/s/km^2)	488	294	235	178	127	79
		h (cm)	-	139	111	80	56	35
2	Terelj-Terelj	Q (m^3/s)	1375	822	670	500	386	243
		q (l/s/km^2)	1127	674	549	410	316	203
		h (cm)		92.0	86.5	77.6	70.5	60.0

To estimate the maximum flood discharge of the Tuul River different statistical models were used including EV-1 and Log-normal with 3 parameters. However these methods provide an underestimation and therefore we recommend to use an empirical curve (Figure 7).

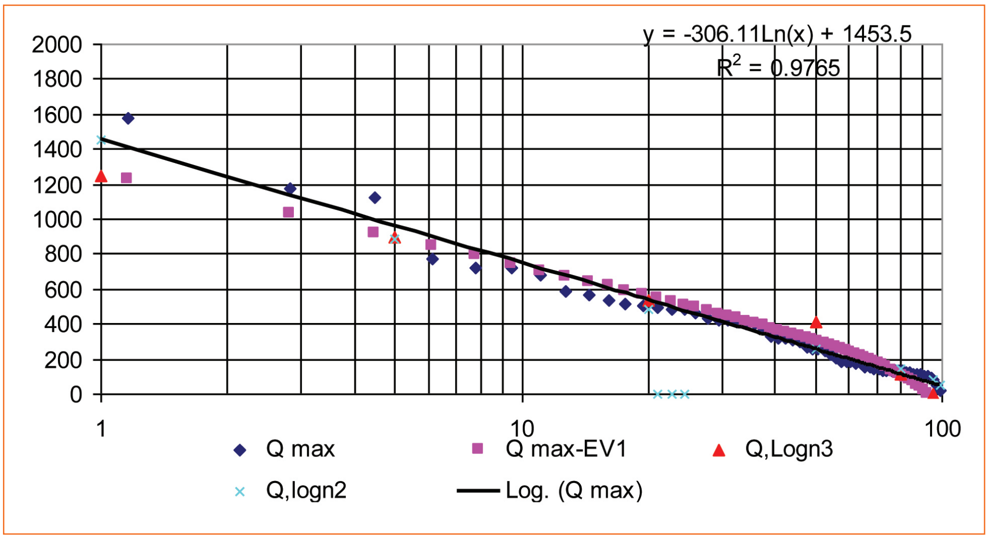
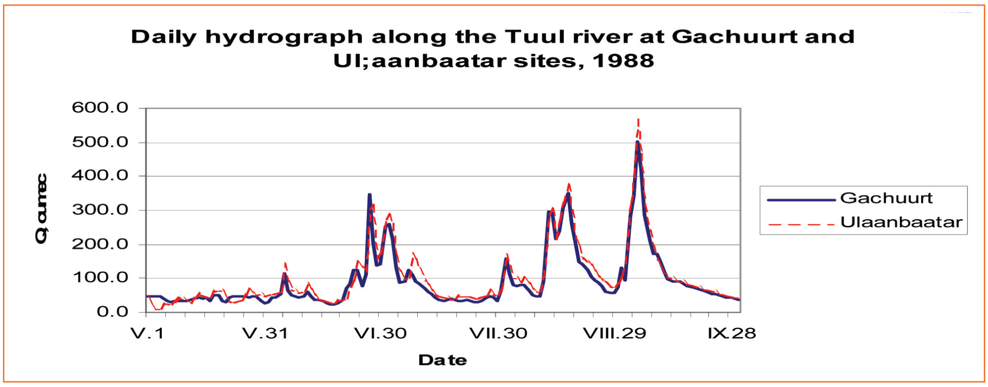


Figure 7. Probability of occurrence curve of the maximum discharge of rainfall flood Tuul River (Tuul –Ulaanbaatar station)

In order to estimate the maximum flood discharge at the Tuul-Gachuurt site, we extended floods series observed at Gachuurt site in 1986-1988 and 1994 using long term data observed at Tuul-Ulaanbaatar site. There is an excellent correlation between the Ulaanbaatar and Gachuurt sites and the flood maximum at Ulaanbaatar always exceeds the flood maximum at the Gachuurt site. The travel time from Gachuurt to Ulaanbaatar varies from several hours till one day depending on the flow conditions (Figure 8).



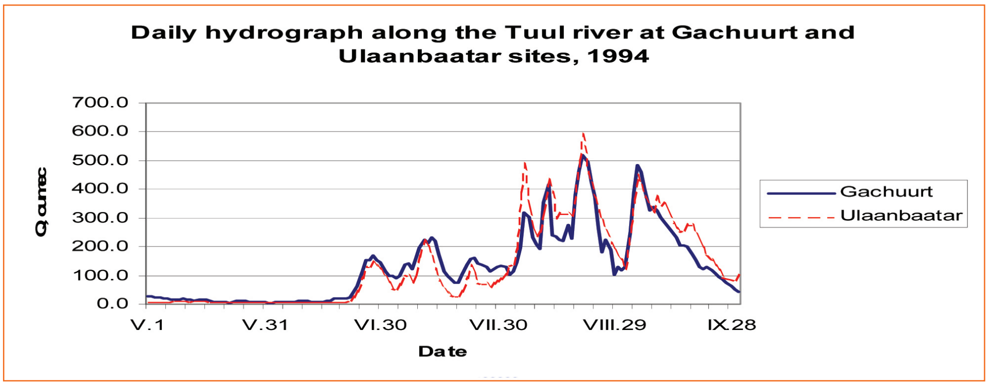


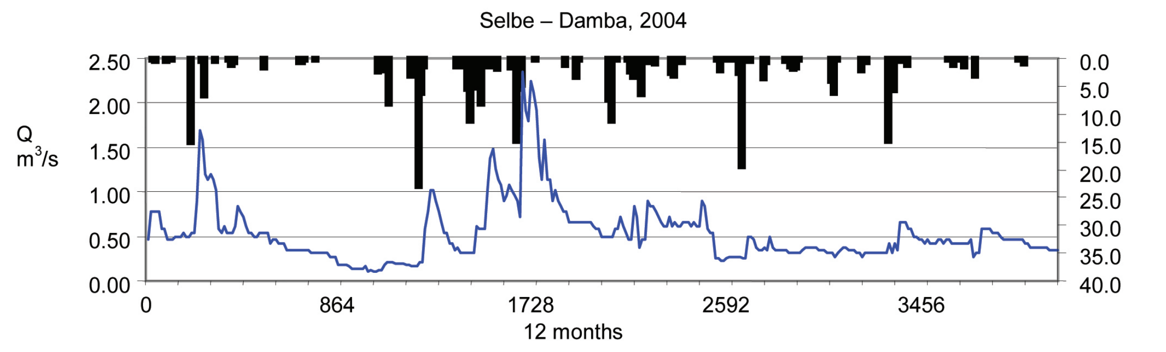
Figure 8. Daily hydrograph at Tuul-Ulaanbaatar and Tuul-Gachuurt

The estimated flood discharges of the rainfall flood with probability of occurrence along the Tuul River are presented in Table 7.

Biggest floods observed in the Tuul River: Since instrumental observation of the flow regime began, several big floods have been observed along the Tuul River in 1934, 1959, 1966 and 1967 and during these floods several tenth of people died and flood damage occurred estimated at several millions of tugrug. For example, the flood water of the rainfall flood which occurred in 1915 reached the bottom of the Gandan (right bank) and Zaisan hills (left side) and Songino Khairkhan district of the present Ulaanbaatar city would be inundated during this flood.

Other big floods have occurred on 10-11 of July of 1966. This flood was caused by two days of rainfall which reached to 103.5 mm and which was about 43% of the monthly mean. The estimated flood discharge at the Ulaanbaatar site was 1700 m³/sec, the velocity of the flood water reached 4-5 m/sec and the water level was raised by 151 cm within one day.

The flow regime and runoff magnitude of small rivers in the Tuul River basin such as the Selbe are directly determined by the rainfall pattern. One single event shows that two days rainfall with amount of 63-104 mm in the Selbe river basin caused a water level rise of about 100 cm after 1-2 days (event in 2003.VIII.14-15) (Figure 9).



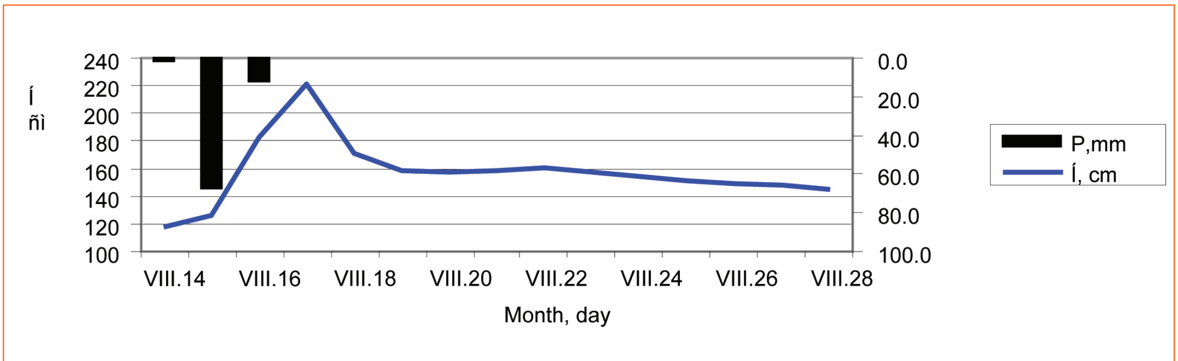


Figure 9. Rainfall runoff relationship in the Selbe river basin

The estimated maximum discharge of rainfall flood with 1% of probability of occurrence of the Selbe river at Sanzai site is 59.4 m³/sec while in downstream site at Dambadarjaa it will be 255 m³/sec. Similar values for small tributaries of the Selbe river vary around 15-50 m³/sec. The maximum discharge of the rainfall flood depends on basic morphometric parameters of the basin and the river such as catchment area, slope etc.

<u>*Low flow:*</u> the minimum 30 days warm period low flow of the Tuul River is 2.0 m³/sec and of the Terelj river is 0.23 m³/sec (Table 8).

Table 8. Minimum flow of the Tuul River

No	River-station		30 days low flow with different probability of occurrence					
			50	75	80	90	95	97
1	Tuul-Ulaanbaatar	Warm period	12.8	7.90	7.30	5.10	4.51	2.0
2	Tuul-Gachuurt	Warm period	16.2	10.5	9.75	7.18	6.49	3.55
3	Terelj-Terelj	Warm period	5.08	2.79	2.38	1.31	0.57	0.23

The low flow at Tuul-Gachuurt is estimated in the same way as the maximum discharge by establishing the relationship with the observed data at the Tuul-Ulaanbaatar site.

4.4. Rainfall – runoff relationship

Rainfall-runoff relationship: the response of the basin to the rainfall amount and intensity or the rainfall-runoff relationship much depends on basin cover condition, soil moisture (antecedent), rainfall amount and intensity, flow condition of rivers, surface and groundwater interrelation and very complex processes. Therefore we need to pay more attention to these studies extending measurement density in space and in time, improving data quality, experiences, software provision, skill and knowledge, training etc. Some examples of different responses of basin or runoff to the rainfall are presented in Figures 10, 11 and 12.

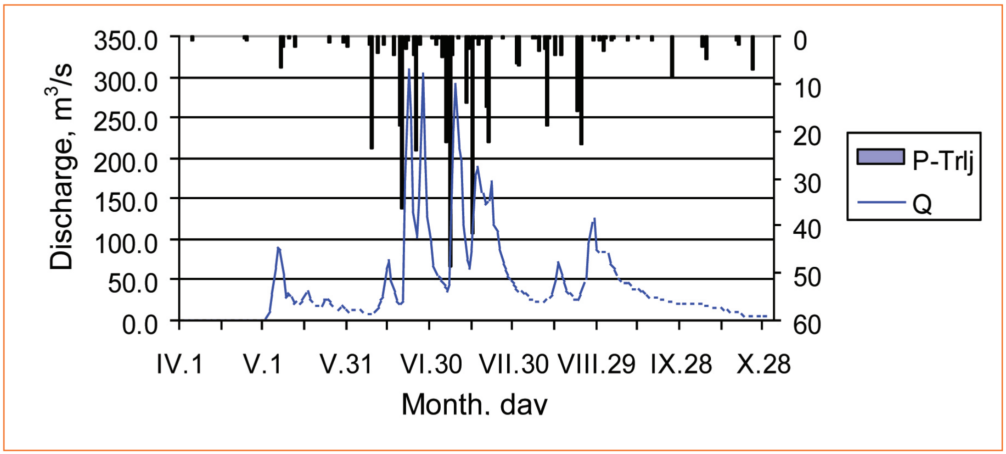


Figure 10. Rainfall-runoff relationship in Terelj-Tuul-Ulaanbaatar, 1986

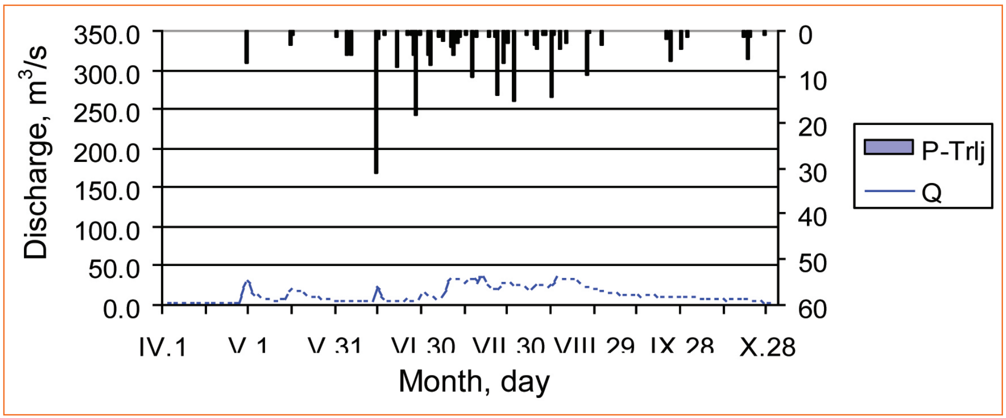
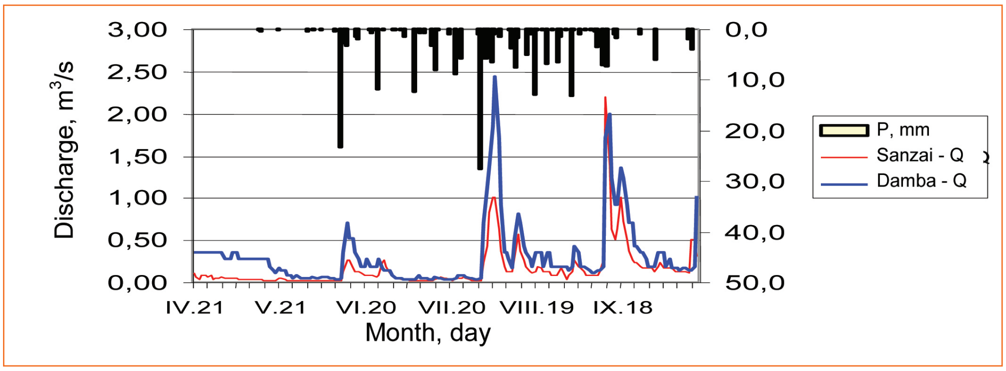


Figure 11. Rainfall-runoff relationship in Terelj-Tuul-Ulaanbaatar, 1996



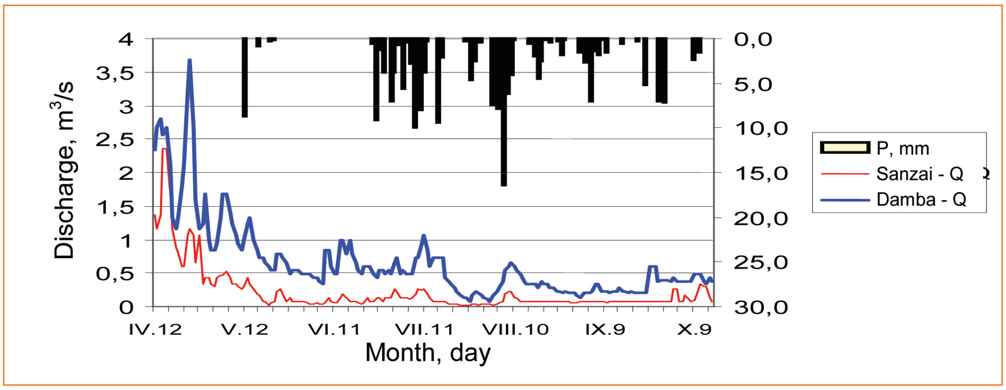


Figure 12. Spring snow melting flood and rainfall flood years (1998 and 1999) in the Selbe river basin

4.5. Ice phenomena, water temperature and sediments

Ice and thermal regime of the Tuul River: Ice phenomena begin at Tuul River in the second decade of October and by the mid of November an ice cover is established along the Tuul River. The mean depth of the ice cover of the Tuul River is 45 cm in November which increases to 66 cm in December. The maximum ice depth is observed in mid February reaching 116 cm. Spring ice phenomena begin from mid April and by the third decade of April ice drifting is observed. The spring ice phenomena end by late April (Table 9 and 10).

Table 9. Ice phenomena

	Date					Duration			
	Beginning of autumn ice phenomena	Autumn	Complete ice cover established	Ice drifting in spring	End of ice phenomena in spring	Autumn	Spring ice drifting	Ice cover	Total duration of ice phenomena
Tuul-Ulaanbaatar									
Mid	X.20	X.25	XI.13	IV.23	IV.28	16	6	150	191
Early	X.10	X.12	X.28	IV.07	IV.15	32	16	181	208
Late	XI.10	XI.29	XI.29	V.07	V.10	1	3	98	165
Terelj-Terelj									
Mid	X.26	X.30	XI.07	IV.12	V.10	14	11	155	181
Early	X.17	X.20	X.26	III.28	IV.16	26	43	174	225
Late	XI.16	XI.16	XI.12	V.28	V.31	5	1	117	179

Table 10. Ice depth, cm

	XI			XII			I.31	II.28	III			IV.10	Maximum	
	10	20	30	10	20	31			10	20	31		cm	date
Tuul-Ulaanbaatar														
mean	19	30	39	43	53	66	97	100	98	93	82	67	116	II.14
max	30	60	91	75	104	122	163	155	157	193	158	145	193	I.10
min	10	13	9	7	5	11	26	22	21	21	13	4	30	III.31
Terelj-Terelj														
mean	22	22	18	28	36	58	79	83	71	77	81	72	100	III.11
Max	70	100	40	70	97	123	126	124	154	166	138	120	165	I.20
min	4	1	8	13	11	14	42	42	26	40	39	30	49	III.31

Table 11. Water temperature

	Date of 0.2°C in spring	Monthly mean							Date of 0.2°C in autumn	Maximum	
		IV	V	VI	VII	VIII	IX	X		T °C	Date
Tuul-Ulaanbaatar											
Mid	IV.24	0.8	7.0	12.2	14.0	14.0	8.2	3.4	X.20	20.0	VII.15
Early	IV.01	4.3	12.9	14.9	17.8	17.6	13.1	9.8	IX.15	26.0	VI.26
Late	V.03	0.1	0.9	8.0	10.1	10.4	2.6	1.0	XI.12	14.0	VIII.10
Terelj-Terelj											
Mid	V.05		3.6	8.6	10.1	10.2	6.4	2.0	X.25	17.1	VII.25
Early	IV.21		8.2	13.9	13.4	13.0	8.1	3.6	X.16	24.6	VI.14
Late	V.17		0.1	2.1	7.3	7.6	3.5	0.2	XI.07	11.4	VIII.22

The water temperature of the Tuul river exceeds 0.2°C in the last decade of April, by May it warms to 7.0°C and the maximum temperature is observed in July with a monthly mean of 14.0°C. The daily maximum is observed in mid of July reaching 20°C and after the water temperature begins to cool down until autumn when ice phenomena begin to be observed (Table 11).

Sediments: The turbidity of the Tuul River varies from 0.2 to 650 g/m^3 and the maximum value of turbidity is observed in June and July. About 80% of the annual suspended sediments pass during the mentioned months. The mean value of the sediment discharge of the Tuul River is 2.65 kg/sec and the mean value of the turbidity is around 109 g/m^3.

4.6. Distribution and dynamic of the macro invertebrates of the Tuul River

Macro invertebrates of the Tuul River have been studied since 1989. There were 10 water stations of the Tuul River included in the investigation.

The Terelj is a main upstream tributary of the Tuul River. Totally, 42 genera of aquatic invertebrates were found for 22 years study.

There are several midstream sites named Uubulangiin Sorog garam (36 genera), bridge of Bayanzurkh (22 genera), bridge of Zaisan (17 genera), bridge of Sonsgolon (11 genera), Songino (upstream /5 genera/ and downstream sites /1 genera/) and Altanbulag.

The water quality of the Tuul River is estimated at each site using Biotic index. The result shows that sampling sites of Terelj, Uubulangiin Sorog garam, bridge of Bayanzurkh and bridge of Zaisan were "Good". The biotic index was poor at upstream and downstream sites of Songino site and Altanbulag site. Compared to the upstream of

Songino, benthic community of downstream site is more diverse.

Biochemistry and chemical is the main factors which affected to water quality of the Tuul River. For example, water is polluted by urban pollution at the upstream sites. At the downstream sites, pollution of mining activity is dominated. In Figure 13, sites are numbered 1 to 9 and macroinvertebrates are classified indicator (Ephemeroptera, Plecoptera and Trichoptera) and others (Diptera, Oligochaeta, Leech etc). At sites 6 and 7, the macroinvertebrate dynamic is decreased and less diverse than other sites.

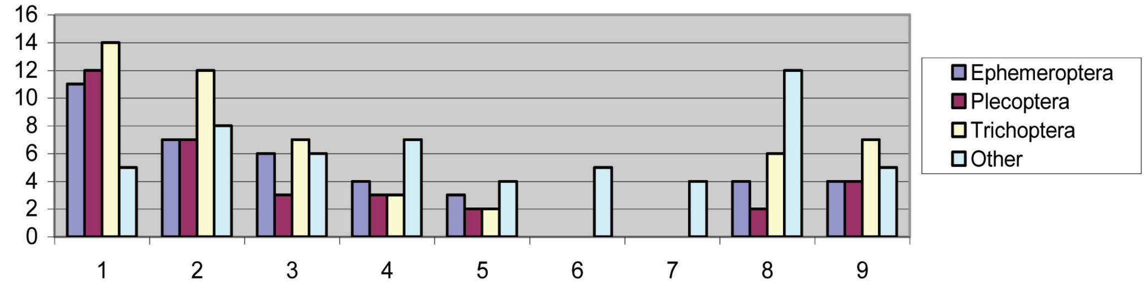


Figure 13. The macro invertebrate community dynamic along the sites of Tuul River

The vertical axis presented number of species while horizontal axis shows 9 sampling locations along the Tuul river from confluence of Tuul-Terelj through Uu bulan, Bayanzurkh, Zaisan (Ulaanbaatar), Sonsgolon, Songino (up and downstream), Khadan khyasa to Altanbulag in Figure 13.

5. Impacts of climate change to the flow regime and water resources

5.1. Present situation of impacts of climate change

The long term variation of runoff of the Tuul River shows that low flow years dominate during the periods of 1945-1957, 1976-1981 and 1996-present while high flow years dominated in 1958-1975 and 1982-1995.

During the period from 1945 to 1976 when anthropogenic impacts were relatively low, the mean runoff of the Tuul River was 25.61 m^3/sec and from 1976 to 1989 the mean runoff was 25.04 m^3/sec. Thus the mean runoff of the Tuul River did not change much during the above mentioned periods.

Recently some seasonal shortage or reduced runoff of the Tuul River was observed near Ulaanbaatar city, especially in the spring period. For example, a reduction of runoff occurred in late April in the last several years. The main reasons for this situation are human influences and climate change.

The annual mean air temperature in the river basin has increased by 2.0 °C in the last 60 years. There is no significant change observed in the precipitation amount. Even there is some increasing tendency in rainfall in the July and August months. Precipitation in April-June has decreased. The climate change is continuing to have an impact on the further drying processes of the river basin while impacts of human activities are expressed in the flow regime changes.

Our studies and analysis identified the following changes in the flow regime of the Tuul River. Where:

1. The duration of single isolated rainfall floods shortened by 2-3 days in the last 60 years, and today it is 12 days while it was about 15 days in 1940s. There are annually about 10 flood peaks observed along the Tuul River. The number of days with a flow rate less than the annual mean becomes larger and is increased by 24 days. It means duration of the low flow periods becomes longer and infiltration to groundwater is possible over a longer period. Rainfall produces short events which contributes less to soil moisture and groundwater. The flood peak of the Tuul River has increased by 20 m^3/sec and the risk of flood disaster is increased.

2. The snow pack becomes unstable and less on overgrazed pasture and cut forest sites and due to this situation snow melting flood becomes longer by 14 days on average and flood peak reduces by 3.1m^3/sec.

3. In the last 60 years the runoff coefficient has increased by 9% and standard deviation also increased by ± 15.6 m^3/sec and thus river runoff distribution becomes more unstable and uneven.

4. The ice cover of the Tuul River melts earlier than previous years and the duration of ice cover becomes shorter by 12 days and duration of ice phenomena- by 8 days in the last 60 years. The main reason of such changes are air pollution of Ulaanbaatar city, soil erosion and certainly general tendency of climate change.

5. The water temperature of the Tuul River has increased by 1.9°C in the last 60 years. At the same time, the ice depth was reduced by 40 cm in the Tuul River.

The results of recent studies show that the mean runoff of the Tuul River decreased by 48.4% since mid of 1990s when low flow years began in the Tuul River basin compared to the previous years mean. Such a decreasing trend was observed also in the seasonal runoff (Table 12 and Figure 14).

Table 12. Runoff decline in last 10 years, Tuul-Ulaanbaatar

	Long term mean, m³/sec	Spring season (VI-VI)	Summer season (VII-IX)	Autumn season (X-XI)	Winter season (XII-III)
Long term mean	25.78	27.47	68.28	10.50	0.28
1996-2007	13.29	15.92	31.81	7.51	0.32
Changes, %	48.4	42.0	53.4	28.5	-14.3

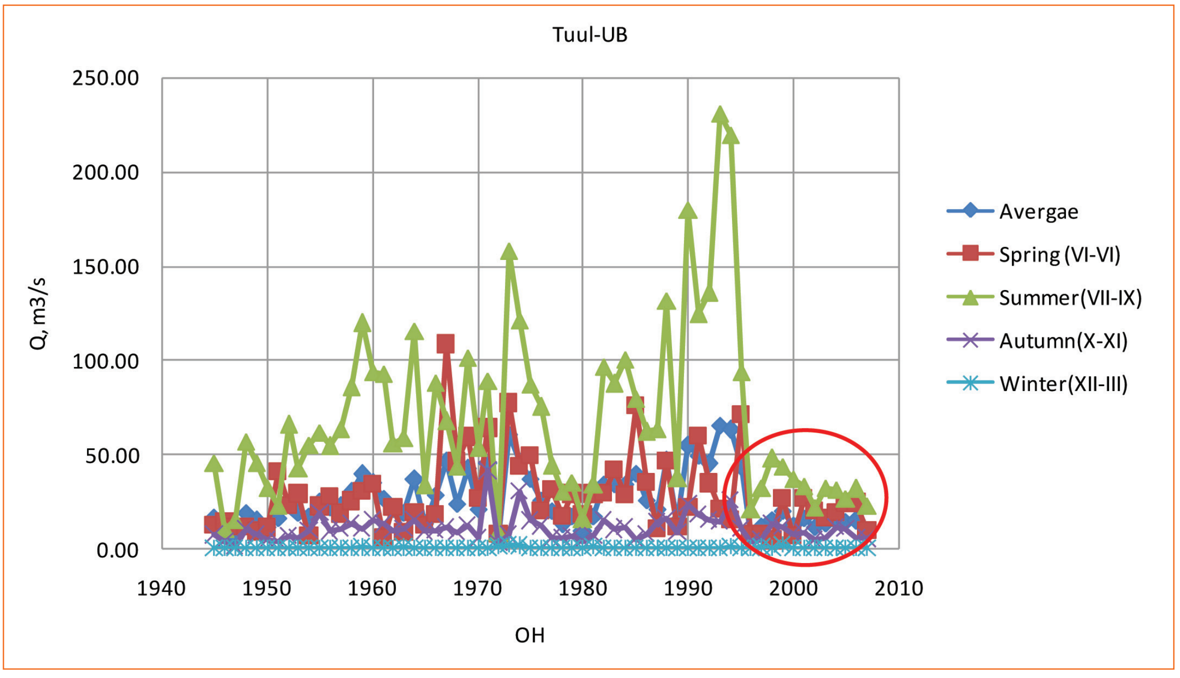


Figure 14. Long term variation of the Tuul River runoff and last 10 years reduction (Tuul Ulaanbaatar)

Impacts of climate change clearly effect ice phenomena and ice cover characteristics. For example, maximum value of ice cover of the Tuul River decreased by 46 cm during the period of 1944-2007. Usually the maximum depth of the ice cover is observed in mid of February in previous years, then recently it observes in mid of January or earlier than by about 30-40 days. For the same period, the duration of ice cover and ice phenomena in the Tuul River basin was shortened by 16 and 10 days, respectively. The mean water temperature of the Tuul River in July increased by 2.5˚C.

5.2. Future trend of impacts of climate change

According to the Greenhouse gas scenario-A2, runoff will increase on average by 10 mm in the high mountain area of the Khentei mountain range by 2020 and in other areas of the Khentei mountain range runoff increase will be around 2-5 mm. But runoff is expected to decrease in the steppe region by 2 mm. However, such runoff increase will be much less than evapotranspiration increase by about 10 times. Thus river basin will continue to dry in near future (G.Davaa, 2007).

6. Conclusions and suggestions

1. Due to the loss of natural regulating capacity which is expressed as infiltrating capacity of soil and recharging capacity to the groundwater which sustain low flow periods, the flow regime of the Tuul River is changed. The main reason of such changes is improper human activities in the Tuul River basin

2. One of the key reasons for the decline of the runoff in the Tuul River basin is deforestation and consequently loss of runoff regulating capacity of the forest. Logging activities in the Tuul River began from mid 1940^{th} and still continue illegally up to now. For example the forest cover of the Tuul River is reduced by 19484 hectare and forest resources decreased by 35%. Therefore reforestation in the Tuul River basin should be one of the important issues of IWRM.

3. The pasture in the Tuul River basin is considered as overgrazed and the surface layer of the soil is much degraded (soil compaction) and hydro-physical properties of the soil coverage are changed. Thus these conditions certainly change the flow regime. Therefore, it is recommended to include the basin area above Gachuurt to the network of the protected area and such measures can support development of optimal pasture management, recovery of the soils and of the vegetation in the basin

4. The increased drawdown of the groundwater at Ulaanbaatar due to an increase in groundwater abstraction indicates the critical situation of the groundwater recharge around Ulaanbaatar area. The surface water runoff loss or groundwater infiltration rate along the Tuul River increases around Ulaanbaatar water supply wells area. If the situation continues then by 2020-2050 shortages of groundwater resources may be faced at the end of the winter period. Therefore, it is needed to explore new groundwater sources around Ulaanbaatar city, to take measures for recharging of groundwater in alluvial deposition of the Tuul River, to establish groundwater monitoring network, to conduct studies and to establish monitoring network for longitudinal losses of the Tuul River runoff. These mentioned measures should take place in the framework of the IWRM planning and implementation.

5. Water quality changes along the Tuul River show that river water from Bayanzurkh till Sonsgolon bridge is less polluted and then up to Songino is very much polluted and the self-purifying capacity of the river is completely lost within this reach. The macro invertebrate community dynamics along the sites of Tuul River show an aquatic environment which is completely lost at Songino. According to the Biotic index, river water is very clean with a grade of 2.30 in the upstream part and from Ulaanbaatar till the confluence with the Orkhon, river water is polluted from less to very much with a grade of 5.01. Therefore, the impact of poorly working water treatment plants should be reduced, improved technologies should be employed and reuse of water and pricing water values should be encouraged. A balance should be found between pricing water as commodity, the cost of providing good quality water and reducing expansion rates for water users.

6. For better assessment of water resources and accurate estimation of runoff, it is needed to extend surface water monitoring network up to 25-30 hydrological gauging stations in the Tuul River basin. Such network can allow to conduct research studies on development of bases for recovering of flow regime, revealing of clear reason of runoff decline etc.

7. The annual water use of Ulaanbaatar's citizens is nearly two times less than the water use rate some of countries facing water scarcity. Therefore it is recommended to study the construction of water accumulation complexes in upstream sites of the

Tuul, Terelj, Selbe and Bayangol rivers based on the detailed studies of ecological and economical criteria.

8. Finally, water resources and flow regime changes in the Tuul River basin under climate change and human activities and related other problems such as recovery of forest cover, pasture and land use, shortage of groundwater resources and its recharge, drinking and industrial water supply, irrigated agriculture, water quality and pollution issues, water treatment, research studies on natural components of the river basin, extension of surface and groundwater monitoring, urban flooding issues should be analysed and decided upon within the framework of the Integrated Water Resources Management planning and implementation approach.

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ANNEX 1. Surface water allocation model RIBASIM

1.1 RIBASIM model

RIBASIM (River Basin Simulation Model) is a generic model package for analyzing the behaviour of river basins under various hydrological conditions. The model package is a comprehensive and flexible tool which links the hydrological water inputs at various locations with the specific water-users in the basin (Deltares).

Working in RIBASIM environment consists from main three parts as following:

- Creating database of all necessary data and enter data from internal and external sources
- Run model with prepared data in the main field
- Analyse the outputs and make

The outcome of a simulation run is the water balance which provides the basic information upon which analysts can produce tangible information to Decision Makers.

The advantages of RIBASIM are that it can provide detailed water balances for the most complex situations. Especially the what-if scenarios multi-year analyses provide a useful framework for decision making. The results can be carefully presented in clear graphs, charts, tables or can even be visualised on the relevant stretch itself using different colours and thicknesses.

1.2 Set up of the RIBASIM model for Tuul basin

The RIBASIM model is used to model the Tuul and Orkhon basins. The model results are of interest as the project prepares detailed water resources management plans for both basins. The model is used to simulate different water use scenarios affecting the river runoff. These scenarios include environmental flow, climate change effect on river runoff and water use predictions. The operation and the effect of the dams planned in each basin are also simulated.

The model is used to analyse the current and the future situation. Scenarios are applied to represent the different options for future developments. The model uses a monthly time step.

Different model versions were prepared for the Tuul basin (Figure 15):

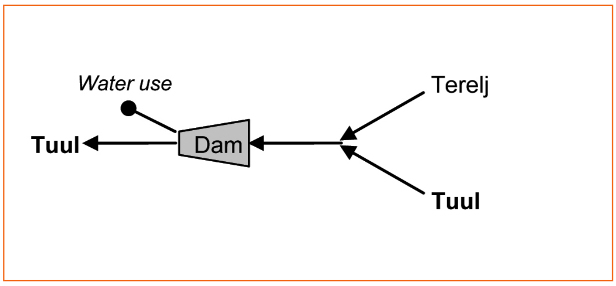
Model 1: a simple model including the proposed dam (Tuul Dam)

Model 2: a model to compare observed and simulated river discharge

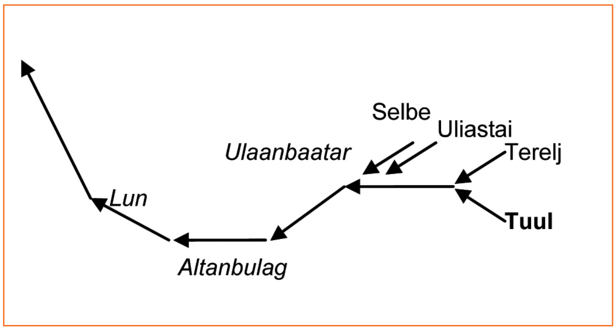
Model 3: a model including all water use and surface water discharge in two model versions:

- with a dam
- without a dam

Model 1



Model 2



Model 3

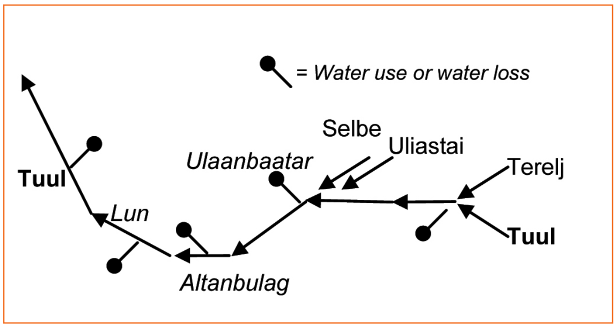


Figure 15. Design of RIBASIM models of the Tuul River

The models were used to simulate the effect of climate change using monthly runoff input derived from daily runoffs calculated with HBV.

1.3. Tuul Basin: Model 1

Tuul model 1 includes the simulation of the Tuul Dam reservoir which is to be constructed upstream of Ulaanbaatar.

The objective of the model is:

- Analysis of the effect of the reservoir on downstream river flow
- Analysis of the operation of the reservoir

The model is run with historical river discharges for three different environmental flow scenarios:

1. no environmental flow
2. maximized environmental flow using a fixed runoff of maximum 2, 5 and 10 m^3/s

3. environmental flow as percentage of the reservoir inflow releasing 25%, 50% and 75% of inflow

The model is also used to simulate the effect of climate change using four climate change scenarios: HADCM3, Wet, Central and Dry.

Model input data

1. Two variable inflow nodes (monthly flow derived from Tuul-Bosgo and Terelj-Terelj gauging stations)
2. One surface water reservoir, properties from dam report (Batdorj, 2008)
3. One public water supply node (representing a constant flow volume of 2.5 m^3/s)
4. One low flow node (downstream of the dam representing turbine discharge)
5. One low flow node (downstream of the dam representing environmental flow)
6. Terminal node (representing river discharge downstream of the dam)

Table 13. Reservoir and turbine characteristics of Tuul Dam

Level (m)	Area (ha)	Volume (McM)
1355	98	1.10
1360	415	12.91
1365	682	40.35
1370	734	75.79
1375	1135	120.77
1380	1677	190.25
1385	2050	283.39
1390	2351	392.60
1395	3154	528.16

Turbine	
Power capacity	6 MW
Power demand	6 MWh = 0.006 GWh
Discharge	16.8 m^3/s

Dam levels:	
spillway level	1392.59 m
turbine intake level	1352.63 m
main gate level	1352.63 m

Data from dam report (Batdorj, 2008): dam site II

Remark: the simulation of the hydro power installation requires the operation rule curves and the properties of the turbine. This information is not available; therefore the water demand for generating electricity is modelled as a low flow node with the required discharge. The discharge of 16.8 m^3/s mentioned in the dam report can not always be maintained and the reservoir will be completely empty in 50% of the years modelled if using this discharge. Therefore a lower discharge was applied: 8 m^3/s (January – March), 12 m^3/s (November, December, April) and 14 m^3/s (May – October). See figures below.

The simulation period is 1995-2008. This is a low flow period compared with the years proceeding this period. It includes only one wet year (1995) which helps to fill the reservoir. The simulation is started with an empty reservoir.

Table 14. Scenarios Tuul River Model 1

Model case	Environmental flow	Climate change	Remark
1.0	None	No	Reference model run 1995-2004
1.1.1 1.1.2 1.1.3	Fixed maximized: 2 m^3/s 5 m^3/s 10 m^3/s	No	Results to be compared with reference model

Model case	Environmental flow	Climate change	Remark
1.2.1 1.2.2 1.2.3	Percentage of inflow: 25% 50% 75%	No	Results to be compared with reference model
1.3.1 1.3.2 1.3.3 1.3.4	Fixed maximized (select one of the three applied scenarios)	HADCM3 Wet Central Dry	Four climate change runs to be compared with model run 1 in one graph
1.4.1 1.4.2 1.4.3	Percentage of inflow (select one of the three applied scenarios)	HADCM3 Wet Central Dry	Four climate change runs to be compared with model run 2 in one graph

The model results are presented in separate graphs showing the variation in reservoir level and the variation of the downstream discharge. The general sheme of the Model 1 is as shown below.

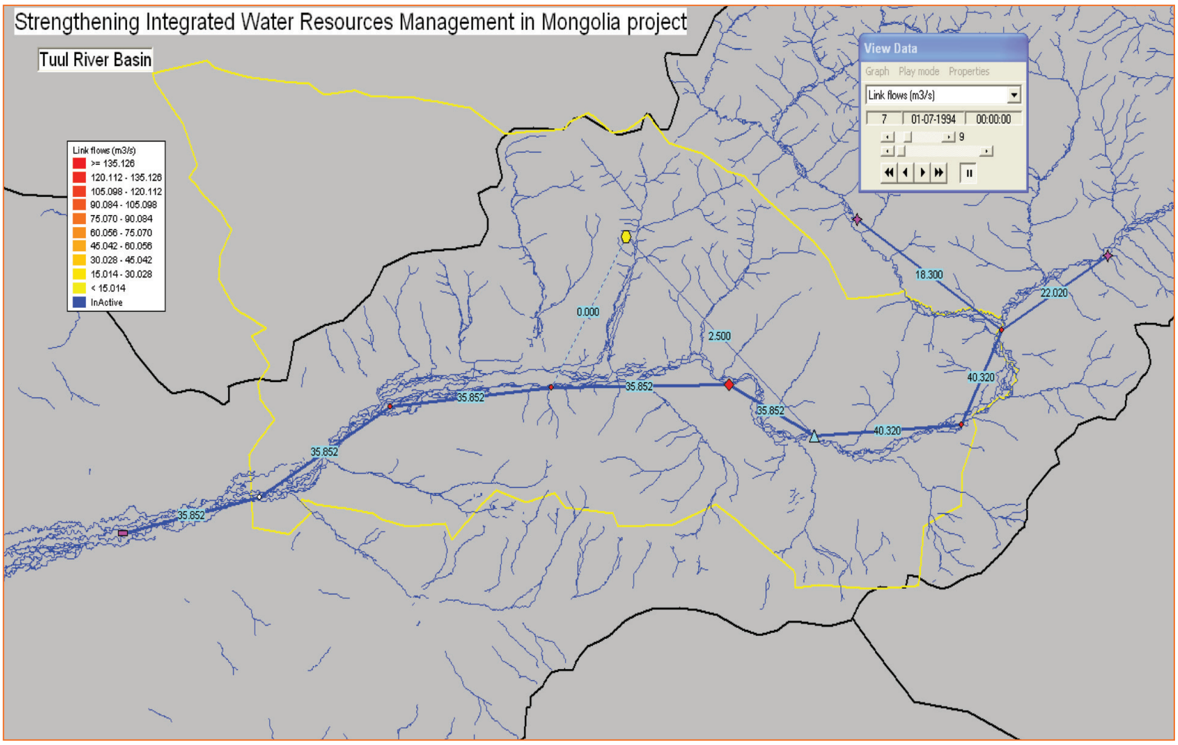


Figure 16. Scheme of the Tuul model 1

Model results

The model results are presented in separate graphs showing the variation in reservoir level and the variation of the downstream discharge.

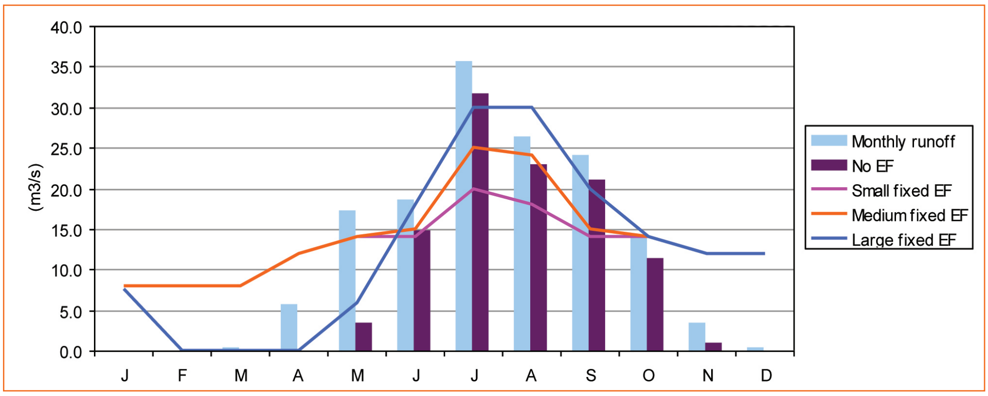


Figure 17. Effect of dam on Tuul monthly median runoff (1996-2008) downstream of the dam for 4 environmental flow (EF) scenarios: (1) no EF, (2) Small fixed EF = 20 m3/s, (3) Medium fixed EF= 25 m3/s, (4) Large fixed EF= 30 m3/s

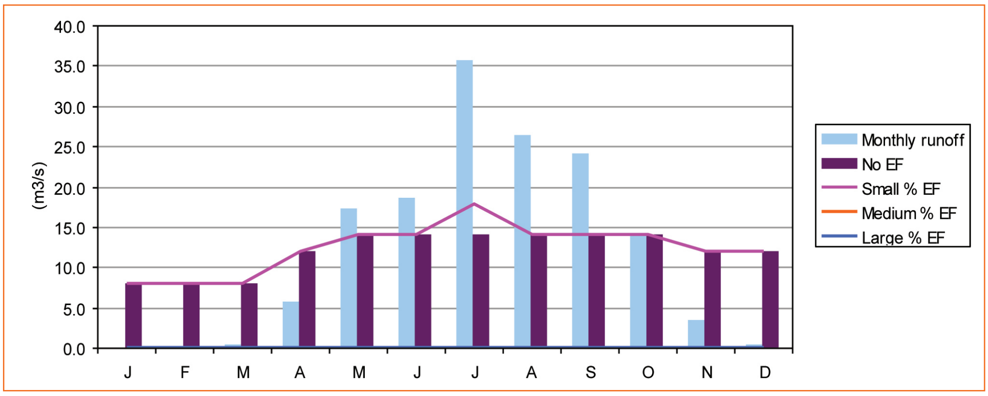


Figure 18. Effect of dam on Tuul monthly median runoff (1996-2008) downstream of the dam for 2 environmental flow (EF) scenarios: (1) no EF, (2) Small % EF = 50% (Medium and Large EF scenarios were not calculated)

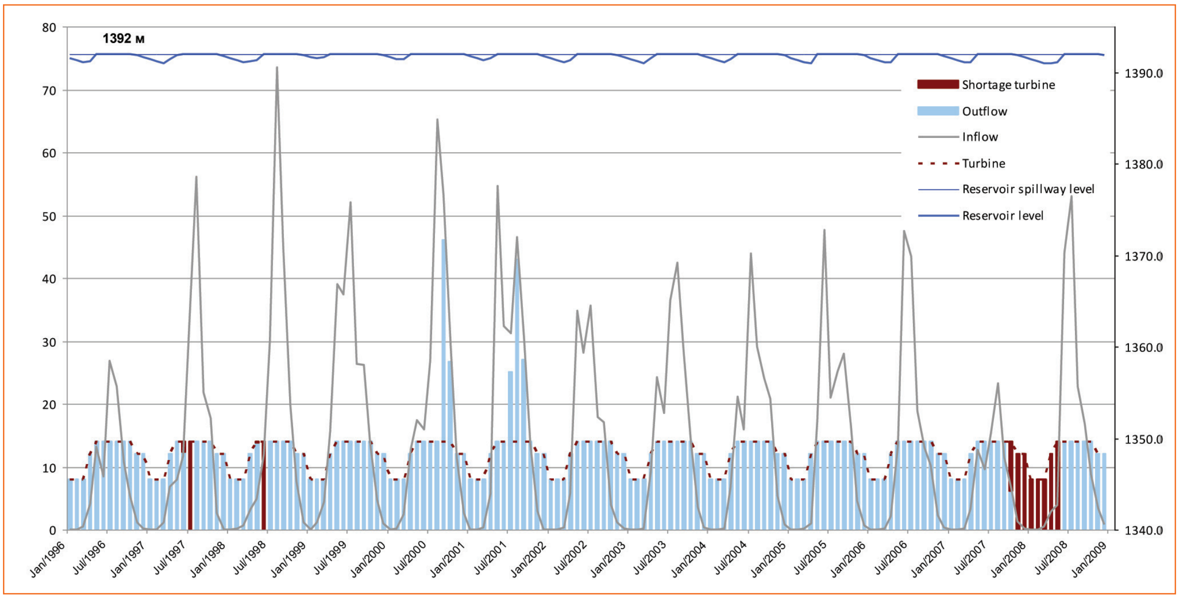


Figure 19. Effect of dam on Tuul monthly runoff downstream of the dam for no environmental flow scenario (1996-2008)

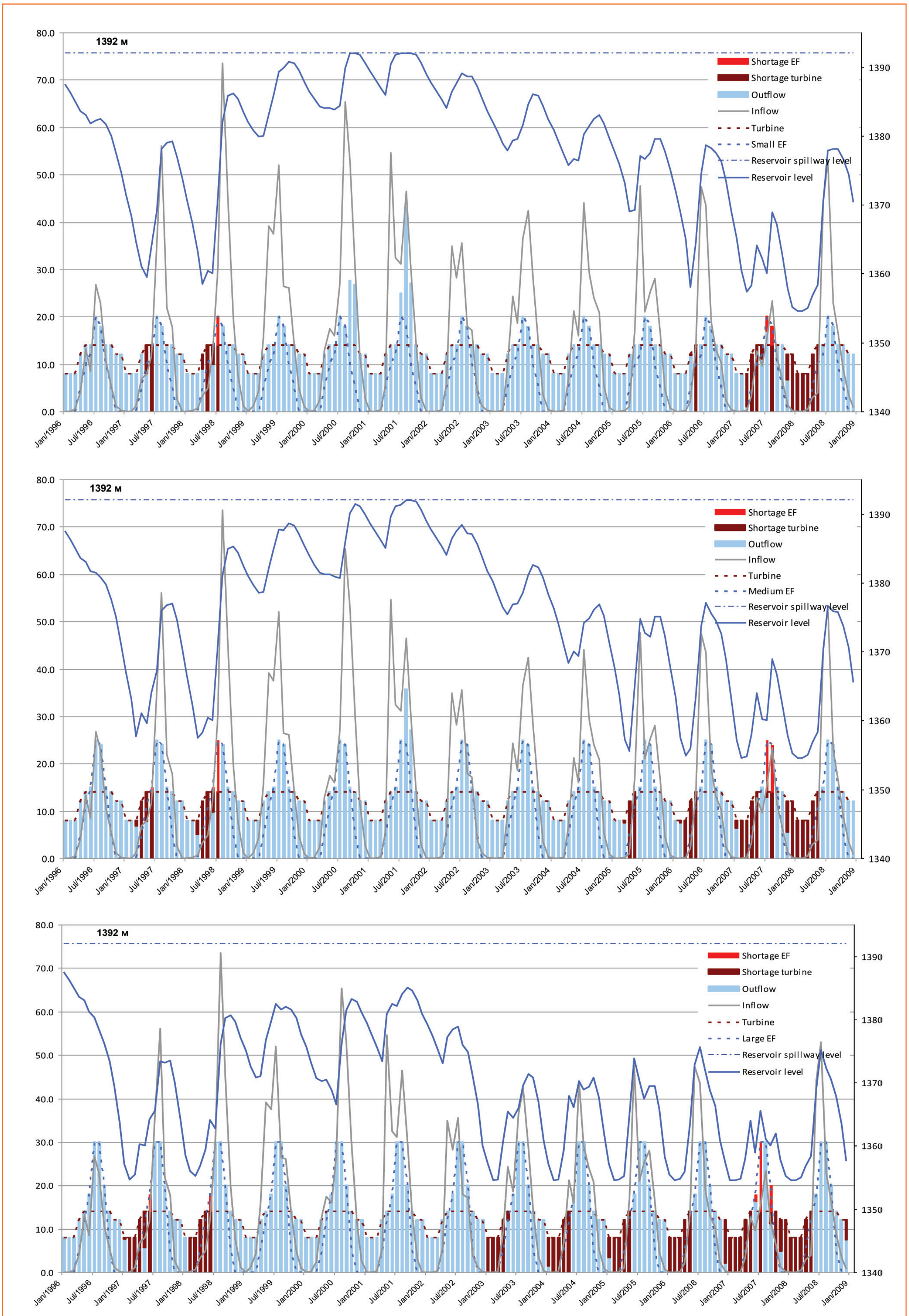


Figure 20. Effect of dam on Tuul monthly runoff downstream of the dam for small, medium and large fixed environmental flow scenario (1996-2008)

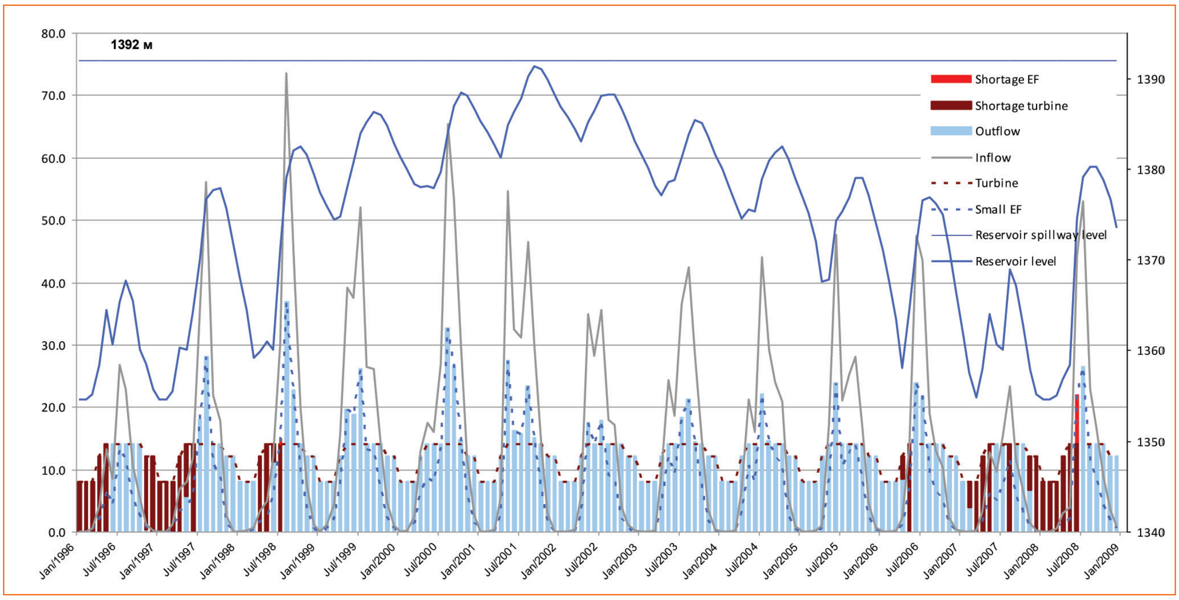


Figure 21. Effect of dam on Tuul monthly runoff downstream of the dam for 50% of inflow environmental flow scenario (1996-2008)

The Figures 17-21 represent the model results including turbine flow and environmental flow. The water released through the turbines can be considered as environmental flow therefore the total environmental includes the turbine flow. The environmental flow is released through the dam bottom gate according the rules set for this flow. The water losses from the reservoir in the model are a constant water supply of 2.5 m^3/s and evaporation of the reservoir water.

Figures 17 and 18 show the effect of the dam on the monthly median runoff of the Tuul River downstream of the dam:

- The scenario with no environmental flow indicates that the downstream median runoff will be reduced by about 2-4 m^3/s in the months June to November. But in the months April and May the downstream runoff is strongly reduced with no flow in April and a small flow in May. These months are needed to refill the reservoir to compensate the water lost during the winter months.
- The scenarios with a small environmental flow indicate that the downstream median runoff will vary between 8 and 25 m^3/s. The downstream runoff will continue in all months as water is released in winter through the turbines.
- The scenario with a large fixed environmental flow indicates that the downstream median runoff will be more or less maintained in the summer months. In the winter months February-April no water will be released due to low reservoir levels.
- The scenario with a small 50% environmental flow indicates that the downstream runoff will vary between 8 and 18 m^3/s.

In general it can be concluded that only large environmental flow measures will maintain the natural flow volumes downstream of the dam in summer and autumn. But the downstream runoff in the spring months may be maintained only when using small to medium environmental flow to conserve sufficient reservoir storage during the winter.

Figures 19-20 show the effect of the dam on the monthly runoff for the years 1996-2008:

- The scenario with no environmental flow (Figure 19) indicates that the downstream runoff will be continuous and will depend on the water released through the turbines. Maximum flows will disappear in most years. However the duration curve shows a considerable change in downstream runoff: the number of months without flow increases from 15% to 45% of the months, the 50% flow decreases from 7.5 to1.5 m^3/s and the 90% flow decrease from 38 to 33 m^3/s.
- The reservoir is full or almost full most of the time
- The scenario with a small environmental flow shows shortages to run the turbines in several years indicating that even the used reduced turbine discharge cannot be maintained always. The required small environmental flow can be maintained in most years, shortages occur only in two years out of 13. Maximum flows in the summer months will be reduced considerably.
- The duration curve shows as change in the downstream runoff: the number of months without flow increases from 15% to 35% of the months for the fixed environmental flow, the 50% flow decreases from 7.5 to 4-5 m^3/s and the 90% flow decrease from 38 to 30 m^3/s.
- The reservoir is rarely full and the reservoir level declines gradually from 2002 to 2008.
- The scenario with medium environmental flow shows more shortages and indicates more problems to maintain the turbine discharge.
- The scenario with a large environmental flow shows shortages in most years indicating that a 95% environmental flow cannot be maintained if the dam is to be used for power generation. Maximum flows in the summer months will be reduced but do reach the required 30 m^3/s in all years.

In general it can be concluded that power generation through turbine flow and large environmental flow requirements cannot be maintained together. In case the dam is to be used for power generation than only small to medium environmental flow requirements can be achieved. The dam will cause a big reduction in peak flows during the summer months whatever environmental flow or power generation scenario is maintained.

1.4. Tuul Basin: Model 2

Tuul model 2 includes the simulation of the Tuul River surface water system only. The model includes the inflow from gauged tributaries like Uliastai and Selbe.

The objective of the model is:

1. Analysis of the observed river runoff
2. Analysis of unobserved inflow into the river
3. Analysis of changes in river runoff along the Tuul River
4. Analysis of the water losses along the Tuul River

The model consists of:

1. Variable inflow nodes (at all upstream gauging stations)
2. Recording nodes (at all gauging stations in the downstream part of the Tuul river)
3. Terminal node (at downstream end of Tuul River)

Water supply nodes representing water use are not included.

Also the future reservoir is not included.

The simulation period is 1994-2008.

Preparation carried out for this model:

1. Completion of runoff records of all stations: filling gaps, correction of errors
2. Conversion of runoff records to monthly values

There are 7 active gauging stations on the Tuul River and it's tributaries. There is no gauging station at the downstream end of the Tuul River. The most downstream station is at Lun. The Terminal Node is located at the confluence with the Orkhon River. The mining activities at Zaamar are inside the model. The next downstream station is at Orkhon on the Orkhon River.

River gauging stations (Variable Inflow Node, Recording Node, Terminal Node):

- Variable Inflow Node:

  Upstream: Terelj River (Terelj, since 1969)
  Tuul River (Bosgo, since 1985)
  Tributaries: Uliastai (Uliastai, since 1993)
  Selbe (Sanzai, since 1984)

- Recording Nodes: Ulaanbaatar (since 1975)
  Altanbulag (since 1997)
  Lun (since 1997)
- Terminal Node: Confluence with Orkhon River

Model results

From hydrological analysis it is expected that the Tuul River is gaining water in the upper part and losing water in the lower part. The transition from gaining to losing water takes place in the area downstream of Altanbulag where the river valley widens. In the river reach downstream of Zaamar the river may be gaining water again due to the narrowing of the river valley.

Ungauged small tributaries exist in the upper part of the basin and in the lower part of the Tuul River contributing varying but unknown volumes of inflow. This inflow is generally small. The runoff is estimated from the comparison of the observed and the simulated runoff.

The difference between simulated and observed flow is equal to the estimated water loss minus the unknown inflow. Comparison of the estimated infiltration at the well fields with the calculated difference between simulated and observed flow should indicate whether this difference does represent the water loss. This comparison is best done by calculating the average difference for the simulated period excluding years with a large unknown inflow.

Expected changes in runoff caused by inflow or water loss:

- Water loss due to abstraction of groundwater at the Upper Well Field; abstraction here is on average 43,000 m^3/day or about 0.5 m^3/s; water loss by infiltration of river runoff is expected to be 0.5 m^3/s or less;

- Inflow of water from small tributaries between Nalaikh and Bayanzurkh; quantity unknown;
  - Water loss upstream of Ulaanbaatar gauging station due to abstraction of groundwater at the Central Well Field; abstraction is on average 98,000 m^3/day

or about 1.1 m³/s; water loss by infiltration of river runoff is expected to be 1.0 m³/s or less;

- Water loss downstream of Ulaanbaatar gauging station until Altanbulag gauging station due to abstraction of groundwater at the Industrial and Meat Complex Well Fields, by private wells and by the Power Station 3 and 4 well fields; abstraction is estimated on average 50,000 m³/day at the Industrial and Meat Complex Well Fields (including private wells), and 55,000 m³/day at the Power Station 3 and 4 well fields; in total about 1.2 m³/s; water loss by infiltration of river runoff is expected to be 1.0 m³/s or less;
- Water loss downstream of Altanbulag gauging station until Lun gauging station due to abstraction of groundwater is not expected because groundwater use is minimal; however the river runoff is expected to decrease due to water loss by natural infiltration;
- Inflow of water from small tributaries downstream of Ulaanbaatar is not expected and probably restricted to large rainfall events; quantity unknown;
- Water loss downstream of Lun gauging station due to abstraction of groundwater is not expected because groundwater use is minimal; the river runoff is expected to decrease due to water loss by natural infiltration until Zaamar but further downstream water losses are not expected because the river valley becomes narrow again as the river flows through a hilly zone; the river runoff is not expected to change much due to the mining activities at Zaamar.

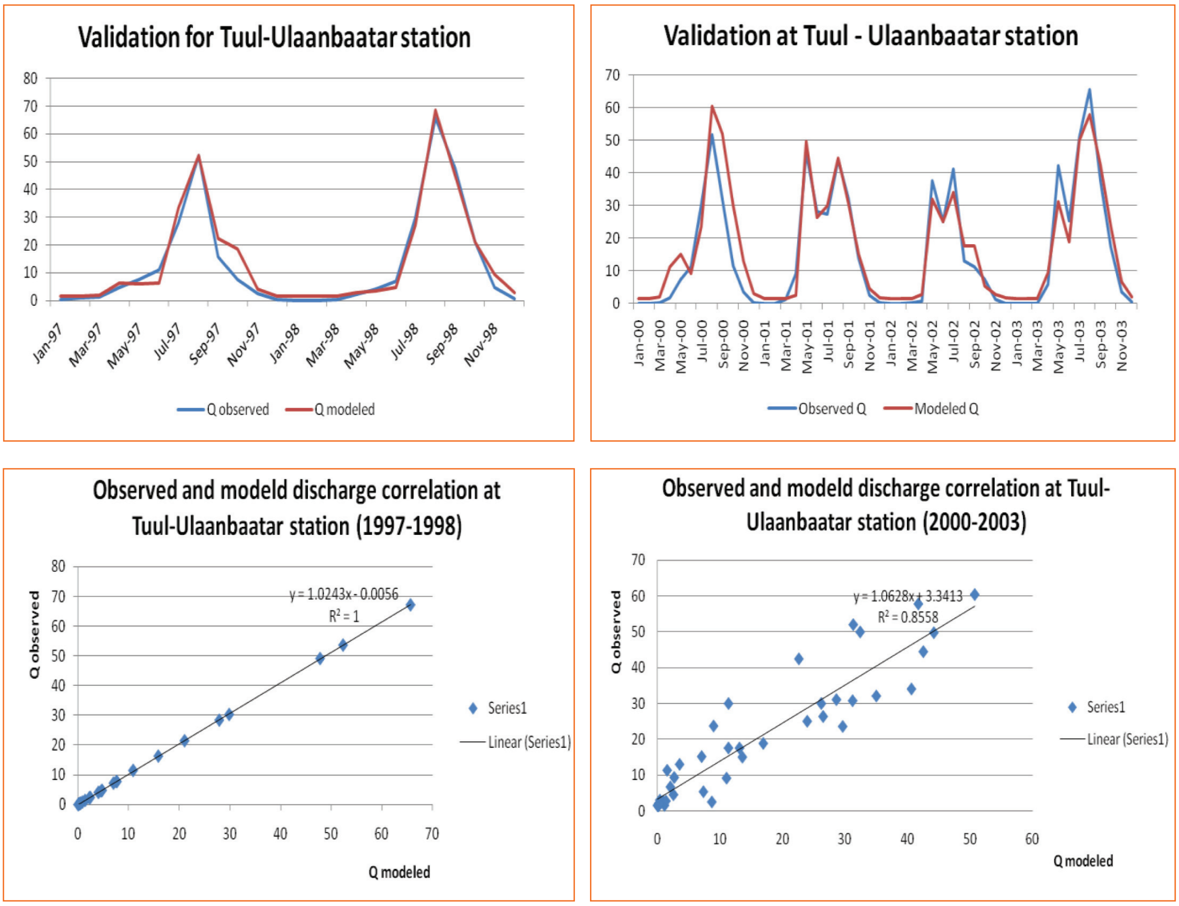


Figure 22. Observed and simulated runoff Tuul basin

1.5. Tuul Basin: Model 3

Tuul model 3 includes the complete water balance of the surface water in the Tuul Basin. It is a simple model including surface water runoff and infiltration of surface water as a result of groundwater use. Along the Tuul River water use is mainly from groundwater sources. No attempt is made to model the groundwater reservoir because it is difficult in RIBASIM to model realistically the exchange of water between the surface water and the groundwater.

The water use as abstraction of groundwater is therefore modeled as water loss from the surface water (see below for explanation).

The objective of the model is:

1. Analysis of the Tuul Basin water balance
2. Analysis of the effect of environmental flow and climate change scenarios
3. Analysis of effect of current and future water use on the water resources

The simulation period is 1994-2008 (14 years). This is a low flow period compared with the years proceeding this period. It includes only one wet year (1994).

The model consists of:

1. Variable inflow nodes (at all upstream gauging stations Terelj, Tuul-Bosgo, Uliastai and Selbe)
2. Recording nodes (at all gauging stations in the downstream part of the Tuul: Ulaanbaatar, Altanbulag, Lun)
3. Loss flow nodes representing groundwater abstraction in well fields; these abstractions are related to water use in Ulaanbaatar and soum centres, industrial water use and mining water use
4. Terminal node (at downstream end of Tuul River)

A model version including the proposed Tuul Dam is also prepared. This model has three additional nodes:

1. Low flow node (representing environmental flow)
2. Surface water reservoir (future water reservoir)
3. Public water supply node (representing supply from reservoir)

The water loss or infiltration modelled in RIBASIM is less then the annual groundwater use volume because recharge to the groundwater is from three sources: (1) infiltration of surface water from Tuul river, (2) infiltration of rainfall, (3) groundwater inflow from adjacent areas. Only the infiltration of surface water from the Tuul River is included in the RIBASIM model.

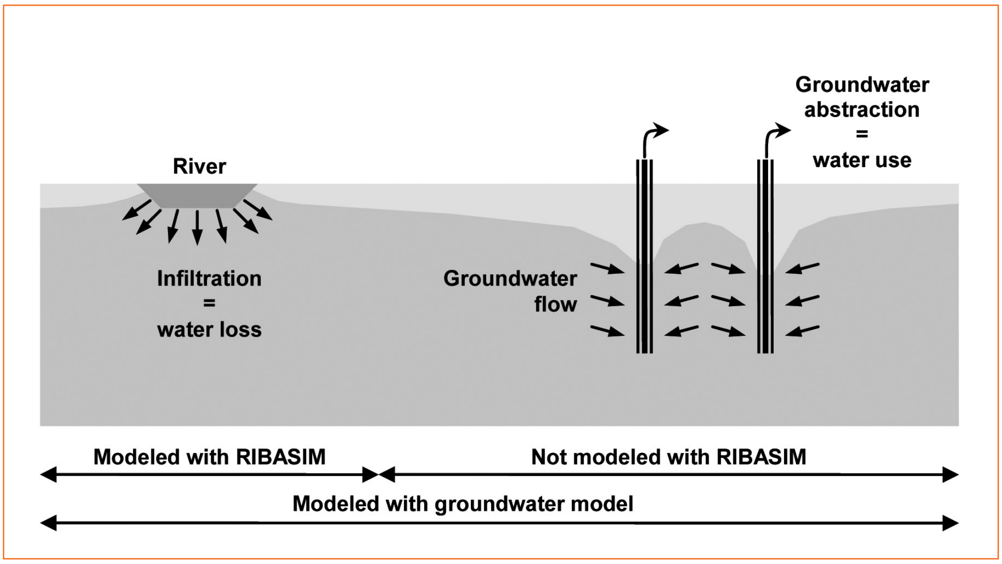


Figure 23. Modelling groundwater abstraction in RIBASIM

The infiltration at the well fields determined with the groundwater model is shown below. The upper well field and the wells of Power station 4 are outside the groundwater model area. The total infiltration at Ulaanbaatar is 86.5% of the total groundwater abstracted.

Table 15. Groundwater abstractions (m^3/day)

Zone	Abstraction	Well field
Zone 1	-	-
Zone 2	28,350	Central well field east
Zone 3	70,308	Central well field west
Zone 4	50,431	Industrial and Meat well field, private wells
Zone 5	29,286	Power station 3 well field
Total	178,375	

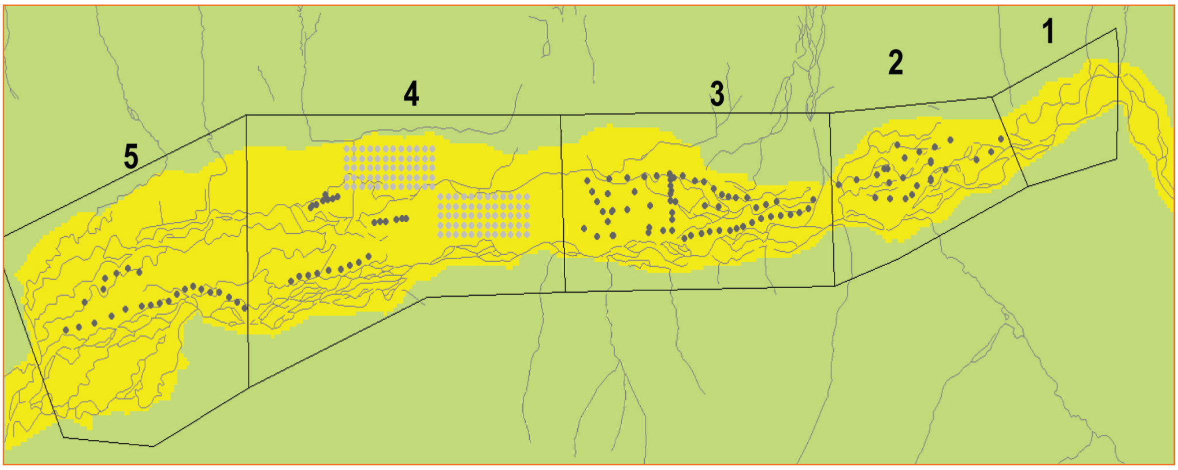


Figure 24. Groundwater abstraction zones

Table 16. Surface water infiltration (m^3/day)

	Central well field	Meat and industrial well field	PP3 well field
JAN	0	0	0
FEB	0	0	0
MAR	0	0	0
APR	291,943	190,737	13,527
MAY	136,807	112,078	5,381
JUN	112,002	94,822	2,871
JUL	103,213	86,322	1,837
AUG	99,022	81,510	1,223
SEP	96,759	78,561	724
OCT	95,428	76,419	358
NOV	94,562	74,847	0
DEC	0	0	0

The recharge to the groundwater reflects the seasonality of the river flow and the subsequent infiltration. There is no infiltration in the winter months. Infiltration starts in April and is highest in the first months. In the summer and autumn the infiltration reduces as the groundwater reservoir becomes recharged. The annual variation of the groundwater storage derived from the groundwater model is shown below:

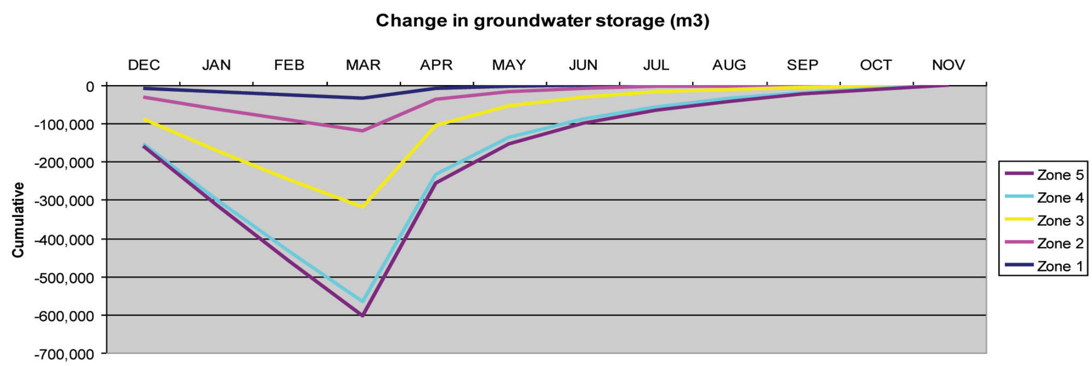


Figure 25. Groundwater storage variation derived from groundwater model

Model results

The model results are presented in graphs showing that the difference between simulated and observed flow is 1.38 m^3/s and that the average water use is 0.99 m^3/s (Figure 26). But the flow difference at Tuul –Altanbulag station is 5.53 m^3/s which can be caused by measurement unreliability or additional unknown water uses. Therefore a separate analysis of the recorded runoff of Tuul River stations was done (see Annex 6).

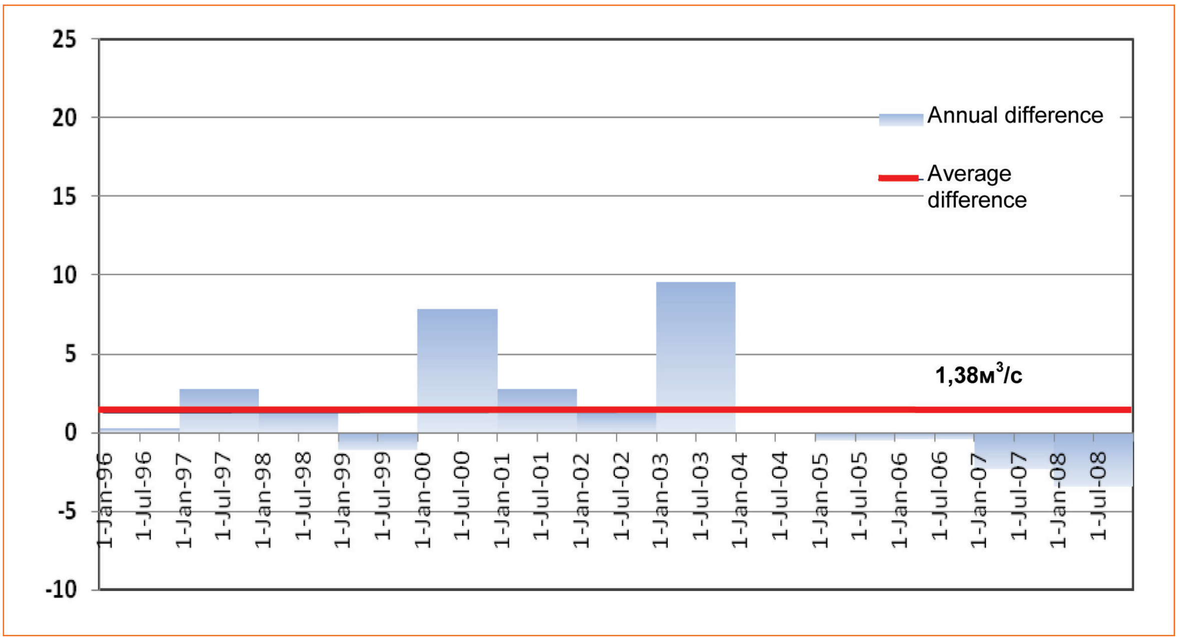


Figure 26. Difference between measured and calculated flows averaged by year at Ulaanbaatar (1996-2008) in cub m/sec

Generally it can be concluded that there is not much effect to the regime of Tuul River. However if look into the seasonal distribution of the flow it can be observed shortage of water resources for water use, especially in spring time.

Conclusions for RIBASIM

- From Tuul Model 1, in general it can be concluded that power generation through turbine flow and large environmental flow requirements cannot be maintained together. In case the dam is to be used for power generation than only small to medium environmental flow requirements can be achieved. The dam will cause a big reduction in peak flows during the summer months whatever environmental flow or power generation scenario is maintained.
- From Tuul Model 2, can conclude that changes in runoff along the river may be caused by inflow of groundwater (drainage) to the river and inflow from rainstorms not observed at the inflow nodes. Both inflows are unknown. In some years with a high unknown inflow the water loss may not be determined accurately.
- Generally can be concluded that there is not much effect from water use to the regime of Tuul River however if look into the seasonal distribution of the flow it can be observed shortage of water resources for water use in certain period, specially in spring time. It caused by the shortage of ground water which is part of Tuul River water resources.

ANNEX 2. Surface water sources and it's changes

The Tuul River basin is located in the central part of Mongolia and contributes its water to the Arctic Ocean Basin. Tuul River is formed by the confluence of two streams named Nomin and Nergui at the south-western slope of the Khentei Mountain and flows to west and northwest direction. Tuul River is 819 km long, with a catchments area of 49774.4 km^2. It drains into the Orkhon River which is the main tributary of the Selenge River.

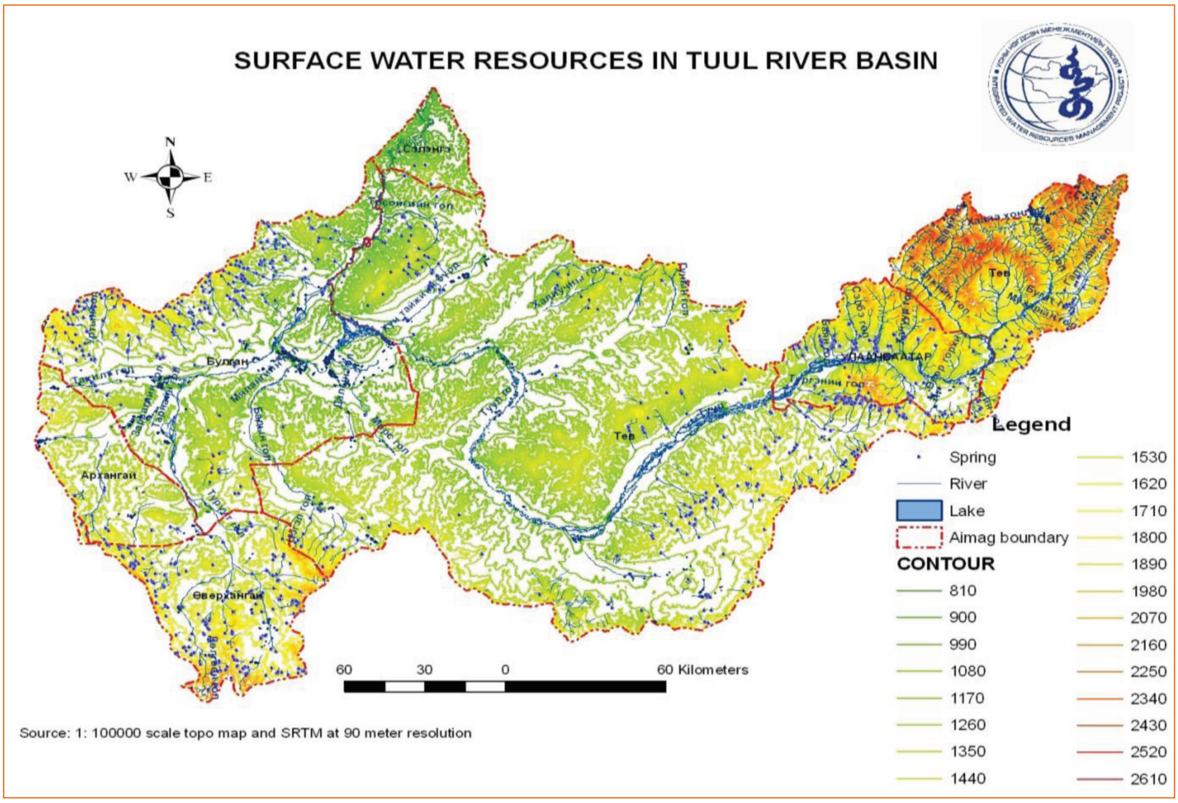


Figure 27. Tuul River Basin Map

As shown in Figure 27, the majority of Tuul River water is drained by the main tributaries like Khiidiin, Khag, Galttai, Baruun Bayan, Terelj and Kharbukh Rivers and totally 19 rills (with the length less than 2.5 km) and 72 small rivers and 6 major rivers mentioned above drainage their water into Tuul River. Khiidiin River originates from Khiidiin Davaanii and Khiidiin Suman Rivers and flows to south from their headwaters and joins to Tuul River from the west site. Khiidiin, Khag, Baruun Bayan, Terelj Rivers enter from west Galttain, Kharbukh Rivers enter to Tuul River from east respectively.

Beside the Tuul River there are many surface water sources such as small rivers, lakes and springs which play important role in water supply of local livelihood. Not much information available about these waters.

The field investigation was carried out in conjunction with water inventory work to identify changes of water sources. As one of the field trip purpose was the assessment of natural surface water resources and identifying the priority problems related to these surface water bodies within Tuul River basin we had conducted investigation of surface water condition within each soum and summaries it in the graph (Figure 28).

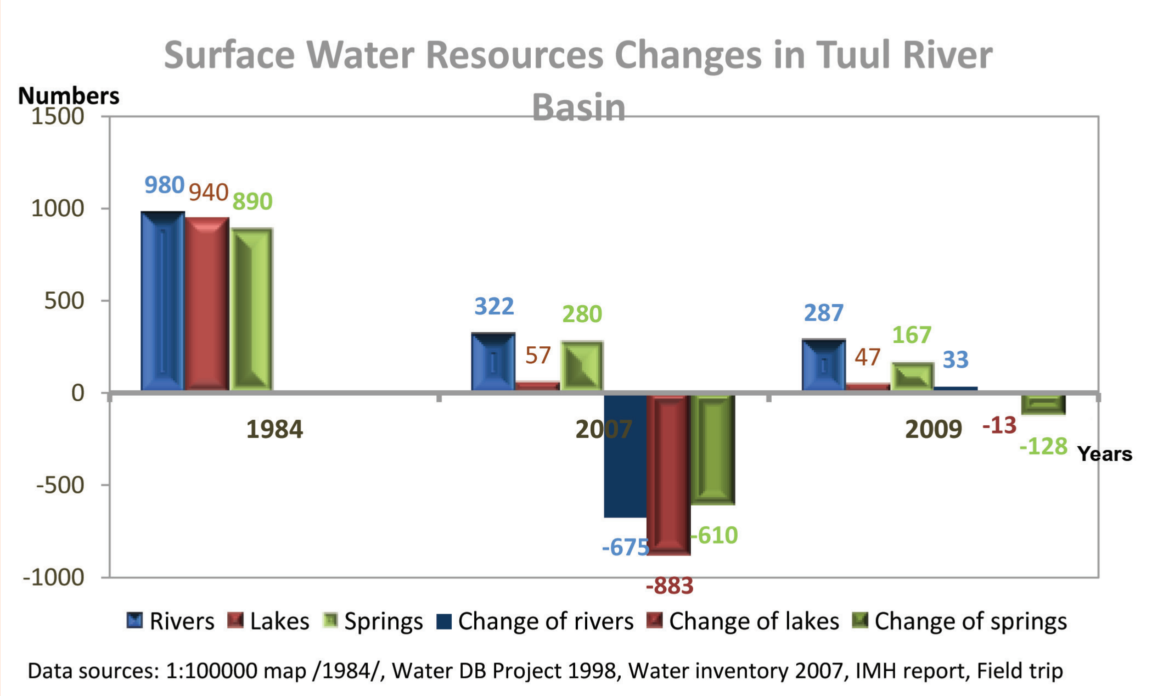


Figure 28. Surface Water Source Assessment in Tuul River Basin

The example of surface water source change in Zaamar soum of Tuv aimag is shown the Figure 29. The 99.9% of this soum area belongs to Tuul River basin (Khishigsuren P, 2009). As Soum Governor stated only the Tuul River flows continuously in soum territory, most of the small rivers, lakes and springs had dried up last few years. By 1984 map information this soum had more than 40 springs and around 30 small and medium size lakes. And by 2007 water inventory data had 15 rivers 4 lakes and 29 springs and 5 mineral waters.

Nowadays they have very few source of surface water and have faced the water supply shortage.

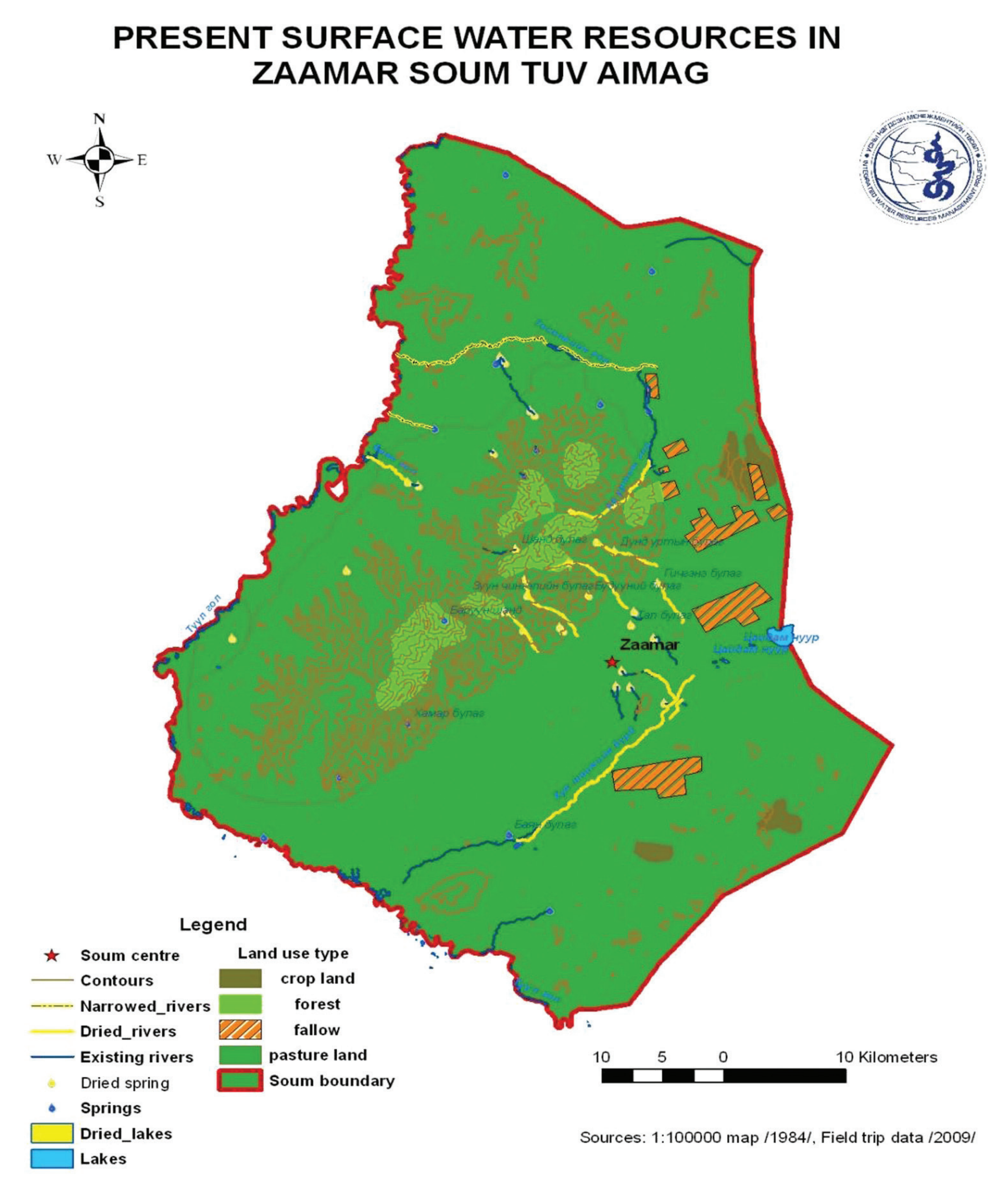


Figure 29. Surface Water Condition in Zaamar soum, Tuv aimag

If compared to 1984 (1:100000) map information, lakes number was decreased nearly by 900 till present, but number of lakes with the surface area >0.1sq km that time was 44. This map was created in 1984 on the general military map of Mongolia from 1942. So it is suppose to be the reliable source of information what we had and it was chosen to be compared. From 890 springs of that time now we have 152 existing springs within the basin which is decreased by more than 700. Even comparing to 2007 water inventory data the number of lakes and springs were dropped down by 23 to 54% this autumn. This shows that natural surface water source decline is occurring continuously within the Tuul River basin.

Table 17. Available surface water sources in soums

Aimag	Soum	Rivers					
		2007	2009	2007	2009	2007	2009
Tuv	Bayanunjuul	-	5	9	3	18	16
	Zaamar	13	3	2	1	14	4
	Lun	-	2	0	2	1	1
	Bayantsogt	9	7	0	1	1	0
	Undurshireet	-	2	0	0	0	1
	Ugtaaltsaidam	2	2	2	2	13	15
	Erdene	152	152	-	0	1	1
	Argalant	-	0	-	0	1	0
	Erdenesant	4	10	-	4	2	10
	Bayankhangai	-	0	-	0	3	1
	Zuunmod	1	1	-	0	0	0
	Altanbulag	1	2	0	1	14	16
Bulgan	Gurvanbulag	8	7	5	5	4	3
	Khishig-Undur	9	13	2	2	47	40
	Buregkhangai	20	11	2	0	42	4
	Mogod	11		8		59	
	Dashinchilen	4	5	9	4	8	2
	Bayannnuur	3	3	3	2	0	1
	Rashaant	20	3	2	1	3	3
Ukh	Burd	6	6	3	3	7	7
Akh	Ugiinuur	7	7	15	15	2	2
	Khashaat	3	3	2	2	0	0
Sel	Orkhon - Tuul	6	5	0	0	7	5
Ulaanbaatar	Khan- uul	10	10	1	1	7	7
	Baga nuur	1	1	0	0	7	7
	Bayanzurkh	18	18	0	0	10	10
	Nalaikh	0	0	0	0	2	2
	Bayangol						
	Sukhbaatar	6	6	0	0	4	4
	Chingeltei	1	1				
	Bayankhangai						
	Songinokhairkhan	7	7	1	1	21	21
Total		322	287	57	47	280	167

- visited

ANNEX 3. Main issues related to surface water in the Tuul basin

The hydrological investigation combines available datasets from mining, tourism, pasture and land use patterns to describe the underlying causes of hydrological condition changes and determine key processes that affect the catchments of the Tuul River basin. Due to the large size of the Tuul River basin the investigation was limited to certain areas not reaching the very edge of basin.

The Tuul River and its water resources play a significant role in social, economic and environmental development of the country. As many research studies shows that Tuul River is the most polluted and affected by anthropogenic activities river in Mongolia.

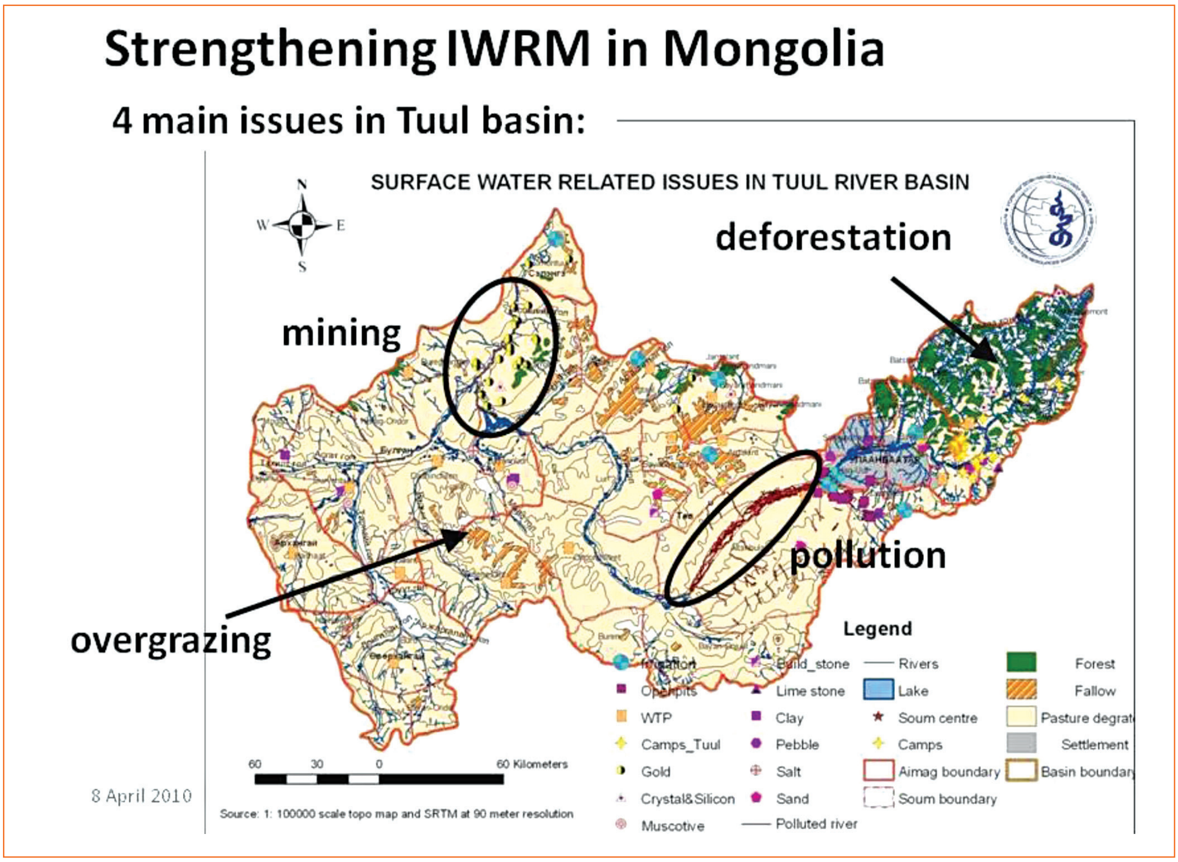


Figure 30. Human induced activities in Tuul River basin

As shown on map the main causes leading to degradation and pollution of the soil and water are as following:

Not proper working WWPT of cities and soum centres

Studies on Tuul River pollution and water quality had conducted by many organizations like Ecological Department of Geo-ecology Institute, Central Environmental Laboratory and Laboratory of State Implementation Agency. As mentioned in their research the main polluters are waste water from central treatment plants. Consequently water becomes curiously polluted, loses its clarity and transparency and its self- purifying distance increases (Ch, Javzan and others, IGE). The water pollution problem needed to be urgently addressed before irreparable damage occurs, affecting the river ecology and human health (Natasha Roza B, IGE, 2005). Main polluters waste water and dry waste of the Ulaanbaatar city, Zuunmod and from other 20 soum centres. None of Waste Water Treatment Plants work properly.

Figure 31. Tuul River condition during the field trip (sludge in channel)

But nowadays the situation is getting worst and Altanbulag Deputy Soum Governor said people are really stressed about the water quality of Tuul River.

Commonly distributed solids wastes in creeks and dry beds

Solid waste is another source of pollution in Tuul River basin. During the flood they wash away with water and add pollution affecting the water quality.

Figure 32. Nalaikh River Embankments

Unmanaged mining activities without restoration work

Mainly the camps does not cause much problems now days, but accumulation of the tourist camps within the certain places could cause the degradation of the soil and lead to water source deterioration. Example in Terelj area there are 18 tourist camps within one valley. It also causes the accumulation of herders around this area.

Overgrazing pasture/ desertification

Number of livestock has increased dramatically till became the overgrazing pasture problem in each soum. Also this is the main cause of surface water source degradation. It's affecting the water where the small rivers and springs feed comes absence of vegetation cover causes decreasing soil moisture generates more direct runoff.

Uncontrolled forest use/forest fire

During the investigation have not been registered much information related to forest farms except 2 companionship in Bureg Khangai soum, Bulgan aimag. But most of the winter fire woods for soum heating are prepared from forest and each soum has a certain planned wood income for soum budget to come from fire wood

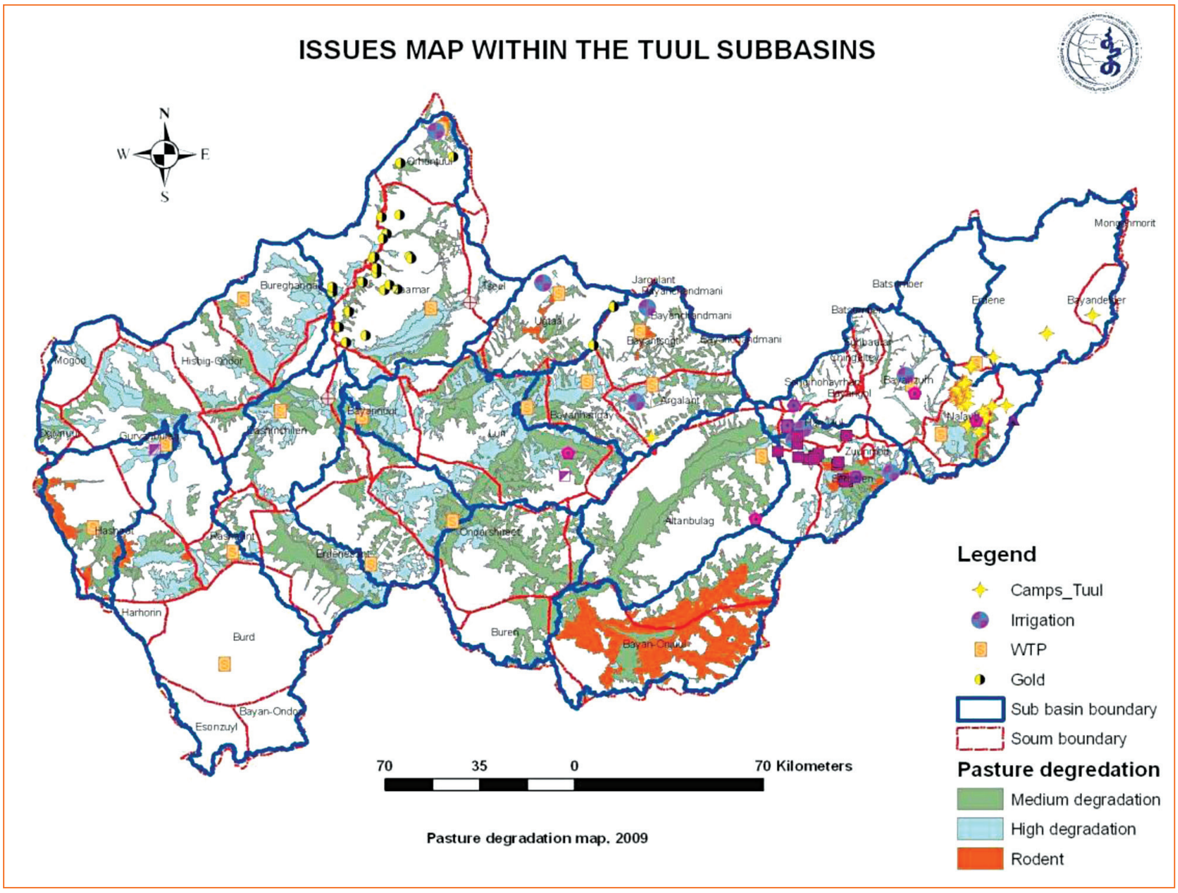


Figure 33. Main issues within the each sub basin of Tuul River

ANNEX 4. Tuul river sub basins

Sub basins were defined within the Tuul River basin using the hydrologic units (watersheds) developed by Terrain pre-processing in Arc Hydro. Sub basins were derived using Terrain processing analysis in Arc Hydro and pictures from each processing steps are shown below.

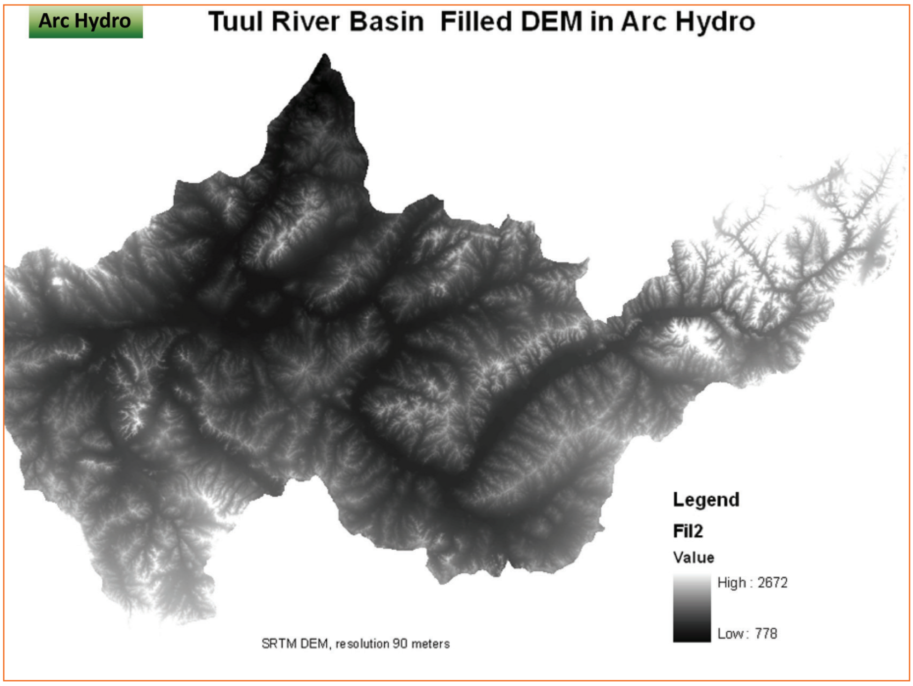


Figure 34. Filled DEM of Tuul River basin

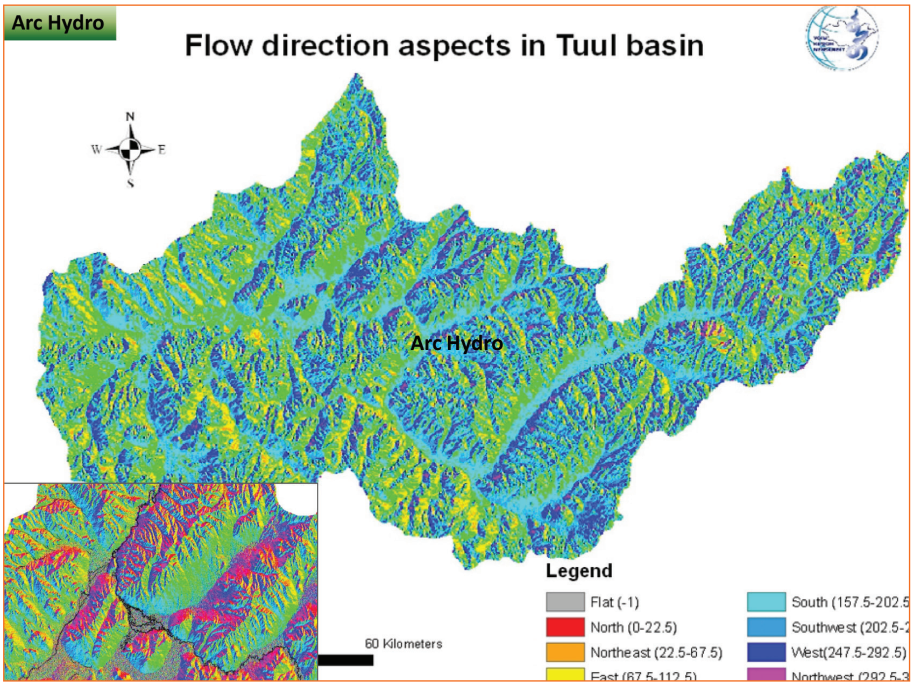


Figure 35. Flow direction in Tuul River basin

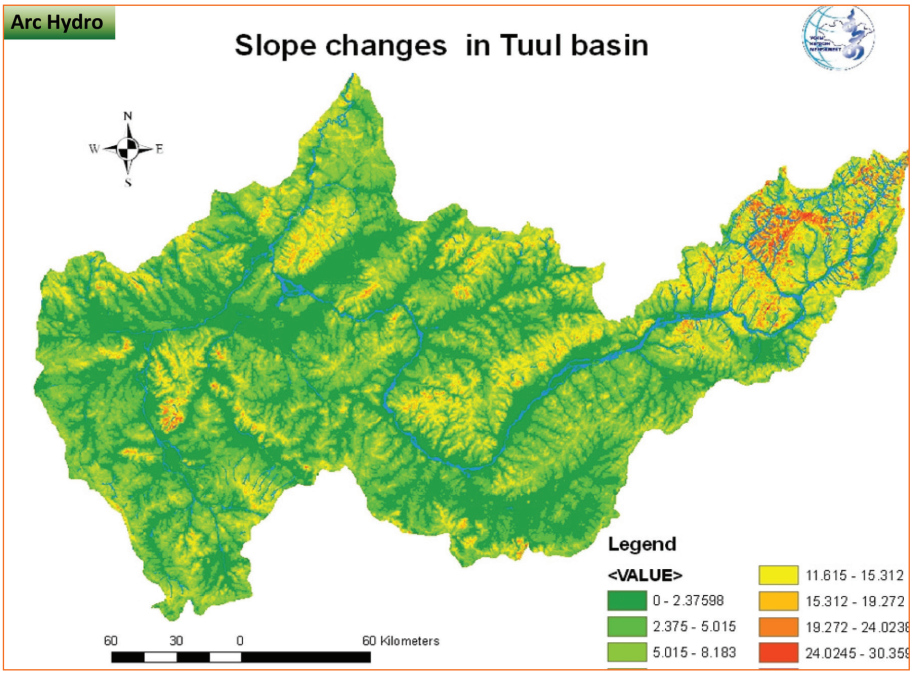


Figure 36. Slope of the terrain in Tuul basin

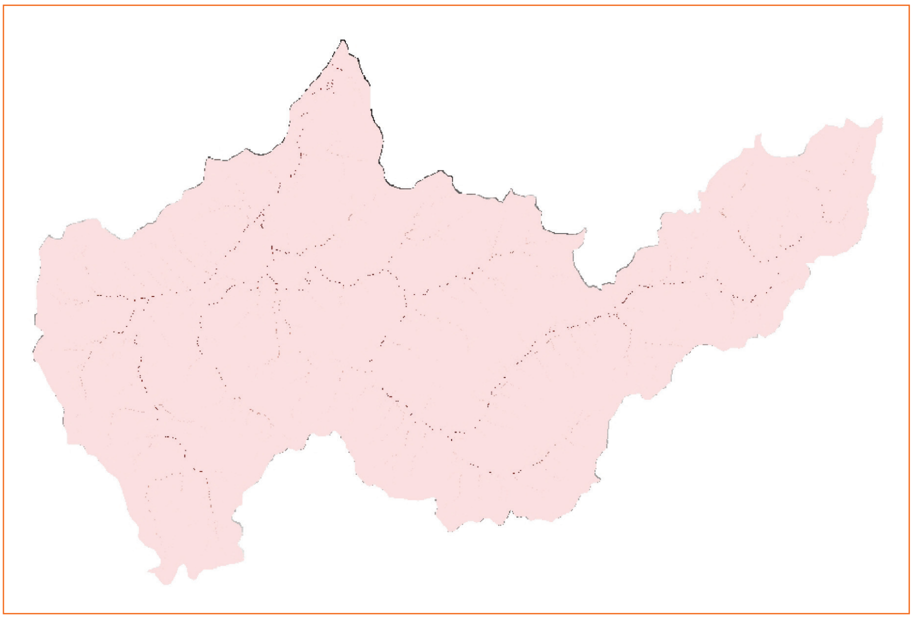


Figure 37. Flow accumulation map

Depending on the accuracy of the used images and data quality sub basins within basin can be defined differently, in our case we delineated 25 and 49 sub basins in Tuul basin.

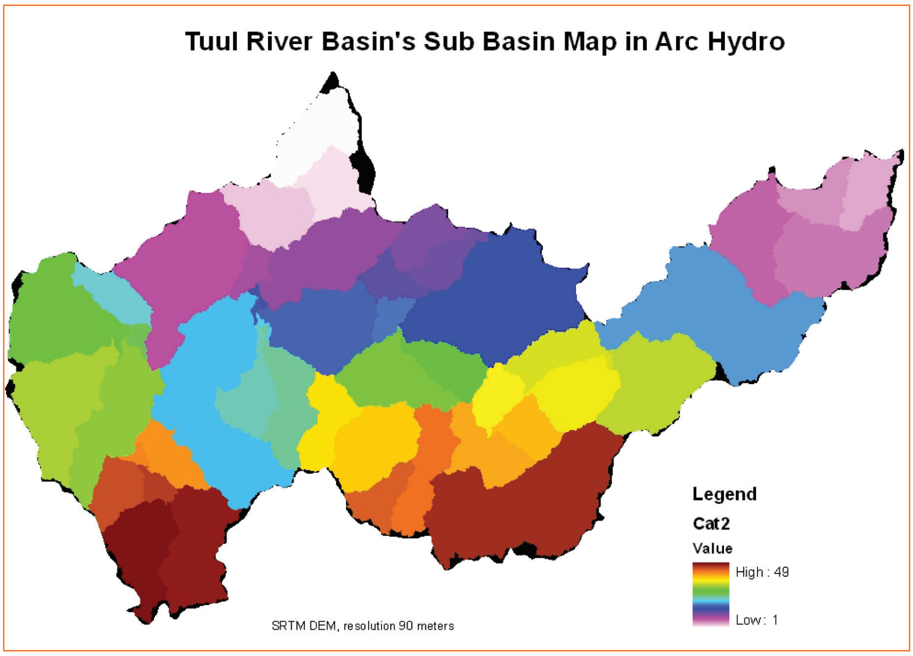


Figure 38. Sub basin delineation in Tuul River Basin

ANNEX 5. Updated morphometric characteristics of Tuul basin

The catchment area of Tuul River were defined by two methods, first is to draw watershed lines manually on 1:100000 scale map with 20 meter of contour lines. Second was method to derive automatically using 90 meter resolution STRM DEM. The determined catchments are shown below and comparing results from methods the catchment area of Tuul River basin was found as 49774.3 sq km.

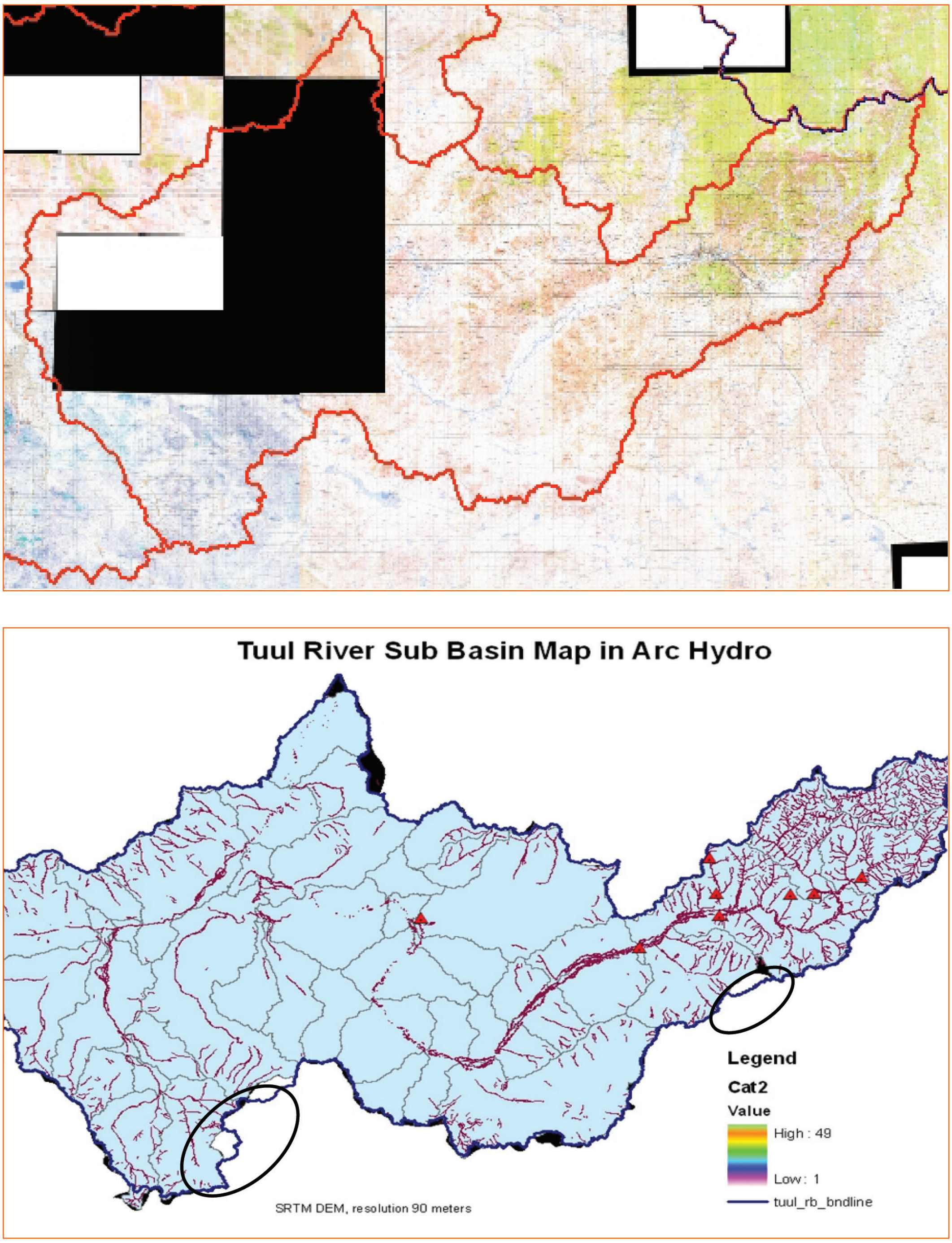
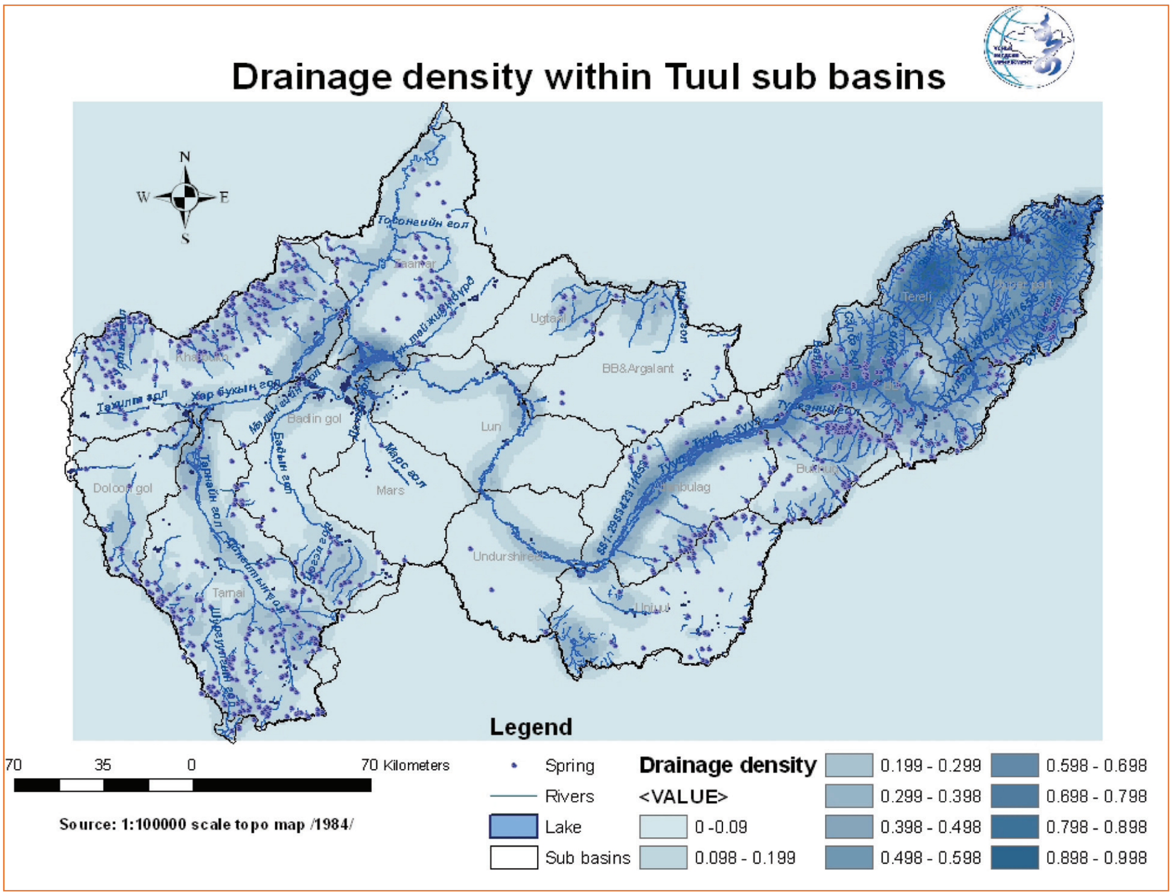


Figure 39. Differences in watershed delineation of Tuul basin a/ 1:100000 map b/ (SRTM 90m)



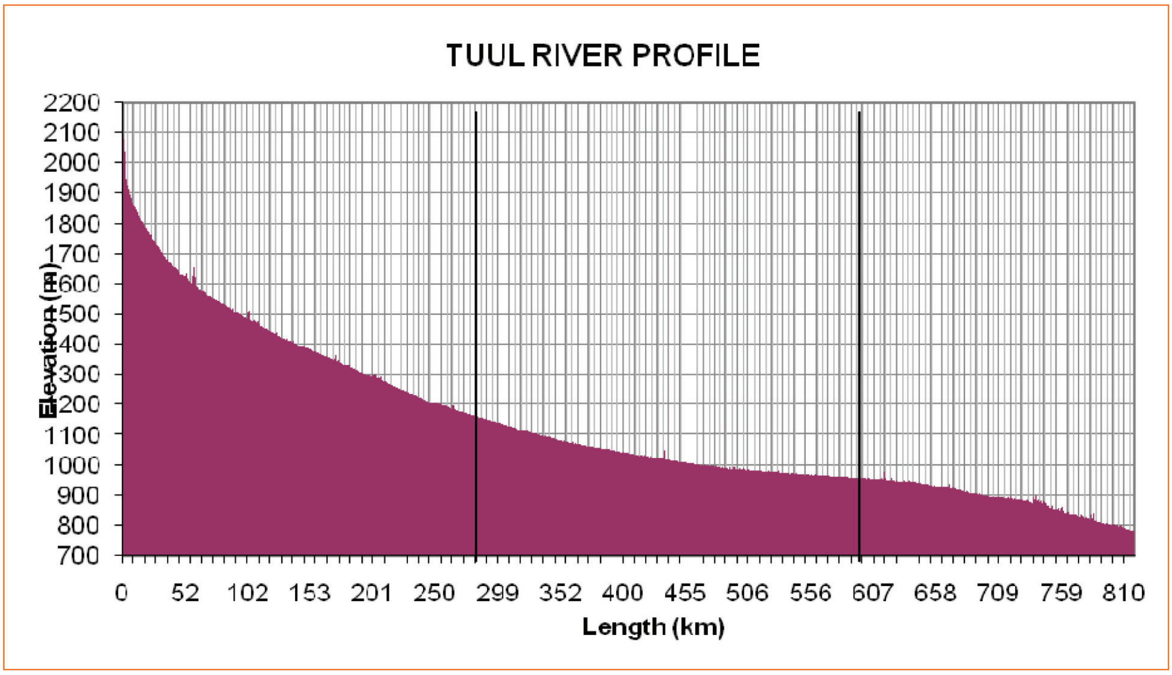


Figure 40. Profile of main channel

In the upper part the Tuul River has a steep long valley and narrow deep channel, slope gradient is high causing the fast flowing turbulent water. Tuul River starts to slow down in the middle part the river and valley become wider and gentle and in many places occur the dispersion of main channel.

Figure 41. Typical valleys in the middle part of Tuul River

Lower part of Tuul River has a flat open wide floodplains and deeper channels. Due to mining activities in this part the river has a more deposits and silk sediments. The main characteristics of the valley and channels are presented in following table.

	Upper part	Middle part	Lower part
Main characteristics	▪ Steep / V-shaped Valley ▪ Narrow / shallow channel ▪ High velocity/fast flowing water	▪ Open, gentle sloping valley with floodplain ▪ Wider / deeper channel, dispersion ▪ More suspended sediment	▪ Flat and wide floodplain ▪ Wide, open valley ▪ Wider / deeper channel ▪ More deposit

ANNEX 6. Tuul runoff analysis

The observed runoff at the gauging stations along the Tuul River is important input into the RIBASIM water allocation model. The reliability of the available runoff records therefore is essential to obtain a good quality model output. An analysis of the runoff records was done to verify and if necessary correct the available runoff records.

The analysis of the runoff records was done for the period 1998-2008. An overview of the annual average runoff is shown in Table 18. The hydrographs of the monthly discharge are included in Figure 46.

Table 18 Average observed runoff (m^3/s) main gauging stations Tuul River (1998-2008)

	Terelj	Bosgo	Uliastai	Selbe	Ulaanbaatar	Altanbulag	Lun
1998	7.16	9.49	0.36	0.08	15.29	-	17.68
1999	7.92	-	0.59	0.07	20.14	-	17.44
2000	6.48	13.27	0.27	0.13	12.22	-	8.72
2001	9.76	8.49	0.69	0.16	16.06	-	12.03
2002	5.45	6.69	0.36	0.10	11.14	5.17	5.68
2003	7.13	7.83	0.61	0.25	13.03	8.48	7.36
2004	7.89	6.18	0.47	0.08	14.51	12.17	6.92
2005	6.27	7.27	0.24	0.11	14.25	8.63	10.28
2006	5.95	6.74	0.32	0.13	13.41	8.45	10.93
2007	2.90	4.15	0.06	0.03	9.36	4.94	6.08
2008	5.40	7.73	0.23	0.06	16.78	6.67	9.25

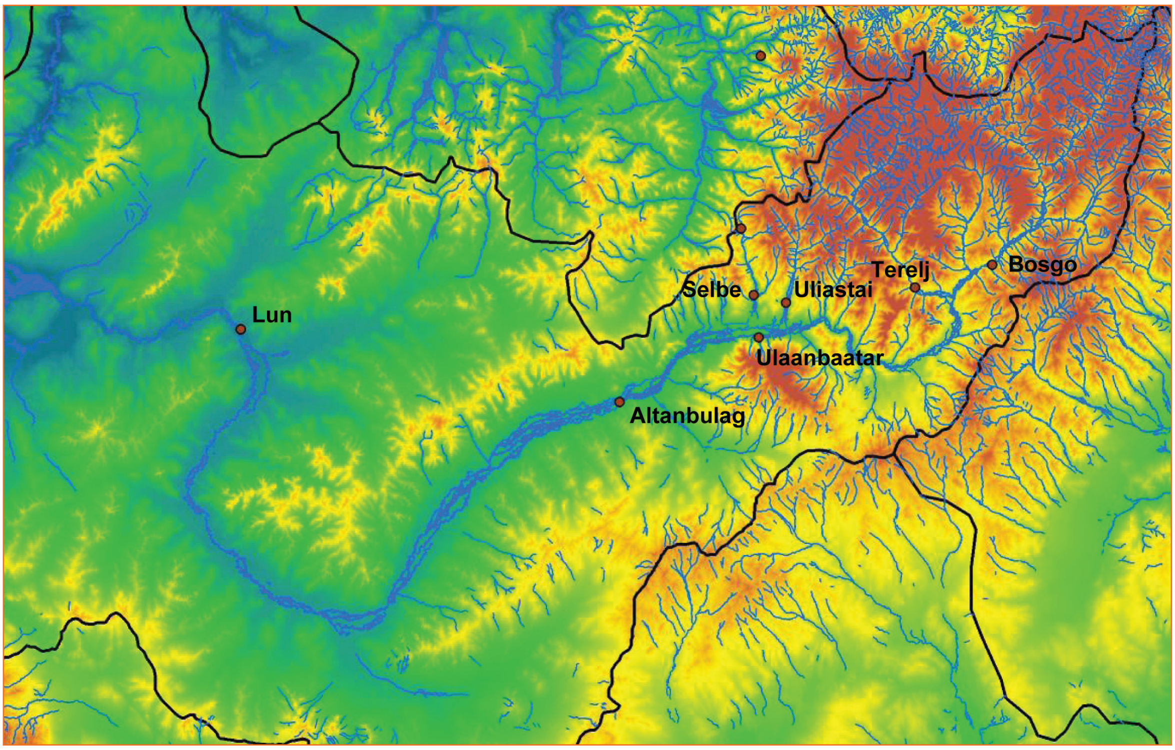


Figure 42. Location of gauging stations along Tuul River

Analysis of runoff data

The runoff at Ulaanbaatar (Zaisan station) is expected to be similar to the total runoff measured at Terelj and Bosgo. The contribution from small tributaries is negligible. The only observed tributary is the Uliastai.

Figure 43 shows the total average annual runoff observed at Terelj and Bosgo. Some remarks may be made:

In 2000 the runoff observed at Bosgo is higher then expected. The relation between the daily runoff values shows a deviation for part of the year (August-November, see *Figure 47*). Apparently too high runoff values were determined at Bosgo for this period.

After 2000 the relation between the three stations is stable.

In 2007 and especially in 2008 the observed runoff at Terelj is lower than expected.

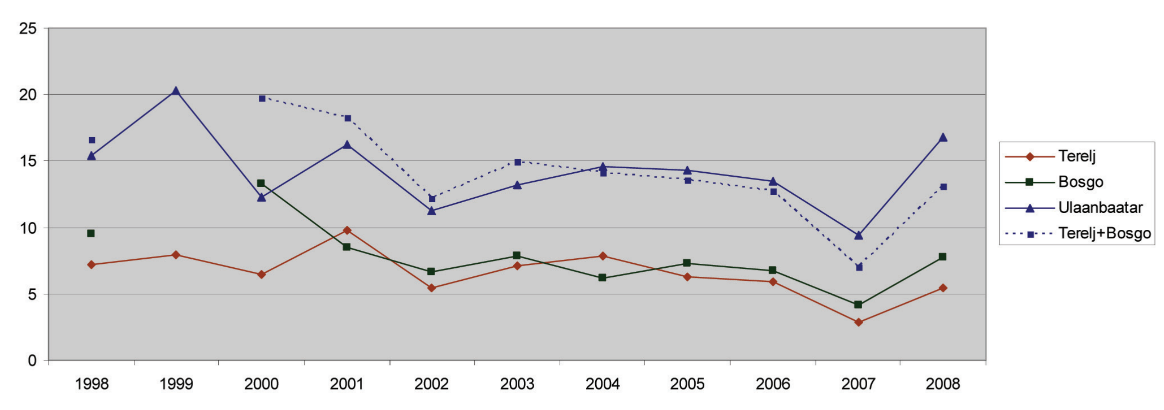


Figure 43. Average annual runoff (m3/s) at Bosgo, Terelj and Ulaanbaatar 1998-2008

The average annual runoff observed at Bosgo and Terelj shows a gradual decrease compared with the runoff at Ulaanbaatar. An explanation is not available.

Considering the more or less stable relation (see *Figure 48*) between the Bosgo and Terelj stations and Ulaanbaatar station it may be concluded that the runoff records from these stations may be used without correction.

The observed runoff at Ulaanbaatar is considered reliable and will be used without correction. However it is known that peak flows are not accurate because these cannot be measured.

The relation between the runoff at Tuul-Altanbulag and Tuul-Lun with the runoff at Ulaanbaatar also shows a variable more or less stable relation since 2002 (see *Figure 49*). However when looking at the annual flows then some doubt exists about this relation (Figure 44).

The runoff at Ulaanbaatar is expected to be similar to the total runoff measured at Altanbulag and Lun. The contribution from small tributaries is negligible. The only observed tributary is the Selbe which enters the Tuul downstream of the Ulaanbaatar gauging station at Zaisan.

Figure 44 shows the total average annual runoff observed at Ulaanbaatar, Altanbulag and Lun. The values shown in this graph should be analysed taking into account the following considerations:

1. The natural process of the Tuul river means it is gaining discharge upstream of Altanbulag and loosing discharge downstream of Altanbulag or Khustai (actually

the location is not known exactly where the transition takes place from gaining to loosing discharge, but it is expected to be in this area as the valley widens here);

2. The groundwater abstraction at Ulaanbaatar causes a loss in discharge upstream of the Ulaanbaatar station and also between the Ulaanbaatar and Altanbulag discharge stations;

3. The water loss between Altanbulag and Lun depends on the magnitude of the runoff: during low flow the water loss (in percentage) is expected to be small or negligible; during high flow water is lost by flooding of dead river arms and other low lying areas; during low flow the river discharge remains in the main river channel and infiltration of river water is expected to be small or not existing. There is no significant groundwater use along the river downstream of Altanbulag.

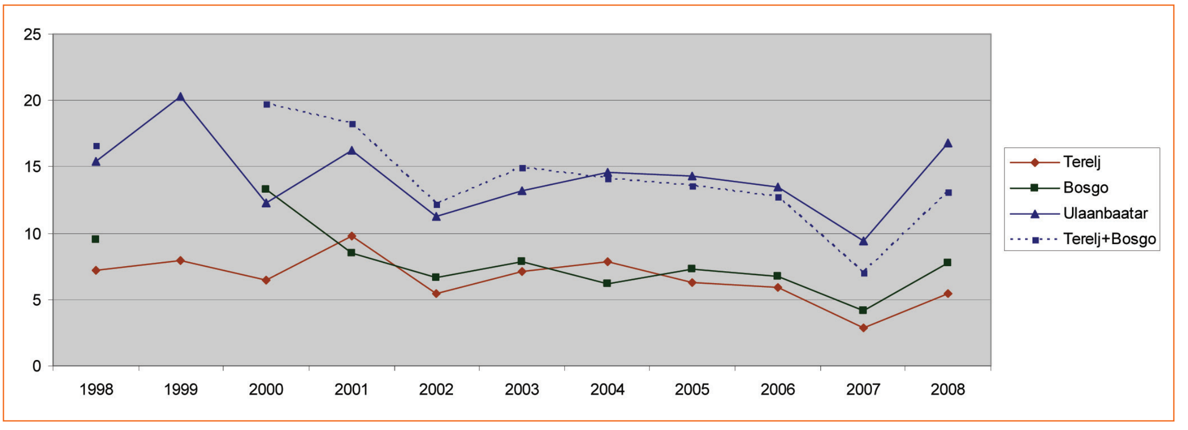


Figure 44. Average annual runoff (m3/s) at Lun, Altanbulag and Ulaanbaatar 1998-2008

Table 19 Percentage of runoff at Altanbulag and Lun (1998-2008)

	Ulaanbaatar	Altanbulag	Lun	% of Ulaanbaatar	
	m^3/s	m^3/s	m^3/s	Altanbulag	Lun
1998	15.29	-	17.68		115.6%
1999	20.14	-	17.44		86.6%
2000	12.22	-	8.72		71.4%
2001	16.06	-	12.03		74.9%
2002	11.14	5.17	5.68	46.4%	51.0%
2003	13.03	8.48	7.36	65.1%	56.5%
2004	14.51	12.17	6.92	83.9%	47.7%
2005	14.25	8.63	10.28	60.6%	72.1%
2006	13.41	8.45	10.93	63.0%	81.5%
2007	9.36	4.94	6.08	52.8%	64.9%
2008	16.78	6.67	9.25	39.8%	55.2%

The observed runoff at Altanbulag and Lun is lower then expected in many years. Considering the low flows during this period the runoff is expected to be between 70-90% of the runoff at Ulaanbaatar.

The hydrographs of the years 1998-2008 at the stations Ulaanbaatar, Altanbulag and Lun are shown in Figure 46. The hydrographs indicate:

- In 1998-2000 the hydrograph at Lun shows an expected pattern with lower peaks and a higher and longer recession
- After 2001 the hydrograph at Lun does not show all peaks and the recession in

some of the years seems too small

- The observations at Altanbulag appear better in the period 2002-2006

Conclusions

Considering the relation of the daily runoff and the comparison of the hydrographs it is possible that the observations at Altanbulag and Lun indicate a too low runoff. A correction is needed to use the runoff records from these stations in the RIBASIM model.

1. The discharge records of Altanbulag are too low:
   - During low flow the discharge at Altanbulag is expected to be somewhat smaller than the flow observed at Zaisan due to water losses by groundwater use: estimated difference 10%
   - During average flow conditions the discharge at Altanbulag is expected to be a little less than the flow observed at Zaisan: estimated difference 10% less
   - During high flow conditions the discharge at Altanbulag is expected to be similar than the flow observed at Zaisan: estimated difference 0%
2. The discharge records of Lun are too low:
   - The hydrograph of 1999 shows the expected relation between Ulaanbaatar and Lun;

The above estimates were used to correct the observed discharges from IMH. The relation between Ulaanbaatar and Lun observed in 1999 was used to calculate the Lun discharge (see Table 20 and Figure 45.

Table 20. Observed and corrected runoff at Ulaanbaatar, Altanbulag and Lun (m3/s)

	Ulaanbaatar observed	Altanbulag observed	Altanbulag calculated	Lun observed	Lun calculated
1998	15.29	-	14.87	17.68	13.24
1999	20.14	-	19.45	17.44	17.71
2000	12.22	-	11.70	8.72	11.18
2001	16.06	-	15.39	12.03	14.34
2002	11.14	5.17	10.57	5.68	10.20
2003	13.03	8.48	12.38	7.36	12.06
2004	14.51	12.17	13.75	6.92	13.42
2005	14.25	8.63	13.50	10.28	13.16
2006	13.41	8.45	12.84	10.93	12.30
2007	9.36	4.94	8.67	6.08	9.10
2008	16.78	6.67	16.34	9.25	15.05

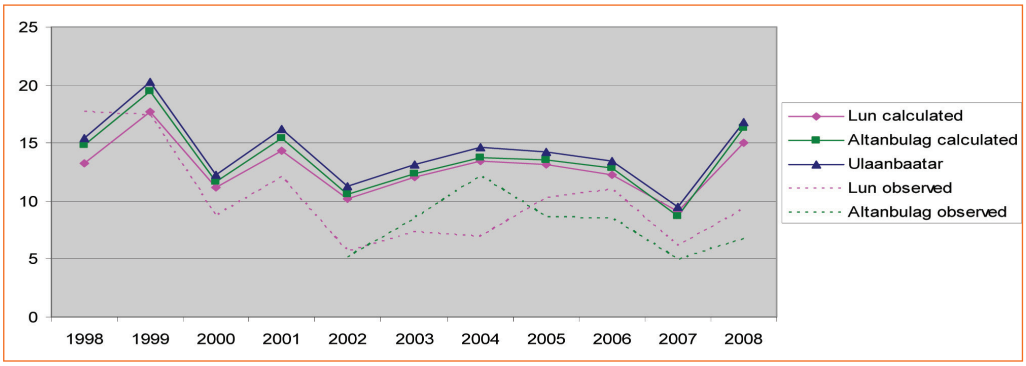


Figure 45. Average annual calculated runoff (m3/s) at Lun, Altanbulag and Ulaanbaatar 1998-2008

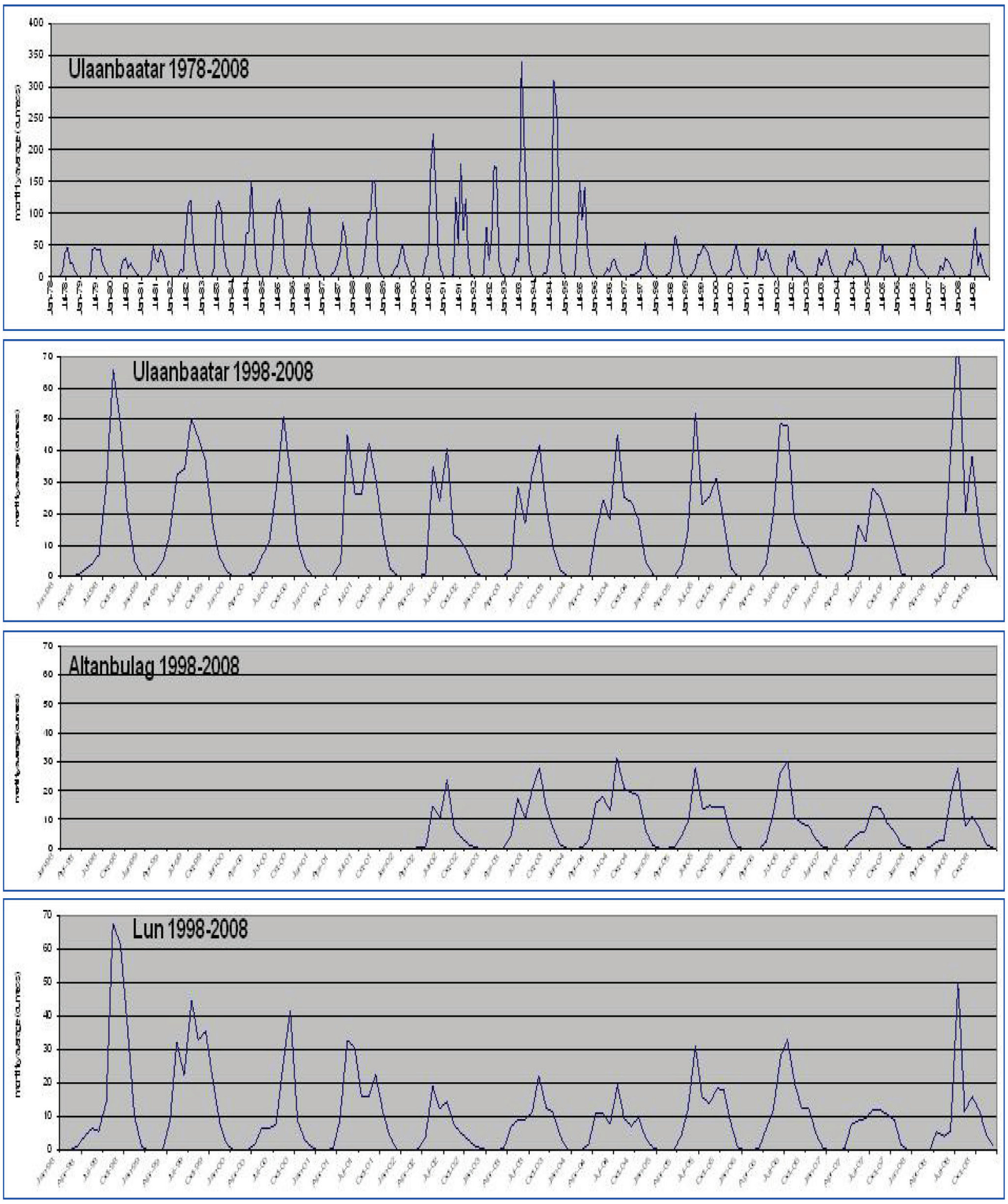
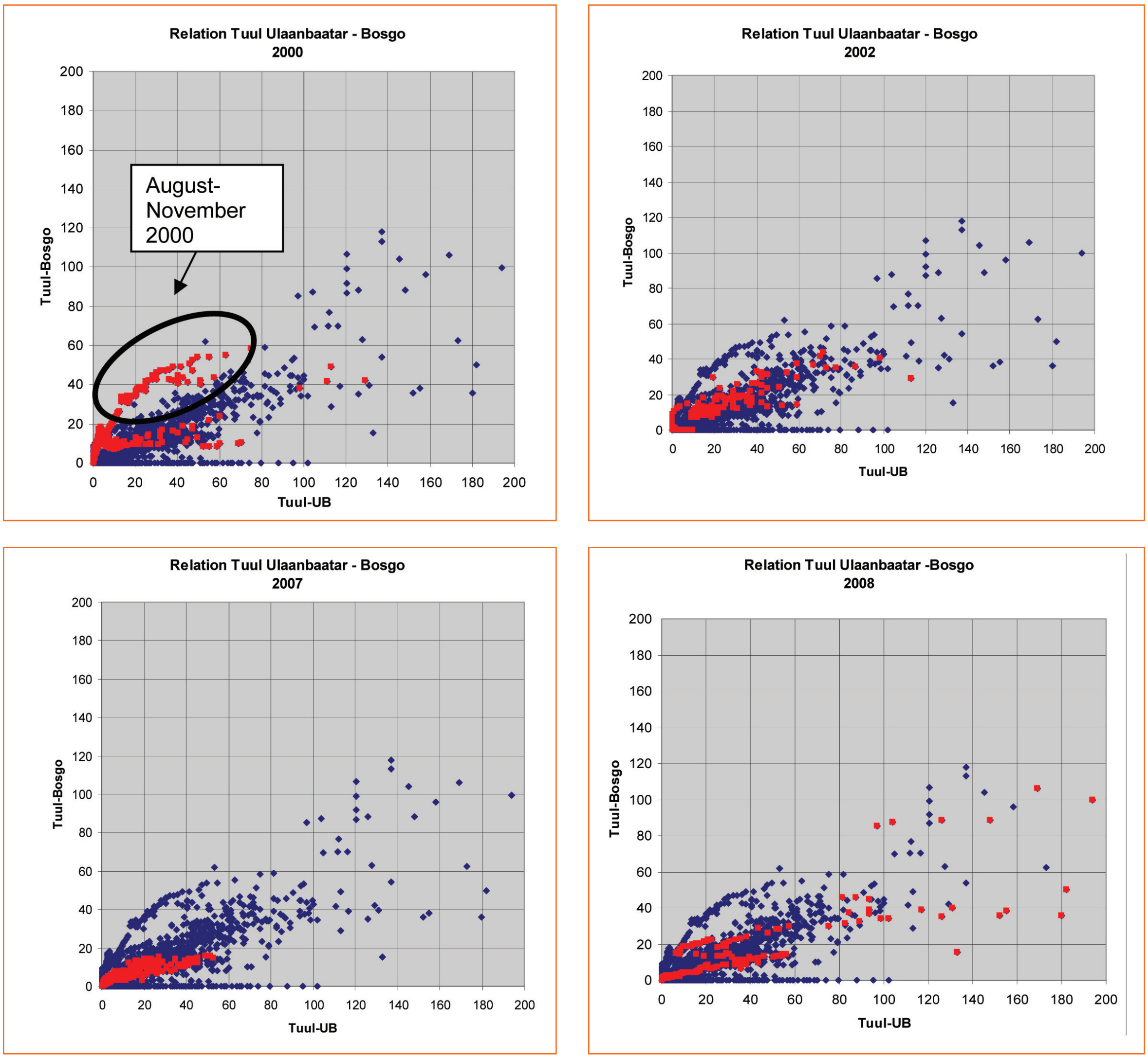
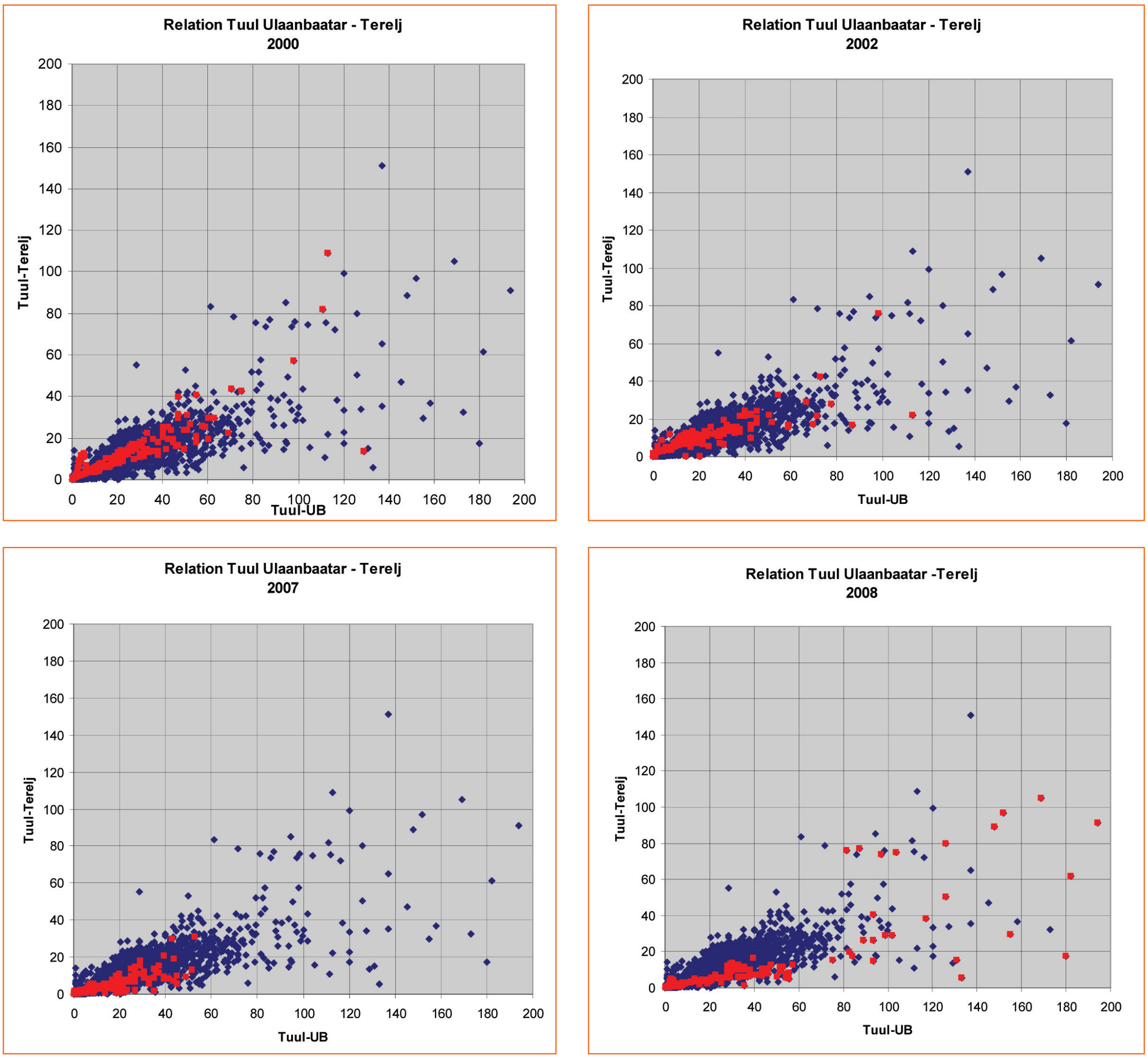


Figure 46. Tuul monthly runoff



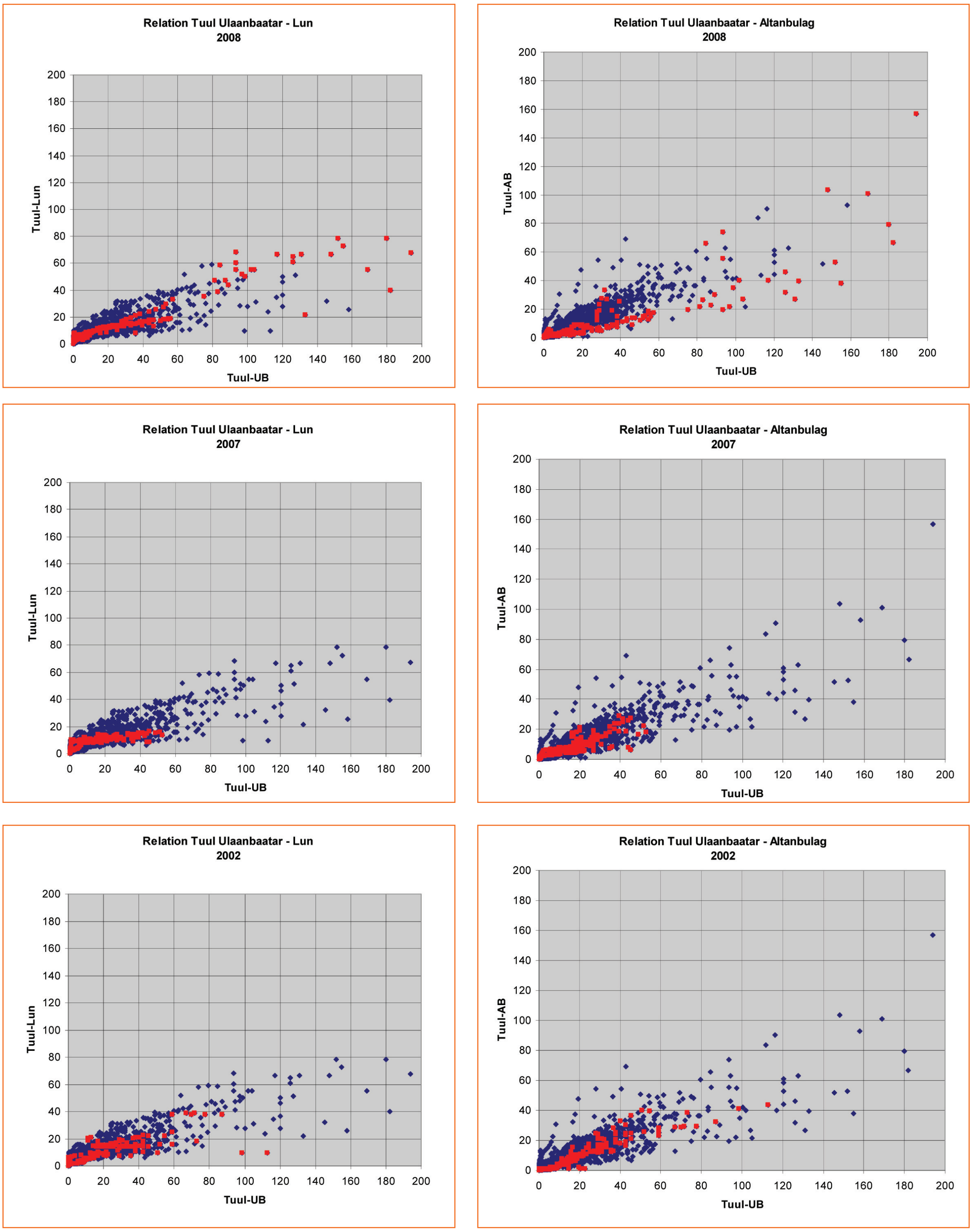
Explanation: blue points all data 2000-2008, red points: data specific year
The plots were made using a delay between the stations of 1 day between Bosgo and Ulaanbaatar and 2 days between Terelj and Ulaanbaatar

Figure 47. Relation daily runoff Bosgo and Ulaanbaatar



Explanation: blue points all data 2000-2008, red points: data specific year
The plots were made using a delay between the stations of 1 day between Bosgo and Ulaanbaatar and 2 days between Terelj and Ulaanbaatar

Figure 48. Relation daily runoff Terelj and Ulaanbaatar



Explanation: blue points all data 2002-2008, red points: data specific year
The plots were made using a delay between the stations of 1 day between Ulaanbaatar and Altanbulag and 4 days between Ulaanbaatar and Lun

Figure 49. Relation daily runoff Ulaanbaatar-Altanbulag and Ulaanbaatar-Lun in three years: 2008, 2007 and 2002

Runoff at Ulaanbaatar, Terelj and Lun

Correlation Hydrographs: Ulaanbaatar – blue, Lun – pink, Terelj - green
Ulaanbaatar-Lun
Blue dots: 2002-2008

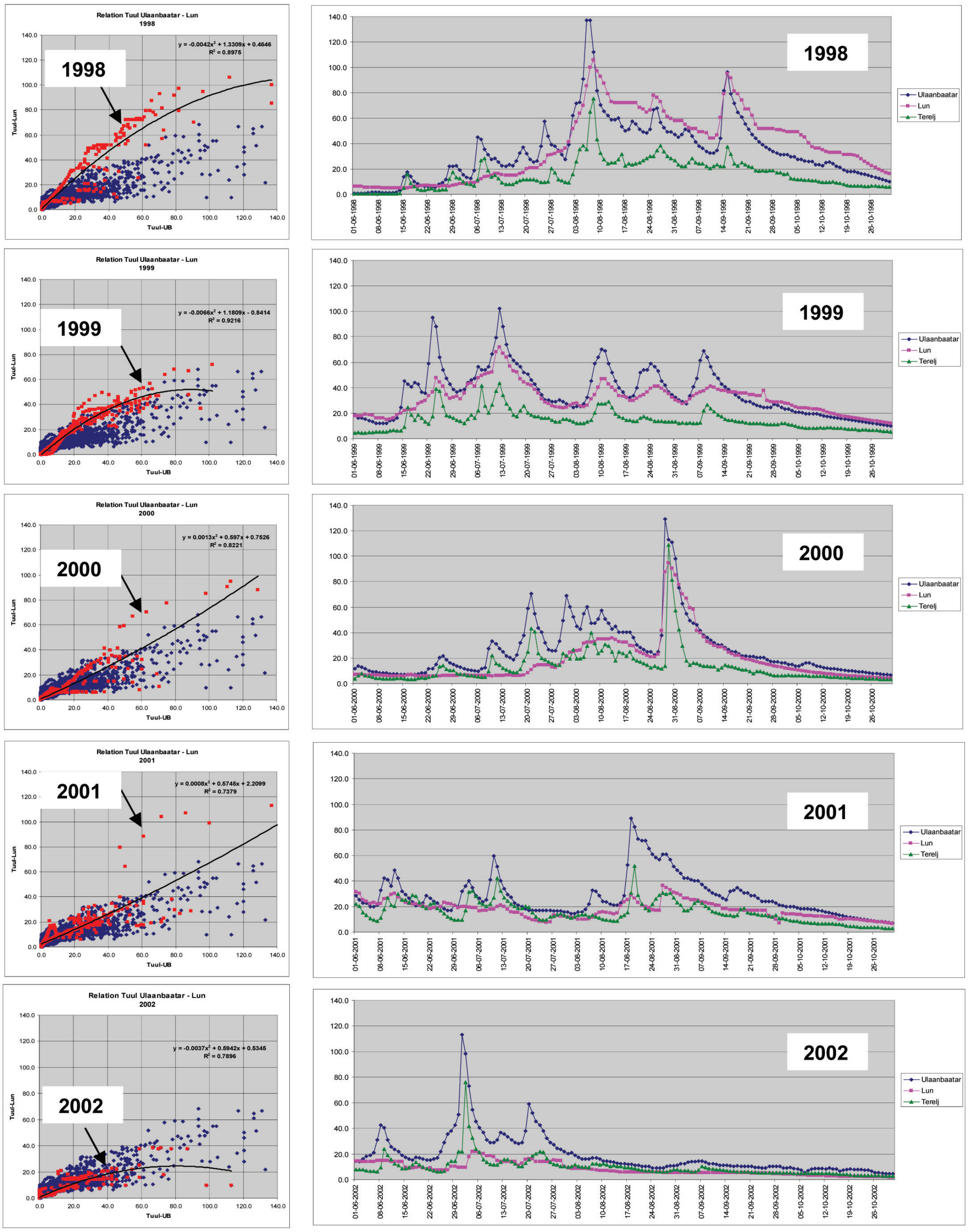


Figure 50. Runoff at Ulaanbaatar, Terelj and Lun

Runoff at Ulaanbaatar, Altanbulag and Lun

Hydrographs:
Ulaanbaatar – blue, Altanbulag – pink, Lun - green

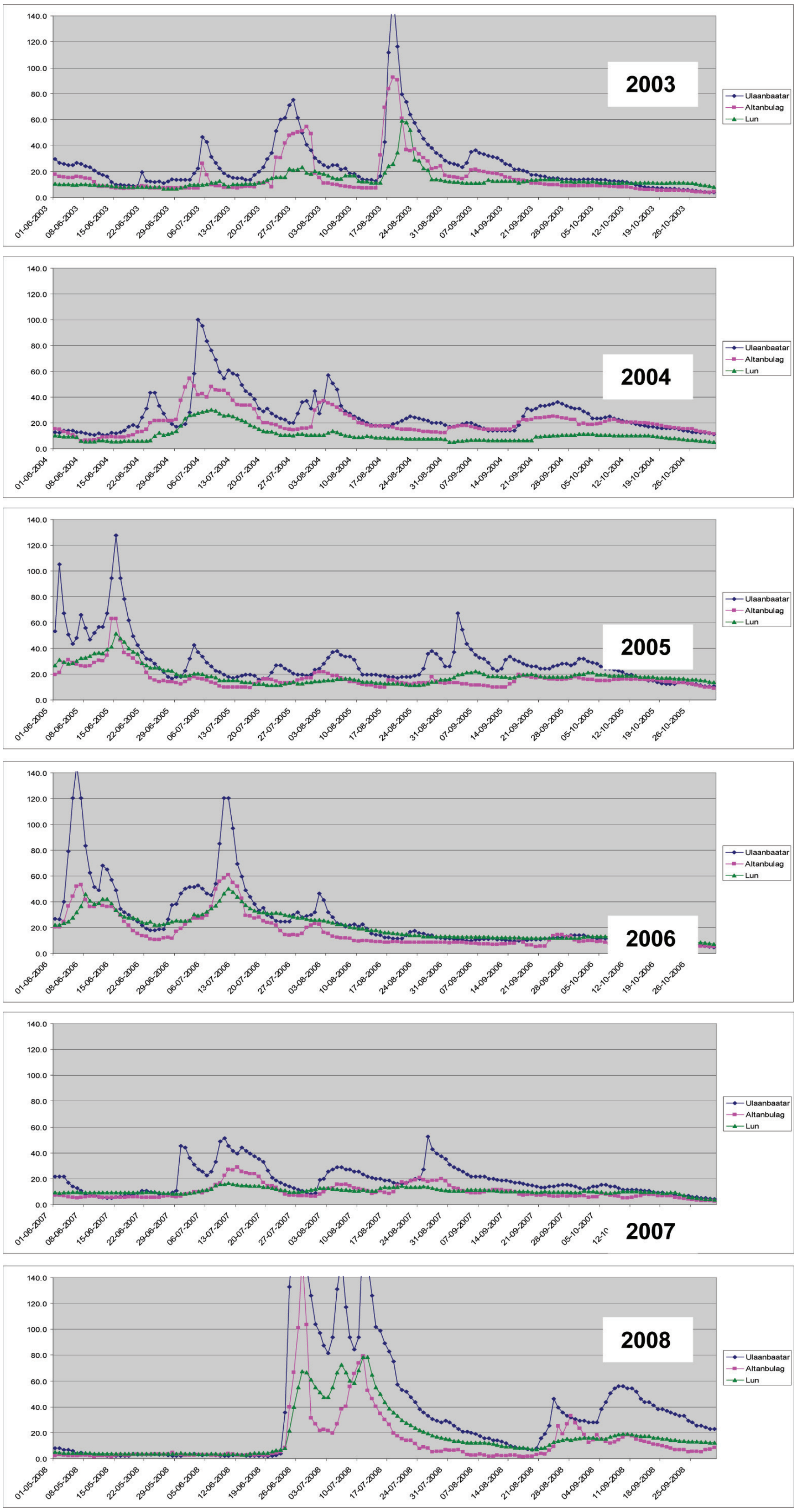


Figure 51. Runoff at Ulaanbaatar, Altanbulag and Lun

ANNEX 7. Surface water resources map of Tuul basin

Source: IMH

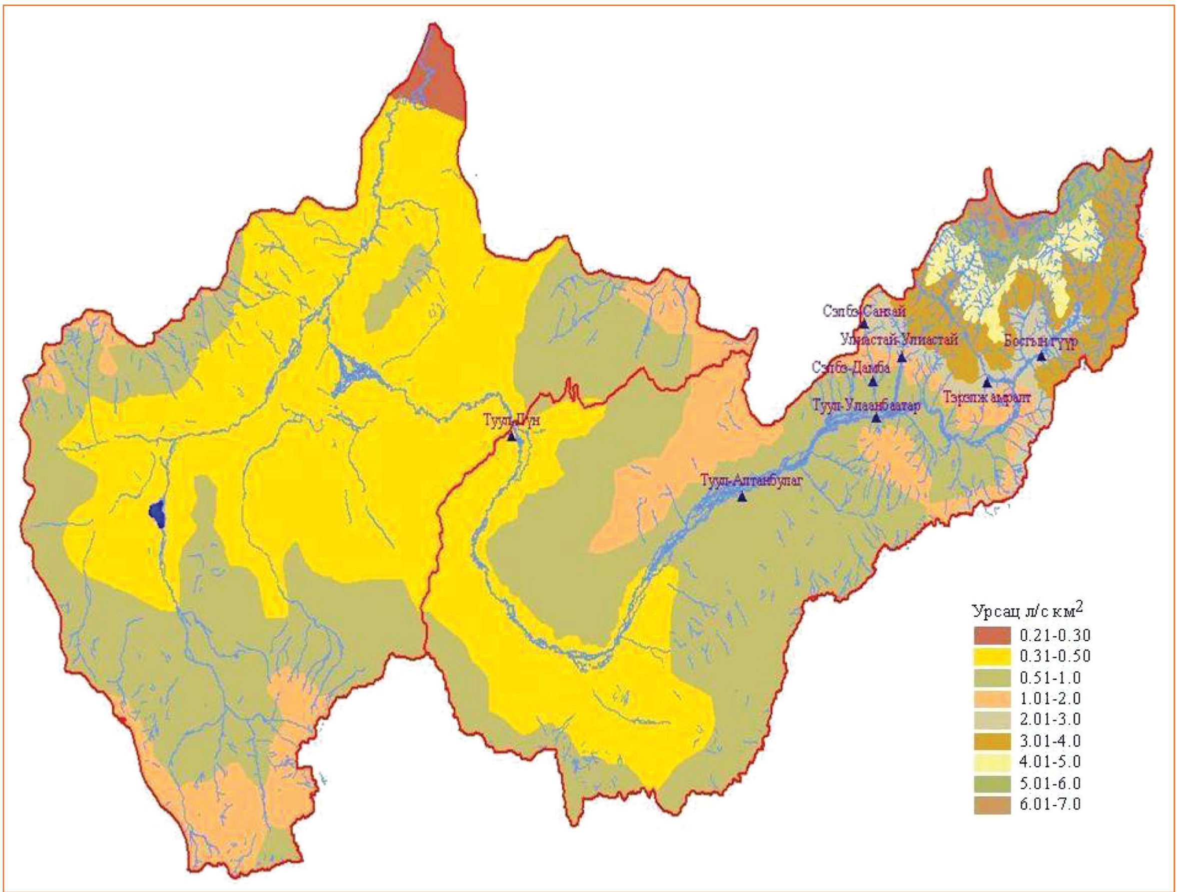


Figure 52. Specific run off map of Tuul River Basin

Part 3.
GROUNDWATER RESOURCES

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1. Introduction

Assessment of groundwater resources based on the hydrogeological general pattern of the Tuul river basin determines the current and future problems of groundwater use and in a way to define direction of further implementation measurements it is became as one of integral matters to improve integrated water resources management. Groundwater assessment of the Tuul river basin assists to solve the following three main goals as:

- To assess the present level of groundwater study and to indicate the direction of the development of groundwater studies to be reflected in the integrated water resources management plan of the Tuul river basin
- To improve access to ground water information
- To improve the groundwater assessment studies in the Tuul river basin

A meeting was organized in which the methodology was approved used for assessing the potential exploitable groundwater resources in which participated the Ministry of Nature, Environment and Tourism, the Ministry of Food, Agriculture and Light Industry, the Geo-ecology Institute, private companies, researchers, scientists and teachers.

2. Used data and information

Two maps form the basis for the compilation of the Exploitable Groundwater Resources Map:

1) the Hydrogeological Map of Mongolia at scale 1:1,000,000 [1] (see Figure 1);

2) the Map of "Multi-year Mean Flow of Surface Water and Groundwater" at scale 1:1,000,000 [2] (see Figure 2).

Additional information is obtained from:

1) Database of groundwater deposits

2) Borehole information from groundwater database

In this methodology and other documents associated with hydrogeology and groundwater resources are used some terminologies like aquifer, inter-granular aquifer, fissured aquifer, confined, unconfined groundwater, renewable groundwater resources, potential exploitable resources and others. The definition of such terminology is given in Annex 1.

2.1. Using the Hydrogeological Map of Mongolia at scale 1:1,000,000

The work on the German-Mongolian regional Hydrogeological Map of Mongolia 1:1,000,000 was started in 1991. The map was published in 1996. A description in English was published in 2003 [1]. The map was digitized by the WA and is available as shapefile. The legend of the map indicates the productivity and the type of permeability:

- Intergranular aquifers
- Fissured aquifers, including karst aquifers
- Intergranular or fissured aquifers with local, limited groundwater resources or rocks with essentially no groundwater.

The Hydrogeological Map of Mongolia also shows the lithological composition:

1) Intergranular aquifers;

- Holocene and Pleistocene alluvial, alluvial- proluvial, alluvial-lacustrine, lacustrine, aeolian deposits also in proluvial, proluvial-alluvial, dilluvial-proluvial, dilluvial, glacial, fluvial-proluvial deposits;
- Neogene, Paleogene, Upper Cretaceous, Lower Cretaceous aquifers;
- Permian, Triassic, Jurassic bedding inter-granular aquifers;

2) Fissured aquifers;

- Pre-Permian fissured aquifer in fractured, sub vertical sedimentary rocks;
- Meso-Paleozoic igneous fissured aquifer rocks.

The productivity of the aquifer is indicated with the international standard colors (Figure 1).

The classification used for yields of wells and springs is:

High yield:	> 5 l/s
Moderate yield:	0.5 – 5.0 l/s
Low yield:	0.01 – 0.5 l/s

The yield of wells and isolated springs in areas with essentially no groundwater is mostly in the order of 0.01 – 0.1 l/s.

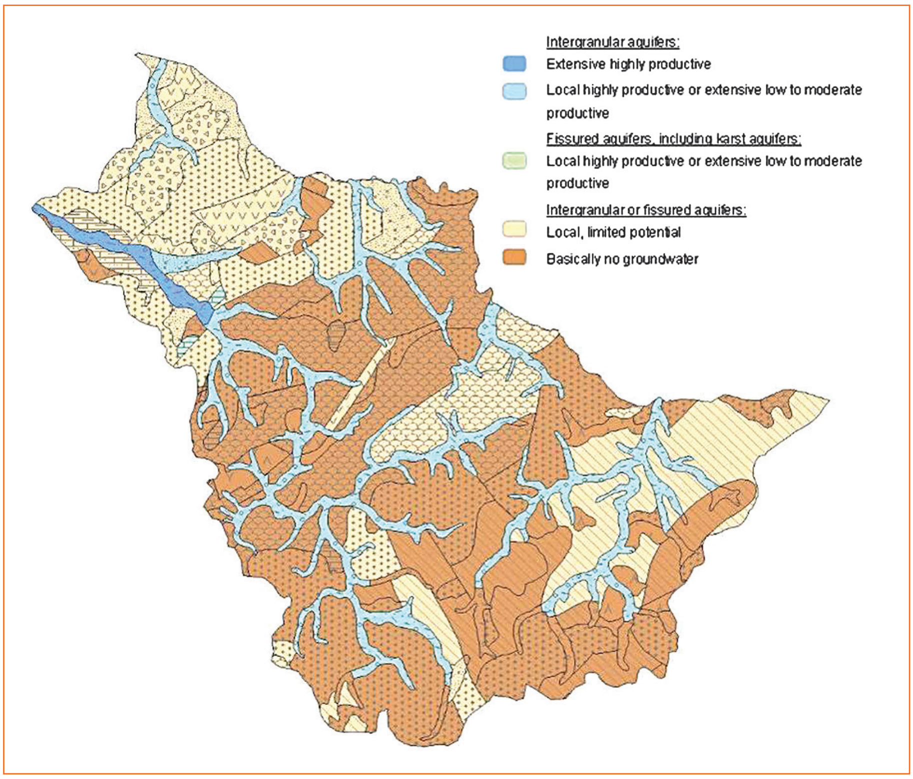


Figure 1. Example (Eroo Basin) of part of Regional Hydrogeological Map of Mongolia 1:1,000,000 (Jadambaa N., Grimmelmann W., Kampe A, 2003)

The above yield classification is used to estimate the potential exploitable groundwater resources in the basins. The 3 classes were transformed to 7 classes using the rock lithology notices on the Hydrogeological Map of Mongolia scaled at 1:1,000,000. Relying on hydrogeological mapping, work experience in exploration, distribution areas are identified with the groups - 1) > 10 l/s/km^2, 2) 3-10 l/s/km^2, 3) 1-3 l/s/km^2, 4) 0.3-1.0 l/s/km^2, 5) 0.03-0.3 l/s/km^2, 6) 0.003-0.03 l/s/km^2, 7)< 0.003 l/s/km^2, and methodology for calculating approximate exploitable groundwater resources distributed in those areas are used.

2.2. Using the map of “Multi-year average flow of surface and groundwater” 1:1,000,000

The Map of “Multi-year average flow of surface and groundwater” at scale 1:1,000,000 was created and printed by the Trest experts in Aero-geology research institute in Moscow, Russian Federation in 1981 [8]. The map shows the surface water runoff as contours and the groundwater flow as polygons. The groundwater flow polygons represent the total flow which originates from groundwater flow and infiltration of surface water and precipitation. Therefore the map is also sometimes designated as groundwater flow map.

The groundwater flow indicated on the map may be considered to correspond with the renewable (or natural) groundwater resources. The map presents a classification of the renewable (natural) resources per 1 km^2: lower than 5 mm/year (or less than 5,000 m^3/year/km^2), 5-20 mm/year (or averaging 12,500 m^3/year/km^2), 20-50 mm/year (or averaging 35,000 m^3/year/km^2), 50-100 mm/year (or averaging 70,000 m^3/year/km^2), 100-200 mm/year (or averaging 150,000 m^3/year/km^2), more than 200 mm/year (or averaging more than 200,000 m^3/year/km^2).

In the scope of the “Strengthening IWRM in Mongolia” project, the expert D.Batjargal digitized the Multi-Year Mean Flow of Surface water and Groundwater Map and the map of the Eroo basin is taken from the map as example (Figure 2).

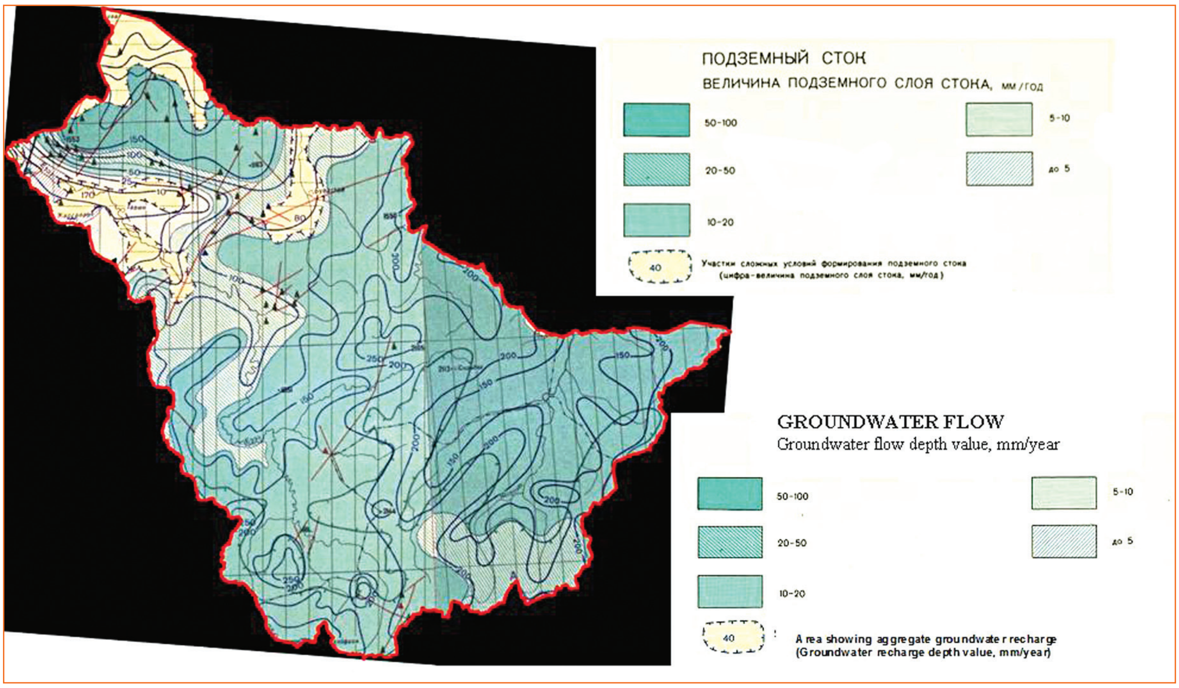


Figure 2. Example (Eroo Basin) of part of the “Multi-year average flow of surface and groundwater” Map 1:1,000,000 (1981)

The renewable groundwater resources derived from the digital version of the “Multi-year Mean Flow of Surface Water and Groundwater” Map is compared with the Hydrogeological Map of Mongolia to determine the renewable groundwater resources.

2.3. Using data of groundwater deposits

For the calculation of inferred groundwater resources is used the database on investigations of groundwater deposits. These investigations provide information on exploiting boreholes: yield, drawdown on the period of hydrogeological exploration pumping, hydrogeological parameters- thickness, transmissivity, specific yield, capacity, main aquifer yield, hydrogeological and groundwater development maps, results of chemistry analyses and other information. Total inferred groundwater resources are calculated like the result of detail before us hydrogeological studies of groundwater sources (deposits) by 29 basins and by each of them. All information is collected from the Water Authority and from the Geological Information Center.

Previous hydrogeologists calculated the exploitable groundwater resources by industrial categories - A, B, C1 and by non- industrial or forecast category C2 according to Russian old instructions. But at present time Russia already changed old instruction and Mongolia does not have any new instruction yet. Therefore we will use the sum of all exploitable resources of the groundwater deposits as shown in Table 10. More information about categories- A, B, C1 in Annex 1.

2.4. Using borehole data

On the 1:1,000,000 Hydrogeological Map of Mongolia is shown location of several more informative boreholes which were drilled in the basin. Some data and information on drilled wells is tabulated on the map.

Borehole information is derived also from the borehole database provided by the WA which contains information from more than 17,000 boreholes. We use this data for defining the potential exploitable resource.

3. Methodology to calculate renewable groundwater and potential exploitable resources by basin

3.1. Introduction

The objective is to prepare the map on "Groundwater natural renewable resources and potential exploitable resources" scaled at 1:1,000,000 for each water basin and to identify and estimate the groundwater natural renewable resources and potential exploitable resources. The groundwater natural renewable resources have a composite character as they are depending on precipitation, hydraulic connection between surface water and groundwater and groundwater flow from adjacent areas. For an explanation see Annex 1.

3.2. Methodology to compile the renewable groundwater resources map and to calculate the renewable groundwater resources by basin

The groundwater flow (composed of lateral groundwater flow and recharge from infiltration of surface water and precipitation) is shown on the 1:1,000,000 scale "Multi-year Mean Flow of Surface Water and Groundwater" Map with unit mm/year and in order to convert this measurement into m^3/day, the simple formula is used:

$$Q = 2.74 \cdot h \cdot F$$

Q – renewable groundwater resource (m^3/day),
h – groundwater flow (mm/year).
F – flow area, km^2.

The values used as groundwater flow h are:

< 5 mm/year	average applied: 5 mm/year	or 5,000 m^3/year/km^2
5-10 mm/year	average applied: 7.5 mm/year	or 7,500 m^3/year/km^2
10-20 mm/year	average applied: 15 mm/year	or 15,000 m^3/year/km^2
20-50 mm/year	average applied: 35 mm/year	or 35,000 m^3/year/km^2
50-100 mm/year	average applied: 75 mm/year	or 75,000 m^3/year/km^2
100-200 mm/year	average applied: 150 mm/year	or 150,000 m^3/year/km^2
>200 mm/year	average applied: 200 mm/year	or 200,000 m^3/year/km^2

The total renewable groundwater resources in the Tuul Basin will be estimated as sum of the river basins renewable groundwater resources.

3.3. Methodology to calculate the potential exploitable groundwater resources in water basin

The potential exploitable groundwater resources of a river basin are identified and are shown on the map of the basin at scale 1:1 000 000. The methodology of calculation is by water balance equation. This methodology combines the estimates of the renewable and non-renewable resources and is used for calculation of potential exploitable groundwater resources both in alluvial aquifers distributed in big river valleys and in granular or fissured aquifers distributed in areas with little or no recharge. The potential exploitable groundwater resources is calculated from

$$Q_a = Q_n + \frac{\mu V_e}{t}$$

where

- Q_a – Potential exploitable groundwater resources, m^3/day,
- Q_n – Natural resources or groundwater flow in alluvial aquifer, m^3/day,
- V_e – Main aquifer volume, m^3,
- μ – Groundwater storage coefficient in main aquifer, interval between 0.1-0.03,
- t – Operating period of water supply system (e.g. 7300 days = 20 years)

The methodology which is used in the “Strengthening Integrated Water Resources Management in Mongolia”-project is based on the experiences of hydrogeological mapping and prospecting before 2008. The methodology consists of the determination of the potential exploitable groundwater resources in a basin based on the estimate of the aquifer yield per unit area (1 km^2). The aquifer yield per unit area is divided into 7 classifications as –

- more than 10 l/s or “large resources”,
- 3-10 l/s or “larger than medium resources”,
- 1-3 l/s or “medium resources”,
- 0.3-1.0 l/s or “lower than medium”,
- 0.03-0.3 l/s or “low resources”,
- 0.003-0.03 l/s or “very low resources”,
- < 0.003 l/s or “basically no water resources”

The classification is consistent with the classification of 3 classes used in the 1:1,000,000 Hydrogeological Map of Mongolia. A map of each river basin is created with a proper scale and the total potential exploitable groundwater resources for each basin are calculated.

The classification is applied using the lower yield of the production wells in each aquifer zone. This possibly provides an under-estimate of the resources which is considered better than over-estimating the expected resources.

For example, the exploitable groundwater resources of the Holocene aged intergranular alluvial aquifer located in the lower part of the Tuul River are classified as 1-3 l/s but are approximated as averaging 1 l/s from 1 km^2 area and this is applied to the whole area of this class. If the groundwater resources are estimated by a hydro-geological survey, the approach used is to take the lower yield of the production wells and to enlarge the investigated area 2-3 times to illustrate the potential exploitable groundwater on the resources map.

Table 1. Methodology to define water content in aquifers of Upper and Lower Cretaceous period

Aquifer dimension	Area (F) - km^2 Thickness – m
Total aquifer volume	V= F* m, mln m^3 or km^3
Quantity of available groundwater	Specific yield SY(0.03 - 0.1) Q = SY *V, mln m^3

The data needed includes aquifer thickness (m), well yield (Q, l/s), drawdown (S, m), specific capacity (q, l/s/m), static level, piezometric head (h, m), permeability coefficient (k, m/day), transmissivity (T=130xq, m^2/day), potential drawdown (S_6=0.5 m, 50% of aquifer thickness for unconfined aquifer, or S_6=0.5(m+h), 50% of aquifer thickness + head for confined aquifer), potential safe yield (Q_6=qxS_6).

4. Geomorphology and hydrogeology of the Tuul River Basin

4.1. Introduction

As a result of the long term high density of population and livestock in the capital city of Mongolia, Ulaanbaatar City, the study of the groundwater in the Tuul River Basin was done irregularly but comparatively better that in other places. The hydrogeological research is done accompanied by studies on the natural environment, geomorphology and geology which have a high significance for groundwater distribution and its formation.

The hydrogeological mapping in the total area of the Tuul river basin was done at a scale of 1:500,000 and in the surrounding of Ulaanbaatar City at a scale of 1:100,000. The Tuul river valley was studied with a comparatively higher accuracy as its hydrogeology, engineering geology as a result which of it has generally definite geo-morphological and geological structure.

Source: Hydrogeological Map 1:1,000,000 [10]

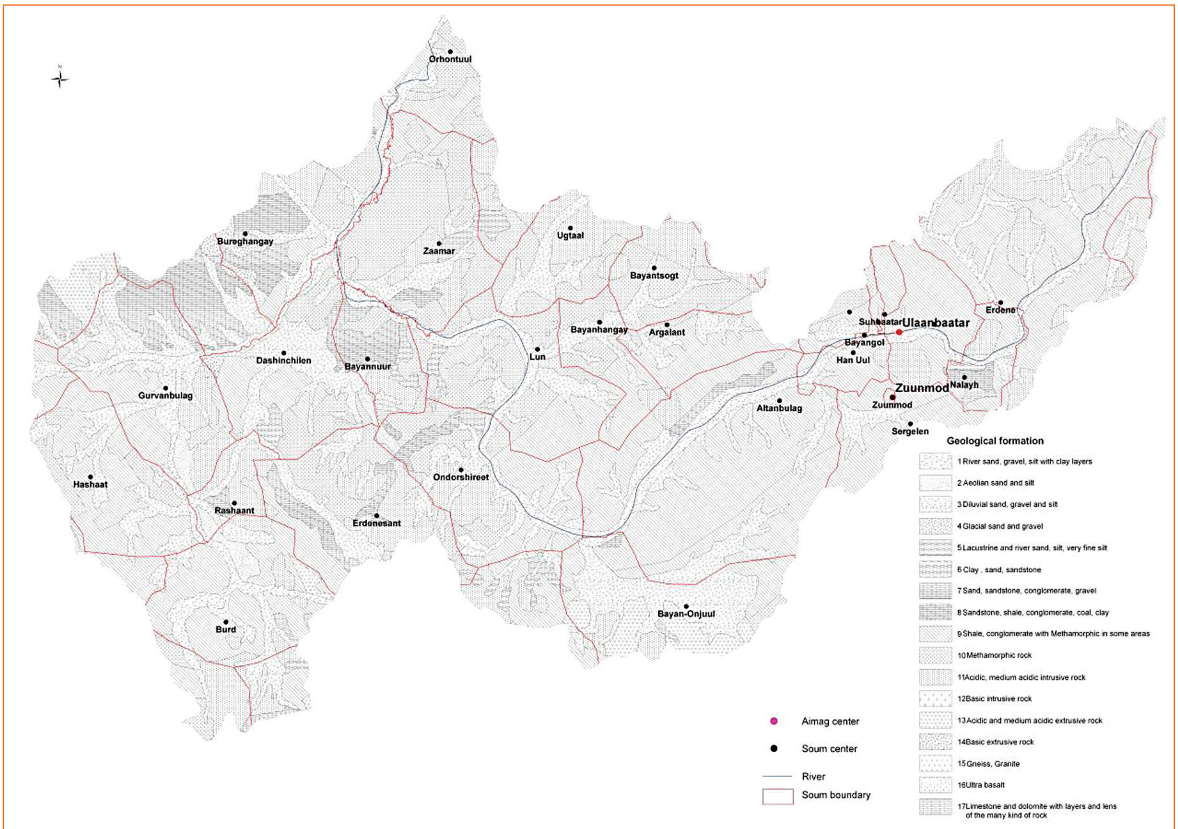


Figure 3. Geological Map Tuul Basin (for legend see also Figure 6)

4.2. Geomorphology, geology

As of geomorphology the Tuul river basin is included generally in mountainous regional area and formed from mountain range, its mountainside and foot, streams, river mount, valley and narrow ravines. The Tuul river source is located on 2600 m above sea level in mountainous side of Khentii mountain range and its end consists of a wide valley with a height of around 800 m where it merges with the Orkhon River. The mountains surrounding the named river basin become a recharge region of groundwater, the valley at Ulaanbaatar City is an accumulation, transference foot region. Tuul river valleys have narrowed and wide interchanged parts, where its narrow part may be formed as pushed foot region.

Geological structure of the named basin covers granite rock penetrated the sedimentary, magic rocks of Cambrian, Devon, Carbon periods frozen on depth at Jurassic and Triassic periods that distributed covering these main rocks consists of sandstone of light-grey color, aleuropelite, tertiary gravel sand of red, reddish color and pelagic clay, loam, sand thin stratum, also sand, gravel, clay and shingle rocks formed in quaternary period.

Tertiary (Neogene, Paleogene) sediments are averagely 80 m thick, mainly have clayish structure of not penetrated water. Modern quaternary or Holocene aged alluvial, lake, wind originated sediments distributed along Tuul river valley contains comparatively high content of groundwater resources.

In this basin as noted by geologists there are two large regional fractures known as North Tuul and South Tuul fractures.

4.3. Hydrogeology

In the Tuul river basin there are two kinds of aquifers: granular (formation) and fissured aquifers (region). There are mineral springs emerging from both granular and fissured aquifers (Ulaanbaatar, Ar Janchivlan, Ovor Janchivlan carbon dioxide cold springs). Granular formation formed within lower Cretaceous, Neogene, Quaternary deposits and fissured aquifers are formed within Cambrian, Devon, Carbon sedimentary, metamorphic rocks of Cambrian, Devon, Carbon or sedimentary rocks of Jurassic and Triassic periods.

Age and lithology /the branch of geology that studies rocks: their origin, formation, mineral composition and classification/ types of sedimentary rocks distributed wholly in Tuul river basin are generally integrated and classified as granular when dominantly granular and as fissured when dominantly fissured. Taking into consideration groundwater study level, its movement character here are separated 6 types of granular zone and 2 types of fissured aquifers. All these formations, hydrogeological basic data is shown by Table 2.

Table 2. Aquifer formation of the Tuul River Basin, some geological indicators of the region

№	Aquifer formation, name of region	Used borehole quantity data	Water depth (low-high) *[m]*	Drawdown (low-high) *[m]*	Yield *[l/sec]*	Mineralization *[gr/l]*
1	Holocene alluvial formation	300	0.2-6.0	0-23.0	1-105.0	0.1-0.60
2	Pleistocene proluvial, proluvial-alluvial formation distributed along Tuul river valley	200	2.0-11.5	1.9-20.5	0.5-24.1	0.5-1.5
3	Holocene-Pleistocene alluvium, proluvium formation distributed along affluent river	270	0.2-12.0	2-40	0.5-8.0	0.3-1.2

№	Aquifer formation, name of region	Used borehole quantity data	Water depth (low-high) *[m]*	Drawdown (low-high) *[m]*	Yield *[l/sec]*	Mineralization *[gr/l]*
4	Neogene sediment formation	20	(19.37 -119)*	2-40	0.5-3.8	0.5-1.6
5	Cretaceous sediment formation	85	1.5-80	-	0.3-10	-
6	Formation in rock in Triassic-Jurassic sediment	45	3-33.0	1-15.0	1-1.3	0.2-0.3
7	Zone in sedimentary, metamorphic, effusive rocks of Paleozoic period	30	3.7-60.0	4.5-17.0	0.07-25	0.1-1.2
8	Zone in intrusive rocks	115	8.6-26.5	2.66-5.12	0.1-4.3	0.1-0.7

Sources: Hydrogeology-engineer-geological survey reports are used /which were conducted between 1933 and 2008/. The most important are: V.N.Popov (1932-1933), Z.A.Lebedeva (1933), K.A.Gomaniko, I.A.Anpipov (1944-1946), U.S.Jelubovski (1948), U.Mukhin, A.Botcharov (1956-1957), R.A.Kriger (1959-1960), V.A.Zaitsev, L.N.Kazuiseva, Z.V.Davletshina, N.N.Tichomirova and others (1974-1975, 1981-1985), Z.Narangerel (1968-1970), N.Jadambaa (1974-1977), N.Jadambaa, Z.Tserendorj, L.Enkhkhishig (1978-1980) and JICA (1992-1995) research report.

Ps: aquifer formation in Neogene sediment contains pressured water.

4.3.1. Granular aquifer formation in Holocene aged alluvial sediment

The granular aquifer formation of alluvial sediment from the Holocene period (modern quaternary-upper quaternary age that is noted in research materials before 1990) was first studied by V.N.Popov (1932-1933), Z.A.Lebedeva (1933) at a depth of 23.7-91.0 meters in 6 hydrogeological boreholes drilled near the old Electricity station 1 and its yield was fluctuated between 2.1-10.2 l/sec. It was concluded that the aquifer may have water generally with comparatively rich resources.

From these first 6 boreholes in borehole number 233 in unconsolidated deposit of recent alluvial origin, thickness of aquifer is 61 m and at the same time the researchers named above considered that it is Neogene and Cretaceous water formation and region.

The PNIIS (Project Scientific Research Institute of Engineering Building) Scientific Institute of the Russian Federation drilled in the period of 1981-1985 boreholes numbered 2011 (near Central Source) and 2052 (near Industrial Source) and in 1975 borehole number 3 was drilled (near the Power Plant – 3), where yield of the modern-upper quaternary alluvial water stratum distributed in the valley of the Tuul river basin reached 50.0 l/sec, 70.3 l/sec, 105.0 l/sec respectively and boreholes with the largest yield were encountered during drilling work for exploitation.

The yield of most boreholes drilled during exploration in the upper layer of the aquifer formation of alluvial sediment origin of Holocene age in the area of the central source is fixed at 23.7-48.8 l/sec, with a drawdown of 0.24-3.3 meters. The yield of most boreholes drilled in the industrial area is 14.4-36.9 l/sec, water level drawdown is 0.65-18.84 meter respectively. The yield of the 1-9th boreholes that are in regular operation since 1960s fluctuated in that time between 25-40 l/sec.

The quality of the water in the upper layer of the aquifer formation in the sediments of alluvial origin of Holocene age answers to the standard requirements that is fresh and soft with hydro-carbonate sodium, hydro-carbonate –calcium content contained up to 0.1 g/l of mineralization, 1.1 mg/l of nitrate, 0.1 mg/l of iron.

4.3.2. Granular aquifer formation in Pleistocene aged alluvial, proluvial, alluvial-proluvial sediment

This formation is distributed on the west side of the Tuul river valley forming terraces, where aquifer sediment is dominantly formed from bank gravel, gravel, sand, sandy loam and mild clay. This aquifer sediment has a thickness fluctuating between 19.5-33.5 meters. The internal small clay layers and lenses have a thickness of 2.6-20.0 meters.

The water in this formation is some times under pressure. For example, the water pressure in boreholes numbered 46, 155, 174 and 133 that were drilled near Amgalan was 4.4 m, 2.6 m, 2.0 m and 11.5 m respectively. The capacity of this formation is distributed unevenly: the yield of 24.6 l/sec in borehole number 2005 lowered the water level with 1.9 meters which is considered as most high yield in alluvial sediment of Pleistocene age, while the lower yield of 0.9 l/sec in borehole number 317 drilled near the end of Uliastai river lowered the water level with 10.0 meters .

The water in the alluvial sediments of Pleistocene age has content of hydro-carbonate, calcium-sodium; calcium-magnesium with a mineralization of 0.704 g/l and a hardness of 8.87 mg-equiv/l.

4.3.3. Granular aquifer formation in alluvial, proluvial, proluvial-alluvial sediment of Holocene-Pleistocene age in side valleys

This formation is formed in deltas near the mouth of side rivers such as Selbe, Uliastai, Tolgoit River and formed from debris. Aquifer sediment is formed from dust, clayish sand, sandy loam and sharp fractured materials such as gravel, grit, sometimes boulders. Water is encountered in this formation at a depth of 0.2-11.3 meters but mainly is fixed at a depth of 4-6 meters. Total thickness of this formation is 16-36 meters.

The highest yield of 8.0 l/sec in this formation lowered the water level by 8.1 meters in borehole number 318 drilled in appeared to smooth fractured debris in delta of Uliastai river but borehole number 312 drilled in the mouth of the same river has a much less yield of 0.5 l/sec.

The water in this formation has a chemical content of sulphate-chloride-magnesium-sodium; chloride-sulphate-sodium; has a mineralization of 1.5 g/l, a hardness of 8.3 mg-equiv/l, and in most cases can not answer to the standard requirements for drinking and domestic tap water by any indicators and some boreholes reveal nitrate, nitrite pollution.

4.3.4. Granular aquifer formation of continental origin of Neogene age

Infiltration sediment mainly with red color of continental origin of Neogene age on whole Tuul river basin is covered by quaternary deposits and distributed limitedly. Aquifer formation consists of sand, conglomerate clay, sandy loam, clay adhesively with coarse gravel and grit within mild clay.

In hydrogeological borehole number 138 drilled on the embankment of Gandan groundwater was encountered in massive breccias at a depth of 119 meters and also in borehole number 147 on this embankment the first layer of 2 stratums containing water was encountered from a depth of 19.37 meters, a second layer was encountered from a depth of 156 meters. Water encountered in the above mentioned two boreholes drilled on the embankment of Gandan including borehole number 182 has a pressure of 87.2-130.0 meters.

In borehole number 286 drilled near Amgalan thin confined layers were found with a thickness of 1.0-1.75 meters. The top of the layers were 17.4 meters and 36.75 meters deep, and the static water level was 15.5 meters, that gave pressure between 1.9-21.25 meters.

In borehole drilled near Meat industries 2 thin layers containing groundwater within sediment of Neogene age were encountered that pressure was 5.0-41.8 meters.

Several dry boreholes were drilled in Yarmag and old Naadam embankment but an aquifer shaped like a lens was encountered at a depth of 24.3-50.0 meters. The static water level was at a depth of 1.0-14.7 meters. Water resource and yield are not high in the red color continental Neogene aquifer.

The yield of the borehole drilled in Amgalan was 3.5 l/sec, the yield of the borehole number 147 drilled on embankment of Gandan was 0.5 l/sec, and the yield of the borehole drilled near Yarmag was 2.0-3.8 l/sec respectively. The abundant water is not suitable for drinking water by chemical composition according standards.

4.3.5. Granular aquifer formation in Triassic – Jurassic aged sediments

This formation is distributed in the Tuul river valley around Khustai mountain range and on the lower hills on the west side of Kharvakh (Khar bukh) river. Spring water is found in the aquifer formation in sedimentary deposit of Jurassic age near Khustai mountain range.

On the Hydrogeological map of Mongolia with scale 1:1,000,000 at the left side of Kharvakh (Khar bukh) river (west side) there is borehole numbered 50 drilled to a depth of 33 meters in a valley on the slope of a mountain revealing an aquifer formation with sediments of Triassic age. The aquifer formation revealed in boreholes numbered 51, 52 in sediment of Triassic age has a hydraulic relation with a proluvial aquifer. The confined water level revealed in these boreholes by 1-15 meters it shown on the hydro-geological map that its yield was fluctuated between 1-1.3 l/sec and drawdown was 1-15 meters.

4.3.6. Granular aquifer formation in Cretaceous aged sediments

This aquifer has a limited distribution within the boundary of Tuul river basin. But it has much distribution around Nalaikh district. Artesian water was found in the boreholes which once drilled in Nalaikh.

Before 1990, mining water leakage and groundwater started to be used for farming. Also dryness increased and groundwater recharge became scarce. Due to human activities and natural process, groundwater level is decreasing. The number of artesian boreholes decreased. At the end of 2007, only one borehole with artesian water remained.

4.3.7. Fissured aquifers in sedimentary, sedimentary-metamorphic, effusive, effusive-metamorphic, metamorphic rocks of Paleozoic age

This region is distributed on the mountainous area surrounding the Tuul river basin. The yield of the boreholes drilled in the fissured aquifers fluctuates between 0.07-25.0 l/sec, the water content is dominantly hydro-carbonate-sodium, hydro carbonate-sodium-calcium with mineralization of 0.1-1.06 g/l.

In boreholes numbered 184, 257, 258, 143 that were drilled in fissured aquifers in effusive rocks of Paleozoic age located to the north-east of Ulaanbaatar City water was encountered within sandstone, shale at a depth of 14.9, 13.0 and 40.0 meters and in boreholes drilled in Tolgoit, at the west side of the city, groundwater was encountered at a depth of 4.7-15.85 meters within metamorphosed sandstone.

In boreholes numbered 86, 98, 103, 107, 128, 146 drilled in the valley of Ulaanbaatar City groundwater is encountered at a depth of 3.7-40.0 meters. The yield fluctuates between 0.07-5.6 l/sec but mainly it has very little or less yield.

Along the tectonic fracture regions there are a lot of springs with it's a maximum yield of 14 l/sec.

4.3.8. Fissured aquifers in intrusive sediments

Fissured aquifers in intrusive sediment of Jurassic era are located in the whole Tuul river basin in the large granite massive and other small areas of Bogd Mountain, Gorkhi-Terelj, Erdene sant, Ugtaal tsaidam.

Groundwater was encountered in several boreholes drilled in Zaisan at the bottom of Bogd Mountain near the prison camp and the hospital of hepatitis disease. At the National University of Agriculture a groundwater-layer is encountered at a depth of 11-26 meters. In borehole number 264 the drawdown is 2.66 meters for a yield of 3.48 l/sec, and in borehole number 265 where groundwater is encountered in a fissured granite aquifer between 8.6 to 51.4 meters depth with a yield of 4.3 l/s and a drawdown of 5.12 meters.

The water resources of granite bodies is higher than of sedimentary rock of Paleozoic era. Water mineralization in the granite is 0.1 g/l and less but spring water mineralization fluctuates between 0.162-0.679 g/l.

Taking into consideration the general hydro-geological condition of the Tuul river basin fresh groundwater in this basin is found in three basic layers as Quaternary layer, Neogene, Cretaceous, Paleozoic and water in the first layer is high permeability and short time need to replenish, the second layer is weak and the third layer is heavy replenish.

V.V.Romanova, D.V.Efimova, Z.Tserendorj have evaluated the tritium accumulation in a multi-years research study in samples taken from borehole 4 of the central source of Ulaanbaatar City. They noted that groundwater exchange time in the quaternary sediments of the Tuul river valley is 8.46 years. In samples taken during the Nalaikh-Capital Mine operation from the groundwater at a depth between 150-316 meters the groundwater exchange time within Cretaceous aged deposits is 210 years. The Dondogdulam spring yield from tectonic fissured aquifers in metamorphosed sedimentary rock of Paleozoic age is determined at 120 years.

5. Groundwater resources of the Tuul River Basin

5.1. Natural renewable groundwater resources

The total area of the Tuul River Basin is 49,774 km^2 where renewable groundwater resources are formed annually to a total of 960.0 million m^3. There are 20 soum centers and 2 cities: Zuunmod and Ulaanbaatar City located in this basin.

From these 12 soum centers have extremely low renewable resources or 0-5 mm/year*km^2, 2 soum centers have low renewable resources or 5-10 mm/year*km^2, 1 soum center is located on area with average renewable resource or 20-50 mm/year*km^2 and 6 soum centers are located on area with mixed renewable resources of 40-80 mm/year*km^2.

The maximum renewable groundwater resources in the whole Tuul river basin is 160 mm/year*km^2 near the source of the Tuul river. Along the river valley it is 40-100 mm/year*km^2 with the comparatively higher renewable resources near the Khentii mountain range.

Table 3. Renewable groundwater resources calculated in the Tuul basin

№	Classification of renewable resources *(mm/year/km²)*	Area *(km²)*	Average flow *(mm/year)*	Renewable resources *(mln m³/year)*
1	Extremely low (0-5)	33,923	5	170
2	Low (5-10)	2,512	8	20
3	Low to average (10-20)	2,053	15	31
4	Average (20-50)	2,157	35	76
5	Average to high (50-100)	2,859	75	214
6	Mixed (40-160)	6,270	40-160	450
	Total	**49,774**		**960**

From this table it is clear that extremely low renewable resources cover an area of 33,923 km^2 or 68.1% of the total area of the Tuul river basin containing 17.3 percent of the total renewable groundwater resources. An area of 6270 km^2 or 12.5% of the total basin area with renewable resources of 40-160 mm/year contains 46.8 percent of the renewable groundwater resources. The most renewable groundwater resources are formed and recharged in the granular alluvial deposits of the river valley.

5.2. Potential exploitable groundwater resources

The summary of the potential exploitable groundwater resources per 1 km^2 area of Tuul river basin is shown in Table 4.

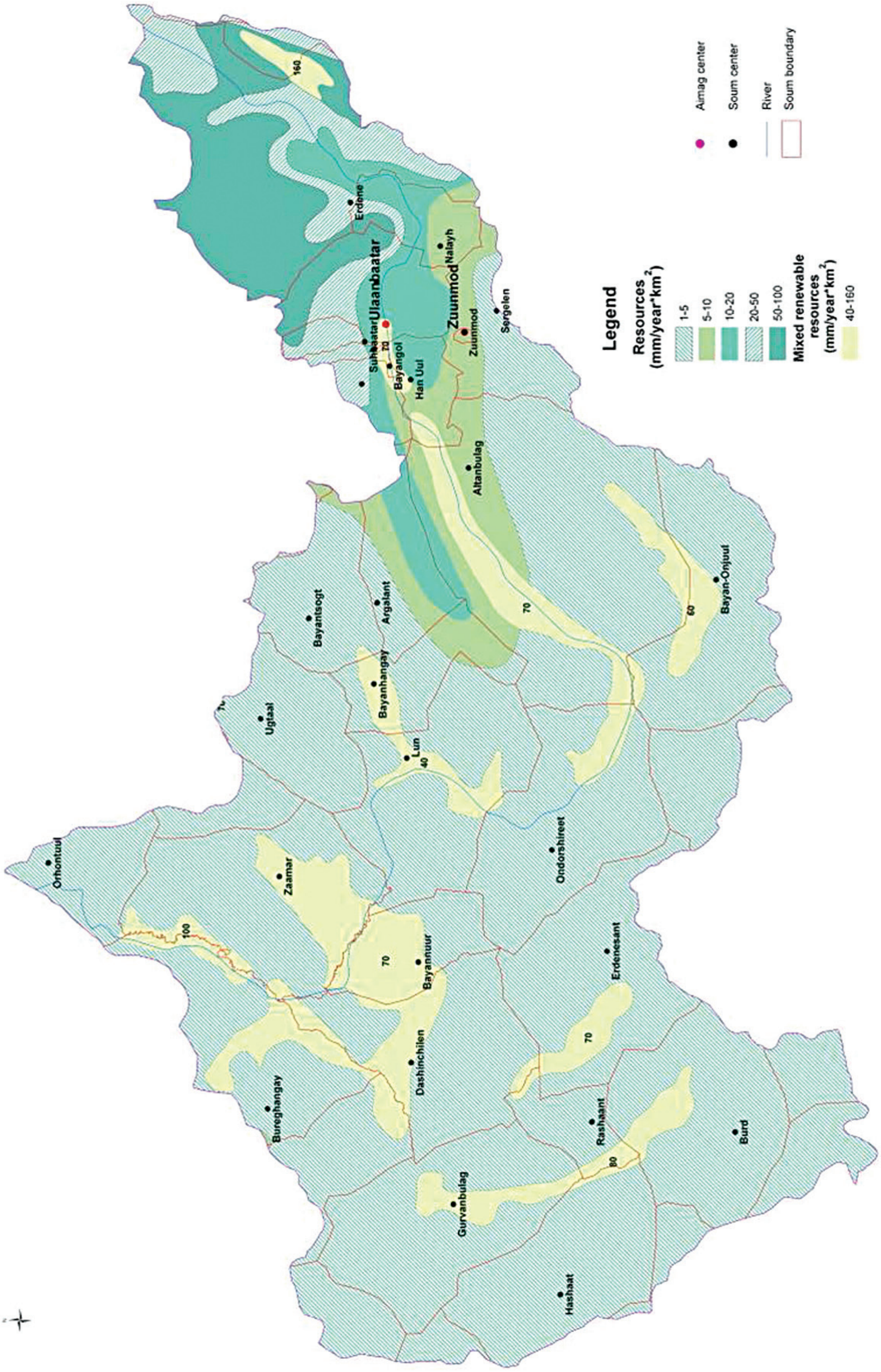


Figure 4. Renewable groundwater resources map of the Tuul River Basin

Table 4. Classification used in estimation of potential exploitable groundwater resources per unit area

№	Classification	Potential exploitable groundwater resources per unit area			
		fluctuation		Average in estimation	
		m³/year	*l/sec*	*m³/year*	*l/sec*
1	High	>315,360	>10	315,360	10
2	Medium to high	315,360 - 94,600	3-10	94,600	3
3	Medium	94,600 - 31,536	1-3	31,536	1.0
4	Low to medium	31,536 - 9,461	0.3-1.0	20,500	0.65
5	Low	9,461 - 946	0.03-0.3	5,200	0.165
6	Very low	946 - 94.6	0.003-0.03	520	0.0165
7	No water	<94.6	<0.003	95	0.003

In the Tuul basin the classification "basically no groundwater" takes into consideration 3 factors: (1) region without springs, (2) bare rocks and (3) permafrost mountaintops. Also areas with heavy conditions not accessible for drilling machines are included in this classification. The geology of this area dominantly comprises folded metamorphic, sedimentary and metamorphic-sedimentary rocks, and also intrusive rocks (for example part of intrusive massive rocks near Erdenesant), effusive rocks, effusive-sedimentary rocks.

Table 5 shows that on the area of the Tuul river basin of 49,774 km^2 a total of 641 million m^3/year (0.641 km^3/year) of potential exploitable groundwater resources are formed of which 596 million m^3/year or 92.9 percent of the total resources are formed in 20 percent of the total area.

Table 5. Potential exploitable groundwater resources

Index	Area *(km²)*	*l/sec*km²*	*m³/year*km²*	Resource *(mln m³/year)*
1	165.6	10	315360	52
2	3705	3	94608	351
3	6123	1	31500	193
5	246	0.65	20500	5
6	633	0.65	20500	13
7	1278	0.165	5203	6
8	2239	0.165	5203	12
9	49	0.0165	520	0
12	12879	0.0165	520	7
13	22456	0.003	94.6	2
Total	**49,774**			**641**

Table 5 does not include index numbers 4, 10 and 11 which means that there is not distributed water layer of this kind in this basin. These numbers shows to what type of aquifer and formation and also it is possible to see Potential exploitable resources of groundwater from map legend.

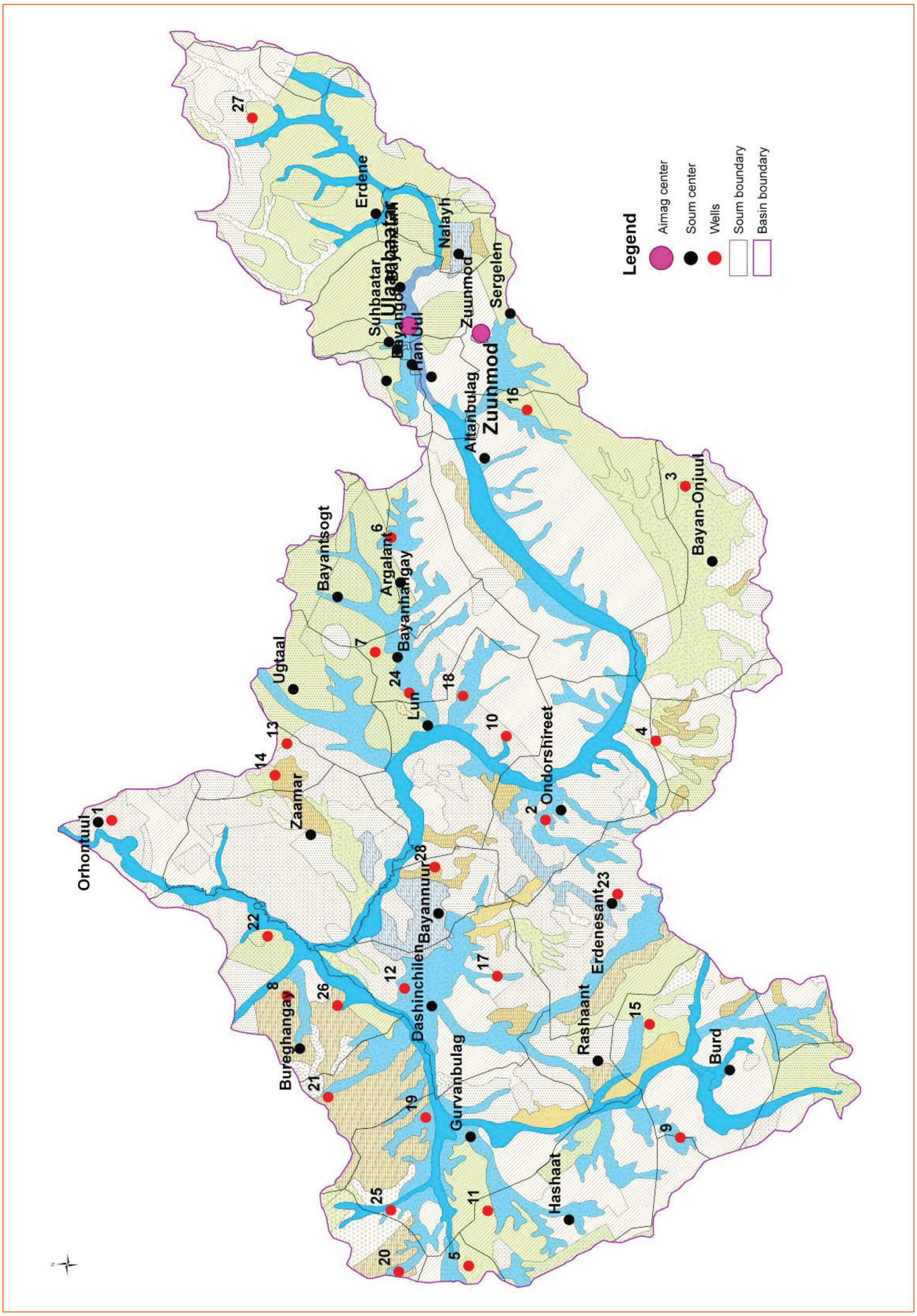


Figure 5. Potential exploitable groundwater resources map of the Tuul River Basin

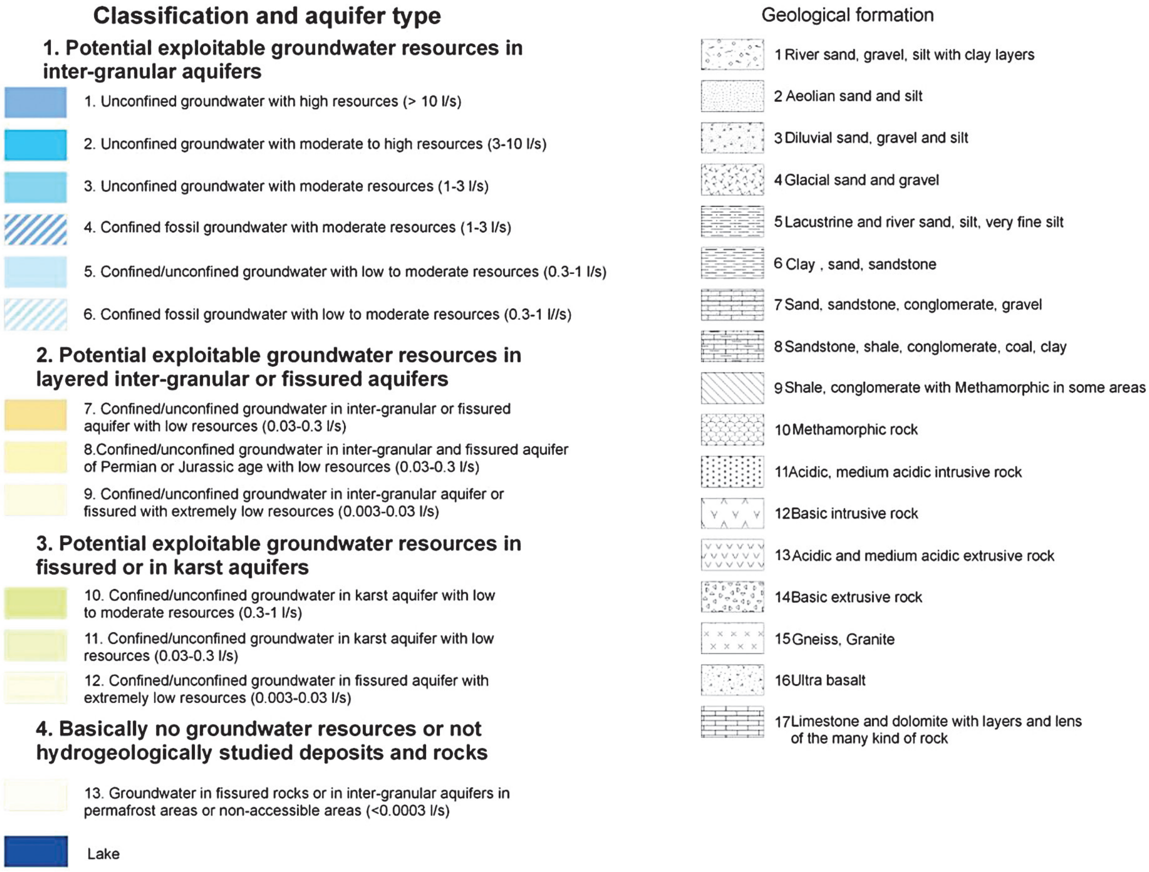


Figure 6. Legend of potential exploitable groundwater resources map

Table 6. Borehole data

№	Static level [m]	Mineralization [mg/l]	Drawdown [m]	Yield [l/sec]	Depth of water encountered [m]
1	48.0	0.9	14.0	2.0	70.0
2	16.0	0.4	1.0	4.0	
3	10.1	0.7	5.7	1.2	
4	17.0	0.3	15.0	2.0	
5	25.0	0.2	15.0	3.3	
6	35.0	09	6.0	3.3	
7	2.6	0.3	9.1	12.0	
8	67.5	0.4	1.4	2.7	
9	49.0	0.3	15.0	1.6	
10	16.0	0.4	16.0	2.0	30.0
11	22.5	0.7	10.5	1.0	39.0
12	5.0	0.3	6.3	1.8	
13	33.0	0.1	12.0	1.0	
14	0.2	0.3	4.0	0.7	
15	5.1	0.2	2.4	10.2	
16	41.0	0.4	1.0	6.6	47.0
17	4.8	0.3	0.5	2.0	
18	3.8	0.5	1.0	2.0	
19	3.5	0.2	0.5	6.6	
20	60.0	0.5	5.0	2.0	80.0

№	Static level *[m]*	Mineralization *[mg/l]*	Drawdown *[m]*	Yield *[l/sec]*	Depth of water encountered *[m]*
21	6.0	0.2	15.0	1.0	
22	33.0	0.3	7.0	1.3	
23	3.0	0.5	1.0	1.0	
24	52.0	0.4	9.0	2.0	
25	14.0	0.4	0.3	1.3	
26	1.0	0.3	1.0	1.0	
27	23.0	0.2	3.2	8.1	
28	25.0	1.0	2.0	1.0	

5.3. Exploitable groundwater resources

There are 20 soum centers and 2 cities: Zuunmod and Ulaanbaatar City located in this basin. Water exploration prospecting work for the purpose of water supply was executed in Ulaanbaatar and Zuunmod cities only.

There have not been any groundwater prospecting works for the purpose of water supply of the soum centers. The soum centers use well, river and spring water in everyday drinking water consumption depending on the soum location, the availability of surface- and groundwater and the water supply network. In most soum centers there are 1-2 wells for water supply of the population and for the water needs of organizations or entities and families in the soum center.

Table 7. Properties of soum center water supply wells and aquifers

№	Aimag	Soum	Drilled year	State number	Number of database code	Static water level, *m*	Dynamic water level, *m*	Specific yield, *l/sec*	Pumping yield, *l/sec*	Drawdown, *m*	Depth of well, *m*	Depth to top of aquifer 1, *m*	Thickness of aquifer 1, *m*	Depth to top of aquifer 2, *m*	Thickness of aquifer 2, *m*	Maximum permitted yield from one well, *l/sec*
1	Ovorkhangai	Burd	1971		84	9.5	16.0	1.2	8.0	6.5	92	15.2	5.6	22.8	3.2	1.7
2		Burd	1982		306	16.0	17.0	1.3	5.0	1.0	85	39	4	72	10	6.9
3	Tuv	Lun	1975	4102	75	13.0	14.0	7.0	7.0	1.0	50	22	9			Large resources
4		Lun	1989	9475	522	5.0	6.0	2.5	2.5	1.0	29	7	11	20	9	8.3
5		Lun	1988	9433	480	12.0	13.6	1.6	2.5	1.6	40	14	1	24	8	2.6
6		Bayan-Onjuul	1975	4120	90	23.0	43.0	0.1	1.0	20.0	50	33	7			0.6
7		Bayan-Onjuul	1984	7538	366	25.5	27.0	0.2	3.0	15.0	60	28	4	45	13	1.2
8		Ondor-Shireet	1978	5736	168	64.0	67.0	0.4	1.2	3.0	125	64	61			8.5
9		Ondor-Shireet	1990	9510	557	8.5	24.0	0.5	8.0	16.0	56	12	16	39	2	1.6
10		Altanbulag	1974	3317	59	10.5	26.0	0.1	2.0	15.5	61	41	10			1.6
11		Altanbulag	1989	9455	502	29.0	31.0	1.0	2.0	2.0	53	40	10			6.3
12		Argalant	1982			53.0	40.8	0.3	3.8	12.2	90	47	18			1.1
13		Argalant	1982			49.0	35.2	0.3	4.2	13.8	90	85	5			3.7
14		Bayankhangai	2009			37.0	64.0	0.1	2.0	27.0	70	38	12	54	6	0.5
15		Bayantsogt	1986	9375	423	35.0		0.6	4.0	6.5	69	40.5	19.5			4.7
16		Zaamar	1974	3322	58	15.0	23.0	0.3	2.0	8.0	52	28	14	44	6	1.2
17		Sergelen	1980	6196	228	29.7	30.7	1.3	1.3	1.0	58	30	28			11.0
18		Sergelen	1980	6197	229	29.5	30.4	1.6	1.4	0.9	56	41	10			10.1
19		Sergelen	1986	9359	408	24.0	32.0	1.0	8.0	8.0	61	40	3	50	5	3.6
20		Sergelen	1988	9431	478	35.0	46.0	0.9	2.5	2.7	65	46	8			5.3
21		Ugtaal	1979	6160	200	30.0	34.0	0.4	1.6	4.0	109	37	13	86	23	2.6
22		Ugtaal	1987	9395	442	22.0	36.0	0.7	2.8	4.0	60	42	10			6.3
23		Erdene-Sant	1982			35.0	48.0	0.2	2.5	13.0	73	48	4	51	8	1.4
24	Bulgan	Rashaant												Large resources		7.8
25		Gurvanbulag	1973	2635	71	4.0	8.0	0.3	1.2	4.0	50	6.1	47.9			4.5
26		Gurvanbulag	1978	4777	107	36.0	40.2	0.3	1.3	4.2	96	36	25	74	8.5	3.6
27		Dashinchilen	1974	3145	80	5.2	10.9	0.2	1.3	5.7	55	5.2	34.8	Large resources		7.5
28		Bayannuur	1982	6575	183	5.0	10.0	0.6	3.0	5.0	88	73	11			14.2
29		Bureg-Khangai	1976	3658	100	5.5	6.8	0.8	1.0	1.3	10	5.5	31.5			8.5
30		Khishig-Ondor	1989	6710	311	3.5	4.0	2.0	1.0	0.5	32	19	11			7.7
31	Arkhangai	Khashaat				12.0	19.0	0.6	4.0	7.0	56	25	5	Large resources		9.0
32	Selenge	Orkhon-Tuul	1965	956	67	4.8	5.0	16.6	3.3	0.2	73	7	23			Large resources

5.3.1. Exploitable groundwater resources of Ulaanbaatar City

There are 3 basic sources in Ulaanbaatar City: Central, Industrial and Meat Complex (Figure 7 and Figure 8), beside them there are centralized sources comprising 218 boreholes in total named Upper, Power Plant – 3 and Power Plant – 4. The approved exploitable groundwater resource of the municipal centralized sources is 278.4 thous. m^3 per day, but as of today 261.6 thous. m^3 is abstracted daily. In the ger districts, summer camps and industries with non-centralized supplemental sources 78.1 thous. m^3 is abstracted daily from 576 boreholes. In the whole city total abstraction is 339.7 thous. m^3/day from 794 boreholes total.

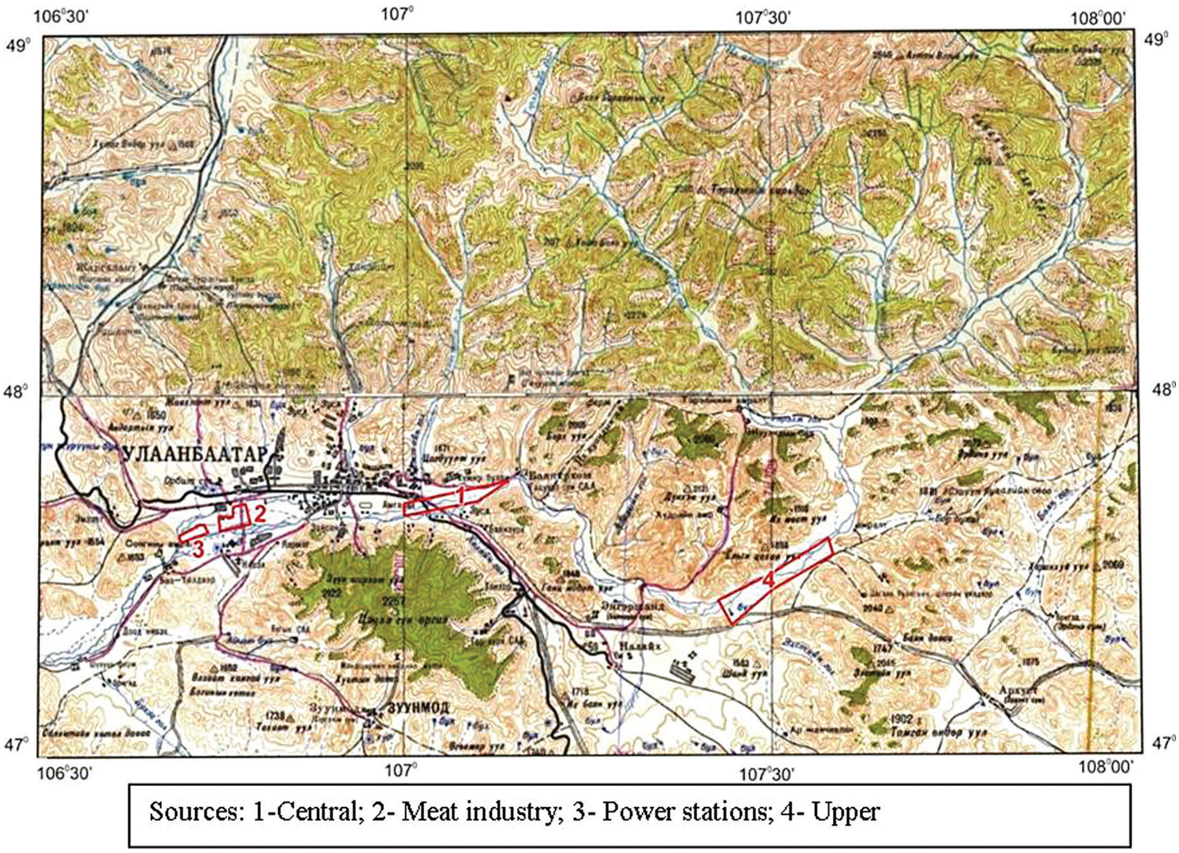


Figure 7. Location of central sources of Ulaanbaatar City

Location of boreholes in Central, Industrial and Meat Complex water supply sources of Ulaanbaatar city

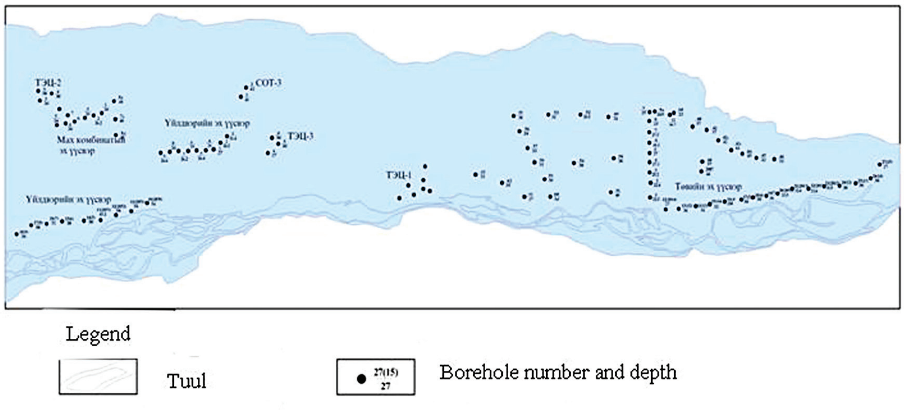


Figure 8. Location of water supply sources of Ulaanbaatar City (including power plant sources)

As of 2007 there are 96 wells in operation at the Central Source: № 1-9 and 12-27 wells (boreholes) were put into operation in the period 1961-1974, № 40-46, 48-51 and 52-63 wells were put into operation in the period 1980-1984 respectively. By decree number 7 dated 20th June, 1980 of the joint meeting of Mineral Resource Reserve Commission of the People's Republic of Mongolia and USSR /former Russian Federation/ it was officially approved as groundwater resource in alluvial aquifer in the wide part of the Tuul River near Ulaanbaatar City. Other deposits in the Tuul Valley which were approved later are: Yarmag, Sonsgolon, Buyant-Ukhaa new district, Confluence of Tuul and Uvur Gorhi, Confluence of Tuul and Terelj (Table 9).

Table 8. Exploitable groundwater resources in alluvial aquifer of the Tuul River near Ulaanbaatar City

Name of sources	Classification, resources (thousand m^3/day)		consumption, type of use (as recommended)
	A+B	C1	
Central	90.3	34.8	Domestic, industrial
Upper	89.7	-	Domestic, industrial
Industrial	30.3	-	Domestic, industrial
Meat Complex	8.6	-	Domestic, industrial
TES-1	3.5	-	Used in technical
TES-2	4.9	-	Technical use
TES-3	2.5	-	Technical use
TES-4	41.4	-	Technical use
Other	7.2	35.8	Technical use
Total	**278.4**	**70.6**	**Consumption, use**

(Approved by Mineral Resource Reserve Commissions of Mongolia and USSR)

Table 9. Recently studied groundwater deposits for water supply of Ulaanbaatar city

City	Deposit name	Resources, m^3/day
Ulaanbaatar	Tuul valley of Yarmag, Sonsgolon (2011)	26,201
Ulaanbaatar	Buyant-Ukhaa new district (2010)	22,550
Ulaanbaatar	Confluence of Tuul and Uvur Gorhi (2003)	11,750
Ulaanbaatar	Confluence of Tuul and Terelj (2007)	40,062
Total		**100,563**
Ulaanbaatar	Khui doloon khudag (2007); this deposit is located in the Kharaa river basin but can be used for water supply of UB.	3,845
Total		**104,408**

Taking into consideration the high risk of groundwater pollution in the delta deposits of the Selbe River it is necessary to deduct 24.0-34.8 thousand m^3 from the estimation of the Central Source as it is specified in 1980. Currently it is becoming clear, that groundwater is polluted in some boreholes of the Central Source (for example, boreholes located close to Narantuul market). The approved water resource volume of the central water supply of Ulaanbaatar City is impossible to be extracted, as explained by officials of USUG (the Ulaanbaatar Water Supply and Sewerage Company) to the population. Therefore, it is necessary to define the current situation in detail using boreholes and groundwater flow estimation.

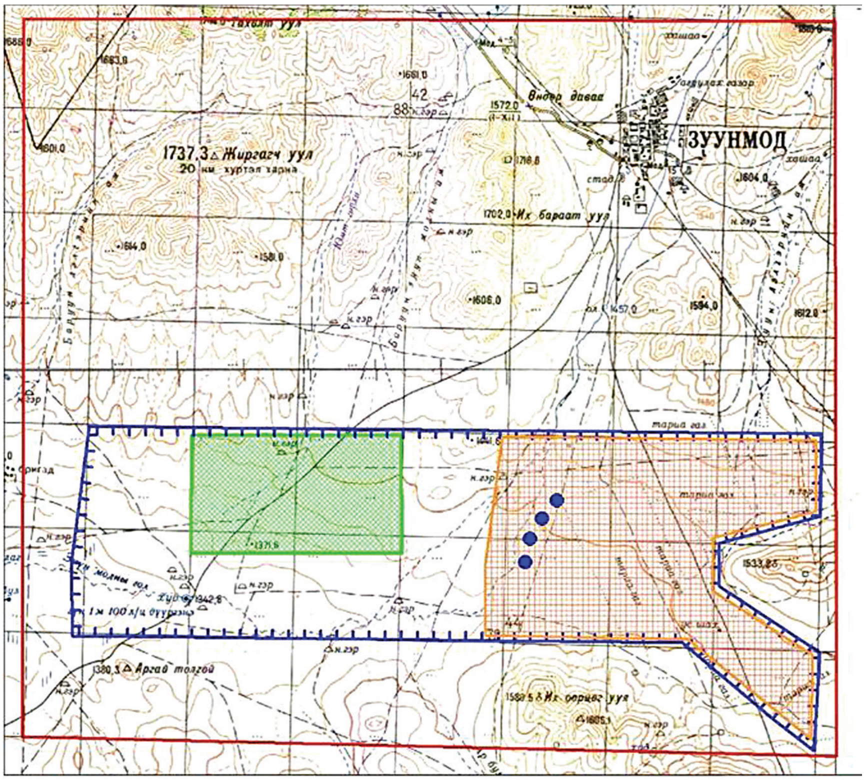
The groundwater utilization in Ulaanbaatar City and its districts was regularly increased during recent years and many new boreholes were drilled. As a result of studies provided by the Water Authority in 2005, 2010 and by other researchers for last years it is estimated that 339.7 thousand m^3 of groundwater is abstracted using around 800 wells in Ulaanbaatar City and its districts.

5.3.2. Exploitable groundwater resources of Zuunmod city

The water resources of the centralized water supply of the capital of the Tuv aimag named Zuunmod city is located in the Khoshig valley.

Zuunmod city has two kinds of water sources: central source and private wells. The central source is composed of exploitation wells in Khoshig valley and the prospecting work to define the water resources was done by Ch.Gombosuren in 1980 during which 13 prospecting-exploration boreholes were drilled. The groundwater resource was calculated as 3,695 m^3/day, in alluvial-proluvial deposits distributed in the Khoshig valley. As of 2009 680 m^3 per day is used from this central source. The wells of the central source and private wells have a yield which fluctuates between 0.7-18 l/sec.

In 2007 the east part of this deposit was reinvestigated during which 7 exploratory boreholes were drilled to a depth of 53.0-78.0 meters and 3 monitoring boreholes were drilled to a depth of 30.0 meters. The result of the investigation was a total of 6356.25 m^3/day (73,55 l/sec) of groundwater exploited resource by category A+B divided as 2619.79 m^3/day (30.31 l/sec) by category A and 3736.46 m^3/day (43.24 l/sec) by category B.



Legend

Hydrogeological research area in 1979-1980 for use of water supply source for

Hydrogeological research for new airport water supply in 2006-2007

Water utilizing area of current source of Zuunmod city central water supply and

Water supply wells of Zuunmod city centralized water supply

Figure 9. Overview of Khoshigiin khondii valley deposit of Zuunmod, Tuv aimag

5.3.3. Groundwater deposits

ln recent years by state budget financing prospecting work on groundwater resources was done and re-evaluation was made in Khoshgiin khondii valley and at Khui doloon khudagt of the Tuv aimag. Also prospecting works were done in the valley of Ovor gorkhi, arm of the Tuul river basin and the Terelj-Tuul river confluence with the purpose to increase the water supply of Ulaanbaatar city.

Ar Janchivlan is a mineral spring deposit and a study was done to use the mineral spring water for the purpose of treatment.

Table 10. Registration of groundwater deposits with approved resources

№	Aimag	Name of deposit	Resource, m^3/day
1	Bulgan	Rashaant	678.2
2	Arkhangai	Khashaat	776.92
3	Tuv	Zuunmod /1979, 2007/	4500, 6356.2
4	Tuv	Ar janchivlan	96.36
5	Tuv	Arguitiin river	16606
6	Ulaanbaatar	Confluences of Tuul river and 'Ovor gorhi' or South stream	11750.4
7	Bulgan	Dashinchilen	7.5
8	Ulaanbaatar	Terelj and Tuul valley	40061.9
9	Ulaanbaatar	Buyant-Ukhaa new district	22550.42
10	Ulaanbaatar	Tuul valley of Yarmag, Sonsgolon	26201

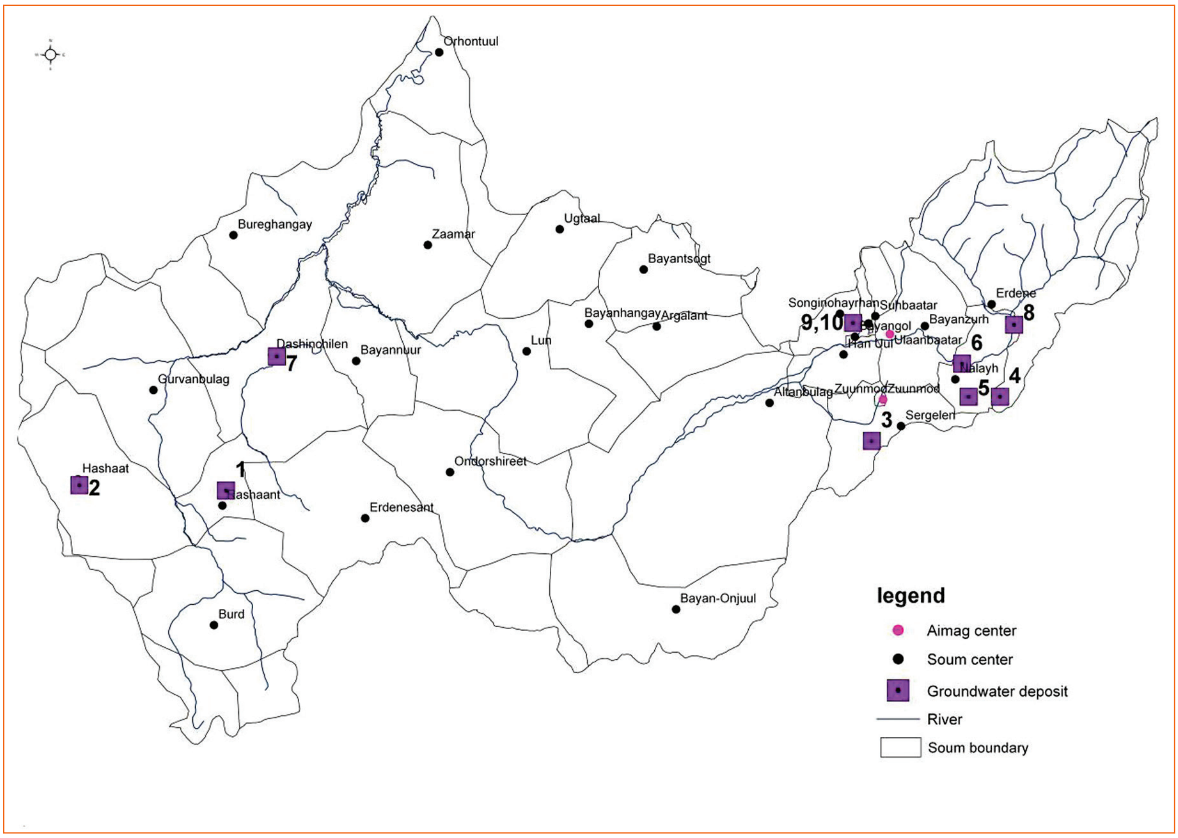


Figure 10. Location map of groundwater deposits

6. Groundwater monitoring

6.1. Previous research

The study of the groundwater regime on regional level is made by processing hydrogeologically relevant information about the basic concept of the water regime, its protection and rehabilitation, the ecological changes in the area, the impossibility to restore its natural environment, the deficit of water caused in very short time by human activity and the possible pollution of the resources and water layers, the necessity to calculate its vulnerability, the geological boundaries and the estimation of its recharge condition.

The study of the groundwater regime involves the measurement of regime elements such as groundwater level, groundwater chemical composition and temperature.

The study of the groundwater regime in scientific research work in the period until 1991 was implemented by classification of natural condition regime, destroyed regime and mixed regime. All monitoring data and information taken from the observation of the groundwater regime in local areas, cities, provincial centers and soums has been recorded in observation books submitted for document processing and work reports. But after 1991 the named observation group was joined with the groundwater sector of the Institute of Water Policy under the Ministry of Natural Environment which submitted 3-year work results in reports until 1991.

The study of the groundwater regime was impossible to be financed after 1991 and therefore in frame of the contractual work of the Ministry of Natural Environment the study of the groundwater regime was done by the Institute of Water Policy in the period 1996-1998 only near the water supply sources of Ulaanbaatar City and after 1997 to 2000 research work was interrupted. Since 2001 the Institute of Geo-Ecology under the Mongolian Academy of Sciences observed and studied groundwater level fluctuation in natural and damaged regime of groundwater near the water supply sources of Ulaanbaatar City" in the thematic program of "Regularity and ecological changes of groundwater regime" of the project "Fundamental study of water resource and ecological protection of Mongolia" implemented in the period 2001-2004.

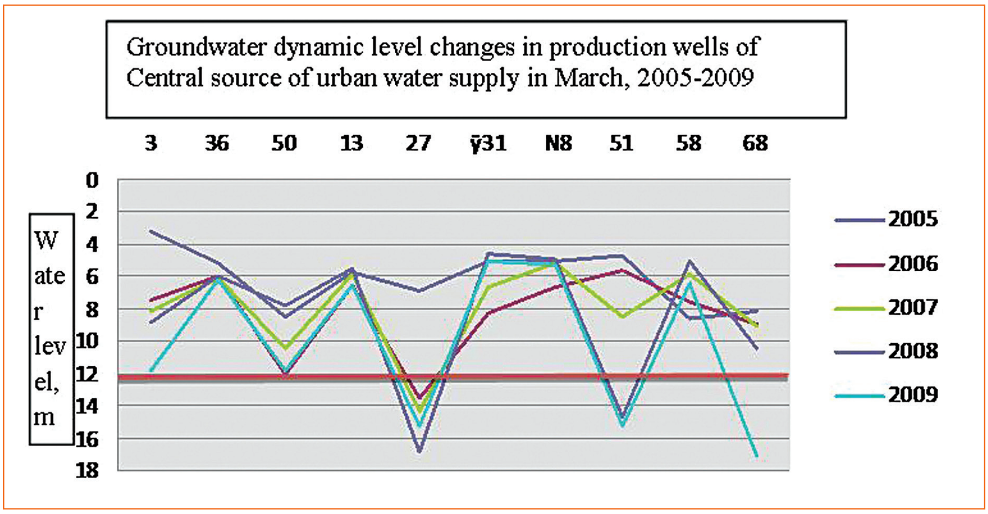
6.2. Research of groundwater regime at Ulaanbaatar City water supply sources

The first study at Ulaanbaatar City was done in 1946 to 1948 by K.I.Gomaniko (specialist of USSR) on 58 wells located at different levels with a result that fixed water level fluctuation (amplitude A=1.6m) at 1.6 meters. After this the Russian Hydro-project Institute (R.A.Kriger, 1961) studied in the period of 1959-1960 and determined that the annual amplitude of groundwater level fluctuation at the Central Source was 1.0-1.3 meters on the west terrace of Tuul river and was 1.8-2.4 meters near the river mid bed and increased to 2.1 meters.

The groundwater level in the alluvial deposits of the Tuul river valley decreased 1-2m since 1959-1960 due to the abstraction of water for drinking water supply and technical water supply.

By results of water regime observations made by the expedition of the PNIIS Institute of the Russian Federation in the period of 1979-1980 the amplitude of groundwater level fluctuation was (A) 2.7 m and by result of water regime observations made by Geo-Ecology Institute (GTserenjav, D.Unurjargal) in period of 1997-1998 amplitude of groundwater level fluctuation was (A) 3.1 m and prognosis it will be 3.7 m in 2020, 4.6 m in 2050. It means that the groundwater drawdown in the production wells of the urban water supply sources will be increased during the normal and middle water supply period and that the groundwater will be exhausted in 2050. In addition water scarcity will arise in short time if water probability will decrease up to 95 percent and water scarcity disaster may arise possibly in one year [5].

In wells with damaged sub-regime condition at the Central Source for water supply of Ulaanbaatar measurement of groundwater level changes were made in 10 wells, the measurements as of 2005-2009 are shown in Figure 11.



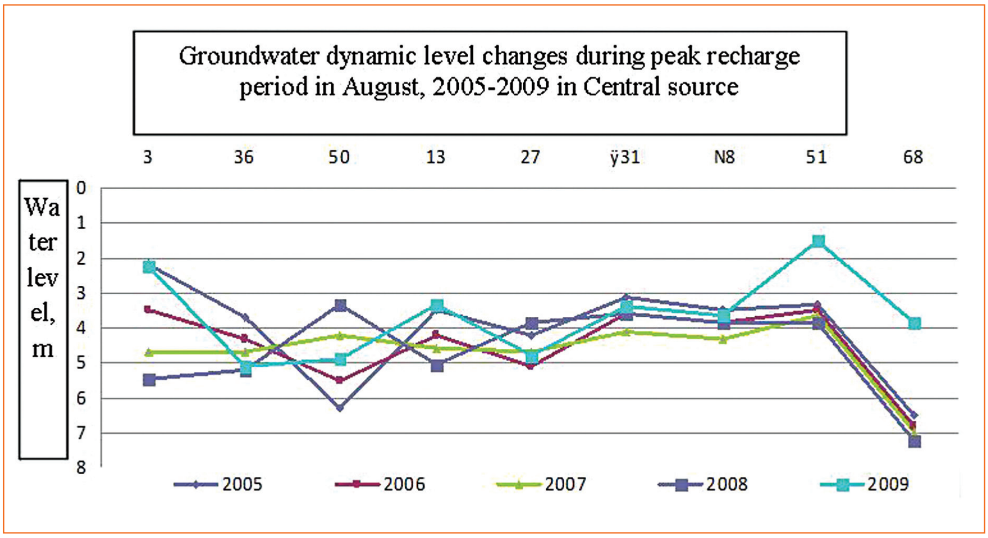


Figure 11. Dynamic and static groundwater level of Central sources wells (2005-2009)

From the graph in Figure 11 it may be concluded that:

- the groundwater table was lowered to 7.5-16.3 m below ground level in production wells during the period with no groundwater recharge in March of 2005-2009;
- the groundwater level increased to 1.5m below ground level during peak period of groundwater recharge
- groundwater level decreased in maximum level until 16.3m in 2005-2009.

The results of the data interpretation by Geo-Ecology Institute (GTserenjav, D.Unurjargal) indicate:

- The drawdown of the groundwater level is relatively less in the first pumping production wells which are located along the Tuul River. The groundwater drawdown was 4.1-10.07m in the production wells №12, 14, 17 at the beginning of the recharge period in March and April, 2001 and groundwater drawdown reduced to 1.3-2.05m during the peak recharge period. The groundwater drawdown increased to 7.68-9.51 m at the beginning of the recharge period in 2003 and reduced to 1.21-2.12 m during the peak recharge period in 2003.
- The drawdown of the groundwater level increases in the production wells located in a perpendicular position to the Tuul River. The drawdown increased to 8.16-10.6 m at the beginning of the recharge period in March and April, 2001 in the production well №5, and the drawdown reduced to 4.15-3.01m in the peak recharge period in 2001. The groundwater drawdown increased to 9.02-10.03 m at the beginning of the recharge period in 2003, and reduced to 5.15-4.034 m during the peak recharge period in 2003.
- In the production wells No 30, 32 located far away from the river, the groundwater drawdown increased to 13.14-13.28 m at the beginning of the recharge period in March and April, 2001, and the groundwater drawdown reduced to 5.56-7.24 m during the peak recharge period in 2001. The groundwater drawdown increased to 12.91-14.14 m at the beginning of the recharge period in 2003, and reduced to 6.2-6.06 m during the peak recharge period in 2003.

6.3. Current monitoring of groundwater resources for water supply

The largest consumption of groundwater in Mongolia takes place in Ulaanbaatar City with it's high industrial and human density area. Therefore the water supply sources of Ulaanbaatar City, including the technical water sources of Power Plant 3 and 4, should be under regular control and its water level monitoring points should be subjected for measurement work regularly. At the moment monitoring of groundwater levels is done by USUG (3 boreholes), Geoecology Institute (4 boreholes), MUST (2 boreholes) and Water Authority (2 boreholes).

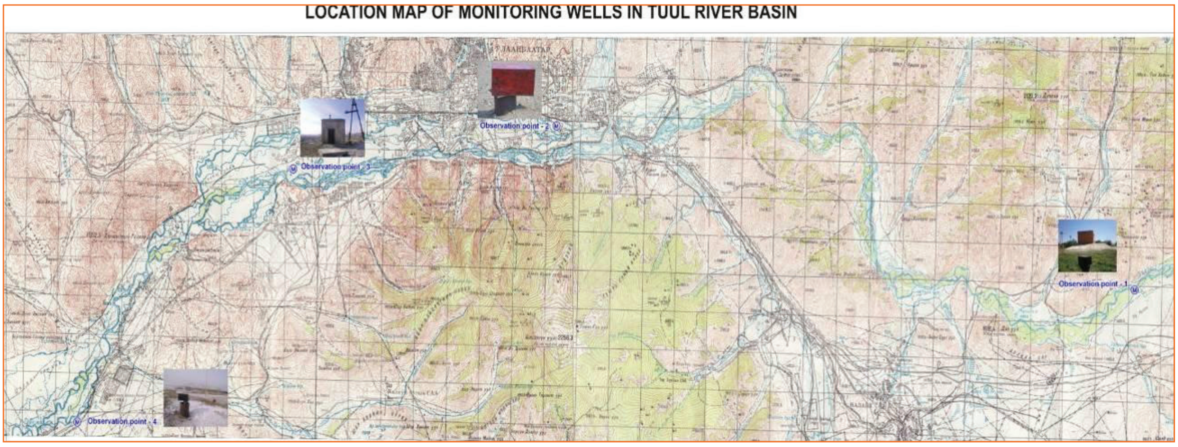


Figure 12. Point location of currently working monitoring observation (Geo-ecology Institute)

6.4. Monitoring boreholes in frame of the project

In the frame of the “Strengthening Integrated Water Resource Management in Mongolia”-project as implemented by the Water Authority monitoring of groundwater is implemented in the pilot basin of the Tuul River in 6 boreholes equipped for observation work. Automatic loggers are installed to measure the water level in these wells. The measurement data should be collected every 3-6 months. When visiting the borehole water level must be measured and optionally a water sample may be collected to analyze the groundwater quality.

Table 11. Registration of groundwater monitoring wells in the Tuul basin

№	Province and city	Soum	Well depth m	Measurement start date	Coordinate	
					X	Y
1	Ulaanbaatar north	Central source	25	2011.02.16	106°58'21.6"	47°54'13"
2	Ulaanbaatar south	Central source	25	2011.06.14	106°58'24.4"	47°53'57"
3	Tuv	Altanbulag	41	2011.08.26	105˚56'40.7"	47˚32'45.3"
4	Tuv	Lun	35	2011.08.26	105°11'47.4"	47°51'21.2"
5	Bulgan	Dashinchilen	23	2011.06.03	104˚01'46.7"	47˚53'14"
6	Ovorkhangai	Burd	50	2011.01.19	103˚46'59.5"	46˚58'42.2"

Figure 13. Location of monitoring boreholes in the Tuul river basin

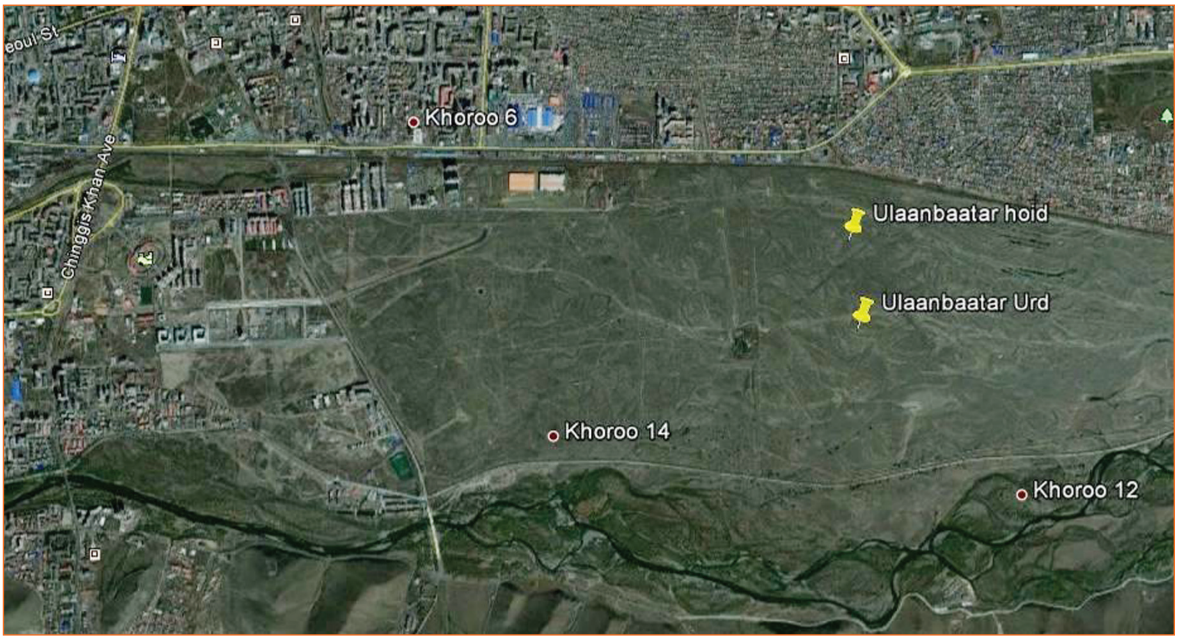


Figure 14. Location of monitoring boreholes in the Ulaanbaatar

The measurement data obtained from the monitoring well established in the Central Source of Ulaanbaatar City shows that the groundwater level was decreasing in the period of December-May and increasing in the period of May-August because the recharge from river and rain. Groundwater level was decreasing very small in August-December. In this period abstraction and recharge were almost in proportion in both wells.

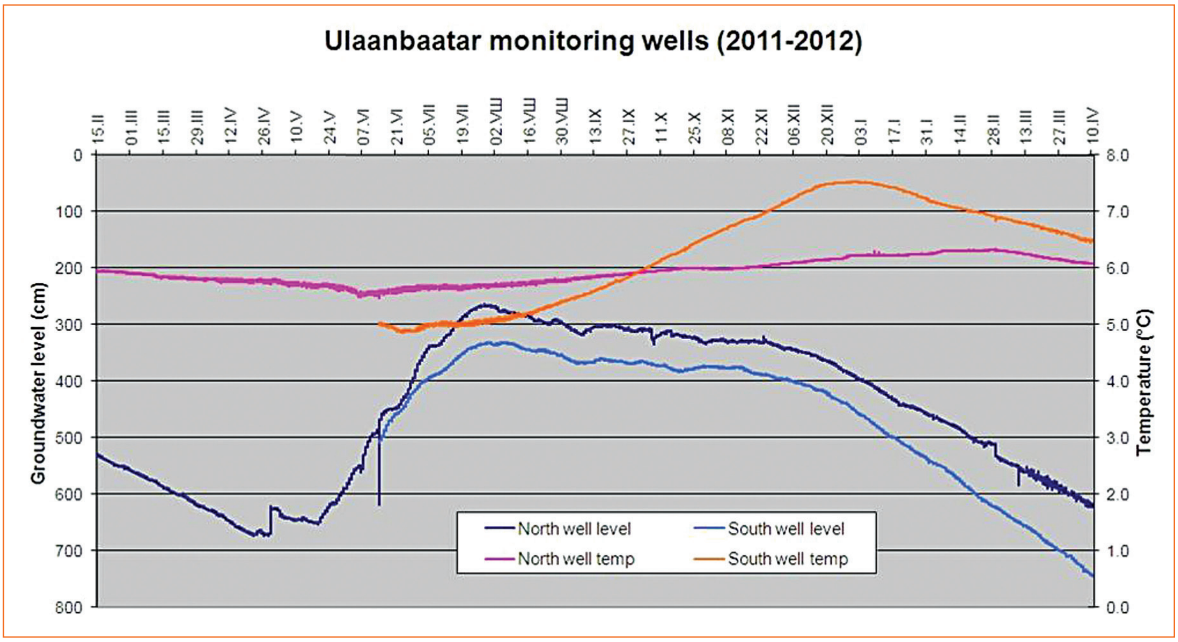


Figure 15. Data from monitoring boreholes located in Central Source of Ulaanbaatar City

The temperature in the north well was less variable than in the south well. The South well is located near the river and the variation in the temperature probably is due to the recharge from the river.

7. Issues of strengthening integrated water resources management

With a purpose to extend duration of boundary 1st condition of aquifer formation in alluvial deposit of Tuul river valley it is necessary to build dike cascade knitting in small part Tuul river or to develop preliminary documents related to exploitation of surface water and energy due to what to build the bigger dam to knit Tuul river, to find a new resource of less reserve providing prospecting-exploration work on Gatsuurt, Selbe, Tolgoit, Deendii river valley.

By line of the Millennium project with a purpose to develop farming around Ulaanbaatar City it is implementing project works to bore wells with yield capacity of 0.6 l/sec in minimum (2160 l/hour or drinking-bowl for 150-200 cow-herds within 2 hours). All these activities probably are reflected in integrated management plan.

To implement the National “Water” Program it is considered to elaborate the “Integrated Water Management Plan” of whole Mongolia and 29 basins. Below some recommendations related to groundwater are provided for the “Integrated Water Resources Management Plan” of the Tuul River Basin in frame of the implementation of the National “Water” Program.

In the frame of protecting groundwater used as water supply resource:

1. To survey of current condition of water supply resource of Ulaanbaatar and Zuunmod cities in 2012
2. To provide a study to establish new protection and infiltration zones of these resources in 2012
3. To determine the regime adhered to take region and zones under protection in 2012
4. To develop and implement measures to limit negative effect of activities in protection and infiltration zones of water supply resources of Ulaanbaatar and Zuunmod cities, to define its location and scale in period of 2012-2014
5. To implement design projects to furnish and protect drinking water and spring resources around Ulaanbaatar and Zuunmod cities including their affluent rivers in period of 2011-2015
6. To improve and protect the springs and yield continued in frame of implementation of design works and projects to protect yield of 20 springs in provinces located in Tuul river basin where to take measures on its modernization in period of 2016-2021.
7. To put into the integrated water fund of Hydrology Authority materials and data of prospecting research works on groundwater deposits kept in the Geological Fund
8. To provide mapping of groundwater in Tuul river basin in scale of 1:200,000
9. To prepare detailed data of all wells drilled in the area of Ulaanbaatar City to be registered in State water information fund in cadastre
10. To obtain accurate measurements of annual groundwater use and to carry out regular monitoring on water resources of Ulaanbaatar and Zuunmod cities to operate groundwater model using this data.
11. To carry out research study in places that have insufficient data as of today and have no water quality information of groundwater resources.
12. Should prepare the National groundwater program, set up national groundwater network

8. Used publications

1. Published reports and materials of groundwater deposits and unpublished reports of hydrogeological studies available from geo-data centre fund of the Mineral Resource Authority 1932-2009.
2. N.N.Bindeman, L.S.Yazvin, "Assessment of groundwater usage resource" (methodology handbook). Publication "Nedra", M, 1970.
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4. G.Dolgorsuren, Project leader, Water database of Tuv, Selenge, Arkhangai, Bulgan and Uvurkhangai aimags, Ulaanbaatar, Geoecological Institute, 1996-1998.
5. N.I.Drobnokhod, L.S.Yazvin, B.V.Borevskii, "Instruction of methodology by hydrogeological map in closed territory with a scale of 1: 500,000, 1:200,000 and 1:50,000, Publication "Nedra",M, 1968. "Assessment of groundwater resource" Publication "Visha school", Kiev, 1982.
6. N.Jadambaa, Ch.Javzan and et al, "Study of reverse impact on environment from mining activities" Mission report of the Parliament. Instruction by usage classification of drinking, industrial and terminal groundwater resources, Ulaanbaatar, 2005.
7. Methodology recommendation on resource classification and forecast of drinking, technical and mineral groundwater resources. "Methodological guidance" approved by the resolution No.69 of Minister of Natural Resource, Russia in 2007.
8. "Methodology to make a design and calculation of the map for groundwater resources by using overall basins in Mongolia", 2010.
9. "Geology and Mineral Resources in Mongolia" serial literature Vol.4 and 8. "Lithosphere tectonic plate", Ulaanbaatar, 2009.
10. Hydrogeology Map of Mongolia. Scale 1:1,000,000, Ulaanbaatar, Hannover, total of 14 pages, 1996.
11. D.Unurjargal, L.Janchivdorj, P.Bayarmaa, "Grounwater Monitoring Assessment" report, Ulaanbaatar, Geoecological Institute, 2010.

ANNEX 1. Explanation of groundwater terminology

Hydrogeological definitions

Aquifer:	a geologic formation, group of formations, or part of a formation that can store or transmit water in sufficient quantities and which is capable of yielding a significant amount of groundwater to wells or springs.
Intergranular aquifer:	an aquifer composed of loose or compact grains (sand, gravel or clay) in which the groundwater is stored in the pores between the grains.
Fissured aquifer:	an aquifer composed of hard rock in which the groundwater is stored in cracks, fractures or fissures.
Confined aquifer:	an aquifer bounded above and below by confining units with a distinctly lower permeability than that of the aquifer itself.
Confined groundwater:	groundwater stored in a confined aquifer which when penetrated by a well or borehole will rise above the top of the aquifer (also called artesian water)
Unconfined aquifer:	an often shallow aquifer with a phreatic (free) groundwater table
Unconfined groundwater:	groundwater condition in which the upper surface of the zone of saturation forms a water table under atmospheric pressure (also called phreatic groundwater))

Definitions groundwater resources

Renewable groundwater resources are groundwater resources which are replenished on average every year by infiltration of precipitation, by infiltration of surface water or by flow from adjacent groundwater aquifers or reservoirs.
Synonyms used: natural groundwater resources

Non-renewable groundwater resources are groundwater resources created in the past which in modern times do not receive recharge from infiltration or groundwater flow.
Synonyms used: fossil groundwater

Potential exploitable groundwater resources are groundwater resources which may be abstracted from renewable and/or non-renewable groundwater resources taking into account the dimension (area, saturated thickness) and the properties (intergranular, fissured) of the aquifer, the recharge to the aquifer and the estimated capacity of the proposed wells.

Exploitable groundwater resources are groundwater resources which may be abstracted from the potential exploitable groundwater resources in a restricted area taking into account the possible number and the properties of the boreholes used to abstract the groundwater.

The sequence in which the *renewable* groundwater resources, the *non-renewable* groundwater resources and the *exploitable* groundwater resources are considered in the assessment of the groundwater resources is indicated in Figure 16.

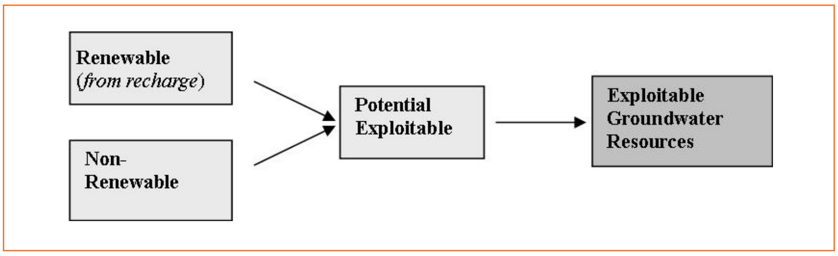

Figure 16. Sequence considered in the assessment of the groundwater resources

The calculated *exploitable* groundwater resources volume takes into account the conditions under which groundwater can be abstracted. Therefore the exploitable groundwater resources in a river basin are always smaller than the *renewable* and *non-renewable* groundwater resources. The *exploitable* groundwater resources are available annually:

- In areas *with renewable* groundwater resources for an indefinite period;
- In areas *without renewable* groundwater resources for a limited period only until the resources are depleted.

The planning of groundwater exploitation should always use the estimate of the *exploitable* groundwater resources volume.

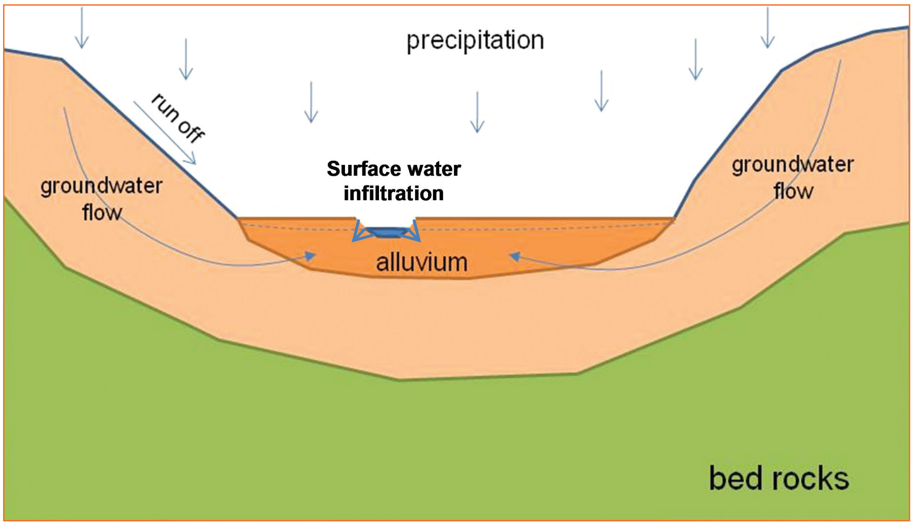

Figure 17. Renewable groundwater resources in an unconfined alluvial aquifer: recharge by infiltration of surface water and precipitation and groundwater flow from adjacent areas

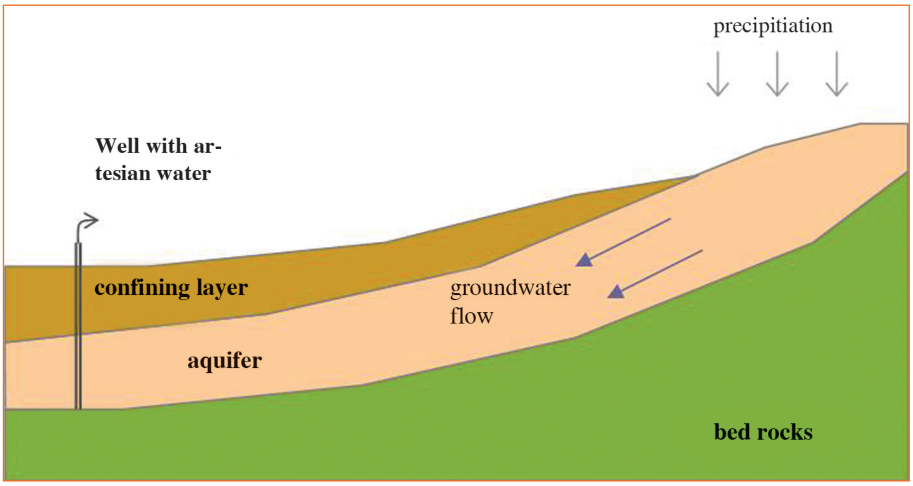

Figure 18. Groundwater resources in a confined aquifer: recharge by infiltration of precipitation in distant elevated area and groundwater flow to aquifer in low lying area

The groundwater resources in a confined aquifer are considered *renewable* in case groundwater flow recharged by current infiltration from precipitation is significant and are considered *non-renewable* in case groundwater flow recharged by current infiltration from precipitation is insignificant.

Class A, B and C groundwater resources

Groundwater exploitable resources are the resources which are estimated by preliminary and detailed exploring work, including prospecting and assessment, reviewed and approved by the authorized organization. According to the definition in article 3.1.10 of the Water Law, the potential and exploitable resources can be understood as similar with groundwater exploitable resources. As for Mongolia before 1990, hydrogeologists calculated groundwater exploitable resources of groundwater deposits by industrial categories - A, B, C1 and by non-industrial or forecast category C2 according to Russian old instructions. But in 2007 Russia already changed the old instruction and Mongolia does not have any new instruction yet. At present situation under categories A, B and C1 of groundwater potential exploitable resources (reserve) we are suggesting the following:

A. As for Class A estimation, it is necessary to conduct groundwater abstraction for 3 or more years and the average productivity of the pumping facility in the last 3 years will be included in class A.

B. As for Class B estimation of the groundwater potential exploitable resources, a network of drillings will be used with distance between drillings of 200-1000 m in intergranular aquifers, 150-800 m in fissured aquifers. If groundwater resources are considered as Class B, all the yields shall be determined by a single experimental pumping test, some part shall be conducted the package or group pumping test.

Parameters of granular and fissured aquifers such as lithology, thickness, distribution border and boundary of aquifer system and the water pressure and water level will be determined by exploratory drilling; and hydrogeological calculation parameters will be determined by graph-analytic method (Cooper-Jacob, Theis) and steady state and unsteady state groundwater flow formulas, using results of experimental pumping.

C. For estimating the groundwater with Class C1 or C2, a network of drillings will be used with distance between drillings of 400-1000 m in intergranular aquifers, 300-800 m in fissured aquifers, 300-1200 m in one direction tectonic break zones or border and edge zone. The yield of Class C1 groundwater resources will be determined with a single pumping test. Parameters such as lithology, thickness, distribution border and boundary of aquifer system and the water pressure and water level will be determined by exploratory drilling; and hydrogeological calculation parameters will be determined by graph-analytic method (Cooper-Jacob, Theis) and steady state and unsteady state groundwater flow formulas, using results of experimental pumping.

Part 4.
WATER QUALITY AND ECOLOGY

Prepared by: B.Odsuren[1],
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Consultants: G.Dolgorsuren[2], Ph.D
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Introduction

The Tuul river basin occupies 3.2 percent of the Mongolian territory. Half the national population lives in this basin and take their drinking water from here. Ulaanbaatar City is established in the valley of the Tuul River. The water supply of the City derives its water from the shallow alluvial aquifer. The growth of the population and the pressures caused by human activities in the basin are increasing. These cause many changes to the surface water and groundwater quality and to the ecological condition of the basin.

The Tuul river natural and flow regime are disturbed and the river water is becoming polluted. It is necessary and important: to protect the Tuul river basin water resources from pollution and scarcity; to improve the prevention of negative effects from human activities; to decrease environmental damages and to provide an ecological balance. In order to plan and develop measures to determine the Tuul river basin water pollution level and to prevent scarcity and pollution, an integrated water resources management plan of the Tuul river basin needs to be prepared.

Developing an integrated water resources management plan of Mongolia is a vital component of the "Strengthening Integrated Water Resources Management in Mongolia" project. The integrated water resources management plan of Mongolia determines the technical and economical options to supply the future water demand of the socio-economic sectors and defines the water resources.

Within the framework of the project, the required data was collected, analyzed and assessed in order to develop the "Water Resources Management Plan of Tuul River Basin".

This part covers the Tuul river basin water quality and its changes; the main causes of the environmental degradation; the climate change effects on water quality and environmental services and a vulnerability assessment of the groundwater. The recommendations and guidance on limiting the ecological loss and decreasing the negative impacts on the ecosystem caused by humans (which are based on the assessment of these subjects) have been developed and included in this part.

Chapters 2 and 3 were prepared by B. Odsuren of the Institute of Geoecology. Chapters 4 and 5 were prepared by the project team member Julien Demeusy. Chapter 6 on aquifer vulnerability was prepared by the project team member B. Ulzisaikhan.

1. Data and information

The main objective is to determine the Tuul river basin surface water and groundwater chemical components, features, pollution and their changing regime and to define measures to protect from pollution and improve the water quality which will be included in the Water Resources Management Plan of the Tuul River Basin.

The following goals have been recommended in order to implement this objective. They are:

1. Collecting required data and materials for research work and analyzing previously conducted analysis' results;
2. Analyzing Tuul river water chemical components, features and pollution and outlining its changes;
3. Defining groundwater chemical components and current quality level in and around Ulaanbaatar city;
4. Defining groundwater pollution in and around Ulaanbaatar city
5. Analyzing chemical components and pollution of water supply sources of aimag and soum centers which are located in the Tuul river basin

In this report are included the Tuul river, all districts of Ulaanbaatar City and the 24 soums with territories in the Tuul river basin of Tuv, Arkhangai, Uvurkhangai, Selenge and Bulgan aimags.

Many scientists conducted researches on the water quality of the Tuul River. For example: N.Tsend, A.Munguntsetseg, G.Tuvaanjav, Ch.Javzan and J.Ariunjargal. These scientists wrote in their research works that river water components start to change from somewhere near Ulaanbaatar and pollution increases due to human activities.

The Tuul river hydro-chemical researches have been conducted since 1970's or in other words, from the time when the water research laboratory of the Geo-ecology Institute operated as "Central Chemical Laboratory of Hydrochemistry". Between 1980 and the mid 1990's, monitoring points were established along the river length and samples were taken and analyzed each month. During the last few years, many activities, international projects and contract works related to Tuul river research, have been implemented. For example:

1. Scientific and technological project "Mongolian Water Resources and Complex Research to Protect and Study Its Ecology" (2000-2004)
2. Contract work called "Ecological Study of Tuul River Water Environment", which was conducted by the order of "Khustai National Park" center (2003-2004)
3. "Using Stable Isotope for Water Ecosystem Assessment" project which are being implemented on the Tuul river example with the cooperation of Ecological Study Center of Kyoto University of Japan, (still continues since 2003)
4. Ecological monitoring and research contract work of "Altan Dornod – Mongol" LLC gold mine (till now since 2003)
5. "Water Resources and Water Environment Ecological Research of Big River Basins" (2005-2007)
6. "Integrated Water Resources Management of Selenge River Basin" project, by the cooperation of Environmental Institute of the Republic of Korea and the

Natural Resources Use Institute of Buryatia (2008-2011)

7. "Tuul River Integrated Water Resources Management Modeling, Water Environment Ecological Research" scientific and technological work (2008-2010)

These works have been implemented and conducted Tuul river hydro-chemical and pollution research. The Central Laboratory of Environment takes samples from chosen points in the Tuul River each month and analyses them. Groundwater in the Tuul river aquifer is relatively well studied. The component and water quality research of the Ulaanbaatar city centralized water supply sources were conducted by Soviet experts in the years 1956-1960, 1968-1975, 1977-1984 and by Japanese experts between 1993 and 1996.

In 1986, G.Tuvaanjav, a researcher, conducted research on water reservoir kiosks' water near central sources and Uildver Kombinat.

Water analysis of kiosks near the city was conducted by the Hydro-chemical central laboratory of Water Policy Institute until 1989. The research work was almost abandoned between 1990 and 2000. Between 1996 and 1998, research was conducted monthly at 24 boreholes along the Tuul River. In 2005, water samples were taken and analyzed from 33 boreholes of Ulaanbaatar city districts.

The research works, relevant to this report, are shown below.

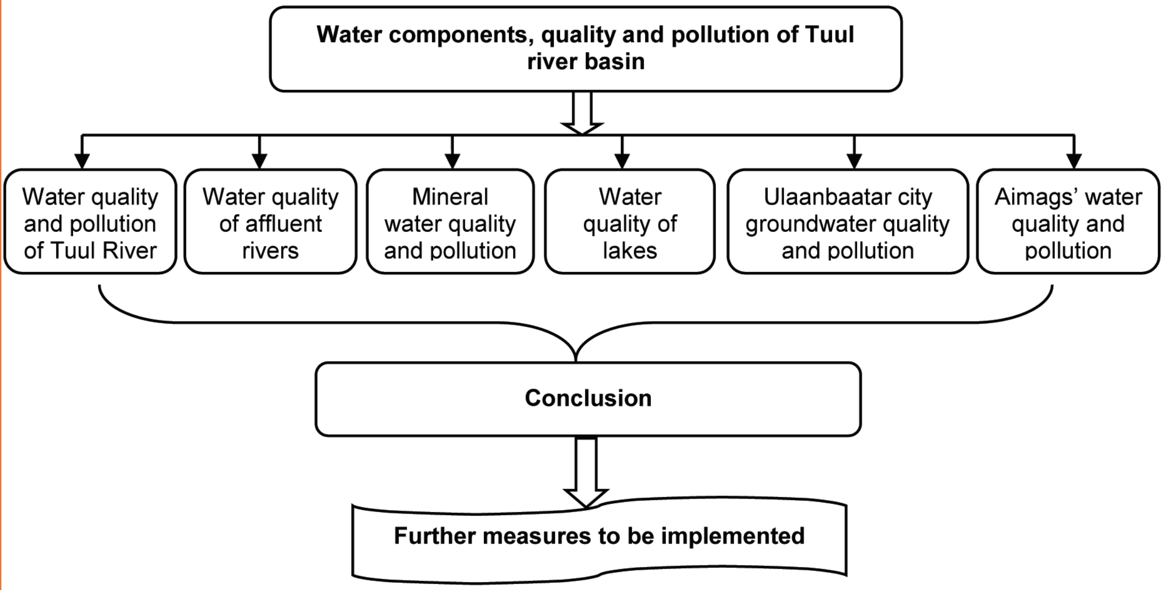

Figure 1. General scheme of research work

When processing the research results, the following comparisons were made: river water chemical components and quality were compared to the "Water environment quality parameter MNS 4586-98" standard (see Annex 1) and "Freshness level classification norm of surface water" (see Annex 2); wastewater discharging to Tuul river was compared to "Water quality. Effluent standard. MNS 4943: 2000".

Groundwater chemical components and quality was compared to the general standard MNS 4943-2011. Drinking water was compared to the standard to protect environment and health MNS 0900:2005.

A.O.Alyekin's classification was chosen out of many classifications that classify natural water by its chemical components. In other words, all natural water is classified into 3 depending on anion majority as (hydrocarbonate, sulphate and chloride); classified into 3 depending on cation majority as (calcium, magnesium and sodium) and classified into 4 by its type.

There are many water mineralization classifications and A.M.Ovchinnikov's classification was used as it is widely used in hydrogeology. It is presented in Table 1.

Table 1. Classification of natural water mineralization

№	Mineralization level	Mineralization, *g/l*
1	Fresh or little bit mineralization	<0.2
2	Fresh or average amount of mineralization	0.2-0.5
3	Fresh or relatively high mineralization	0.5-1.0
4	Salty or high mineralization	1.0-3.0
5	Salty or little bit bitter	3.0-10.0
6	Very salty or bitter	10.0-35.0

According to the drinking water national standard of Mongolia, the approved maximum hardness level is not higher than 7.0 mg-eq/dm^3. The suitable high level is set at 5.0 mg-eq/dm^3.

O.A.Alyekin's water hardness classification was used which is widely used in hydro-chemical practice. It is presented in Table 2.

Table 2. Water hardness classification

№	Hardness level	Hardness, *mg-eq/l*
1	Very soft	<1.5
2	Soft	1.5-3.0
3	Moderately hard	3.0-6.0
4	Hard	6.0-9.0
5	Very hard	>9.0

The above mentioned classifications were applied when assessing chemical components and features of the Tuul river basin surface water and groundwater.

2. Surface water quality and pollution in the Tuul river basin

2.1. Quality, chemical composition and pollution of the Tuul River

Of all big rivers in Mongolia the most strong ecological change is happening in the Tuul River. The upstream part of the Tuul River is of primarily undisturbed nature, unpolluted and has very low mineralization because of minimal human activities. Also many clear and fresh mountain rivers flow in to the river. But starting from the capital, the chemical composition and water quality changes because of the technological influence and human activities along the flow of water.

In June and September of 2002-2004, the Institute of Geoecology carried out at 13 sampling points along Tuul river from Lun Bridge to the Tuul confluence with the Orkhon River to study the effects on the Tuul river ecology caused by companies exploring for gold in Zaamar region. The results of the study showed increased mineralization, hardness and pH from neutral (7.1) to weak alkalinity (8.1) along the Tuul River.

In 2009-2010, according to studies by the Institute of Geoecology, the mineralization of the Tuul River is very low. At most points under 100 mg/l upstream in the river from Bosgo Bridge until the confluence with the Nalaikh waste water discharge into Tuul River. On the other hand the mineralization increased to 269.56 and 129.40 mg/l, respectively at the next point which is below the Nalaikh waste water discharge with high mineralization flow into river.

But it is purifying within its flow from Bayanzurkh Bridge to upstream of the UB WWTP. Mineralization of the river is increased again from Upper Songino waste water discharge, and the amount of mineralization running constant when compared to points before capital. The river flows into Orkhon River without purifying because of pollution from Zaamar area and waste water discharge of the CWWTP.

From Figure 2, there is observed natural order of mineralization increase of the Tuul River along its flow. The results can be correlated with amount of precipitation, discharge of the waste water from CWWTP, rock property and human activities.

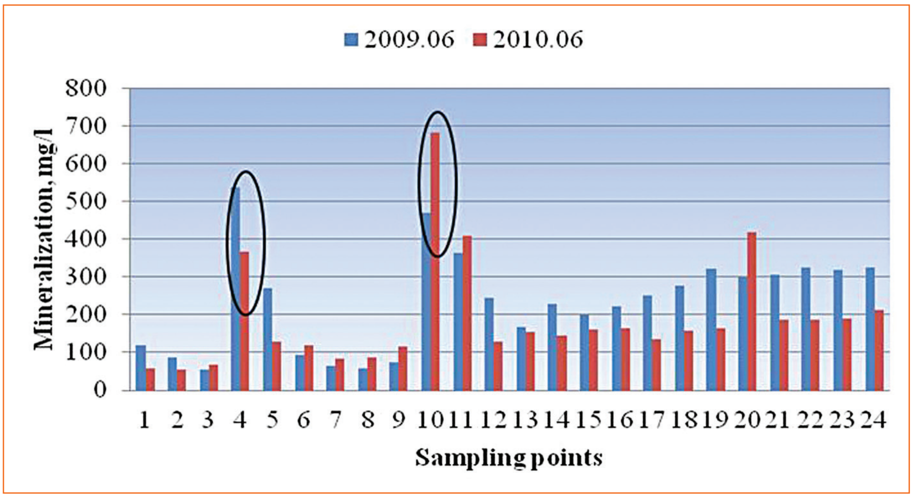

Figure 2. Longitudinal distribution of mineralization of the Tuul River Basin (2009-2010)

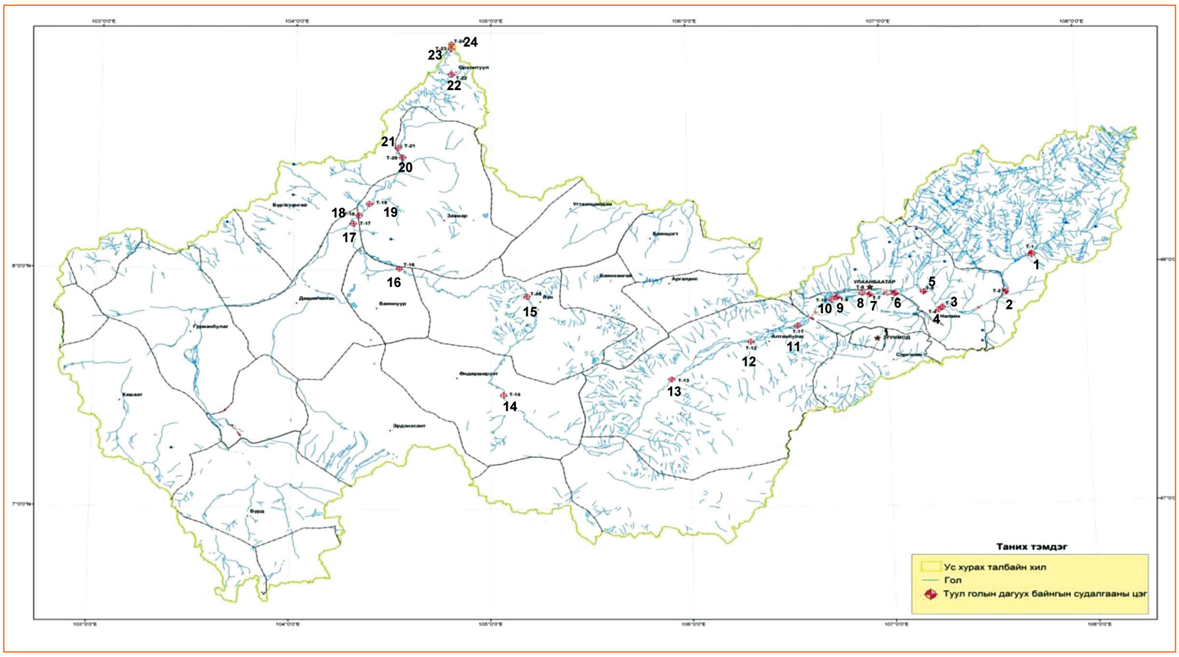

Figure 3. Longitudinal sampling sites in the Tuul River Basin

Sampling points: *1-'Bosgo' bridge, 2-Kharztai, 3-before confluence with waste water of Nalaikh, 4-The waste water stream from Nalaikh district, 5-Tuul-after confluence with waste water of Nalaikh, 6-"Bayanzurkh" bridge, 7-"Zaisan" bridge, 8-"Yarmag" bridge, 9-The upstream of the UB WWTP, 10-Waste water of WWTP, 11-Upper Songino after waste water discharge, 12-Shubuun factory, 13-Altanbulag, 14-Khustai, 15-Undurshireet, 16-"Lun" bridge, 17-Tumstui, 18-Zaamar-clear point, 19-"Zaamar" bridge, 20-Near "Shijir Alt" Co, Ltd 21- Near "Khos Khas" Co, Ltd, 22-Ariin khundii, 23-Near Orkhontuul soum, 24-Branch of Orkhon and Tuul*

In 2009-2010, a total of 24 points (22 points from Tuul River and 2 points from waste water treatment plant) were included for studying chemical composition of Tuul River. The results are shown by representation points comparing to previous study.

<u>1. Tuul River, "Bosgo" bridge</u>. In 2009, June - water is included in the chloride class, calcium group, the third category of Alyekin's classification, very fresh (mineralization 119.51 mg/l) and very soft (hardness 1.30 mg-eq/l). The ionic structure of the Tuul River in Bosgo is dominated by calcium cation and the chloride anion. In 2010, June - water is included in the hydrocarbonate class, calcium group, the first category of Alyekin's classification, very fresh (mineralization 57.45mg/l) and very soft (hardness 0.45 mg-eq/l).

<u>4. Nalaikh waste water</u>. In 2009-2010, Nalaikh WWTP discharge water is included in the hydrocarbonate class, calcium group, the first and second category of Alyekin's classification, fresh (mineralization 538.49-368.63 mg/l) and soft-softish (hardness 2.45-3.45 mg-eq/l). The ionic structure of the Nalaikh waste water is dominated by calcium cation and the hydrocarbonate anion. The mineralization of Nalaikh waste water is high 4.5-6.4 times more than the Bosgo site.

<u>5. Tuul-after confluence with waste water of Nalaikh</u>. The water is included in the sulphate class, sodium group, the second category of Alyekin's classification in 2009 and in the hydrocarbonate class, sodium and calcium group in 2010, very fresh-fresh (mineralization 269.56-129.40 mg/l) and very soft-soft (hardness 1.3-0.85 mg-eq/l).

<u>7. Tuul River. "Zaisan"</u> bridge. Zaisan bridge water is included in the hydrocarbonate class, calcium group, the first category of Alyekin's classification, very fresh

(mineralization 66.15-85.33 mg/l) and very soft (hardness 0.6-0.65 mg-eq/l). The ionic structure of the Tuul River in Zaisan is dominated by calcium cation and the hydrocarbonate anion. The average mineralization of Tuul River around Zaisan is 103.72 mg/l between March, May, July and October in 1997. The ionic structure of the Tuul River in Zaisan is dominated by calcium (14.20 mg/l) cation and the hydrocarbonate (58.80 mg/l) anion. The pH is 7.63.

9. The upstream of the UB WWTP. The water is included in the hydrocarbonate class, calcium and sodium group, the first and second category of Alyekin's classification, very fresh (mineralization 75.16-114.64 mg/l) and very soft (hardness 0.45-1.30 mg-eq/l). The ionic structure of the Tuul River in the upstream of the WWTP is dominated by calcium and sodium cation and the hydrocarbonate anion.

10. Waste water from WWTP. The water is included in the hydrocarbonate class, calcium and sodium group, the first and second category of Alyekin's classification, very fresh (mineralization 75.16-114.64 mg/l) and very soft (hardness 2.55-4.15 mg-eq/l).

11. Upper Songino after waste water discharge. The content of main ions increased 5-4 times compared with the upstream of the UB WWTP site which means mineralization become 365.3-408.6 mg/l, hardness become 1.35-2.20 mg-eq/l.

Tuul. After waste water discharge 2009.06.22

Lower Songino bridge after waste water discharge 2011.09

Upstream of the UB WWTP, the water was included in the hydrocarbonate class, calcium and sodium group, but after waste water discharge, water chemical composition and quality is changed therefore in 2009, the water is included in the sulphate class, sodium group, and in 2010, the water is included in the hydrocarbonate class, sodium group.

13. Tuul River. "Altanbulag" bridge. The water is included in the hydrocarbonate class, calcium group, the second category of Alyekin's classification, very fresh (mineralization 167.2-154.8 mg/l) and soft-very soft (hardness 1.60-1.40 mg-eq/l). In 2008, mineralization was 137.25 mg/l and hardness was 1 mg-eq/l.

Altanbulag Bridge

16. Tuul River. "Lun" bridge. The water is included in the hydrocarbonate class, calcium group, the first and second category of Alyekin's classification, fresh-very fresh (mineralization 223.0-164.21 mg/l) and soft-very soft (hardness 2.45-1.45 mg-eq/l). The mineralization increased 1.6-2.2 times compared with results of 2002-2004, but in regards to class and group there were no change between samples taken. In 2008, mineralization 273.89 mg/l and hardness 1.40 mg-eq/l were almost same.

19. Tuul River. "Zaamar" bridge. The water is included in the hydrocarbonate class, sodium and calcium group, the first category of Alyekin's classification, fresh-very fresh (mineralization 321.82-165.2 mg/l) and soft-very soft (hardness 1.9-1.45 mg-eq/l). In 2008, mineralization 417.95 mg/l and hardness 3.40 mg-eq/l which is high.

20. Tuul River. Near "Shijir Alt" Co, Ltd. In 2009, the water is included in the hydrocarbonate class, sodium group, the first category of Alyekin's classification, fresh (mineralization 300.38-417.97 mg/l) and soft-softish (hardness 2.1-4.85 mg-eq/l). In 2010, it is changed and included in the hydrocarbonate class, calcium and magnesium group, the third category of Alyekin's classification. Changing water class and group is related to external affects on present environment.

24. Branch of Orkhon and Tuul. The water is included in the hydrocarbonate class, calcium and sodium group, the first category of Alyekin's classification, fresh (mineralization 324.45-212.70 mg/l) and soft (hardness 2.65-1.90 mg-eq/l). It is an increase when compared with results of Tuul-Zaamar Bridge.

From the research results along the Tuul River, the mineralization and hardness increases and chemical composition changes along the river when compared to downstream points. Especially, in 2010, June - Tuul River, "Bosgo" bridge (Clear point) water is included in the hydrocarbonate class, calcium group, the first category of Alyekin's classification, very fresh (mineralization 57.45 mg/l) and very soft (hardness 0.45 mg-eq/l), and at last point, it changes, and the water is included in the hydrocarbonate class, calcium and sodium group, the first category of Alyekin's classification, fresh (mineralization 324.45-212.70 mg/l) and soft (hardness 2.65-1.90 mg-eq/l).

Changing water class, group and category and increasing mineralization downstream are chemical pollution caused by human activity starting from Ulaanbaatar city and flowing into Orkhon River without self purifying.

2.2. Study on the aquatic fauna (hydrobiology)

Among the previous records of invertebrates of the Tuul River, 170 species were reported, with most of them distributed in the upper part of the Tuul River, upstream of Ulaanbaatar. According to study of researchers of the Institute of Geoecology in 2003-2004, 43 species were found in places with 'good' water quality. Of these, 31 species are inhabitants of very clean water. In the Bayanzurkh part of the Tuul River 30 species were collected, from which 15 species are found in water of "fairly good" water quality. 8 species were reported in Tuul River of the Songino, all of which can live in water of 'very poor' quality.

In Sonsgolon and Songino, the number of aquatic organisms has been declining due to pollution and were dominated by species such as *Herpobdella sp* from Hirudinea, *Tubifex tubifex* of Oligochaeta, Chironomus plumosus of Chironomidae, Limnea stagnalis and Planorbis sp of Mollusca. The number of individuals ranged from 411 to 478 per square meter (summer 1997). This shows that the species which can tolerate water pollution are dominating [2].

Fish

Quality was assessed based on fish samples collected from 6 stations beginning at Bosgo Bridge until the branch of Orkhon and Tuul. Near the branch of the Tuul and Terelj, water is fresh to slightly polluted category due to Phoxinus phoxinus 70% and Loaches 30%. Near Bosgo Bridge water is fresh due to 80% of fish was Phoxinus phoxinus with 2.8 index of S-saprobe. Around Nalaikh found 4 species fishes and 90% of these were Burbot which is indicator of polluted water. Therefore, this part water is becoming polluted. However, fish species of slightly polluted water are mainly found from Nalaikh until branch of Orkhon and Tuul [3].

2.3. Water pollution of the Tuul River

Surface water pollution is controlled by water temperature, nitrate compound, dissolved oxygen, phosphor and oxidation of permanganate.

As can be seen from last years research results, the pollution indicators are rapidly increasing, bringing a change to 'polluted' category (standard of surface water downward trend) after waste water discharge when Tuul river water decreased or when the waste water from waste water treatment plant flows into the river bed. This is related to amount of waste water increased by rising water usage of the organizations, industries and population of the city. Also it can be related to old equipment and technology, and insufficient capacity of the treatment plant.

The water pollution of the Tuul River has increased each year, negatively affecting the river water quality, ecological condition and hydrobiological regime.

Following is presentation of water analysis results in 2009-2010 compared with previous analysis results for determining water pollution of the Tuul River:

Concentration of ammonium. The concentration of ammonium is shown in Figure 4.. As can be seen from Figure 4., the concentration of ammonium in the Tuul river water after the discharge of the waste water from Nalaikh is 3.8-3.2 times more than the 'much polluted' category of the surface water standard. At next point after the waste water discharge from the UB WWTP, ammonium azote is 5.4-12.4 times more than 'much polluted' category of the surface water standard. Thereafter ammonium ion is observed at other points, and is included from 'polluted' to 'much polluted' category. It is clear that flow from the Tuul River into the Orkhon River is not purified.

The concentration of ammonium azote in the waste water of the Nalaikh and Central Treatment Plant should be compared with the standard of 'Effluent treated wastewater general requirements (MNS 4943: 2011)'. The concentration of ammonium azote in the Nalaikh waste water did not exceed the permissible maximum level. The concentration of ammonium azote in the waste water of CWWTP is 1.4 (2009) -1.3 (2010) times more than the wastewater effluent standard.

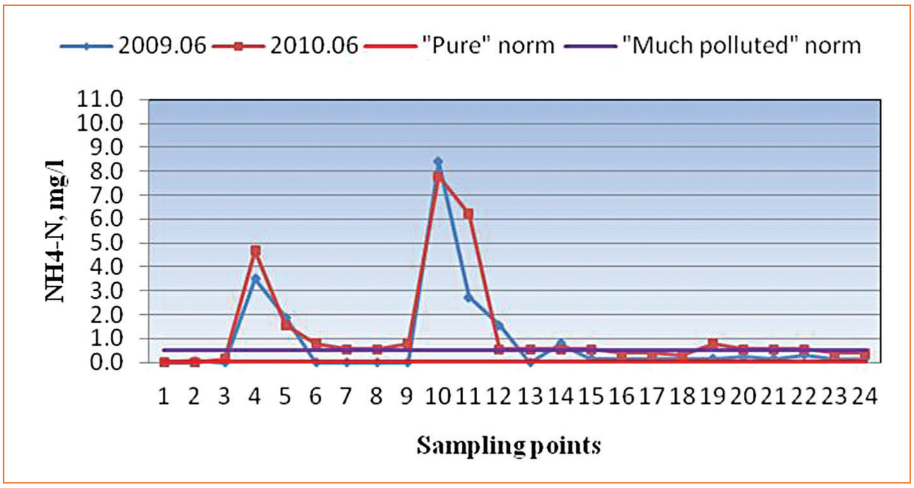

Figure 4. Concentration of ammonium in the Tuul River (2009-2010)

Sampling points: *1-'Bosgo' bridge, 2-Kharztai, 3-before confluence with waste water of Nalaikh, 4-The waste water stream from Nalaikh district, 5-Tuul-after confluence with waste water of Nalaikh, 6-"Bayanzurkh" bridge, 7-"Zaisan" bridge, 8-"Yarmag" bridge, 9-The upstream of the UB WWTP, 10-Waste water of WWTP, 11-Upper Songino after waste water discharge, 12-Shubuun factory, 13-Altanbulag, 14-Khustai, 15-Undurshireet, 16-"Lun" bridge, 17-Tumstui, 18-Zaamar-clear point, 19-"Zaamar" bridge, 20-Near "Shijir Alt" Co, Ltd 21- Near "Khos Khas" Co, Ltd, 22-Ariin khundii, 23-Near Orkhontuul soum, 24-Branch of Orkhon and Tuul*

The concentration of ammonium in 1997 is shown in Figure 5.

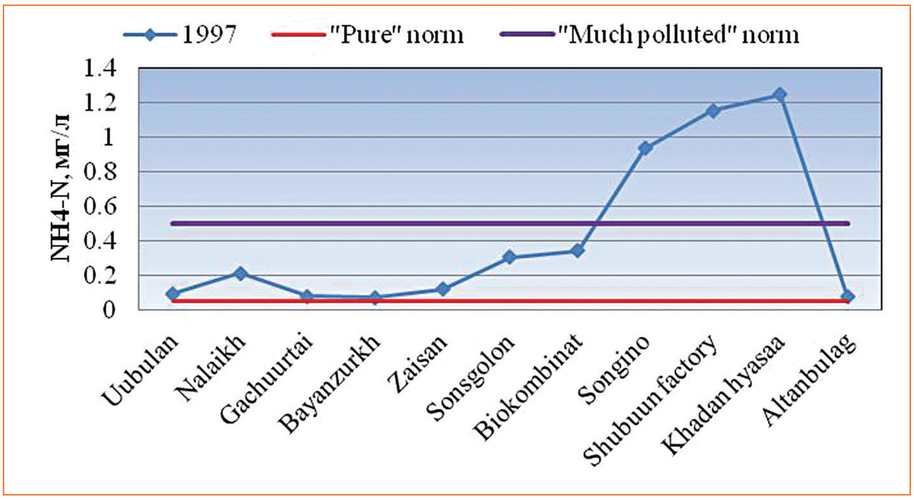

Figure 5. Concentration of ammonium in the Tuul River (1997)

As can be seen from Figure 5. the concentration of ammonium exceeded the 'much polluted' category of standard for surface water at Songino, Shubuun factory and Khadan Khyasaa points. The concentration of ammonium in 2010 increased when compared with 1997 at Bayanzurkh Bridge, Zaisan Bridge and Altanbulag points.

Aquatic animal and plant residency will degrade if increasing amount of ammonium ion continues into the future. Therefore, there is a need to take substantial measures to protect the Tuul River from pollution. First, measure is to decrease amount of ammonium ion discharging from primary sources. Secondly, decrease transfer of ammonium created in the environment by agricultural activities.

Dissolved oxygen. The dissolved oxygen is a very important indicator of a water body's ability to support aquatic life.

As dissolved oxygen levels in water drop below 5.0 mg/l, aquatic life is put under stress.

Oxygen levels that remain below 1-2 mg/l for a few hours can result in large fish kills. Many aerobe (oxygen needs for life activity) organisms cannot survive when amount of dissolved oxygen decreases from certain level.

The amount of dissolved oxygen differs in the natural water. Following factors affect dissolved oxygen, and fluctuate during day and seasonably because of these factors: volume and velocity of water flowing in the water body, climate/season, the type and number of organisms in the water body, altitude, dissolved or suspended solids, and amount of nutrients in the water, organic wastes, riparian vegetation and groundwater inflow [19].

The concentration of dissolved oxygen is shown in Figure 6. As can be seen waste water of the CWWTP is included in the 'extreme polluted' category of the standard of surface water due to the concentration of dissolved oxygen. Downstream flow below the waste water discharge, river water is included in the 'polluted' category of the standard of surface water until Khustai; thereafter it is flowing into the Orkhon River with less pollution.

Generally, dissolved oxygen often decreases at points after waste water discharge because present conditions have an increased amount of bacterial growth, which uses the organic substances found in the waste water.

In 2008, dissolved oxygen was 8.88 mg/l at the Altanbulag bridge site. In 2009-2010, dissolved oxygen (5.38-5.6 mg/l) was 1.6 times more than result of 2008. In 2008, dissolved oxygen was 8.69 mg/l at the Lun bridge site; it is 1.3 times less than result of 2010.

Changing dissolved oxygen is related to time and above factors.

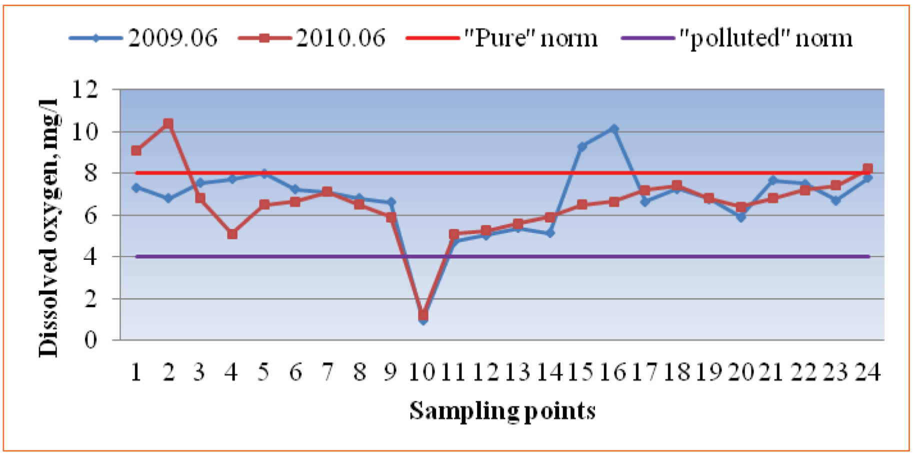

Figure 6. Concentration of dissolved oxygen in the Tuul River (2009-2010)

In past years, joint scientists and researchers from Institute of Geoecology, MAS and Center for Ecological Research, Kyoto University is doing a survey of the Tuul River. In 2006, they made 48 hours measurement in the waste water of CWWTP.

They observed that fish cannot breathe because no oxygen was available during the night caused by reduced amount of dissolved oxygen in the waste water from CWWTP.

Concentration of phosphate ion. All points From Biokombinat until Undurshireet are included in the 'Polluted' category by standard of surface water due to the amount of phosphate ion.

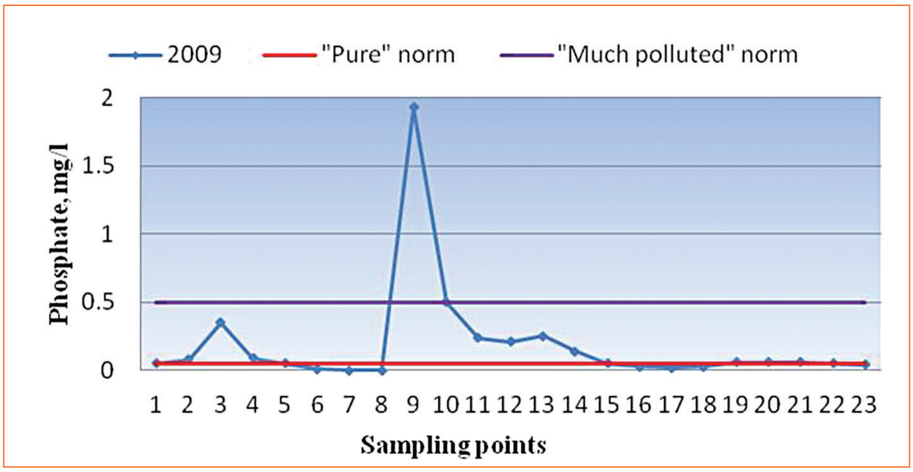

Figure 7. Concentration of phosphate ion in the Tuul River (2009-2010)

Sampling points: *1-'Bosgo' bridge, 2-before confluence with waste water of Nalaikh, 3-The waste water stream from Nalaikh district, 4-Tuul-after confluence with waste water of Nalaikh, 5-"Bayanzurkh" bridge, 6-"Zaisan" bridge, 7-"Yarmag" bridge, 8-The upstream of the UB WWTP, 9-Waste water of WWTP, 10-Upper Songino after waste water discharge, 11-Shubuun factory, 12-Altanbulag, 13-Khustai, 14-Undurshireet, 15-"Lun" bridge, 16-Tumstui, 17-Zaamar-clear point, 18-"Zaamar" bridge, 19-Near "Shijir Alt" Co, Ltd 20- Near "Khos Khas" Co, Ltd, 21-Ariin khundii, 22-Near Orkhontuul soum, 23-Branch of Orkhon and Tuul*

Suspended solids. One of the sources of the Tuul River pollution is the negative influence of the gold mining or human activities. For example: the amount of suspended solids of the Tuul river is 2.0-5.6 times increased at the Bayanzurkh bridge, Zaisan bridge, Yarmag bridge and upstream of the UB WWTP sites when compared with Bosgo bridge and Kharztai sites.

In 2009 and 2010, the amount of suspended solids is 1.4-4.4 times more than 'pure' category of the standard of surface water near gold, gravel and sand mining in the area of Altanbulag, Lun, Zaamar soum, Tuv province. It is included in the 'Slightly polluted' to 'Polluted' category of the standard of surface water.

The gold, gravel and sand mining in the Ulaanbaatar, Altanbulag and Zaamar area involves mechanic pollution of the Tuul river water.

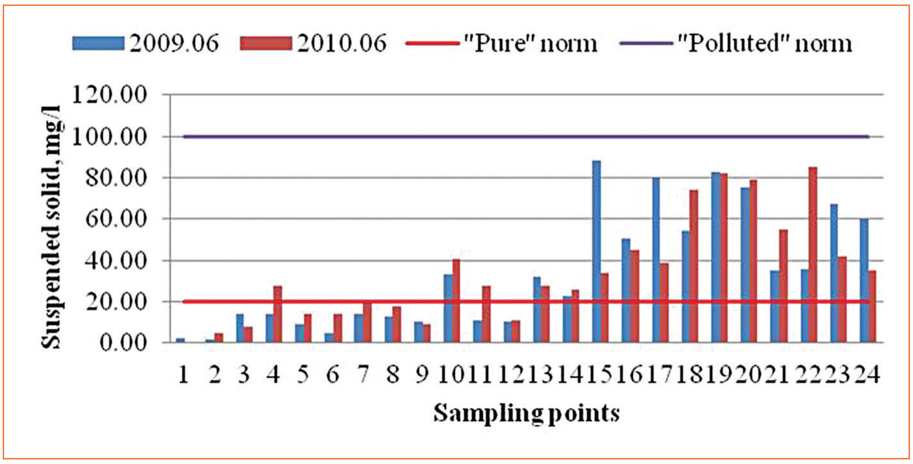

Figure 8. Amount of suspended solids in the Tuul River (2009-2010)

Sampling points are same as in Figure 4. and Figure 5.

Oxidation of permanganate. The Tuul River water is relatively low polluted by amount of oxidation of permanganate.

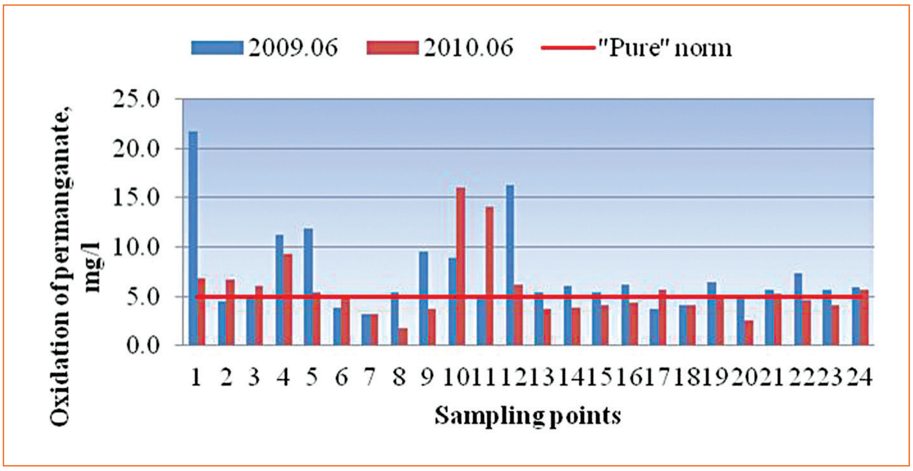

Figure 9. Oxidation of permanganate in the Tuul River (2009-2010)

Sampling points are same as in Figure 4., Figure 5 and Figure 8.

Water bacterial pollution

According to 1970 study of Banzar. Eo and Baani. J, Tuul river water is very clean until Gachuurt; around Yarmag and Songino bridge water is IV category polluted and downstream Songino water was self purified.

In 1984-1993, researchers of sanitation sector, State institute of bacteriology, contamination and sanitation developed 10 years analysis results of the Tuul River water. According to 10 years average of 11 points, Tuul River water was relatively clear or included in the II category of classification of very pure ranks of surface water. Around Nalaikh, Gachuurt, Biokombinat and Shubuun factory, water was included in the III category due to indicator of zoogenic pollution and bacteriology. As research results from General Agency for Specialised Inspection in May, July and October, 2007, Tuul River water is included in the 'Extreme polluted' or V category due to bacteriology, and in the III-IV category due to ammonia, nitrite and oxidation of permanganate in May. By analysis of General Agency for Specialised Inspection in 2007, one bacillus 18.75-19.2 ml is very pure (more 10) at near Uubulan and Gachuurt but one bacillus is 0.18-0.74 ml and pollution of bacteria reached in the amount to raise illness [15].

Heavy metals in the Tuul River

Analysis results of heavy metals are shown in Table 3. The research was done through a joint Mongolian-Korean- Russian research project. As seen in Table 3, the concentration of heavy metals were at all stations below II category or pure by standard of surface water. Most heavy metals have an increasing tendency progressing downstream. Also, relatively high concentration of heavy metal near Tuul River-Terelj can be related to geological conditions. The point is pure as there are no external factors [4].

Table 3. Concentration of heavy metals in the Tuul River (2008), [μg/l]

№	Name of the sampled site	Chromium Cr	Manganese Mn	Iron Fe	Cobalt Co	Nickel Ni	Copper Cu	Zinc Zn	Arsenic As	Cadmium Cd	Lead Pb
	Classification of pure ranks of surface water–"pure" norm	10	100	500	20	50	50	1000	500	5	50
1	Tuul, Terelj	1.50	6.41	131.00	0.22	0.75	1.64	18.80	0.93	0.20	1.97
2	Waste water of Nalaikh	1.56	160.00	338.00	0.82	3.52	3.44	130.00	6.60	0.06	1.03
3	The upstream of the UB WWTP	0.68	11.21	178.58	0.17	0.94	1.44	28.59	1.01	0.02	0.47
4	Waste water of WWTP	7.86	115.29	388.90	0.43	2.88	2.81	75.55	1.76	0.03	0.70
5	Tuul, Tavantolgoi bridge	0.71	33.95	272.58	0.24	1.08	1.46	63.84	1.15	0.02	0.41
6	Tuul, Altanbulag bridge	0.93	60.76	360.48	0.32	1.35	2.24	598.45	1.61	0.02	0.53
7	Tuul, Khustai	0.82	33.58	320.83	0.32	1.57	1.70	98.52	2.32	0.01	0.46
8	Tuul, Zaamar bridge	1.07	42.06	254.71	31.27	3.06	2.76	52.41	9.55	0.12	0.31
9	Tuul, "Shijir Alt" Co. Ltd bridge	1.28	26.67	254.96	0.67	3.02	2.79	54.68	9.73	0.16	0.51
10	Tuul, Lun bridge	0.70	73.29	222.513	0.21	1.99	1.74	54.00	3.89	0.02	0.43

2.4. Water quality and chemical composition of tributaries of the Tuul River

Scientists of the Institute of Geoecology, MAS are analysed to take around 60 samples of lake, streams and rivers from upstream tributaries of the Tuul River on September, 2006. Table 4 shows the mineralization, hardness, pH and combinations of azote.

Table 4. The chemical composition of the tributaries around upstream of the Tuul River

№	Name of the sampled site	pH	T /C⁰/	Mineralization, mg/l	Hardness, mg-eq/l	NO_2 mg/l	NO_3 mg/l	NH_4^+ mg/l	Oxidation of permanganate, mg/l
1	Akhlan river / tributary of the Terelj/	6.44	7.3	94.6	0.50	0.01	1	0.1	0.96
2	North Bayan river	7.17	-	76.4	0.40	0.0	0.0	0.3	2.40
3	North Subuin river	6.69	6.5	103.0	0.45	0.0	0.0	0.2	1.60
4	Beck	6.81	6.7	79.2	0.40	0.0	0.0	0.2	1.92
5	North Saikhan river /right tributary of the Terelj/	6.79	6.2	114.0	0.90	0.0	0.0	0.4	3.36
6	Zur khuzuunii stream	6.97	8.5	103.0	0.50	0.0	0.0	0.5	3.20
7	Shar bulag river	6.4	6.6	145.2	1.75	0.0	0.0	0.2	1.76

№	Name of the sampled site	pH	T /C°/	Mineralization, mg/l	Hardness, mg-eq/l	NO_2^- mg/l	NO_3^- mg/l	NH_4^+ mg/l	Oxidation of permanganate, mg/l
8	Khagiin river	7.17	8.5	78.4	0.25	0.0	0.0	0.3	1.92
9	Daichingiin river	7.5	-	131.5	1.15	0.0	0.0	0.2	1.44
10	Biluut river /right tributary of the Terelj/	6.78	6.5	89.7	0.55	0.0	0.0	0.2	1.52
11	Zuun Botgont river	7.29	10.1	255.2	2.60	0.0	1.0	0.2	1.36
12	Talttain river /eastern tributary of the Tuul river /	6.85	6.3	125.6	0.80	0.0	1.0	0.1	1.60
13	Bugat river /eastern tributary of the Tuul river /	7.06	7.2	188.3	1.65	0.0	1.0	0.1	2.08
14	Zuun Bayan river	7.3	11.5	100.8	0.60	0.0	1.0	0.1	2.24
15	River of south mouth of the Borkh /right tributary of the Talttain/	7.21	6.3	228.1	2.55	0.0	0.0	0.1	1.76
16	Shabart river /right tributary of the Terelj/	6.25	5.5	80.0	0.45	0.0	0.0	0.2	1.44
17	Saikhanii river	6.53	5.7	62.2	0.25	0.0	0.0	0.2	2.24
18	Judegiin river	7.06	5.5	143.0	1.30	0.0	0.0	0.2	3.20
19	Shar bulag mineral water	7.98	4.3	264.7	1.30	0.0	0.0	0.1	3.36
20	Bulnain river	7.44	9.5	171.8	1.30	0.0	0.0	0.1	4.82
21	Chuluut river	7.24	6.9	100.4	0.40	0.0	0.0	0.0	5.15
22	Bayanbulag stream	8.19	12.5	271.7	3.0	0.0	0.0	0.0	4.77
23	Dund bayan river	7.02	7.2	81.2	0.50	0.0	0.0	0.0	3.68
24	Ikh Nartiin river	6.84	7.0	93.2	0.70	0.0	0.0	0.0	1.78
25	Spring/Near Gachuurt/	6.98	3.7	382.0	3.52	0.0	0.0	0.0	3.52
26	Nerstiin river /tributary of the Terelj/	7.35	8.6	88.6	0.50	0.0	0.0	0.0	4.32
27	Ger khadnii river	6.99	6.5	70.8	0.20	0.0	0.0	0.0	1.28
28	Khalzan Botgontiin river	7.41	10.1	250.9	2.50	0.0	0.0	0.1	1.10
29	Artsat river	7.09	8.4	82.6	0.45	0.0	0.0	0.1	1.23
30	Nergui stream	7.3	6.5	141.2	0.90	0.0	0.0	0.2	1.41
31	Bugat river /tributary of the Terelj/	7.26	3.7	100.3	0.60	0.0	0.0	0.0	1.47
32	Uliastain river	6.93	7.4	183.1	1.45	0.0	0.0	0.0	1.22
33	Shar stream	7.27	5.3	115.0	0.90	0.0	0.0	0.5	1.46
34	Zaan Terelj	7.23	9.0	92.2	0.35	0.0	0.0	0.0	1.86
35	Nergui river	6.9	2.3	88.2	0.40	0.0	0.0	0.0	4.16
36	Ar stream /tributary of the Terelj/	7.47	3.8	159.6	1.15	0.0	0.0	0.0	1.25
37	Spring/Gachuurt/	7.56	14.7	352.4	3.20	0.0	0.0	0.0	2.24
38	Uliastain dund river	6.64	6.4	134.1	1.35	0.0	0.0	0.1	0.88
39	Zuun Uliastain river	7.29	2.4	260.6	2.70	0.0	0.0	0.0	4.16
40	Shalzkhan stream	7.43	5.3	107.8	0.65	0.0	0.0	0.1	4.48
41	Tyamiin river	7.31	6.9	129.0	0.85	0.0	0.0	0.0	4.96
42	Dendi river	7.53	14.6	293.2	2.95	0.0	0.0	0.0	4.64
43	Khorkhiin river /tributary of the Terelj/	7.15	7.6	100.4	0.70	0.0	0.0	0.1	4.16
44	Baruunbayangiin river	7.08	6.4	101.9	0.70	0.0	0.0	0.1	3.84
45	Beck /tributary of the Khorkhan river /	7.14	5.0	105.7	0.45	0.0	0.0	0.1	3.36
46	Shireegiin river	7.2	8.0	184.9	1.65	0.0	0.0	0.1	4.32
47	Ikh bulag/right tributary of the Baruun Bayangol	7.73	4.2	227.0	2.10	0.0	0.0	0.1	3.04
48	Nergui river	7.05	8.6	102.7	0.55	0.0	0.0	0.2	2.56
49	Takhilgatain spring	7.2		217.1	1.75	0.0	0.0	0.0	1.92
50	Spring of the Gachuurt river	7.1		347.6	3.50	0.0	0.0	0.1	2.08
51	Beck	7.3		89.4	0.30	0.0	0.0	0.1	3.20
52	Terelj spring	7.6		263.0	2.30	0.0	0.0	0.1	3.52
53	Spring	7.36		363.0	3.80	0.0	0.0	0.0	4.16
54	North Bayangol river	7.12		207.3	1.90	0.0	0.0	0.1	1.76
55	Eastern Bayangol river	7.21		357.0	3.60	0.0	0.0	0.0	1.57

The upstream part of the Tuul River has many small springs and rivers which have originated from the Namya and Nergui rivers. One of the first large tributaries of the Tuul River is Khag River. The Khag River (before it flows into the Tuul river) water is included in the hydrocarbonate class, sodium group, the first category of Alekin's classification, very fresh (mineralization 78.4 mg/l) and very soft (hardness 0.25 mg-eq/l). Water is clear but it is included in the 'Slightly polluted' category by standard of surface water due to the concentration of ammonium.

The ionic structure of the Khag River is dominated by the sodium cation and the hydrocarbonate anion. The cation balance is such that $Na^{+}+K^{+}>Ca^{2+}>Mg^{2+}$ and the anion balance is $HCO^{3-}>SO4^{2-}>CI^{-}$ respectively. Deed Khukh Lake, Dund Khukh Lake, Dood Khukh Lake locate at right side of the river and Khagiin Khar lake at eastern side of the river.

One of the largest eastern tributaries of the Tuul River is Galttai River. The Galttai River water is included in the hydrocarbonate class, sodium group, the first category of Alekin's classification, very fresh (mineralization 125.6 mg/l) and very soft (hardness 0.80 mg-eq/l). It is included in the 'Pure' category by standard of surface water.

The tributaries upstream of the Tuul River have under 100 mg/l mineralization, very soft mostly less than 1 mg-eq/l hardness and often pure.

Research results of doctor Munguntsetseg.A, Tsagaan bulag, Tosongiin bulag, Khailaastiin bulag and Bayangoliin bulag places the water in the hydrocarbonate class, calcium group, the second category of Alekin's classification, fresh-medium level of mineralization and softish -hardish. But upstream of the Toson and Khailaast rivers water is included in the hydrocarbonate class, sodium group, the first category of Alekin's classification, fresh-medium level of mineralization and soft-softish. The amount of suspended solid (67-150 mg/l) in the Tsagaan bulag and Toson river water, respectively. It is 3.35-7.5 times more than 'Pure' category of standard of surface water. Water flow with this suspended solid pollution in the Tuul River affects the river water ecology [12].

The amount of mineralization and hardness of the above tributaries is shown in Figure 10 and Figure 11.

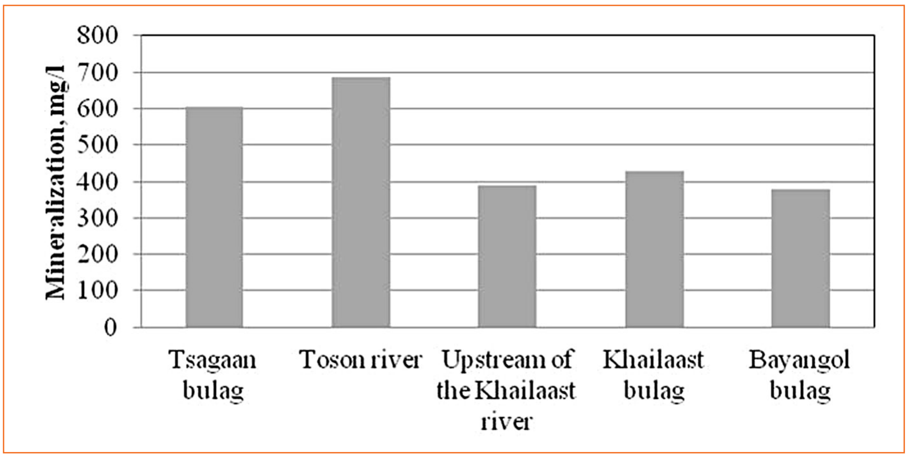

Figure 10. Mineralization of the Tuul River tributaries in the Zaamar area

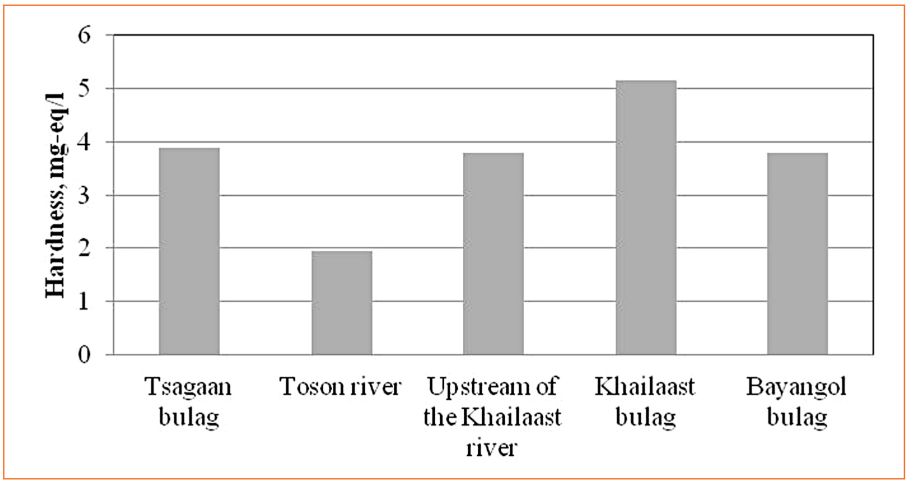

Figure 11. Hardness of the Tuul River tributaries in the Zaamar area

2.5. The quality and chemical composition of mineral water in the Tuul River Basin

The mineral water is natural water that water has unusual quality and composition which has positive affects for all human body. Mongolian uses of mineral water for medical purposes have been known for a long time such as bathing, drinking and washing etc.

The mineral water divides into 3 basic zones in the whole Mongolian territory. Including:

1. Cold mineral water (I zone) with carbonic, carbonate calcium or calcium magnet. In this zone includes mineral waters of Orkhon River Basin, Ulaanbaatar, Ar and Ubur Janchivlan.
2. Cold mineral water (II zone) with high mineralization and mixed composition.
3. Hot mineral water (III zone)

The mineral waters in the Tuv province

Research of Dr Tseren and other researchersf ound over 40 mineral waters locate in the Tuv province. From these Minj and Estei are located in the deep of the taiga and others in the forested area, mountain and steppe zone.

Regarding all of Mongolia, northern part from Ulaanbaatar includes the hot mineral water zone and southern part include in the I zone with carbonic. Acid, alkalinity and different type mineral waters are located in the Tuv province because Tuv province locates in the center of 3 zones. General indicators of the mineral water in the Tuv province shown in table 5.

Table 5. The mineral waters in the Tuv province

№	Name of mineral water	Location	Mineralization, *mg/l*	Hardness, *mg-eq/l*	pH	T °C	CO_2 *mg/l*	Description
1	Ulaanbaatar	On the bank of the Tuul River	0.5-1.5	6.0-19.0	5.8-6.0	3-4	1.8	Total iron Fe (22-49 mg/l)
2	Selbe	5km northward from center of city	0.23	2.45-2.60		2	Carbonic, and use for icterus, liver and choler.	
3	Bayantsogt	47°41′ 107°29′40″	1.25	11.47	6.2	2	1.45	Drink for gripe
4	Ar Janchivlan	47°36′ 107°37′	1.2-1.76	14.50-17.95	6.2-6.45	1-2	1.6-1.89	Fe (25-39 mg/l)
5	Rashaant	47°43′30″ 108°07′30″	0.41	6.25	6.8	0		Carbonic and rich in magnesium. Drink for insufficient acid
6	Nuurent	47°42′30″ 108°17′10″	Carbonic and rich in Fe.Drink for stomach and gripe. The mineral water destroyed in the exploiting field of the Baganuur coal mining.					
7	Baruun Baidlag	47°53′30″ 108°17′	1.96	18.84	6.0	4	1.79	Fe 29 mg/l, Similar with Ulaanbaatar rashaan
8	Dund Baidlagiin dood rashaan	47°57′ 108°22′20″	Carbonic and drink for stomach problems, insufficient and increase acid, chest hate, leukaemia, tabefaction, tire and dizziness. It needs to study accurately.					
9	Dund Baidlagiin deed rashaan	48°04′ 108°11′15″	Rich in hydrosulfuric acid and tasty sulfure. There is a need to study accurately.					
10	Burkh	48°05′ 108°33′	0.37	3.43	5.4-5.8	2.5-7.0	2.23-2.33	Very rich in carbonic
11	Galttai (Bulnai)	48°09′20″ 108°05′	0.26	1.30	7.98	1.4		Cold mineral water with hydrosulfuric.
12	Gutai	48°10′ 107°56′30″	The mineral water is good for uteris illness, blood loss, and leukaemia and lose weight. There is a need to study accurately.					
13	Minj	49°09′ 108°05′	1.0		5.7	0.8-3.4	2.13	Very rich in carbonic
14	Teel	48°24′40″ 105°36′40″	0.48	2.85	7.4	2	0.5	Muddy
15	Khailaastain	48°08′ 104°29′	It has slightly carbonic and iron, and used for increasing stomach acid and hypoacidity in autumn. But it destroyed due to Zaamar gold mining.					
16	Dersen bulag	47°10′ 104°30′12″	1.0	6.08	7.8	3	0.02	Hydrosulfuric and muddy
17	Delgeriin Khungar	47°02′05″ 104°30′05″	0.94	12.10	6.6	7	0.12	Good for stomach. There is a need to study accurately.
18	Saaral moritiin	46°41′ 104°26′05″	1.31	19.50	7.6	19		H_2S-10.4 mg/l and not much yield
19	Elgene	46°50′30″ 107°52′	0.48	5.50	6.7	5	0.03	It uses to drink for stomach.
20	Estein khaluun rashaan	46°35′55″ 107°50′45″	0.24	0.20	7.8	34		The mineral water has hypoacidity and use to drink for heart, lung, bone massage, skin and stomach.
21	Dondogdulamiin rashaan	Sharga morit	0.24	3.70	7.0	2		It was drinking for stomach problems but suddenly infiltrated.
22	Ikh tengeriin rashaan	In the mouth of Bogd mountain						Drink for increase of stomach acid. There is a need to study accurately.

There are only brief indicators about mineral waters in the Tuv province because of available study material and studied context of the mineral waters in the Tuul River Basin. Further there is a need to protect the water resource availability, to establish accurately medical direction, resource, to protect from pollution of mineral water basin and to expand study of mineral water in the basin.

2.6. Quality and chemical composition of the lakes in the Tuul River Basin

Following is information for the 8 lakes in the Tuv province related to available materials.

Khutul Lake. The lake is salty and located above 1361 m and 10 km eastward from center of Erdenesant soum. Its total length is 1.9 kilometres, 1.4 kilometres width, 2.0 km^2 square and 6.2 kilometres shoreline length. On the bottom of lake has black clay muddy and under mud has saline layer. The lake is recharged by rain and groundwater. Amount of mineralization is 104.3 g/l, and it is included in the sodium chloride and sulphate magnesium type. It is rich in salt resource.

Tsaidam Lake. The lake is salty and located above 1056 m and 18 km eastward from center of Zaamar soum. Its total length is 3.0 kilometres, 2.0 kilometres width and 3.5 km^2 square. On the bottom of lake has black clay muddy and saline aquifer. The mud is used for hospital and saline for animal food. Amount of mineralization is 147.07 g/l, and it is included in the sodium chloride and sulphate magnesium type.

Khar Lake. The lake is salty and located above 960m in the Ugtaaltsaidam soum. Its total length is 2.9 kilometres, 0.7kilometres width, 2.2 km^2 square and 6.6 kilometres shoreline length.

Tugul Lake. The lake is salty and located above 960m in the Ugtaaltsaidam soum. Its total length is 1.3 kilometres, 0.8 kilometres width, 1.1 km^2 square and 4.0 kilometres shoreline length.

Khagiin Khar Lake. The lake is fresh and located above 1820 m in the upstream of the Tuul River in the Erdene soum. It exists due to a block in the aquifer of early glaciations, very beautiful and surrounded by mountain and forests. Its total length is 2.5 kilometres, 1.1kilometres width, 2.0 km^2 square and 6.2kilometres shoreline length. Maximum water depth is 25 m. Several rivers and streams empty into the lake and it flow into Tuul River via Khooloin River. Water temperature is 15.0-17.0^{0}C in July and August.

On the bottom of lake spreaded black clay, sand and boulder stone. In the shallow part have algae. There are abundance fish, wild animal and births of The Arctic Ocean. It is possible to use for onshore relaxation, journey, sport and hunting.

Khukh Lake. The lake is fresh and located above 1840 m near Khayankhonkhor River in the Erdene soum. It exists due to a block in the aquifer of early glaciations, very beautiful and surrounded by mountain and forests. It empty into the Khayankhonkhor River by small stream, further flow into the Tuul River. Its total length is 1.2 kilometres, 0.8 kilometres width, 0.6 km^2 square and 3.0 kilometres shoreline length. The water depth is 16 m. Water temperature is 13.5-15.3^{0}C in July and August which is considered coldish.

On the bottom of lake has aquifer of early glaciations. There are fish of The Arctic Ocean, and Elk come to drink water during summer time. Mungun and Mungun Khul lakes locate near the lake. It is possible to use for onshore relaxation, journey, sport and hunting.

Khonogtolgoin Lake. The lake is fresh and located above 2020 m at front of Khentii Mountain in the Erdene soum. Its total length is 1.1 kilometres, 0.7 kilometres width, 0.6

km^2 square and 2.8 kilometres shoreline length. The maximum water depth is 4 m. The lake has different kind of fish. It is possible to use for onshore relaxation and journey.

Khurkhree/Kherkhluur/ Lake. The lake is fresh and located above 1700 m at front of Khentii Mountain in the Erdene soum. It is from glaciations and beautiful island with forest. Its total length is 0.9 kilometres, 0.5 kilometres width, 0.5 km^2 square and 1.2 kilometres shoreline length. The water depth is 7 m.

The Kherkhluur stream flows into the lake, and a small stream from the lake empties-into the Tuul River. Water temperature is 14.5-16.1^{0}C in July and August so water is cold. On the bottom of lake spreaded black clay and boulder stone. The algae grow in the shallow part of the shore. There are abundance fish. It is possible to use for onshore relaxation, journey, sport and hunting [18].

All above mentioned lakes such as Khagiin Khar and Khukh lakes (fresh) need to be protected from over consumption and pollution.

3. Groundwater quality in the Tuul river basin

3.1. Groundwater quality and chemical composition of Ulaanbaatar City

Groundwater is the major source of water supply for the biggest cities of Mongolia. The groundwater shortage occurs in urbanized area of Mongolia and depends on climate change, population growth and urbanization. Therefore the monitoring of groundwater resources and its water quality is most important topic of development of groundwater in Mongolia.

Groundwater quality of Ulaanbaatar city varies depending on geological formation.

We have been investigated the chemical composition, quality and presence of pollutants in the groundwater surrounding Ulaanbaatar in 2006. The results from different districts were then compared, to come to conclusions about the variations of groundwater quality across the study area. The results have been presented together with previous groundwater survey data. While giving estimation of quality in the well water used "Drinking Water Standard MNS 0900:2005". The districts are grouped by similar behaviour of water chemical composition. Especially, Sukhbaatar and Chingeltei district's water has high mineralization and hardness, but Khan-Uul district's water is relatively fresh and soft.

For comparison and processing results from previous studies were used including: Ulaanbaatar groundwater monitoring results prior to 1990, results from a study of 24 wells along the Tuul River conducted between 1990 and 2000, and results from 10 wells sampled in 2005. Totally analyzed over 400 samples for groundwater quality.

As can be seen from Figure 12 and Figure 13 the water mineralization and hardness of the Chingeltei and Sukhbaatar districts are higher than other districts. The average groundwater hardness was between 3 and 7.5 mg-eq/l. The average groundwater mineralization was between 300 and 600 mg/l.

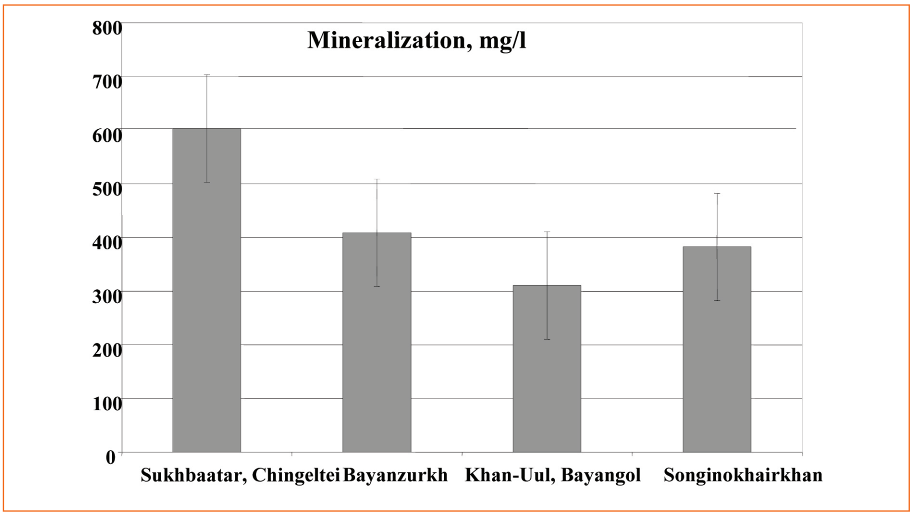

Figure 12. The average groundwater mineralization of districts in Ulaanbaatar

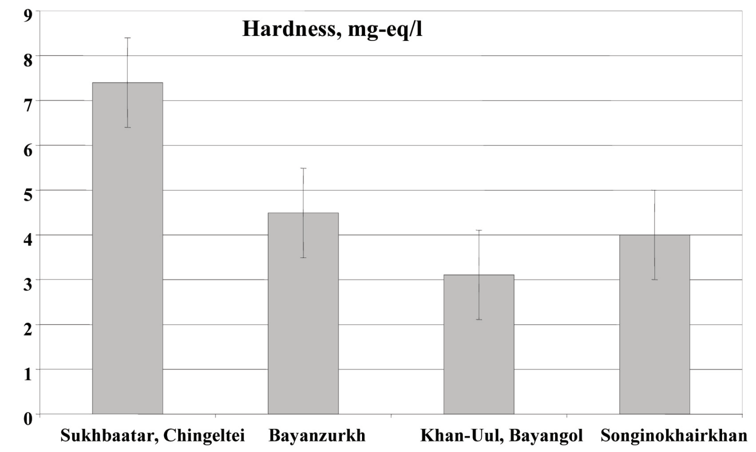

Figure 13. The average groundwater hardness of districts in Ulaanbaatar

The pH is shown in Figure 14. Correct determining pH is a chemical reaction, further bound to solve in the human organism. The pH is indicated between 6.5-8.5 in the drinking water standard and the pH of groundwater of the Ulaanbaatar city suitable for drinking water standard. In other words, pH is slightly acid to slightly alkalinity /pH 6.5-8.5/.

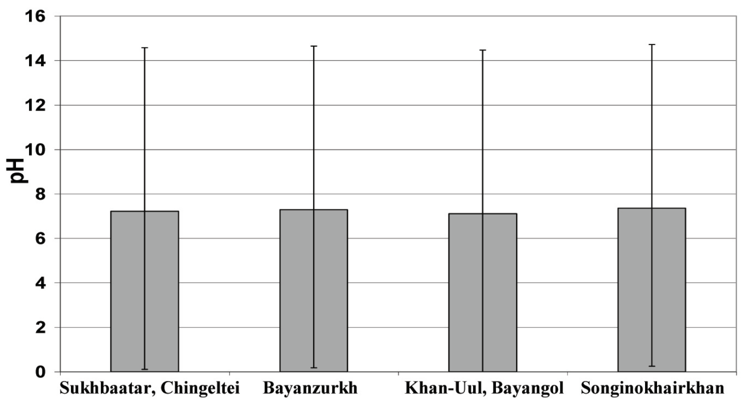

Figure 14. The pH of districts in Ulaanbaatar

North and northeast part of the capital territory (Sukhbaatar and Chingeltei districts).

The amount of nitrite, nitrate, calcium, magnesium and mineralization and hardness of groundwater in area Denjiin Myanga was higher than drinking water standard. And on the larger scale, these two districts have the highest mineralization and hardness of the Ulaanbaatar area. This is largely related to the geological formation and sediments of that area. Also there is pollution due to waste water and garbage from the nearby ger district. There is a need to do further study.

For example, the mineralization and hardness of well water sampled near the Denjiin Myanga trade centre was 2072.0 mg/l and 25.25 mg-eq/l, respectively. The mineralization and hardness of well water sampled near the 72nd school was 1424.9 mg/l and 20.50 mg-eq/l, respectively. These samples are both in the sulphate class, calcium group and belong in the third category of salty, very hard water. These two districts have high mineralization and hardness, also have pollution indicators therefore, there is a need to soften, freshen and clean. Amount of average mineralization and hardness are shown in Figure 15 and Figure 16.

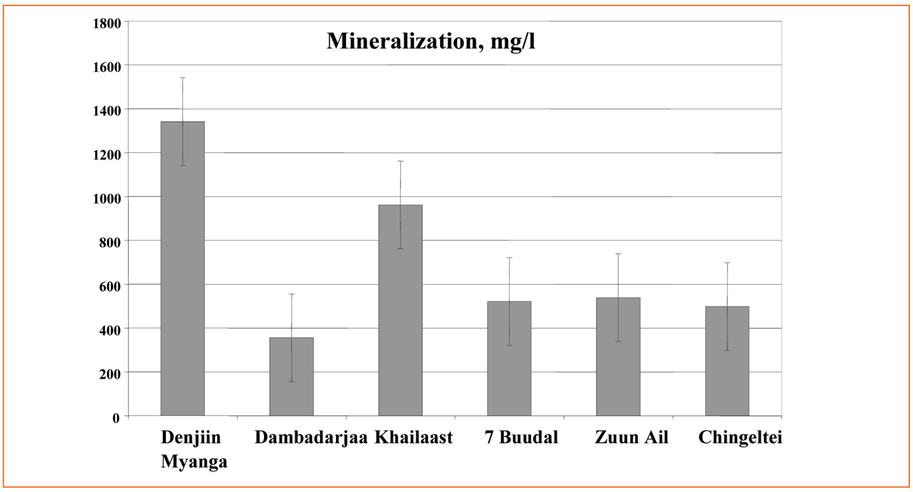

Figure 15. The total water mineralization of the Chingeltei and Sukhbaatar districts

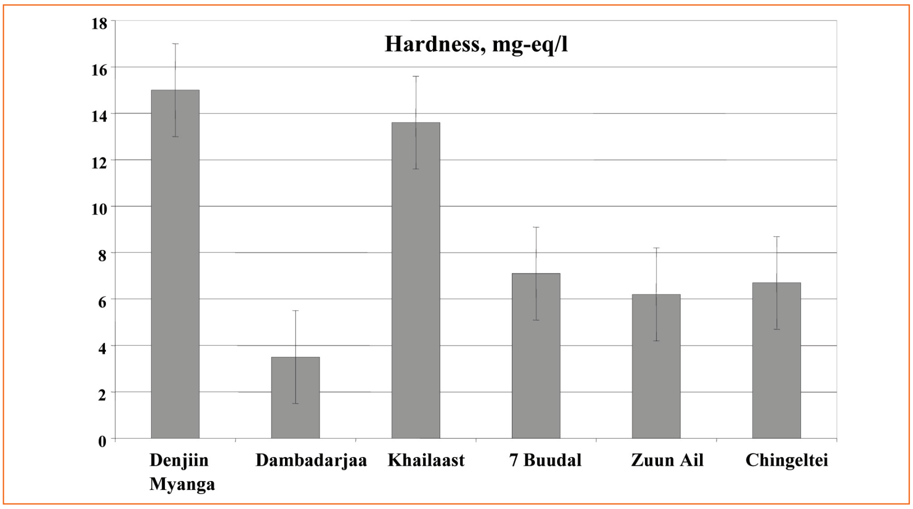

Figure 16. The total water hardness of the Chingeltei and Sukhbaatar districts

East part of the capital territory (Bayanzurkh district).

The level of iron was high in some part of Bayanzurkh district.

The mineralization (1724.5 mg/l) and hardness (21.6 mg-eq/l) of the well water at the 2nd khoroo, Dari-Ekh sample site was the highest in this district. Nitric compounds, which are contamination indicators, were also detected at this site.

Narantuul, Tsaiz, Ulaankhuaran and Amgalan all had high mineralization and hardness. Contamination indicators such as nitrite, ammonium and iron were also detected.

For example: Ulaankhuaran, the “Khuu” district well, has mineralization of 1165.5 mg/l (165 mg/l higher than the drinking water standards) and is very hard with 11.0 mg-eq/l (4 mg-eq/l higher than the standard). Nitrite and ferric iron concentrations are 0.6 mg/l (0.5 mg/l above the standard) and 0.8 mg/l (0.5 mg/l above the standard), respectively.

The high mineralization and hardness is related to sediments and geological formation.

The nitrite and ferric iron levels are high due to contamination from industrial and domestic waste.

This district has relatively less mineralization and hardness when compare with north and northeast part. But some areas have high mineralization, hardness and pollution. There is a need to soften, freshen and clean.

Amount of average mineralization and hardness have been shown in Figure 17 and Figure 18.

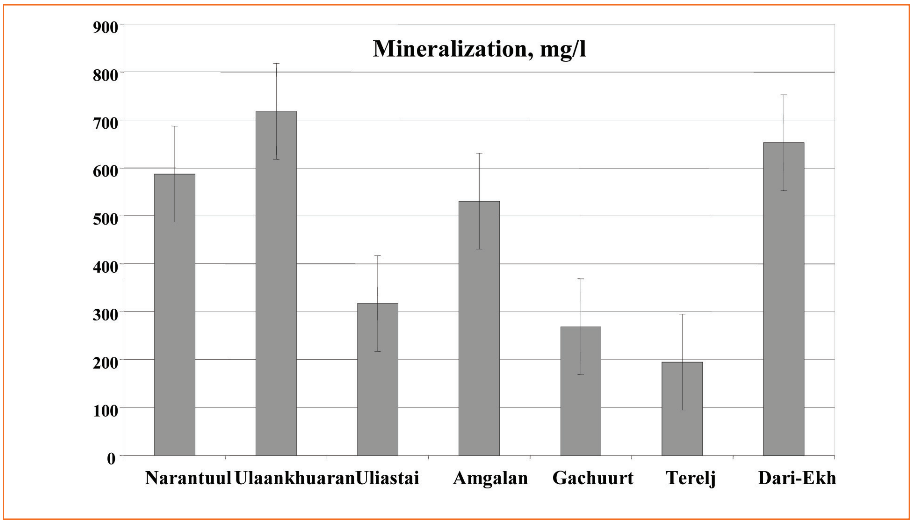

Figure 17. The total water mineralization of the Bayanzurkh district

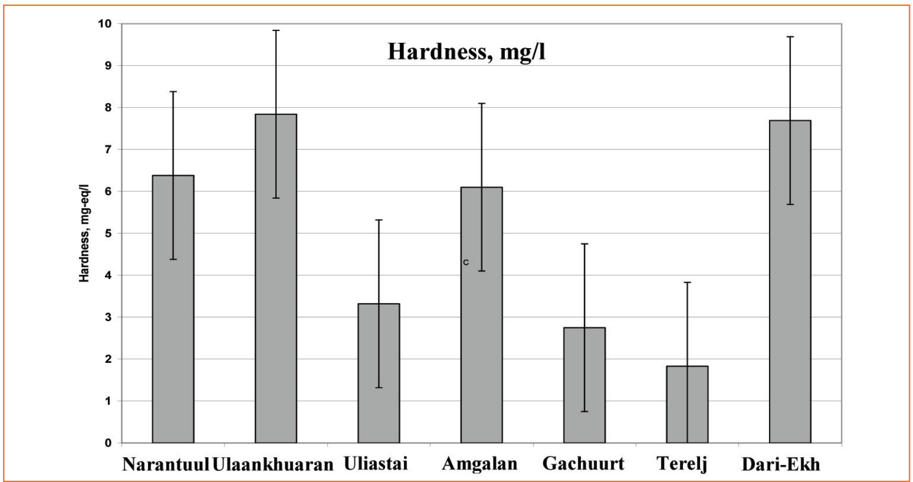

Figure 18. The total water hardness of the Bayanzurkh district

From the results of north and east parts of Ulaanbaatar, nitric compounds and iron were detected in a way. Especially, Denjiin myanga, Dambadarjaa, Zuun ail, Khailaast, Narantuul, Ulaankhuaran and Amgalan area. This is showing that groundwater is polluted at these areas. It is related to population density of Denjiin Myanga and Narantuul trade center, and concentration of ger districts. Therefore, it is necessary to provide to apartments of ger districts a treatment of toilet waste and sewage, to improve environment hygiene of the biggest trade centers, and it is need to manage the problems of trash around them by state and public organization.

Southwest part of the capital territory (Khan-Uul and Bayangol districts).

High levels of iron ions were observed in the Depo and Uildber areas due to mineral waters flowing underground. While at the Zaisan well very fresh, soft water is found due to continuous recharge from the Tuul River. Some individual wells located near industries in the Uildber area exhibited high concentrations of contamination indicators, however this was not observed in the total area averages.

The water samples of the well near "APU" Co. ltd was slightly acidic (pH 5.9) and contained ferrous iron. This is largely due to the underground mineral water flow in that area. This region had relatively low mineralization and hardness compared other regions.

Amount of average mineralization and hardness are shown in Figure 19 and Figure 20.

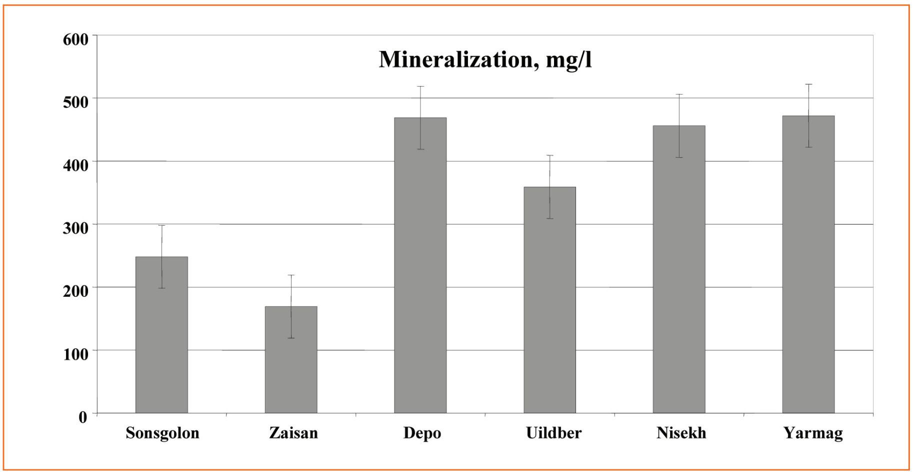

Figure 19. The total mineralization of the Khan-Uul and Bayangol districts

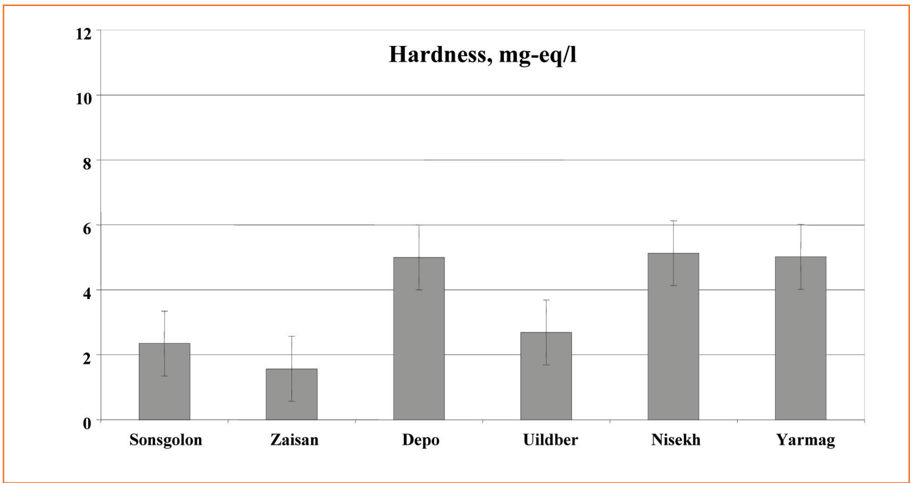

Figure 20. The total hardness of the Khan-Uul and Bayangol districts

These districts have relatively fresh and soft water when compared with other districts.

West part of the capital territory (Songino Khairkhan district).

Results for this district indicated little groundwater contamination. The water has low iron content and is not particularly hard; however it is not as fresh as the water in the Khan-Uul and Bayangol districts. In general the water in this region is fresh and soft, however the water sample of the Namzoldechinlen Temple well was found to be very hard (10.85 mg-eq/l). Amount of average mineralization and hardness are shown graph below.

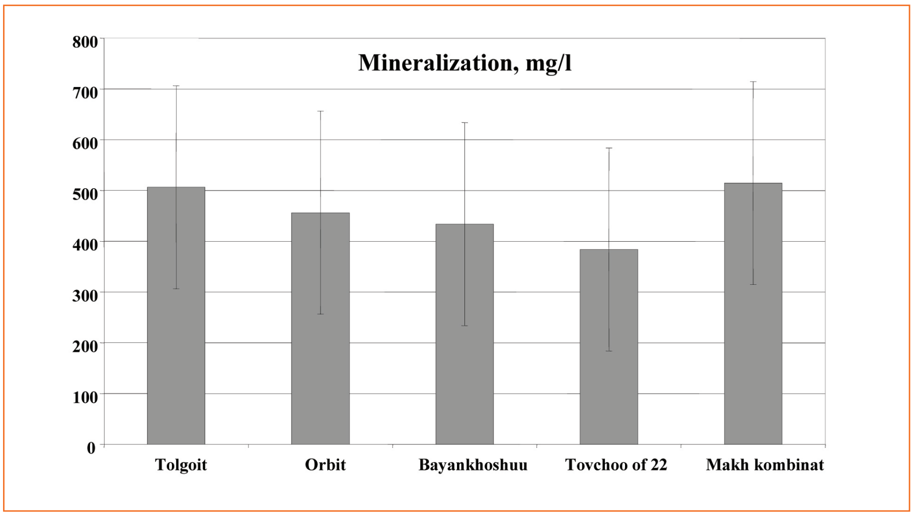

Figure 21. The total mineralization of the Songino Khairkhan district

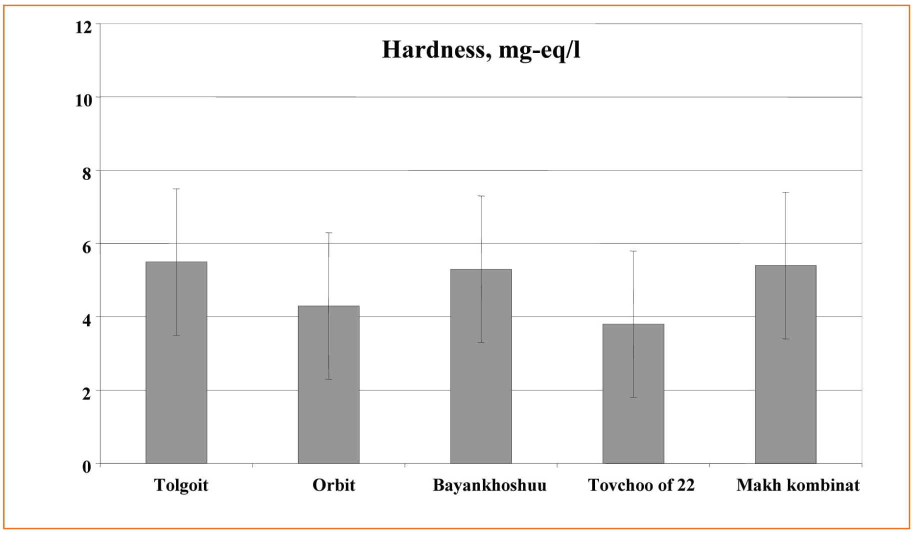

Figure 22. The total hardness of the Songino Khairkhan district

Combined analysis results of groundwater of west, southwest and south parts of the capital show relatively less pollution when compared with results of north and east parts. But iron ion in the near Depo and Uildber areas was 3-9 times more than standard. Also near Tolgoit and Makhkombinat water was quite pollution trend.

The scientists determined that there is a rise in sickness rate within animals and population due to lack and excess of the microelements in the natural water. Therefore, studying microelements is of great importance for hygienic and sanitary conditions. The concentration of the heavy metals in the five representation points is shown in Table 6.

Table 6. Concentration of heavy metals in the groundwater (2006), [µg/l]

Sample name	Elements						
	Mn	Fe	Cu	Cd	Pb	Zn	Cr
Nisekh-apartment stop well	<0.01	0.36	0.06	<0.003	<0.02	0.20	<0.01
Well of last stop, Chingeltei district	<0.01	0.13	0.07	<0.003	<0.02	0.20	<0.01
Well of child jail, Zaisan	<0.01	0.09	0.08	<0.003	<0.02	0.04	<0.01
Well of the Sharkhad's hospital	<0.01	0.16	0.10	<0.003	<0.02	0.03	<0.01
Well of left side of the temple, Dambadarjaa	<0.01	0.27	0.08	<0.003	<0.02	0.04	<0.01
MNS 900:2005	0.1	0.3	1.0	0.003	0.01	5.0	0.05

This analysis was carried out by the Mongolian University of Science and Technology. It shows that no elements exceed the standard limits.

3.2. Wells of central system of the Ulaanbaatar water supply

The results of groundwater sampling along the Tuul River in 2005 when compared with 1996 and 1997 are shown in Figure 23. As can be seen with analysis results of 2005, the ionic structure of groundwater along the Tuul river is included in the hydrocarbonate class, calcium group, from first to second category of Alekin's classification. It is classed as very fresh to fresh and from very soft to softish. pH was between 6.74-6.94.

These graphs show that mineralization and hardness are consistently higher at the Meat Packing Factory well, than at the other two points sampled along the Tuul River.

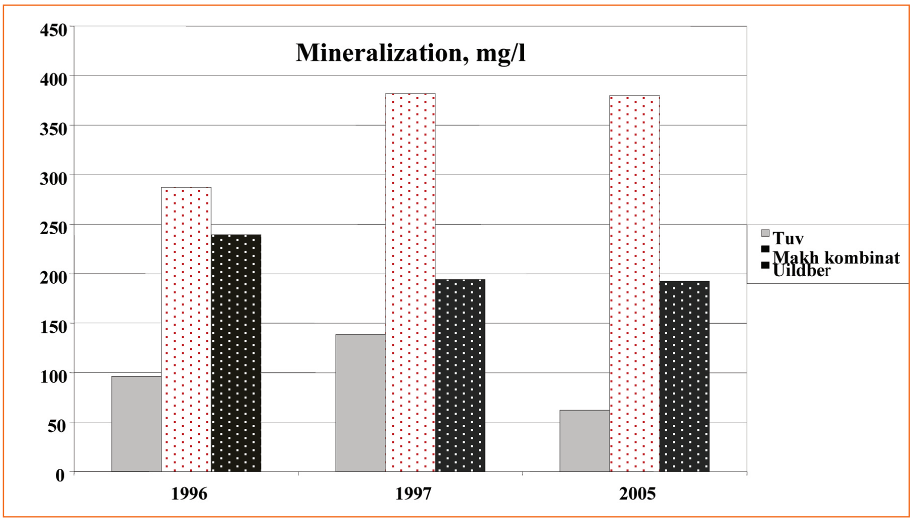

Figure 23. Groundwater mineralization along the Tuul River (1996, 1997, 2005)

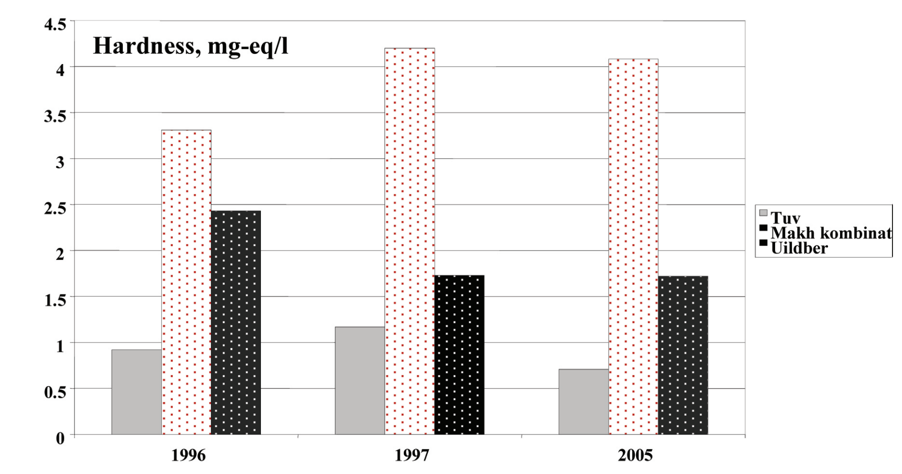

Figure 24. Groundwater hardness along the Tuul River (1996, 1997, 2005)

The pH decreased between 1996 and 2005 at the three points along the Tuul River. There are many factors which affect pH, so it is difficult to determine the exact reason for these changes. Change of pH indicates that this water has been polluted with domestic and industrial waste water and with released pollutants from decomposition of organic matter.

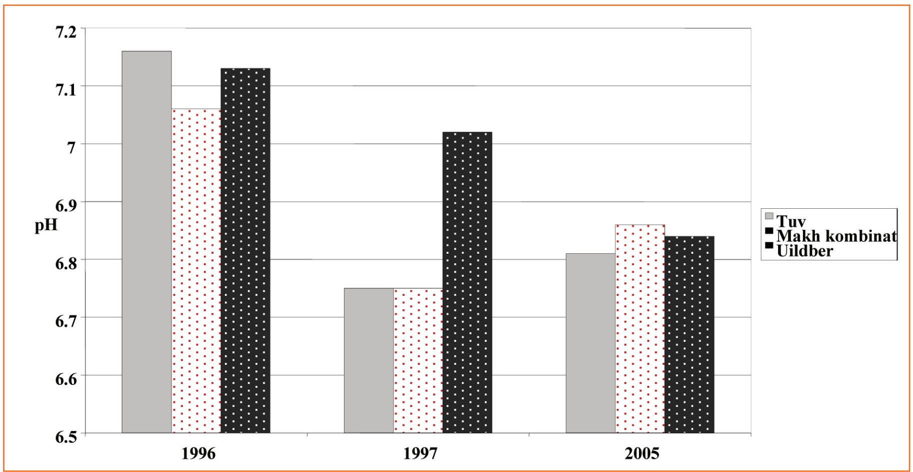

Figure 25. Groundwater pH along the Tuul River (1996, 1997 and 2005)

The chemical composition and quality of the well water along the Tuul River varied spatially and temporally.

The chemical composition and quality of groundwater in the Meat Packing Factory is consistently worse than at other sample sites along the Tuul River. The Tuul River is affected by the intense industrial activity of that region.

The main cation of the groundwater along Tuul River is calcium and the anion is hydrocarbonate. The cation and anion ratios are $Ca^{2+} > Mg^{2+} > Na^{+}+K^{+}$ and $HCO_3^{-} > SO_4^{2-} > Cl^{-}$, respectively.

As seen from above condition, human activities, tectonics feature and geological formation are main factors in the variance of groundwater quality and chemical composition [14].

3.3. Groundwater quality and chemical composition of soums and provinces in the Tuul River Basin

Testing includes wells which are located in the 24 soums of total 5 provinces in the Tuul River Basin. The provinces and soums are shown in Table 7.

Table 7. The soums and provinces in the Tuul River Basin

№	Province	Soum
1	Arkhangai	Khashaat
2	Bulgan	Rashaant, Bayannuur, Dashinchilen, Gurbanbulag, Buregkhangai, Khishig-Undur
3	Uvurkhangai	Burd
4	Selenge	Orkhontuul
5	Tuv	Buren, Tseel, Sergelen, Bayan-Unjuul, Erdene, Erdenesant, Argalant, Bayantsogt, Ugtaal, Altanbulag, Zaamar, Bayankhangai, Undurshireet, Lun, Zuunmod

Tuv province

The analysis results of 52 wells in 2005-2011 and 133 wells in 1973-1990 from a total of 15 soums in Tuv province (included from Institute of Geoecology). The mineralization and hardness are shown in Figure 26 and Figure 27. As seen from the graphs, average mineralization and hardness of drinking water of the soums, Tuv province fluctuated between 264.0-564.0 mg/l and 2.07-5.2 mg-eq/l, respectively. Results are in the fresh-medium level of mineralization and soft-hard. All wells that were involved in the research are suitable to use as drinking water for people considering all analysed parameters, which are specified in the drinking water standard [5].

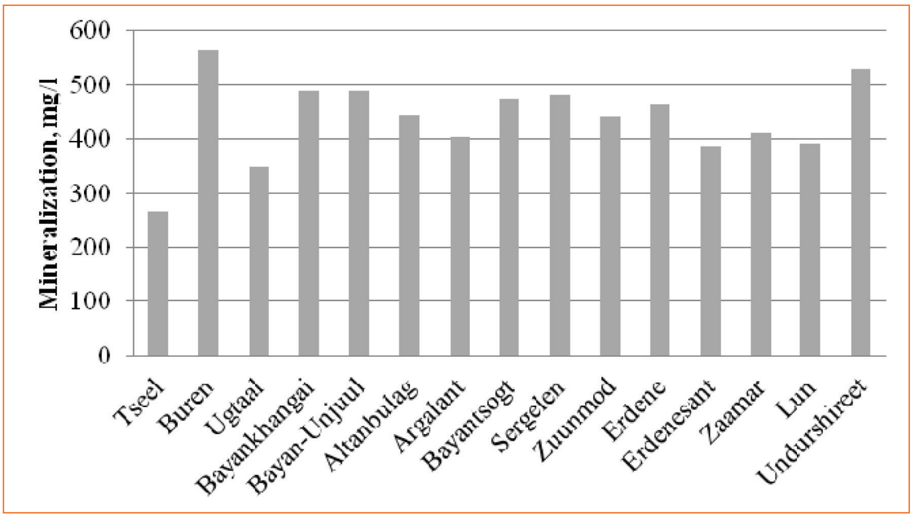

Figure 26. The water mineralization of soums in the Tuv province

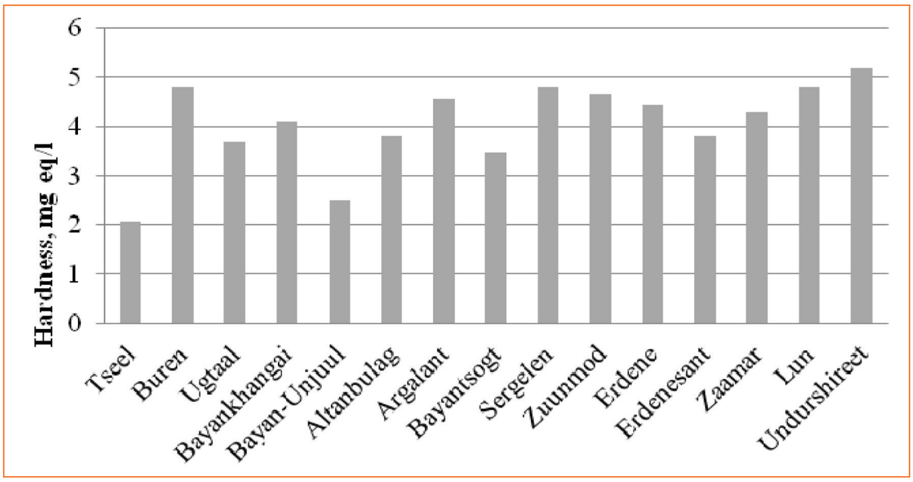

Figure 27. The water hardness of soums in the Tuv province

Uvurkhangai province

The mineralization and hardness analysis results of total 11 wells in 1971-1988 and 2 wells in 2010 included from Burd soum, Uvurkhangai province are shown in Figure 28 and Figure 29. As seen from the graphs, fresh-medium level of mineralization (average mineralization 359.7-635.8 mg/l) and softish (average hardness 3.83-4.98 mg-eq/l) [9].

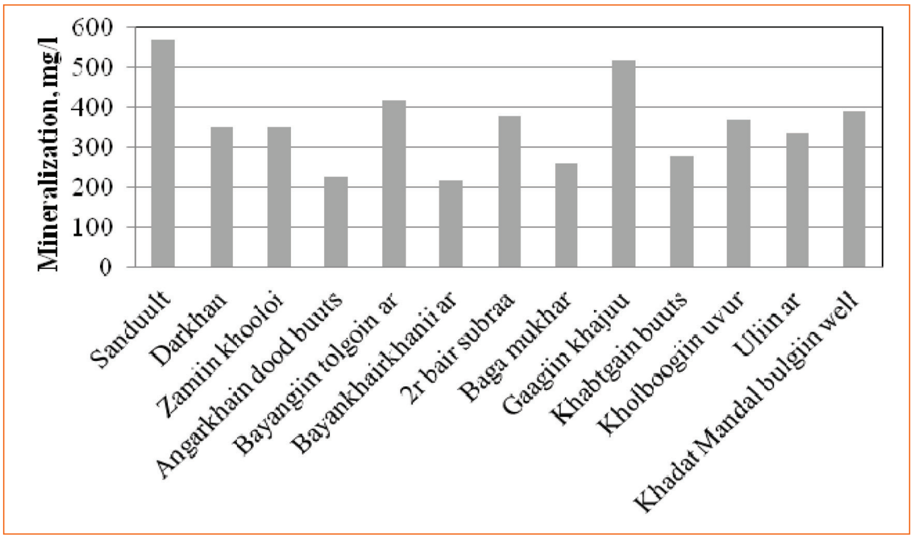

Figure 28. The water mineralization of Burd soum, Uvurkhangai province

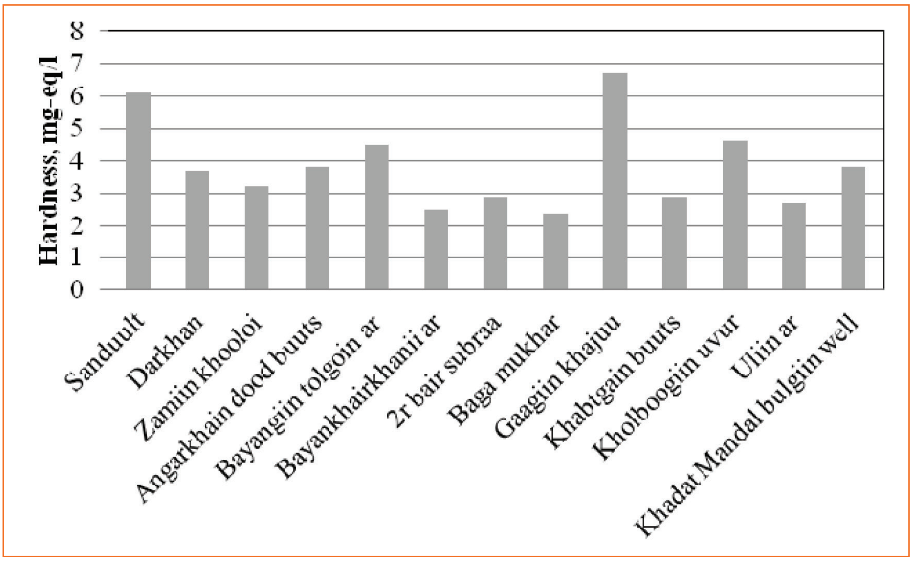

Figure 29. The water hardness of Burd soum, Uvurkhangai province

Bulgan province

The average water mineralization and hardness of wells in 6 soums, Bulgan province is shown in Figure 30 and Figure 31. As can be seen from graphs, the average mineralization and hardness of drinking water of the soums fluctuated between 436.5-651.4 mg/l and 3.8-5.3 mg-eq/l, respectively. Results are in the fresh-medium level of mineralization and softish-hard. All wells that were included in the research are suitable to use as drinking water for people by all analysed parameters, which are specified in the drinking water standard. But some wells water has high concentration of mineralization and hardness. Particularly, mineralization of the Toormiin Khooloi water (1010 mg/l) and hardness (12.8 mg-eq/l) in the Gurbanbulag soum, mineralization of the Bayantsagaan water (1730 mg/l) and hardness (13.7 mg-eq/l) in the Khishig-Undur soum, mineralization of the Baashint Denj water (1570 mg/l) and hardness (10.7 mg-eq/l) in the Bayannuur soum, are not suitable for drinking water standard. Therefore, there is a need to treat them.

The analysis results of 2 wells in the Rashaant soum, 1986 and 2006, 9 wells in the Bayannuur soum, 1971-1989, 21 wells in the Dashinchilen soum, 1962-1985, 2006, 2009, 32 wells in the Gurbanbulag soum, 1965-1987, 2006, 19 wells in the Buregkhangai soum, 1966-1989, 2007, 2010 and 10 wells in the Khishig-Undur soum [7] follows:

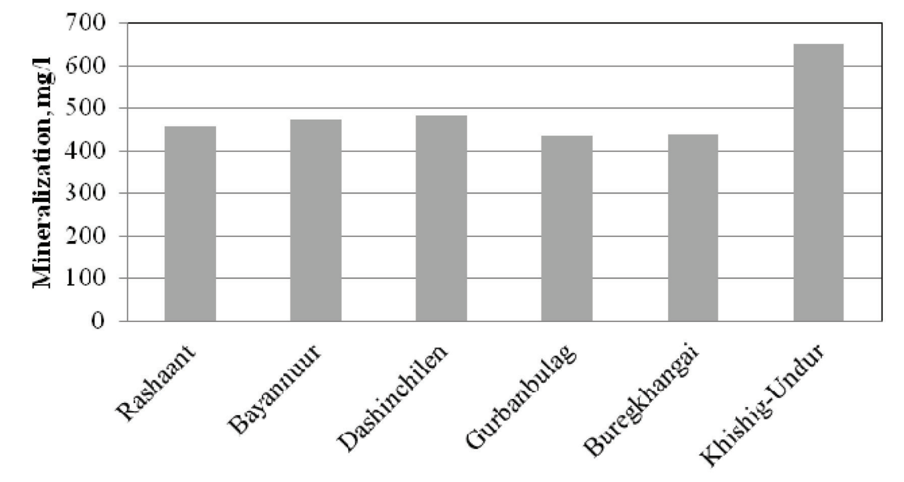

Figure 30. The water mineralization of soums in the Bulgan province

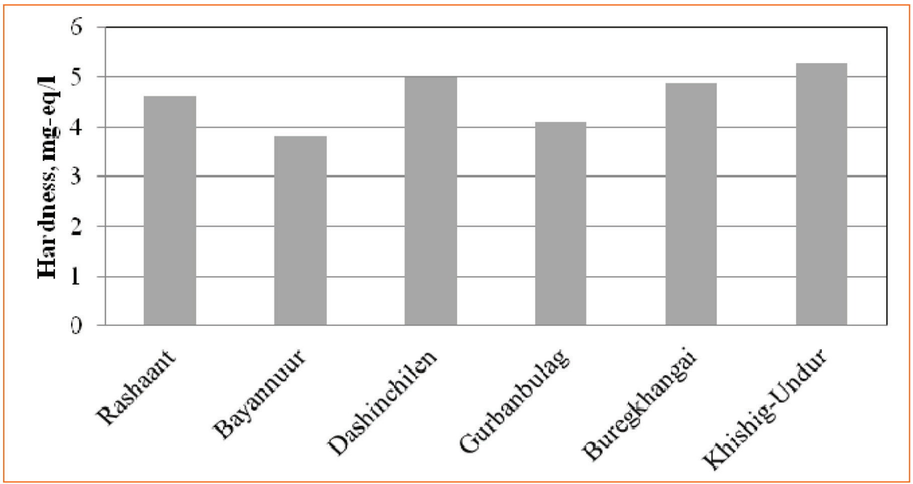

Figure 31. The water hardness of soums in the Bulgan province

Arkhangai province

In 1985, water of wells in the Khonkhoriin ekh and Berkhiin dugii, Khashaat soum is fresh (mineralization 300 mg/l) and softish (hardness 3.2-3.1mg-eq/l), pH=7[6].

Selenge province

The amount of mineralization and hardness of the 8 wells in the Orkhontuul soum, 1979 and 2011 is shown in Figure 32 and Figure 33 [8].

As seen from the graphs, the water is fresh to salty (mineralization 403.0-1682.0) and softish to hard (3.3-6.9 mg-eq/l). Generally, groundwater of this soum was fresh and soft, and just Rashaant tosgon, “Ikh Nomt” LLC’s water was salty and hard. In other words, it is not suitable to use for drinking water for people by all analysed parameters, which are specified in the drinking water standard. Therefore, there is a need for treatment.

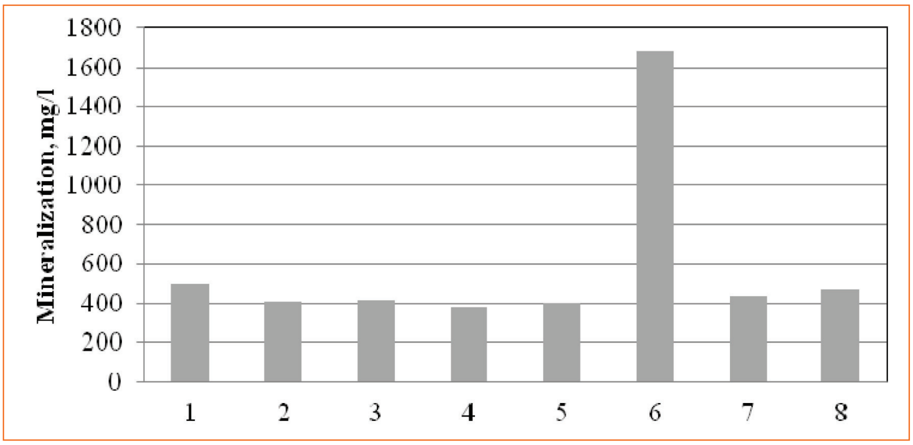

Figure 32. The water mineralization of Orkhontuul soum, Selenge province

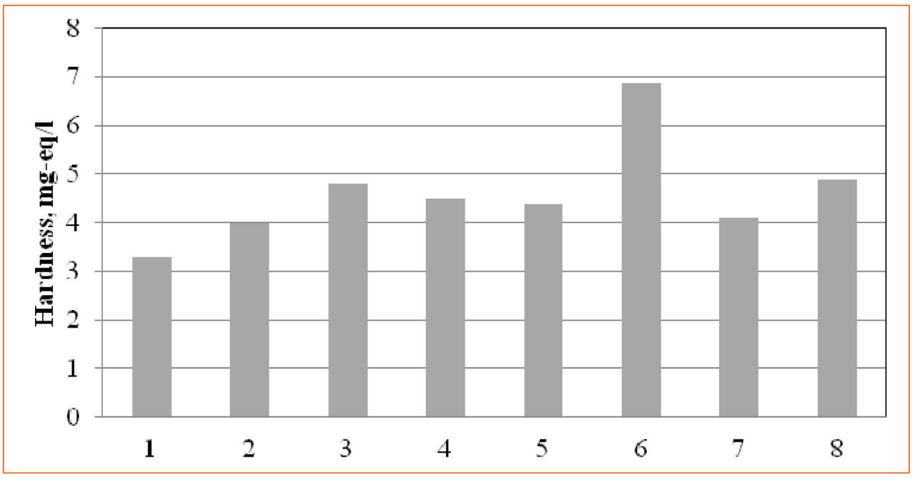

Figure 33. The water hardness of Orkhontuul soum, Selenge province

Sampling points: *1. Constructional office, 2. "Suun Dalai" herders group well, 3. "Nukhurlul" herders group well, 4. "Bayantuul" herders group well, 5. "Bayan-Uguumur" herders group well, 6. Rashaant tosgon, "Ikh Nomt" LLc well, 7. Bore well(IV), 8. Bore well*

It is not possible to conclude about the chemical composition of the present soum by analysis results of the above mentioned soum's wells because whole area of the present soum is not included. It is only possible to express general tendency.

It may be possible to deliver different kind of natural water in the one soum area. There is a need to do analysis of hydrochemical and bacteriology by drilling a well and conduct repeated analysis during time of use.

4. Ecological conditions

4.1. Habitats

The Tuul River basin offers various ecological zones, with different conditions regarding slopes, morphology of the river, riparian vegetation. The upstream part of the basin, with its many small valleys and pronounced slopes, harbors torrents recharged by snowmelt and rainfall. Downstream Ulaanbaatar, the valley is wider and the Tuul separates in several channels, depending on the discharge. Morphogenic flows occur after summer rainfall, redistributing habitats in the floodplain. This changes of habitat distribution is typical for rivers with braided channels and participate to the good ecological conditions of the valley. Floods regularly occur, increasing soil moisture beneficial for vegetation and for pastoral activities.

The evaluation of the quality of river habitat carried out by the Asia Foundation from 2007 to 2009 contains too few sites to be representative of the different zones of the river basin. However the assessment of habitat quality and distribution can be valuable if it is performed on a regular interval all along the river.

4.2. Fish

The Tuul River basin harbours only one endangered species (*Hucho Taimen*), one vulnerable species (*Brachymystax lenok*) and two near threatened species (*Leuciscus idus* and *Thymallus arcticus*). A few species have been introduced accidentally or for commercial purpose (*Cyprinus carpio*). The list of the fish species detected in the Tuul River basin is reported in Annex 5.

The main threat reported by the Red List of Mongolian Fish for these endangered or vulnerable species is the degradation of their natural habitats, more than a direct loss of water quality.

The endangered Siberian sturgeon *Acipenser baerii* used to occur in the Tuul River [8] but are not reported in the latest inventory of fish species. It is not clear when this species disappeared. Reports from 1999 still mention migration of the Siberian sturgeon in the lower parts of the Tuul.

No data are available on fish stocks in the different parts of the Tuul River or its tributaries. Spawning sites for salmonids are not defined either, but must be located in the upstream parts of the Tuul River were conditions (e.g. hydrology, slope, particle size of the river bed) are the most appropriate for their specific needs.

4.3. Amphibians

The Siberian Salamander (*Salamandrella keyserlingii*), the only amphibian species which lives in the Tuul River basin, is considered as Rare (Mongolian Red book) and benefits from a regional "vulnerable" status. According to the Mongolian Red List of amphibians, dominant threats for this species are habitat degradation, and water pollution especially downstream of Ulaanbaatar.

Kuzmin [10] reported a decline of species in different sites of the Tuul River basin between the mid 1980s and 2004, even in areas with lower human pressures (e.g. upstream of Ulaanbaatar city). This means that the conditions for amphibians are degraded though no specific causes were reported.

4.4. Birds

The Tuul River basin harbors few important bird areas, and even less sites used by water birds. The Dashinchilen Bayan Lake, a small saline steppe lake surrounded by extensive steppe grassland, is the only area recognized as an Important Bird Area which hosts flyway population of congregatory waterbirds species in the Tuul River basin [11]. It is located on Bayannuur and Dashinchilen soum, 230 km west from Ulaanbaatar (Figure 34).

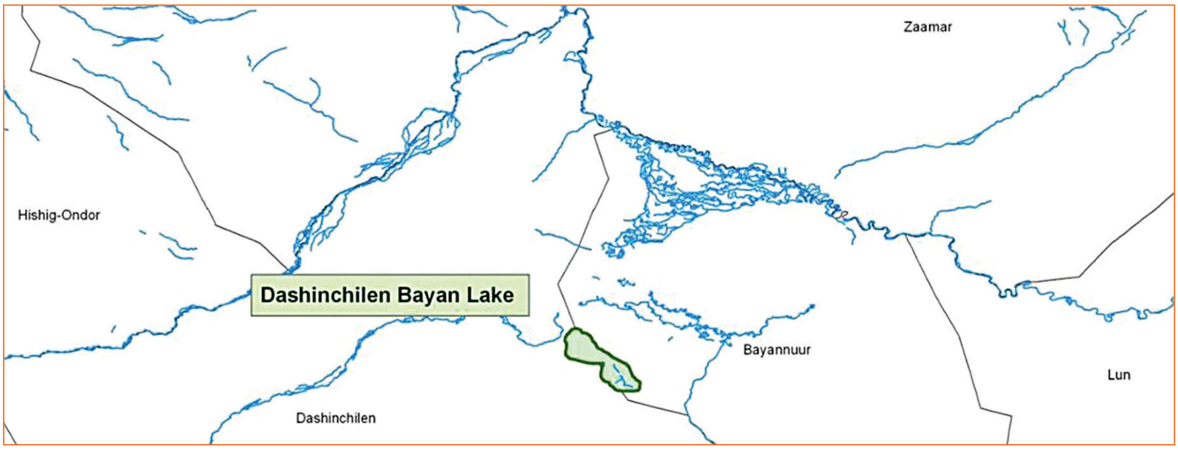

Figure 34. Location of Dashinchilen Bayan Lake

4.5. Specific ecological sites

The upstream part of the Tuul River basin is significantly covered by areas with a national protected status. The Gorkhi-Terelj National Park and Khan-Khentii Mountain protected area cover almost the totality of the river basin upstream Gachuurt soum. No RAMSAR sites are located in the Tuul River basin.

Despite the protected status, human pressures increased in Gorkhi-Terelj NP and in Khan-Khentii Mountain protected areas in the last decades. The main pressures reported are the loss of forest cover due to fires in the Khan-Khentii Mountain protected area, and the degradation of land cover in Gorkhi-Terelj National Park [21].

Also the grazing pressure increased in the last two decades in Gorkhi Terelj National Park, modifying land cover especially in the vicinity of Terelj River, one of the tributaries of the Tuul.

Due to its proximity to Ulaanbaatar city, many tourist camps have been installed in the southern part of Gorkhi-Terelj National Park during the last two decades. This increase of tourist establishments has been carried out with little planning regarding solid waste disposal and sewage treatment. Carrying capacity is thought to have been exceeded in the zone between the Tuul River Bridge and the Terelj River where there are more than 80 camps in a relatively small area of some 25 kilometers in length and 5–10 kilometers in width [22]. North of Terelj River, human pressure is lower, but over the last year several companies have started to build permanent camps and electricity lines. Tourist development may spread in this area in the next years.

Downstream of Ulaanbaatar the Khustain Mountain National Park is the most important protected area attracting many local and international tourists.

Local protected areas are more numerous in the basin albeit smaller in area. These are under the responsibility of local governments, independently from the State Administrative body, giving considerable freedom to the local government and communities. It is difficult to have a clear overview of the policies and their enforcement for each local protected zone. For instance, a major part of Zaamar soum belongs to a local protected area though mining activities occur in the area, with no or limited soil remediation of the former mining sites.

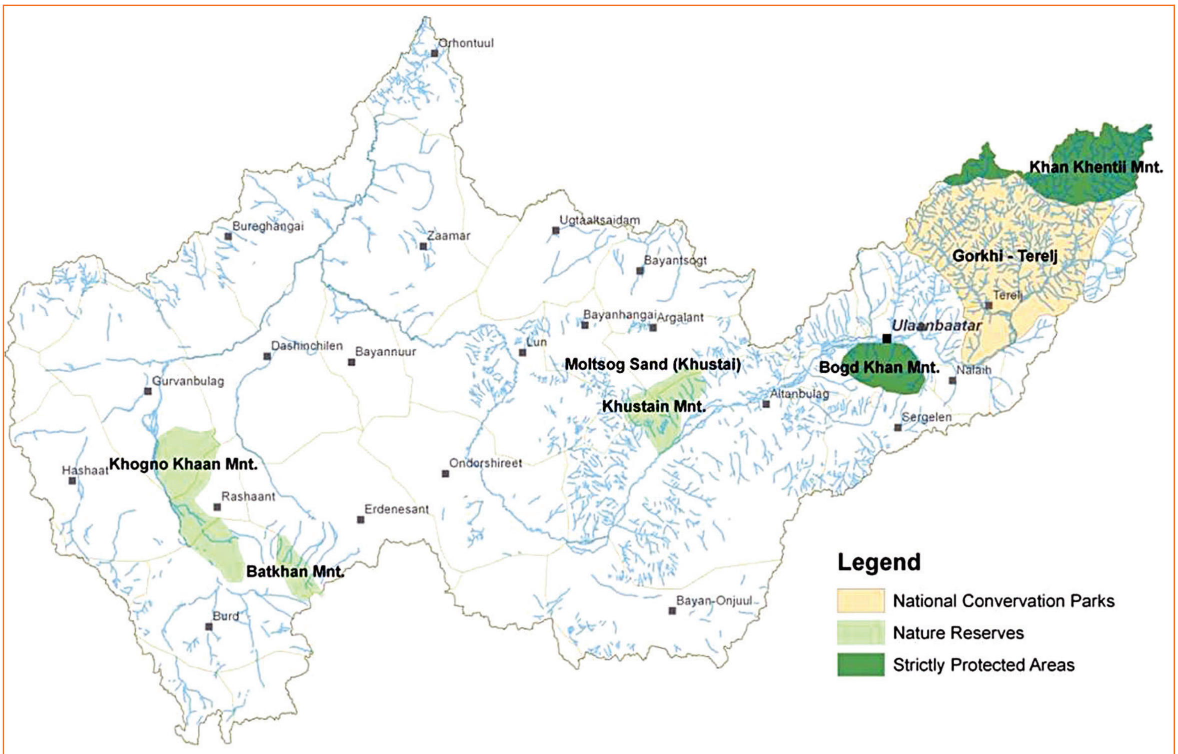

Figure 35. National protected areas in Tuul River basin

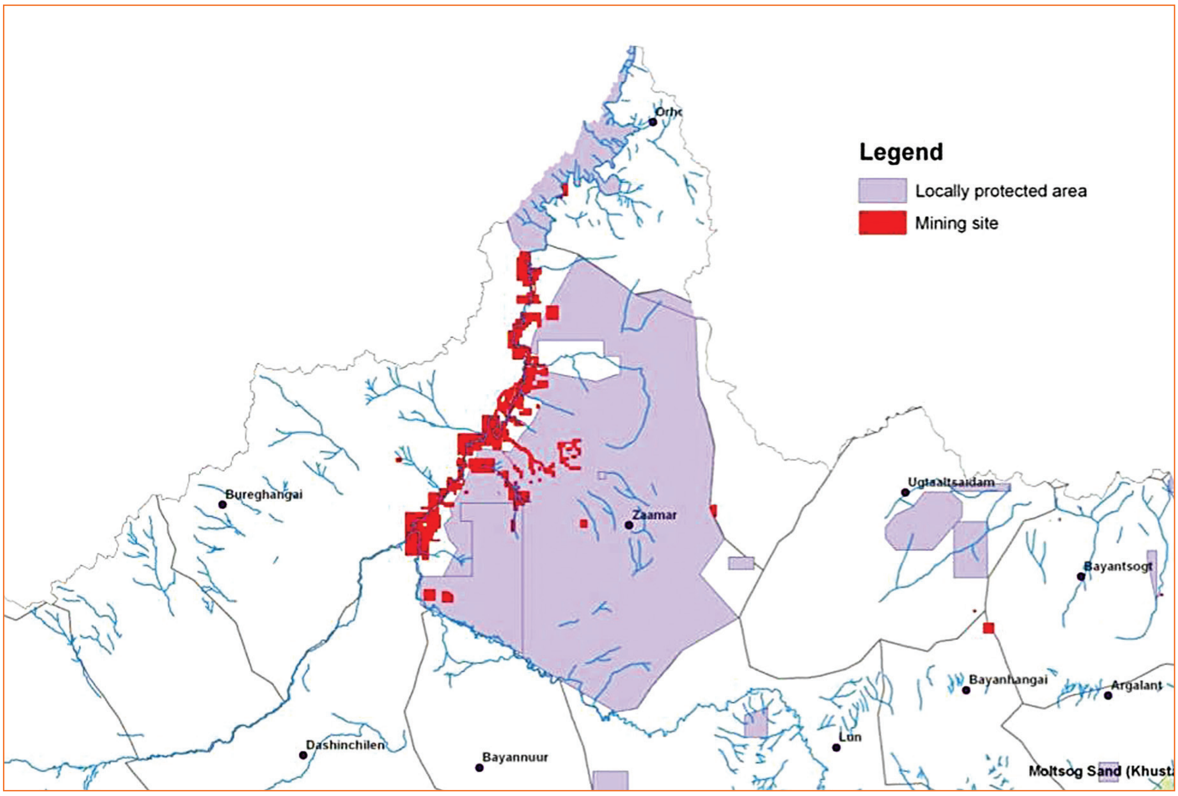

Figure 36. Location of Zaamar goldfield and local protected areas

5. Human impacts on water quality and ecology

5.1. Domestic pollution

Data on water quality clearly shows that Ulaanbaatar city has a strong negative impact on the Tuul surface water quality, whereas settlements situated in the upstream part of the Tuul basin do not influence the surface water quality significantly.

The efficiency of the WWTP of Ulaanbaatar has been reported to range between 60-70% [1], but shows a high inter-annual variability; according to Orchlon, [23] power cuts could significantly affect the efficiency of the treatment as waste water is poured directly into the river without treatment during power cuts.

This WWTP is outdated and has not been designed to treat the current quantity of effluent. A new WWTP, with an appropriate pre-treatment of industrial waste water is necessary in order to limit the impacts on water quality in the Tuul downstream of Ulaanbaatar.

Upstream of Ulaanbaatar, the waste water treatment plant of Nalaikh has an outdated technology as well. Although data shows currently that the Nalaikh urban centre does not affect the surface water quality of the Tuul significantly, the urban development in the vicinity of Ulaanbaatar may pose problems in the near future. As the distance between Nalaikh and the well fields of the Ulaanbaatar drinking water supply is small, it is necessary to implement proper treatment of the Nalaikh waste water, taking into account the expected increase of pollution sources.

Downstream of Ulaanbaatar It seems that settlements do not affect the surface water quality, but data are lacking to confirm this hypothesis.

5.2. Pressure from livestock

The total number of livestock is expected to increase in the Tuul River basin in the next two decades. Herders are widely spread in the basin, except in Khan Khentii strictly protected area in the most upstream part.

The grazing pressure is significant and rising in the Gorkhi-Terelj National Park, according to WWF [21]. Data are missing to assess whether or not it affects tributaries of the Tuul.

Mandakh [24] reported that the soil cover of Altanbulag soum, Tuv aimag, downstream of Ulaanbaatar (Figure 37) suffers from grazing pressure, with 56% of the area being overgrazed. This degradation of the soil cover has direct impacts on surface water quality, as it increases erosion and transfer of soil particles to the streams. As climatic conditions, vegetation cover and herder practices are very similar in the soums located downstream, we can assume that the grazing pressure is affecting soil cover in all soums in the middle and low parts of the river basin.

It is not clear to what extent degradation of soils and vegetations due to overgrazing affects water quality and biology in the Tuul River basin. Hayford [25] reported that water temperature, conductivity, and pH of Mongolian streams significantly increased with increased erosion. Impact on aquatic insects is less significant. Domesticated herbivores remove riparian vegetation which destroys or disturbs habitats necessary for the protection, dispersal, and mating of adult aquatic insects, but according to the survey, most communities of adult aquatic insects in Mongolia are not yet strongly impacted by grazing and erosion.

Figure 37. Location of Altanbulag soum in the Tuul River basin

On a national level, studies mention that the reduction of functioning wells has forced herders to use pasture areas near surface water bodies. This concentration livestock increases soil degradation and erosion in the floodplains, risk of water contamination via their dungs, impacts on riparian vegetation (especially around lakes) and competition for water between livestock and wildlife as well.

Restoring wells could lower pasture pressure and irremediable land degradation in some areas. However one of the drawbacks could be that increasing the number of functioning wells would be followed by an increase of livestock, hence land degradation. Restoration of wells should go with a limitation of livestock number in riparian zones severely affected by land degradation.

5.3. Use of pesticides and fertilizers

Despite the proximity of Ulaanbaatar, irrigated areas just represent 0.02% of the Tuul River basin. They are concentrated just downstream of Ulaanbaatar but along permanent surface water only. Figure 38 indicates only sums where irrigation occurs, and not the specific location of irrigated areas.

No data has been found on pesticide or fertilizer use specifically in this basin. On a national level, the use of fertilizer is reported to have increased from 2002 to 2008 from 4.9 kg N/ha to 8.2 kg N/ha (figure 39) [26], but it is still much lower than in other countries such as the Netherlands or USA (>100 kg N/ha in 2008). Mainly chemical fertilizers such as nitrate, double super phosphate and potassium chloride are used [27]. The lack of financial resources to apply agro-chemicals is one of the reasons reported for the light use of fertilizers [28].

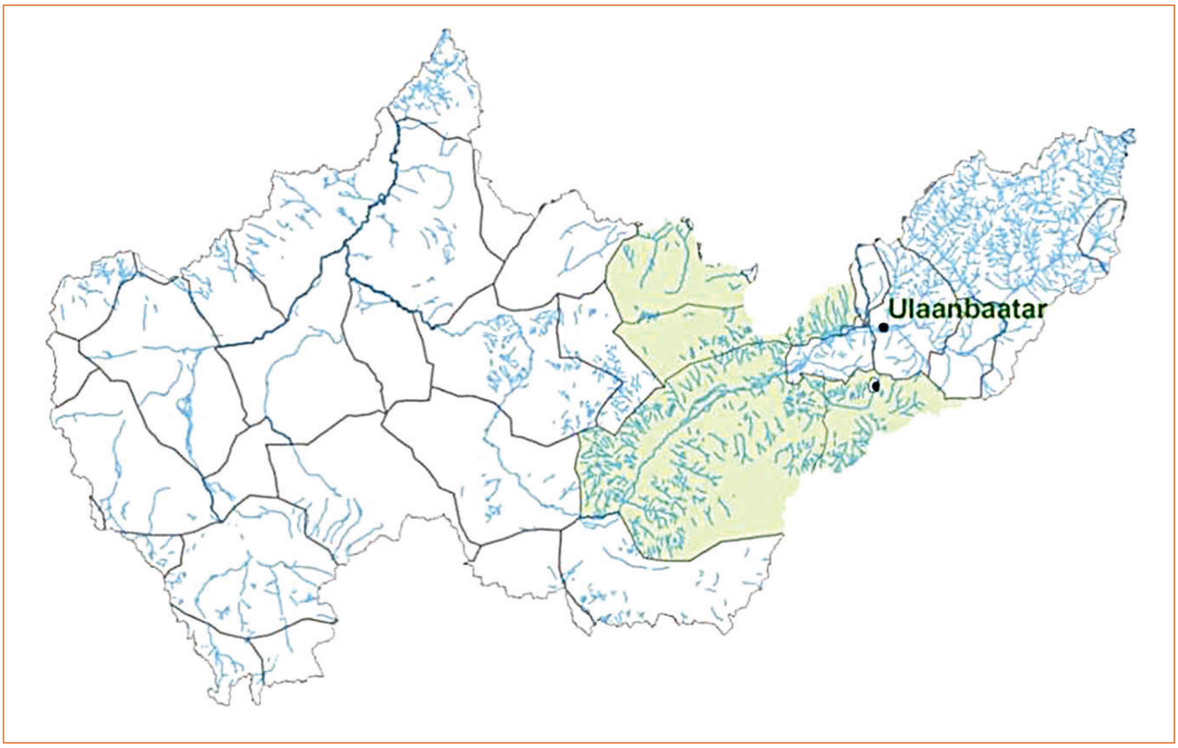

Figure 38. Location of sums with irrigated areas in the Tuul River basin

A slight increase of N and P concentrations was however observed downstream crop areas in the Orkhon and Kharaa Rivers during the last decade [27] [28]. Impact of this increase of nutrient use in the Tuul River basin is difficult to assess through surface water quality data, as concentration of nitrates and phosphate from fertilizer use cannot be differentiated from them released by Ulaanbaatar WWTP.

Source: FAO

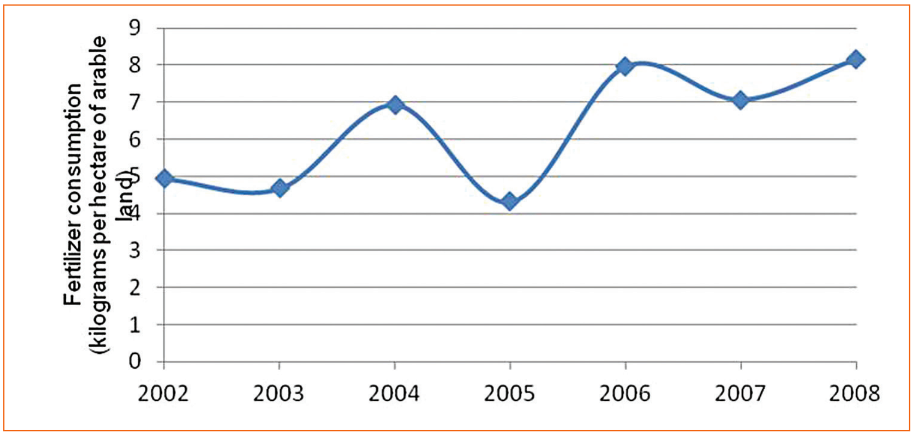

Figure 39. Fertilizer consumption per ha of arable land 2002-2008

Persistent Organic Pollutants (POPs), as insecticides, herbicides, fungicides and rodenticides have been used in Mongolia for plant protection, especially between 1986 and 2003, when most of the toxic POPs have been banned [29]. For instance more than 250 tons of hexachlorobenzene, a carcinogen fungicide used on wheat to control fungal disease, have been used in the end of 1980s in Lun soum, Tuv aimag. As these compounds are persistent, they might still be present in soils or sediments.

Impact on water quality cannot be assessed as there is no data on water or sediment content for these elements.

5.4. Industrial pollution

Most of the industries are located in the vicinity of Ulaanbaatar. Their effluents are very different from domestic effluents, being more concentrated in organic pollutants and containing hazardous compounds specifically involved in manufacturing or industrial processes. Treatment of these effluents has to be adapted to their characteristics. The “Khargia” treatment facility has been implemented in Ulaanbaatar in 1972 to pre-treat those industrial effluents before they reach the central waste water treatment plant but the facility stopped functioning due to out-dated techniques and technologies [30]. Heavy-loaded industrial effluents reach subsequently the central system which is not designed to correctly handle this kind of waste water, and disturbs the whole treatment process. Very few data have been available on the composition of the effluents reaching the central WWTP, but for instance removal efficiency of chromium was just 58% from November to March in 2005. The renovation of the industrial “Khargia” treatment facility is under consideration, but no schedule has been approved yet.

Tanneries use industrial processes that represent a direct threat for water quality, as it involves the use of hazardous compounds directly transferred in the effluents. Forty-six tanneries were registered in Ulaanbaatar in 2008 (26 functioning permanently, the rest of them work during winter time only). They all use chromium-based technologies to process skin, hide and wool [31]. All tanneries are supposed to pre-treat their waste water before discharging it to the central waste water treatment plant. However in Ulaanbaatar most of the new settled tanneries do not have waste water pre-treatment plants and are not connected to the central sewerage [32].

Levels of hexavalent chromium exceeding the Mongolian standards detected downstream of Ulaanbaatar (chromium levels (CrIII) ranged from 15 to 64 mg/kg in sediment samples downstream the central WWTP*)* [33] but are already significant upstream according to the data of the Central Laboratory of Environmental Monitoring. This means that chromium-based skin, hide or wool processing occurs upstream, and may represent a threat to groundwater used for drinking supply.

Chromium can be easily accumulated in biological tissues, such as fish and grass grazed by livestock. A wider monitoring of Chromium pollution, assessing trivalent and hexavalent Chromium concentrations in surface water, sediments, and in biological tissues (riparian vegetation, fish, and livestock) is needed along the Tuul River to evaluate the impact of tanneries on water quality, ecology and human health. In the meanwhile, public awareness and safer practices should be reinforced regarding skin, hide and wool processes, and the ban of hexavalent Chromium should be reinforced as data show it is still being used.

Mongolian treatment plants are not designed to handle heavy metal pollution in waste water. As the economy coming from the tanneries is important and use of chromium is almost impossible to ban, proper pre-treatment systems on site are the only solution to reduce the transfer of trivalent chromium in the river systems. Recent studies showed that the use of zeolite during the pre-treatment process, a mineral easily available in Mongolia, gave good and cost-effective results to decrease chromium contents in waste water [34].

5.5. Mining

Mining in the Tuul basin

As seen on Figure 40, mining activities occur in the river basin, and mostly in the valley of the Tuul River itself. The biggest concentration of mines is found in the downstream part of the basin, in Zaamar and Buregkhangai soum. This mining zone, also called the Zaamar goldfield area is about 80 km long. Because water is essential for gold mining operations, mining stops during the winter months due to ice.

Other important mines in the Tuul basin are at Nalaikh (coal mining) and south-west of Ulaanbaatar (gravel and sand). The effect on the water resources and water quality by these mines is negligible, but the damage to the landscape and vegetation is considerable.

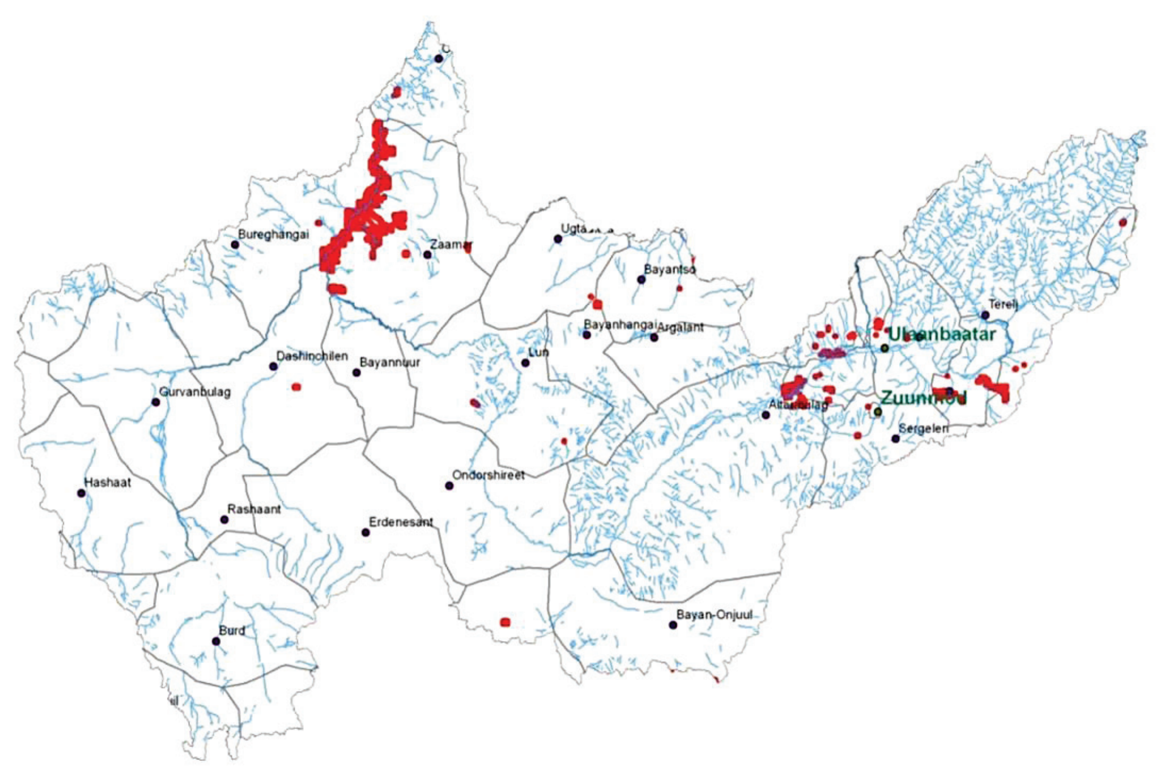

Figure 40. Location of registered mining sites (red dots) in the Tuul River basin

Exploitation of the Zaamar goldfield started in October 1995 in the Khailaast placer gold deposit area. In 2004, 36 companies were active on the banks of the Tuul River and its tributaries along a zone of approximately 20 km long. The zone significantly expanded since, being approximately 80 km long in 2010.

Water for dredging and washing is taken from the Tuul River, groundwater and from precipitation. The water consumption is not known or monitored but is probably negligible. Reservoir ponds are constructed to insure a constant water supply for the mining operation. Direct release of water to the Tuul River is not allowed due to the risk of negative impacts on drinking water quality, though it regularly happens.

Mainly physical processes are used for the recovery of gold. Use of chemicals, such as mercury is not involved, gravitation methods being sufficient to recover the gold. The resulting effluent is directed to tailing ponds where the coarsest material down to fine sand settles, and the still-turbid water is then recycled back to the wash plant or illegally discharged to the Tuul River. The systems used to reduce the quantity of suspended solids in the streams (settlings ponds) are reported to be inefficient due to a poor design and the lack of management of the sediments trapped in the ponds. Discharge of highly turbid water occurs by overtopping or collapse of the dams of the settlings ponds. Overall, water use generates excessive volumes of effluents that are harder to manage than smaller volumes with more concentrated particles [35].

Impacts by mining on surface water quality

Stubblefield et al. (2005) [36] and [37] showed that suspended sediment concentrations downstream of the mining sites in the Zaamar goldfield had a high variability from year to year. Results showed that the quantity of total suspended solids exceeded the limit for the “very polluted” class according to the Mongolian classification (>100 mg/l) in summer 2005 and 2006. However periods of heavy precipitation can influence the quantity of total suspended solids in the river, and make it hard to assess the contribution due to the climatic conditions or due to the mining activities alone.

Release of fine particles of soil generates a higher transfer of phosphate in the stream, as Stubblefield reported. Concentrations of PO4- were higher than the Mongolian standards (0.1 mg/l) in all the water samples analyzed in the Zaamar goldfield in October 2010. Phosphate is the limiting factor for eutrophication in the Tuul and Orkhon Rivers and the increase of nutrients in the stream may lead to the acceleration of the eutrophication process in some parts in the rivers downstream, especially in ponds disconnected from the main stream after floods.

A better design and maintenance of the settling systems could significantly limit the impacts on surface water quality, and would involve limited costs for the mining companies. Even though the stretch of river impacted by the Zaamar goldfield appears to be limited, as it is located near the confluence with the Orkhon River, this zone creates a barrier for fish migration that could migrate from different basins to the Tuul River basin. This risk is increase as mining activity occurs in summer when most of the salmonids and the Siberian sturgeon migrate upstream.

Informal mining and use of heavy metals

The first reports of illegal mining by ninjas in the Zaamar goldfield were in the late 1990s, and at that time were limited to the placer gold deposits in the Khailaast Valley, a tributary of the Tuul River. The survey work for the Strategic Environmental Impact Assessment prepared 1999 for the World Bank did not mention any informal gold mining in the area, it being small and mainly localized at that time in the Khailaast Valley. This is confirmed by the results of Eco-Minex fieldwork in the Zaamar Goldfield in the summers of 1995, 1996, 1997, 1998 and 1999. Ninja activities started in 2000 and reached almost 10,000 ninjas in Zaamar soum (Tuv Aimag) and Buregkhangai soum (Bulgan aimag) which is situated on the left bank of the Tuul. No recent census or practice survey has been found on illegal miners in the Zaamar goldfield.

According to Grayson [38] and Navch [39], the recovery methods did not significantly involve mercury of other heavy metals in Zaamar gold field in the mid-2000. Only 1.2% of the informal miners were using mercury for amalgamation of gold in 2004, compared to about 50% in Bor Nuur soum, Kharaa river basin. This is confirmed by analysis carried out in 2005 and 2006 that did not detect mercury in water samples in this area [37].

However, a more recent survey [40] reported an important use of mercury for gold recovery in this area, though not mentioning any figures or detailing practices. The use of new recovery methods, using heavy metals, may have progressed in recent years. As mentioned earlier more recent studies show contents of heavy metals exceeding the Mongolian standards, but with no details about the distribution of heavy metals in the water samples [17]. Ninjas practices may have changed in the last years, with an increasing use of mercury to recover gold.

As heavy metals distribution tends to be very variable in water samples, it is difficult to assess whether or not mercury is significant pollutant of the surface water in and downstream the Zaamar goldfield area, having only short-term monitoring available. A wider survey, including an inventory of ninjas practices and analysis of soil and water samples is needed.

As there are very few methods to clean water and soil from heavy metals, it is necessary to limit the source of pollution. Limiting the availability of mercury in the Zaamar goldfield would be more efficient than controlling ninjas practices.

Impacts by mining on riparian vegetation and river banks

The physical deterioration of the river banks by mining activities has a big impact on riparian vegetation, bed morphology, and the adjacent floodplain along several dozens of kilometers. Damages result from open pit extraction and gravel deposit on the valleys floodplain. They affect not only surface water quality and the ecological conditions of the Tuul, but greatly limit valuable pasture areas in the floodplain and access to drinking water points for livestock. Ways of migration for herders along the river are restricted as well.

Impacts on the river banks are hardly separable from placer mining activities, but many of the former mining sites in Zaamar goldfield have not been through a proper land rehabilitation process. It has been reported that rehabilitation of former mining sites increased since 2003, but as yet, remedial work is basic and crude, relying on earthmoving machinery, whereas the Mongolian regulations and standards include the stripping, storage, and reuse of topsoil; maximum permissible angles of final slopes; and a procedure for revegetation and aftercare [35].

Reuse of original soil is important to avoid the occurrence of exotic species, especially concerning vegetal species. Correct conservation of the top soil removed, enforcement of land rehabilitation, use of local species of plants and monitoring of revegetation on former mining sites needs to be enforced.

Impacts by mining on fish population

The Zaamar goldfield area represents an issue concerning the connection between the Tuul River basin and the rest of the arctic basin river network in Mongolia. In order to ensure the sustainability of their population, some species would definitely need new specimens from the other part of the arctic basins. The Zaamar goldfield area generates a barrier for fish species due to the low water quality and morphological degradation of the river bed. For instance, pools where fish used to rest disappear because of the sedimentation of fine particles released by the mining sites.

This limits fish migration from other basins. The upstream part of the Tuul is then disconnected from the rest of the arctic basin populations, which increases the risk of extinction for vulnerable and endangered fish species. Even if direct impacts are localized on a specific stretch of the Tuul River, it eventually disturbs the natural fish populations and compositions on the whole river basin.

Land reclamation is not correctly enforced in this area. A correct rehabilitation of the former mining sites would limit its later exploitation by illegal miners and renew the valuable grazing area which it occupied. Without reclamation the land has a limited potential for use. Non reclaimed areas are inhospitable for animal husbandry and have geotechnical unstable slopes. In addition, non-grass weeds were found to flourish in unreclaimed areas further rendering the area inhospitable for animal husbandry [41].

5.6. Forest management

The Tuul River basin has an important forest cover when compared to the national average. Approximately 113,672 hectares of the Upper Tuul Basin, upstream of Ulaanbaatar is forested. More than 95 percent of the forest is located inside the Gorkhi-Terelj National Park and Khan Khentii Strictly Protected Area. Forests are dominated by Siberian Larch (*Larix Sibirica)* and Siberian Pine (*Pinus Sibirica).* Together the two species account for 93.5 percent of the natural forest area. The remainder is comprised of small patches of Scotch pine, Birch, Spruce, Poplar, Willow, and Aspen.

The main factor of deforestation is forest fire. According to Farukh [42] Khentii aimag, constituting the upstream part of the Tuul basin is one of the three most fire prone aimags in Mongolia (Selenge and Dornod aimag are the other two). Forest fires occur mostly at two different periods, spring and autumn, when the climate is the driest. Most of the forest fires occur after several days of droughts, and are man-made though often unintentionally generated. Inappropriate logging techniques and behaviour seem to be the cause of most of the forest fires.

Due to the increasing population in Ulaanbaatar, wood demand significantly increased in the last decade. However fuelwood for the capital city is not harvested just on Tuul River basin. The river basin in the north (e.g. Kharaa river basin) provides a significant quantity of wood used in Ulaanbaatar.

In the upper part of the basin, where forest cover is more important, effects of wood harvesting is highly localized. It is logically not possible to obtain reliable data on the volume of wood harvest in the basin as 85 to 90% total wood consumption of Ulaanbaatar is derived from illegal sources [43]. Even if wood harvested for fuelwood is mostly dead wood.

Forest pests are another factor of forest deterioration in the river basin. Pest outbreaks have increased in the last decade, as dry conditions reinforce their occurrence. Main pest species in Tuul River basin are the Siberian caterpillar *Dendrolimus Sibiricus* and the Gipsy moth *Lymantria Dispar.*

Loss in forest cover generates impacts on the hydrology and water quality of Tuul River and its tributaries, especially in the upstream parts of the river basin.

During spring, shade from the trees shields the ground from the summer heat of the sun, and so retards the rate of seasonal thawing of snow and permafrost. Little information was available on the changes of discharge linked to deforestation in the Tuul River basin; however studies carried out in the Kharaa river basin, which has similar properties, showed that a reduction of forest cover leads to a significant increase of runoff peaks [44]. A 90% reduction of forest cover would almost double runoff peaks in comparison to the calibration period, clearly showing that land-cover changes strongly influence runoff generation. Krasnotshekov [45] reported that surface water discharge increased by 10-80 times during the snow melt period in East Khentii area.

These changes may have only little effect on the Tuul discharge but smaller tributaries upstream can be locally impacted and show a much higher variability of discharge.

Deforestation has a direct impact on soil erosion as well, increasing the transfer of soil particles in the streams after rainfall. Logging activities has local impacts, plus accelerated soil compaction, which interrupted water infiltration. Reduced infiltration rates lead to increased overland flow and accelerated soil erosion. According to Park (2005) water content and bulk density, were more affected by logging than forest fire.

This increase of turbidity in the streams is difficult to quantify, but can have negative effects on biology, as clogging can occur in the upper tributaries of the Tuul River, which harbor valuable spawning sites. It can be expected that this increasing quantity of soil particles transferred in the stream will generate increasing concentrations of organic material and nutrients in upper tributaries, and favor risks of eutrophication.

Forest fires appear to be the main factor of deforestation in Tuul River basin, though impact of logging can be locally more impacting. Reinforcement of the management tools to fight against forest fires in spring and autumn is needed. Special attention to this threat should be carried out after several days of droughts, where fires are more likely to happen. As many of the forest fires are man-made, access control to the Khan Khentii strictly protected area should be reinforced in spring and autumn months.

5.7. Commercial and recreational fishing

According to the *Mongolian red list of fishes*, fishing is one of the threats for vulnerable or endangered fish species. Recreational fishing occurs mainly in the upstream parts of the Tuul River basin, which harbor most of the symbolic species (e.g. salmonids). No data are available on catches and anglers` practices. The upstream part of the Tuul seems to host less recreational fishermen than other basins of the Arctic Ocean drainage (for instance Kharaa and Eroo river basin). However, as the number of recreational fishermen is increasing, pressure on symbolic species such as the Taimen is increasing and may contribute to the rarefaction of specimens.

Regulations on fishing periods are available and in accordance with spawning periods. Actions should be taken to reinforce catch-and-release practices for recreational fishermen.

The Tuul River basin has never been intensively used for commercial fishing purposes. Some cases of poaching may occur in the upper part of the Tuul, due to the proximity of Ulaanbaatar market.

Pressure from recreational and commercial fishing is currently relatively low compared to the loss of appropriate aquatic habitats.

5.8. Invasive species

No ecological problems related with invasive plants along the Tuul have been reported. Risks of colonization by invasive species increase on bare soils, such as former mining sites, as the Zaamar goldfield.

Some species of fish have been accidentally or voluntarily introduced in the Tuul such as the common bream or the East Asian catfish. Now they reached equilibrium and do not seem to generate impacts on aquatic habitats or other fish species. It seems not necessary to carry out actions to reduce their population in Tuul River basin.

5.9. Tourism

In the Tuul River basin, tourism is essentially concentrated in the upstream part of the basin, in Gorkhi-Terelj National Park. Tourist activities related to aquatic systems in this area are mainly swimming, rafting and fishing. But the river counts as an important part of the general attractiveness of the area as well.

The number of tourist camps has significantly increased in the two last decades. Between 1996 and 2007 domestic visitor numbers more than quadrupled from 25,000 to 106,300, and international tourist entries rose from 6,000 to 27,000. Until 2003 there were only 30 tourist ger camps. Now, more than 150 land permits to run tourism activities in the National Park have been issued. A total of 180 tourist establishments operate in Gorkhi-Terelj National Park and its buffers. This development has been carried out with little planning regarding solid waste disposal and sewage treatment. North of Terelj River, human pressure is lower, but over the last year several companies have started to build permanent camps and electricity lines. Tourist development may be spreading in this area in the next years.

No direct impacts have been noticed on water quality downstream of the camp area. The majority of the tourists are present from June to August when the dilution capacity of the streams is the highest. However installation of permanent buildings spread in the last years in the southern part of Gorkhi-Terelj National Park. And the increase in the number of cars along the river increases risks of accidental pollution.

Attractiveness of the park is mainly due to the preserved conditions of the park. Impacts on ecological conditions will damage the reputation of the site and lower its economical activity, it is therefore important to establish a careful control of activities and development to avoid new sources of pollution in the upstream part of the Tuul River basin. Public awareness is one of the cost effective ways to limit tourists' hazardous practices.

In the other areas on the Tuul River basin, tourists activities are scarce and do not represent a significant threat to water quality or ecological conditions. The main other attractive tourist area in the basin at Khustai National Park is well managed and does cause major environmental problems.

5.10. Reservoirs and Hydropower plants

No reservoirs or hydropower plants are actually located in the Tuul River basin. A project to implement reservoirs upstream of Ulaanbaatar, in order to increase the availability of water for drinking water supply and to generate electricity is under consideration. Characteristics of the infrastructure are not defined yet, as several locations are still under consideration.

A dam will have multiple impacts on water quality and ecological conditions, on a significant stretch of the river upstream and downstream of the dam site.

Impacts upstream of the dam site

Concerns about water quality can occur in the reservoir itself, where in general the stagnation of the water body increases the risk of eutrophication compared to a free flowing river. The eutrophication process is favored by the immobility of the water body, an increase of the temperature in the uppermost layer of water, and sufficient concentrations of nutrients. The biological productivity of the Tuul river, e.g. capacity to develop and host large algae populations, depends on its concentration in phosphorus (currently the limiting factor). As concentration of phosphorus is not expected to increase drastically in the upper part of the basin in a near future, risk of eutrophication is expected to be low for dam sites upstream Nalaikh.

Eutrophication in the reservoir could lead to sanitary problems, with the increase of possibly toxic algal concentration in the uppermost layer of the reservoir, and eventually depletion of oxygen in the water. Colour, smell, and water treatment problems can occur in summer time, especially as temperatures are expected to rise in the next decade. As the water in the reservoir is meant to be used for water supply, it is necessary to carefully monitor and to implement actions to limit the eutrophication process, in order to avoid an augmentation of the treatment costs. Protection of the upstream catchment area regarding organic pollution will be the best way to avoid issues regarding water quality in the reservoir.

There is uncertainty related to the sedimentation process inside in the reservoir, as very little data is available on the sediment load in the Tuul River. In any case sediment transport will be impacted as well, with a greater sedimentation, especially of fine particles, in the upstream part of the reservoir, due to the deceleration of the flow. This process can occur on a long stretch of river, longer than the stretch occupied by the reservoir itself. The composition of aquatic habitats will be affected with a deposition of finer material that can occur up to several kilometers upstream of the dam site. Species distribution for vegetation, macro-invertebrates and fish will be affected.

Sediments will accumulate behind the dam and may be a factor of pollution for the water in the reservoir. Though no particularly polluting industries or activities are currently located upstream, the quality of the water and sediments should be monitored to assess whether or not water quality is affected by the quality of the sediments.

A flushing gate is the best way to limit sediment deposition in the reservoir, but needs to be carefully designed and managed to fulfill its function.

Changes will occur as well in fish species distribution in the reservoir. A shift will occur from populations adapted to fast flowing rivers such as salmonids species to species used to lentic conditions such as cyprinidaes.

The dam will create a physical barrier blocking fish migrations. According to the data we have, the height of the dam (>30m) will not allow the implementation of a cost effective fishway. Environmental off-sets should rather focus on preservation of river bed or restoration of spawning sites in other parts of the basin.

Impacts downstream of the dam site

The major impact downstream of the dam site will be due to the change of discharge and seasonal river regime.

Morphological flows, which shape the river bed by erosion and sediment transport, naturally happen between June and September after heavy rainfall. They are valuable for ecology as they create a new pattern of habitats. A decrease in occurrence and in intensity of morphological flows is expected after the dam construction [4]. This will not only impact the morphology of the bed and aquatic habitats but will have effect on riparian vegetation as well, with a better implementation of tree species as disturbances created by flows in the floodplain will be reduced. The general morphology of the Tuul may tend to lose its braided aspects on some stretches and shift to a meandering river with a singular main channel most of the time.

The impact on the floodplain productivity is hard to evaluate, but floods generally carry nutrients and increase moisture content in the soil, which is beneficial for grass productivity, hence livestock activities. The decrease in flood occurrence, especially before the vegetation period, may decrease the vegetation cover in the floodplain, increase soil degradation, and diminish available area for pasture.

River flow downstream of the dam may be reduced during the snowmelt period when the reservoir will be filled up. This can result in a prolonged period with low flows until the summer rains. Groundwater tables in spring are expected to recover later which will negatively affect vegetation growth, especially for wetlands, whereas these ecosystems significantly participate in the self-purification process, especially concerning the removal of ammonium and nitrate [19]. The reduction of flood occurrence on wetlands is difficult to assess downstream of the dam

Depending on the hydropower regime water will be released in winter months, whereas actually the discharge of the Tuul is almost null upstream Ulaanbaatar from mid November until the end of March. Batdorj [46] estimated this flow at 14.49 m^3/s from November to April. No information has been found on the behavior of this flow during the cold winter months, and on how much discharge will flow through Ulaanbaatar to increase the dilution capacity of the stream downstream the WWTP.

Design and management of the projected dam(s) has not been defined as yet; it is therefore difficult to predict the impact of sediment flushing from the dams. The purpose of sediment flushing is to discharge sediment accumulated behind the dam without affecting too much the reserve of water. The best period seems to be in summer, when the dam is full and overflow occurs.

The release of a high quantity of fine sediments in a short period of time could have a strong impact on river ecology; water quality could be degraded and populations of macro-invertebrates and fish could suffer from a peak of suspended sediments in the water. A modeling of sediment release should be performed to assure that the quantity of particles in the outflow does not exceed the concentration that can occur during a natural event, for example after a rainfall period at the same period of the year.

5.11. Impact of climate change on water quality and environmental services

The annual runoff of the Tuul River is expected to increase, especially due to higher precipitations during summer months (most of the climate models suggest a rise in discharge starting in May reaching its maximum in July and August).

Summer rainfalls are often under the form of convective storms, with an important volume of rain concentrated in a short period of time. During these episodes, several processes occur. The dilution capacity will increase with runoff but this increase will mostly occur at times when the dilution capacity is already highest, i.e. in summer. Increase of annual runoff will have little effect on the dilution of pollution at times when the quality is lowest, i.e. from autumn to spring.

Furthermore, the increase of surface runoff after heavy rainfall will amplify erosion, and cause a higher sediment load in the Tuul and its tributaries. This process will be enhanced by the deforestation in the upstream part of the basin. Degradation of land cover and steep slopes will generate a significant afflux of fine particles and nutrients in the upstream tributaries during rainfall. In this context, protection of forested areas is much needed to reduce impacts from climate change on water quality.

Combination of a loss of forest cover plus more frequent or heavier rainfalls will increase clogging and habitat loss especially as the upstream part of the basin hosts most of the habitats for salmonids. Degradation of the water environment and of fishing conditions (due to turbidity) will reduce the attractiveness of the upstream part of the basin for tourism.

An increase of the floods and morphogenetic flows frequency in summer is expected. This will increase the changes and modify the distribution of aquatic habitats in the floodplain. Water content in the soil will increase in valuable pasture areas, and could improve vegetation growth and limit soil degradation due to livestock in the floodplain.

The temperature of the surface water is expected to increase in the summer months. The eutrophication process is currently limited by nutrients and mineral availability and the temperature of the water. As nutrient and mineral concentration is increasing in some reaches of the Tuul, an increase in water temperature will diminish dissolved oxygen in surface water and enhance the risk of bacteriological and algal development, causing threats to livestock conditions when surface water is often used as drinking source. Riparian vegetation should be protected to ensure a shadow cover in order to limit the increase of water temperature.

Table 8. Summary of impacts on water quality and ecology

Source of pressure	Location in the basin	Type of pressure	Impacts on Water Quality	Impacts on Ecology	Degree of impact	Impacts on ecological services	Recommendations
Domestic pollution	Nalaikh, Ulaanbaatar	Insufficient treatment of domestic effluents	Organic pollution	Degradation of habitat conditions	Severe	Degradation of water quality	Implement new treatment facilities in Ulaanbaatar. Carry out a survey on water pollution in the ger district.
Industrial pollution	Nalaikh, Ulaanbaatar	Insufficient treatment of industrial effluents	Heavy metals, Chromium from tanneries	Risk of chronic contamination of riparian vegetation and aquatic species.	Severe	Degradation of water quality Risk of pollution transfer from water to livestock or crops	Improve pre-treatment on site and establish proper treatment facility for industrial effluents. Reinforce ban of hexavalent chromium.
Mining activities	Zaamar goldfield	Uncontrolled operation of mining activities	Suspended solids in the Tuul River. Increase in use of mercury for gold recovery.	Degradation and loss of habitats. Increased risk for invasive species breaking out.	Severe	Degradation of water quality Threats to livestock and human health Loss of valuable pasture area in the floodplain	Improve design and management of storage ponds. Improve inspection of mining activities. Enforce land remediation in former mining zones.
Tourism	Gorkhi-Terelj National Park		Risks of accidental pollution	Disturbance	Low	Degradation of Gorkhi-Terelj National Park attractiveness	Control activities and development of tourist camps. Develop public awareness.
Livestock	Near rivers, lakes and water points	Concentration of livestock	Risk of bacteriological contamination	Degradation of the floodplain cover and riparian vegetation.	Medium	Degradation of water quality	Rehabilitate non functioning wells Install new wells.
Dams and reservoirs	Upstream of Ulaanbaatar	Change in river flow regime.	Eutrophication in reservoir Concentration of fine sediments	Barrier for fish migration and separation of fish population. Modification of sediment balance. Clogging of habitats when sediments are released.	High	Loss of valuable floodplain and wetlands downstream. Risk of degradation of water quality, increasing treatment costs. Loss of self-purification capacity. Possible diminution of valuable fish stock.	Monitoring of sediment and water quality in the reservoir. Regular release of accumulated sediments through a flushing gate. Protection and restoration of river banks as off-sets rather than a fishway if not cost effective.
Deforestation	Khan Khentii protected area	Deforestation due to forest fires, logging and forest pests	Increase of soil erosion and transfer of nutrients in the soil.	Change in river flow regime Clogging of habitats	Medium	Degradation of water quality Degradation of attractiveness for tourism	Improve access control to Khan-Khentii area in spring and autumn
Agriculture	Actually downstream Ulaanbaatar	Possible increase in use of fertilizer / pesticide: transfer of nutrients to the stream / shallow aquifers.	Increased risk of eutrophication. Transfer of POPs to the streams and shallow aquifers.	Toxicity for fish	Low	Risk of degradation of water quality Toxicity for livestock downstream	Minimum distance between the crop area and the streams

6. Aquifer vulnerability assessment

There are various methods to assess groundwater vulnerability to pollution in regional aquifers. This type of assessment is widely used in water resources management. As for groundwater pollution, when determining vulnerability, the DRASTIC method based on GIS is used for determining the vulnerability index (DVI).

The terminology "vulnerability" for groundwater pollution, was first introduced by Jean Margat (BRGM), a hydro-geologist, in late 1960s. The word "vulnerability to pollution" means that it expresses the protection levels that prevent pollution particles' penetrating into the aquifer. The general concept of vulnerability to groundwater pollution is based on the theory of "the physical environment which surrounds the aquifer has protection levels and it has a capacity to protect the aquifer from polluting particles when they penetrate into the soil". The physical properties near and above the aquifer are different according to their distribution. It means that groundwater in one area may be very vulnerable to pollution and groundwater in the other area may be less vulnerable to pollution.

The assessment of vulnerability to pollution is conducted and expressed in tables and figures which are very vital information for conducting groundwater quality management, providing authorities with information on the level of decision making and establishing protection levels.

There are many methods used to assess whether groundwater is vulnerable to pollution or not. This kind of estimation is widely used in water resources management and in the level of decision making. There are many methods used for vulnerability assessment. They are categorized into 5 parts. They are:

1. Analog method
2. Hydro-geological method
3. Matrix method
4. DRASTIC method
5. Index method

The vulnerability assessment for groundwater pollution is conducted by the DRASTIC method. The DRASTIC method is an empirical model which was conducted by the US Environmental Protection Agency (Aller.et.al. 1985). This model determines a vulnerability index for pollution on the basis of factors and influences that show how hydro-geological conditions react when polluting particles penetrate into the aquifer. The equation is:

$$DVI = \sum_{i=1}^{n} F_i * W_i$$

where: *DVI - Drastic Vulnerability Index*

F_i - input variables including aquifer depth, recharge, aquifer properties, soil properties, vadose zone properties and hydraulic conductivity. The input variables are categorized depending on feature and size. They have factors which range from 1 to 10.

W_i - impact weight of pollution vulnerability for each input variable. The impact weight varies from 1 to 5.

Depending on the available information, all input variables or some of them, are used and the vulnerability index is determined by spatial distribution or spot values. The calculated results are categorized into low, average and high (Table 9).

Table 9. Outputs of vulnerability calculation or index meaning classifications

№	Vulnerability classification	Vulnerability calculation output or index
1	Extremely low	50-63
2	Very low	63-76
3	Lower	76-89
4	Low	89-102
5	Average	102-114
6	High	114-127
7	Higher	127-140
8	Very high	140-153
9	Extremely high	153-166

Brief explanation of the input parameters that are used for the DRASTIC model

Depth to aquifer is the distance that polluting particles travel from the surface to the aquifer. It is a very important parameter that expresses the time, during which polluting particles pass the physical soil environment before reaching the aquifer. Groundwater in a confined environment possesses a natural protection and the vulnerability for pollution is lower than that of groundwater in an unconfined aquifer environment. The depth to the aquifer is determined by the difference between the height of the aquifer top and the topographical elevation of the surface. The measurements are expressed in metric units.

Recharge is the total amount of water that penetrates into the aquifer from the surface. The water originates from precipitation or from water used for crop or garden irrigation.

Aquifer media. The groundwater aquifer consists of rocks, gravel, sand, silt and clay which are capable to pass penetrating water. The aquifer can be observed in different depths in the underground. There can be a layer with a low capacity of groundwater flow above the groundwater aquifer. Such a layer is called "Aquitard". The lower limit of the aquifer is called "Aquiclude". This part is not capable to pass penetrating water.

Soil texture. The soil is the first layer where polluting particles pass before percolating to the groundwater. The pollution concentration changes in the soil due to processes including bio-chemical reaction, absorption and evaporation. These processes depend on soil texture, soil thickness/depth, physical structure of soil texture and types of polluting particles. For example: the water penetrating capacity is very low in layered-clayey soils. The possibility for the polluting particles to pass through this layer is reduced.

Topography. The topography levels determine how long polluting particles remain on the surface area. If the surface slope is large, then there is a higher possibility of polluting particles flowing with surface water. So, polluting particles' penetration into the soil is decreased, and pollution levels are reduced.

Vadose zone. This zone contains the layer from the soil bottom to the top of the aquifer. In this zone, rock pores are partly (unsaturated) or fully (saturated) filled with water. The saturated and unsaturated parts of the vadose zone have an important effect on the concentration and quality of the polluting particles and whether penetrated polluting particles in this zone become more harmful or harmless. In other words, the number and quality of the polluting particles may be changed through the processes of bio-chemical reaction, absorption, evaporation, filtering by mechanical filter, neutralizing, dispersing and chemical reaction.

Hydraulic conductivity expresses the groundwater flow speed to cover the distance in unit time through the aquifer's pores and fractures. It also determines at what speed polluting particles inside the aquifer are travelling. Depending on the hydraulic conductivity groundwater may travel several meters or only a few centimeters of distance in few hundred years' time. Polluting particles will quickly flow through an aquifer with high hydraulic conductivity. Hydraulic conductivity can be isotropic in all directions of the aquifer and it can be anisotropic in horizontal and vertical directions of the aquifer.

The following 2 steps should be taken when preparing input data to determine the vulnerability index.

- Depending on the input variable maximum and minimum values, categorize from 1 to 10 and give a factor to each category (Table 10).
- Allocate a weight between 1 and 5 to each input variable which were given factors. The weight indicates the size of effect of the input variable in the calculation.

Table 10. Classification of DRASTIC method input variables and their factor value

Input variable	Classification	Factor
Depth of aquifer, m	0-5	10
	5-15	9
	15-30	7
	30-50	5
	50-75	3
	75-100	2
	>= 100	1
Recharge, mm	0-5	1
	5-10	3
	10-15	6
	15-20	8
	>= 20	9
Soil texture	Very thin	10
	Gravel	10
	Sand	9
	Shrinking and/or Aggregated Clay	7
	Sandy mud	6
	Clayey	5
	Brown clayey	4
	Muddy	3
Topography, degrees	0-2	10
	2-6	9
	6-12	5
	12-18	3
	>= 18	1
Vadose zone	Muddy	1-2
	Shell clay	2-5
	Chalk stone	2-7
	Sand rock	4-8
	Layered limestone, sandstone, shell	4-8
	Muddy sand, gravel	4-8
	Metamorphic/Igneous	2-8
	Sand, gravel	6-9
	Basalt	2-10
	Karst limestone	8-10

Input variable	Classification	Factor
Hydraulic conductivity	1-100	1
	100-300	2
	300-700	4
	700-1000	6
	1000-2000	8
	>= 2000	10
Aquifer alluvial and rock	Shell	1-3
	Metamorphic/Igneous	2-5
	Weathered Metamorphic/Igneous	3-5
	Very thin sandstone and limestone	5-9
	Sandstone	4-9
	limestone	4-9
	Sand, gravel	6-9
	Basalt	2-10
	Karst limestone	9-10

The classification, factor and the weight can be changed according the data quality and its accuracy. The classification, factor and weight can be determined based on the knowledge and the experience of the people who collected, processed and used the data and the condition of the areas. The accuracy of the vulnerability index for groundwater pollution depends on the input data accuracy, weight and factors and calculation-making experts' capacities.

Calculation. The sequence of data preparation and calculation is presented in Figure 41. The input data was derived from maps of hydro-geology, precipitation, soil, surface elevation, borehole data and index. The input data are: groundwater aquifer depth, recharge, aquifer, soil, topography, vadose zone and hydraulic conductivity.

In order to simplify the calculation, each input data was converted to a 30x30 m grid raster version. After that, each input data was classified in terms of values and quality separately.
Each classification was given factors due to its influence on pollution. Each input variable, that already got factors, was given weight due to its influence on the calculation.

Advantages of DRASTIC method:

- the method assesses pollution vulnerability of groundwater in local areas and regions;
- the method pre-determines areas which might have been affected by pollution;
- the method assists in monitoring, assessment, management and decision making as well as planning etc.;
- the method plays a very vital role to take measures including: to develop planning, management and policy; to make decisions; to give understanding for the public about groundwater protection and pollution risks.

Disadvantages of DRASTIC method:

- often data is lacking when conducting assessment of large areas;
- the method does not include the presence of pollution sources.

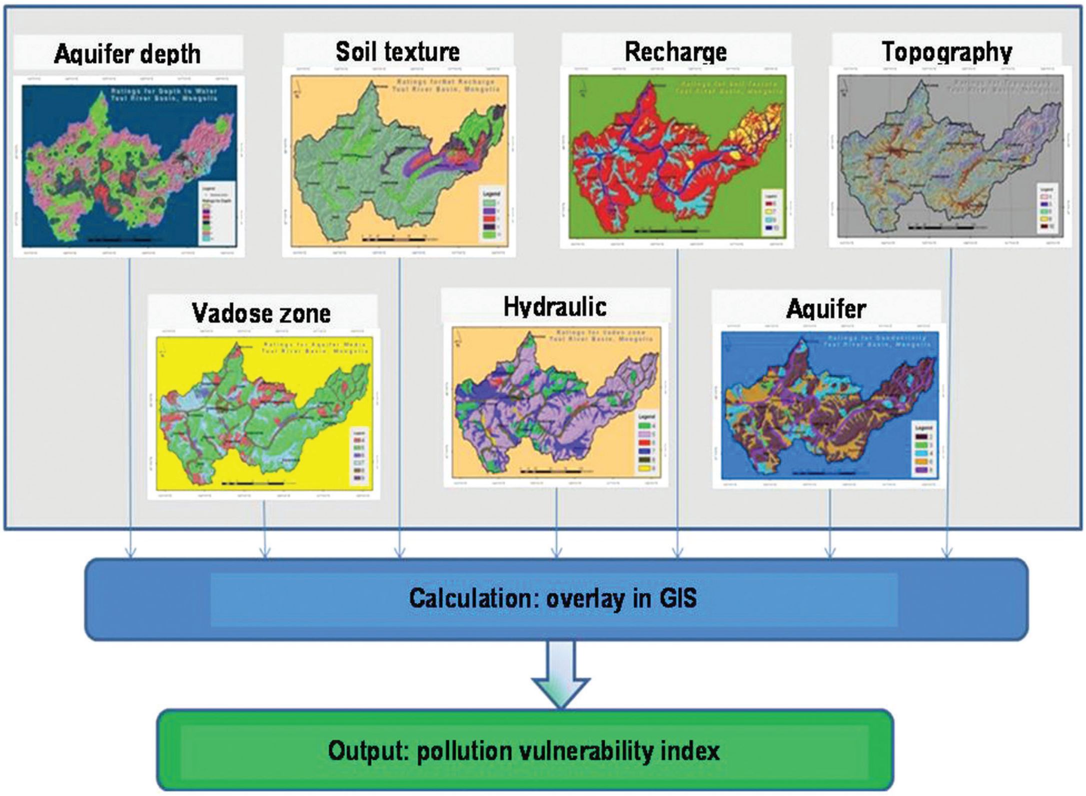

Figure 41. Sequence of input data preparation and calculation activities

Result: Zuunmod city drinking and domestic water supply. When determining the vulnerability index for groundwater pollution, data from the report on hydro-geological research was used. The research was conducted in Khushgiin Khundii in 2007. Zuunmod is the capital of Tuv aimag of Mongolia. The research was conducted by "Tuv-Water" LLC between 2006 and 2007 with the purpose of searching water supply for the new international airport. It was conducted with financial assistance from the Japanese Government. In total 73.55 l/sec exploitable groundwater resources were discovered, industrial level A - 30.31 l/sec and industrial level B - 43.24 l/sec.

As for geological formation, lower carbonate age sedimentary rock and quaternary sedimentary aquifer dominate the research area. Alluvial-proluvial origin sedimentary aquifer groundwater is recharged by precipitation water in warm seasons and by lateral flows as well. The highest annual precipitation amount is in the months of May, July and August. The lowest is in the months of January, February and March. The following data from hydro-geological boreholes' /which were drilled during the research stage/ were used. They are: geological well log, static water level and hydro-geological parameters which were calculated by analytical equation.

Table 11. Input variables and calculated vulnerability index by each borehole

Borehole	Depth to aquifer, m	Rain recharge, mm/year	Soil texture	Topography, degrees	Conductivity *m / day*	Soil between the soil texture and the aquifer	Type of aquifer rocks	Vulnerability index
1	3.35	6	Plant layer, 0-20cm	0-2	10.8	Gravel	Smooth gravel of sandstone and shell	146
2	3.2	6	Brown soil, plant layer, 0-30cm	0-2	4.57	Sand	6-8 cm diameter gravel	138
3	6.05	6	Brown soil, plant layer , 0-30cm	0-2	3.76	Gravel stone	Big particle gravel stone	127
4	3.8	6	Brown soil, plant layer 0-40cm	0-2	4.16	Fine particle sand	Big and average particle gravel	123
5	5.8	6	Brown soil, plant layer 0-30cm	0-2	15.75	Compact-layered sand	Sand rock layer	147
6	5.52	6	Brown soil, plant layer 0-40cm	0-2	5.13	Compact-layered clay	1-6 cm diameter gravel	133
7	10.7	6	Brown soil, plant layer 0-50cm	0-2	2.16	Fine particle sand	1,5-5 cm diameter gravel	109

The calculated groundwater vulnerability is compared in Table 12 with the DRASTIC method vulnerability classification limits.

Table 12. Calculation-conducted boreholes' vulnerability index, by vulnerability classifications

Vulnerability classification	Index	Borehole numbers where vulnerability assessment was conducted						
		1	2	3	4	5	6	7
Extremely low	50-63							
Very low	63-76							
Lower	76-89							
Low	89-102							
Average	102-114							+
High	114-127			+				
Higher	127-140		+		+		+	
Very high	140-153	+				+		
Extremely high	153-166							

According to the calculation results the vulnerability index in Khushigiin Khundii fluctuates between 109 and 147. The boreholes are for the drinking water and water supply of Zuunmod city. The vulnerability classification is higher than average and all boreholes except borehole 7 are included in the category of high, higher and very high in terms of pollution vulnerability. The objective of the calculation was to determine the groundwater pollution vulnerability of the boreholes which were designed for drinking water and water supply of Zuunmod city, located in the Tuul river basin.

According to the calculation results, the groundwater is very easy to be polluted in this region due to human activities.

Result: Tuul river water basin

The calculation results are presented in Figure 42 showing the areas which can be affected very easily or very difficult by pollution. The calculation results or pollution vulnerability are categorized as lower, low, average, high, higher, very high and extremely high. Their areas are compared to the total area of the basin (Table 13).

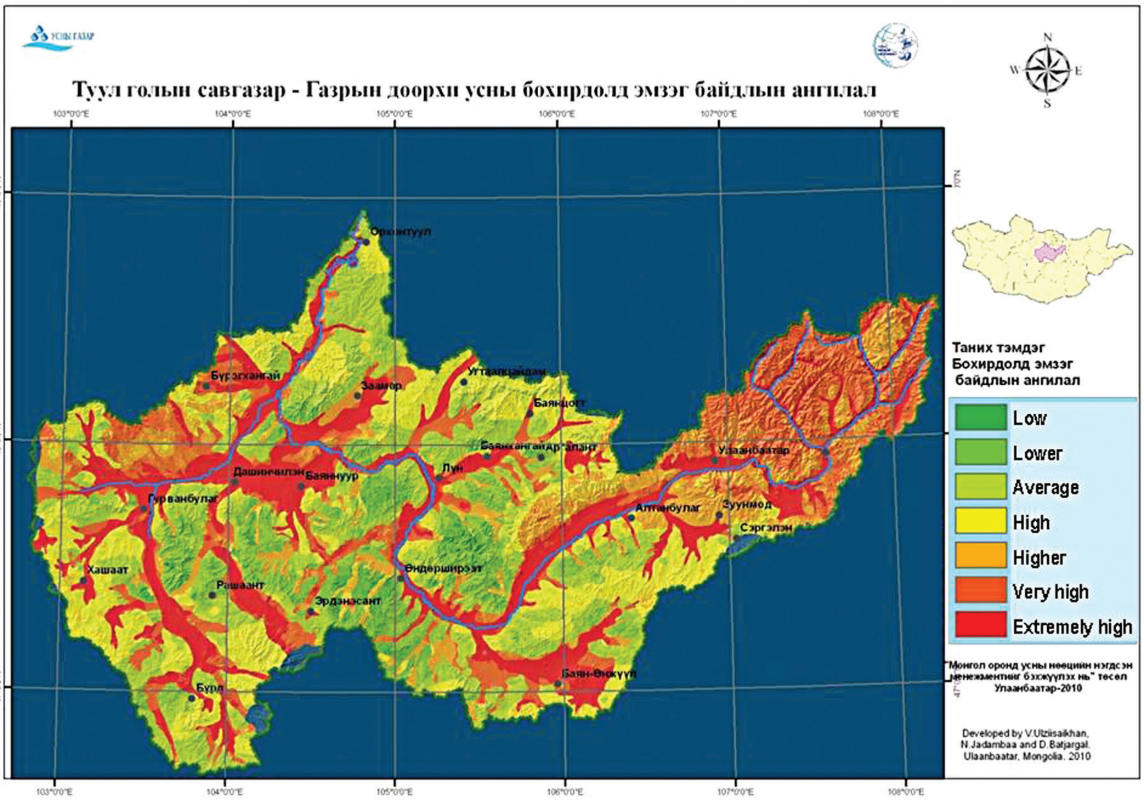

Figure 42. Pollution vulnerability classification of Tuul river basin aquifer

Table 13. Pollution vulnerability classification of Tuul river basin aquifer and its areas

№	Pollution vulnerability classification	Pollution-vulnerable area percentage of Tuul river basin
1.	Low	1.2%
2.	Lower	8.2%
3.	Average	20.5%
4.	High	20.2%
5.	Higher	11.4%
6.	Very high	17.8%
7.	Extremely high	20.7%

In order to have more understandable calculation results, the pollution vulnerability is categorized into three categories as low, average and high and each area of these 3 is compared to the total area of the basin (Figure 43, Table 14).

Table 14. Area of each classification (low, average, high) for aquifer pollution vulnerability

№	Pollution vulnerability classification	Pollution-vulnerable area percentage of Tuul river basin
1	Low (50-102)	9.4%
2	Average (102-140)	52.1%
3	High (140-166)	38.6%

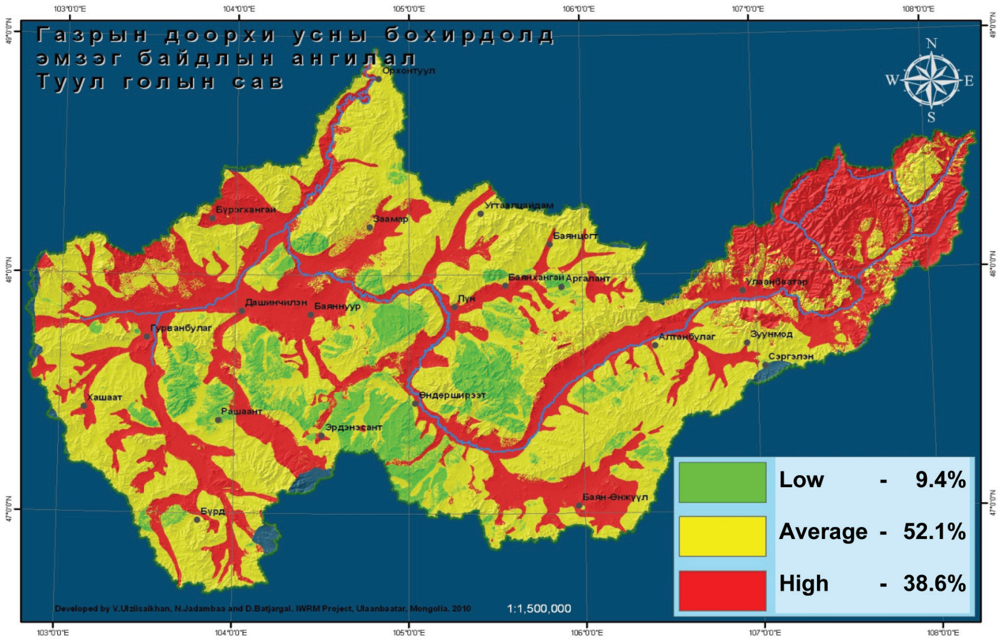

Figure 43. Pollution vulnerability figure by three classifications as low, average and high

Conclusion. According to the figure, urban areas overlap the areas with a high pollution vulnerability classification. This may cause negative impacts for the population health. The country supplies much of its drinking and domestic water demand from groundwater. The pollution vulnerability is categorized into 3 parts as low, average and high. The low classification occupies 9.4 percent, the average classification occupies 52.1 percent and the high classification occupies 38.6 percent of the total river basin area.

7. Conclusions and recommendations

7.1. General conclusions

Water quality and ecological conditions are severely degraded in the Tuul River basin downstream of Ulaanbaatar, whereas in the upper part of the basin surface water quality still remains good or excellent. The concentration of the population and the inappropriate management of the pollution emitted by Ulaanbaatar city have the biggest impact on water quality. Pollution is essentially organic. Impacts from the ger district area on Tuul water quality are hard to assess. The stretch of the river affected downstream of Ulaanbaatar has increased in the last decade. The main point source pollution is the discharge of the central waste water treatment plant and untreated effluents pour directly into the Tuul River. New treatment facilities, including better treatment of industrial effluents is necessary to limit the degradation of the water quality.

The second major impact on the Tuul River basin is due to the mining activities in the Zaamar goldfield area. Surface water quality is affected by high levels of turbidity that could be easily lower with a better management of settling ponds. Remediation of former sites is not properly carried out and impact of river morphology remains, with risks of invasive species breaking out on bare soils. Latest studies mention the recent development of the use of mercury by illegal miners for gold recovery.

Grazing pressure is reported to be high downstream of Ulaanbaatar but too few data are available to assess if this affects significantly the water quality and the ecological conditions. The rehabilitation of non functioning wells in certain areas could dilute the grazing pressure around the water bodies but may increase as well the total livestock number. In the eventuality that a program of rehabilitation of wells is carried out, it should integrate a limitation of livestock number increase to avoid adverse effects.

Construction of a dam on the Tuul River could generate multiple effects on water quality and ecology on a wide stretch of the river upstream and downstream of the reservoir(s) site(s). Eutrophication and degradation of water quality in the reservoir could become a major issue as water stored should become a source for water supply. Protection of the catchment area against organic pollution (especially phosphorus) is the most effective way to limit water treatment costs. Impacts on environmental flow should be carefully studied as modifications of flood and morphogenetic flow frequency will change river morphology, distribution of aquatic habitats and human uses in the floodplains downstream. The management of fine sediments trapped in the reservoir should try to imitate the natural sediment balance, and avoid a massive release of sediments in a short period of time.

7.2. Conclusions on water quality

1. The mineralization of the Tuul River water is very fresh, under 100 mg/l at most points in the upstream part of the river which is from Bosgo Bridge to the discharge point of Nalaikh waste water. The mineralization of the river increases again from Upper Songino after the waste water discharge of the Ulaanbaatar CWWTP and the amount of mineralization content without decreasing when compared to points before the capital. From the results of mineralization, the river flow into Orkhon River is without natural purification because of pollution from Zaamar area and waste water discharge of the CWWTP. Water class, group and category and

increasing mineralization changes downstream because of chemical pollution and human activity starting from Ulaanbaatar city and it flows into Orkhon River without self purification.

2. As can be seen from last year's research results, the pollution indicators are rapidly increasing downstream after the waste water discharge of the Ulaanbaatar CWWTP. At the next sampling point after discharging the waste water, ammonium azote is 5.4-12.4 times more than 'much polluted' category of the standard of surface water. Thereafter ammonium ion is observed at other points, it is included from 'polluted' to 'much polluted' category. From the results of ammonium, it is clear that flow from the Tuul River into the Orkhon River is polluted and not purified. This is related to increased amount of waste water by growing water usage of the enterprises, industries and population, also out of date treatment plant equipments and technology, unsatisfactory primary cleaning of the industries and enterprises waste water, insufficient capacity. The water pollution of the Tuul River has increased each year, negatively affecting the river water quality, ecological condition and hydrobiological regime.

3. From upper Songino after waste water discharge to the Altanbulag Bridge river water is not suitable for livestock and resident use.

4. Under-refine or completely unrefined waste water from industries and enterprises in the Ulaanbaatar and Nalaikh district discharging into Tuul River and capital waste water network is basic reason of river water pollution.

5. The groundwater system surrounding Ulaanbaatar recharges from both the Tuul River and from precipitation. General groundwater is hydrocarbonate class, in the calcium group and the first category of very fresh and soft water. The mineralization of the groundwater naturally increases with the downstream flow.

6. The chemical composition and water quality of groundwater from wells beyond the Tuul River Zone differs. Specifically, water of some wells in the Khan-Uul district contain ferrous iron and are slightly acidic. This water has similar properties to naturally occurring mineral waters.

7. As can be seen from the study results, the wells in the Khailaast, Denjiin Myanga, Bayanburd and Zuun Ail areas have relatively high mineralization and very hard water. The wells in the Dari-Ekh, Ulaankhuaran, Amgalan, Tolgoit and Bayankhoshuu exhibited slightly less mineralization and hardness.

8. Contamination indicators are increasingly higher than standards in the last few years, due to the expansion of population and industry in Ulaanbaatar.

9. The Tuul River water near Ulaanbaatar city is greatly affected by chemical and household pollution. It is also possible to influence in the groundwater quality of river floodplain.

10. Mineral waters in the Tuv province are used mainly for stomach pain, and contain hydrosulfuric acid, iron and carbonic.

11. Groundwater of soums in the Tuul River Basin is mainly fresh and soft, but some areas have high mineralization and hardness. Notably, Toormiin khooloi of the Gurbanbulag soum and Bayantsagaan of the Khishig-Undur soum, Baishint Denj of the Bayannuur soum in the Bulgan province and "Ikh Nomt" Co.Ltd in the Rashaant tosgon, Selenge province wells water are not satisfactory for drinking water.

7.3. Recommendations

1. Every organization and industry (especially, leather and wool processing and washing) implementing activities on the Tuul River floodplain and valley need to meet the level required for primary cleaning of their waste water. Therefore, it is necessary to strengthen internal control (laboratory analysis and its control), restructuring of the equipments and constant work. Also it is necessary to stop direct discharge waste and under-refined waste water into Tuul River.
2. Implement and decide immediately issue of rehabilitation of treatment plant facility and extension of the CWWTP.
3. Implement control work of soums, provinces and state with precise schedule for refined waste water and technological activity of the central treatment plant and enterprises in the Tuul River Basin.
4. In accordance with the future needs there is an urgent need to apply reuse refined waste water technologies in the enterprises in order to protect against river water pollution and support water saving policy. Relocate industries and enterprises from capital city that discharge deeply polluted water and need to take extra measures.
5. Take all measures for protecting river water against pollution such as regulate to wash cars and materials in the river water and eliminate trash problems because rain and snow runoff water in creeks carry pollutant to the river.
6. Restrict construction activities within the flood plain of the river according the laws for water and forest.
7. Take measures to increase water yield and flow, and stop activities that explore sand, gravel and mining work along bank and source of the Tuul River which directly affects water yield and causes pollution.
8. Future water resource management plans need to be implemented and water quality studies expanded. Water of different quality should be used for different purposes and in different amounts. It is important to plan groundwater extraction and allocation accordingly.
9. Industries and individuals are required to perform more and more water treatment due to increasing mineralization and hardness of supplied water.
10. Specialists such as chemists, chemical technologists, hydro geologists, doctors, hygienists and hydro-engineers need to organize together in order to continuously monitor surface and groundwater, protection from pollution, assure suitable use water resources, apply modern technologies of water treatment and develop integrated database of water information.

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ANNEX 1. Surface water standard: MNS 4586–98

No	Substance	Unit	Permissible
1	pH		6.5-8.5
2	DO	*mgO/l*	not less than 6&4
3	BOD	*mgO/l*	3
4	PICH	*mgO/l*	10
5	NH_4-N	*mgN/l*	0.5
6	NO2-N	*mgN/l*	0.002
7	NO_3-N	*mgN/l*	9.0
8	PO_4-P	*mgP/l*	0.1
9	Cl-chlorine	*mg/l*	300
10	F-fluorine	*mg/l*	1.5
11	SO_4-sulfate	*mg/l*	100
12	Mn- manganese	*mg/l*	0.1
13	Ni- nickel	*mg/l*	0.01
14	Cu- copper	*mg/l*	0.01
15	Mo- molybdenum	*mg/l*	0.25
16	Cd- cadmium	*mg/l*	0.005
17	Co- cobalt	*mg/l*	0.01
18	Pb- lead	*mg/l*	0.01
19	As- arsenic	*mg/l*	0.01
20	Cr-chromium	*mg/l*	0.05
21	Cr^{6+}	*mg/l*	0.01
22	Zn- zinc	*mg/l*	0.01
23	Hg- mercury	*mg/l*	0.1
24	Oil	*mg/l*	0.05
25	Phenol	*mg/l*	0.001
26	Active and washing substances	*mg/l*	0.1
27	Benzapyren	*Mkg/l*	0.005

Note: DO > 6 mgO/l for summer time and DO > 4mgO/l for winter time.

ANNEX 2. Surface water classification (MNET 1997)

№	Classification parameters	Measurement unit	Water quality classification				
			Very fresh	Fresh	Little polluted	Polluted	Very polluted
			1	2	3	4	5
1. Oxygen regime parameters:							
1.	Dissolved oxygen (DO)	mg/l	9 <	8 <	6 <	4 <	4 <
Not concerning the definition of samples before 9 am and pm							
2.	Oxygen satisfaction	Percent	90 <	75 <	60 <	40 <	40 <
3.	Biochemical oxygen demand (BOD)	mg/O_2/l	< 3	< 5	< 10	< 15	15 <
4.	Chemical oxygen demand (COD)	-	< 10	< 15	< 25	< 50	70 <
5.	Oxidization /O_2/	-	< 3	< 5	< 10	< 20	30 <
6.	H_2S	-	Not appear	Not appear	< 0.1	< 1.0	1.0 <
2. Mineralization component parameters:							
7.	Total hardness	N^0	< 10	< 15	< 20	< 30	40 <
8.	Calcium Ion (Ca^{2+})	mg/l	< 45	< 90	< 150	< 200	300 <
9.	Magnum Ion ($Mg^{\geq 4}$)	-	< 15	< 30	< 50	< 100	200 <
10.	Dry rests of the dissolved substances	-	< 200	< 300	< 500	< 800	1200 <
11.	Chlorine Ion /Cl/	-	50	< 150	< 250	< 350	500 <
12.	Sulfur Ion (SO_4 +)		< 50	< 100	< 200	< 300	400 <
3. Bio pollution parameters:							
13.	Ammonium nitrogen (NH_4^+)	mg/l	< 0.02	< 0.05	< 0.1	< 0.3	0.5 <
14.	Nutrients nitrogen (NO_2^-)	-	< 0.002	< 0.005	< 0.02	< 0.05	0.1 <
15.	Nitrate nitrogen (NO_3)	-	1	< 3	< 5	< 10	20
16.	Bio nitrogen (NO_3)	-	< 0.3	< 0.5	< 1.0	< 2.0	2.0 <
4. Special parameters:							
17.	pH	-	6.5 8.0	6.5 8.5	6.0 8.5	6.0-9.0	5.5-9.5
18.	Total iron ($Fe^3 + Fe^{2+}$)	-	< 0.3	< 0.5	< 1.0	< 1.5	1.5 <
19.	Manganese (Mn^{2+})	-	< 0.05	< 0.1	< 0.3	< 0.8	1.5 <
20.	Phenol (C_6H_5OH)	-	Not appear	< 0.001	< 0.002	< 0.005	0.01 <
21.	Phosphate (PO_4^{3-})	-	< 0.02	< 0.05	< 0.1	< 0.5	0.5 <
22.	Total phosphorus	-	< 0.025	< 0.1	< 1.0	< 2.0	2.0 <
23.	Active washing substances in surface	-	Not appear	< 0.1	< 0.5	< 1.0	1.0 <
24.	Oil and grease	-	Not appear	< 0.05	< 0.1	< 0.3	0.5 <
25.	fats	Quality	-	Not appear	Not appear on the water surface		
26.	Odor and taste	Quality and assessment	No strange odor and taste				
27.	Color	Quality assessment	No color	No color	bit	Color	-
28.	Clearness	Cm	35 <	< 30	< 25	< 20	< 20
29.	Suspended solids	mg/l	< 10	< 20	< 50	< 100	100 <

№	Classification parameters	Measurement unit	Water quality classification				
			Very fresh	Fresh	Little polluted	Polluted	Very polluted
5. Bacteria studies parameters:							
30.	Colin titer		10 <	< 1.0	< 0.1	< 0.01	< 0.01
31.	Pathogens		None	None	None	None	None
32.	General microbial number		< $5*10^5$	< 10^6	< 3.10^6	< 5.10^6	< 5.10^6
6. Hazardous substances							
33	Cyanide ion (CN)	mg/l	Not appear	Not appear	< 0.01	< 0.05	0.1 <
34.	Mercury (Hg^{2} +)	-	-	-	< 0.001	< 0.005	0.005 <
35.	Arsenic (As^{3+})	-	< 0.2	< 0.5	< 1.0	< 1.5	1.5 <
36.	Fluorine	-	< 0.2	< 0.5	< 1.0	< 1.5	1.5 <
37.	Boron (B)	-	None	-	< 0.5	< 1.0	1.0 <
38.	Selenium (Se^{2+})	-	Not appear	< 0.01	< 0.05	< 0.1	1.0 <
39.	Zinc (Zn^{2+})	-	< 0.2	< 1.0	< 2.0	< 5.0	5.0 <
40.	Tungsten (W)	-	None	None	None	< 1.0	1.0 <
41.	Copper (Cu^{2+})	-	< 0.01	< 0.05	< 0.1	< 0.5	0.5 <
42.	Cadmium (Cd^{2+})	-	Not appear	< 0.005	< 0.01	< 0.1	0.1 <
43.	Cobalt (CO_2^{+})	-	0.01	< 0.02	< 0.05	< 1.0	1.0 <
44.	Molybdenum (MO_2+)	-	0.001	< 0.1	< 0.5	< 1.0	1.0 <
45.	Silver (Ag)	-	0.001	< 0.01	< 0.02	< 0.05	0.05 <
46.	Nickel (Ni^{2+})	-	0.01	0.05	0.1	0.2	0.2
47.	Sulfate	-	None	None	None	None	*
48.	Lead (Pb^{2+})	-	< 0.01	< 0.05	< 0.1	< 0.2	0.2 <
49.	Chrome (Cr^{3+})	-	None	< 0.02	< 0.1	< 0.5	0.5 <
50.	Chrome (Cr^{6+})	-	None	< 0.01	< 0.05	< 0.1	0.1 <
51.	Free Chlorine (Cl)	-	0.0	0.0	0.0	< 0.05	0.1 <
7. Saprobe quality:							
52.	Pantle-Puck	-	1.0	1.5	2.0	2.5	2.5
53.	Sladchik classification	-	Kseno (KH)	Oligo (O)	Oligo -Beta - mezzo /O-? -m/	Alpha -mezo (? -m)	Poli (P)

ANNEX 3. Definition for classification of surface water quality in Mongolia (MNE 1997)

Classes	Definition
1 Very clean	Sections of water bodies with pure, usually oxygen saturated, nutrient-poor water; low bacteria content and directly use for drinking purpose, suitable for all kinds of water usage.
2 Clean	Water bodies with small amount of inputs of organic or inorganic nutrients but without or slightly oxygen depletion, low bacteria content and use for drinking and food production purposes after disinfection and filtration, directly utilize for fishing factory.
3 Slightly polluted	Section of water bodies with slight pollution, not a good oxygen supply, inputs of organic or inorganic nutrients, some bacteria content and not suitable for drinking and food production purposes, if no choice use it above mentioned purposes after treatment, disinfection, filtration and can use directly for livestock, recreation, sport purposes.
4 Moderately polluted	Water bodies with inputs of organic, oxygen consuming substances capable of producing critical oxygen depletion; fish kills possible during short periods of oxygen deficiency; declining numbers of macro-organisms; certain species tend to produce massive populations and use for irrigation, industrial process after filtration.
5 Heavily polluted	Sections of water bodies with heavy organic, usually low oxygen content; localised deposits of anoxic sediment; filamentous sewage bacteria, occasional mass development of a few micro-organisms, which are not sensitive to oxygen deficiency, periodic fish kills occur, after filtration, use for some industrial process, which is not take part in human.
6 Dirty	If value of water quality index exceeds 5th degree, it is belongs to this class. Sections of water bodies with excessive pollution by organic, oxygen depleting sewage; processes of putrefaction predominate; prolonged periods of very low oxygen concentrations or total deoxygenating; mainly colonised by bacteria, no fish stocks; loss of biological life in the presence of severe toxic inputs and can not use any purpose.

Source: [MNE, 1997b]

ANNEX 4. Short description of some protected areas in the Tuul river basin

Ecosystem basin	Biodiversity values	Unique ecosystem values	Relevant provisioning services	Relevant cultural services
Khan-Khentii Mountain	Medical plants-284 species, nutrient plants-529, nutritive plants-46, vitamin plants134 are recorded. In Kherlen river 23, in Onon river recorded 28 fish species. In total 253 bird species recorded in this area. In Khentii mountain about 50 species small mammals are recorded.	This area is water source for Orkhon and Tuul Rivers. Total forest cover area is 11.2 million ha in Mongolia. About 40 % of forest resources is located only in Khentii mountain. In this area mostly distributed mountain taiga, mountain permafrost, forest grey, mountain black brown alluvial soil.		Eldest region of Chingis Khaan, this is specific region for taiga natural zone, this is real practice place for protection of three rivers (Tuul, Onon and Kherlen) and very good historical area
Gorkhi-Terelj National Park	Dominant forest species is larch, birch, spruce and pine. Also different shrubby plants grow in this area. Dominant fauna: Deer, bear, swine, ore, fox, wolf, lynx, antelope, sable, brock and marten. Dominant birds: grouse, popinjay, pigeon, crow and pie.	There is spread mostly black brown and brown soil. Also dominant soil is forest grey, mountain shallow brown. The brown soil spreads in southern slopping of mountain and black brown soil is by riparian zone.	Many tourist camps, resort places are located in this area.	
Bogd Khaan mountain	This mountain is the southern part of Khentee mountains range, the borderline between forest steppe and steppe regions, the southern borderland of the larch forest, and is of a special significance in the climate formation of the surrounding area. Species here are characteristic of the taiga, mountain forest steppe, and steppe zone, including over 500 species of vascular plants, 9 trees, 47 mammals, 194 birds, 4 reptiles, and 2 amphibians.	There are about 20 streams in surrounding area of Bogd Khaan mountain. There are 32 springs and most of them are located in head of valley. Most of rivers, streams and springs are occupied in area of 404 square km and 52.5% of the area is covered by forest. The 22.9 thousand ha area is covered by forest. It has 55.8% of total area of Bogd Khaan mountain. Larch-56.8%, cedar-22.2%, spruce-15.4%, pine-1.4%, birch-2.6% and bushes-1%.		Many grave mound, deer stones and tombs surrounded by Bogd Khaan mountain. Recognized as a sacred mountain, its history much related with religious civilization and settlements such as Manzchir Hiid monastery established in!750.

Ecosystem basin	Biodiversity values	Unique ecosystem values	Relevant provisioning services	Relevant cultural services
Khustain nuruu	Rich in deer, roe, swine and different species of rodents. There are recorded more that 126 bird species. Dominant plants for sandy soil spread in this area.	**Rivers-** Altanbulag, Urtiin us, Bayanbulag, Bayanii us, Jargalantiin us, Tariatiin us. **Springs-** Hoshootiin, Tariatiin and Zuun Artsatiin	This area represents characteristics of steppe regions of the west-southern part of Khentee mountain range. Due to its sufficiency of fodder and water resources, as well as geographical suitability, the takhi (wild horses) from the Takhi Protection Foundation of Holland and Askani-Nova of Ukraina are re-introduced in this area.	Deer stone at the Hoshoot mountain.
Batkhaan mountain	It has not rich in fauna, but there have not many deer, roe, swine, fox, wolf, lynx, rabbit and marmot.	In southern and northern sloping have many small rivers and they are going to Badiin river. Back Jargalant river flows to west and it joints to Hogno Tarni river.		It is a component of the Khangai and Khentee mountainous state and is an ancient historical and cultural monument. There are many grave mounds and tombs. Many lizards step and consolidated bones from the 4th century in this area.
Khogno Khaan mountain	Medical plants are about 100 species, crop fodders about 100 species, fruits- about 10 species, tea plants-5 or 6, nutritive plants are about 3-4	It is specific that there grow taiga and steppe plants, at the same time. Also, it is specific that there are 2-3 different natural zones happened upon at the same place. The Hognohaan mountain is biggest valley of Tarniin river. Eastern inflow of Tarniin river is Chuluutiin river. Chuluutiin river flows to Harhiin river and Tuul River. In eastern part of Tarniin river is located sandy dune, it continues about 80 km. This sandy dune has occupied pasture area of Tarniin and Jargalant rivers.		Many historical and cultural monuments are supporting in this area. For example, grave and mounds in northern slope of Batkhaan mountain and along the Jargalant river

ANNEX 5. List of fish species in the Tuul river basin

Fish species in the Tuul river basin and regional status according to "IUCN Red List Categories and Criteria" (*Source: Ocock, J. and G. Baasanjav (2006) The Fish List of Mongolia)*

Scientific name		Common name	Regional Conservation Status
Salmonidae			
Hucho	*taimen*	Taimen	Endangered
Brachymystax	*lenok*	Lenok	Vulnerable
Thymallidae			
Thymallus	*arcticus*	Arctic grayling	Near Threatened
Esocidae			
Esox	*lucius*	Pike	Least Concern
Cyprinidae			
Carassius	*gibelio*	Prussian carp	Least concern
Rutilus	*rutilus*	Roach	Least concern
Leuciscus	*baicalensis*	Siberian Dace	Least concern
Leuciscus	*idus*	Ide	Near Threatened
Eupallasella	*percnurus*	Lake minnow	Data deficient
Phoxinus	*phoxinus*	Common minnow	Least concern
Cyprinus	*carpio*	Asian common carp	Least concern
Balitoridae			
Barbatula	*toni*	Siberian stone loach	Least Concern
Siluridae			
Silurus	*asotus**	East Asian catfish	Least Concern
Percidae			
Perca	*fluviatilis*	Perch	Least concern
Lotidae			
Lota	*lota*	Burbot	Data deficient
Cobitidae			
Cobitis	*melanoleuca*	Siberian spiny loach	Least concern

*: *commercially introduced species*

PART 5.
SOCIO–ECONOMIC CONDITION

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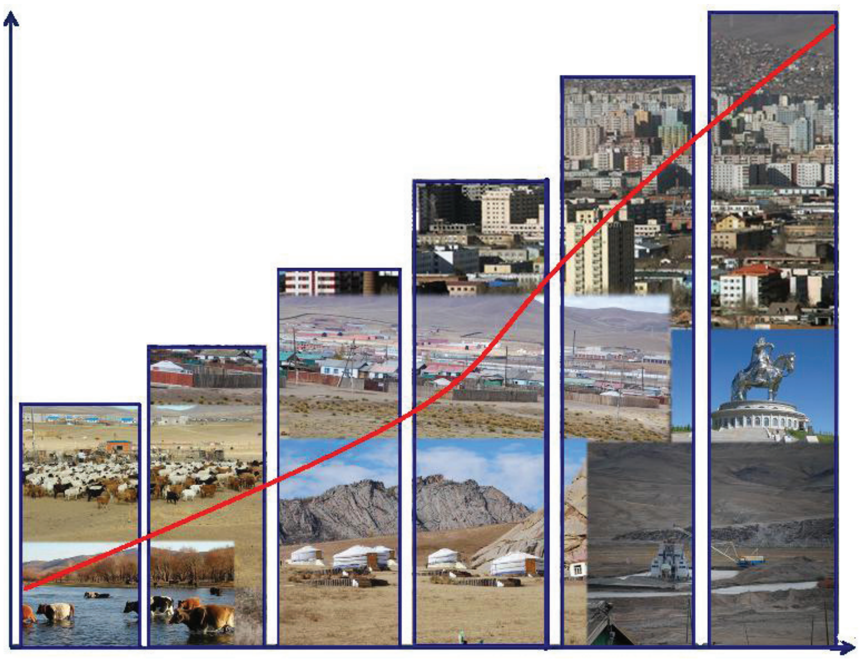
Consultants: Ts.Baldandorj[1], Ph.D
N.Chagnaa[1], Consultant engineer of Mongolia

[1] *"Strengthening Integrated Water Resource Management in Mongolia" project*



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1. Introduction

Water availability in Mongolia is constrained by low and unreliable precipitation and high evaporation rates. Some years ago, almost half of the population received water from sources regarded as unsafe, such as unprotected wells, rivers, run-off or snow and about 35% of the total population used water from a centralized supply system (apartment and ger area). There is evidence that many small lakes, ponds, rivers, creeks and springs have dried up or diminished in size and water tables have declined in recent years due to human activities, climate variability and possibly climate change. Moreover, effluent from households, factories, and tanneries, processing plants, waste disposal sites and road runoff is polluting many of Mongolia's rivers. Sewerage coverage is one of the lowest in Asia, which is causing widespread contamination of surface and groundwater both in Ulaanbaatar and secondary cities.[1] This situation calls for drawing up an IWRM plan by national and river basin level.

Experience from other countries shows, that in many countries river basin organizations have been established and work successfully. In Mongolia IWRM was started to develop and River basin organizations are established based on these experiences. Tuul and Orkhon River Basin belong to the areas where population and industries are concentrated, in other words, many problems related to water resources are found here. Tuul and Orkhon River Basin were selected to prepare water management plans as it is very important to introduce and implement basin water management in Mongolia.

The capital of Mongolia Ulaanbaatar City, situated in the Tuul River Basin, is the political, economical, cultural, scientific and educational center of Mongolia and the City plays an important role in the Mongolian economy. Industrialization and urbanization have a destructive effect on the environment of the city and on the nearby water resources. Rapid growth of the population of Ulaanbaatar put an additional pressure on the ecosystem and causes environmental degradation and pollution near the city. To reduce these effects, the city council planned to establish new towns and settlement areas around Ulaanbaatar.

This assessment report was prepared to assess the current socio-economic condition in the Tuul River Basin, determining the importance of water use and water demand, and of the current and future development approach of the water sector. The following tasks have been carried out:

i. Data collection and analysis for the Tuul River Basin management plan;

ii. Analysis of the current socio-economic situation of the Tuul River Basin;

iii. Data collection and assessment of water use and demand of the Tuul River Basin;

iv. Analysis of the investment and financing situation of the water infrastructure, including a review of foreign investments, donor aid and existing loans in the water sector at the River Basin level;

v. Economic assessment of the water resources of the Tuul River Basin;

vi. Definition of all required economic figures, projections and indicators for the design of alternative strategies for the river basin plans;

vii. Assessment of data concerning water prices and water use fees for all sectors and translation of strategies to future projections of water fees and prices.

This report was prepared using input from mission reports of consultants Jarit van de

[1] UNDP Mongolia Common Country Assessment, 2005

Visch, B.Bat, G.Davaadorj, U.Borchuluun and U.Tsedendamba and also inception phase assessment reports. The subchapters 6.1-6.3 were prepared by the water tariff expert of the project T.Davaanyam.

The socio-economic analysis will help to work out the Basin management plan, to set up a water management policy and to define necessary activities for the action plan in order to achieve the local development programs' goals.

2. Data Collection and Sources

Data and information are essential for doing an accurate assessment of the socio-economic condition, so its sources, accuracy and consistency should be certain. A list of all collected data and information is presented in *Annex 1*. *Table 1* shows a summary of the data sources and type of data used for the Tuul River Basins current situation.

Table 1. Data sources used for the socio-economic analysis

Type of data	Source	Confirmation
Administration	Mongolian National Atlas	Mongolian National Atlas, MAS, IG 2009
Population	NSO, www.statistic.mn,	Statistical Yearbooks, NSO, UB 2007-2011, Population and Housing Census-2010 main results
Macroeconomic	WB, IMF. NSO, MF, MFALI, www.pmis.gov.mn, www.statistic.mn, www.ulaanbaatar.mn, www.bulgan.mn, www.tuv.mn	Statistical Yearbooks, NSO, UB 2007-2011, The Budget Project of Mongolia 2009-2011, GoM 2008, Regional Development program of Ulaanbaatar and Central region, Aimags' Development Programs
Agriculture	NSO, MFALI, MF, www.pmis.gov.mn, www.statistic.mn, www.bulgan.mn, www.ulaanbaatar.mn, www.tuv.mn	Statistical Yearbooks, NSO, UB 2007-2011, Agriculture, NSO,UB 2007-2010, Budget Project of Mongolia 2009-2011, GoM, 2008
Industry	NSO, MFALI, MF, www.pmis.gov.mn www.statistic.mn	Statistical Yearbooks, NSO, UB 2007-2011, Budget Project of Mongolia 2009-2011, GoM, 2008
Water tariff and fee	MF, WA, ALACGC, USUG, PUSO, OSNAAG, related web sites, government officers	Local Governments, USUG, PUSO and OSNAAG's Orders

The project team organized a field trip in the Tuul RB in September 2009. They observed the current condition of the water use and demand, the water resources protection, water tariff and fee issues and inspected water supply and wastewater treatment facilities and their use. Data and information were collected through meetings with local government organization representatives and big water users as well as through questionnaires. The study on the water supply situation of Ulaanbaatar City and Tuv aimag as well as the willingness-to-pay was conducted through the questionnaires. A brief report of the field trip is included in *Annex 3*.

By January 2011 data collection had been completed. The base year used in the framework of the IWRM methodology in Mongolia is 2008.

3. Methodology

The IWRM approach is new in Mongolia. Therefore, international experience, existing methods, guides, and handbooks of GWP, WB and other International organizations have been used for the socio-economic analysis of Mongolia. Especially the guidance document: "Economics and the environment" of the Water Framework Directive of the European Union was useful.

The socio-economic analysis comprises an analysis of the current situation and an assessment of the potential economic approaches for developing the future IWRM situation, both on National level and on River Basin level.

Analysis Current Situation

The main purpose of the situation analysis is the definition and assessment of the current situation, main stakeholders and issues, development trends by economic development stage (by 2015, 2021). A situation analysis consists of the following phases:

- Scope definition, i.e. the boundary of the area taken into account in the base case;
- Analysis of the current socio-economic and ecological situation on national and River Basin level;
- Forecast of development trends;
- Definition of the main issues in relation to water;
- Determination of the main stakeholders;
- Assessment of interests, power, and potential resources of the stakeholders and its importance in relation to other stakeholder groups.

Economic Analysis

The items taken into account in the economic analysis in the field of water management were the following:

- Definition current situation and actual issues of water use on the national and river basin level;
- Setting up realistic water use and protection goals, which will support sustainable socio-economic development, based on limited economic resources for the water sector;
- Developing scenarios and relevant measures and activities for achieving the goals, which is also input into the cost effectiveness analysis;
- Assessment of impacts of the scenarios of socio-economic development in order to identify the scenario(s) that best support sustainable development;
- Identification and development of economic and financial instruments that support the selected scenarios.

Figure 1 shows how the economic elements relate to the overall IWRM project elements.

*Source: Economics and the Environment –
The Implementation Challenge of the Water Framework Directive, 2003*

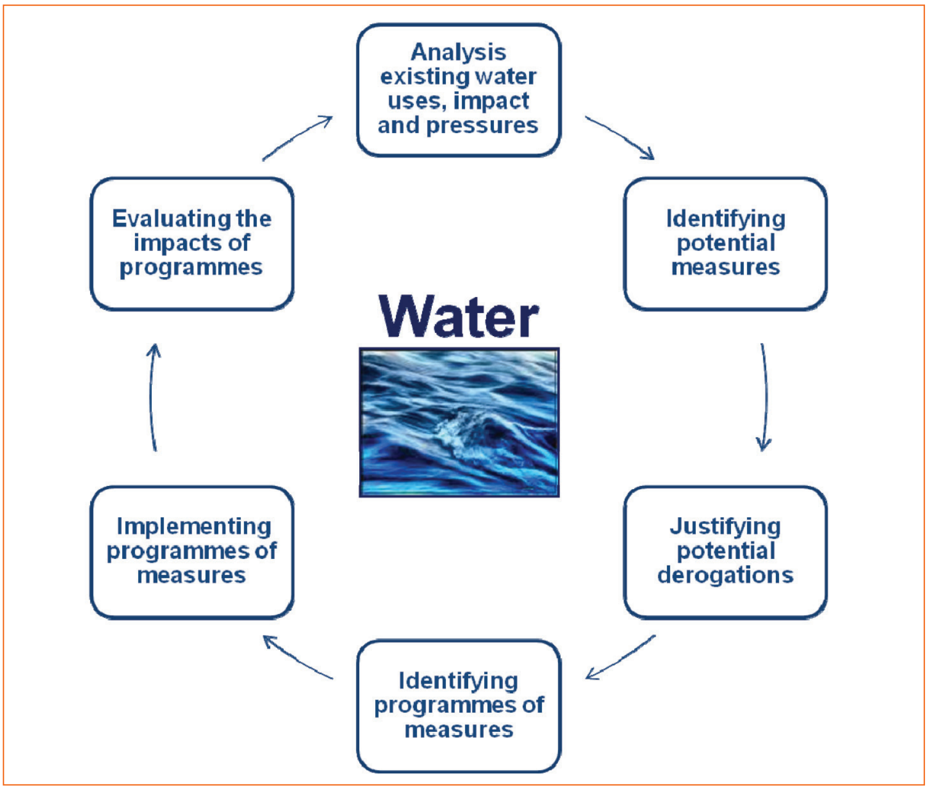

Figure 1. Economic elements are linked and must be integrated

The economic analysis consists of the following stages: [53]

- Analysis of existing water uses, impact and pressures:
  - Economic importance of water uses and water sectors investment based on the analysis of the current socio-economic situation;
  - Assessment existing water pricing system;
  - Trends in water supply and demand;
  - Economic valuation of water;
- Identification of potential measures:
  - Assessment of unitary costs of measures present in the scenarios;
  - Assessment of effectiveness of measures;
  - Selection of potential measures based on cost effectiveness and cost benefit analysis;
- Justification of potential derogations:
  - Assessment of costs and benefits of packages of measures;
  - Identification of measures that lack investment;
  - Assessment of cost recovery levels and definition of possible cost recovery levels;
  - Proposal for cost recovery levels for the derogations and definition of timing of justification;
- Identification of programs of measures:
  - Identification of the cost effectiveness of a set of measures;
  - Assessment of the role of pricing as a measure;

- Implementation of programme of measures;
- Evaluation of the impacts of the programme.

Approach

In the year 2009, by order 332, the Ministry of Nature, Environment and Tourism defined 29 River Basins in Mongolia. For the pilot River Basin Management plan of the "Strengthening Integrated IWRM in Mongolia" project, the Orkhon and Tuul River Basins have been selected.

Common research methodologies and approaches like primary and secondary data collection and analysis, and statistical and mathematical approaches were used for the economic analysis. A computational framework in Excel facilitated the analysis of the data, i.e. the analysis of the current socio-economic situation and the economic analysis. The computational model consists of a tailor made socio-economic model and a model for the Social Cost Benefit Analysis. The following approaches were used:

a) Analysis of the current socio-economic situation and forecast of development trends: Data has been collected and analyzed to determine current and future policy and assess development programmes on national, regional and Aimag level.

To arrive at the River Basin level based on data available on national and regional level, several socio-economic indicators were attributed to the River Basin based on its share of the Soum territory (like population number, livestock number and agriculture share of the GDP), hydrological characteristics and water use. The macroeconomic, indicators like GDP and industrial share of the GDP, were estimated per Aimag and Soum located in the River Basin.

b) Water demand analysis: The most important part of the socio-economic analysis is the water demand analysis. The demand for water was broken down into separate components according to its use (drinking water, water for irrigation, water for industrial purposes, etc.), and the distribution of the demand (daily, seasonally, etc.).

It is important to note that if the water network has not been well maintained in the past, the demand analysis should include the associated leakages. That is to say that the total water supply is made up of the final consumption (total demand) and the leakages.

The water demand analysis methodology is described in more detail in "the Water Demand handbook".

c) Population growth: To estimate future drinking water demand it is necessary to estimate population growth. For this purpose estimates made by the NSO were used to estimate future population numbers on a national level (1B, 2B and 3A versions of "Population Prospect of Mongolia 2008-2030", which corresponds with high, basic and low scenarios respectively). The population growth in the Orkhon and Tuul River Basins was estimated by drawing a trend line based on population growth in the last 5-10 years of the Aimags and Soum located in the River Basin, and compared with the national prospect. The trend line is based on the simple extrapolation-arithmetic increase method. This method is based on the assumption that the population increases at a constant rate:

$$P_t = P_0 * (1 + r * t) \quad (1)$$

P_t – population in year t;
P_0 – population in the base year;
r – average growth rate of the population
t – year

d) Livestock growth: The future livestock growth trend is based on data in the "Mongolian livestock programme", which was approved by resolution №23 of the

Parliament of Mongolia (SGHM). The livestock growth rate in the River Basins was estimated based on past growth trends of livestock numbers in the Aimags and Soums that are located in the River Basin.

e) Social economic analysis of the RB: The macroeconomic indicators like GDP, industrial product has estimated by aimag, soum center, which are located in the basin and some indicators like population number, livestock number and agriculture product has calculated based on proportion of soum area.

f) Water tariff analysis (water pricing): The water tariff analysis is based on the current water tariff rates, relevant laws and other legal documents in relation to water use, natural resource use fees, financial reports of water supply and sewage organizations, statistical yearbooks, and water pricing methodology of Administration of Land Affairs, Construction, Geodesy and Cartography (ALACGC. [34]

The price of water is a key determinant of both the economic efficiency and the environmental effectiveness of water services. Water tariffs can play an important role in water conservation, effective water allocation and revenue sharing based on social benefits. [42]. For this project, the current water pricing system in Mongolia and its influencing factors was assessed and a water pricing system for achieving various IWRM objectives was developed. [67]. A summary of the approach is given in the figure below *Figure 2*.

A step-wise approach is followed for water tariff decision-making. This approach is based on – but not ruled by – sound economics. In this approach two key criteria are important:

- Financial sustainability, requiring the collection of sufficient revenues to meet present and future financial obligations, that is, operating costs as well as the Capital costs of facilities and infrastructure; and
- The user pays principle, which holds that consumers should pay an amount equivalent to the burden of their consumption on society. This implies that charges should attempt to recover full costs, including not only operation, maintenance and Capital replacement, but taking into account foregone benefits (opportunity costs), as well as any externalities (damages to third parties)

The steps that underlie this approach are described below.

Step 1: Establishing the need for change:

The first step is the identification of the need for change. This means that the objectives the new tariff structure aims to achieve or contribute to need to be clear. Examples are:

- Cost recovery
- Sustainability
- Distributive justice
- Tariff system

Enhancing the recovery of costs is a likely objective, but water management decision-makers typically operate in a force field of different and sometimes contradictory objectives. Examples of these contradictory objectives are:

- The "demographic challenge", that is, the obligation to provide more and more people with a basic quantity of good quality water;
- The "efficiency challenge" whereby water management operators need to be converted into efficient and viable organizations;
- The "supply challenge", being the need to supply water to various water users that may have conflicting demands, in order to safeguard the food production or energy production to the population.

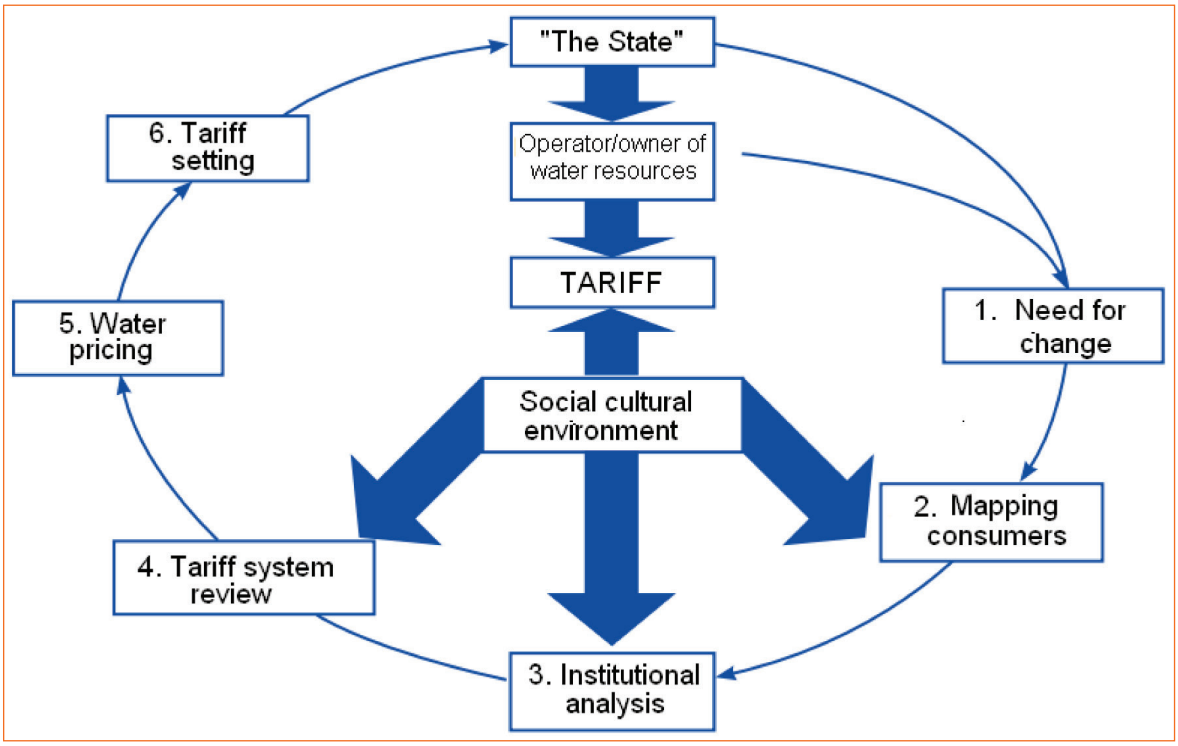

Figure 2. Framework for water tariff decision-making

Step 2: Mapping of consumers;

The next step is to assess who provides and who consumes water. As water moves through a hydrological cycle, its ownership – whether formally established or not – changes hands at a number of transfer points. This step identifies these transfer points and describes the parties in the chain. This review includes assessing customary rights, attitudes towards paying for water, required service levels and more. [69]

Step 3: Institutional analysis:

The institutional analysis consists of analyzing the social cultural value associated with water, i.e. how do water users perceive water, the legal power of the institutes responsible for water vis-a-vis the power of the users, the skills of the institutes, e.g. Collection efficiency and Operational efficiency, and finally the level of privatization/ decentralization in the water sector. [44].

Step 4: Review of the existing tariff system:

The following step is to take stock of the existing water tariff system: what are its strengths and weaknesses and what trends would affect the system. This step results in an understanding of acceptable practices and helps define the strategy for introducing a new system.

A water tariff is a powerful and versatile management tool. The set up of a tariff system gives decision makers the possibility to focus on social objectives like poverty reduction, or to pay more attention to economic goals, like production or employment. This means that water tariffs have to be satisfying to the average interest of all kind of stakeholders. [69]

Step 5: Calculating the cost of water.

In this step, the economic, social and environmental value of water on the basis of contemporary economic analysis is defined, thereby focusing on long-term marginal

Capital cost, operational cost and rent, and subsidies.

In the process of defining the tariffs, the following basic issues were important:

- Cost recovery: From the water supplier's point of view, the main purpose of the tariff is cost recovery. Before design can begin, there must be a decision as to how much costs the tariff should recover. Tariff design, then, aims to achieve this target. To a large extent, this consists of setting the various prices and charges in the tariff at a high enough level, which has little to do with the other details of tariff design.
- Economic efficiency: Generations of economists have insisted on the importance of this objective, and specified that it can be achieved by setting all prices equal to their relevant marginal costs.
- Equity and fairness: These terms are often used either together or interchangeably. In fact, they have different meanings. Equity required in public utility tariff design usually means that users pay amounts which are proportionate to the costs they impose on the utility. Fairness, on the other hand, is wholly subjective. Each participant in a tariff design process may have a different notion of the meaning of fairness. One may think it is fair to set a high price for industrial water use, another may not. One may think it is fair to charge all customers the same price (even when, because of cost of service differences, this is not necessarily equitable), while another may believe that fairness requires subsidies to some customers. A marginal cost-based tariff is expected to be equitable, but not necessarily fair.
- Public acceptability: A successful tariff design is one that is not controversial, and/or which does not serve as a focus of public criticism on the water supply agency.
- Political acceptability: A tariff design that is objectionable to political leaders will lead to loss of political support and may cause increased political interference in the operations of the agency.
- Simplicity and transparency: A tariff design should be easy to explain and easy to understand. It should be possible for most users to know what price they are paying for water.
- Net revenue stability: When water use changes as a consequence of weather or economic conditions, revenue and cost should change by approximately equal amounts. When this does not happen, cyclical changes will result in net revenue volatility, creating cash flow and financing difficulties for the agency.
- Ease of implementation: The promulgation and implementation of the revised tariff should not encounter significant barriers in terms of legal authority, administration competence, information requirements, or billing procedures.
- Affordability: Water tariffs should be affordable to its users.

Tariff setting:

Based on the calculation of costs, the new tariffs have to be approved and implemented according to the law.

The water use payment is equal to multiplication of used amount of water and tariff rate per unit. [69]

In terms of water pricing, Mongolia's pricing policy is decentralized; local authorities are entitled to set up and revise the water tariffs. Although in theory, the Mongolian Government gives priority to the interests and water needs of the poor and marginalized, in practice, the current pricing scheme has become pro-industry and pro-wealthy due to weak regulations. [44]

d) Water economic valuation. As payment to a large extent depends on the willingness to pay (WTP) of the water users, a survey has been held in the Ger area of Ulaanbaatar, in some Soum centers of the Tuul River Basin and in Khovd, Bayankhongor, Bayan-Ulgii and Gobi-Altai Aimags. Willingness to pay reflects the maximum amount a person would be willing to pay, sacrifice or exchange in order to receive a good or to avoid something undesired, such as pollution. The results of the survey have shown us that most of the people were willing to pay 1.5 times more than what they currently pay for water. This result is compatible with the WB's study "The Economic Value of the Upper Tuul Ecosystem of Mongolia".

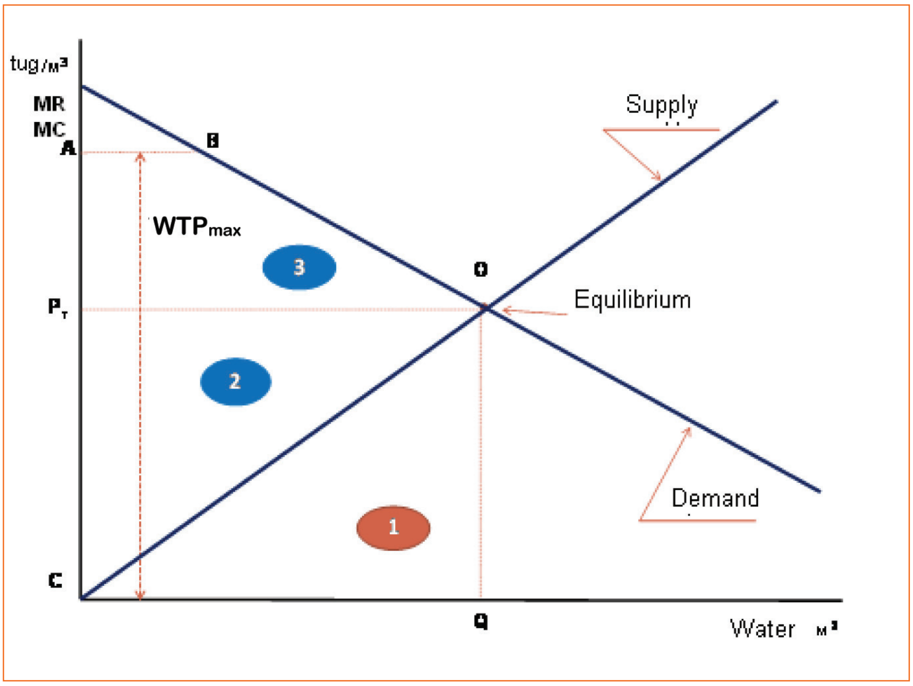

Figure 3. WTP and consumer and producer surplus

Figure 3 shows demand and supply curves and areas of economic surplus of services and goods. The marginal revenue (MR) and the marginal cost (MC) for an additional unit of water are shown on the vertical axis in tugrug/m^3. The water demand and water supply are shown on the horizontal axis in m^3. The water economic value is defined by the consumer and producer surplus [39]. For this purpose the economists have used the terms: consumer and producer surplus.

In the market equilibrium price is determined by the market price at which the supply of an item equals the quantity demanded. Otherwise, price and WTP of consumers equals to the marginal cost. Before the equilibrium, marginal WTP[2] is higher than market price.

In the step identifying potential measures the water demand scenarios have to be defined. Based on existing water supply capacity and water demand scenarios measures and costs have been defined. Using least cost analysis and cost effectiveness analysis the effective measures have been defined. Also social cost-benefit analyses were applied.

2 Marginal WTP is costumers' ability to pay for an additional unit of water.

4. Demography and Administration

4.1. Administration

The Tuul River Basin is located in the central part of Mongolia crossing the economic regions of Ulaanbaatar, Tuv and Khangai. Ulaanbaatar City and five aimags: Arkhangai, Bulgan, Uvurkhangai, Selenge and Tuv are located in this basin. Tuv aimag occupies the largest part of the basin area: 59.3% and Selenge aimag occupies the smallest part of the basin area: 1.6% (see Figure 4).

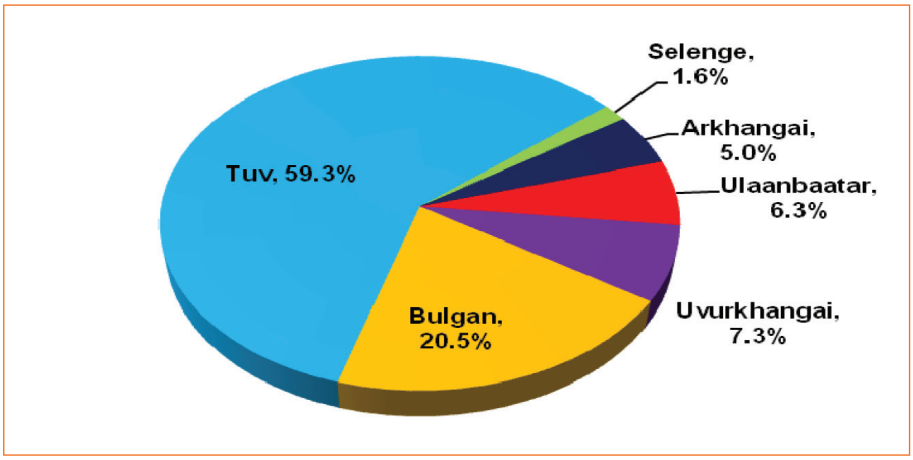

Figure 4. Composition of the Tuul River Basin territory

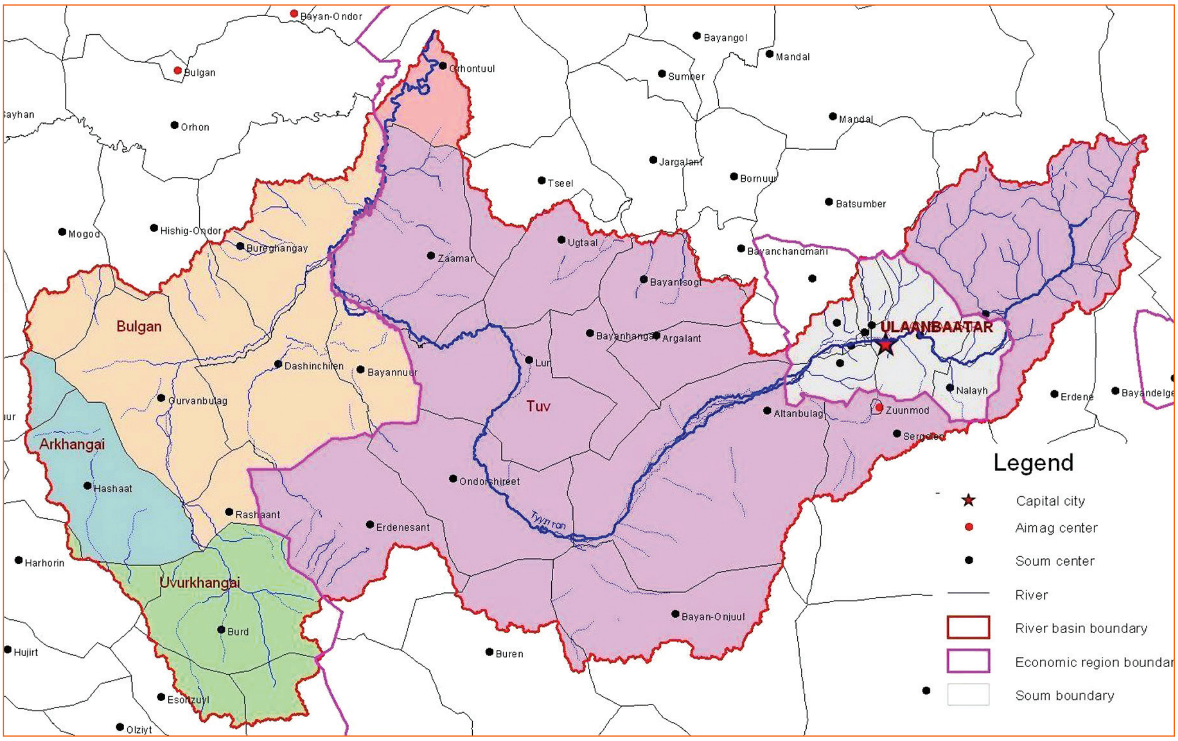

Figure 5. Administrative units and economic regions in the Tuul RB

Table 2. Administrative units in the Tuul River Basin

№	Aimag	Soums and districts	Aimag and soum centers	Nr. of bags and Khoroos	percentage in Tuul RB, %	
					from territory	from pasture
1	Arkhangai	Ulziit			0.02	0
2		Ugiinuur		1	17.6	17.9
3		Khashaat	Khashaat	4	83.6	83.3
4	Bulgan	Bayannuur	Bayannuur	2	100	100
5		Buregkhangai	Buregkhangai	3	57.9	62.3
6		Gurvanbulag	Gurvanbulag	6	100	100
7		Dashinchilen	Dashinchilen	4	100	100
8		Mogod		1	22.0	26.0
9		Rashaant	Rashaant	3	100	100
10		Khishig-Undur		3	39.4	45.1
11	Uvurkhangai	Bayan-Undur		1	14.4	15.9
12		Burd	Burd	5	92.7	93.4
13		Yusunzuil		1	21.8	18.2
14		Kharkhorin		1	11.2	13.4
15	Selenge	Orkhontuul	Orkhontuul	2	28.0	28.1
21	Tuv	Bayanchandmani			5.6	4.0
19		Batsumber			0.4	0.4
18		Bornuur			0.3	0.3
16		Delgerkhaan			0.1	0.1
17		Jargalant			0.2	0.2
20		Mungunmorit			0.4	0.4
30		Altanbulag	Altanbulag	4	94.0	88.7
29		Argalant	Argalant	2	86.7	84.7
22		Bayandelger			13.1	7.4
23		Buren		2	20.2	46.1
26		Bayan-Unjuul	Bayan-Unjuul	2	46.8	100
34		Bayankhangai	Bayankhangai	2	100	90.9
31		Bayantsogt	Bayantsogt	3	90.2	18.5
33		Zaamar	Zaamar	4	99.9	100
36		Zuunmod	Zuunmod	6	100	100
35		Lun	Lun	3	100	100
37		Undurshireet	Undurshireet	4	100	100
24		Tseel		2	23.5	22.0
25		Sergelen	Sergelen	2	29.0	28.8
32		Ugtaal	Ugtaal	3	90.4	94.4
27		Erdene		3	50.7	62.1
28		Erdenesant	Erdenesant	4	74.0	71.6
43	Ulaanbaatar	Bayangol		20	100	100
40		Bayanzurkh		24	99.9	100
41		Nalaikh		6	99.9	100
38		Songinokhairkhan		25	31.0	6.8
42		Sukhbaatar		18	99.9	100
44		Khan-Uul		14	100	100
39		Chingeltei		19	98.6	100
-	-	37 / 7	1 / 19	83 / 126	-	-

As for administrative units, Ulaanbaatar City and 37 soums (including Zuunmod regional pillar city) of above-mentioned five aimags are located in this basin. In total 19 soum centers and the territory of 8 soums whole and another 29 soums partly belongs to the basin (see Figure 5).

The administrative units and the percentage of the area of aimags, soums and cities, which are located in the Tuul River Basin, are presented in Table 2.

Ulaanbaatar City: 7 out of 9 districts of the capital are located in Tuul River Basin. The territory of Bayangol and Khan-Uul districts totally, 98.6-99.9% of the territory of Bayanzurkh, Nalaikh, Sukhbaatar and Chingiltei districts, and 31% of the territory of Songinokhairkhan district belongs to the basin. When estimating socio-economic indicators, the above first 6 districts are included totally and Songinokhairkhan district is included except Jargalant village.

Tuv aimag: Zuunmod city as aimag center of Tuv aimag and 11 other soum centers like Altanbulag, Sergelen, Bayan-Unjuul are located in the basin. The territory of Bayankhangai, Undurshireet, and Lun soums totally; 86.7-99.9% of the territory of Altanbulag, Argalant, Bayantsogt, Ugtaal and Zaamar soums; 20.2-74% of the territory of Bayan-Unjuul, Buren, Tseel, Sergelen, Erdene and Erdenesant soums; 0.1-13.1% of territory of 6 other soums belong to the basin. For the economic analysis demography and economic data were used of Zuunmod city and 16 soums, that have more than 5% of pasture located in the Tuul RB.

Uvurkhangai aimag. 11.2-92.7% of the territory of Kharkhorin, Bayan-Undur, Yusunzuil and Burd soums is located in the basin. The socio-economic estimation was conducted based on these soums.

Selenge aimag. The center of Orkhontuul soum and 28% of the soum area are located in the basin. This soum is located near the confluence of the Tuul and Orkhon rivers. This soum is important in terms of water management.

The socio-economic analysis of the Tuul River Basin was conducted based on 7 districts of Ulaanbaatar City, Zuunmod soum and 28 other soums, which have more than 5% of pasture land inside the basin.

If the pasture area inside the basin is under 5% the following things should be taken into account when estimating basin socio-economic indicators:

- Location of administrative center
- Location of big water consumers and users
- Environmental condition; surface and groundwater resources
- Influence on the soum socio-economic sectors

When developing water management plans, it is important not to leave behind parts of soums, which are located in more than 2 river basins.

4.2. Demography

4.2.1. Population Density and Growth

In 2010, about 1098.8 thousand people were living in aimags and soums, which are located in the basin. This is 42.8% of the total population of Mongolia. Some 97.2% of the population was living in urban areas and soum centers and 2.8% in rural areas. The urban population percentage is high due to Ulaanbaatar City located in the basin (see Table 3). In 2010, out of the total population of the Tuul RB 52.7% are female.

In the same year, population density was 24 persons per km^2, which is 14 times higher than that of state average (1.7). The highest density is 6277 persons/km^2 in Bayangol district and the lowest density is in Erdene soum of Tuv aimag[1], which is 0.3 persons/

km². The population density map is presented in Part 1, figure 19.

Recently, the average population growth was 3.4-4.8%, which is 1.8-2.7 times higher than the average growth of the country. The main reason of the high growth rate is migration to the Capital.

Table 3. Tuul River Basin population in thousand persons

Capital and aimag	2004	2005	2006	2007	2008	2009	2010	
							Total	rural
Arkhangai	3.6	3.6	3.5	3.4	3.3	5.8	3.4	2.2
Bulgan	13.3	12.9	13.1	13.2	13.1	13.6	13.6	8.0
Uvurkhangai	4.5	4.6	4.6	4.6	4.5	4.5	4.2	3.7
Selenge	1.7	1.7	1.7	1.5	1.5	1.7	2.0	0.6
Tuv	43.7	44.4	43.6	43.8	43.7	28.1	42.7	16.0
Ulaanbaatar	882.5	918.5	952.6	990.1	1032.4	1082.9	1125.4	0.0
Total	949.4	985.8	1019.1	1056.5	1098.5	1136.5	1191.3	30.6
Average growth, %		3.8	3.4	3.7	4.0	3.5	4.8	-

Figure 6 shows how the population was divided over the various age groups, showing that in total about 67% of the population is at present in the working age group. As about 84% of the people outside the working age group were children under 14 years old, it can be concluded that the labor force resource is high. The demographic burden on 100 working age persons was 49, from which some 40 were children and 9 are elder people. The recent years' growth rate of the working age population was affected by the 1990s high birth rate.

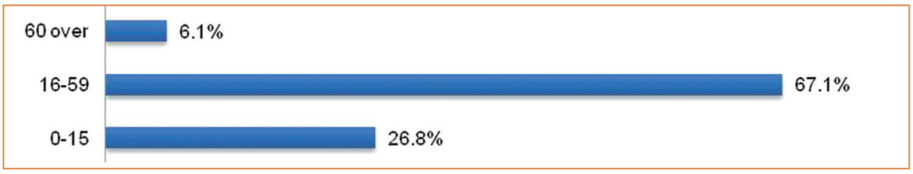

Figure 6. Population by age in Tuul River Basin, 2010

Population Prospect

The future population growth is important for estimating future drinking water demand. In the basin management plan, three scenarios have been used for estimating the water demand: high, medium (basic) and low that correspond with the scenarios of The Population Prospect of Mongolia 2010-2040 by NSO, and first scenario of population growth of Ulaanbaatar city estimated by Design and Research Institute of the Capital. Table 4 and Figure 7 show the estimated population numbers under these three scenarios until the year 2021. According to the medium scenario, the total population of the Tuul RB may reach 1552.4 thousand persons and the population of 7 UB districts, which belong to the Tuul RB, 1485.8 thousand persons.

Table 4. Population prospect of Tuul RB in thousand persons

Capital and aimag	2008	2010	2015	2020	2021
Ulaanbaatar	1032.4	1125.4	1322.3	1458.5	1485.8
Arkhangai	3.3	3.4	3.3	3.4	3.4
Bulgan	13.1	13.6	13.3	13.6	13.7
Uvurkhangai	4.5	4.2	4.2	4.3	4.3
Selenge	1.5	2	2.0	2.0	2.0
Tuv	43.7	42.7	42.1	43.0	43.2
Total	1098.5	1191.3	1387.2	1524.8	1552.4

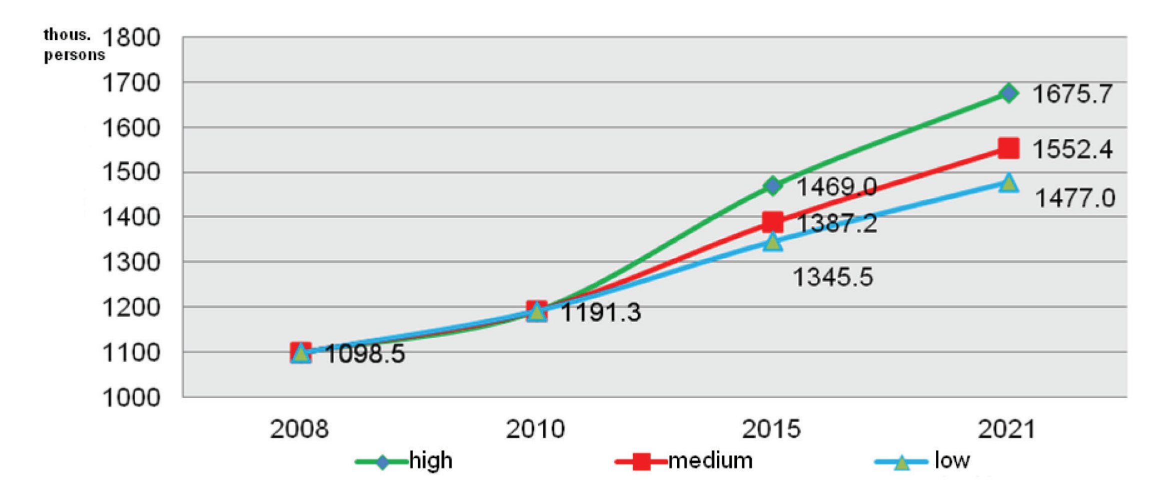

Figure 7. Population growth of the Tuul RB by growth scenarios

Urban and Rural Population

The percentage of the urban population in the Tuul RB is high because of Ulaanbaatar. The City has a rapid urbanization due to high development of infrastructure, industry and services.

In 2010, about 95.7% of the total Tuul RBs population was living in the urban area. Urban and soum center population was in total 97.4% from the total Tuul RBs population of 1160.7 thousands persons. From which 1125.4 thousand persons were living in Ulaanbaatar, 15.3 thousand in Zuunmod city and 20.0 thousand in soum centers and other settlements.

Some 75% of the soum centers and urban areas in Tuul River Basin have a total population up to 1000 and the rest has a population over 1000. Ulaanbaatar City has the most people and 94% of the basin population lives in it. This is some 1032.4 thousand people. This is 96.7% of Ulaanbaatar City population. Sergelen soum center of Tuv aimag has the minimum population: 0.3 thousand (see Figure 8).

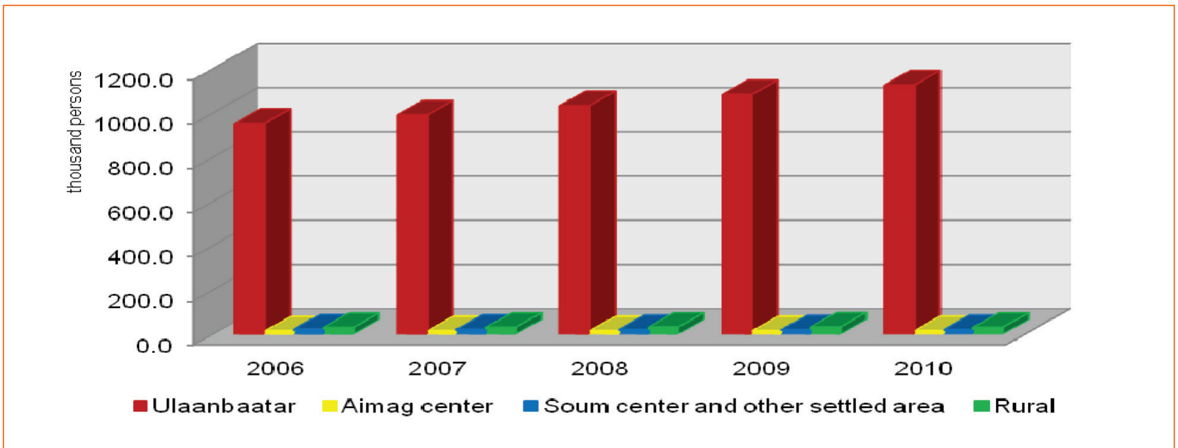

Figure 8. Tuul River Basin population

Table 5. Urban and rural population in thousand persons

Capital, aimag and soum center	2008	2009	2010	2015	2021
Arkhangai	0.8	0.8	1.1	1.1	1.2
Khashaat	0.8	0.8	1.1	1.1	1.2
Bulgan	4.5	5.1	5.5	5.4	5.6
Bayannuur	0.7	0.9	0.7	0.7	0.7
Buregkhangai	0.9	0.9	0.8	0.8	0.8
Gurvanbulag	1.1	0.6	1.2	1.2	1.3
Dashinchilen	0.9	1.0	1.1	1.1	1.1
Rashaant	0.9	1.7	1.7	1.7	1.7
Uvurkhangai	0.5	0.5	0.5	0.5	0.6
Burd	0.5	0.5	0.5	0.5	0.6
Selenge	0.9	1.1	1.3	1.3	1.4
Orkhontuul	0.9	1.1	1.3	1.3	1.4
Tuv	28.0	26.7	26.7	26.3	27.0
Altanbulag	1.0	0.9	0.9	0.9	0.9
Argalant	0.8	0.8	0.8	0.8	0.8
Bayan-Unguul	0.4	0.6	0.7	0.7	0.7
Bayankhangai	0.8	0.8	0.8	0.8	0.8
Bayantsogt	0.9	0.9	0.8	0.8	0.9
Zaamar	1.5	1.6	1.5	1.5	1.5
Zuunmod	14.8	14.8	15.3	15.1	15.5
Khailaast	2.7	2.6	2.2	2.2	2.3
Lun	1.3	0.9	0.9	0.9	0.9
Undurshireet	0.6	0.4	0.4	0.4	0.4
Sergelen	0.3	0.5	0.5	0.5	0.5
Ugtaaltsaidam	1.4	0.4	0.5	0.5	0.5
Erdenesant	1.5	1.5	1.4	1.4	1.5
Ulaanbaatar	1032.3	1082.9	1125.5	1322.3	1485.8
Total	1067.0	1117.1	1160.6	1357.0	1521.4

Tuul RBs current and future projected population is presented in Table 5. From soum centers and settlements: 2 soum centers have under 500 persons, 10 soum centers 500-1000 persons, 5 soum centers 1000-1500 persons, 2 soum centers 1500-2000 persons and Khailaast village of Zaamar soum over 2 thousand persons. The soums with the highest population are Rashaant of Bulgan aimag (1687 persons) and Zaamar of Tuv aimag (1548 persons) and the soums with the lowest Sergelen (487 persons) and Undurshireet (357 persons) of Tuv aimag.

According to the Tuul RB medium scenario population projection, in 2021 urban and soum center population will reach 1521.4 thousand persons, which is a 42.6% increase from the 2008 population of 454.4 thousand persons. This growth depends mainly on the Ulaanbaatar population growth.

4.2.2. Population of Ulaanbaatar

Bayangol, Bayanzurkh, Nalaikh, Chingeltei, Khan-Uul, Sukhbaatar and Songinokhairkhan (except Jargalant village) of Ulaanbaatar belong to the Tuul RB. In 2010, the population of Ulaanbaatar reached 1151.5 thousand persons or 41.4% of the total country population. From these 97.7% or 1125.4 thousand persons were living in the Tuul RB, which is 94.7% of the total basin population.

Of the total Ulaanbaatar population 22.9% is living in Bayanzurkh district, 21.7% in Songinokhairkhan, 15.9% in Bayangol, 12.7% in Chingeltei, 11.8% in Sukhbaatar, 9.6% in Khan-Uul and 2.7% in Nalaikh district. According to the 2010 statistical information, the districts with the highest density were Bayangol (6277 persons/km^2) and Chingeltei (1651 persons/km^2) and with the lowest density was Nalaikh district (46 persons/km^2).

Since 1990s, the rights to open internal migration of Mongolian citizens' were confirmed as Mongolia moved towards to a democratic society. It was one of the reasons for the rapid growth of Ulaanbaatar's population.

The last 10 years' average growth of the basin population was 3.9%. In 2010, the population of Ulaanbaatar increased by 5% or 55.1 thousand persons, and the last two years increased by 8.8% or 94.4 thousand persons from which 93.1 thousand people were in the Tuul RB. As of 2010 statistics information, 45.8% of the population growth was an additional growth of officially migrated people to the Ulaanbaatar.[3] In the same year 39.7 thousand persons migrated to Ulaanbaatar, from which most were unemployed people and 10.1 thousand were persons illegally residing longer than 6 months. This concentration of people in the capital is becoming one of the critical problems for Ulaanbaatar and Mongolia.

The economy and population of Ulaanbaatar is growing rapidly, creating problems regarding safety and healthy living conditions for the population; regarding the land use situation in and near the city; regarding deteriorating environmental conditions; regarding increasing pollution and pressure on the ecosystem; and regarding the imbalanced economic development of the regions. To tackle the problems the General Development Plan of Ulaanbaatar City was developed until 2020 and development tendencies until 2030. In the general plan, new towns and villages are planned to develop near the city, and city development regions are identified in order to reduce the rapid population growth of Ulaanbaatar and to decrease the ger area.

The General Development Plan of Ulaanbaatar City aims to develop industry, energy, mining, processing industry and logistics in the Nalaikh, Emeelt-Argalant and some other towns; to develop agriculture, tourism, aviation and logistic in the Tuul-Shuvuu, Bio-Songino, Gachuurt and Hushigtiin khundii; to develop towns, villages and new settlements around Ulaanbaatar and to establish and to extend their infrastructure. Due to this planning the population in the towns around Ulaanbaatar will reach 350-400 thousand persons.

Table 6 presents the current and future population of towns, villages and new settlements around Ulaanbaatar. In 2021, out of 1.5 mln persons of Ulaanbaatar about 200 thousand live in the new settlements around the city. Most of these towns are not connected to the centralized water and waste water systems and in the future should focus on their infrastructure development.

Table 6. Population of towns and villages around Ulaanbaatar

No	Town	Definition	Location	Population, *thousand persons*				
				2008	2009	2010	2015	2021
1	Nalaikh	town	Nalaikh district	27.9	28.9	30.2	34.3	40.0
2	Emeelt, Argalant	town	CKhD, 20^{th} khoroo	9.9	10.0	9.3	11.1	13.6
3	Tuul-Shuvuu	village	KhUD, 13^{th} khoroo	3.5	2.6	3.7	4.6	5.9
4	Gavijiin shand	new settlement						
5	Bio-Songino	village	KhUD, 12^{th} khoroo	5.6	5.8	5.8	7.2	9.3
6	Ulziit	village	KhUD, 14^{th} khoroo	2.5	2.8	3.1	3.8	4.9
7	Gachuurt	village	BZD, 20^{th} khoroo	6.6	6.2	6.1	7.8	10.3
8	Aero city	New city	Khushgiin khundii	-	-	-	100 thous. people	
9	Student city	New city	Shiveetiin khundii	-	-	-	100 thous. people	
10	Terelj	village	Nalaikh, 6^{th} khoroo	1.2	1.3	1.3	1.5	1.7

[3] NSO, Migration data

No	Town	Definition	Location	Population, *thousand persons*				
				2008	2009	2010	2015	2021
11	Nisekh	village	KhUD, 9,10,16th khoroo	20.3	21.1	22.3	27.6	35.6
12	Yarmag	khoroo	KhUD, 7,8th khoroo	14.7	14.9	15.7	19.5	25.2
13	Nukht	khoroo	KhUD, 6th khoroo	7.8	7.9	7.9	9.8	12.7
14	Uliastai	village	BZD, 10th khoroo	10.0	10.5	10.9	13.9	18.5
15	Khonkhor	village	BZD, 11th khoroo	4.2	4.8	5.5	7.0	9.3
16	Nairamdal	village	SKhD, 22nd khoroo	10.5	11.9	12.9	15.3	18.9
-	Total			124.7	128.6	134.7	163.2	206.0

*Explanation: * The student city was planned near the Nalaikh district but later replaced to Shiveetiinh khundii, which is located in the Kherlen River basin.*

The population projections of the seven districts of Ulaanbaatar, which belong to the Tuul RB, are presented in Table 7.

Table 7. Population prospect of Ulaanbaatar

Districts	2008	2010	2015	2020	2021
Total	1032.3	1125.5	1322.3	1458.5	1485.8
Bayangol	169.3	185.1	217.5	239.9	244.4
Bayanzurkh	235.2	266.0	312.5	344.7	351.2
Nalaikh	29.1	31.5	37.0	40.8	41.5
Songinokhairkhan	226.8	246.5	289.6	319.4	325.2
Sukhbaatar	133.1	136.9	160.9	177.5	180.8
Khan-uul	98.8	112.1	131.7	145.3	148.0
Chingeltei	140.0	147.4	173.2	191.0	194.7

4.2.3. Households in the Tuul River Basin

In 2008, there were some 260.7 thousand households in the basin which is 38.5% of the total number of Mongolian households. In 2010 this increased to 303.8 thousand households or 40.9% of the total number of Mongolian households. There are on average 3.9 persons per household which is higher than the national average (3.7). In Ulaanbaatar City there are on average four persons per household (see Table 8).

Table 8. Number of households in the Tuul River Basin, 2010

Aimags and capital	Population, *thousand persons*	Household, *thousand households*	Persons *per household*
Arkhangai	3.4	1.0	3.5
Bulgan	13.6	4.1	3.4
Uvurkhangai	4.2	1.2	3.5
Selenge	2.0	0.5	3.8
Tuv	42.7	12.9	3.3
Ulaanbaatar*	1125.4	284.2	4.0
Total	1191.3	303.8	3.9
National total	2780.8	742.3	3.7
Percentage in the national total	43.2	40.9	-

**Average of Ulaanbaatar City districts which are located in the Tuul River Basin.*

The average household size is highest in Songinokhairkhan district (4.4) of Ulaanbaatar City and lowest in Bayandelger soum of Tuv aimag and Bayan-Undur soum of Uvurkhangai aimag (2.6). According to the statistical information, the average countrywide household size was 4.4 persons in the 1990s which decreased to 4 in 2010. In 2021, the household number of the Tuul RB may reach 423.8 thousand households.

4.2.4. Employment

In 2010, *there were 1863.4 thousand potentially productive people* on *the national level, of which* 1147.1 thousand were actually economically active, and 1033.7 thousand were employees. From the economically active population some 415.1 thousand persons or 36.2% and 379.4 thousand employees or 36.7% were living in the Tuul RB.

In 2010, the labour participation was lower than the country average due to the high student numbers. The economic active population was 1071.5 thousand in Tuul RB. Table 9 gives an overview of the employment indicators of the Tuul RB by capital and aimags. In the Selenge and Uvurkhangai aimags labour participation rate and employment were high, in the Bulgan and Ulaanbaatar unemployment was high. For example, in Ulaanbaatar there were 33.1 thousand unemployed people, from which only 8.8 thousand were registered as unemployed. In 2010, unemployment in Ulaanbaatar was 8.7%. Table 10 shows the number of employees by economic activities.

Table 9. Employment in the Tuul RB in thousand persons, 2010

Indicators	Ulaanbaatar	Arkhangai	Bulgan	Uvurkhangai	Selenge	Tuv	Total	Country total	Percentage in the country total
Total population	1125.4	3.4	13.6	4.2	2.0	42.7	1191.3	2780.8	43.2
Population of working age	756.6	2.2	8.9	2.6	1.3	28.1	799.6	1863.4	42.9
Economically active population	382.7	1.8	7.1	1.9	0.9	20.6	415.1	1147.1	36.2
Employed	349.6	1.7	6.1	1.8	0.9	19.4	379.4	1033.7	36.7
Unemployed	33.1	0.1	1.1	0.1	0.02	1.2	35.7	113.4	31.5
Registered unemployment	8.8	0.1	0.01	0.04	0.5	1.5	10.9	38.3	28.4
Labour force participation rate, %	50.6	85.3	80.5	74.5	68.0	73.4	51.9	61.6	-
Employment rate, %	91.3	93.0	84.8	95.1	97.9	94.0	91.4	90.1	-
Unemployment rate, %	8.7	7.0	15.2	4.9	2.1	6.0	8.6	9.9	-

Table 10. Employees of the Tuul River Basin in thousand persons, 2010

Economic activities	Ulaanbaatar	Arkhangai	Bulgan	Uvurkhangai	Selenge	Tuv	Total	Country total	Percentage in the country total
Agriculture, forestry, hunting	6.9	1.2	3.7	1.2	0.3	9.6	22.9	346.6	6.6
Mining industry	8.3	0.0	0.0	0.1	0.1	0.2	8.7	34.1	25.4
Manufacturing sector	36.0	0.0	0.2	0.1	0.1	1.0	37.3	64.8	57.6
Electricity, heating and aero condition	5.8	0.0	0.1	0.0	0.0	0.1	6.0	12.4	48.3
Water supply and waste management	3.5	0.0	0.1	0.0	0.0	0.2	3.7	7.8	47.5
Construction	33.9	0.0	0.1	0.0	0.0	0.6	34.6	48.8	71.0
Sales and services	116.3	0.2	0.6	0.2	0.1	2.9	120.4	222.7	54.1
Hotels and restaurants	17.1	0.0	0.1	0.0	0.0	0.1	17.4	27.7	62.9
Financial, insurance and bank service and communication	18.2	0.0	0.1	0.0	0.0	0.3	18.7	30.2	62.0
Government, science and education	68.0	0.2	0.9	0.2	0.1	3.0	72.4	165.2	43.8
Social and health services	17.8	0.1	0.2	0.1	0.0	0.8	18.9	40.3	46.9
Other services	15.4	0.0	0.0	0.0	0.0	0.6	16.1	29.9	53.8
Other	2.4	0.0	0.0	0.0	0.0	0.0	2.4	3.2	75.4

Some 97.4% of the Ulaanbaatar City economic active population, 97.5% of the employees, 36.2% of the country's economic active population and 37.6% of the employees live in the basin.

4.2.5. Living Standard

Human Development Index

The Human Development index (HDI) is one of the socio-economic indicators that measure the country's development by combining indicators of life expectancy, educational achievement and income. Since 1997 Mongolia started to publish a Human Development Report supported by UNDP. The MDGs based Comprehensive National Development Strategy of Mongolia aims to reach a HDI of 0.83 in 2015.

In 2010, Mongolia's HDI was 0.622, which ranks the country at 100 out of 169 countries placing it in the Medium Human Development countries [122]. This HDI is slightly below the World average of 0.624 and that of East Asia and the Pacific, which is 0.650. By UNDP's estimation Mongolia's life expectancy index was 0.748, the education index 0.674 and the GDP per capita index 0.477. According to the WB classification of Gross national income per capita by the Atlas methodology, Mongolia's GNI per capita reached 1630 USD categorizing it as a "Lower middle income country".

Table 11. Human development index

Aimags and capital	2006	2007	2008	2009	2010
Arkhangai	0.674	0.699	0.718	0.724	0.722
Bulgan	0.692	0.711	0.730	0.735	0.739
Uvurkhangai	0.660	0.677	0.689	0.696	0.694
Selenge	0.687	0.731	0.742	0.738	0.750
Tuv	0.684	0.699	0.718	0.729	0.739
Ulaanbaatar	0.739	0.745	0.764	0.774	0.790
State average	0.712	0.737	0.745	0.750	0.764

According to the NSO information in 2010, the HDI of Ulaanbaatar City was higher than the state average by 0.026 units and other aimags of the basin were lower by 0.025-0.070 units (Table 11). Recently the average life expectancy is increasing and in 2010, it was in Ulaanbaatar 63.8, in Tuv aimag 69.8, in Selenge, 68.9 and in Bulgan 69.4 and they were higher than the state average (68.1). Two aimags were lower than the state average: 67.7 in Arkhangai and 67.9 in Uvurkhangai. The development programs of regions and aimags aim to improve HDI by increasing life expectancy, education level and per capita GDP.

Household Income and Expenditures

The NSO started conducting researches on population, household income and expenditures since 1966. In 2010, monthly average household income was MNT 448.0 thousand: in Ulaanbaatar was MNT 529.3 thousand, which was higher than the state average by MNT 81.3 thousand (Table 12)

Table 12. Monthly average income and expenditure per household, in MNT

Indicators		2006	2007	2008	2009	2010
Income	Country average	200 179	263 681	363 594	402 525	448 027
	Urban	181 165	269 472	406 667	454 854	498 172
	Rural	207 588	254 090	305 216	331 600	386 605
Expenditure	Country average	228 172	292 488	367 466	437 602	450 602
	Urban	232 188	308 016	421 924	471 336	501 042
	Rural	211 644	266 768	293 653	391 883	387 937

At the national level, 86.4% of the household income is monetary income and 9.3% is from household business. In Ulaanbaatar 97.1% of the household income is monetary income and 2.9% is from household business and other sources. In Ulaanbaatar from total monetary income, 51.7% is from salary and wages and 17.4% is from pensions and allowances.

Since 2000, the NSO conducts quarterly sample surveys on wages: the “Survey on average wages and salaries of employees”. Based on this survey the average wages and salaries are calculated by economic sector, type of enterprise, ownership form and by age, gender and occupation type. According to the survey results the average monthly salary of employees was MNT 341.5 thousand in 2010, which is an increase of 13.6% compared to the previous year and a 24.5% increase compared to 2008 [93]. Furthermore, the average monthly real wage of employees increased by 3.2% compared to 2009. In the mining and quarrying sector the average real wages and salaries even grew with 28.1%. However in the social services sector it decreased by 11.7%.

In 2010, the monthly average expenditure per household reached MNT 450.6 thousand at national level, which is translated in an urban expenditure of 501.0 thousand MNT and rural expenditure of MNT 391.9 thousand. The share of monetary expenditure in the average expenditure per household was 86.5% (Figure 9).

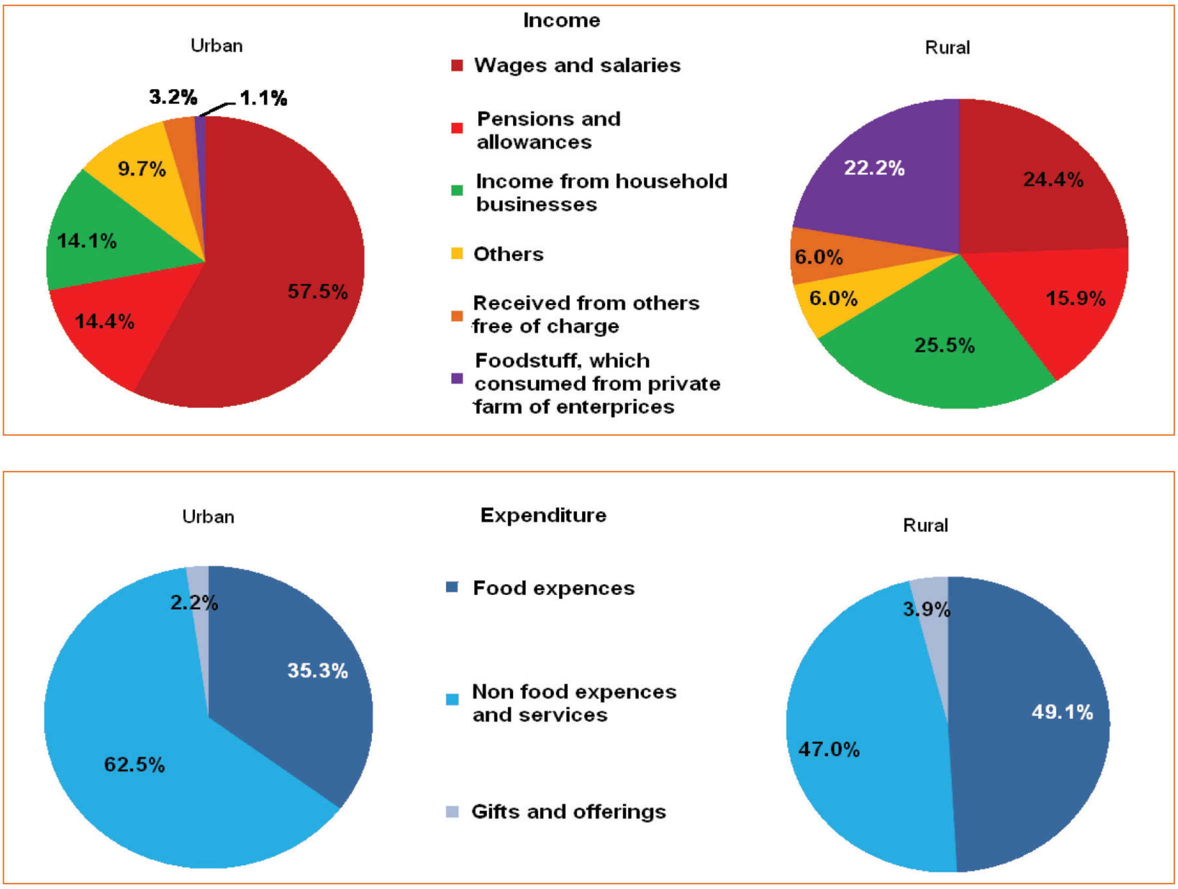

Figure 9. Composition of Household income and expenditure, 2010

In 2010 in Ulaanbaatar, the monthly average expenditure per household reached MNT 534.9 thousand, from which 97.1% was monetary expenditure including 33.5% food expenses and 63.5% was non food expenses and services.

According to the Tuul River Basin survey, water and wastewater expenses from the average monthly expenditure of a family of 4 persons in the Ger area were estimated at MNT1.8 thousand, whereas households in apartments connected to the central water supply system without water meter pay MNT 18.7 thousand (water 12.8 and wastewater 5.9). This equals 0.3-4% of the monthly average household income.[4] However, for low-income family it is 0.7% in the ger area and 7.3% in apartments. This shows us that when considering the water tariff situation more attention should be given to the low-income families in apartments.

Poverty and Living Standard

Since 1998, according to the Law on Statistics and the Law on Defining Minimum Subsistence Level of Population (from 1998) the NSO has defined the minimum subsistence level of the population by region. Table 13 shows the minimum subsistence levels in 2006-2010.

Table 13. Minimum Subsistence Level of Population

Region	Minimum Subsistence Level, MNT/per month per person					
	2006	2007	2008.II	2008.X	2009	2010
Central: Tuv, Selenge	39 000	56 700	73 100	90 800	91 200	91 700
Khangai: Uvurkhangai and Bulgan	38 300	54 600	70 600	89 000	90 600	91 500
Ulaanbaatar	42 800	60 100	73 300	94 800	101 100	101 600

One of the indicators showing the living condition of the country is the poverty indicator. The poverty indicator includes poverty headcount, gap and severity. The poverty headcount index indicates the proportion of the population that lives below the poverty line.

Table 14. Poverty headcount index, by region and % (NSO)

Indicator		2002-2003	2007-2008	2009	2010
Country average		36.1	35.2	38.7	39.2
	Urban	30.3	26.9	30.6	32.2
	Rural	43.4	46.6	49.6	47.8
Region	Western	51.1	47.1	48.7	51.1
	Khangai	38.7	46.6	55.2	51.9
	Central	34.4	30.7	29.3	29.3
	Eastern	34.5	46.7	43.8	40.6
	Ulaanbaatar	27.3	21.9	26.7	29.8
Location	Capital	27.3	21.9	26.7	29.8
	Aimag center	33.9	34.9	37.0	36.2
	Soum center	44.5	42.0	42.6	38.8
	Rural	42.7	49.7	53.2	54.2

The Millennium Development Goals (MDGs)-based Comprehensive National Development Strategy of Mongolia" aims to reduce the poverty headcount index by 2 times and to "create a regulatory mechanism to ensure full participation of all forms of enterprises and citizens in poverty reduction and rapidly to reduce poverty".

Contrary to the MDGs aims, the poverty headcount index has increased to 39.2% in 2010, which is composed of an increase of 7.9% in the Capital, 4.5% in rural areas, 1.3% in Aimag centers and a decrease of 3.2% in Soum centers. The main reason for the rapid

[4] By recommendation from EBRD water and waste water expense have to be under 5% of household income.

growth of poverty in the Capital is the migration of herders who had lost their property in the 2009-10 dzud.

Water Poverty Index (WPI)

In 2002, with the purpose to express an interdisciplinary index that links household welfare with water availability and water scarcity, C. Sullivan and a research group of the Economic Department of Keele University defined a Water Poverty Index. Applying this to 140 countries rates Mongolia at the 4th level with a low WPI (see Figure 10).

Source: http://maps.grida.no/go/graphic/water-poverty-index-by-country-in-2002

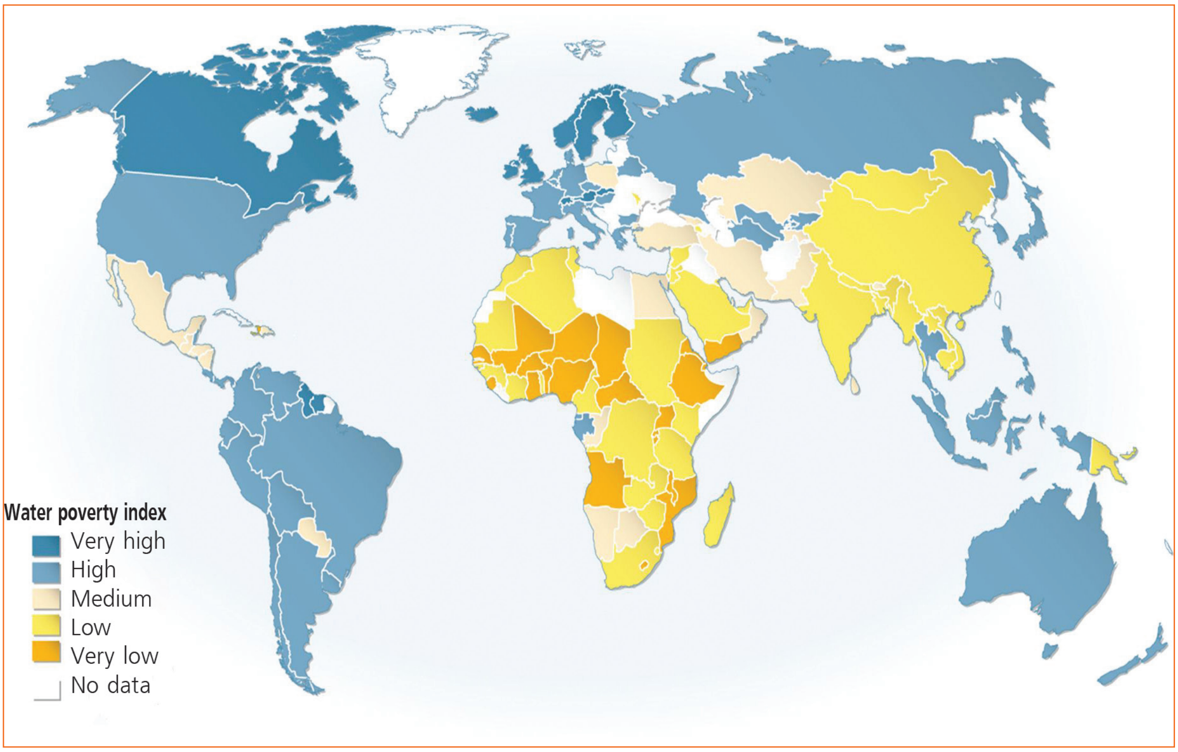

Figure 10. World WPI map

The WPI is defined by the following 5 indicators:

1. *Resources* indicate water availability and quality. This index combines internal water resources and external water inflows.
2. *Access* is defined from 3 components: percentage of the population with access to safe water, percentage of the population with access to sanitation and an index which relates to irrigated land as a proportion of arable land to internal water resources. This index takes account of water and sanitation needs and agricultural water supply.
3. *Capacity* is defined by GDP per capita, under-5 mortality rate, education index and Gini coefficient (measure of inequality based on the Lorenz curve). This index shows the relationship between socio-economic variables and access to water and quality.
4. *Use* has 3 components: domestic water use per capita, industrial use and agricultural water use (m^3/cap/year).
5. *Environment* is defined by environmental indicators, which reflect water provision management.

Mongolia was ranked 60th from 147 countries. From the components that determine the WPI, Mongolia scored lowest on access to water and sanitation. This component will be improved if the water supply and sanitation situation in Ger and in rural areas is improved. Table 15 presents the WPI of various countries.

Table 15. Some countries WPI

No	Country	Resource	Access	Capacity	Use	Environment	WPI	HDI*
1	Haiti	6.1	6.2	10.5	6.5	5.8	35.1	0.467
2	Nigeria	6.4	4.4	4.4	9.9	10	35.2	0.274
42	China	7.1	9.1	13.2	12.1	9.7	51.1	0.718
46	Vietnam	10	6.4	14.4	13.3	8.3	52.3	0.682
48	India	6.8	11	12.1	13.8	9.5	53.2	0.571
58	Nepal	10.2	8.7	11.2	12.6	11.8	54.4	0.48
60	Mongolia	11.1	8.8	12	11.2	11.8	55	0.569
68	Singapore	1.2	20	16.8	7.8	10.3	56.2	0.876
79	Kazakhstan	10	13.3	15.6	10.1	9.4	58.3	0.742
93	Belarus	6	20	18.5	8.8	7.3	60.6	0.935
95	Argentina	12.4	11.9	15.3	8.5	12.8	60.9	0.842
105	Korea	6.1	19.3	17.7	8.4	10.9	62.4	0.875
108	Russia	13	12.6	16.1	9.1	12.5	63.4	0.775
114	Japan	8.1	20	18.9	6.2	11.6	64.8	0.928
116	USA	10.3	20	16.7	2.8	15.3	65	0.934
131	Netherlands	7.9	20	18.2	8	14.4	68.5	0.931
135	Turkmen	10	17.7	14.7	16.7	10.9	70	0.73
146	Canada	15.5	20	18.7	6.9	16.5	77.7	0.936
147	Finland	12.2	20	18	10.6	17.1	78	0.925

Source: C.Sullivan, 2002

4.3. Society and Culture

4.3.1. Education

The education index[5] of Mongolia is relatively high: 0.925 in the 2010. The education system of Mongolia consists of pre-school education, primary and secondary education and higher education.

Due to the location of the science and education center of Mongolia-Ulaanbaatar, the Tuul river basin has a relatively large number of educational organizations. Most of the universities, colleges and vocational and technical schools are located in Ulaanbaatar. In the 2010/2011 academic year, there were over 160 thousand students studying in over 100 universities and colleges and 13 thousand students in the vocational and technical schools. These were about 90% of the high educational organizations and students of Mongolia.

In the 2010/2011 academic year, 200 thousand children were studying in over 230 schools, of which about 200 schools or 89% are located in Ulaanbaatar and about 93% children in Ulaanbaatar. According to the statistical information, the number of schoolchildren in the rural area is reducing, while in Ulaanbaatar it is rapidly increasing due to the migration to the Capital. Some schools are engaged in three shifts. In Ulaanbaatar, the average schoolchildren number is over 900 per school and outside Ulaanbaatar 600 per school. [110]

5 One component of HDI, wich is measured by the adult literacy rate and the combined primary, secondary, and tertiary gross enrolment ratio. In 2009 the overall countries education indices were 0.280-0.993.

In same year of 2010/2011, about 45 thousand children are enrolled in about 260 kindergartens, of which about 90% is located in Ulaanbaatar.

4.3.2. Culture

The Mongolians are one of the nations who preserved their nomadic cultures to this time. The people of Mongolia have a coherence with mother nature and respect it as the basis of life. This ideology is absorbed in Mongolian tradition and custom. The Mongolians consider water as a source of life and name rivers as mother. For example: Tuul river is named as "Khatan Tuul" in a respectful way. Some 300 years ago, a city was founded near Khatan Tuul river and Khan Bogd mountain. Later the city became the center of the country's development, and it is known as Ulaanbaatar now. Mongolian famous poets and writers praised the Tuul River in their works.

Until this time, herders follow the Tuul riverside in 4 seasons with their livestock in search of good pasture. The work schedule within households became traditional also. The women are responsible for water discharge in the household. Mostly, men carry the water. In the urban ger districts, children sometimes carry water. A questionnaire was conducted in ger districts of Ulaanbaatar City which showed: 45% adult men, 29% adult women, and 26% children carry water for the household. Another questionnaire was conducted in Altanbulag soum of Tuv aimag. The result of the questionnaire is: 62.7% adult men, 20.9% adult women and 16.3% children carry water. When comparing this questionnaire to a survey[3] called "Who carry water in the household" which was taken in 2004, the participation of men increased and participation of women and children decreased.

In urban areas, 50% of people carry water from a distance of 200 meters, 43% from up to 1 kilometer and 7% of people carry water from a distance of more than 1 kilometer. In soum centers, the indicator is 22.9%, 50% and 27.1%. For carrying water, 73% of people in Ulaanbaatar and 68.8% of people in rural areas spend 1 hour. In Ulaanbaatar, 10% of people and in rural areas 4.2% of people spend some 2 hours for carrying drinking water from the kiosks.

As in the above mentioned survey "Who carry water in the household", 11% of Ulaanbaatar City ger district households carried water over a distance of 1 kilometer. In our research, this percentage dropped to 7%, a decrease by 4%. This is a very important indicator that shows how well measures on ger district water supply are taken. As for nomadic herders, they obtain their water demand from protected sources like engineering designed kiosks. It is a good development, but it does not change the water quantity used.

The herders still use less than 10 liters water per person a day. Centralized water supplies and sewerage networks were introduced in Mongolia during the 1960s. As of 2010, 37.9% of the population who live in the Tuul River Basin had a connection to the centralized water supply and sewerage network. Only 1.2% of the population obtains their water from unprotected water sources like springs and ponds. One of the issues in Tuul River Basin is the river water pollution. Due to the river water pollution, households who live along the downstream part of the river face difficulties. For example: it is impossible to water livestock from the Tuul River downstream of Ulaanbaatar City due to water pollution.

It is clear that this has affected daily life of people. In soums like Altanbulag and Undurshireet, people drill wells along the river streams and water their livestock. Also there will be an extra fee added to drinking water production and it will be impossible to spend some quality time near water due to pollution and nasty smell. In this situation in developed countries, water users in the upstream part of the river pay compensation and tax depending on the pollution severity.

There is also a disadvantage related to nomadic livestock in the basin and in most part of the country. It is the concentration of livestock. The number of livestock increase in areas where there are rivers, springs and ponds. It causes water pollution and overgrazing. It even causes localized desertification. It means that we should pay attention to pasture water supply.

By improving ger district and rural water supply, our country can increase WPI. Globally poverty is described as follows: the state of one who lacks possibility, choice, security and authority which are required to enjoy rights of culture, economy, politics, and society. In order to decrease poverty related to water in our country, we need to supply people with good quality water, and increase the number of households who live in apartments connected with centralized water supply and sewerage. The water supply to rural and ger district people should be increased and sewerage issues need to be solved.

As for the results of the questionnaire taken in Tuul River Basin, the majority of the poor people live in Ulaanbaatar City ger districts. In Ulaanbaatar City ger districts, 1 liter of water costs MNT 1-1.5 and it takes on average 1-2 hours per day for carrying water. One person uses 7-10 liter water per day for drinking water. This is 2.0-3.6 times lower than the water demand per person (20-25 liter) which was estimated as sufficient by the World Bank and international organizations. Summary of the survey on Tuul river basin, which was conducted project, presented in the Annex 3.

4.3.3. Health

The Mongolian Human Development Policy aims to have a sustainable population growth and establish decent conditions for a long and healthy life. In line with this statement, the Government has successfully implemented measures that improved the health situation, of which the most notable were the “Strategy for the reduction of maternal death 2005-2011”, the “Reproductive Health national programme 2005-2011”, the “Action plan to reduce maternal death” and the “National strategy of medicament security and supply”.

According to statistics, there were about 2.3 thousand health institutes at national level as of 2010 and 40% or over 900 institutes are located in aimag and soums of the basin. From which 90% are located in Ulaanbaatar.

Maternal mortality which took place in the river basin was 47% of the total maternal mortality in the country in 2010 while infant mortality was some 40% of the total infant mortality. Also the number of patients suffering from infectious diseases was 53% of the total of the country (22 thousand). Of the patients in the basin, some 50% suffered from a viral hepatitis, one of the infectious diseases caused by polluted water. [109]

4.3.4. Future Trend of Social Development

It is stated in the 1st guidance of the six leading guidance’s of the integrated national development policy which is based on the Millennium Development Goals that “it shall achieve the Millennium Development Goals and develop Mongolian citizen in all aspects”. In scope of this guidance, it is also stated that “it shall adhere to a policy to fully achieve the Millennium Development Goals and bring the human development index at 0.83 by 2015”.

Development programmes of the region and aimags have been processed and approved based on above guidance. The Tuul river basin is crossing the economic regions of Ulaanbaatar, Central and Khangai. It is stated in the development programme of the Central region that the average life expectancy of the population is about to reach age of 66 and unemployment level as of 1998 is to decrease two times by 2015.

The development programme of Khangai region aims at bringing the average life expectancy at 69, increase the population growth to 1.8%, decrease number of registered unemployed below 2% and bringing the number of households under normal living standard below 10%. Also it will seriously focus on improving the level of housing supply for the population.

The Ulaanbaatar economic region development program aimed in 2015 to decrease the growth of migration by 50% compared to 2005, to reduce poverty level 2 times, to improve education facilities and education quality.

It is stated in the development programs of the Aimags in the basin to aim for creating convenient and stable living conditions for the population, bringing the average annual growth to the average national level, by encouraging employment and reducing unemployment.

5. Economic condition

5.1. Economic development

5.1.1. Gross Domestic Product

The Tuul River Basin occupies only 3.18% of Mongolia's territory. But some 40.9% of the population lives there. It is a very vital region in terms of society and economy. The economic regions of Central and Khangai as well as Ulaanbaatar region are included in the basin.

When calculating GDP of the basin, we have focused on Ulaanbaatar and Zuunmod, the economic center of Tuv aimag (Figure 11).

Source: NSO

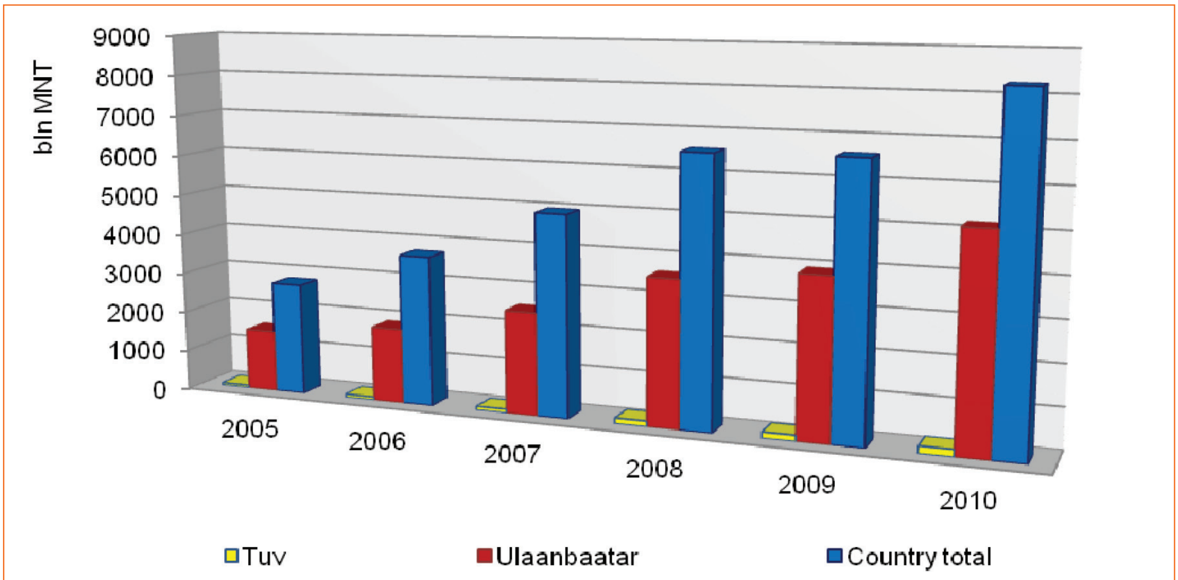

Figure 11. GDP of aimags and Ulaanbaatar in the Tuul River Basin at current year prices

In 2010 in Ulaanbaatar value produced was MNT 5174.1 billion and in Tuv aimag was MNT 182.1 billion, which was some 64.9% of Mongolia's GDP. In other words, some 60% of Mongolia's GDP is produced in the Tuul River Basin.

Between 2004 and 2006, the percentage of GDP produced in the basin decreased from 56% to 52%. This is related to the increase in production of the Khangai region and the agricultural production of the Central region. Since 2007 the share of Ulaanbaatar's GDP in Mongolia's total GDP has been increasing. The percentage of GDP and its structure are presented in Table 16 and Table 17.

Table 16. Share of Ulaanbaatar City and Tuv aimag in the country's GDP, at current year prices

Aimag and capital	2005	2006	2007	2008	2009	2010
Tuv	2.1	2.0	1.8	2.1	2.3	2.2
Ulaanbaatar	54.9	50.0	51.2	54.8	59.4	62.7

Table 17. GDP structure of Ulaanbaatar City and Tuv aimag at current year prices, 2010

Aimag and capital	Percentage, %		
	Agriculture	Industry, construction	Service
Tuv	73.8	3.5	22.7
Ulaanbaatar	0.8	28.6	70.6

Source: NSO

The service sector produced about 60% of Ulaanbaatar's GDP and 74% of Tuv aimag GDP is from agriculture. Most part of the production comes from agriculture in other aimags and soums in the basin. The reason is that there are not any big centralized towns and industries.

As of 2010, the GDP per capita in Ulaanbaatar was MNT 4493.0 thousand, which was 1.5 times higher than the state average, due to the high development of the industry and services (Table 18). For other aimags, it was 12-66% lower than the state average. The reason is that they mainly focus on agriculture and the other economic sectors' least development.

The GDP per capita in the basin is compared to the state average and it is presented in *Table 18* and Figure 12.

Table 18. GDP per capita in the basin in MNT thousand/year, at current year prices

Region, aimag, capital	2006	2007	2008	2009	2010
State average	1969	1896	2465	2432	2993
Khangai region	2453	2409	2631	2300	2638
Arkhangai	1021	1012	1593	1543	1543
Bulgan	1161	1107	1766	1804	1936
Uvurkhangai	773	729	1002	1030	1012
Central region	1190	1069	1638	1634	1993
Selenge	1384	1318	2051	1828	2361
Tuv	1198	1062	1605	1707	2019
Ulaanbaatar	2568	2459	3354	3519	4493

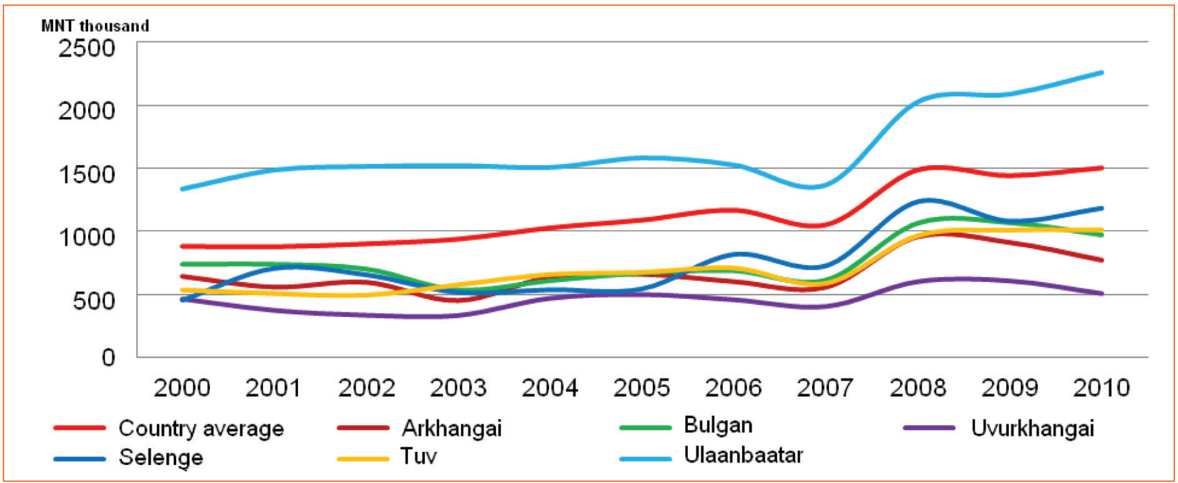

Figure 12. GDP per capita in aimags in the basin, at current year prices

Between 2004 and 2010, the average annual growth of the GDP per capita was 8% in state average. The highest was in Selenge aimag and lowest in Ulaanbaatar. The indicator of Ulaanbaatar is the lowest which is due to the high population growth.

In consideration of some factors which may affect the future development of the Tuul river basin:

Advantages:

- A relatively high development of infrastructure,
- Good market condition due to high density of population and concentration of industry,
- Possibility to develop foreign trade by railway and aviation,
- Plenty of human resource with relatively high education,
- Near the science and technological centers,
- Excellent condition for the development of tourism due to large number of historical and cultural places and natural sites connected by a well developed infrastructure,
- Convenient soil and climate to run intensified livestock husbandry and crop farming,
- Good condition for the industrial development related to the financial condition.

Disadvantages:

- Loss of land use policy and the high concentration of population in Ulaanbaatar,
- Increasing trend in unemployment and poverty due to high migration rate of the population,
- Infrastructure capacity cannot meet the needs of ger and suburban areas,
- Share of the manufacturing is low,
- Due to overgrazing, ecological conditions may deteriorate such as desertification and pasture degradation, etc.
- Environmental degradation due to man-made impacts is occurring. For example: air pollution, Tuul river water pollution, groundwater pollution, soil pollution near Tuul river area and increase of negative mining impacts.

5.1.2. Infrastructure

The river basin houses Ulaanbaatar City which is the country's social and economic center. The infrastructure is well developed in the basin. The Chingis Khaan international airport is located 18kms south west of Ulaanbaatar and it has communication with the following cities: Tokyo, Seoul, Berlin, Moscow, Erkhuu and Beijing.

Figure 13. International air route map of Mongolia

The railway is very important for Mongolia, which is located between 2 big countries and it connects Europe and Asia. The railway is vital in terms of economy. In Mongolia, we have 1.8 thousand kilometers long railway network. Some 1.1 thousand kilometers railway is connected with the trans-Siberian and Chinese railways. The railway is about to be increased due to increasing development of mining.

Auto road

Mongolia has a total of 11 thousand kilometers paved and improved gravel state roads and some 38 thousand kilometers paved and improved local roads.

Since 2001, the "Millennium Road" started to be built along the horizontal and vertical axis. It started from Ulaanbaatar City. Between 2000 and 2009, investment in the auto road sector increased 9.8 times. In total 1960 km paved road, 480 km pebble-covered road were built. In 2010, 1.5 thousand kilometer road is projected to be built, including 110 kilometer paved road from Bulgan's Dashinchilen to Arkhangai Orkhon.

State roads connecting to 7 other aimag centers pass through Tuul River Basin, except Ulaanbaatar City, from which 40% were paved road. Ulaanbaatar and Zuunmod city connected by paved road with some 45 km long and are connected with each other by local road. Ulaanbaatar City is connected with the following places by asphalt road: Nalaikh, Gatsuurt, Shuvuun fabric, Terelj camp, Baganuur and Northern camps.

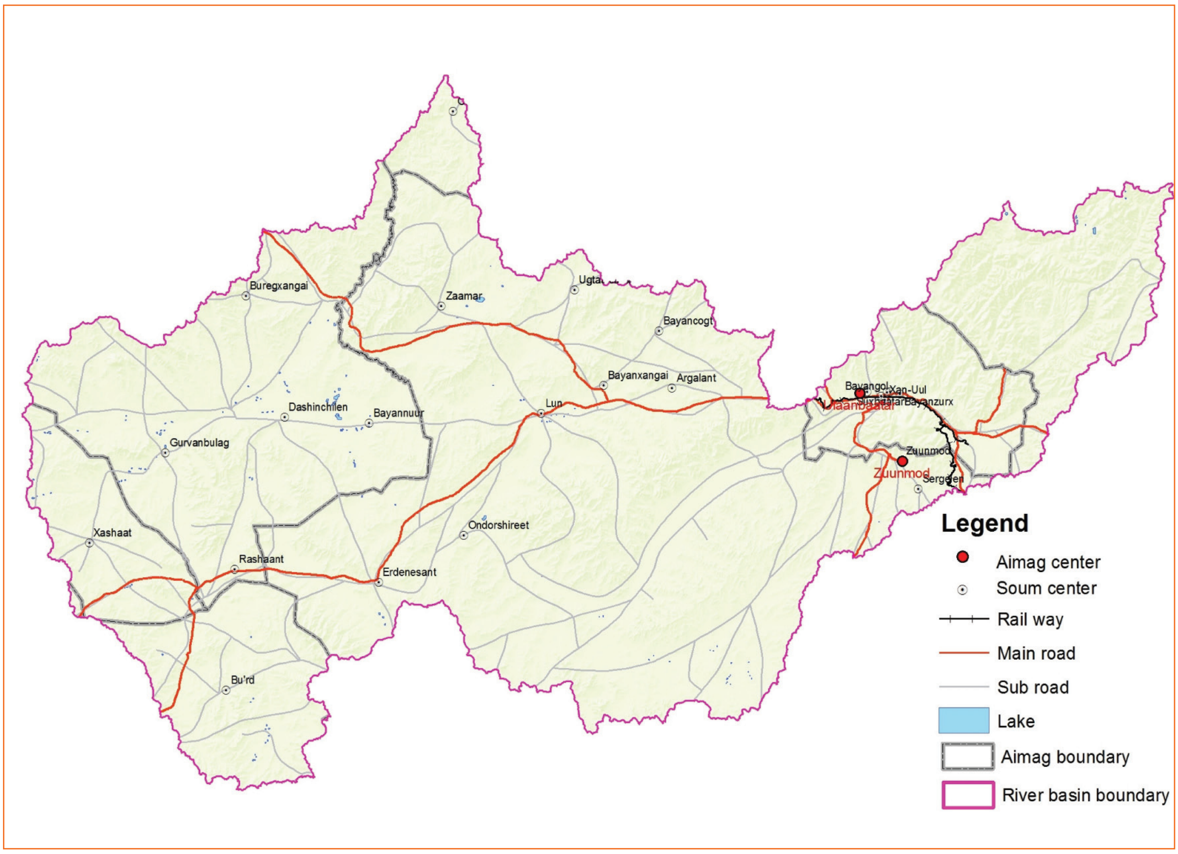

Figure 14. State and local level road map Of Tuul river basin

Ulaanbaatar has some 427.6 km auto road, from which 76.9 km is state, others are local level road. Ulaanbaatar City is connected with the following places by paved road: Nalaikh, Gatsuurt, Shuvuun fabric, Terelj camp, Baganuur and Northern camps. Between 2005 and 2008, some 60 km auto road and one bridge were built and expanded and some 304.7 thousand m^2 repairing work was conducted in central roads and roads within districts of Ulaanbaatar. In 2010, some 24 km paved road was built and 21.0 thousand m^2 roads were repaired.

As planned in the Ulaanbaatar region development program, the road network of the region will reach capital city standard of average developed countries. In Tuv aimag the development program plans to improve road networks.

Energy

Tuul River Basin belongs to the Central energy system. Therefore it has a more reliable energy supply than other regions. The basin occupies some 90% of the central energy network. There are 3 power plants and the total installed electricity capacity is 712 MW. The total installed thermal capacity is 1786 Gcal/h. 35-220 KW -1300 km long electricity transmitting lines are used for distributing electricity to the consumers.

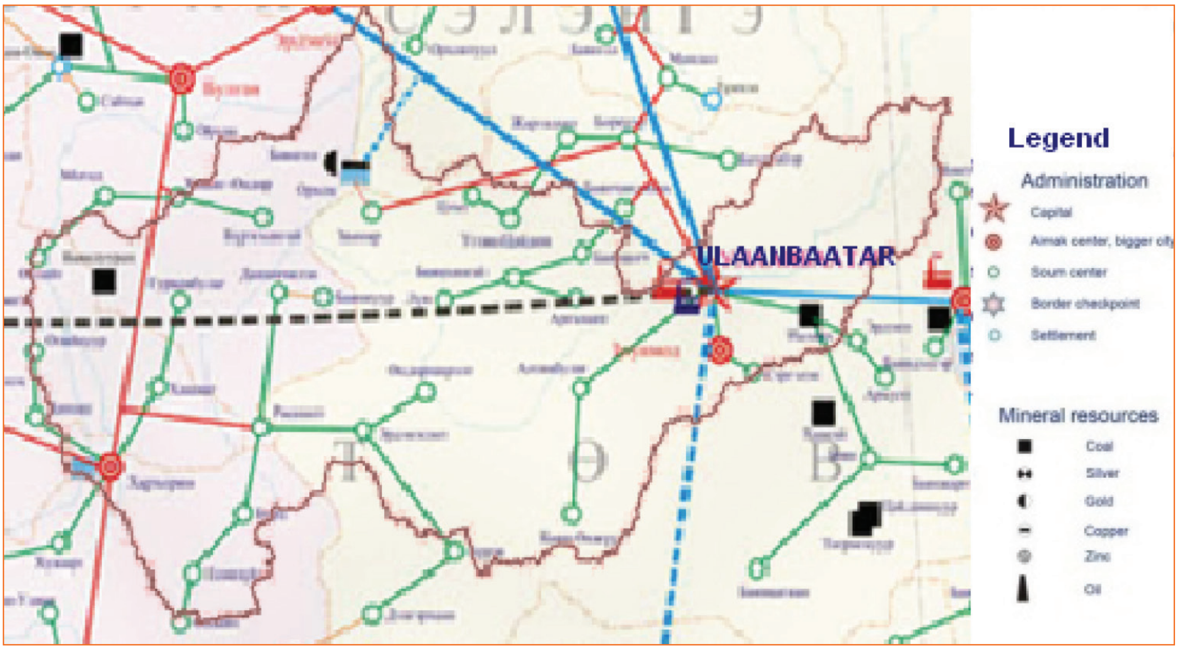

Figure 15. Electricity network in the TRB

The part of the energy system, which are located in the TRB presented in *Figure 15*. The soum centers of the basin are connected to electricity. There are centralized thermal systems in the soums of Ugtaal, Argalant, and Zaamar. The other soum organizations supply their thermal needs from heating stoves. Some 50% of the households use solar and wind energy and it plays an important role in their lives. In Mongolia, we need to expand the size of renewable energy use.

Ulaanbaatar City is well supplied by electricity, but in the last few years, population growth has increased as well as services and productions are developing rapidly. Due to these issues, energy demand is rising quickly. In some cases, sub-station and transparent centers' capacity decrease in ger districts and city center. Also, the level of energy supply decreases, and it becomes impossible to supply big energy consumers with energy and heat in the city center in terms of equipment.

It shows that consumers need to be supplied by nature friendly, cheap and reliable energy. The power plant number 5 is scheduled to be built and it will increase the basin's water demand.

Water supply and sewerage system

Due to high urbanization in the TRB, there is a relatively good developed water supply and sewerage system.

Water supply system. Ulaanbaatar city has a water supply network with a large capacity. The Ulaanbaatar city's water supply system include 4 water sources, 6 water transfer pumping stations, 175 deep wells (boreholes), 232 kiosks connected to the centralized system, and 298 unconnected kiosks, 350.3 km water supply pipes and 172 km water supply lines in the ger area. The pipelines inside apartment area belong to the OSNAAG. Ulaanbaatar City supplies good quality ground water for the drinking water needs. The water is purified by chlorination stations and then distributed to the consumers.

Nalaikh district is isolated but its drinking water is supplied from the upper sources of USUG. The Nalaikh district has a centralized water supply network, and water for ger areas population is provided by 23 kiosks. Also Nisekh, Bayangol and Biocombinat have local water supply systems.

On example of Ulaanbaatar, about 10 years ago only 14.5% of the total consumers had their water metered, the ratio between pumped and sold water was 50.6% and only 49.1% of the pumped water per day was billed. Nowadays USUG has metered 99.9% of the consumers that is 100% of the organizations. Due to the installation of water meters and activities related to water losses reduction, the drinking water use per person in 2010 decreased to 230.8 l/per day compared to 272.3 l/per day in 2008.

Zuunmod city has a water supply and sewerage system. The water supply source with capacity of 1550 m^3/ per day is located in the Khushgiin khundii. The water supply system includes 2 reservoirs, 2 pumping stations and 20.5 km distribution pipelines. In the ger area 17 kiosks provide drinking water for the population. Moreover Bayannuur and Rashaant soum centers of the Bulgan aimag, Orkhontuul of the Selenge, and Argalant, Bayankhangai, Zaamar and Erdenesant soum centers, and Khailaast village of the Tuv aimag have local water supply system.

Sewerage system. The Ulaanbaatar's sewerage system includes 147.7 km long sewerage pipelines, a Central wastewater treatment plant with treating capacity of 230.0 thousand m^3/per day, and "Khargia" wastewater treatment plant, which has a capacity to treat 13.8 thousand m^3 industrial wastewater per day.

The wastewater treatment plant of Zuunmod city was built in 1993 and has 25.5 km long sewerage pipelines. In 2010-2012, this wastewater treatment plant was reconstructed by state budget (MNT 1700 mln.)

Although water supply and sewerage system is developed adequately most of these networks were constructed in 1960s and technologies need to be renewed. For example: for the 2009 survey, 70%-treated waste water from Nalaikh district waste water treatment plant flowed through ger districts and joined the Tuul river. It causes infection diseases in the warm season. It should be noted that much attention is paid on industrial waste water treatment. Last few years, state policies on water supply are intensified. But USUG and some Housing and Communal Service Authorities are in loss. It means that cost and tariff system should be renovated and water loss needs to be minimized.

From soums, there were located in the TRB, Rashaant of the Bulgan aimag, Orkhontuul of the Selenge aimag, and Erdenesant of the Tuv aimag and Khailaast village have working a local treatment plant, but treatment level is very low. Also in the Bayannuur of Bulgan, Bayankhangai, Bayantsogt, Zaamar, Sergelen and Ugtaal of the Tuv aimag was built wastewater treatment plants, which were broken down.

Some tourist camps and sanatoriums have their own treatment plant and treated wastewater is discharged to the soil or nearby cities wastewater treatment plant by truck.

Due to rapid urbanization, expanding city, industrial development there are increasing needs for repair and expand water and sewerage systems.

The some developed countries stopped using chlorination stations since 1990s and started using silver-sand filter and UV radiation. These new technologies are better for people's health. So we need to introduce these kinds of new technologies in Mongolia.

Communication

Last few years, information and communication systems have developed in Ulaanbaatar City and other aimags. Some mobile phone companies except Mongolian Telecom Company are operating and they are Mobicom, Skytel, Gmobile and Unitel.

Mongolian national television, TV-25 television and several radio stations are operating. Also internet services are used widely.

5.1.3. Organizations

The infrastructure is well developed and market capacity is high in the Tuul River Basin. It enables industries to develop. The basin entities and organizations are mostly concentrated in Ulaanbaatar City. The organizations that do business in the field of agriculture and mining are concentrated in other aimags and soums of the Tuul River Basin. As of 2010, some 24 thousand entities and organizations were doing business and it occupies 68.4% of state total.

Some 79% of the organizations in the basin operate in the field of trade and services; 10.7% in the field of construction and processing industries; 1.3% in agriculture and 1.1% in mining and extraction industries (Table 19).

Table 19. Number of organizations operating in the Tuul River Basin, 2010

Aimag, capital	Agriculture and forestry	Mining and quarrying	Manufacturing	Construction	Electricity, gas and water supply	Trade, service and communication	Financial activities	Other services
Arkhangai						4	1	6
Bulgan	5		5		5	32	5	20
Uvurkhangai	1		1		1	5	1	4
Selenge	3		1			6	1	3
Tuv	27	3	44	2	12	298	29	89
Ulaanbaatar	284	256	1511	994	51	15722	2759	1768
Total	320	259	1562	996	69	16067	2796	1890

Source: Local area statistics agency information

Private business people work in the field of retailing, services and agriculture. The Government of Mongolia has followed policies to support small and medium businesses, and businessmen. It is very important to develop domestic industries, to increase jobs and improve the living standard of the population.

5.2. Agriculture

Agriculture plays an important role in the Mongolian economy. This sector provides for the population's needs for food and agro-industry

In 2010, the production of the agriculture sector amounted 15.9% from Mongolia's GDP. As of 2010, agricultural production occupied 0.8-78.9% in the Basin aimag GDP. The minimum was in Ulaanbaatar City, 0.8%. It was 68.1-78.9% in the other aimags.

5.2.1. Livestock

Development outline of livestock

Pastoralism has developed in a classical way in many countries with a high level of urbanization. Under the current condition where climate change has intensified, it is good for our country to have a combined development of intensified animal husbandry and agriculture. By doing so, the aim is to decrease the dependence on natural conditions like drought and famine.

Herders: In 2008, there were some 171.1 thousand herder households nationally which decreased to 160.3 thousands herders families in 2010. In 2010, of the country total 5.7% or 9.1 thousand herder families and 5.6% of 18.3 thousand herders live in this basin (Table 20).

Table 20. Number of herder households and herders in the Tuul River Basin

Aimag	Herder household, *thousand households*					Herders, *thousand persons*				
	2006	2007	2008	2009	2010	2006	2007	2008	2009	2010
Arkhangai	0.6	0.7	0.7	0.7	0.7	1.1	1.2	1.2	1.3	1.3
Bulgan	1.9	2.0	2.2	2.2	2.2	3.7	4.1	4.7	4.4	4.4
Uvurkhangai	1.1	1.0	1.0	1.0	1.0	2.3	2.2	2.1	2.1	1.9
Selenge	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
Tuv	3.9	4.0	4.0	4.2	4.2	7.8	8.1	8.2	8.0	8.4
Ulaanbaatar	1.5	1.5	1.3	1.5	0.9	3.0	3.8	3.2	3.6	2.2
Total of TRB	9.0	9.3	9.2	9.6	9.1	18.1	19.4	19.5	19.6	18.3
State total	170.8	171.6	171.1	170.1	160.3	364.4	366.2	360.3	349.3	327.2
Percentage of state total	5.3	5.4	5.4	5.7	5.7	5.0	5.3	5.4	5.6	5.6

Livestock. In 2008, there were 2951.2 thousand livestock which decreased to 2853.5 thousand livestock in 2010. Some 8.8% of Mongolia's total livestock lives in this basin (see *Table 21*). The number of animals per household is higher than the state average because location is close to big cities.

In 2010, 47.6% of total livestock of the TRB was in Tuv aimag, 31.1% in Bulgan aimag, 8.2% in Uvurkhangai, 7.5% in Arkhangai and 1.5% in Selenge aimag. From the total of the TRB livestock 87% are small animals and 13% are big animals. The share of the goats in the small animals is 41% which is close to the appropriate proportion defined by scientists. In Mongolian traditional pasture animal husbandry experience, it is normal if the goat percentage in the small cattle is 25-30% (Figure 16).

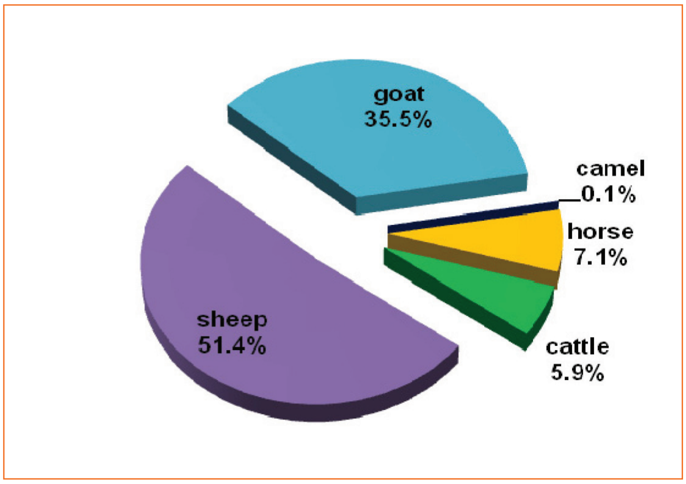

Figure 16. Livestock structure in the Tuul River Basin, 2010

The increasing goat percentage happened not only in Mongolia but also around the world due to increasing cashmere demand on the world market.

The number of livestock in the TRB is presented in *Figure 17*. Since 2002 Nationwide, there have been good conditions of nature and weather since 2002. This had a positive impact on the livestock numbers. And in 2008 the livestock of the TRB was doubled compared to 2004. Due to the 2009 dzud the livestock number was decreased. The highest losses were in Ulaanbaatar and in Tuv aimag. For example Argalant of Tuv aimag (42%), Nalaikh district (46%), Khan-Uul district (40%) lost over 40% of the livestock. The main reason for this was overgrazing nearby Ulaanbaatar.

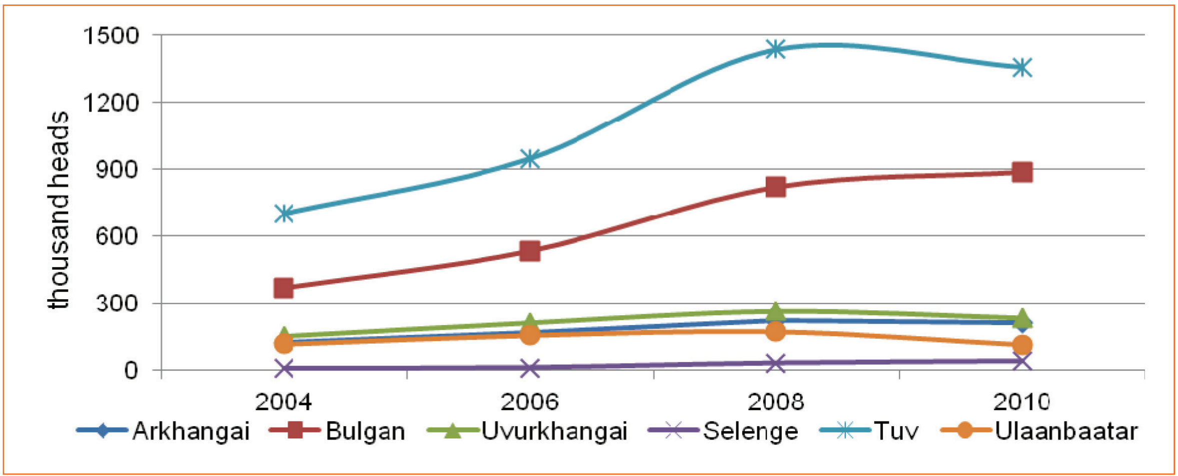

Figure 17. Livestock number in the aimags in the TRB, in thousand heads

Figure 20 of the Land use report presents the livestock density. Most densely soums of the TRB were Zuunmod of Tuv (1654 head/per 100 ha) and Rashaant of Bulgan (195 head/per 100 ha) and lowest density were in Sergelen of Tuv (16 head/per 100 ha), Erdene of Tuv (22 head/per 100 ha).

Table 21 shows livestock numbers and number of livestock per 100 ha in term of sheephead. More detailed information in Annex 5.

Table 21. Livestock types, 2010

Aimag and capital	Livestock, thousand heads						In term of sheephead	
	Total	camel	horse	cattle	sheep	goat	number	per 100 ha of the pasture
Arkhangai	214.8	0.3	12.2	8.0	125.3	69.1	321.9	133
Bulgan	888.0	0.6	59.9	44.7	471.8	311.0	1442.1	148
Uvurkhangai	233.5	0.3	15.5	6.1	132.5	79.1	350.3	99
Selenge	43.0	0.1	2.7	2.9	20.6	16.7	72.6	106
Tuv	1357.7	0.8	101.4	74.1	678.7	502.8	2289.0	93
Ulaanbaatar	116.5	0.1	10.3	31.6	37.7	36.8	332.9	271
Total	**2853.5**	**2.2**	**201.9**	**167.4**	**1466.5**	**1015.6**	4808.9	114
Total of the country	**32392.2**	**267.1**	**1901.7**	**2151.0**	**14273.9**	**13798.5**	54821.0	49
Share to the total of the country	8.8	0.8	10.6	7.8	10.3	7.4	8.8	-

The livestock structure change was compared in the timeline of the last 5 years. The percentage of goats is decreased by 3.5 points; the percentage of big animals is decreased by 0.7 points and the percentage of sheep increased by 4.4 points. In the other word the share of the small animals to the total was increased and the share of the big animals to the total was decreased.

In 2010, nearby Ulaanbaatar there were some124 farms with about 5 thousand cows; in Tuv aimag were some188 farms with about 8 thousand cows, which were 48.1% of the Mongolian high breeding animal farms. An average cows per farm was 40 in Ulaanbaatar, 43 in Tuv aimag, which was higher than nationwide average (33 cows). While near Ulaanbaatar are located most of the dairy farms of Mongolia that cannot satisfy the milk demand of Ulaanbaatar city. In addition in the Tuv aimag located 11 meat farms and one wool farm.

The regions' development program planned to develop intensive livestock farming near Ulaanbaatar for the purpose to meet food needs of the population.

Apart from the 5 main kinds of livestock, other livestock is raised and used for the population food demand in the basin. As of 2010, some 100 households and 10 entities managed pig husbandry; about 300 households and 9 entities managed chicken farming. There were in total 8.2 thousand pigs which are 28% of the total number of pigs counted nationally. Some 239.1 thousand chickens are bred which is 66.4% of the state total. The following animals are bred in a small number as well: deer, donkeys, rabbits, bees and musk deer.

Factors affecting animal husbandry in Mongolia

Pasture and hay resources

In 2010, The Tuul River Basin had 43438.2 km^2 of pasture and 4808.9 million livestock in term of sheep head equals. There were 114 sheep head per 100 ha on a basin average. This is 2.3 times higher than the national average.

Animal husbandry foremost relies on pasture and water. As of the survey on pasture, an annual pasture grass reserve of Mongolia in term of fodder unit is about 33 mln tons. According to the assessment on pastureland use of the Research Institute of Animal Husbandry and other related organizations from 2000, it is enough for 70-86 million livestock in term of sheep head equals, if climate and environmental conditions are stable and water supply is adequate. However, grazing capacity can decrease to 50 million livestock in term of sheep head equals depending on climate and environmental conditions like dzuds, droughts or severe precipitation. [78]

NAMHEM each year define grazing capacity of the winter and spring pasture, based on livestock number, yield and grazing period. According to the 2011 survey of grazing capacity by NAMHEM, of the soums which belong to the TRB, in Orkhontuul of Selenge aimag overgrazing was very high and some bags of Khashaat of Arkhangai aimag, of Bayankhangai, Ugtaal, Erdenesant, Erdene and Undurshireet of Tuv aimag had overgrazing (*Figure 18*).

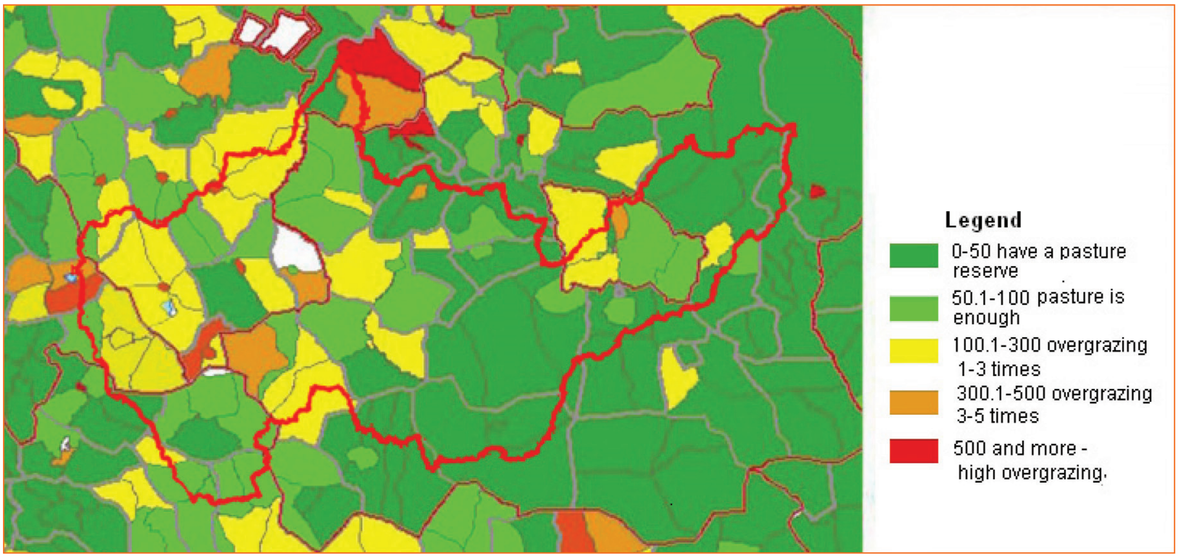

Figure 18. Grazing capacity in the TRB, 2011

Pasture capacity depends on the yield, grasses and number of livestock and other factors. The average yield of grasses per ha are 3.8 centner in spring-summer and 2.2

centner in autumn-winter from which will be eaten by livestock 2.7 centner in spring-summer and 1.7 centner in autumn-winter. Sheep needs 2 kg grass per day and an average 7.3 centner grass per year. If pasture is used 2 times per year then grazing capacity is 50-60 sheep per 100 ha. According to this estimation, in most of the TRB aimags the pastureland is overgrazed.

Table 22 and *Table 23* show hay harvesting and forage production in the TRB. In 2010 in the TRB there was harvested 67.1 thousand ton hay and produced 2.8 thousand ton forage, which were in term of fodder unit 33 thousand ton. It satisfies only 25.1% of fodder needs of the livestock in the TRB.

Table 22. Hay harvest and forage of the TRB

Aimag, capital	Hay, *ton*				Forage, *ton*			
	2007	2008	2009	2010	2007	2008	2009	2010
Arkhangai	2024.0	3036.0	1554.2	2295.0	124.4	172.0	69.0	33.4
Bulgan	7076.5	10158.0	9059.1	12846.6	191.6	387.2	298.5	404.5
Uvurkhangai	4335.7	4195.9	1404.1	1815.1	477.4	502.1	607.9	742.0
Selenge	4215.0	2810.0	3372.0	8992.0	0.0	0.0	0.0	0.0
Tuv	29896.8	39894.0	40847.8	31095.5	599.9	372.2	1184.8	1171.1
Ulaanbaatar	11632.6	15725.8	21318.5	10022.4	353.6	393.0	309.8	446.0
Total	59180.6	75819.7	77555.7	67066.7	1746.7	1826.5	2470.0	2797.0
Total of the country	933100	1030900	912300	1137300	35388.7	34440.8	25815	32745
Share to the total of the country	6.3	7.4	8.5	5.9	4.9	5.3	9.6	8.5

Table 23. Hay harvest and forage of the TRB, in term of fodder units

Aimag, capital	Hay harvest		Forage		Total
	output, ton	fodder units	output, ton	fodder units	
Arkhangai	2295.0	1032.8	33.4	33.4	1066.2
Bulgan	12846.6	5781.0	404.5	404.5	6185.5
Uvurkhangai	1815.1	816.8	742.0	742.0	1558.8
Selenge	8992.0	4046.4	0.0	0.0	4046.4
Tuv	31095.5	13993.0	1171.1	1171.1	15164.1
Ulaanbaatar	10022.4	4510.1	446.0	446.0	4956.1
Total	67066.6	30180.0	2797.0	2797.0	32977.0

Livestock water supply

Water supply is vital to develop animal husbandry. The number of livestock increased a lot and pasture is getting insufficient. The Government is paying attention to this problem and taking measures to improve pasture water supply. New wells are being drilled and maintained. On a basin scale, some 5.2 million m^3 water is required for livestock needs on average per year. This quantity is supplied from wells, springs and rivers in summer time and in winter time, it is supplied from wells and snow. (For more detailed information see Part 6)

In 2010, in Ulaanbaatar 5 new boreholes were constructed and 4 wells were repaired and in the Tuv aimag some 89 new wells were constructed and 66 wells were repaired.

According to the field works, need to pay more attention to the livestock water supply of Argalant, Bayan-Unjuul, Bayankhangai, Bayantsogt, Buren, Ugtaaltsaidam, Zaamar and Erdenesant of the Tuv aimag and of Dashinchilen of the Bulgan aimag.

Production of livestock husbandry

Meat production: In 2010, some 8373.7 thousand livestock were used for food nationally and 745.6 thousand livestock was used for food in the basin. In the TRB there produced 17.7 thousand ton meat by slaughter weight (Table 24 and Table 25). Also was produced over 10 ton pork.

In the future it is necessary to develop high breeding animal farms for purpose of reduce or keep on at an acceptable level the livestock number and increase meat export.

Table 24. Livestock number used for food in the basin, in thousand heads, 2010

Aimag, capital	camel	horse	cow	sheep	goat	total
Arkhangai	0.0	1.3	1.2	26.9	9.7	39.2
Bulgan	0.1	7.8	7.9	141.0	111.9	268.8
Uvurkhangai	0.0	0.5	0.1	19.3	2.0	22.0
Selenge	0.0	0.0	0.0	0.0	0.4	0.4
Tuv	0.2	13.6	13.3	181.3	138.3	346.7
Ulaanbaatar	0.0	2.3	8.1	28.1	29.9	68.4
Total	0.5	25.5	30.6	396.6	292.4	745.6
Percentage of state total	1.7	12.4	8.0	9.2	8.5	8.9

Remark: aimags' sum only for the parts belonging to the Tuul River Basin

Table 25. Meat production by slaughtering weight, in thousand tons, 2010

Aimag, capital	camel	horse	cow	sheep	goat	total
Arkhangai	0.0	0.3	0.0	0.5	0.1	0.9
Bulgan	0.0	1.8	0.1	2.5	1.6	6.1
Uvurkhangai	0.0	0.1	0.0	0.3	0.0	0.5
Selenge	0.0	0.0	0.0	0.0	0.0	0.0
Tuv	0.1	3.2	0.2	3.2	2.0	8.6
Ulaanbaatar	0.0	0.5	0.1	0.5	0.4	1.6
Total	0.1	5.9	0.5	7.1	4.2	17.7
Percentage of state total	1.7	24.1	1.0	9.2	8.5	8.7

Milk production: As of 2010, 338.4 million liters of milk was produced on a national scale and some 40.6 million liters of milk was produced in the TRB. This supplies only 55.5% of the Ulaanbaatar City and Tuv aimag milk products demand (*Table 26*). In the future for purpose to increase dairy production supply need to develop dairy farms nearby Ulaanbaatar.

Table 26. Dairy production of TRB, in thousand liters, 2010

Aimag, capital	camel	horse	cow	sheep	goat	total
Arkhangai	3.1	192.9	934.1	166.2	60.6	1356.9
Bulgan	5.0	1931.4	5833.7	753.2	467.1	8990.2
Uvurkhangai	0.6	206.4	388.6	143.6	99.7	838.9
Selenge	0.6	133.2	424.2	29.1	23.7	610.9
Tuv	6.6	1983.3	8323.1	734.0	456.8	11503.8
Ulaanbaatar	7.5	2609.0	13224.1	882.2	572.9	17295.6
Total	23.4	7056.3	29127.8	2708.2	1680.7	40596.3
State total	4000	32100	242800	22400	37200	338500
Percentage of state total	0.6	22.0	12.0	12.1	4.5	12.0

Wool and cashmere production: In 2010, 23.5 thousand t of sheep wool and 6.3 thousand t of cashmere were produced on a national scale. Some 7.2 t or 0.7% of wool of camel, 2.8 thousand t or 11.7% wool and 0.5 thousand t or 8.4% of cashmere were produced in the basin (*Table 27*).

Table 27. Wool and cashmere production, in tons, 2010

Aimag, capital	Camel wool	Sheep wool	Cashmere
Arkhangai	1.1	154.5	22.9
Bulgan	1.5	541.9	98.9
Uvurkhangai	1.1	182.8	29.5
Selenge	0.2	13.1	3.5
Tuv	3.0	885.8	177.6
Ulaanbaatar	0.3	978.7	193.1
Total	7.2	2756.9	525.5
State total	1066.8	23467.4	6259.1
Percentage of state total	0.7	11.7	8.4

Leather manufacturing: Some 16.8 million pieces of hides were manufactured on a national scale in 2010 of which 5% or 484.2 thousand was prepared in the basin. The percentage of horse and sheep hides is the maximum in the state total: 7.6 and 6.4% resp. (*Table 28*)

Table 28. Leather production, in thousand pieces, 2010

Aimag, soum	camel	horse	cow	sheep	goat	total
Arkhangai	0.0	2.8	3.1	32.6	14.1	52.6
Bulgan	0.1	8.9	8.8	151.5	121.2	290.6
Uvurkhangai	0.0	1.5	0.8	26.8	10.4	39.5
Selenge	0.0	0.0	0.0	0.2	0.5	0.8
Tuv	0.3	14.6	14.1	190.2	146.0	365.1
Ulaanbaatar	0.0	3.0	10.6	41.4	40.6	95.7
Total	0.5	30.9	37.4	442.7	332.7	844.2
State total	35.4	406.3	735.7	6955.9	6371.5	16784.7
Percentage of state total	1.4	7.6	5.1	6.4	5.2	5.0

Food production demand: The ongoing policy implemented by the Government of Mongolia to provide the domestic demand with domestic products and to improve the food security is creating convenient conditions for the development of agriculture and food production. Consequently, it enables to supply the domestic demand of meat and vegetable by domestic products. Ulaanbaatar City is located in the basin and the cities of Darkhan and Erdenet are nearby. This is the advantage.

The average food demand of the population in the aimags of the basin which may be provided internally has been calculated based on the statistics of 2010, as well as appendix 4 and 5 of order No.257 by the Health minister. Please see Table 29 for details.

Table 29. Food demand of aimags in the basin which may be provided internally as of end of 2010

Food products	unit	Ulaanbaatar	Tuv aimag	Central region
Meat and meat products	*t*	78877.8	6178.7	31448.4
Milk	*thous. l*	68226.4	5344.4	27201.7
Yogurt and curd	*thous. l*	93904.8	7355.8	37439.6
Flour and bakery product	*t*	42029.8	3292.3	16757.2
Potato	*t*	58841.7	4609.2	23460.0
Vegetables	*t*	84059.5	6584.6	33514.3
Fruit	*t*	75653.6	5926.1	30162.9
Vegetable oil	*thous. l*	10513.2	823.5	4191.6

The following products are needed for population food demand a year on average on a national scale: 167.6 thousand tons of meat, 344.6 thousand tons of dairy products, 285.9 thousand tons of pastry, 303.7 thousand tons of potatoes and vegetables, 318.2

million pieces of eggs and 22.4 thousand tons of vegetable oil. Ulaanbaatar City needs 67.0 thousand tons of meat, 114.2 thousand tons of dairy products, 121.3 thousand tons of potatoes and vegetables, 127.1 million pieces of eggs and 8.9 thousand tons of vegetable oil.

This demand is increasing every year due to population growth and living standard. By the year of 2021, the country needs the following products for population food demand: 202.1 thousand tons of meat, 415.3 thousand tons of dairy products, 366.1 thousand tons of pastry, 366.1 thousand tons of potatoes and vegetables, 383.5 million pieces of eggs and 26.9 thousand tons of vegetable oil. As for Ulaanbaatar City, the following are needed: 103.0 thousand tons of meat, 211.7 thousand tons of dairy products, 175.6 thousand tons of pastry, 186.6 thousand tons of potatoes and vegetables, 195.5 million pieces of eggs and 13.7 thousand tons of vegetable oil.

Mongolia has the potential to meet the food needs of the population by domestic production. The development of the irrigated crops contributes to achieve the goals of Mongolia, to satisfy internal food needs through domestic-eco-friendly safety products. The irrigation creates proper conditions for high yield. Mongolia produced internally the above mentioned food products except vegetable oil and some fruits and vegetables. The fruits and oil plants can grow only on irrigated land in a climate condition Mongolian. In 2010, Mongolia could completely satisfy the annual domestic requirements for wheat and potatoes and for vegetables by about 54% due to implementing the food safety policy.

Table 30 shows food consumption of some products in 2010. According to the meat and meat production of per person in Ulaanbaatar were by 2.7 kg higher than country average, vegetables were by 1.4 kg higher from country average and milk and dairy products consumption by 43.1 kg and potatoes consumption in Ulaanbaatar was by 10.5 kg lower than lower than country average.

Table 30. Consumption of some food products, in model person

Food products	Food need per person	Average food consumption on state level	Average food consumption of Ulaanbaatar
Meat and meat products, kg	68.5	74.1	76.8
Milk and dairy product, l	140.8	122.7	69.6
Flour and bakery product, kg	116.8	128.7	128.4
Eggs, ps	130	17	62
Potato, kg	51.1	60.9	50.4
Vegetables, kg	73.0	29.8	31.2

Food consumption of the Ulaanbaatar and aimag centers can be increased due to development of intensive farming. For the development of intensive farming an important role will play water supply.

Development trend of livestock husbandry

In 2010, the "Mongolian Livestock" National program was adopted through the 23rd resolution of Parliament of Mongolia. The objective of the program is to develop a livestock sector that is adaptable to changing climatic and social conditions and create an environment where the sector is economically viable and competitive in the market economy, to provide a safe and healthy food supply to the population, to deliver quality raw materials to processing industries, and to increase exports.

Furthermore, the program is to ensure a sustainable development of the livestock sector and to create a legal environment that will promote economic turnover; to improve traditional livestock breeding and to develop cooperation between nomadic herding and the intensive livestock keeping. It also aims to increase its the productivity and to improve the quality livestock products and to improve efficiency; to develop the livestock sector based on regions; to restore destroyed pastureland; to improve fodder production; and develop a market system of livestock products.

In the relation to the livestock water supply, the Livestock program aimed the following: based on herders' ideas and initiatives to implement exploration work to find appropriate sites for the new water wells, and to develop cost-sharing practices for the building and operating water sources. Also there were planning to develop ownership system and implement of the transfer responsibility for the use, protection and maintenance of new and repaired wells. The program projects the number of wells to be newly constructed in 2012 to reach 2400, in 2015 to reach 3600, and in 2021 to reach 2686 wells, while on the other hand the National Water program presents a construction target of 800-1000 wells per year.

The Ulaanbaatar regions' program planned to improve livestock sectors the organization of labour, to develop the livestock intensive farming and to increase supply of agriculture products. In the Tuv aimag development program aimed to maintain the sustainable development of livestock sector, to develop rapidly the intensive livestock farming and to improve pasture use and protection.

Livestock growth forecasting: When calculating the Tuul River Basin livestock growth forecasting, it is compared with the projection done by the Ministry of Food, Agriculture and Light Industry and the tendency of last 5 years' growth of the river basins aimag and soum livestock. The growth was calculated by each aimag and soum by livestock type.

The Tuul River Basin livestock number will reach 3297.5 thousand in 2021 by medium scenario (Table 31 and *Figure 19*).

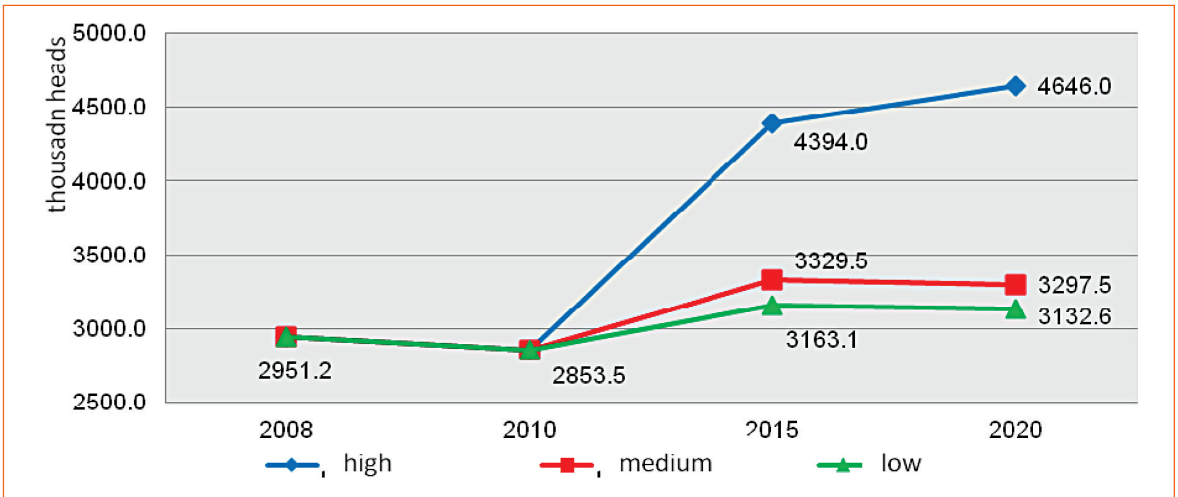

Figure 19. Livestock growth scenario

Table 31. Livestock growth projection of the Tuul River Basin until 2021

Aimag	Livestock type	2008	2010	2015	2021
Arkhangai	Total	221.9	214.8	248.8	243.1
	camel	0.3	0.3	0.4	0.5
	horse	14.8	12.2	20.0	25.2
	cow	8.7	8.0	13.9	20.2
	sheep	122.4	125.3	147.0	144.0
	goat	75.6	69.1	67.4	53.1
Bulgan	Total	821.1	888.0	1034.4	1019.9
	camel	0.3	0.6	0.7	0.9
	horse	52.0	59.9	98.5	124.3
	cow	35.0	44.7	78.4	113.3
	sheep	415.6	471.8	553.5	542.4
	goat	318.2	311.0	303.3	238.9
Uvurkhangai	Total	264.5	233.5	267.7	259.0
	camel	0.3	0.3	0.4	0.4
	horse	17.0	15.5	24.1	30.0
	cow	6.9	6.1	10.7	15.5
	sheep	143.8	132.5	155.5	152.3
	goat	96.5	79.1	77.1	60.7
Selenge	Total	34.0	43.0	50.2	49.7
	camel	0.1	0.1	0.1	0.2
	horse	2.4	2.7	4.4	5.6
	cow	1.9	2.9	5.2	7.5
	sheep	14.5	20.6	24.2	23.7
	goat	15.2	16.7	16.3	12.8
Tuv	Total	1435.6	1357.7	1581.6	1561.8
	camel	0.9	0.8	0.8	1.0
	horse	105.4	101.4	164.1	206.3
	cow	69.9	74.1	130.0	187.9
	sheep	688.9	678.7	796.3	780.3
	goat	570.4	502.8	490.3	386.2
Ulaanbaatar	Total	174.2	116.5	146.9	164.0
	camel	0.0	0.1	0.1	0.1
	horse	8.8	10.3	12.4	14.2
	cow	32.2	31.6	54.3	78.1
	sheep	63.1	37.7	44.2	43.3
	goat	70.0	36.8	35.9	28.3
Basin total	Total	2951.2	2853.5	3329.5	3297.5
	camel	1.9	2.2	2.6	3.1
	horse	200.4	201.9	323.5	405.6
	cow	154.7	167.4	292.5	422.5
	sheep	1448.3	1466.5	1720.7	1686.1
	goat	1145.9	1015.6	990.4	780.1

5.2.2. Crop farming

Farming is one of the basic agricultural production sectors. The basin is located close to the market. This region has a suitable condition in terms of economy and weather.

Ulaanbaatar City. As of 2010, crop was planted on 1042.7 hectares. The irrigation area was 116.5 hectares or 11.2%. The following is harvested by 51 farming-companies and 5.2 thousand household. In 2010, there were harvested 4870.9 tons of potatoes from 597.2 hectares, 2566.3 tons of vegetables from 354.3 hectares, 30.5 thousand tons of hay and 497.5 ton of hand-fodder. Some 40% of the total crop was harvested by the companies and 60% was harvested by households.

Currently, greenhouse farming is developing rapidly due to higher concentration of population in Ulaanbaatar. In 2010, there were planted 59.3 ha and harvested by314 tons cucumber and 211.5 tons tomatoes. According to the crop, 40% of total potatoes and 70% of total vegetables in the TRB were harvested nearby Ulaanbaatar (*Table 32* and *Table 33)*. Although the market condition is good in Ulaanbaatar City, the total crop decreased over the last 3 years. The reason is that total cultivated area was reduced and the number of farming-households and farms scaled down.

Table 32. Crop farming nearby Ulaanbaatar

Indicator		unit	2006	2007	2008	2009	2010
Sown area		ha	1272.9	1192.3	1146.5	1134.1	1042.7
from which	Potato		703.6	649.3	630.8	634.2	538.6
	Vegetable		404.2	376.8	407.0	366.5	344.7
Crops	Potato	t	6159.3	5540.0	4079.3	4870.9	5297.5
	Vegetable		4210.7	3816.9	3220.2	2566.3	3014.4
	Greenhouse		1096.3	776.4	951.4	525.5	784.9
Yields per hectare	Potato	c/ha	87.5	85.3	64.7	98.4	98.4
	Vegetable		104.2	101.3	79.1	87.4	87.4
Stakeholders	Households	thous. household	6.4	5.7	5.2	4.9	4.9
	Organisations	ps	78	57	51	49	49

Table 33. Crop by districts

District	Potato, t				Vegetable, t			
	2007	2008	2009	2010	2007	2008	2009	2010
Chingeltei	323.0	78.0	79.5	77.2	352.5	87.0	91.5	89.1
Nalaikh	149.9	122.8	157.7	94.0	44.8	104.7	82.5	29.1
Bayanzurkh	230.0	286.0	365.6	395.5	81.0	239.0	152.2	197.4
Sukhbaatar	596.4	571.2	345.2	254.2	627.7	425.2	105.4	67.8
Khan-Uul	1124.7	1179.3	793.4	801.2	639.4	692.5	478.9	990.9
Bayangol	197.4	91.5	249.6	236.8	688.5	646.2	450.4	447.2
Total	2621.4	2328.8	1991.0	1858.9	2433.9	2194.6	1360.9	1821.5

Aimags and soums of the basin. In the last few years, the cultivation of grain, potatoes and vegetables has intensified. Most people of soum centers supply their vegetable demand by cultivation and they also sell vegetables in the market.

As of 2010, the aimags and soums in the Tuul River Basin there were cultivated: 20.4 thousand ha cereals, 831.7 ha potatoes and 384.6 ha vegetables and were harvested: 25 thousand tons of cereals, 8 thousand tons of potatoes and 3.6 thousand tons of vegetables (Table 34).

Table 34. Soum crop data in the basin

A. Cereals and forage

Aimag and soum	Cereals									Forage		
	Sown area, ha				crop, ton				yield, c/ha	Sown area, ha	crop, ton	yield, c/ha
	2007	2008	2009	2010	2007	2008	2009	2010				
Arkhangai										10	35	35
Khashaat										10	35	35
Bulgan	770	818	695	1445	345.8	1050	696	1704	11.8			
Buregkhangai	540	668	680	800	183.8	1050	681	529	6.6			
Gurvanbulag	50	50										

Aimag and soum	Cereals									Forage		
	Sown area, ha				crop, ton				yield, c/ha	Sown area, ha	crop, ton	yield, c/ha
	2007	2008	2009	2010	2007	2008	2009	2010				
Dashinchilen	180	100		530	162			1060	20.0			
Rashaant			15	115			15	115	10.0			
Tuv	6167	6557	16579	18907	3929	5863	28891	31086	16.4	2031	5140	25.3
Argalant	20	600	1850	2850	106	780	3435	2329	8.2	840	2331	27.7
Bayankhangai										300	1620	54.0
Bayantsogt	1365	1350	3060	2900	810	1350	1783	1760	6.1	520	480	9.2
Zaamar				275				260	9.5			
Lun										13	32	24.6
Sergelen	40	50	82		32	42	120					
Ugtaaltsaidam	4292	3957	9813	11379	2941	2941	21588	24989	22.0	182	500	27.5
Erdenesant	450	600	1774	1503	40	750	1965	1749	11.6	172	177	10.3
Total	6937	7375	17274	20352	4275	6913	29587	32790	16.1	2041	5175	25.4

B. Potatoes

Aimag and soum	Sown area, *ha*				crop, *t*				yield, *c/ha*
	2007	2008	2009	2010	2007	2008	2009	2010	
Arkhangai	4.6	1.9	2.5	2	30.96	5.6	7	3.7	18.5
Khashaat	4.6	1.9	2.5	2	30.96	5.6	7	3.7	18.5
Bulgan	57	62.3	67	92	505.4	467.4	643.5	857	93.2
Bayannuur	6	6	7	7	54	42	73	63	90.0
Buregkhangai	16	16.3	17	17	111.4	130.4	161.5	170	100.0
Gurvanbulag	15	18	19	19	135	99	171	162	85.3
Dashinchilen	16	17	18	18	168	136	178	162	90.0
Rashaant	4	5	6	31	37	60	60	300	96.8
Uvurkhangai	3	4.5	3	3	24	24.2	7.5	32	106.7
Burd	3	4.5	3	3	24	24.2	7.5	32	106.7
Selenge	60	86	100	90	840	1204	1160	950	105.6
Orkhontuul	60	86	100	90	840	1204	1160	950	105.6
Tuv	534	427.94	500.6	644.7	2517	4002	4578	6110	94.8
Altanbulag	36	44	45	45	210	295	367	550	122.2
Argalant	10	20	21	25.4	98	180	253.2	268	105.5
Bayan-Unjuul	0.5	1	2	3	0.6	8	11	48	160.0
Bayankhangai	6.5	2.8	6.8	18	0.9	12.1	38.2	84.4	46.9
Bayantsogt	52	60	60	85	502	540	545	680	80.0
Lun	9	10	18	33	7.2	60	75	63	19.1
Zaamar	24	31	32	35	220	378	291.2	433	123.7
Zuunmod	10	23.24	26.4	34.1	91.4	91.4	138.7	94	27.6
Undurshireet	3	4.5	6.2	8.1	20.4	24.3	74.4	122.2	150.9
Sergelen	40	38	48	60	90	323	385.5	360	60.0
Ugtaaltsaidam	121	160.4	178.2	225	958	1925	2141	2756	122.5
Erdene	30	20	42	50.1	210	51	130.2	455	90.8
Erdenesant	192	13	15	23	108	114	127.5	196.7	85.5
Total	658.6	582.64	673.1	831.7	3917	5703	6396	7953	95.6

C. Vegetables

Aimag and soum	Sown area, *ha*				crop, *t*				yield, *c/ha*
	2007	2008	2009	2010	2007	2008	2009	2010	
Arkhangai	2.7	0.7	1.0	0.7	2.9	1.5	1.3	7.7	110.0
Khashaat	2.7	0.7	1.0	0.7	2.9	1.5	1.3	7.7	110.0
Bulgan	36.0	37.0	28.3	37.0	303.0	287.5	288.0	316.0	85.4
Bayannuur	13.0	13.0	5.0	6.0	110.0	104.0	68.0	51.0	85.0
Buregkhangai	6.0	5.0	5.0	6.0	36.0	40.0	46.0	61.0	101.7
Gurvanbulag	6.0	8.0	6.3	8.0	54.0	36.0	57.0	72.0	90.0
Dashinchilen	7.0	7.0	7.0	7.0	67.0	59.5	70.5	72.0	102.9
Rashaant	4.0	4.0	5.0	10.0	36.0	48.0	46.5	60.0	60.0
Uvurkhangai	1.0	1.5	1.5	1.5	7.2	4.0	5.0	14.2	94.7
Burd	1.0	1.5	1.5	1.5	7.2	4.0	5.0	14.2	94.7
Selenge	50.0	60.0	65.0	45.0	650.0	971.0	780.0	458.0	101.8
Orkhontuul	50.0	60.0	65.0	45.0	650.0	971.0	780.0	458.0	101.8
Tuv	324.0	427.9	303.1	300.4	1478.1	1766.0	2555.3	2843.3	94.6
Altanbulag	36.0	44.0	44.0	40.0	210.0	328.2	299.0	450.0	112.5
Argalant	10.0	20.0	5.0	5.0	78.5	50.0	52.0	48.0	96.0
Bayan-Unjuul	0.5	1.0	1.0	2.0	0.9	4.0	1.9	21.1	105.5
Bayankhangai	6.5	2.8	1.1	1.8	0.5	0.2	1.5	2.5	13.9
Bayantsogt	52.0	60.0	60.0	62.0	400.0	540.0	600.1	558.0	90.0
Zaamar	24.0	31.0	6.0	7.9	44.0	55.0	57.6	57.0	72.2
Zuunmod	10.0	23.2	16.5	20.3	57.1	84.1	50.4	74.4	36.7
Lun	9.0	10.0	5.0	5.0	4.5	5.0	9.6	9.8	19.6
Undurshireet	3.0	4.5	0.3	2.0	14.6	8.0	1.0	20.0	100.0
Sergelen	10.0	38.0	40.0	30.0	120.0	121.5	280.0	320.0	106.7
Ugtaaltsaidam	121.0	160.4	64.2	66.5	128.0	176.0	707.2	760.0	114.3
Erdene	30.0	20.0	15.0	8.0	100.0	12.0	90.0	72.5	91.2
Erdenesant	12.0	13.0	45.0	50.0	320.0	382.0	405.0	450.0	90.0
Total	413.7	527.1	398.9	384.6	2441.2	3030.0	3629.6	3639.2	94.6

The crop of the Tuul river basin by aimag was presented in *Table 35*. In the TRB were harvested 9.2% of cereals 8 6.3% of potatoes and 7.2% of vegetables from country total cereals, potatoes and vegetable.

The grain cultivation depends on the year's weather conditions. The reason is that it is mostly cultivated without irrigation. The following soums have harvested more cereals from 1 hectare than state average as of 2010: Dashinchilen of Bulgan aimag and Ugtaaltsaidam of Tuv aimag. The potatoes and vegetables are cultivated with irrigation and higher-than-state-average crops were harvested in Altanbulag and Bayan-Unjuul of Tuv aimag in 2010. In some soums harvest volume was low like 13.9 and 18.5 centners.

Table 35. Sown area and crop in the basin, by aimag

Aimag and capital	Sown area, *ha*				crop, *t*			
	2007	2008	2009	2010	2007	2008	2009	2010
Cereal								
Bulgan	770	818	695	1445	345.75	1050	696	1704
Tuv	6167	6557	16579	18907	3929	5863	28890.5	31086.4
Total of the TRB	6937	7375	17274	20352	4274.75	6913	29586.5	32790.4
Total of country	121777	153951	252390	259197	114778	212894	391659	355061
Percentage to total,%	5.7	4.8	6.8	7.9	3.7	3.2	7.6	9.2
Potato								
Arkhangai	4.6	1.9	2.5	2.0	31.0	5.6	7.0	3.7
Bulgan	57.0	62.3	67.0	92.0	505.4	467.4	643.5	857.0

Aimag and capital	Sown area, *ha*				crop, *t*			
	2007	2008	2009	2010	2007	2008	2009	2010
Uvurkhangai	3.0	4.5	3.0	3.0	24.0	24.2	7.5	32.0
Selenge	60.0	86.0	100.0	90.0	840.0	1204.0	1160.0	950.0
Tuv	534.0	427.9	500.6	644.7	2516.5	4001.8	4577.7	6110.3
Ulaanbaatar	301.0	323.3	326.2	269.3	2621.4	2328.8	1991.0	2648.8
Total of the TRB	959.6	906.0	999.3	1101.0	6538.3	8031.8	8386.7	10601.8
Total of country	11461.5	12291.5	13524	13813.7	114440	134773	151211	167956
Percentage to total, %	8.4	7.4	7.4	8.0	5.7	6.0	5.5	6.3
Vegetable								
Arkhangai	2.7	0.7	1.0	0.7	2.9	1.5	1.3	7.7
Bulgan	36.0	37.0	28.3	37.0	303.0	287.5	288.0	316.0
Uvurkhangai	1.0	1.5	1.5	1.5	7.2	4.0	5.0	14.2
Selenge	50.0	60.0	65.0	45.0	650.0	971.0	780.0	458.0
Tuv	324.0	427.9	303.1	300.4	1478.1	1766.0	2555.3	2843.3
Ulaanbaatar	237.7	289.8	296.7	258.5	2433.9	2194.6	1360.9	2260.8
Total of the TRB	651.4	816.9	695.6	643.2	4875.1	5224.6	4990.5	5900.0
Total of country	6134.5	6409.9	6517.9	7032.2	76430.5	78552.7	77976	82266.4
Percentage to total, %	10.6	12.7	10.7	9.1	6.4	6.7	6.4	7.2

The basin supplied 6.9% of Ulaanbaatar City potato demand and 3.4% of vegetable demand in 2008 and it's increased to 18% of potato demand and 7% of vegetable demand. It is effective to increase the vegetable production in this region.

Between 2005 and 2010, 17 irrigation systems with capacity of 800 ha were rehabilitated and built with state investment in the Tuul River Basin (Table 36).

Table 36. Irrigation systems of the Tuul River Basin, 2010

№	Location		Name of irrigation system	Area, *ha*
1	Tuv	Sergelen	Uvurbayan Ulaan	60
2			Uguumuriin am	100
3			Khushigiin khundii	10
4			Bayanburd	10
5		Altanbulag	Akhmad	9
6			Bayariiin sanaachlaga	10
7		Bayantsogt	Dund urt	57
8			Guna	70
9		Argalant	Sagsai	55.6
10		Ugtaaltsaidam	Manz	150
11	Ulaanbaatar City	Khan-Uul	Turgenii goliin adag	75
12			Munkh-Undarga	90
13			Songinii mod urjuuleg	43
14			Songinii mod urjuuleg	22
15			Batiin	3
16		Bayanzurkh	Gatsuurtiin bayantuhum	8
17			Artsat	22
Total				794.6

Development trends of farming. The Government of Mongolia is following a policy to supply the population food demand, food security, grains and vegetables in the country. The policy is being implemented successfully.

Although this basin is located in the Khentii mountainous region and it is possible to cultivate crops, regional desertification has been noticed in recent years. This is due to climate change. So, in order to have a reliable harvest, it is required to develop irrigation. The irrigation is required to develop farms of potatoes, vegetables, fruits, and trees. The Ministry of Food, Agriculture and Light Industry has set a goal to increase the irrigation area and make it to the level of 1990.

In 1990 there were some 30 irrigation systems with capacity of over 2 thousand ha engineering irrigation in the Tuul River Basin. It will be possible to increase the irrigation area to the level of 1990 only when maintaining these irrigation systems (Table 37). There are 66.9 thousand hectares of crop area in the basin and some 20% is used.

The arable area is 109.4 thousand hectares and it shows that there is a possibility to increase irrigation.

Table 37. The irrigation systems that once operated in the Tuul River Basin before 1990s

Aimag, capital	Name of soum and district	Name of irrigation system	type	Capacity /ha/
Arkhangai	Khashaat	Tsaidam	simple	130.0
Bulgan	Bayannuur	Daliin bulag	engineering	57.0
		Shar tal	simple	560.0
		Bor bulan	simple	350.0
	Buregkhangai	Jajiin bulag	simple	6.0
	Gurvanbulag	Sainturuu	simple	13.0
	Dashinchilen	Myalangiin gol	simple	4.0
	Khishig-Undur	Shand	simple	30.0
Uvurkhangai	Burd	Borigdoi	simple	50.0
Tuv	Altanbulag	Buhugiin gol	simple	6.0
	Bayan-Unjuul	Bayanbulag	simple	3.0
	Bayantsogt	Guniin ferm	engineering	70.0
		Dund urt	engineering	57.0
		Urumdmul hudag	simple	1.0
	Bayankhangai /Atar/	Buduun dugar	simple	3.0
	Buren	Urumdmul hudag	simple	1.0
	Zaamar	Ar-Urt	engineering	125.0
	Zaamar	Zaamariin gol	simple	2.0
	Lun	Enkhiin hudag	simple	4.0
	Undurshireet	Uyangiin hudag	simple	4.0
	Sergelen	Khoshgiin hudag	simple	3.0
	Ugtaaltsaidam	Bor hujir	simple	4.0
	Tseel	Bor hujir	simple	11.0
	Erdene	Uubulan	engineering	36.0
	Erdenesant	Urtiin gol	simple	5.0
Ulaanbaatar	Bayanzurkh	Uvurbayan	engineering	74.0
		Khar usan tohoi	engineering	95.0
		Uliastain-Am	engineering	240.0
	Khan-Uul	Buhugiin gol-1	engineering	150.0
		Buhugiin gol-2	engineering	189.0
Total				2283.0

The main things that should be taken into consideration when building and using irrigation systems:

- Protect soils and change crops annually
- Create an environment to optimize crop harvests following the norms of irrigation, procedures and agrotechnology.

The Ulaanbaatar region development program aimed to develop ecological clean technologies based on livestock and crop row materials. The Tuv aimag development program planned to increase wheat production to the 20% of total wheat production of Mongolia. Moreover in the development program aimed to complete irrigate vegetable area and to define irrigation development zone and in 2023 to reach irrigated are to 2500 thousand ha.

5.3. Industrial development

Tuul river basin is the region where industries are most developed in Mongolia. The industrial concentration is high in Ulaanbaatar City and in other aimags the concentration is mainly in the aimag centers. In soum centers, there are small industries that supply the local area.

In 2010, in Ulaanbaatar City were produced MNT 1914.5 billion industrial products and sold MNT 2187.3 billion industrial products at current prices, which increased industrial output by 47.4% and sales by 57.9% compared to 2009 (*Table 38*). The industrial sector employed 26.3 thousand people. Recently, the industrial output and sales of Ulaanbaatar are growing rapidly. In 2010, share of the export to the sales reached to 56.6% compared to 38.2% in 2008. Main reason for growth of the industrial outputs is the growth of mining and quarrying, milk and dairy production, flour and chemical production. [112]

Table 38. The industrial outputs and sales of Ulaanbaatar in MNT million, at current year prices

Year	Output	Sales	From sales	
			domestic	export
2006	695 925.0	697 262.1	339 107.3	358 154.8
2007	960 395.7	960 411.0	559 966.4	400 444.6
2008	1 092 645.8	1 127 994.7	697 496.7	430 498.0
2009	1 298 692.2	1 384 885.5	816 248.6	568 636.9
2010	1 914 524.5	2 187 321.4	950 249.9	1 237 071.6

According to *Figure 20*, in 2010 the share of the manufacturing reached 35.5% and mining and 35.5% and mining and quarrying 54.5% in industrial production.

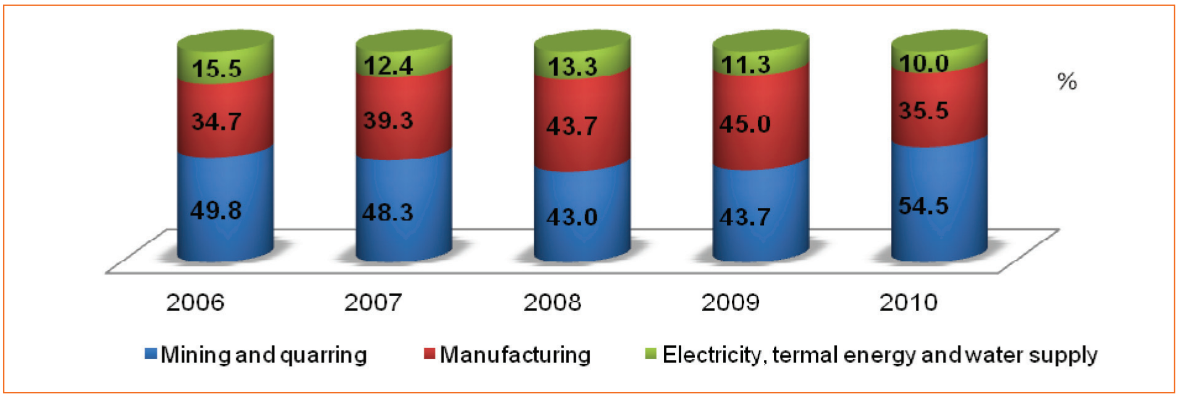

Figure 20. The industrial sector structure of Ulaanbaatar City

In 2010, the entities of Tuv aimag made the products of MNT 7457.5 million at current prices and of MNT 3847.6 million at constant year prices of 2005, which is decreased by 12.8% from 2008 (Table 39 and 40). The reason is that decrease of the alcohol and beverage production, milk and dairy production and mining and quarrying. There is a high chance of losing possibilities to sell the products in the case that competitiveness is insufficient although the entities' location is good in terms of economy. The total production of Tuv aimag consisted of followings in 2010: electricity, thermal energy and water supply 62.6%, manufacturing 17.9%, and mining and quarrying 19.5%. Over thousand people worked in the industrial sector.

Table 39. The industrial production of Tuv aimag in MNT million, at constant prices of 2005

Industrial sector		2007	2008	2009	2010	Growth 2010/2008, %
Total production		5066.6	4412.1	3997.5	3847.6	87.2
Of which	Mining and quarrying	1435.7	1172.7	1033.3	748.6	63.8
	Manufacturing	1322.8	1086.5	699.6	688.7	63.4
	Electricity, thermal energy and water supply	2308.1	2152.8	2264.6	2410.3	112.0

Table 40. The industrial production of Tuv aimag in MNT million, at current prices

Industrial sector		2007	2008	2009	2010	Growth 2010/2008, %
Total production		6936.3	7636.2	7721.2	7960.6	104.2
Of which	Mining and quarrying	2457.7	2734.1	2749.4	2059.4	75.3
	Manufacturing	2186.6	2098.1	1382.0	1593.3	75.9
	Electricity, thermal energy and water supply	2292.0	2804.0	3589.8	4307.9	153.6

5.3.1. Light and Food Industries

Agricultural raw material processing industry

Tanneries and leather industry. Tanneries sector produced 8% of GDP and constituted 15% of total jobs in 1992. However, in 2001, the production reduced and the employment decreased to 1% of total employees.

In 2001, in order to support tanneries sector and increase processed products' export The Government of Mongolia approved "Leather" program by the resolution number 114. As result of the program is tanneries manufactured some MNT 360.7 million products in Ulaanbaatar city and MNT 140.8 million products at constant prices of 2005 in Tuv aimag in 2010.

In tanneries sector, there are some 40 industries which have a capacity of processing 9.2 million skins a year and some 200 small industries are operating that manufacture end products. Only three of them are located in rural area and the rest is in Ulaanbaatar. Some 35 industries do first processing; 5 industries for deep processing; 4 industries for processing furry skins; 8 industries for leather boot manufacturing; 180 industries for leather products and clothes; 4 industries for leather and furry clothes; research center and one technological wastewater treatment plant.[6]

The tanneries of Ulaanbaatar have used some 0.2 million cubic meter water in 2010. According to regional development programs' objectives, tanneries sector production will grow by 6.9% each year. By the year of 2021, tanneries sector will use 0.3 million cubic meter water a year.

Tanneries and raw material processing industries use some 30 kinds of chemical substances for the technology, which have become one of the causes of water pollution. The tanneries in Ulaanbaatar city are supplied from the centralized network and their wastewater is treated by "Khargia" wastewater treatment plant.

[6] "Social economic development of Mongolia in 2009" NDIC, UNs population fund

"Khargia" wastewater treatment plant was established in 1972 and it expanded in 1985. The capacity of the wastewater treatment plant is 13000 cubic meter per day. At present, the wastewater treatment plant treats 7000-8000 cubic meter water per day. Due to old equipments, the WWTP supplies high-level wastewater to the central pipelines since it is not capable of doing it. It increases the Central wastewater treatment plant's load. Also it is one of the sources that pollutes Tuul River. In order to solve these problems, "Khargia" wastewater treatment plant has changed into Ulaanbaatar city-owned company.

In order to reduce pollution in tanneries' industrial wastewater, first processing industries participated in the assessment of environmental impact. In addition, nature friendly technology and equipment are being introduced. "Mongol Shevro" and "Darkhan nekhii" companies' tanneries involved in the project "Introducing clean industrial method". In result of these their industrial waste decreased 2-5 times.

In the framework of "Program for great construction and mid-term goals" from 2011, detailed survey will be conducted in industries that cause environmental pollution. Some of the industries will be moved from Ulaanbaatar city. Also, it is necessary to include in the IWRM plan that new technologies need to be introduced which treat wastewater.

Wool and cashmere processing industries. This sector is one of the main sectors which produce export products. Mongolia is capable of processing 32.4 thousand tons of wool and cashmere a year. Some 68.2% is sheep wool; 20.5% is cashmere and 11.3% is camel wool and other stuff.

The wool and cashmere production is developing rapidly due to high global demand. The wool and cashmere sector produced MNT 169.2 billion products or 3.6% of industrial sector in 2010. MNT 135.6 billion products were made in Ulaanbaatar city. MNT 42.1 million products were made in Tuv aimag. (*Table 41*)

Table 41. Production of wool and cashmere products

Product types	unit	2006	2007	2008	2009	2010	2010/2009, %
Combed cashmere	*ton*	1 064.4	1 554.7	1 723.8	1 586.7	824.7	52.0
Washed wool	*thous. ton*	0.2	0.9	1.2	1.2	1.6	133.3
Carpets	*thous. m^2*	89.2	87.0	108.8	50.5	42.2	83.6
Knitted products	*thous. pieces*	4 518.8	4 214.0	2 139.7	631.3	795.8	126.1
Camel wool blanket	*thous. meters*	34.4	37.7	35.0	36.9	12.3	33.3
Felt material	*thous. meters*	21.9	26.7	20.5	21.9	37.7	172.1
Leather clothes	*thous. pieces*	0.6	2.9	1.4	10.0	2.6	26.0

According to the table, combed cashmere production decreased by 48% than that of previous year in 2010. The camel wool blanket decreased by 67.7% and felt production increased.

As for sector's export, raw wool export increased and it reached USD 7.6 millions or 8.0 thousand tons in 2010. The raw cashmere export decreased by 13.2% than of previous year or 3.1 thousand tons. Due to price growth, its revenue reached 104.9 million dollars or increased by 14.4%. The combed cashmere export volume decreased by 39.8%, but its revenue reached 68.8 million dollars after its price growth revenue increased by 0.7%. At present, some 54 industries are operating in the sector. 6 of them have domestic investment and remaining 48 have foreign investment.

At present, some 54 industries are operating in the sector. 6 of them have domestic investment and remaining 48 are joint venture companies with foreign investment. 51% of joint ventures have Chinese investment and others have 10 countries' investment including American and Japanese. 9 of the industries are garment industries and 44 are first processing industries. 5 of the industries are in rural areas and 48 are in

Ulaanbaatar city. Some 4.2 thousand people are working in this sector. The big industries of the sector are as follows: "Govi" company, "Goyo" Co, Ltd, "Altai cashmere" Co, Ltd, "Sor cashmere" Co, Ltd and "Buyan" company. Some small industries of the sector closed due to the 2008-2009 global economic crisis. The following big industries are also operating in Ulaanbaatar city: "Monmyandas" Co, Ltd; "JJ Khuvsgul Knitting" Co, Ltd; "Selenge Knitting" Co, Ltd; "Cashmere fine-Asia" Co, Ltd; "Monnoos" company; "Eermel" company; "Novanooluur" Co, Ltd and "Ulaanbaatar Carpet" company.

According to monitoring by GASI, the wool-washing industries discharge its wastewater to the central sewerage network. In addition, the industries used different type's water filters with small capacity. There was no solution which equipment to use in which industry. Some 70-80% of the industries did not meet the industrial wastewater requirement to supply to the central pipelines. The pollution level is 5-8 times higher than standard level. As for the IWRM plan, attention should be paid to introduce nature-friendly technology, which treats wastewater to the standard level and reuse water in the raw material processing industries. Moreover, the introduction of financial and economic incentive is important.

Other sectors of the light industry

Garment industries: Garment industry is one of the biggest industrial sectors of Mongolia. It produced 35% of industrial sector's GDP and constituted 55% of employees in 2001.

The Government of Mongolia approved the program and started implementation of the program "Developing production of garment products" in 2003 in order to increase the production of sewn products; increase export volume and supply population needs by domestic products. The sector's export amount was USD 17.9 million in 2008. In 2010, the amount was reduced 30 times and reached USD 589.6 thousand. As for the sector's employees, there were 4.7 thousand employees in 2007, which decreased 3.1 times and reached 1.9 thousand in 2010. They produce and supply following things in domestic market: labor clothes, uniforms of police officers and firefighters, yurt cover and student uniforms. There is a large demand in domestic market, but production not increased due to financial possibilities and lack of material availability.

There are some big industries in Ulaanbaatar: "IKOS" Co, Ltd; "Temujin mench" Co, Ltd; "Anar Teks" Co, Ltd; "Suljee" company and "Borte". In 2010, Ulaanbaatar's industries produced MNT 2718.2 million garment products at current prices and MNT 154.5 million garment products produced in Tuv aimag.

Wood working industries. This sector produced MNT 6605.5 million products in Ulaanbaatar MNT410.0 million products produced in Tuv aimag at current prices in 2010. The sector supplies construction door, window, floor, furniture, yurt wooden frames and furniture to the domestic market.

Some 300 entities are operating in the sector of wood preparing and processing industries. Of which 90 are located in Ulaanbaatar and about 3 thousand people work there. Mongolia's furniture import amount has increased in recent years and reached USD 20 million in 2008 and USD 17.7 million in 2010, which shows domestic industries can increase their production.

The Government of Mongolia approved and started to implement action program of "Restoring wood processing sector and solving unemployment and social problems of the sector" in 2000.

Paper, paper production and publishing industries: Some 220 entities have been registered, from which over 90% are located in Ulaanbaatar and some 4 thousand people are working there. About 20% of them are fully equipped big industries.

Some 30% of the publishing products are textbooks; 20% are newspapers and magazines; 15% are commercials and 10% are packages and labels. In 2010, there were produced MNT 15.8 billion products in Ulaanbaatar city. The production of paper products reached MNT 8.8 billion at current prices in 2010.

Other productions: In recent years, the tobacco industry is developing in Mongolia. In 2010, MNT 36.5 billion products were produced in Ulaanbaatar city. It increased by 2.9% compared to the previous year and covers 5.4% of manufacturing.

In current year, the liquid fuel, chemical, coke and rubber industries produced MNT 30.9 billion products at current prices, this was 50.8% of the manufacturing.

Food industries

As of 2010, there were manufactured MNT 398.7 billion products by food industries in Ulaanbaatar city and MNT 0.3 billion products in Tuv aimag.

Ulaanbaatar: In 2010, from total food products manufactured by Ulaanbaatar some 7.3% or MNT 29.0 billion of milk dairy production; 7.8% or MNT 31.2 billion of meat production; 19.4% or MNT 77.5 billion of flour and pastry production; 54.2% or MNT 215.9 billion beverage production and 11.3% or MNT 45.0 billion products in other food production.

Table 42. Food production of Ulaanbaatar city in MNT million, at current prices

Products	2006	2007	2008	2009	2010
Milk, dairy products	2 689.7	5 722.1	14 281.8	20 087.3	29 026.7
Meat products	7 584.2	8 749.4	24 665.6	33 339.7	31 240.0
Flour	16 216.6	32 183.0	50 708.7	67 116.0	77 514.8
Beverage /including alcohol/	29 592.1	51 652.1	86 080.0	131 597.6	215 943.6
Other food products	25 260.2	28 038.2	43 305.4	46 126.0	45 031.5
Total	81 342.8	126 344.8	219 041.5	298 266.6	398 756.6

Flour and flour products are playing important role in food consumption of the Mongolians. In 2010, 127.1 thousand tons of flour and 26.9 thousand tons of flour products produced in Ulaanbaatar city. Some 70 industries are operating in Mongolia with a capacity of manufacturing 380 thousand tons of flour. They include “Altan taria” company, “Ulaanbaatar flour” Co, Ltd, “Dornod flour” Co, Ltd, “Atar urguu”, “Uguuj chikher boov” and “Talkh chikher” Co, Ltd. In addition, there are some 300 small and medium industries that manufacture flour products.

In 2010, 11.3 thousand tons of meat and meat products processed in Ulaanbaatar city. There were registered 32 slaughter industries with a capacity of processing 85 thousand tons of meat a year on average. Some 18 of them are operating regularly. Some 1.3 thousand people are working there. There are some big industries in Ulaanbaatar. They include “Makh impex” Co, Ltd; “Dorniin govi” Co, Ltd and “Just” group. In addition, 100 small and medium industries are operating in Ulaanbaatar city.

The sector exports beef, mutton, horsemeat, pet food and canned meat products. In Mongolia, the meat resources are sufficient, but herd structure is not very convenient. The number of cows and horses are low in comparison with small animals. The meat and meat products’ equipment and technology do not meet the world standard. In addition, there is lack of safety transport to export meat and meat products to other countries except two neighbours. It is difficult to increase export due to above-mentioned issues.

In 2010, there were produced 16.9 million liter milk and dairy products in Ulaanbaatar city that was increased by 69% from previous year. There are 90 industries in Mongolia with a capacity of processing 220 thousand tons of milk per day. About 20 of them operate regularly and use 40% of the capacity. The biggest industry is “Milk” Co, Ltd with 350 employees. Some 60 small and medium industries are operating.

In 2010, 16.8 million liter of alcohol and 67.6 million liter of bottled water and beverage were produced in Ulaanbaatar city. Most aimags have beverage industries. There are 15 alky, 93 alcohol, 21 beer and 14 wine industries with special permission in our country. About 40 alcohol and alky industries are located in Ulaanbaatar city. The following industries have more than 100 employees. They include “APU” company; “Mon-Erdene” Co, Ltd; “UFC” Co, Ltd and “MCS Coca Cola” Co, Ltd. 100 small and medium industries operate in Ulaanbaatar city.

Table 43. Production of major food products of Ulaanbaatar

Products	unit	2006	2007	2008	2009	2010	2010/ 2008,%
Flour	*thous. ton*	57.2	62.2	55.1	93.3	127.1	136.2
Flour products	*thous. ton*	25.1	26.4	33.4	30.0	26.9	89.7
Meat products	*thous. ton*	3.7	4.2	10.9	16.7	11.3	67.7
Gut	*thous. loop*	270.9	123.2	144.2	543.2	881.7	162.3
Milk and dairy products	*mill. liter*	3.8	5.1	7.1	10.0	16.9	169.0
Alcohol and wines	*mill. Liter*	3.3	4.2	13.0	13.0	16.8	129.2
Beverage and water	*mill. liter*	23.2	45.4	45.0	42.9	67.6	157.6

Tuv aimag. In 2010, there were produced MNT 257.8 million of food products at current prices in Tuv aimag. From total food production some 13.2% or MNT 33.9 billion milk and dairy products, 0.6% or MNT 1.5 million flour and flour products, 15.6% or MNT 40.1 million beverages, water and beer products and 70.7% or MNT 182.3 million other food products.

Table 44. Tuv aimags food products in MNT million, at current prices

Products	2006	2007	2008	2009	2010
Dairy products	0.0	18.5	24.9	37.0	33.9
Grain flour	2.8	0.6	0.0	0.7	1.5
Beverage /including alcohol/	172.6	195.1	152.9	78.7	40.1
Other food products	86.4	156.6	185.5	153.8	182.3
Total food products	261.8	370.8	363.3	270.2	257.8

Table 45. Tuv aimags food production

Products	unit	2006	2007	2008	2009	2010	2010/ 2008,%
Bread and pastry	*ton*	192.7	134.8	129.0	168.0	183.2	109.0
Beverage and water	*thous. liter*	42.6	53.3	5.6	-	-	0.0
Alcohol and wines	*thous. liter*	60.4	55.8	11.9	17.1	8.7	50.9
Milk	*thous. liter*	15.8	13.2	14.9	19.0	17.5	92.1
Water demand	*thous. m^3*	1.6	1.6	0.6	0.6	0.7	104.9

As of 2010, there were produced 183.2 tons of bread, 8.7 million liter of alcohol and MNT 17.5 million of milk (at constant prices of 2005). The beverage industry of the aimag did not function since 2009. In addition, alcohol production declined due to poor competitiveness in the market.

Future Trend of Light and Food Industry

The Mongolian MDG-based Comprehensive National Development Strategy aimed to develop economy of Mongolia based on nanotechnology, transit transport, logistic networks, and mining and agricultural product industry. The Government of Mongolia approved “Industrialization program of Mongolia” by the 299th resolution in 2009. The main objective of the program is: to increase competitiveness of Mongolia through developing processing industry with high-tech equipment that is based on domestic raw materials and sources.

Also industries will be developed in a way of increasing end products by scaled up the raw material processing level. The centers that support small and medium industries will be built in aimags and activities will be expanded. The fodder industries will be built depending on regional features. Provision of the population by safety food will be improved by developing greenhouses, increase domestic food production and building warehouses.

The Government of Mongolia approved the policy document “The trend to develop industries in local areas” in June 2009 by the 178th resolution. By implementing this project, 900 industries and factories will be construct in aimags between 2009-2012 and about 9.9 thousand people will be employed.

The Mongolian policy on food sector focuses on increasing productions and improving food products’ quality and safety in the framework of regional development of economy. The Government of Mongolia started developing “National Food security programme” since 2009. By the year of 2012, the products of food processing industries will be increased by 30% than that of 2007. The processed meat production will be increased by 35% or will reach to 50.0 thousand tons and meat export will reach to 20.0 thousand tons. By the year of 2016, the milk amount that processed by industry will be increased 2 times than that of 2012 and the meat export will reach to 38.0 thousand tons. More than 60% of meat products for the population will be processed by the industry. The following things will be produced in Mongolia: eggs a 100%, 20% of butter; 25% of fish; 15% of the fruits; 5% of rice and less than 40% of vegetable oil. The implementation period of the program is 8 years and it will cost USD 780.98 million. From sum some 39.5% is from state and local government budgets; 45.7% is from private sectors and 14.8% is from foreign aid and loans.

The following will be done in surrounding towns and villages of Ulaanbaatar and TRB: support the establishment of small and medium industries that process vegetables; constructing industries that process skins and manufactures knitted products; improving technologies and equipment of cashmere industries. (*Table 46* and *Table 47*)

Table 46. Planned major industries at local area

Industry	Bulgan	Uvurkhangai	Tuv	Ulaanbaatar
Fatten livestock	+		+	
High breeding livestock farm	+		+	
Milk processing plant (per soum)	+	+	+	
Milk cooling center, point	+	+	+	+
Milk farm with 50 cows	+	+	+	
Fodder farm and plant		+	+	
Greenhouses (in all soums)	+	+	+	
Vegetable processing plant			+	
Warehouse for keeping potatoes and vegetables				+
Greenhouse center				+
Fruits and berries processing plant			+	
Salt factory			+	+
Starch plant			+	
Poultry farm (construct and expand)	+	+	+	+
Service center (aimag, soum center)	+	+	+	
Wool washing and felt plant	+	+	+	

Source: Government resolution number 178, 2009

The Tuv aimag's development program planned following: every single household will be a manufacturer; start the movements "1 household-1 product", "1 bag-1 product" and "1 soum-1 product" for the purpose of creating a brand product for each soum.

Table 47. Industries direction of the regional and aimags' development program

Capital, aimag and soums	Direction
Arkhangai	
Khashaat	Create competitiveness brand production; Establish meat, wool, cashmere and skin processing small and medium enterprises; Develop mining, light and food industry, tourism and irrigated crops in Ugii region
Bulgan	
Buregkhangai	Small industry of flour; milk processing plant
Bayannuur	Food industry and vegetable, fruits and berries processing plant, sea-buckthorn processing plant and patent fuel
Gurvanbulag	Milk processing plant; patent fuel; service' center; salt plant
Dashinchilen	Model-meat industry, fatten livestock, meat processing complex; milk processing plant; Food industry and vegetable, fruits and berries processing plant; patent fuel; service' center
Rashaant	patent fuel; water bottling plant
Uvurkhangai	
Burd	Creation brand product related to One town-one product program; support small and medium industry
Selenge	
Orkhontuul	Support small and medium industry; agricultural raw material processing plants
Tuv	
Argalant Bayantsogt Bayankhangai Bayan-Unjuul Zaamar, Lun Undurshireet Ugtaal, Sergelen Erdenesant	Develop small and medium industry: - Agricultural raw material processing plants with new technology, - Shoes, fur and felt factory, garment factory, and support small and medium light industries - Creation brand product - Food industry - Service' center
Zuunmod	"Zuunmod" development complex: - Factory for processing cosmetics, perfume and enzyme products from animals raw material; - Information technology; - Biotechnology; - High quality leather, cashmere and garment production industry
Ulaanbaatar	
Districts	Patent fuel plant; support garment industry and improve technology; in towns and villages develop vegetable, fruits and berries processing plants, first processing industries of wool and cashmere, garment factory, to move tanneries and iron factories from center of Ulaanbaatar to Baganuur and Bagakhangai, develop food and light industries with high technology
Nalaikh	"Nalaikh" Business complex: milk processing, flour and pastry factories, slaughter house, meat processing plant, fish and vegetable processing plant, patent fuel, iron casting factory, support small coal plants of Nalaikh; expand brick plant
Emeelt-Argalant	First processing factories for wool, cashmere, leather and skin, logistic, trading, small and medium industries for food
Tuul-Shuvuu	Poultry and pig farms, greenhouses, small and medium industries for food, сав, packing industry, service
Bio-Songino	Livestock medicine factory, sanatorium, nano-biotechnology
Ulziit	Potatoes, vegetable cropping and vegetable, fruit and berries greenhouses
Gachuurt	Recreation
Aero-city	Airport, information technology, trade service, business center, logistic
Student city	Universities and colleges, services

5.3.2. Mining and Quarrying

The mining sector is one of the rapidly developing economic sectors of Mongolia. As of 2009, 170 research and 120 use licenses were delivered in the basin. Some 220 licenses were delivered in Ulaanbaatar city. Recently in the TRB located about 30 gold mines, 36 gravel and asphalt plants, 19 brick factories. About location of the licensed area please see figure 23 of Land use report.

The tourism and agriculture are the basic economic activity trends of the Gorkhi-Terelj natural park. It is located in Erdene soum area of Tuv aimag. Most part of the territory belongs to the Khan Khentii protected area and mining activities do not exist there. There is one chalkpit in the territory of Erdene soum. The Nalaikh coalmine is located in Erdene soum as well.

There are many sandpits and pebblepits in the territory of Altanbulag soum of Tuv aimag and, they have huge negative impact on environment. For example, green area is decreasing and high dusting.

The gold mines are located in Zaamar soum of Tuv aimag and Buregkhangai soum of Bulgan aimag. The Zaamar area mines are having a negative impact on Tuul River and pollute the river. As of 2009, about 30 organizations and entities were operating in the gold-mining sector. The entities and organizations except Monpolimet did not do rehabilitating at the required level.

The mining production occupies some 20% of Tuv aimag's industrial products and over 50% of Ulaanbaatar city productions. The mining sector employed about 50% of industrial employees. The sector's production statistic information include by entity's belonging not by location.

In Mongolia, mining is developing rapidly, but the number of heavy industries is low. There are some 10 metal processing and maintenance industries in Mongolia. There are also 50 factories and plants and 314 service centers related to the metal and automobile maintenance. In Ulaanbaatar, there are some maintenance factories. As of 2010, metal processing sector produced MNT 1580.7 million of products in Ulaanbaatar city.

The followings are planned in Tuv aimag's development program: to use natural resources mines without implicating heavy damage; increase citizens' participation; constructing entities by local area investment; developing heavy industry sector; developing master plan to renew the structures of aimag's mineral resources sector and keep the growth of mining production.

5.3.3. Energy

In 2010, some MNT 169.0 billion electricity and thermal energy were produced at current prices in Ulaanbaatar city and it was increased by 15.2% compared to 2009. It distributed 3173.9 million KWh electricity and 5.1 million Gcal thermal energy. Ulaanbaatar city has good energy supply and energy demand is increasing due to migration and increasing services and industries.

Figure 21 and *Table 48* shows Central energy zones electricity supply and demand. In Ulaanbaatar, sometimes energy transmitting center's capacity lacks in ger districts and city center. In terms of technical capacity, it is getting difficult to supply big energy consumers in city center. It means that consumers need to be supplied with nature-friendly, cheap and reliable energy. In the concession list is included the projected fifth thermal energy station with 450 MW capacities.

Table 48. Electricity and thermal energy

Products	unit	2006	2007	2008	2009	2010
Electricity energy	mill.KWh	2518.9	2678.3	2924.5	3381.8	3650.2
Thermal energy	thous. Gcal	4654.8	4771.8	5024.1	6365.9	6435.8
Electricity and heat production	MNT mill. at current prices	95945.9	102509.2	127317.8	146267.9	168994.8

Source: www.mmre.energy.mn

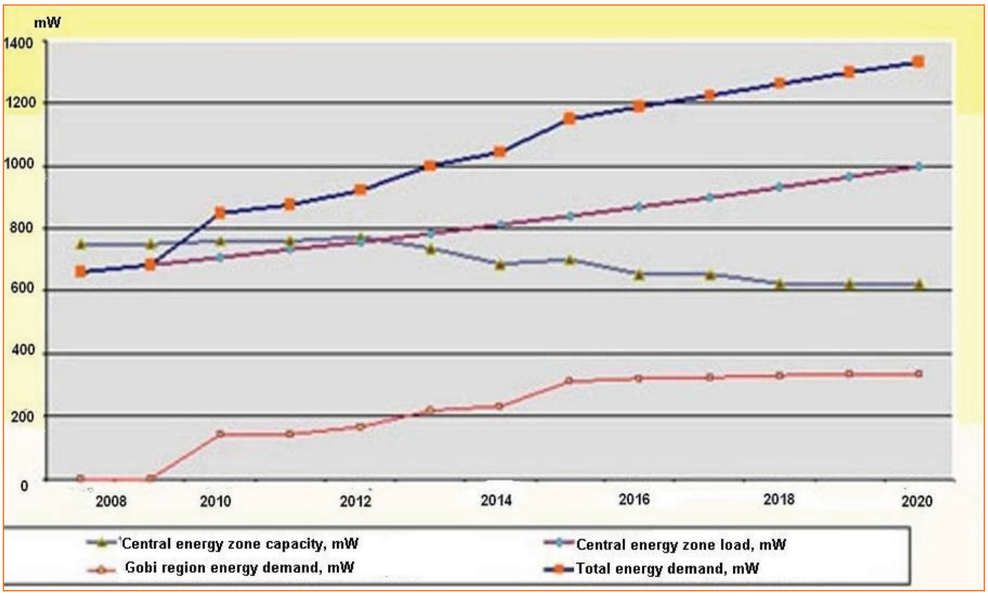

Figure 21. Electricity use and production of Central region energy system

The soum centers of the basin are connected to the energy networks. Ugtaal, Argalant and Zaamar soums have connection to central heating pipelines. Other soums' entities supply from small size heating stoves. 50% of total nomadic families uses solar and wind energy. It is important to expand the renewable energy use frame in our country.

The thermal power plants use much water and technical water is used for technology, cooling and auxiliary facilities. The thermal power plant number 4 is the main energy producer of central region energy system. In 2009, it used 10.4 million cubic meter water and water loss was 14.4% in 2000. The water loss was 6.5% in 2009.

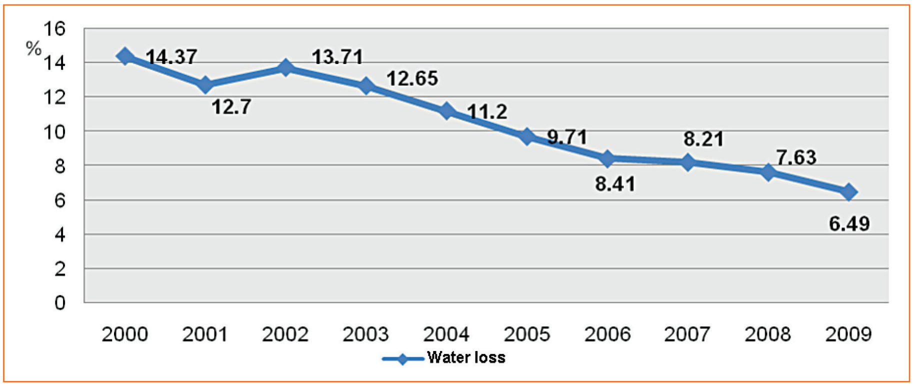

Figure 22. Water loss survey of 4th thermal power plant

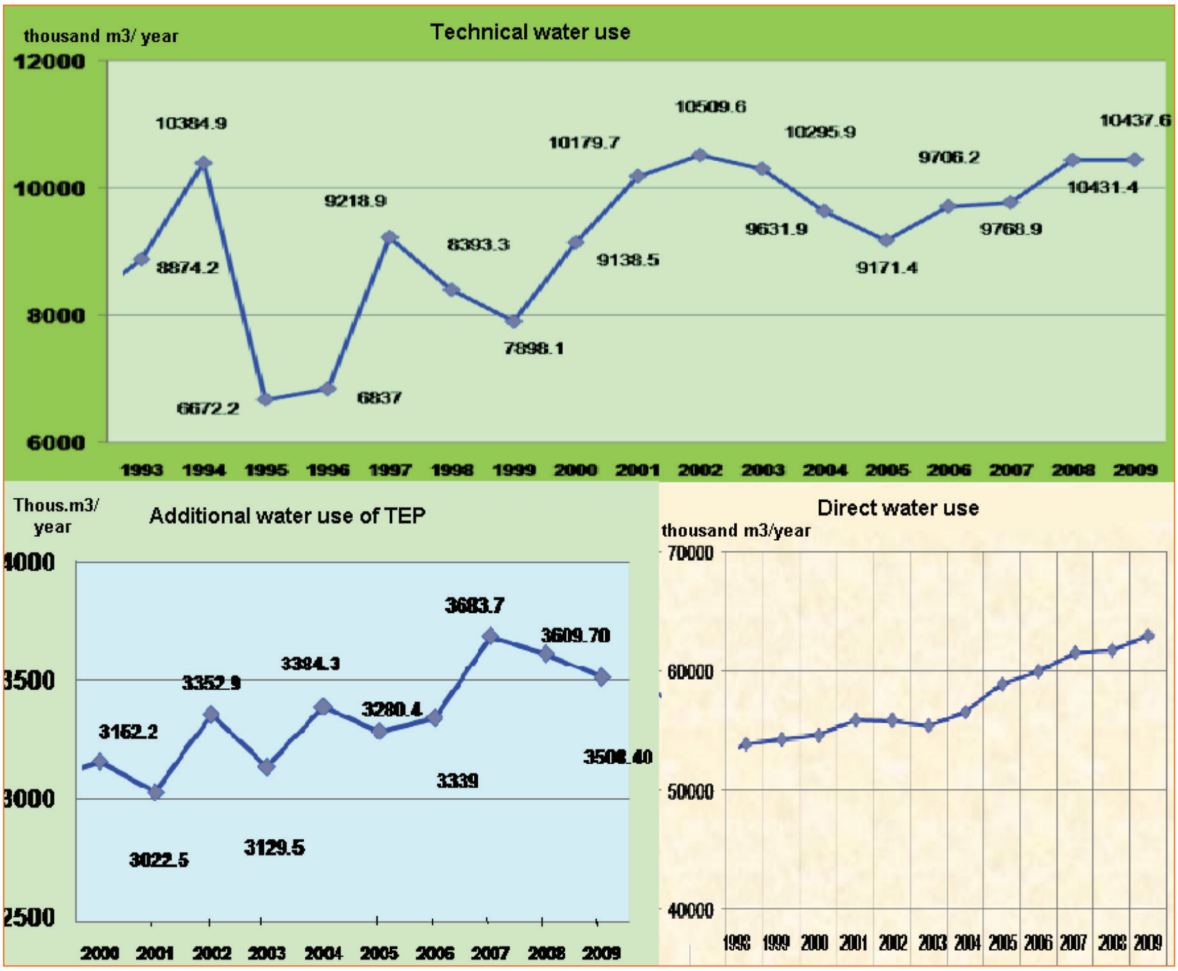

Figure 23. Water use survey of 4th thermal power plant

The fourth thermal power plant is decreasing its water loss according to the survey. The influencing factors of water loss are old pipelines and it is not fully metered (water use is not fully connected to water meter). New technologies need to be introduced in order to decrease water loss of thermal power plants. Current capacity of the thermal power plants in the basin are presented in *Table 49*. As of 2010, the thermal power plants in the basin used 22.5 million cubic meter water and this number will be 24.0 million cubic meter if thermal power plant is constructed.

Table 49. Capacity and water demand of thermal power plants

Thermal power plant	Capacity			
	Electricity, *MW*		Thermal energy, *Gcal.h*	
	Project	Current	Project	Current
TPP-2	24	21.5	93.5	93.5
TPP-3;5	148/300	136/-	570/700	570/-
TPP-4	540	560	1185	1185
Total	712	717.5	1848.5	1848.5

5.3.4. Construction and construction materials

As of 2010, construction sector produced 1.7% of GDP and MNT 350.8 billion of construction works and major maintenance works were done. Some 308 entities of Ulaanbaatar city constructed MNT 239.9 billion of buildings and houses. 34.4% of total construction works are apartment blocks; 28.1% are other-purpose buildings and 37.5% are engineering constructions. About 130 apartments for 42.0 thousand households were constructed between 2000 and 2010. Moreover, 7 industrial-purpose buildings; 32 trade and service buildings; 70 office, hospital, education and cultural buildings; 67 engineering and 27 other-purpose buildings were constructed.

Some 17 entities and organizations of Tuv aimag did 7372.3 million tugrugs worth of construction works in 2010. 154 apartments; 15 trade, service and industrial buildings; 89 kiosks/boreholes; 10 farmer houses and 29 other buildings were constructed. There are 72 entities with permission to manufacture construction materials. About 50 of them are in Ulaanbaatar city (*Table 50*). There is a steel wire industry in Altanbulag soum of Tuv aimag.

Table 50. Ulaanbaatar city and TRB-located aimags' construction material industries

District and soums	Sand and gravel	Cement	Brick	Beton mortar	Beton mortar, ibeton and metal construction	ibeton and metal construction	Metal construction	Others	Total
Bayangol				5	3	2		4	14
Bayanzurkh		1		2	1	2		6	12
Songinokhairkhan	1		4	2	1		1	1	10
Sukhbaatar	1			2	1			3	7
Khan-Uul				1	1	2		4	8
Chingeltei				1					1
Nalaikh		1					1		2
Tuv, Altanbulag							1		1
Total	2	2	4	13	7	6	3	18	55

The following construction materials were produced in Ulaanbaatar city in 2010: 1.5 thousand tons of chalk; 42.9 thousand tons of cement; 33.0 thousand cubic meter concrete mix; 1.7 thousand cubic meter concrete; 18.4 million pieces of bricks; 17.4 tons of hardware and 68.1 thousand pieces concrete materials. 100.5 thousand tugrugs worth of iron materials were produced in Tuv aimag.

5.4. Services and Public Utilities

The service sector occupies 70% of the Ulaanbaatar City and aimag GDP in the Tuul River Basin. Some 60% of employees work in the service sector.

5.4.1. Housing and Public Utilities

The Ulaanbaatar Water and Sewerage Authority and Housing and Communal Service Authority are responsible for the Ulaanbaatar city water supply and sewerage. There are 3 companies and 17 kontors in Housing and communal Service Authority. In addition, 33 private companies with special permission operate in the field.

According to the report of USUG ss of 2010, 52.1 million cubic meter water was extracted and 43.1 million cubic meter water was distributed in Ulaanbaatar city. In 2006, water loss was 27.1% and it was 17.2% in 2010. The volume of water extracted decreased by 3 million cubic meter and water distribution decreased by 0.1 million cubic meter compared to 2008. (*Table 51*)

Table 51. Extracted and distributed water and treated wastewater in million m³/year

Types	2006	2007	2008	2009	2010	2010/2009, %
Extracted water	55.4	56.3	55.1	52.9	52.1	98.5
Distributed water	40.4	41.9	43.2	43.8	43.1	98.4
Water loss %	27.1	25.6	21.6	17.2	17.2	100.3
Waste water treated by central WWTP	55.9	55.2	54.9	53.7	54.0	100.6
Supplied waste water by pipelines	39.1	41.0	42.6	41.3	42.1	101.9
Waste water calculation loss %	30.05	25.72	22.40	23.12	22.08	95.5

Source: Report of USUG-2010 and 2011

77.3% of water supplied by Ulaanbaatar Water and Sewerage Authority is used for population drinking water and 22.7% for organizations and entities. The number of people who live in apartments increased last few years. But, water demand did not change a lot and it is due to water meter/counter and increased water price. The ger district water demand did not increase due to unsolved wastewater issues, water carrying time and population water-keeping capacity.

Table 52. Drinking water and wastewater demand of Ulaanbaatar in million m³/year

Consumers			2006	2007	2008	2009	2010	2010/2009,%
Drinking water	Population	Centralized system		31.5	32.2	32.4	32.0	98.7
		Kiosks	31.3	1.0	1.1	1.2	1.3	110.6
		By transport		0.01	0.01	0.05	0.01	28.3
	Organizations		9.9	10.0	9.1	9.2	9.9	107.3
	Total		41.2	42.6	42.5	42.9	43.2	100.8
Waste water	Population		29.1	31.1	30.9	30.7	31.5	102.6
	Organizations		10.4	11.0	12.0	10.6	10.6	100.0
	Total		39.4	42.1	42.9	41.3	42.1	101.9

Source: Report of USUG-2010 and 2011

In 2010, Ulaanbaatar Water and Sewerage Authority added distributing water price by 35% (VAT included). Due to it, amount of water used by one person decreased from 261 liter to 230.8 liter. The water price sensitivity was -0.33.

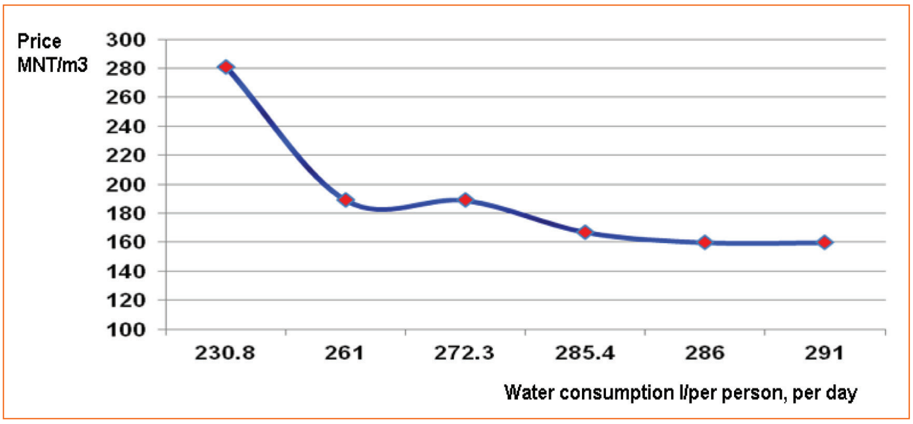

Figure 24. Drinking water demand of apartment households

Ulaanbaatar Water and Sewerage Authority and Housing & Communal Service Authorities are operating at loss although the Government has taken some measures on water supply and sewerage. One of the reasons is water cost and tariff system. It should be renewed.

As for basin aimags and soums, Zuunmod, Erdenesant, Rashaant, Orkhontuul and Khailaast towns have water supply and sewerage centralized systems. Moreover, following companies are operating in the field of water supply and sewerage services: Tuv chandmani in Zuunmod soum; Tuuliin Khishig in Orkhontuul; “Mongol alt” Co, Ltd in Khailaast village of Zaamar soum. Those places have centralized system of water supply and sewerage. However, wastewater treatment level is too low.

Other soum centers supply from boreholes and use pit latrines. Water filters were installed in some soums’ boreholes and they are having a good impact on people’s health. Sometimes those filters are frozen in winter and people who are responsible do not have knowledge how to change them. They should be trained. The drinking water hardness is high in Bayan-Unjuul, Buren and Dashinchilen soums. Therefore, those soums’ people carry their drinking water from long distance.

According to Tuul river basin survey, 74.5% of boreholes in the basin soum center boreholes is used by agreements and rents. On the one hand, it lightens budget pressure. On the other hand, 60% of the renters have income lower than minimum salary amount. If they do not have other income resources, it is including to the low income people. They do not have resources to repair if there is a big breakdown. Most soums rely on budget asset and international aid organizations. Water price system needs to be renewed. This issue should be solved in local area level. The subsidy system should become clear.

The number of population who lives in urban areas of TRB and connected to centralized system and supply from protected sources is high. (*Table 53 and* Table 54)

37.1% of population who lives in Tuul river basin is connected to centralized water supply and sewerage system as of 2008. It was 37.7% in 2010. 99.0% of them lives in Ulaanbaatar city. As of 2010, 62.5% of Ulaanbaatar population is connected to centralized system.

Table 53. Connection to the centralized system and sewerage in TRB, 2010

Drinking water supply source	Population, *thous. people*	Percentage	Scope
Centralized network	448.8	37.7	Urban area and village apartments
Kiosks connected to centralized network	271.5	22.8	Ulaanbaatar city ger districts, aimag and soum centers
Kiosks by transport	455.8	38.2	
Rivers, springs, glaciers, ponds	15.2	1.3	Rural population, herders
Total	1191.3	100	-

Table 54. Ulaanbaatar 7 districts’ population connection to the drinking water supply

Drinking water supply source		2008		2010	
		thous. people	*Percentage, %*	*thous. people*	*Percentage, %*
Connected to centralized system	Apartments	402.2	37.7	443.6	39.2
	Kiosks	228.2	21.4	263.1	23.3
Kiosks by transport		197.2	21.2	218.7	19.3
Other sources		204.8	19.7	200.0	12.2
Total		1032.4	100	1125.4	94

About Tuul River basins drinking water supply connection presented in *Table 55*.

Table 55. Population connection to the drinking water supply n the TRB

Drinking water supply source		2008		2010	
		thous. people	Percentage,%	thous. people	Percentage, %
Connected to centralized system	Apartments	407.1	37.1	448.8	37.7
	Kiosks	233.6	21.3	271.5	22.8
Kiosks by transport		208.7	19.0	229.2	19.2
Protected boreholes and springs		12.3	1.1	15.2	1.3
Other sources		236.6	21.5	226.6	19.0
Total		1098.5	100	1191.3	100

Public bathhouse: There were 336 public bathhouses in basin aimags and soums which have a capacity to serve 2.1 thousand people in one session as of 2010. If they use current capacity, they are able to serve 12.1 million people a year.

According to the survey of Health Department of Ulaanbaatar, 20% of Ulaanbaatar city ger districts inhabitants take a shower once a week; 12% once in 1-2 weeks time and 81% of households takes shower over a week. On average, ger district person takes a shower once in 2 weeks. The bathhouses of the basin aimags and soums supply only 50-60% of the population sanitation needs.

According to some survey about shower, per person uses 60-180 l water when takes once shower and if they using water safety technology 27-99 l once per person. Based on these results the Mongolian norm needs to be renewed since many technologies that decrease water loss are being introduced.

In future, if that one person uses 120 l water/ once taking shower, it will be 3932.3 thousand cubic meter per year in 2015 and 4968.4 thousand cubic meter per year in 2021.

Future development trend of sector

The Government of Mongolia approved "Millennium Development Goals based-Comprehensive National Development strategy" by the 12th resolution of 2008. According to the third strategic objective of the 5th propriety strategy of Mongolia's development; "Water National Program" will be developed and implemented. In 2010, the Government of Mongolia approved "Water National Program" and started its implementation in 2010. If the program is implemented successfully, we will have possibility to implement some 50 complex measures and invest MNT 2 trillions.

As reflected in the "100000 apartment blocks" program, 75-80 thousand household-apartment blocks will be built in Ulaanbaatar; 25 thousand household-apartment blocks will be built in aimag centers and main cities of the regions. Some 22 ger districts of Ulaanbaatar city will be involved in the program "Turning ger districts into apartment districts". If this program and objectives reflected in Ulaanbaatar city Master plan are achieved successfully, 80% of Ulaanbaatar city population will be living in apartments by the year of 2020.

There are 33 projects related to water supply and sewerage sector in the concession list. It will increase the private sector participation. 26 projects out of 33 will be implemented in Tuul river basin. The water supply sector development plays a key role for the achievement of Mongolia's Millennium development objectives. Therefore, following items should be included in the water management planning:

- Introduce technology that improves ger district water supply;
- Establish water supply and centralized system in soum centers;

- Improve herders' water supply;
- Establish sewerage system in ger districts and soum centers; introduce small capacity treatment equipment and new technology;
- Search possibilities to introduce micro loans and receive international aid for the financing of the activities;
- Improve operations of current wastewater treatment facilities;
- Renew water tariff system.

5.4.2. Services

200 entities are operating in this sector and 1.2 thousand people are employed there. According to the 2007 survey, some 60 thousand people are working in the service sector. In addition, about 98% of the sector's activities belong to the informal sector.

Laundry and dry cleaning: in Mongolia, there are not many laundry places. People do laundry at home. In warm season, people wash their clothes and cars in the river. There is a laundry place called "Metro Express" in Ulaanbaatar where people can do laundry. It has not become that popular due to location and tariff.

There are some 60 laundries and dry cleaning in Ulaanbaatar. The laundry services and dry cleaning places mostly connected to centralized water supply and sewerage networks.

Beauty and hairdressing services: Beauty and hairdressing services occupy most of the service organizations. There are some 500-beauty and hairdressing service places in Ulaanbaatar. There are some 89-service spots in Zuunmod soum and 84 of them are private.

Car wash: The car wash is one of the services that pollute water a lot. For the last few years, living standard of the Mongolians is growing and number of cars has rapidly increased. As of 2010, there were 254.5 thousand cars in whole country and 64.0% or 162.7 thousand is in Ulaanbaatar city. For the basin aimags, there were 3.3 thousand cars. Total number of the cars in the basin aimags is 166.0 thousand cars.

Some 40 car washing centers officially operate in Ulaanbaatar. The car maintenance centers do car washing as well. The registered car washing centers are generally connected to centralized systems and have water meters. However, some people are illegally washing car and do not use the water meter and discharge wastewater directly to the soil, which is become one of pollution sources of environment.

It is difficult to define water use for car washing and there is no water use norm. It was defined as follows based on surveys in Ulaanbaatar. If the car is washed at home, some 5-15 liter water is used. As for car washing center, 25-40 liter water is used for small size car. Some 80-100 liter water is used for big car. According to the survey conducted in United States in 2002, 28-38 liter water is used for small size car; 57-76 liter for medium size cars and 95-114 liter water for big cars. The results are close to each other. In warm season, car is washed 2-4 times a month on average and 1-2 times in winter. In 2010, 159.3 thousand cubic meter water a year has used in the basin, if the calculation is as follows: 40 l water is used for per car on average and it is washed 2 times a month. Although the use is low, polluting level is high.

Sales, hotel and restaurant services: Some 370 thousand people employed. It is one of the important economic sectors. As of 2010, there were 15.0 thousand sales-service centers and 800 hotels and restaurants in Ulaanbaatar. As for basin aimags, there are 100 sales-service centers, hotels and restaurant services. The hotels and restaurants in aimag centers are connected to centralized network, but in soum centers, they are supplied from kiosks and boreholes.

Public administration organizations: There are some 300 organizations and 76.0 thousand people work there.

Green area: According to Ulaanbaatar statistic data, there was 7139.3 thousand square meter gardens and 3625.9 thousand square meter lawn area and 2828.1 thousand trees in Ulaanbaatar. There was 2.5 hectares green area in Zuunmod soum in 2008. In 2010, there was no registered green area in the area. Some parts of the gardens and lawn area are watered by special systems and some parts are watered by some kind of equipment of the organizations.

5.5. Tourism

The tourism sector is developing intensively in the Tuul River Basin and it is the main place where the tourists pass through. As of 2010 data of MNET, some 70 tourism organizations were in business of which 67% is located in the Khan Khentii special protected area. The capacity of the tourist camps is receiving 4000 people a day. 90% of the tourist camps operate in a seasonal cycle.

The following tourist attractions are located in the basin, they include: Bogdkhan mountain, Gorkhi, Terelj, Ar Uvur Janchivlan, Elsen tasarkhai, Khugnukhan mountain, Khustai, Rock paintings of Ikh tengeriin am, Hun-era tombs of Belkh area, Tombs of Songino mountain, Rock paintings of Gachuurt, Rock paintings of Nukht, Palace ruin of Tooril khan of Khereid, Bogd Khaan Palace museum, Choijin lama temple, Geser temple, Dambadarjaa monastery, Megjid Janraisag monastery and Gandan monastery. These are the basis of tourism development.

Figure 25. Ger camps near Gorkhi-Terelj

A survey of tourism organizations located in the basin has been conducted in 2009. The drinking water supply and sewerage facilities are important for sustaining the comfort of the tourists. Most tourist camps in the basin have their own boreholes and use pit latrines. As of 2010, Terelj hotel had water supply and sewerage networks and WWTP built by Canadian technology. The big tourist camps like UB2, Tiara resorts and Saran travel, they all have boreholes and a sewage pit. Their waste water is treated by Nalaikh WWTP. The Khustai national park has its own WWTP. It is important to supply tourist camps with a reliable source of drinking water and introducing small size WWTPs

Sanatorium: Mongolia has about totally 100 spas and sanatoriums, from which only 27 were accredited in 2010. In the TRB located following accredited sanatoriums:

- "Ar Janchivlan" sanatorium and "Takhilt" rehabilitation therapy of Tuv aimag
- Ulaanbaatar: "Orgil" and "Ulaanbaatar" sanatorium and spa center, "Arga bileg", "Amarsanaa gunj", "Saikhan gazar", "EMJJ", "Erdenet khun", "Enkh-Undarga", "Unu-Ekh", "Jargalan" and " Khasu khandgait sanatoriums.

Development trends of the sector

The Government of Mongolia has set goals in the Millennium Development Goals-based Comprehensive National Development Strategy as follows:

- develop the necessary tourism infrastructure,
- build large complexes,
- receive some 1 million tourists by 2015,
- intensify development of the tourism sector and
- improve service quality, and increasing tourist number close to that of Mongolian population in the year of 2021.

The Ministry of Nature, Environment and Tourism has developed a project of program "Tourism" in 2011 to elevate the tourism sector into a leading economic sector by way of developing stable tourism.

The Ulaanbaatar Region Development program aimed to develop tourism to the global market scale and to support sustainable growth GDP of the sector. In the framework of these objectives planned to improve services in the tourist camps and centers, establish high level hotels in the main tourist zones, include Ulaanbaatar region to the international tourism network and develop the national scale tourist center.

The Tuv aimags development program planned to develop tourism to the one main economic sector of the aimag, to set up hotel and tourist camp network, to establish National complex in Manzushir, construct central regions culture and sport center in Zuunmod and to develop tourism to the international level.

To achieve these objectives it is necessary to improve water supply and sanitation situation in the tourist camps and centers.

5.6. Economic Development Trend

To forecast the socio-economic development of Mongolia, it is wise to take account of the impact of global development trends on the development in Mongolia, as well as the impact of positive and negative effects of globalization. By the year 2020 the world economy will have expanded by 80% compared to its size in 2000, and per capita income is likely to increase by 50%. Fundamental changes are occurring in the patterns of global production, trade, employment and wages. For example, in the developed regions with an ageing population, a knowledge/service based economy is the driver for generating revenues, whereas production processes are more and more transferred to developing countries.[7]

Countries in Asia are becoming more integrated in terms of their trade and economic relations, and discussions are underway with regard to establishing the Asian Monetary Fund and introducing a single Asian currency.[8] China, Mongolia's main trading partner, is quickly recovering from the global financial crisis and underpins the growth of the mining sector in Mongolia. Nevertheless, the rising food prices all over Asia about 10% are a disturbing factor.[9] Furthermore, the tightening of China's monetary policy has also lead to a slowdown of the growth of Mongolian the economy.[10]

The Millennium Development Goals based Comprehensive National Development Strategy of Mongolia approved by the 12th resolution of 2008 of State Great Khural of Mongolia; comprehensively describes Mongolian Governments policy for the next fourteen years. The policy aims at promoting human development in Mongolia, in a humane, civil, and democratic society, and intensively developing the country's economy, society, science, technology, culture and civilization in strict compliance with global and regional development trends. According to this strategy, "Mongolia chooses an export-oriented manufacturing and services dominated, private sector led economic growth and development strategy". The main objective of the economic policy is:

- to achieve, in 2007-2015, the Millennium Development Goals,
- reach an average annual economic growth of 14 percent,
- increase GDP per capita to at least 5,000 USD, and establish the basis for intensive economic development;
- to maintain an average annual economic growth at no less than 12 percent in 2016-2021,
- consolidate and develop a knowledge-based economy,
- increase GDP per capita to a minimum of 12,000 USD,
- create economic capacity and resources to reach the level of the world's middle income countries.[11]
- to rationally manage inflation and maintain annual inflation rate lower than 3 percent and eliminate the inflation pressure on the economy by 2021.

In April 2011 the GoM presented the "Budget statement of Mongolia 2012, Budget projections for 2013-2014" in which it says "In 2011, in the economy of Mongolia is expected to grow 10.8%, the mining sector will grow with 10.6% and the non-mining sector with 10.8 %". *Table 56* presents the main macroeconomic indicators of Mongolia till 2015. The highest growth of the mining sector is expected in 2012, reaching 49% and other the sectors' growth ranges between 9% and 12%. In the mining sectors development the "Oyu-Tolgoi" and "Tavan Tolgoi" developments will play a major role. Within the rapid economic growth, inflation is not expected to decrease considerably and the national consumer index is expected to range at about 8-9% (*Table 56*).

7 Worldbank, Millennium Development Goals based comprehensive national development strategy of Mongolia, 2007
8 Worldbank, Millennium Development Goals based comprehensive national development strategy of Mongolia, 2007
9 ADB, Mongolia Development Outlook, 2011
10 Worldbank, Mongolia Quarterly Update, 2011
11 Worldbank, Millennium Development Goals based comprehensive national development strategy of Mongolia, 2007

Table 56. Main indicators of macro economy of Mongolia

Indicators	unit	2009	2010	2011**	2012**	2013**	2014**
GDP growth	%	-1.3	6.1	10.8	16.6	14.8	15.4
Mining sector	%	5.8	6.3	10.6	49	24.6	26.1
Non-mining sector	%	-2.7	6.1	10.8	9.4	11.8	11.7
GDP per capita	*thous. MNT/ capita*	2408.2	2987.2	3603.3	4870	5694.5	6684.1
GDP per capita	*USD/capita*	1664.8	2420.6	2948	4105.9	4988.6	6084.2
Change of consumer prices	%	4.2	13	9.7	9	8	8
GDP at 2005 constant prices	*thous. MNT*	3913.7	4154	4601.2	5365.9	6159.4	7106.4
Unemployment* rate	%	3.5	3.1	2.9	2.8	2.7	2.6

Source: www.iltod.mn
Comment: *Registered unemployment rate
**Projection

In 2011, the update of the "General Development Plan of Ulaanbaatar city until 2020" was started. It is still in the discussion stage. The Ulaanbaatar city development vision is that "Ulaanbaatar will be a city that meets the development level of world developed countries' capital cities; to value people; to have capacity to compete in global market in terms of economy; to have economy and services that are based on hi-tech".

The water issue has an important role to develop Ulaanbaatar city further. Particularly, strategic objectives were included related to the water issues: to protect fresh water resources; to create rational water use management ; to plant trees at flow generating source of Tuul, Tolgoit, Selbe, Uliastai rivers; to have surface water and groundwater layers under local area protection; to conduct flood risk assessment; to improve flood facilities; to move households that are located in risky areas; to establish combined farming and pastoral farming based on intensive animal husbandry and irrigation in the agricultural regions; to establish reliable water supply sources; to support private sector investment in infrastructure development and strengthen public and private sector partnerships.

The following issues were included in the Khangai and Central regions' development programs and aimags' comprehensive development policies. They include: to support small and medium industries; to develop farming based on irrigation and intensive animal husbandry in the agriculture; to improve infrastructure of tourist camps and sanatoriums; to expand tourism services; to develop industries and mining intensively; to improve measures to supply population with fresh water that meets hygienic requirements; to increase water supply level; to use water wisely; to expand and renovate urban area water supply and sewerage pipelines; to protect water resources.

Table 57 shows the main targets of the macro economy of Ulaanbaatar and some regions in the TRB.

Table 57. Main macro economic targets of the TRB, in 2015

Target	Economic region		
	Ulaanbaatar	Tuv	Khangai
Social development			
Average annual growth rate of population, %	Decrease migration on 50%	0.8	1.8
Enrolment ratio in pre-school, %	75	80.0	100
Enrolment ratio in primary education, %	-	99.0	100
Infant mortality rate, per 1000 live births	-	5.0	-
Life expectancy at birth, years	69	66	69
Unemployment ratio, %	-	1.0	2
Share of the poorest households, %	-	-	under 10
Reduce poverty (from 1998)	2 times	2 times	
Macro economy			
GDP growth, %	7.7	19.5	6.9
GDP growth of industrial sector, %	7.4	22.5	6.8
GDP growth of manufacturing, %	6.9	7.3	6.7
GDP growth of mining and quarrying, %	76.1	25.2	7.9
GDP growth of energy sector, %	11.9	10.6	-
GDP growth of agriculture, %	7.4	7.1	6.8
GDP growth of crop sector, %	-	6.7	6.4
GDP growth of livestock farming, %	-	7.2	6.9
GDP growth of service sector, %	7.9	6.8	6.9
Environment			
Reduce water pollution (from 2004), %	-	25.0	-
Growth of the expenditures on disaster prevention (from 2004), %	-	50.0	50.0

6. Water pricing

6.1. Water Supply and Wastewater Tariffs

According to the survey on water use by the project in 2009, a person who lives in a ger district of an urban area uses 8-10 liter water a day on average. This is 2.5-4 times lower than norm of WHO. As for some urban consumers that have a centralized water system connection, their water use exceeds that of developed countries. This is due to unwise use of water and pipeline leakages.

Drinking water supply of Ulaanbaatar City: On average, Ulaanbaatar City ger district inhabitants use 6-8 liter drinking water a day. A 4-member ger district household uses 30-40 liter drinking water a day. Some 40% is used for cooking, 30% for laundry and the remaining 30% is used for private and domestic needs. By installing water meters in apartments, water use is decreasing. Also water use is getting closer to the some developed counties level.

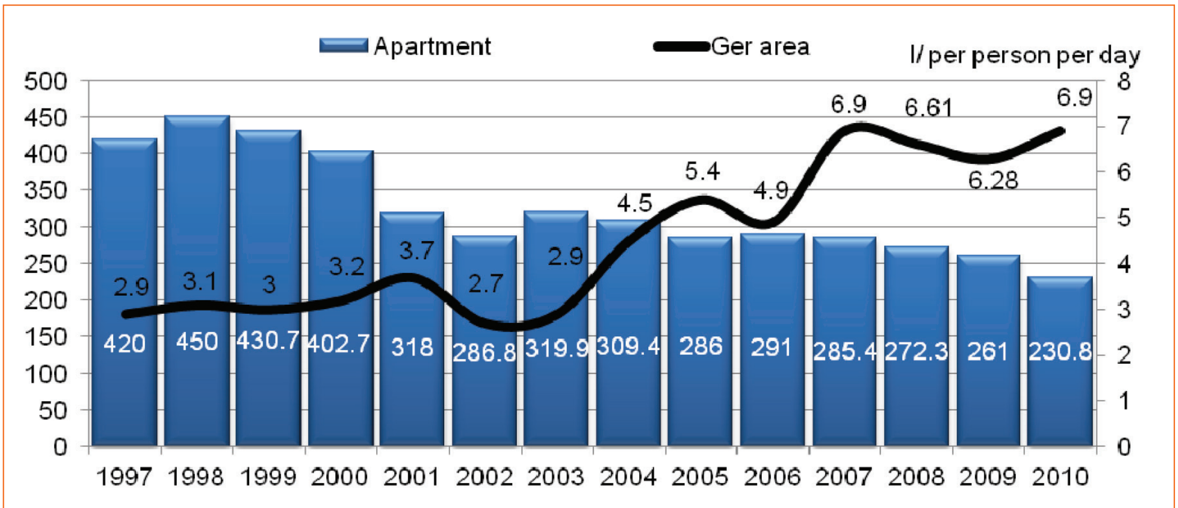

Figure 26. Drinking water consumption per person of the Ulaanbaatar

The installation of water meters in apartments connected to the centralized water system had a good impact to decrease the unwise use of water. As of 2010, average use per person was 230.8 liter a day. The water extraction volume and usage cost will drop due to the above mentioned situation. In 2010 the water supply department of Ulaanbaatar Water and Sewerage Authority distributed 33.3 million cubic meter drinking water to the population and 9.8 million cubic meter drinking water to organizations and entities through 176 boreholes, 4 pumping stations and 348.6 km long pipelines. The Department of water supply transportation supplied Ulaanbaatar City households with drinking water by using 60 water trucks, 287 kiosks, 94.6 km pipelines and 179 central system-connected kiosks. The consumers paid a water fee based on their average water use, which as apartment inhabitant's was 230.8 liter a day and as ger district inhabitants, it was 4.9 liter a day.

As specified in the law on water, water supply organizations are non-profit organizations. The water price is reviewed by the Ulaanbaatar City or Local Governor's Office. The water supply organizations receive subsidies from the local budget if they cannot compensate operational expenses or in case there are not enough funds for technical renovation.

The water use tariffs differ in Ulaanbaatar City depending on consumer type and water supply source. The Ulaanbaatar City water tariff and fees change regularly.

Table 58. Water tariffs of USUG in Ulaanbaatar

Consumer types	Water tariff, MNT/m³				
	2005	2007	2008	2009	2010
Water distributed to industries and service shops by centralized system	315	329	610	610	882
Water distributed to budget organizations by centralized system	315	329	610	610	882
Water distributed to domestic needs by centralized system	160	167	189	189	319.78
Water distributed to apartments with water counters	160	167	189	189	319.78
Water truck- water distribution to organizations that are 10kms away	2435	2435	2435	2435	2435
Water truck-water distribution to organizations that are farther than 10km	2609	2609	2609	2609	2609
Water truck-water distributed to camp area households	2000	2727.27	2727.27	2727.27	2727.27
Water sold at water kiosks	500	909.09	909.09	909.09	909.09
Water transportation to the households	1000	1818.18	1818.18	1818.18	1818.18

A change in water tariff was made on 1st of September, 2008 by the order №167 of Water Agency director on 19 August 2008. The drinking water and wastewater fees were changed on the basis of following laws and regulations: the law on ''Urban water supply and sewerage usage'' article 9, 9.1.7; law on ''State and municipal property'' article 20, 20.1.9, 20.1.10; official document №1/259 of Ulaanbaatar City Governor's Office, 2010; and official document №05/236 of Fair Competition and Consumer Agency. The order №A/137 appendix of Water Agency director issued on 23 June 2010, are presented below (*Table 59*).

The drinking water and wastewater fees for apartments and organizations were changed by the order №55 of Housing and Communal Service Agency director on 5 July, 2010. The order is followed by Housing and Communal Service Agencies of Ulaanbaatar City (*Table 60*).

Table 59. Wholesale price of USUG to the OSNAAGs in MNT

Type of service	Unit	Tariff	From which		
			Resource fund	VAT	Basis tariff
Water	m³	281.00	5	25.09	250.91
Waste water	m³	161.70	0	14.70	147.00

**Service tariff of Ulaanbaatar Water Supply and Sewerage Authority*

Table 60. Water supply and sewerage service tariff for apartments and organizations

Type of service			Tariff	From which		
				Resource fund	VAT	Basic tariff
Apartment	Metered , MNT/m³	Water	319.78	5	28.62	286.16
		Wastewater	183.48		16.68	166.80
		Total	503.26			452.96
	Without meter, MNT/m³	Water	464.00	5	41.73	417.27
		Wastewater	212.45		19.31	193.14
		Total	676.45			610.41
Organizations	Metered, MNT/m³	Water	852.00	5	77.00	770.00
		Wastewater	462.00		42.00	420.00
		Total	1314.00			1190.00

**Service tariff of Housing and Communal Service Agency*

Table 61. Water supply and sewerage service of Ulaanbaatar

Indicators	Unit	2006	2007	2008	2009	2010
Distributed drinking water	*thous. m^3*	55449.1	56256.5	55098.3	52896.6	52079.3
Sold water	*thous. m^3*	40494.1	42861.0	43817.6	42200.2	43111.8
-Population	*thous. m^3*	31100.9	32968.0	33105.5	32407.8	33276.3
-Organizations	*thous. m^3*	9393.2	9893.0	10712.1	9792.4	9835.5
Collected wastewater	*thous. m^3*	39442.7	42117.0	42883.5	41281.4	42077.3
-Population	*thous. m^3*	29073.8	31080.8	30864.1	30654.5	31451.4
- Organizations	*thous. m^3*	10368.9	11036.2	12019.4	10626.9	10625.9
Revenue of water supply	*Mill. MNT*	8145.0	9276.7	10646.7	11476.9	12900
-Population	*Mill. MNT*	5171.6	5987.7	6205.1	6096.2	7328.5
- Organizations	*Mill. MNT*	2973.4	3288.9	4441.6	5380.7	5465
Revenue of wastewater disposal	*Mill. MNT*	4613.3	4924.7	5778.6	6416.3	7111.3
-Population	*Mill. MNT*	2850.9	3048.3	3027.1	3007.4	3661.5
- Organizations	*Mill. MNT*	1762.4	1876.4	2751.5	3408.9	3449.8

The USUG (Ulaanbaatar Water and Sewerage Authority) total sales were MNT 20719.1 million in 2010. The sales were increased by 8.1% or MNT 1560.5 million compared to the previous year. The water supply earning is MNT 11644.5 million or 56.2%, wastewater earning is MNT 7260.74 million or 35%, transported water revenue is MNT 1255.5 million or 6% and other activity revenue constitutes 2.8% from total sales. The Ulaanbaatar City-owned 21 companies worked at a loss of MNT 1701.1 million in 2009. In 2010, the loss was MNT 1938.9 million, increased by 13.9% compared to the previous year loss.

The water resource use fee is collected from industries and organizations by USUG and OSNAAGs with water service charge. Those fees are collected into the Ulaanbaatar City State Fund. In 2008, some MNT 239.4 million was collected from industries and entities. Some MNT 50 million of that amount was used for protecting water resources and quality. In 2010, some MNT 458.4 million was collected as water resource use fee. MNT Some 243.0 million was spent on protecting water resources and quality as well as restoration.

The water supply organizations functioning in urban areas outside Ulaanbaatar are:

- ''Tuv Chandmani'' communal services, Tuv aimag;
- ''Chandmani-Nalaikh'' communal services, Nalaikh district of Ulaanbaatar City and
- ''Tuuliin khishig'' in Orkhontuul soum.

These organizations and their water supply boreholes belong to the municipal administration. *Table 62* presented above organizations water tariff.

Table 62. Public Urban Service Organizations tariffs in 2010

Type of service		Unit	"Tuv Chandmani" communal services, Tuv aimag	"Chandmani-Nalaikh" communal services, Nalaikh
Connected to the centralized system				
Apartment	drinking water (meter)	*MNT/m^3*	650	304
	drinking water (without meter)	*MNT/per person*	700	2101
	waste water (meter)	*MNT/m^3*		121
	waste water (without meter)	*MNT/per person*	410	897
Organizations	water	*MNT/m^3*	850	220
	wastewater	*MNT/m^3*	690	670

Type of service		Unit	"Tuv Chandmani" communal services, Tuv aimag	"Chandmani-Nalaikh" communal services, Nalaikh
Kiosks	to organizations	*MNT/m³*	-	920
	to population	*MNT/m³*	1000	3000
Water transportation				
Water supply (to organizations)		*MNT/m³*	4500	4000
Water supply (to population)		*MNT/m³*	1500	3000
Transporting sewage by vehicle		*MNT/m³*	-	4400

Source: ALACGC, www.nc-cudpu.gov.mn

Recent years, water meters are being installed at organizations and apartment households in order to decrease water losses and water wasting. New apartment blocks and other buildings are installed with water meters with the financial aid from state and local budget, private investment and foreign aid. The Ulaanbaatar drinking water and waste water tariffs are much lower compared to other aimags in this region. This is the main factor for the unwise use of water.

Rural water supply: The countryside people use rivers, ponds or springs as water supply source. This varies depending on soum location and available surface and groundwater resources. As for the aimag centers, communal service organizations are responsible for water supply services. The service tariff is established by the resolution of aimag and soum Local Representatives' khural's leaders on the basis of organizations steering committee resolutions.

For the soum centers population water supply 1-2 boreholes are used. Some soum center households and companies have boreholes and dug wells within their fences.

The "IWRM in Mongolia" project team visited 21 soum centers of the Tuul River Basin in 2009. Some 64 kiosks and boreholes were used for drinking water supply of the population. 13 of the water reservoirs and boreholes or 25.5% are operated by salary-paid workers. The monthly salary is between 120 and MNT 150 thousand. The others are rented out. The water distributors' income of the rented-boreholes is between MNT 34 and 280 thousand. Some 60.5% of the distributors have income lower than the minimum standard of salary. This is due to the low water tariff and less customers. 1 liter water costs between 0.5 and MNT 5. The most expensive is in Dashinchilen soum of Bulgan aimag, 1 liter water costs MNT 5 for soum population and MNT 4 for soum organizations. The reason for the high fee is that water is transported from a long distance and other expenses related to the water transportation should be compensated. The water income depends on the number of local area water users and kiosks. (*Table 63*)

Table 63. Drinking water tariff for soum center population in the TRB, 2008

№	Aimag	Soum	Water supply source	Drinking water tariff, *MNT/m³*
1	Arkhangai	Khashaat	well and river	1000
2	Bulgan	Bayannuur	well and river	2000
3		Buregkhangai	well and river	2000
4		Gurvanbulag	well and river	1000
5		Dashinchilen	well	5000
6		Rashaant	well and river	1500
7	Ovorkhangai	Burd	well	1000
8	Selenge	Orkhontuul	well and river	1000

9		Altanbulag	well and river	1000
10		Argalant	well	1000
11		Bayan-Unjuul	well and river	1000 *tug/month/family*
12		Bayankhangai	well	1000
13		Bayantsogt	well	1500
14		Zaamar	well	1000
15	Tuv	Zuunmod	well	1500
16		Lun	well and river	1000
17		Undurshireet	well	800
18		Sergelen	well	1500
19		Ugtaaltsaidam	well	500
20		Erdene	well	1000
21		Erdenesant	well	1000

Khailaast village of Zaamar soum in Tuv aimag generates the highest income. The village has a high density of population and only 2 kiosks function there. For the other soums with much population and many kiosks, they are working at a loss. The capital cost and repair expenses are mostly not accounted in the water price. The rental income should be higher than the minimal limit of salary. Some 58.2% of the water distributors are female. The local organizations choose a person who is reliable and settled as a renter.

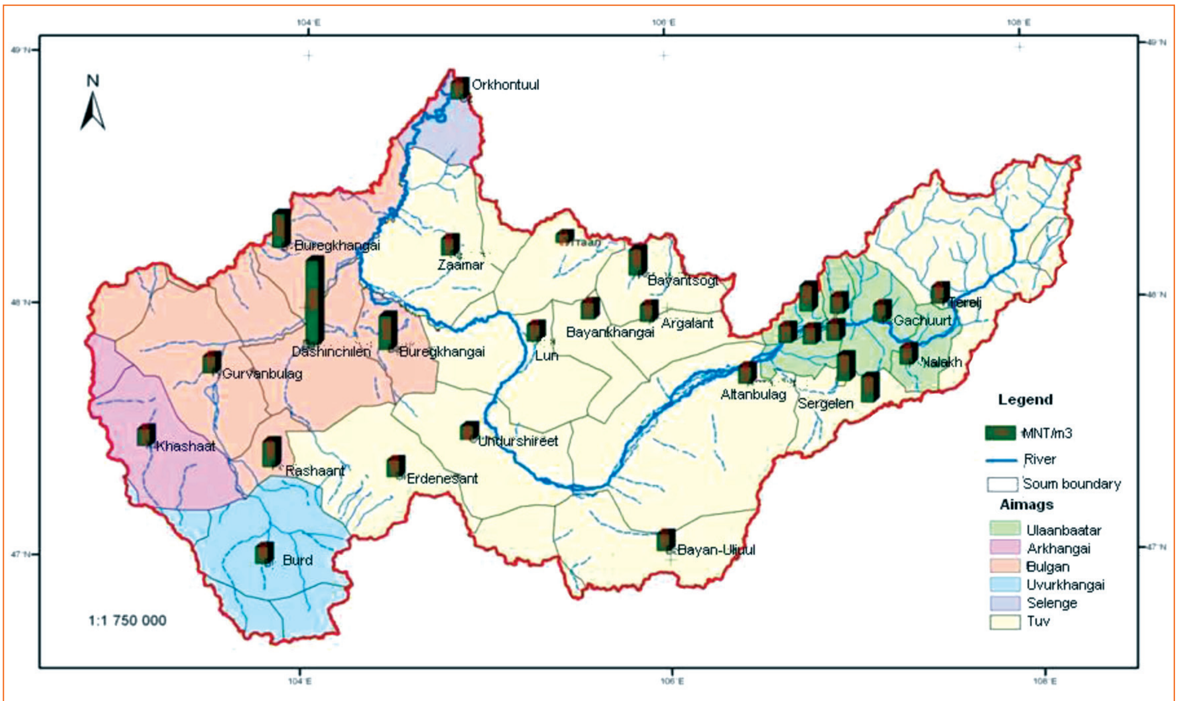

Figure 27. Soum water tariff in Tuul River Basin

Livestock water supply: The main sources of the livestock water supply are wells, rivers and springs. Some soums with little surface water lack pasture wells. The pasture well rent for herders is the main issue for the livestock drinking water tariff. The livestock water demand temporary norm is followed in some soums based on order №153 ''Temporary Norm Approval'' of Nature and Environment minister which was issued on 18th of November, 1995. Some soums have good surface water networks and livestock drinking water is free. (*Table 64*)

Table 64. Soum centers livestock water supply tariff

№	Aimag	Soum	Water supply source	Tariff, *MNT/head*	
				Cattle	Goat and sheep
1	Tuv	Argalant	well and river	1-1.5 MNT/l	
2		Bayankhangai	well and river	6	3
3		Bayantsogt	well and river	20	5
4		Zuunmod	well and river	100	50
5		Undurshireet	well and river	By agreement	
6		Tseel	well	400 MNT/month	100 MNT/month
7		Ugtaaltsaidam	well and river	1 MNT/liter	
8		Erdenesant	well and river	20	2
9	Bulgan	Buregkhangai	well and river	By agreement	
10		Dashinchilen	well	30	10
11		Rashaant	well and river	10	5
12		Khishig-Undur	well and river	7	3

* *Other soums use surface water for livestock watering.*

The livestock water supply source and water tariff are presented in the above table. The livestock water tariffs are different due to surface water scarcity and pasture well abundance. The pasture wells are municipal property and some people can be in charge of these pasture wells within the framework of the owner agreement. The renter is fully responsible for recurrent expenses. The water tariff is established by the resolution of Local Representatives Khural. The standard price for cattle and goat-sheep was set in soums. It is impossible to estimate the revenue.

The reason is that it works as a discussion among herders. The water tariff is low in areas where there is much surface water. In some areas, the water tariff is not established. As for Buren soum of Tuv aimag, the herders who water their livestock from the pasture well formed a risk fund and it seems successful.

Project survey in the TRB in 2009: during the survey team members collected additional information related to the water supply and demand and the water tariff. The survey investigated from where ger district people get their water supply, how much money they pay for drinking water and what is the 'willingness to pay for improving water supply situation''. For this purpose questionnaires were distributed in the following Ulaanbaatar districts: Chingiltei, Songinokhairkhan and Khan-Uul and in Zuunmod and Altanbulag of Tuv aimag. According to the results of the questionnaire, people are willing to pay an extra 50% more than the current water price, if the water supply situation improves. This result was similar to the result of the survey which was conducted by the World Bank and Public-Private Infrastructure Advisory Facility in 2007.

Table 65. Results of the questionnaires

№	Questions	Type	Results, %
1	Who carries water in your family?	Adult man	45
		Adult woman	29
		Boy	18
		Girl	8
2	Which source do you carry water from?	Centralized system	17
		Boreholes	30
		Kiosks	41
		Transportation	12
3	How much time do you spend on carrying water?	1 hour	73
		1-2 hours	17
		2-3 hours	6
		More than 3 hours	4

№	Questions	Type	Results, %
4	How far is your water source?	0-200 meters	50
		201-1000 meters	43
		More than 1000 meters	7
5	Average monthly income of the household	MNT 101 100	43
		MNT 202 201	34
		MNT 404 401	23
6	How much money do you spend on drinking water a month?	No charge	5
		MNT 1200	32
		MNT 1201-4800	45
		More than MNT 4801	18
7	How much money do you pay for 1 liter water?	MNT 1	70
		MNT 2	14
		Do not know	16

6.2. Revenues of Water Use Fee

As example, the wood quantity that was prepared in the upper part of the Tuul River has been used. The market price is some MNT 308 million as estimated on the basis of the "law on use fee of trees that cut from forest". As seen from the following table, most of the trees are used for domestic needs. The people prepared firewood and logs in the upper part of the Tuul River for many years and this had a bad impact on the river basin forest.

As seen in the *Table 66*, 3295 cubic meter log and 8498 cubic meter firewood were prepared in the upper part of the Tuul River and half of it had permission. Also nuts grow in the area of 54900 hectares in the upper part of the Tuul River. Every 4-6 year, there is the period when nuts growth is enormous. When there is a year that nuts grew much, 1662 tons of nut cones are harvested. It means 332.4 tons of nuts. Some MNT 37.24 million is generated as an income from the extra forest wealth. Most of the extra forest wealth includes nuts and fruits. Most of the forest wealth is used for domestic needs and only 15% is sold in the market. Some MNT 43.16 million is generated as an income from nuts sale.

Table 66. Value of firewood and logs prepared in the upper part of the Tuul River

Indicator	Prepared wood, m³/year		Market price, million MNT/year		
	Log	Firewood	Log	Firewood	Total
Wood with permission	643	4384	38.58	87.68	126.26
Wood without permission	606	4114	22.73	82.28	105.01
Wood used for households' extra needs	2046	-	76.73	-	76.73
Total	3295	8498	138.03	169.96	307.99
For local household needs	2046	5456	76.73	109.12	185.85
For sale	1249	3042	61.31	60.84	122.15
Income for state budget			9.65	19.84	29.13

- *The income that collects into state budget is generated from wood fees with permission.*
- *The total quantity of logs that are prepared is much higher than the quantity in the table. The domestic use wood includes household-use wood, fence wood and house wood.*

In 2008, water resource use estimation was done in 113 entities, organizations, 185 deposits and objects of Ulaanbaatar City and 16 aimags. Some MNT 3.7 billion was levied for 97.0 million cubic meter water. This estimation was based on the 1st clause, 26th article, chapter 3 of "law on water". Some MNT 466.3 million was levied for water resource use fee of Tuul River Basin. 20% of water use fee collects into soum's and 80% collects into aimag's budget.

As of "Law on Investment Percentage of Revenue generated from Natural Resource Usage Payments for Measures to protect environment and rehabilitate natural resources", 35% of the water use fee income will be some MNT 211.65 million. It is enough to finance the Tuul River Basin committee and a detailed financial plan is required. As for the soums where the survey was done, there was no money spent on rehabilitation of water and environment.

MNET spent MNT 217.5 million on springs' protection in 2008. This is 7.2% of the total water fee. According to The Water Authority information in 2008, most part of the Tuul River Basin water fees income was collected from mines and particularly gold mines.

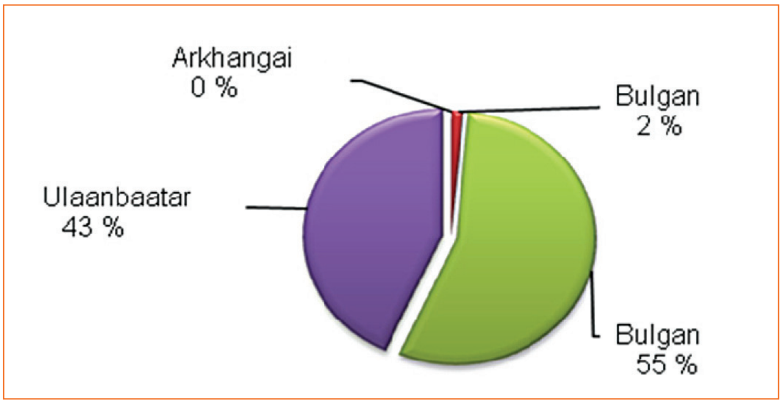

Figure 28. Water use fees revenue structure of Tuul River Basin by aimag, 2008

The water fee and water resource use fee issues are important to develop investment structures and to increase water sector financing. In order to implement the renewed "Law on Water", the Government renewed and re-estimated the water resource use fee revenue in 2005 and 2009. In 2004, the water resource use fee revenue was MNT 250 million and in 2006, it was MNT 2.7 billion, an increase of 10 times. But the water sector finance and investment revenue did not increase a lot. The water use fee revenue was re-estimated in the framework of Government resolution 351 of 2009. Between 2009 and 2010, the revenue of water resource use fee reached MNT 3.2-4.6 billion.

According to article 4, 4.2 of the Mongolian Law on Investment Percentage of Revenue generated from Natural Resource Usage Payments for Measures to protect environment and rehabilitate natural resources, matching funds equivalent to at least 70% of the timber and firewood harvesting fee revenues, at least 20% of the land fee revenues and at least 35% of the water and springs use fee revenues described in article 4.1 of this Law must be spent from the state budget for the purposes of land, water and forest protection and restoration as reflected in the general policies on economic and social development.

In the framework of "Law on Investment Percentage of Revenue generated from Natural Resource Usage Payments for Measures to protect environment and rehabilitate natural resources'', water and springs fee income is collected into the state budget. It is distributed to each aimag through the state budget. The types of natural resource use fee revenue are shown in the following table in terms of soums and aimags which are locate in the Tuul River Basin (*Table 67*).

Table 67. Revenue of Natural resource use fees in MNT thous, 2010

Aimag and soum	Hunting resource use	Water and springs use	Wood preparation from forest	Natural plants use	Land use	Natural resource use
Arkhangai province						
Khashaat		90.0				
Bulgan province						
Bayannuur					1,272.8	
Buregkhangai		102,650.9	6,676.7		63,346.4	61,861.5
Gurvanbulag					739.4	
Dashinchilen		4,071.2			5,735.4	
Rashaant					1,736.5	
Uvurkhangai province						
Burd	4,580.0	400.0				
Tov province						
Altanbulag	16,228.2	200.0	486.0	30.0	6,168.4	
Argalant		201.0			5,081.8	
Bayan-Unjuul	3,392.5	388.1			6,690.2	
Bayankhangai					1,162.9	
Bayantsogt		180.0	5,417.9	30.0	10,551.7	
Zaamar		312,655.5	490.0		104,040.8	1311 986.5
Zuunmod		2,920.1			6,427.0	
Lun	320.0				1,881.7	
Undurshireet	14,976.1				2,074.0	
Sergelen		28,521.4			81,183.1	16,017.5
Ugtaaltsaidam	56.0	700.0	2,884.6		14,857.5	
Erdene	1,057.0	4,745.8	10,004.0	1,750.0	35,402.9	
Erdenesant					8,978.4	
Ulaanbaatar City						
Bayangol		15.5			394.1	
Bayanzurh					146.0	1,960.4
Nalaikh		8,782.7			60,010	28,470.4
TOTAL	40,609.8	466,522.2	25,959.2	1,810	417,881	1,420,296.3

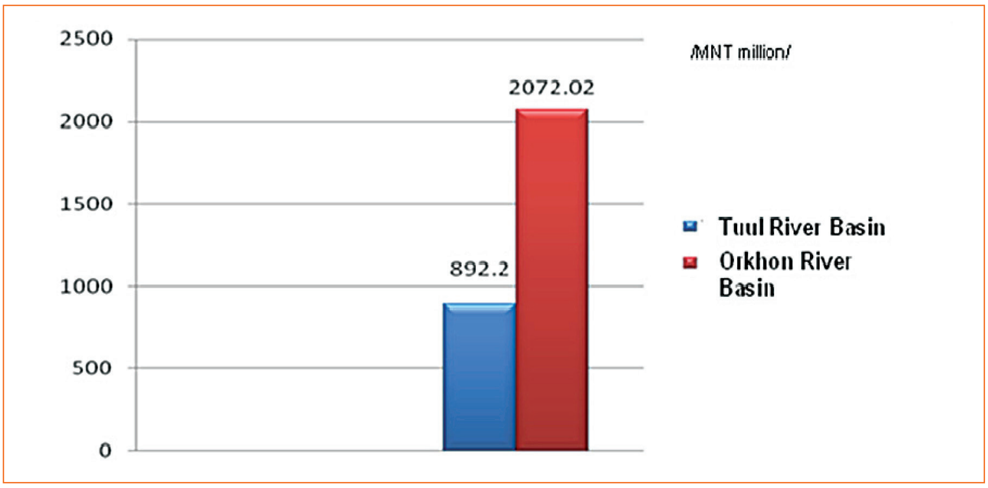

Figure 29. Water use fee revenue in 2010

The water and springs use fee, land use fee, and natural resource use fee constitute most of the environmental fees. These fees are collected into state and local budget. The environment resource use fee is regulated by the law on Government specific fund.

Figure 29 shows Tuul and Orkhon River basins revenue of water use fee.

Water pollution fee: At the local-level water pollution and unwise use of water is caused by mining industries and particularly gold mining. The water is polluted in 28 river basins of 8 aimags due to the impact of gold mining. Many little rivers in Tuul, Eroo, Kharaa and Orkhon river basins are being polluted by a group of gold mines and self-gold miners. The gold miners carry hundreds of sacks of soil to the rivers and wash it. So it pollutes water and some lakes are being dried up. The area near Zaamar soum of Tuv aimag is the major part that has the most negative impact on the Tuul River.

In 2008, 42.9 million cubic meter wastewater was treated by Bayangol, Bagakhangai, and Biokombinat wastewater treatment plants as well as the central wastewater treatment plant, which has 156 km long pipelines designed for treating wastewater from Ulaanbaatar City consumers.

The water polluting compensation revenue is modified on the basis of "Rules to levy water polluting compensation" which was approved by resolution 06, state committee of environmental monitoring in 1992.

6.3. Economic Incentives of Water-Related Activities

Article 35 of the Law on Water of Mongolia specifies to use economic incentives for water protection, for its rational use and for the development of water environment. Currently this article is not being implemented.

6.4. Renewing the Water Pricing System

6.4.1. Current Situation

The water price in Mongolia consists of a water resource use fee, a service fee (tariff) of water supply organizations and subsidies. And the polluter pay principle is just in the beginning. If water is polluted, polluter should pay compensation according to the rules.

According to the Law on Water, water use is classified like water consumption and use. The water consumers are paying water service charge and water users' are paying a water resource use fee. The water pricing system of Mongolia is presented in *Table 68*.

Table 68. Water price types and water pricing principles

Type of price	Scope	Principle	Payer
Water and wastewater tariff	Water supply service	Based on costs	Consumers
Water resource use fee	Water use	Pays for the used amount	Users
Water pollution compensation fee	Water quality	Pollution level and quantity (if more than standard)	Users, who discharged wastewater to the environment (more than standard)
Subsides	Water supply service, investment and others	If water supply organizations work with losses or do not have sufficient funds	State budget or donors

1) Water and waste water tariff: The public utilities services and companies of cities and local areas, which operate in the business of discharging waste water from utilities and mining as well as distributing fresh water, establish fees based on the rules which are obeyed on the basis of discussion with local Representatives' Khural and the Agency for Fair Competition and Consumer Protection. According to the "Law on Urban and settlement area water supply and sewerage use", which is newly approved in 2011, the Council, which manages urban and settlement area water supply, sewerage use and services, will approve and monitor the water tariff and water pricing methodologies.

Usually, water supply and sewerage companies are a monopoly at the local level. Some private water vendors work in ger districts and soum centers. But there are not many and their ability to compete is weak.

The local area administration participates in the water fee establishment. On the one hand, it has the advantage to prevent a monopoly condition, but on the other hand, organizations that operate in the sector suffer from loss due to fixed fees and tariffs. The negative effects are budget pressures and organization bankruptcy. As for expense returns, water supply organizations barely recover operating expenses and depreciation, and in some cases, do not manage to compensate operating expenses at all. It makes water unproductive in economical terms. The legal status of water service pricing presented in the *Table 69.*

Table 69. Legal status of water tariff

Legal acts	Participants in the establishment of water tariff
Law on Water /15.1.3/ Law on Urban and settlement area water supply and sewerage use /3.1.16, 3.1.17,.3.1.18, 10.1.1 / 17th order of Ministry of Infrastructure from 2003* Law on competition /6.1.2/ Order of local Representatives' Khural and order of Executive Board of local property company	MRCUD, ALACGC (Former) Local Representatives' Khural Agency for Fair Competition and Consumer Protection Water supply and sewerage organizations

** After establishing the Regulation Council of urban and settlement area water supply, sewerage use and services will change.*

The local area Representatives' Khural establishes borehole water fees in soum centers and small urban areas. The tariff is established low compared to the costs and there are few consumers. It leads to small amounts of income, which barely compensate operating expenses. The livestock watering boreholes are built and renewed by budget assets and compensation of expenses is hard. The issue is solved in a way that the herders' groups own them.

2) Water resource use fee. The water issue is one of the basic factors that create a stable development of Mongolia. Our country's water resources have an uneven distribution in terms of space and time. It leads to some obstacles when creating a stable social development. According to the "Law on Investment Percentage of Revenue generated from Natural Resource Usage Payments for Measures to protect environment and rehabilitate natural resources", from total revenue of water use fee 35% or more must be spent in order to protect and rehabilitate water resources. The local area administration should allocate some amount of money for the activities to protect water and rehabilitate resources. But, that amount of money is not spent in a useful way. The legal status of water use fee presented in the *Table 70.*

Table 70. Legal status of water use fees

Legal acts	Respondents
Law on Environmental protection Law on Water /9.1.2, 24.1.5, 27.2.6, 30.1/ Law of Mineral springs /Chapter 5/ Law on Use Payments of Water and Spring /4, 6, 7, 8/ Law on Investment Percentage of Revenue generated from Natural Resource Usage Payments for Measures to protect environment and rehabilitate natural resources /4.1.5, 4.2/ General Law on Taxation of Mongolia /7.4.5, 12.1/ 351st resolution of Government of Mongolia "Update the rate of the water use fee" from 2009	- Ministry of Nature, Environment and Tourism (Former) - Water Authority (Former) - Local Governors - Ministry of Finance, General Department of Taxation

For example: water resource use fee income reached MNT 4.72 billion in 2010 and MNT 1.1 billion were spent on water sector management (water sector administration, water resources research and protection) which is 23.8% of the total income.

3) Water pollution compensation fee. Mongolia's economy is booming and water use increases. Also pollution is increasing along with it. The main reasons of the water pollution are growth of construction material industry, mining and raw material processing industry as well as population concentration and urbanization.

The polluter pay principle is in its initial stage and there is a 1992-approved compensation rule on water pollution. Its implementation is very imperfect. The legal status of water pollution compensation presented in the *Table 71*.

Table 71. Legal status of water pollution compensation

Legal acts	Respondents
Law on Environmental protection /4.2.3, 8.4/ Law on Water /30.3/ Law of Mineral springs /16.1.1/ Law on Investment Percentage of Revenue generated from Natural Resource Usage Payments for Measures to protect environment and rehabilitate natural resources /5.1/ General Law on Taxation of Mongolia /6.1/ Rule of the water pollution compensation Evaluation of the environmental damage, assessment methodology of its compensation /2010.5.27/ Water economic, ecological valuation	- Ministry of Nature, Environment and Tourism (Former) - Water Authority (Former) - General Agency for Professional Inspection - Local Governors

4) Subsidy. The water sector requires a lot of subsidies and aid every year due to the low income and insufficient compensation of water supply organizations' expenses. The subsidies are mainly used for population water supply, sanitation and agricultural water supply. In Mongolia, mainly the direct subsidy principles are used.

6.4.2. Possibility to Change Water Pricing System

The Mongolian water sector structures are being changed and renewed due to the changing economic situation. It is required to renew water pricing structures, which are the main economic condition for the sector's existence. The water fee policy acts as a main leverage for water resources, especially water demand management finance and economy. The following changes should be done systematically for fee forming structures in order to have successful water sector activities based on other countries' experience and the research works conducted within the framework of relevant organizations' recommendations.

The price of water is a key determinant of both the economic efficiency and the environmental effectiveness of water services. A water tariff is a powerful and versatile management tool. It is capable of promoting a number of objectives, although tradeoffs among them are commonly required. When specifying a water fee and tariff, the following common objectives should be defined. They are:

- Economic efficiency, resource conservation
- To meet state policy
- Cost recovery and net revenue stability
- Equity and fairness
- Public acceptable
- Simplicity and transparency
- Taking into account the consumer purchasing power

The fee and tariff types and their basic principles that can be used for the fulfillment of the above mentioned objectives are presented in *Table 72*.

Table 72. Water fee and tariff types and principles which can be used further

Type of price	Scope	Main principle	Payer
Water and wastewater tariff	Water supply service	Consumer cost pricing	Consumer
Water resource use fee	Water use amount	Interest-pay- say	Users
Water tax	Water system	Public, differential	Consumers and users
Water pollution fee and compensation	Water quality	Polluter pays	Polluter
Subsides	Water supply service O&M and capital cost	Based on cost recovery	State and local budget, investors and donors

Water will be productive in terms of society and economy in case there is full cost recovery or close to full cost recovery.

1) Water and waste water service tariff: Water pricing principles need to be chosen in relation to state policy. The cost recovery issue is the most important principle when specifying water fees according to privatizing and changing directions of national development concept of Mongolia and public utility service sector.

According to other countries' experience, the cost recovery level of water is established by laws and rules. It becomes the main condition of cost sharing and reliable operation of water supply organizations. It is very important to determine other water related fees. So it is important that the expense compensation level of water is discussed by the relevant organizations in relation to state policy and is formed by special rules. Those relevant organizations are MRTCUD, MNET, WA, MFALI, MF, and the Council for regulation of the urban and settlement area water supply and sewerage use and services. The following organizations need to be involved when establishing fresh water and waste water fees and tariffs. They are MRTCUD, the Council for regulation of the urban and settlement area water supply and sewerage use and services, local area Representatives' Khural, AFCCP and utility organizations.

Fees and tariffs should be based on consumers' interests and they should contribute to new investment conditions and water service organizations' existence.

2) Water resource use fee. The following organizations should participate in the establishment of water resource use fees, water taxes, water polluting fees and compensations. They are MNET, which is responsible for water resources and quality issues; WA; MF; GASI; GDT and local area Representatives' Khural. The main objectives of the fee are to use water resources wisely, to increase use benefits, to provide ecological balance and to protect and rehabilitate water bodies. The fee income is spent on the following things. They are to use water resources wisely, to finance activities to rehabilitate and increase water bodies (water resources explorations), to protect water bodies and to finance administration expenses (for example: RBC).

Attention needs to be paid on the right use of fees and fee revenues should be increased as this should be used in this or that purpose etc. The current revenues should be increased till the level, which encourages users to use water wisely.

3) Water tax. This tax should be established for the purpose of supporting ecosystem services, protecting water bodies from pollution, protecting from water damages and rehabilitating them. The main organizations for establishing water tax are MNET, WA, MRTCUD, MF and local area Representatives' Khural.

The water tax needs to be locally and differential. The water tax has to cover following two issues. They are:

A/ Ecosystem service: This includes water bodies and their recreation services. Differentiation will be based on locations. For example: it will be high in areas like safe ecological zones, which are close to urban areas and water bodies. It will be levied when using water bodies for the purpose of recreation and utility activities. The implementation possibility is high when calculating it within the land fee. The amount will be established in relation to the ecosystem assessment.

B/ Protecting from water damages (flood, soil water etc): This also depends on location. It will be established differently on the basis of whether land and real estate owners are protected from flood and water damages. The amount should be sufficient for the use and administration fees of water enterprise constructions dedicated to prevent from potential water threats. The implementation possibility is high when it is included in the land fee.

Usually, the capital and O&M costs for activities to protect from water threats are consuming by the state budget. In some cases, flood protection and drainage constructions are not built due to shortage of investment and vast damage occurs due to it. We cannot compensate huge amounts of socio-economic damages caused by threats from the water. But by accumulating special fees in some accumulation fund, even if it will not reach cost recovery, may protect against threats from the water. There will be a possibility to pay back after construction of the objects by issuing bonds before accumulation of some assets from the fees.

4) Water polluting fee and compensation. It is less costly to prevent than to rehabilitate already occurred damages by implementing the polluter pay principle and forcing water polluters to pay for it. This is clear from international experiences. The main objectives of the fee are to keep ecological balance, to decrease negative impacts of human activities, to protect the environment and most important to prevent from threats caused by negative human activities on human health, society and economy .

Water polluters will pay this tax. Currently, users are considered as polluters. But we must recognize that all users and consumers who change the natural state of water will be considered as polluters. The example of this is: if livestock number increases, it will cause desertification and increase of surface water pollution. In other words, sustainability of natural resources will be destabilized.

The pollution fee will be levied if the pollutant level is under the standard-approved amount. Also, this fee acts as economic leverage for industries, which pollute water much, to introduce new technologies and reuse water. The fee revenue will be established in relation to activity costs to protect and prevent from pollution, to monitor pollution and administration expenses. It will be accumulated in a special fund and used for this activity. (For example: constructing WWTPs, monitoring water quality etc)

The compensation will be levied in order to erase already occurred damages. The ecological damage is very high and the amount of compensation will at least be equivalent to the expenses used for damage relief. If polluter discharges water to nature whose components have over-standard polluting particles or if polluter pollutes water bodies, fee amount will be levied in relation to its size.

5) Subsidy. Subsidy should be used wisely due to some reasons. They are: living standard of Mongolian population is low; poverty rate is high; weak financial capacity of water supply and waste water discharge organizations and high expense of water constructions. The subsidy is established in relation to state policy and expense compensation level. The following organizations will participate. They are MF, MRTCUD, MNET, WA, MFALI, the Council for regulation of the urban and settlement area water supply and sewerage use and service and local area Representatives' Khural.

Many types of taxes will probably cause psychological and economic pressures for tax payers. Advertisements and information should be done. Because understanding on water fee payment is weak. It can be managed as it will be included in other forms of taxes. It is important not to cause trouble for tax payers and to determine environmental and economic indirect influence on the basis of water related taxes and fees. The amount of water fee and taxes will be established when pay back condition is formed after financing activities using economic methods /bond, loan etc/. The activities are to construct required water constructions and to protect the environment.

6.5. Financial Issues of Basin Organizations

Water resources are one of the vital issues of countries. Country's high level organizations determine water resources policy, its implementation covers many sides. Water issues should be solved in its complex way involving activities of many economic sectors and their interests. According to international experience, water resource management is implemented by water basins and it proves to have good results. So this method is being implemented in our country. At law on water, article 2, clause 19, it is specified as RBC will be established.

At the moment, some 10 RBC have been established officially and are operating. RBCs are being financed by some projects' and their financial issues should be solved immediately. River basin administrations (RBA) under RBC are planned to be established. On average, four people will work. The expense estimate for a RBA is presented in Table 73. If one RBA consists of 1 executive officer and 21 personnel, some MNT 371.0 million is required for annually on average. This cost can be financed from revenue of water use fee. For example, recently revenue of water use in the TRB fee were MNT 160-400 million and the administrative cost of RBA will be covered.

Table 73. Administrative expenses of the Tuul River Basin Administration

Type of expenses	Annual, thous. MNT
Number of staff, persons	22
TOTAL EXPENSES	370.958.9
Salaries with Social insurance premium	141.147.1
Salaries	127.159.6
Social insurance premium from employer	13.987.6
Chancery, telecommunication, postage and freight	9.000.0
Transport (fuel)	12.000.0
Domestic travel	14.000.0
Utilities	12.000.0
Labor safety facilities	2.500.0
Law value and fact depreciable items	500.0
Research and training	7.500.0
Payment for the others organizations work and service, fee and levies	10.000.0
Information and advertising	3.500.0
Other costs	17.644.7

Also the financial sources of RBAs can be stakeholders' donations and aid. In the future it is necessary to study possibilities to use some parts of water related taxes and fees for RBCs and RBAs. The legal environment should be created.

The above mentioned sources will be spent only for administrative expenses of RBAs. Also it is necessary to determine financial sources for the main activities of the RBAs. They are:

- Monitoring water resources
- Developing water related infrastructures, supplying its condition to operate
- Providing possibility to have stable activities/operation of the organization

Some countries solved finances required for these activities through donation, loans and state investments. As for Mongolia, the most possible method is to solve through state budget.

Recommendations:

In Mongolia, the water fee forming structure is established in some degree and it needs to be developed in the future. There are some advantages in a water pricing mechanism: payment collecting mechanism is well established and consumers are well informed. Also water resource use fee charges and the collection mechanism are developed at a suitable level.

The main obstacle in Mongolia is that the cost recovery level of water is not defined clearly in each stage of the water pricing system. In some cases, on the one hand, water supply service organizations face financial difficulties; on the other hand, accumulated income is not used in intended way. So, important issues to be solved firstly in the future are to renew fee forming structures of water sector, to improve coherence of fee types, to determine expense compensation level and to develop financial issues.

The TRB is one of the basins that accumulates many problems and which must be solved. Within this framework first water tax and water pollution fee should be used to finance the Tuul RBA. The Tuul RBA should work in close co-operation with capital and local governments and should monitor the use of the revenue of water use fees and compensation for proper purposes.

7. Water sector investment in the basin

7.1. State Budget Investment and Their benefits

The water sector was affected heavily during the 1990 economic crisis. There were not enough investments in the water sector until 2000. The old facilities were in bad shape since there were no investments. Also the water sector was abandoned due to bad governance. The losses were extremely high. The followings can be noted, for example: agricultural water supply and flood protection.

For the last few years, the economy of our country is recovering. The water sector activities are improving due to increasing number of investments. The Government of Mongolia is paying much attention to the water sector due to environmental change, warming and desertification.

Ulaanbaatar City is located in the Tuul River Basin and water sector investment is increasing year by year more than that of other basins. The Government is investing a lot of money into irrigation since 2000. The Government approved the "3rd Crop Rehabilitation" program in order to supply food demand by domestic products. The investment acts as a grant and the irrigation field size is scaling up. Also it increases people's interests to run business in this sector. The irrigation is vital for our country to have a reliable harvest since our climate is unstable and the desertification is widespread. The investment for the irrigation in the basin is presented in the following table.

Table 74. Irrigation system investment in the Tuul River Basin, million MNT

Year	Total	State	Private
2005	174.91	97.30	77.61
2006	0.00	0.00	0.00
2007	173.50	52.20	121.30
2008	2179.66	476.00	1703.66

The investment in irrigation is increasing much. The investment amount was MNT 2.2 billion in 2010 and state budget investment increased by 4.8 times compared to the 2005 state budget investment. For the last few years, the number of livestock is increasing.

The Government is paying much attention to pasture water supply due to increasing livestock and climate change. Some MNT 11.5 billion was spent on kiosk maintenance and rebuilding in 2007. In 2008, it was MNT 8.9 billion and in 2010 was MNT 7.4 billion. *Table 75* presents the construction and rehabilitation investment costs of aimags, which are located in the TRB.

Table 75. Investment for well constriction and rehabilitation in million MNT

Type of investment	year	Construction			Rehabilitation and repair		
		Bulgan	Tuv	Ulaanbaatar	Bulgan	Tuv	Ulaanbaatar
TOTAL	2006	260.6	367.4	178.7	93.4	233.1	12.3
	2007	589.8	549.6	288.4	69.1	108.8	3.7
	2008	533.6	877.5	335.2	83.5	96.8	10.6
	2009	352.4	1 179.3	340.5	18.4	37.3	4.4
	2010	605	800.9	27.5	26.9	66.5	2

Type of investment	year	Construction			Rehabilitation and repair		
		Bulgan	Tuv	Ulaanbaatar	Bulgan	Tuv	Ulaanbaatar
State budget	2006	53.2	42.6	33.2	21	39.2	4.1
	2007	372.5	341.9	49.7	23.2	73.3	2.2
	2008	281	487.7	162.2	30.1	66	0.1
	2009	86.5	721.7	64	13	0.9	1.8
	2010	211.5	400.4	12	11	5	1.6
Foreign aid and projects	2006	188.8	141.5	78.3	58.8	131.2	3.6
	2007	195.3	99.4	179	43.4	24.6	0.9
	2008	238.8	175.5	165.5	51.8	1	2.5
	2009	253	189	142.9	0.3	22.9	1.9
	2010	365.1	236.2	0	11.7	44.1	0
Private (herders)	2006	18.6	183.3	67.2	13.6	62.7	4.6
	2007	22	108.3	59.7	2.5	10.9	0.6
	2008	13.8	214.3	7.5	1.6	29.8	8
	2009	12.9	268.6	133.5	5	13.5	0.8
	2010	28.4	164.3	15.5	4.2	17.4	0.4

The state budget investment in agricultural and urban water supply and flood protection is increasing intensively. The state budget investment in these sectors is presented in the following table.

Table 76. Water sector investment in the Tuul River Basin in million MNT

Type of constructions	2005	2006	2007	2010
Flood protection and drainage	0.00	607.39	1658.00	1000.00
Water supply and sewerage	400.00	2507.39	17704.90	20652.90
Other	0.00	0.00	15.00	2305.00
Total	400.00	3114.78	19577.90	23957.90

According to the table, investment in the water infrastructure, especially water supply and sewerage system investment increased from MNT 0.4 billion to MNT 20.7 billion. It was increased by 51.8 times. This is due to the following reasons: first, population of Ulaanbaatar City is increasing; water supply and sewerage networks are expanding; and old facilities are being maintained and rebuilt. Some MNT24 billion was invested in 2010 and 78% was spent on the above mentioned activities. The other investments include: Protecting water sources of springs nearby Ulaanbaatar City; and installing water purifying instruments. As for the Tuul River Basin, most of the investment was used for the drinking water and sewerage facilities of Ulaanbaatar City.

In the water sector, especially urban water supply, it is difficult to recover capital cost on a short term according to the examples of developing countries. Much attention should be paid to the tariff structure in order to sustain sector existence. As for Ulaanbaatar City, USUG negotiated with the city council about their water and wastewater tariff. Because of this, the tariff rate remained the same over a long time and USUG operated with losses according to its reports. Much investment was done but its operation faced losses. It means that the tariff structure should be renewed.

The benefits of the flood protection depends on how many people and organizations are protected. Ulaanbaatar City is quite densely populated and has a big concentration of buildings. It indicates that benefits of the investment for flood protection should be high.

It is hard to recover costs according to current tariff structures of the water sector in terms of the amount of money put in the pasture water supply. The boreholes that were maintained and repaired by the state budget investment belong to the local government. In most cases, herders use them in a contract and are responsible for operational expenditures. There is no established depreciation fund and it is tough to compensate expenditures in any way. These factors make financial sources unclear, when there are problems: breakdown or expiration of well use. The irrigation has some advantages, its products can be sold and investment can be compensated.

According to the survey conducted in the Tuul River Basin, old methods are used for the calculation of irrigation system economic benefits. It is difficult to get reliable data on benefits. The economic indicators should be developed which are used for the layout selection process.

A monitoring structure for agricultural investment results is required to be developed also. For example: Tuv aimag's 10-hectare irrigation system "Seniors' initiative" was financed by the Government and local government was not able to locate where it was. The dam of Gun irrigation system was built with technological failures. There was a major breakdown on dam within 1 year period since its operation started and the condition was dangerous. In some soums, authorities were not able to detect where new boreholes were drilled.

7.2. Private Investment and Its Benefits

As for the private investment, it is better spent on boreholes and irrigation system. The reason is that they need small amount of money for the investment. In our condition, there is not a developed system which registers private boreholes.

The amount of private investment is registered only if there is investment from the Ministry of Food, Agriculture and Light Industry. If it is invested 100%, registration and monitoring system need to be developed as well. The irrigation system "Ikh Ungut Trade" has 100% investment and its operation started from 2009 according to the surveys conducted in the Tuul River Basin. It is possible to compensate expenses in 2 years time. As for the multiple investments from different companies, it will take at least 4 years. It differs from projected economic calculations. It shows that calculation mechanism for the state budget investment needs to be developed.

The Government of Mongolia implemented the "3rd Crop Rehabilitation" program between 2008 and 2010. During this period the following measures were implemented release of the draft law on exempting following things from customs taxes and VAT will be developed. They include equipment and spare parts for the crop production; irrigation system equipment; fertilizer and crop protecting substance. Also were rehabilitated old irrigation systems and built new irrigation systems.

7.3. Foreign Aid

World Vision is an international organization which operates in Mongolia. World Vision invested 4,887,252 dollars between 2007 and 2010 in following measures. They include: support irrigation, animal husbandry and small and medium businesses in order to increase household living standard through the Local Development Program, improve infrastructure and provide shelters. The water resource management work (wells, water distribution system, accumulation of rain water and snow, water basin management, small size dam) is included in the main objectives of the risk management component of the "Stable living 2" project's pasture animal husbandry.

Some MNT 11.3 million was spent on building kiosks in places like West Zuunmod and Bayankhoshuu of Zuunmod soum of Tuv aimag in 2010. Some MNT 217.5 million was distributed to the local area budget for the purpose of renovating 7 springs for each aimag in 2010. 145 springs of 20 aimags were renovated. The nature protecting agency of Ulaanbaatar City renovated 16 springs and maintained 4 previously renovated springs. 15 of them was renovated through the financial support of the project programs.

In the framework of Urban pasture project of the Millennium Development Challenge fund, the terms of reference was developed and it is about the start of short training for the local authorities and herders in the field of animal husbandry management, kiosk and irrigation point and marketing management. It will start from January, 2010. The investments on kiosks and irrigation points and fence materials occupy 50-60% of the project finance. (The implementation period of the project is between September, 2010 and September, 2013; and total finance is 11.8 million dollars)

It is difficult to calculate the benefits since there are no integrated registration and management, even though foreign investment in the water infrastructure is high. It is important to register all levels of foreign aid and investments in the water sector. It is vital for the improvement of water sector investment benefits and coherence.

8. Economic Valuation of Water

The economic assessment of water is playing an important role in the decision making of water management. There are many methods to do an economic assessment on water and in this regard, it's been described in the "Water resource assessment and economic evaluation methodology", handbook (only available in Mongolian) edited by the project. In our country, some studies in this field started to be carried out since 1980. A general assessment method for water resource or methodology to determine total water value have been described in "Ecological and economic assessment of water resource of Mongolia and scientific background for use, protection and restoration of water resource" (G.Dolgorsuren) in 2000 and "Methodology of estimation losses of nature and environment and its compensation" approved by order A-156 by Minister of Nature and Environment in 2010.

In scope of the project, a specific market method based on 'study of readiness to process WTP payment' has been used in making economic assessment on water resource in the Tuul river basin. The study of readiness to process payment has been carried out by the World Bank in scope of the "The economic value of the Upper Tuul ecosystem" project. And another study has been conducted by our team in scope of this project and we came up with the same result. In making economic assessment on water resource in the future, it's very important to continuously carry out this sort of study in other basins.

The WTP means the maximum amount of money which customers are able to pay for improving environmental services and it is aimed to improve the related condition or keeping it the same instead of paying for other things by customers.

Please see the result of economic assessment on water in the Tuul river basin which was carried out based on the WTP from Figure 30.

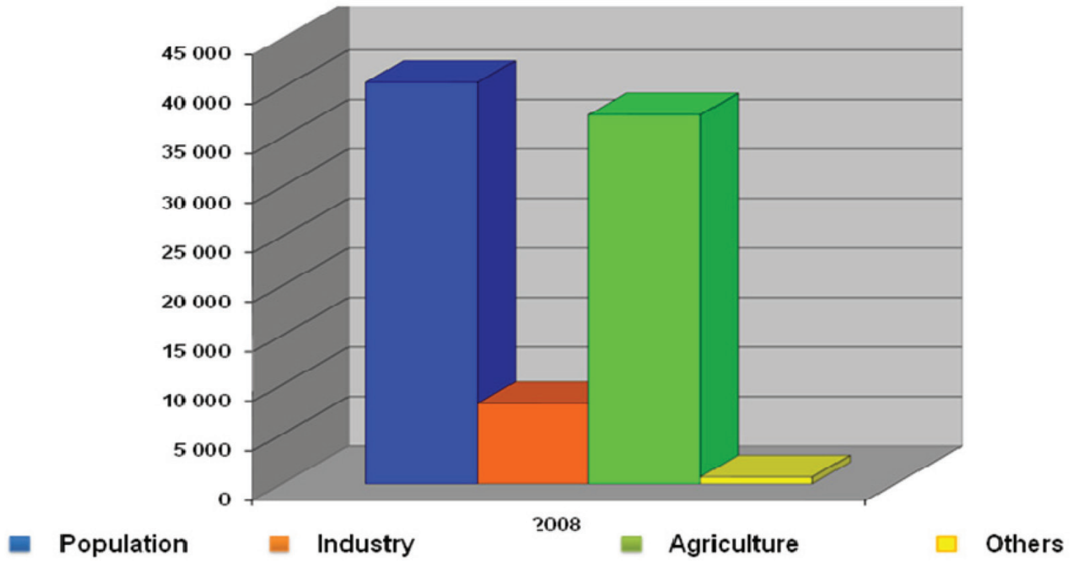

Figure 30. Value of water in the TRB

The drinking water supply sector in the basin is the most important in terms of water use and the agricultural sector stands at the second place. It means that in the future it is necessary to focus on population water supply and agricultural sectors as a priority in tackling issues of the water sector.

9. Recommendations

1. The Tuul river basin covers only 3% of the territory of Mongolia, but holds over 40% of the country population. About 60% GDP of Mongolia is produced in the TRB and it is an economically important region.
2. The infrastructure development in the TRB is sufficient, but needs improvement related to the rapid growth of population and economy.
3. The population water supply is the top-priority issue for the TRB management plan. It includes:
   - Need to rebuilt and expand the centralized water supply and sewerage systems of Ulaanbaatar and Zuunmod in coherence with "Water National Program";
   - Need to improve water supply sources capacity and study of a dam and reservoir in the Tuul River to regulate flow according to water demand estimation, which shows possibility of future water shortages in Ulaanbaatar;
   - To plan measures to support the wise use of water and to reduce water losses;
   - To pay more attention to the water supply and sanitation of ger area population and of herders and to plan measures to implement modern technologies suitable for Mongolian conditions;
   - To introduce modern, new technologies into the water supply and sewerage system that protect human health;
   - To increase per person water consumption in ger and rural areas by improving water supply and sanitation conditions and review of water tariffs etc.
   - To improve drinking water quality in some soums (Bayan-Unguul of Tuv, Dashinchilen of Bulgan) by installing water softener etc.;
   - To plan information campaign for wise water use by population;
4. To pay attention to the agricultural water supply, especially livestock water supply; to strengthen current success of farming, especially irrigation; to expand food production in coherence with population food demand.
   - To plan measures to build ponds and boreholes in order to increase the pasture water supply level; the measure will be reflected in the IWRM measures in coherence with state policies and programs like "Water National Program";
   - To plan improvement measures of investment efficiency in pasture water supply;
   - To plan activities for rehabilitating and building irrigation systems;
   - To develop mechanisms for increasing investment efficiency of irrigation systems;
   - To support development of greenhouses near Ulaanbaatar;
5. To support tourism sector development; to plan activities to introduce new technology, small-capacity water supply and sewerage facilities:
6. For the industrial water supply:
   - To use water wisely and introduce nature-friendly technology;
   - To pay attention to wastewater treatment facilities of wool, cashmere and tannery industries which pollute water a lot;

- To improve water use efficiency of the energy sector;

7. To improve mining water supply:
   - To develop and stimulate the introduction of nature-friendly technology into the mining sector;
   - To develop measures to decrease damage of water resources caused by mining;
   - To define methodologies to calculate results of measures and programs oriented to mining water supply;
8. To organize the rehabilitation and construction of flood protections and drainage works of Ulaanbaatar, Zuunmod city and other settlement areas;
9. To study changes in surface water runoff and groundwater levels due to increasing water consumption and use at Ulaanbaatar and to take measures to identify the cause and reduce the negative impacts.
10. To plan measures for reducing water pollution and to study options to clean the Tuul River bed.

10. References

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ANNEX 1. Data and information sources

№	Data type	Source	Period	Data quality
1. Water use study				
Drinking water supply				
1	Population connection to the centralized system	NSO, Local Governments, USUG, OSNAAGs	2004-2010	good
2	Kiosks and boreholes		2010	acceptable
3	Unprotected sources		2010	acceptable
4	Water supply organizations	MRTCUD, ALACGC	2010	good
2. Sewerage and WWTP				
1	Sewerage connection	MRTCUD, ALACGC, USUG, OSNAAGs	2010	acceptable
2	Connection to the WWTP		2010	acceptable
3	WWTPs		2010	acceptable
Water users and consumers main indicators				
1	Agriculture	MFALI	2004-2010	good
	Sown area		2004-2011	good
	Irrigated area		2004-2012	good
	Livestock	NSO, MFALI	2004-2013	good
	Output		2004-2014	good
	Income		2004-2015	good
	Herders		2004-2016	good
	Agriculture sector employees		2004-2017	good
	Output of the agriculture		2004-2018	good
2	Industry	NSO, Web sites of Ministries	2010	good
	Capacity of the organizations		2010	good
	Employees		2010	good
3	Energy	NSO, Web sites of Ministries	2010	good
	Capacity		2010	good
	Electricity and thermal energy		2010	good
5	Mining and quarrying	NSO, Web sites of Ministries	2010	good
	Companies		2010	good
	Employees		2010	good
	Capacity		2010	acceptable
6	Fishing	NSO, MNET	2010	rare
	Fishing day		2010	rare
7	Tourism	NSO, MFALI, MNET, web sites	2010	rare
	Tourists		2010	rare
	Expenditure		2010	rare
	Employees		2010	rare
	Capacity of the tourist camps		2010	rare
8	Flood protection	MRTCUD, Local government	2010	good
	Protected population		2010	good
	Protected organizations		2010	good
2. Social economic development				
Macroeconomic policy				
1	Agriculture sector policy documents	Ministries, government web site, related documents	to 2011	good
2	Industrial sector policy documents		to 2011	good
3	Mining sector policy documents		to 2011	good
4	Energy sector policy documents		to 2011	good
5	Other sectors policy documents		to 2011	good
Macroeconomic indicators				

№	Data type	Source	Period	Data quality
1	Population growth	NSO, WB, ADB and others	2000-2010	good
2	livestock growth		2000-2010	good
3	Economic growth		2000-2010	good
4	Water tariff, its change	NSO, USUG, OSNAAG	2004-2010	good
5	Technology	MFALI, NDIC and other ministries	2010	good
6	Drinking water consumption	NSO, USUG, OSNAAG	2000-2010	good
7	Agriculture, irrigation systems	MFALI, other ministries	2004-2010	good
8	Industry		2004-2010	good
9	Climate change	MAS, GEI	To 2011	good
Investment				
1	Water supply, sewerage	MF and other related ministries	To 2011	acceptable
2	Measures reducing pollution			rare
3	Flood protection		To 2011	acceptable
4	Drainage		To 2011	rare
5	Technology renovation		To 2011	rare
6	Water supply		To 2011	acceptable
7	Other programs		To 2011	rare
3. Cost recovery of water supply				
Water supply tariff				
1	Current price	USUG, OSNAAG	To 2011	good
	Tariff		To 2011	good
	Mechanism of pricing		To 2011	good
2	Aids, subsides	WB, ADB and local government	To 2011	acceptable
	State and local		To 2011	acceptable
	Total		To 2011	acceptable
Water supply costs				
1	Capital cost	USUG, OSNAAG	To 2011	acceptable
	Construction		To 2011	acceptable
	Rehabilitation		To 2011	acceptable
2	O&M		To 2011	acceptable
3	Administrative		To 2011	acceptable
Environmental costs				
1	Tax, fee	Environmental departments	To 2011	acceptable
2	Valuation	Research reports	To 2011	acceptable
	Environmental assessment		To 2011	acceptable
	Evaluation/ WTP		To 2011	rare
3	Protection costs	Environmental departments	To 2011	acceptable
	Promotion of Water		To 2011	
4. Macroeconomic indicators				
1	GDP	NSO, web site, local Statistical Departments	2004-2010	good
2	Population		2004-2010	good
3	Interest		2004-2010	good
4	Unemployment		2004-2010	good
5	Inflation		2004-2010	good
6	Other data		2004-2010	good

ANNEX 2. Population density of the TRB, 2010

No	Aimag, soum	Percentage of pasture, %	Total	From which			Density, *person/km²*
				Capital, ainag center	Soum center	Rural	
1	Arkhangai		3388		1140	2248	1.4
1	Ugiinuur	17.9	428		0	445	1.4
2	Khashaat	83.7	2960		1140	2110	1.4
2	Bulgan		13586		5536	8050	1.3
1	Bayannuur	100.0	1659		698	961	1.6
2	Buregkhangai	61.8	1863		833	1030	0.9
3	Gurvanbulag	100.0	3133		1243	1890	1.2
4	Dashinchilen	100.0	2362		1075	1287	1.0
5	Mogod	24.4	547		0	547	0.9
6	Rashaant	100.0	3173		1687	1486	5.2
7	Khishig-Undur	45.1	849		0	849	0.9
2	Uvurkhangai		4791	0	536	4255	1.4
1	Bayan-Undur	15.9	383		0	383	0.8
2	Burd	100.0	2876		544	2332	1.2
3	Yusunzuil	22.7	434		0	434	1.0
4	Kharkhorin	13.4	522		0	522	2.0
3	Selenge		1959	0	1311	648	2.4
1	Orkhontuul	28.1	1959		1311	648	2.4
4	Tuv		42716	15295	11413	16008	1.5
1	Altanbulag	100.0	2803		863	1940	0.5
2	Argalant	86.6	1462		781	681	1.5
3	Bayandelger	7.4	46		0	46	0.2
4	Bayan-Unjuul	49.8	1345		696	649	0.6
5	Bayankhangai	100.0	1427		783	644	1.4
6	Bayantsogt	89.8	1763		846	917	1.3
7	Buren	20.5	454		0	454	0.6
8	Zaamar	100.0	5084		3782	1302	1.8
9	Zuunmod	100.0	15295	15295		0	791.5
10	Lun	100.0	2604		903	1701	1.0
11	Undurshireet	100.0	1816		357	1459	0.7
12	Sergelen	26.2	918		487	431	0.8
13	Ugtaaltsaidam	89.5	2234		467	1767	1.6
14	Tseel	22.2	407		0	407	1.1
15	Erdene	57.1	1448		0	1448	0.4
16	Erdenesant	70.7	3612		1448	2164	1.4
	Ulaanbaatar		1125433	1125433	0	0	330.3
1	Bayangol	100.0	185104	185104		0	7158.9
2	Bayanzurkh	100.0	265997	265997		0	191.4
3	Nalaikh	100.0	31458	31458		0	42.0
4	Songinokhairkhan	31.0	246464	246464		0	607.1
5	Sukhbaatar	100.0	136917	136917		0	641.8
6	Chingeltei	100.0	147438	147438		0	1572.7
7	Khan-uul	100.0	112055	112055		0	193.8
	TOTAL	-	1191297	1140728	19944	30625	22.1

ANNEX 3. Summary table of the TRB field trip, 2009

№	Soum, district	Soum center			Sewerage	Tariff, MNT/liter, MNT /per person per month	Number of consumers	Waterconsumption, thous. mi/year	Salary, taous.MNT/ month	Revenue and expenditure of water supplier, thous. MNT/ month			Six of the worker of the wells	Explanation
		Water supply	Wells											
			Ownership	Exploitation						Revenue	Expenditure	Profit and loss		
1	Halaikh, 6th district	Boreholes-3	LPC	rent	-	1	1000	3.3	-	94.5	20.0	74.5	1/f.	Operation cost on renter.
			private	private					-	94.5	20.0	74.5	1/m.	
			private	private					-	81.0	20.0	61.0	1/m.	
3	Nalaikh	Centralized system	LPC	Chandmani Halaikh	1976	w.d-2101 sew-897	4400	364.3	-	543517.9	676941.7	-133423.8		Chandmani Halaikh company have -116 workers, from which male-62, famale-54
		Kiosks-23		rent	-	1	12600	43.2	-				23/f.	
		Boreholes -2	NGO	rent	-		-	-	-	-	-	-	2/m.	
4	Tuv, Zuunmod	Centralized system	LPC	Tuv Chandmani	Mechanical treatment	770	4944	550.0	110-120	114410.8	183002.4	-68591.6		Worker- 250, from which male -208, female-42
		Kiosks-17				1.9;1.5	9861	32.4						
5	Tuv, Sergelen	Borehole-1	LPC	rent	Broken down	1	271	0.9	-	73.2	15.0	58.2	1/m.	Operation cost on renter.
6	Tuv, Altanbulag	Boreholes -3	LPC	rent	-	1	986	3.2	-	133.1	25.0	108.1	1/m.	Operation cost on renter.
										133.1	25.0	108.1	1/f.	
			Army camp	Army camp				2.9	120				1/f.	
7	Tuv, Bayan-Unjuul	Borehole-1	LPC	contract	-	1000 MNT/ household, month	424	1.4	-	100.0	36.0	64.0	1/m.	Operation cost on renter.
8	Tuv, Undurshireet	Boreholes -2	LPC	rent	-	0.8	598	2.0	-	64.6	30.0	34.6	m	Rent-MNT15 thous.
				rent						64.6	30.0	34.6	m	

№	Soum, district	Soum center: Water supply	Wells: Ownership	Wells: Exploitation	Sewerage	Tariff, MNT/liter, MNT /per person per month	Number of consumers	Waterconsumption, thous. ml/year	Salary, taous.MNT/ month	Revenue and expenditure of water supplier, thous. MNT/ month: Revenue	Expenditure	Profit and loss	Six of the worker of the wells	Explanation
9	Tuv, Erdenesant	Centralized system	LPC	rent	Mechanical treatment	1	128	7.0	-	7008.0	6307.2	700.8		Rent-MNT3 thous. , 32 blocks apartment and kindergarten connected. Boreholes for livestock-2.
		Boreholes-4					1401	4.6	-	202.1	50.0	252.4	1/f. 3/m.	
										300.0	200.0	100.0		
10	Bulgan, Rashaant	Centralized system	LPC -3	rent -2	Mechanical treatment	1.5	943	3.1	90	202.5	60.0	42.5	1/m.	Building of soum government and some organizations connected, 1 borehole in reserve
		Boreholes-4								52.1	5.0	47.1	1/m.	
			private	private -1						221.0	121.0	120.0	1/m.	
11	Bulgan, Gurvanbulag	Boreholes-2	LPC	rent -2	-	1	1130	3.7	-	305.1	130.0	175.1		
12	Bulgan, Dashinchilen	Boreholes-3	LPC	rent -2	-	5-for pop., 4-for org.	928	3.0	-	1252.8	900.0	352.8	1/m.	Water transported from 6 km. 1 borehole broken
13	Bulgan, Buregkhangai	Boreholes -3	LPC	rent -3	-	1 2-transport	865	2.8	-	98.6	15.0	83.6	2/f.	Organizations supplied by transport
									-	67.5	6.0	61.5	1/m.	
14	Bulgan, Khishig-Undur	Boreholes -5	LPC	rent -2	-	1	1321	4.3	-	162.0	15.0	147.0	1/f.	
										108.0	8.0	100.0	1/m.	
			private	private						86.7	10.0	76.7	1/m.	
15	Bulgan-Bayannuir	Boreholes -3	LPC	rent	Discharged to soil	2	689	2.3	-	124.0	20.0	104.0		Some organizations are connected
			private	Private-2						124.0	20.0	104.0		
16	Selenge, Orkhontuul	Centralized system	LPC	Tuuliin khishig	Mechanical treatment, and discharged to the river	1430	592	32.4	-	-	-	-		Tuuliin khishig LPC started to work
		Borehole-1				1	354	1.2	-	-	-	-		
17	Tuv, Zaamar	Boreholes -2	LPC	salary	Broken down	0.5 1 transport	1549	5.1	120	418.2	280.0	138.2	2/f. 1/m.	Water transporter by revenue

№	Soum, district	Soum center			Sewerage	Tariff, MNT/liter, MNT /per person per month	Number of consumers	Waterconsumption, thous. ml/year	Salary, taous.MNT/ month	Revenue and expenditure of water supplier, thous. MNT/ month			Six of the worker of the wells	Explanation
		Water supply	Wells											
			Ownership	Exploitation						Revenue	Expenditure	Profit and loss		
18	Zaamar, Khailaast	Boreholes -2	private	rent	Mechanical treatment	1.5	2691	8.8		526.5	350.0	176.5	1/f.	Shijit alt Co.Ltd carried water supply and sewerage, rent-0.9 MNT/l.
				private					-	563.3	200.0	363.3	1/m.	
19	Tuv, Bayankhangai	Boreholes -3	LPC	private	Broken down	1	753	2.5		65.1	15.0	50.1	1/f.	Rent-MNT8 thous.
										65.1	15.0	50.1	1/m.	
										65.1	15.0	50.1	1/m.	
20	Tuv, Argalant	Boreholes -4	LPC	salary	-	1	763	2.5	120	206.0	198.0	8.0	4/m.	1 borehole in reserve
				rent -1					-	-	-	-		
			private	private					-	-	-	-		
21	Tuv, Bayantsogt	Boreholes -2	LPC	rent	Broken down	1.5	949	3.1	-	192.1	31.5	160.7	m	Rent-MNT 1.5 thous.
			private	private					-	192.1	31.5	160.7	2/m.	
22	Tuv, Ugtaaltsaidam	Boreholes -2	LPC	rent	Broken down	0.5	1300	4.7	-	350.0	140.0	210.0	1/m.	
			private						-	300.0	120.0	180.0	1/m.	
22	SKhD, Jargalant	Boreholes -2	LPC	rent	-	1 2.74 transport	1800	5.9		243.0	121.5	121.5	2/m.	Mungun reis CPC carried water supply. Rent-50% from revenue

ANNEX 4. Questionaire for the soum population

.... aimag ....soum

Your: Age ... male ... female... Education ....

1. **Family members** ......
2. **Head of family age, sex:** ....
3. **Education of head of family**
   - *Primary and secondary*
   - *Technical*
   - *Higher*
4. **Who mainly collect the water:**
   - *Adult* *man* *female*
   - *Children* *boy* *girl*
5. **From where do you collect water in the warm season?**
   - *Rivers*
   - *Borehole*
   - *Dug well*
   - *others*
6. **From where do you collect water in the winter time?**
   - *Snow and ace*
   - *Dug well*
   - *Borehole*
   - *others*
7. **Is your drinking water source separate from livestock water source**
   - Yes
   - No
8. **How much time do you spend for water collection?**
   - *To 1 hour*
   - *2-3 hours*
   - *1-2 hours*
   - *Over 3 hours*
9. **From what distance do you collect the water?**
   - *0-300 meter*
   - *301-1000 meter*
   - *Over 1000 meter*
10. **Is your water source is protected?**
    - Yes
    - No
    - *I don't know*
11. **Is your family (in months)**
    - *Income* ....
    - *Expenditure* ....
12. **How much water does your family use in per day?** ...
    - *For food and drinks* ....*l*
    - *For sanitation need* ....*l*
    - *For washing dishes* .... *l*
    - *For washing clothes and cleaning* ....*l on average.*
13. **If will improve your water quality and water supply condition, will you pay additional money? If will how much for per l?**
    - *Yes* ....*MNT*
    - *No*
    - *I don't know*
14. **If will improve your water quality and water supply condition, does your family will use more water for domestic purpose.**
    - *Yes*
    - *No*
    - *I don't know*
15. **Where do you watering your?**
    - *River*
    - *Snow and ace*
    - *Borehole*
    - *Others*
16. **Water for livestock**
    - *Enough*
    - *Not enough*
    - *Need new borehole or wells.*

Date: ………..2009

ANNEX 5. Livestock composition of the Tuul River Basin, 2010

No	Aimag, soum	Total	camel	horse	cattle	sheep	goat
1	Arkhangai	214850	329	12156	7951	125275	69138
1	Ugiinuur	27335	83	1590	1449	14559	9655
2	Khashaat	187515	247	10567	6502	110717	59484
2	Bulgan	887963	577	59924	44676	471778	311008
1	Bayannuur	83547	50	5242	5521	40368	32366
2	Buregkhangai	127354	253	6735	7823	64611	47931
3	Gurvanbulag	262945	89	16144	9853	149599	87260
4	Dashinchilen	177489	106	12438	9618	94699	60628
5	Mogod	50015	3	5240	3082	28939	12752
6	Rashaant	119433	75	8047	4213	60156	46942
7	Khishig-Undur	67180	1	6078	4567	33406	23128
3	Uvurkhangai	233486	342	15462	6118	132490	79074
1	Bayan-Undur	25927	58	1765	903	14134	9067
2	Burd	170029	235	11011	3795	98983	56005
3	Yusunzuil	16914	23	1146	441	8966	6337
4	Kharkhorin	20616	25	1539	979	10407	7666
4	Selenge	43030	114	2682	2948	20584	16703
1	Orkhontuul	43030	114	2682	2948	20584	16703
5	Tuv	1357707	769	101367	74068	678710	502793
1	Altanbulag	125679	13	12346	7806	57359	48155
2	Argalant	51287	6	3518	2871	26968	17923
3	Bayandelger	7860	4	594	420	4260	2582
4	Bayan-Unjuul	70858	98	4995	2604	36348	26812
5	Bayankhangai	74822	3	4511	3607	37383	29318
6	Bayantsogt	67086	65	5553	4117	34304	23049
7	Buren	31499	17	1974	1104	16384	12020
8	Zaamar	164831	44	11098	8727	79409	65553
9	Zuunmod	31971	0	3340	2693	14606	11332
10	Lun	187789	302	12621	8413	98903	67550
11	Undurshireet	144029	43	10371	7130	70335	56150
12	Sergelen	18121	8	2237	907	9420	5549
13	Ugtaaltsaidam	88930	5	7134	6220	42588	32983
14	Tseel	21955	15	1565	1453	10528	8394
15	Erdene	92358	49	5821	8897	45181	32409
16	Erdenesant	178632	96	13689	7100	94734	63013
6	Ulaanbaatar	116488	57	10296	31609	37675	36849
1	Bayangol	32	0	6	26	0	0
2	Bayanzurkh	38483	3	3045	11460	11706	12269
3	Nalaikh	39709	53	3262	7718	15908	12768
4	Songinokhairkhan	3811	0	306	1233	1212	1058
5	Sukhbaatar	3842	0	318	2528	348	648
6	Chingeltei	1507	0	28	895	138	446
7	Khan-uul	29104	1	3331	7749	8363	9660
	TOTAL	2853523	2188	201886	167370	1466514	1015565

Part 6.
WATER SUPPLY, WATER CONSUMPTION–USE, WATER DEMAND AND HYDRO–CONSTRUCTION

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[1] *Strengthening Integrated Water Resource Management in Mongolia project*

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Introduction

The Tuul River originates from the Khentii Mountains and flows into Orkhon River. This is the most overloaded river in terms of water consumption-use by socio-economic sectors as the city of Ulaanbaatar is located in the midstream part of the river. There are 127 small tributaries such as Khag, Khongor, Zuunbayan, Terelj, Khuliin River, Uliastai, Selbe, Kharbukh, etc and these all create the basin with an area of 49774.3 km^2.

Compared to other basins in Mongolia, the Tuul River Basin has the largest number of consumers, its groundwater is used the most, the river is significantly polluted and its ecological balance is being lost.

As of 2008, there were 1098.5 thousand inhabitants in the basin and as of 2010, there were 1191.3 thousand inhabitants, over 4000 small-medium sized industries, 40 mining industries, 16000 economic entities, 170000 ha pasture land, 2951.2-2853.5 thousand livestock, as well as the largest three thermo-power plants, main source of a central power system are located in the basin.

The basin includes some 7 districts of Ulaanbaatar except Baganuur, Bagakhangai districts, and Jargalant village of Songinokhairkhan district, Zuunmod city of Tuv aimag, 2 soums of Arkhangai aimag, 7 soums of Bulgan aimag, 4 soums of Uvurkhangai aimag, 1 soum of Selenge aimag, 15 soums of Tuv aimag and totally the territories of 29 soums, as well as 19 soum centres.

Mongolia's millennium development goals have suggested reducing number of people who can't have an access to safe drinking water down to 40% and number of people who aren't involved in improved sanitation down to 30% by 2015, respectively.

If partial general plan is approved and accordingly, apartments for not less than 80000 households are built in some 35 locations within the framework of the project for 'Housing 100000 Households' which stated in mid-term programme of the 'New Creation' approved by the State Great Khural in 2010, some 70% of Ulaanbaatar population will be enabled to connect to the centralized water supply and sewerage system by 2016.

The government of Mongolia has approved and is implementing programmes such as Water National Programme and Development Programme for Turning Ulaanbaatar Ger Areas into Apartment Area which are significantly important in water supply, social change and innovation.

Within the framework of the above projects and programmes, and legislations approved by the State Great Khural and the government, a report on water supply, water consumption-use and water demand (for 2015 and 2021) has been formulated based on the results and conclusions from the studies carried out by consulting team of the project of Strengthening Integrated Water Resource Management in Mongolia, other legal documents and data obtained from public administrative authorities.

1. Method calculated water consumption–use and water demand

1.1. Water consumption and water demand for people in urban areas

The water consumption in urban areas included in this river basin limited by watershed boundaries, has been calculated per person and per year. The Ulaanbaatar population is divided into apartment and ger area residents and their water consumption has been calculated by each consumer.

And the ger area residents are divided into two terms: supplied by water kiosk connected to the centralized water supply and sewerage network and supplied by water kiosk not connected to the centralized network. In calculating water consumption for people, it is based on water consumption norm and actual water consumption.

Also data of the consumer's department of Water Supply and Sewerage Company of Ulaanbaatar has been used. Current water consumption and future water demand for people are calculated according to the following norms (Table 1).

Table 1. Water consumption norm

Water supply source	Water consumption norm, liter/day			
	2008	2010	2015	2021
Apartment resident connected to the centralized water supply network	230	230	200	160
Apartment resident connected to the centralized water supply network (but without hot water)	175*	175*	170	160
Ger area resident supplied from water kiosk connected to the centralized water supply network	8*	10*	25	30
Ger area resident supplied from water kiosk not connected to the centralized water supply network	6*	8*	15	20
Resident fetching water from open water sources such as rivers, springs and streams	6*	8*	10	15

* *The water consumption in 2008 and 2010 was calculated using the actual water use in l/day per person*

A projection of the basin population in 2015 and 2021 has been calculated by the method that calculated population growth from 2010 to 2040 which released by the National Statistics Committee at national level.

Water consumption for people in aimag centre and urban areas equivalent to aimag centre has been divided into apartment and ger areas and calculated by each consumer based on the report on organisation in charge of water supply issues, number of residents in apartment and ger areas, water meter indication and sold water, etc in the related urban areas.

1.2. Water consumption and water demand for people in rural areas

The water consumption (of herdsmen and farmers) in rural areas and soum centres has been calculated per person and per year. The statistics data organisations release some other data and information related to number of population and livestock and water consumer by administrative unit.

The number of herdsmen and livestock has been calculated by multiplying pasture area included in the related soum territory by density of rural (herdsman) population and livestock in 100 ha pasture area of the related soum.

In calculating water consumption and water demand (after determining number of consumer), a Matlab model created in the scope of the project has been used.

Water consumption for people in soum centre and rural areas in the Tuul River Basin has been calculated based on population and water consumption norm per person per day.

1.3. Water consumption-use and water demand in agricultural sector

Main consumer in agricultural sector is irrigated crop and livestock husbandry.

Water use for irrigation schemes has been calculated based on 'Irrigation norm for irrigated area' considering natural zone and melioration subdivision (or division into regions).

Due to green house is tended to develop in the vicinity of Ulaanbaatar in recent years its water use has been calculated according to 'irrigation norm for irrigated area'.

In view of number, type and age of livestock and seasonal conditions, volume of drinking water for livestock has been calculated based on temporary water consumption norm for livestock. Water consumption for pig and poultry farms calculated based on the norm used in Russia.

1.4. Water use and water demand in industrial sector

Water use has been calculated by each leading sector such as water supply for food and light, mining, processing, energy and heat industries. In calculating industrial water use, it is based on water norm for annual mining, manufacturing output, unit production of the related economic entity as well as conclusion on its water use, and annual report, etc. For some products of which their water consumption norm wasn't determined, it has been calculated by method of comparison to the similar products and service norm.

Water use for mining and processing industries has been calculated based on water norm for unit products.

1.5. Water supply and water consumption of tourist camps and green areas

Water consumption for tourism and tourist camps has been calculated by 'water consumption norm for public utility services' based on number of tourists visited the basin, number of tourist camps and hotels to serve the tourists, classes and capacity of the camp and operation season, etc.

Water use for irrigated lawn, parks, green areas, irrigated forest areas in the capital city and aimag centres has been calculated considering type and quantity of seedlings and trees. In calculating water consumption for green areas, lawn and tree irrigation, it is based on 'temporary lawn irrigation norm' and 'water consumption norm for forestation'.

2. Water supply, water consumption–use and water demand

2.1. Water supply, water consumption and water demand in urban and rural areas

2.1.1. Population of the city of Ulaanbaatar

Picture 1. View of Ulaanbaatar

For geographical location, the Tuul River Basin includes Nalaikh, Bayanzurkh, Sukhbaatar, Chingeltei, Khan-Uul, Bayangol and Songinokhairkhan districts of Ulaanbaatar, whereas Baganuur district is included in the Kherlen River Basin, Bagakhangai district included in Umart Gobi Guveet-Khalkhiin dundad steppe, and Jargalant khoroo of Songinokhairkhan district included in the Kharaa River Basin, respectively.

Industrial fundament was firstly founded in Ulaanbaatar in 1930s. The centralized water supply has been firstly established by carrying out an investigation on water supply for initial thermo-power plant and establishing wells for its use.

Ulaanbaatar was expanding from year to year since 1954 and urban development future planning was forcefully formulated with the support of then-social and domestic designing organisations of Soviet Union (former name of Russia). Consequently, 'the centralized water supply and sewerage system' consisting of pipeline for water abstraction and delivery and domestic and industrial wastewater treatment plant was established in 1959.

Next urban development plans were formulated in 1970 and 2002, respectively and some framework such as studies on supplying water demand, investigation of water bodies/ sources and resources, feasibility studies, design and drawings, construction works, etc have been planned at certain stages by years and performed with the support of the state budget, foreign loan and grant aids.

The capital city is supplied from 4 groundwater water sources (Central, Upper, Industrial and Meat factory) in the Tuul River valley from Zuunmod in upstream part to the Songino Bridge (Picture 2).

Due to increase of water use depending on growth of population and number of organisations that provide civil service and business activities in Ulaanbaatar, some factories, economic entities and citizens have established and are using 589 wells for their own domestic and industrial demand.

Ulaanbaatar is the largest user which abstracts 323.6 thousand m^3 water per day from alluvial aquifer in the Tuul River valley.

Main water supply sources of Ulaanbaatar as follows:

Central source: is located in south-east of the city, the largest source and current water abstraction ranges from 87-90 thousand m^3 from 70-80 wells per day on an average. Water is supplied for water consumers in east, central and north parts of the city through water supply circle network.

Industrial source: is located in the territory of Khan-Uul district and distributed for water demand of factories, economic entities and apartments. This source is to be used for water supply in present time and near future. But in future planning, it would be appropriate to replace water demand of this part with another one or this source is to be used only for drinking water purpose.

Meat factory source: 15 thousand m^3 water is abstracted from 11 wells through 4 pump stations per day on an average and it supplies drinking water to factories, economic entities and apartments in Tolgoit area.

Upper source: 45 thousand m^3 water is abstracted from 55 wells through 5 pump stations and distributed for the purpose of increasing water consumption-use of central part of the capital city.

Table 2. Water volume abstracted and distributed per day by the Water Supply and Sewerage Company of Ulaanbaatar

Quantity of water source	Quantity of well	Project capacity, thous. m^3/day	Water distributed per day, thous. m^3					
			2005	2006	2007	2008	2009	2010
4	176	248.0	157.3	151.7	153.7	150.0	154.4	157.3

110-130 of overall 176 wells in 4 water sources of Ulaanbaatar are frequently used everyday.

In connection with socio-economic development of the basin, water demand will increase in the future. According to the “Second Ulaanbaatar Services Improvement Project” by World Bank, current water sources are expected to be no longer able to supply the city’s water demand from 2015. Please see Figure 2.

Please note that water abstracted from 32 wells established for technological demand of thermo-power plants and 589 wells established for own water demand of citizens and economic entities in Ulaanbaatar is not included in this calculation.

Ulaanbaatar water supply is currently handled by Water Supply and Sewerage Company, 21 offices (under management agreement) of Housing and Public Utility Authority and 22 private companies.

Source: Second Ulaanbaatar Services Improvement Project, 2008

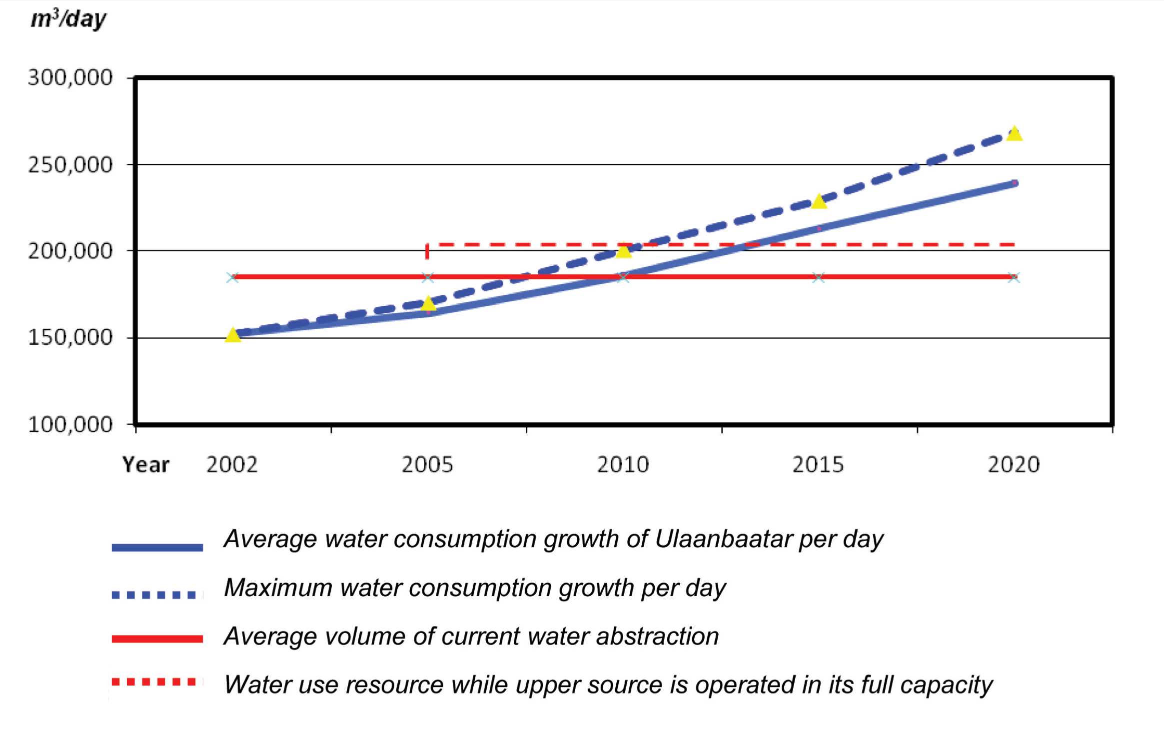


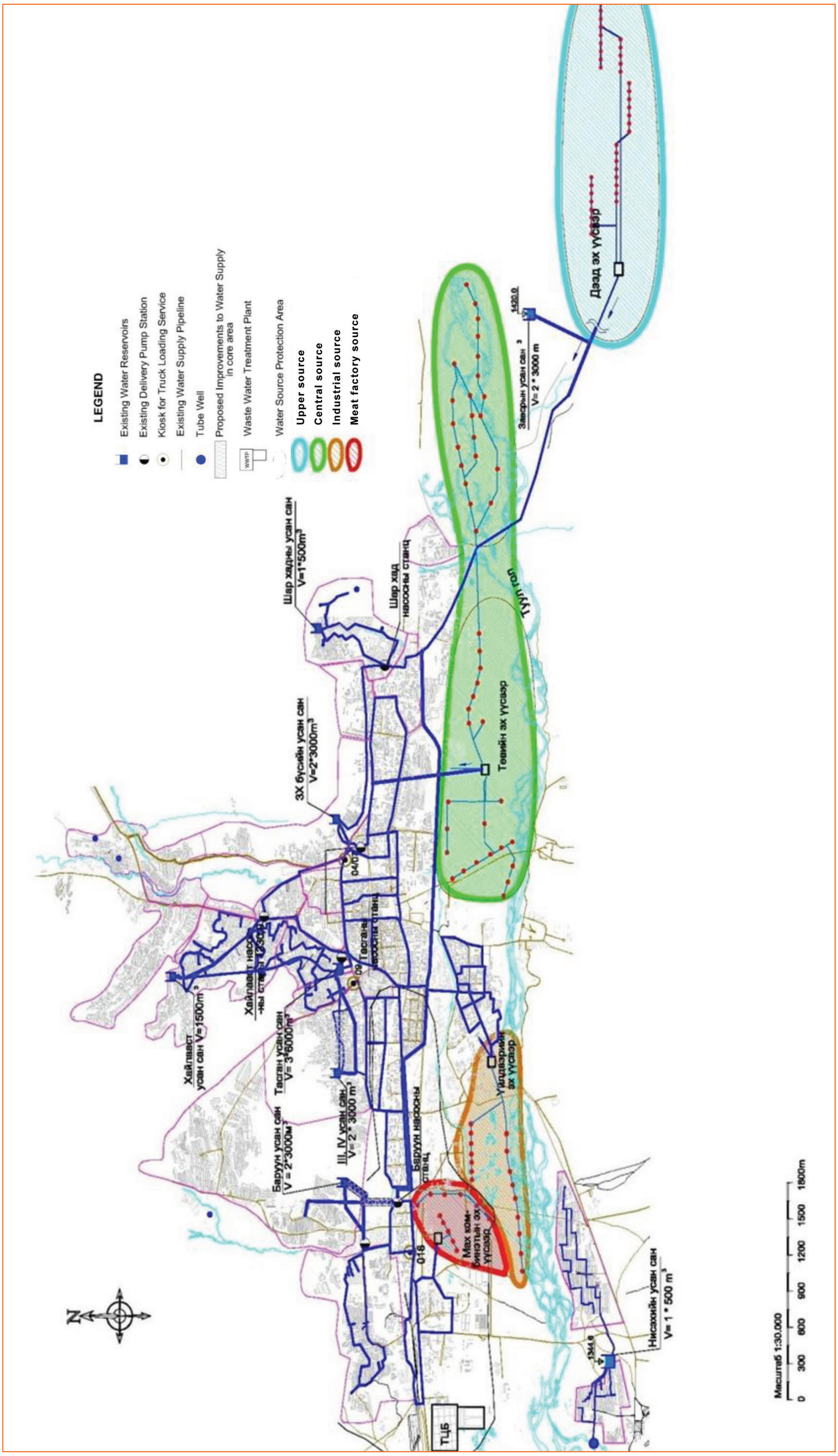
Figure 2. Potential exploitable water resource of water sources in Ulaanbaatar, its water consumption and water demand

Ulaanbaatar residents are divided into two parts: apartments connected to the centralized water supply network and ger area not connected to the network. With regard to how drinking water is delivered and what water supply source is used, it has been determined in 2008 within the framework of the 'Water Supply and Sanitation' project implemented by UNICEF and WHO in Mongolia.

Table 3. Coverage of Ulaanbaatar citizens by water supply sources

№	Involvement in water supply source	Coverage, %
1	Apartment residents connected to the centralized water supply network both hot and cold water	37.7
2	Apartment residents connected to the centralized water supply network, but only cold water	-
3	Residents supplied by water kiosk connected to the centralized water supply network	21.4
4	Residents supplied by water kiosk not connected to the centralized water supply network	21.2
5	Residents supplied from protected water sources	19.7
6	Residents supplied from unprotected water sources	-
7	Other	-
	Total	100.0

Water is delivered to residents of apartments connected to the centralized water supply network through 'Water and Heat Transmission Centre' of Housing Utilization Offices.



Picture 3. Layout of water supply sources in Ulaanbaatar

Water and heat tranmission centres have installed water metre in water distribution pipelines and consumer-households. Consequently, there has been some results such as citizens enabled to control their water consumption, removal of loss and reduction of unproductive expenses. And water consumption per person reached 272.3 l per day by the end of 2008. Compare to average water consumption in other countries, this volume is a substantial.

According to study of Geoecological Institute of Mongolia's Scientific Academy, water meters have been installed in some 5% or 20,000 of overall households connected to the centralized water supply network. As a result, it's been concluded that water consumer with water metre use 100 l water per day.

Currently, Water Supply and Sewerage Company (USUG) have installed water metre in 99.9% of its all consumers. These include public administrative authorities, factories and consumers 100%. And water payment is being processed by indication of water metre.

Water demand for Ulaanbaatar population has been calculated for present time, 2015 and 2021 and shown in Table 4 and it is based on census conducted by the Metropolitan Statistics Authority in 2008 and 2010, result of state census of population and apartments conducted by the National Statistics Committee in 2010, and calculation compared to indicators of water supply and sanitation facilities included in the Millennium Development Goals released by the Ministry of Road, Transportation, Construction and Urban Development (MRTCUD).

Projection of Ulaanbaatar population in 2015 and 2021 has been calculated by methodology calculated population growth 2010-2040 by the National Statistics Committee.

Table 4. Water consumption and water demand of Ulaanbaatar population

№	Water supply source and status of supply		Population, *thous. person*				Water consumption, *thous. m^3 /year*			
			2008	2010	2015	2021	2008	2010	2015	2021
1	Centralized water supply	With hot and cold water	389.0	431.1	636.9	762.7	32653.9	36190.0	46490.9	44541.3
		With cold water	-	-	-	-	-	-	-	-
		From water kiosk	220.6	251.0	318.7	370.3	644.3	916.0	2908.3	4055.2
2	Non-centralized water supply	From water kiosk	219.3	243.4	213.3	305.2	480.3	710.7	1167.9	2227.8
3	From protected source		-	-	-	-	-	-	-	-
4	From non-protected source		203.4	200.0	153.4	47.5	445.5	583.9	559.9	260.3
5	From other sources		-	-	-	-	-	-	-	-
	Total		1032.3	1125.5	1322.3	1485.7	34223.9	38400.7	51126.9	51084.6

Within the framework of the project for '40000 and 100000 households apartments' and direction of 'Comprehensive National Development Policy based Millennium Development Goals' approved by the State Great Khural (Congress) in 2008, many number of households will be enabled to move to a convenient apartments and have an access to the centralized water supply that meets standard requirements, and water access will be increased.

One objective of the integrated water management is to increase number of water consumers connected to the centralized supply network, to coordinate it with water availability and source resource and to consider whether or not providing consumers' demand.

On the other hand, in this time of population growth and water demand increase under limited condition of water resource, some industries that fresh water is not required such as carwash, lawn irrigation, construction concrete production, etc are necessarily expected to reuse wastewater by treating it using high technology. Also it needs to create a new water source and to renew and expand the existing pipeline.

It is necessary to legislate and enforce an economic leverage for the purpose of efficient water use by consumers, and treatment and reuse of wastewater.

According to data of metropolitan public administrative authorities, approximately 20000 migrants migrate to Ulaanbaatar every year and it mechanically grows the population. Considering actual and mechanical population growth of the capital city, several internationally and nationally invested projects have been implemented in order to supply safe drinking water for people. And the projects have been resulted:

- Project for Urgent Maintenance of Equipments for Water Supply in Ulaanbaatar 1997-1999 (with grant aid from Japan),
- Project for Innovation of Equipments for Meat Factory Source 2000 (Denmark),
- Project for Innovation of Equipment for Industrial Source 2001 (China),
- Project for Automation of Equipments for Tasgan Transmission and Pump station in 3rd and 4th Districts 2004 (Russian Sinetik LLC),
- Project for Innovation of Equipments for Upper Source 2005-2007 /with grant aid from Japan/,
- Project for Improving Public Utility Services in Ulaanbaatar 2008 (World Bank).

2.1.2. Population of Zuunmod

Only aimag centre located in the Tuul River Basin is Zuunmod, Tuv aimag centre. State-owned Tuv Chandmani thermo-power plant is responsible for water supply and heat industry of Zuunmod.

Centralized water supply source of Zuunmod is a groundwater and water is abstracted and distributed from the Khushig Valley 12 km in the south-west of the aimag centre.

As of 2008, there have been 14,805 inhabitants of 4100 households in Zuunmod. Of these, some 33.4% or 4944 inhabitants live in apartments connected to the centralized water supply network and 66.6% or 9861 inhabitants live in ger area.

Picture 4. Current appearance of Zuunmod

According to the national census of population and apartments in 2010, in total 15295 inhabitants have been registered in Zuunmod. In terms of water supply network, inhabitants supplied from the centralized water supply network reached 34.1% and increased by 0.7% since 2008.

In recent years, newly built house area is being connected to the centralized water supply network. There is thermo-station in Zuunmod for heat supply for factories and public administrative authorities in winter. But as of 2008, the station didn't operate in its full capacity. Therefore, apartments and offices were supplied from heating stoves with a small capacity.

Annual water consumption of Zuunmod in 2008 and 2010 determined by each water supply source is shown in Table 5 based on its population using 'Temporary water consumption norm' and Microsoft Excel and Word and Matlab programmes.

Table 5. Water consumption and water demand of Zuunmod

№	Water supply source and status of its supply		Population, *thous. person*				Water consumption, *thous. m^3/year*			
			2008	2010	2015	2021	2008	2010	2015	2021
1	Centralized water supply	Hot and cold water	-	-	-	-	-	-	-	-
		Cold water	4.9	5.2	8.8	11.1	315.8	333.1	547.1	649.1
		From water kiosk	5.5	8.4	6.3	4.3	16.0	30.6	57.1	47.5
2	Non-centralized water supply	From water kiosk	4.4	1.7	-	-	9.6	4.9	-	-
3	From protected source			-	-	-	-	-	-	-
4	From unprotected source			-	-	-	-	-	-	-
5	From other sources			-	-	-	-	-	-	-
Total			14.8	15.3	15.1	15.4	341.4	368.7	604.2	696.6

This water consumption has been calculated based on the projection of Zuunmod population in 2015 and 2021 included in the Projection of Mongolia's Population 2010-2040 released by the National Statistics Committee.

2.1.3. Soum centre population

Some 19 soums of Tuv, Uvurkhangai, Arkhangai, Bulgan and Selenge aimags included in the Tuul River Basin. There are centralized water supply network in some soums, but not used. Water source is a groundwater in floodplain of the Tuul River and its tributaries. There is a steel water tank with a capacity of 2-4 m^3 and 2.5 wells for water supply of each soum and inhabitants fetch water from the wells. In some soums, water is delivered to public service establishments of soum centre by water truck and horse-cart, but this is not on regular basis throughout the year.

Wells in soum centres are not only used for the purpose of water supply for people, also its use is combined with domestic activities such as production and vegetable irrigation, etc.

Actions for sterilization and freshening of a drinking water are not taken. General chemical analysis is usually carried out in water when boreholes put into operation, and regular analysis is not carried out according to drinking water requirements and national standards during use of the wells.

Picture 5. Drilled wells for water supply in soum centre

Citizens of soum centre and rural areas are subject to rural population chapter according to classification of the National Statistics Committee. However they are divided into two parts: consumer of soum centre and consumer of rural areas depending on their different water consumption norm and their consumptions have been calculated separately. Current water consumption of soum centres in the basin has been determined by each consumer based on Mongolia's statistics book in 2008 and 2010, summary results of a national census on population and apartments in 2010 (Table 6).

Table 6. Water consumption and water demand of inhabitants in soum centre

№	Aimag	№	Soum	Population, thous. person				Water consumption, thous. m^3/year			
				2008	2010	2015	2021	2008	2010	2015	2021
1	Arkhangai	1	Khashaat	0.8	1.1	1.1	1.2	2.2	4.0	4.8	7.3
2	Bulgan	2	Bayannuur	0.7	0.7	0.7	0.7	1.9	2.5	2.9	4.4
		3	Buregkhangai	0.9	0.8	0.8	0.8	2.4	3.0	3.5	5.3
		4	Gurvanbulag	1.1	1.2	1.2	1.3	3.2	4.4	5.2	7.9
		5	Dashinchilen	0.9	1.1	1.1	1.1	2.6	3.8	4.5	6.8
		6	Rashaant	0.9	1.7	1.7	1.7	2.6	6.0	7.0	10.7
3	Selenge	7	Orkhontuul	0.9	1.3	1.3	1.4	2.6	4.7	5.6	8.6
4	Tuv	8	Altanbulag	1.0	0.9	0.9	0.9	2.8	3.1	3.6	5.5
		9	Argalant	0.8	0.8	0.8	0.8	2.1	2.8	3.3	5.0
		10	Bayan-Unjuul	0.4	0.7	0.7	0.7	1.2	2.5	2.9	4.4
		11	Bayankhangai	0.8	0.8	0.8	0.8	2.1	2.8	3.3	5.0
		12	Bayantsogt	0.9	0.8	0.8	0.9	2.7	3.0	3.5	5.4
		13	Zaamar	4.2	3.8	3.7	3.8	11.9	13.4	15.8	24.0
		14	Lun	1.3	0.9	0.9	0.9	3.5	3.2	3.8	5.7
		15	Undurshireet	0.6	0.4	0.4	0.4	1.7	1.3	1.5	2.3
		16	Sergelen	0.3	0.5	0.5	0.5	0.8	1.7	2.0	3.1
		17	Ugtaaltsaidam	1.4	1.4	1.4	1.4	3.9	5.0	5.9	8.9
		18	Erdenesant	1.5	1.4	1.4	1.5	4.3	5.1	6.1	9.2
5	Uvurkhangai	19	Burd	0.5	0.5	0.5	0.6	1.5	1.9	2.3	3.5
Total				20.0	20.9	20.6	21.1	56.0	74.1	87.4	132.7

Local administration has set a sanitation zone 25 m around the wells used for water supply in soum centres, and wells in some soums are fenced and protected against building construction and apartment for the purpose of industry and service.

Picture 6. Fenced and protected well in soum centre

Picture 7. Water freshening equipment installed in wells of soum centres

Some water freshening and softening equipments have been installed in some wells with highly mineralized drinking water in Bayan-Unjuul soum of Tuv aimag and Dashinchilen soum of Bulgan aimag. But these equipments were frozen in winter and no longer used.

2.1.4. Rural population of soum

Wells for watering livestock established with the purpose of water supply sources for rural people (herdsmen and farmers), mining wells, rivers, streams and springs are used in any part of Mongolia, sometimes water from ice and snow is used in winter.

Picture 8. Boreholes for rural people and livestock water supply

In other words, both people and livestock are supplied from the same source. But in some Gobi and steppe regions, groundwater is, due to high mineralization, unable to be used for drinking purpose. In this case, local citizens select fresh water source on their own and fetch water from there. They may call it as 'Drinking water'.

Geo-ecological Institute has been carrying out number of studies in the field of water mineralization of the Tuul River for many years. According to comparison of recent three years' indicators (in 2008, 2009 and 2010), the mineralization content sharply increased up to 532.5-688.2 mg/l after treated wastewater joining the Tuul River from the central wastewater treatment plant. When it reaches Altanbulag soum of Tuv aimag, mineralization decreases at 169.0-228.8 mg/l and increases again near Zaamar and keeps high mineralization until confluence with the Orkhon River (300.1-388.6 mg/l).

The Tuul River is very fresh in its upstream part not reaching 100 mg/l whereas its mineralization increases by 3-4 times in downstream. But this is within the permissible limit of a chemical component of drinking water quality for people and livestock.

Due to occurrence of a natural phenomenon such as drought of small rivers and disruption of their runoff, herdsman family usually summer in parts that runoff occurs. As a result, plenty of water pollution by dung and it does not meet the drinking water requirement. Therefore, it is necessary consume this water after treatment.

Rural citizens of 29 soums of Arkhangai, Uvurkhangai, Bulgan, Tuv and Selenge aimags are included in the Tuul River Basin.

Inhabitants of bag (sub-soum) centre separate from soum centre, small mining and farming activities runners, herdsmen who use their livestock productivity as their own income source, and permanent rural inhabitants have been involved. Number of water consumer and water consumption have been determined by each soum included in the basin based on Mongolia's Statistics Book 2008 and 2010, summary result of the national census on population and apartments in 2010, and temporary water consumption norm (Table 7).

Table 7. Water consumption and water demand of rural people

№	Aimag	№	Soum	Population, *thous. person*				Water consumption, *thous. m³/year*			
				2008	2010	2015	2021	2008	2010	2015	2021
1	Arkhangai	1	Ugiinuur	0.4	0.4	0.4	0.4	1.0	1.3	1.5	2.4
		2	Khashaat	2.1	1.8	1.8	1.8	4.6	5.3	6.5	10.1
	Bulgan	3	Bayannuur	0.7	1.0	0.9	1.0	1.6	2.8	3.4	5.3
		4	Buregkhangai	0.9	1.0	1.0	1.0	2.0	3.0	3.7	5.7
		5	Gurvanbulag	1.9	1.9	1.9	1.9	4.2	5.5	6.8	10.4
		6	Dashinchilen	1.4	1.3	1.3	1.3	3.1	3.8	4.6	7.1
		7	Mogod	0.5	0.5	0.5	0.6	1.2	1.6	2.0	3.0
		8	Rashaant	2.1	1.5	1.5	1.5	4.7	4.3	5.3	8.2
		9	Khishig Undur	0.8	0.8	0.8	0.9	1.9	2.5	3.0	4.7
2	Selenge	10	Orkhontuul	0.6	0.6	0.6	0.7	1.2	1.9	2.4	3.7
3	Tuv	11	Altanbulag	1.9	1.9	1.9	2.0	4.3	5.7	7.0	10.7
		12	Argalant	1.0	0.7	0.7	0.7	2.2	2.0	2.4	3.8
		13	Bayandelger	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3
		14	Bayan-Unjuul	0.9	0.6	0.6	0.7	1.9	1.9	2.3	3.6
		15	Bayankhangai	0.7	0.6	0.6	0.7	1.5	1.9	2.3	3.6
		16	Bayantsogt	1.0	0.9	0.9	0.9	2.1	2.7	3.3	5.1
		17	Buren	0.5	0.5	0.4	0.5	1.0	1.3	1.6	2.5
		18	Zaamar	1.6	1.3	1.3	1.3	3.6	3.8	4.7	7.2
		19	Lun	1.2	1.7	1.7	1.7	2.7	5.0	6.1	9.4
		20	Undurshireet	1.4	1.5	1.4	1.5	3.0	4.3	5.2	8.1
		21	Sergelen	0.5	0.4	0.4	0.4	1.0	1.3	1.5	2.4
		22	Ugtaal	0.8	0.9	0.9	0.9	1.8	2.7	6.4	9.8
		23	Tseel	0.2	0.4	0.4	0.4	0.4	1.2	1.5	2.3
		24	Erdene	1.4	1.4	1.4	1.5	3.1	4.2	5.2	8.0
		25	Erdenesant	2.2	2.2	2.1	2.2	4.8	6.3	7.8	12.0
4	Uvurkhangai	26	Bayanundur	0.6	0.4	0.4	0.4	1.3	1.1	1.4	2.1
		27	Burd	2.4	2.3	2.3	2.4	5.3	6.8	8.4	13.0
		28	Zuil	0.5	0.4	0.4	0.4	1.0	1.3	1.6	2.4
		29	Kharkhorin	0.5	0.5	0.5	0.5	1.1	1.5	1.9	2.9
Total				30.7	29.4	29.8	31.1	67.6	86.9	107.0	164.9

In the event any soum territory is partially divided by the basin boundaries, soum population has been determined by coordinating rural population density of the relevant soum with size of pasture area included in the basin. Compare to 2008, rural population in 2010 decreased by 3.5%. This is considered due to their migration to soum centre and urban areas.

2.1.5. Conclusion on water supply, water consumption for people:

- In Ulaanbaatar the actual drinking water consumption per day per apartment resident was reduced by 35.0 l in 2010 (237 l/day) compared to 2008 (272 l/day) and closely approached the water consumption norm approved by the Ministry of Nature and Environment. However the actual drinking water consumption by ger area residents did not increase, but kept the same level in 2010 as in 2008 and remained at less than three times the related water consumption norm.
- According to study amongst apartment in which water meter installed, the average water consumption per person per day is 110-120 l. Therefore, it's possible to reduce water consumption of Ulaanbaatar population by two times if water consumption of apartment households is calculated by water meter.
- Capacity of a toilet tank installed in toilet of apartments connected to the centralized water supply network ranges from 8 to 15 litres. If one person uses the toilet 4-5 times a day, some 25% of daily water consumption is used in toilet. It is important to consume fresh water as efficient as possible and especially to install /plumbing/ equipments in water tap and showers, etc of hotels, schools and entertainment places for efficient water consumption.
- There is an experience in China and Germany to reuse wastewater called 'Grey water' for flush toilet which treated after washing bodies and taking shower by collecting, treating and purifying it in a basement or first floor areas of the buildings. It needs to test this experience.
- Usage resource of Zuunmod water supply sources is 6480 m^3 per day in terms of A+B classes. By now 1090 m^3 water or some 16.8% of its capacity is being used and it is tended to use 30.0% by 2012. It needs to study the possibility of establishing international airport and satellite town of Ulaanbaatar based on water resources in Khushig valley on the ground of a complete calculation of Zuunmod water consumption in the future.
- It needs to install water freshening and softening equipments in wells with a high mineralization and hardness used for drinking water purpose in Bayan-Unjuul and Undurshireet soums centres of Tuv aimag and Dashinchilen soum centre of Bulgan aimag.
- Due to the same water supply source for both rural herdsman families and their livestock, herdsmen can't be supplied by drinking water that meets the standard. Therefore, it is considered that it needs to study and tackle issue to provide herdsmen with water freshening, softening and purifying mini-equipments and to provide drinking water to herdsmen of some areas in which surface water is lack and polluted.
- Average water consumption by people in soum centres is 15-18 m^3 per day. According to calculation by capacity of water-lifting equipments installed in wells that used for water supply, water resource is sufficient for drinking water. In the event of establishing industry which might require large volume of water use in soum centre, it needs to determine water source and its resource. It is necessary to deliver fresh water to public service organisations such as schools, hospitals, kindergartens and apartments, etc through pipeline and to establish a partial and integrated wastewater treatment plant.

2.2. Water supply, water consumption-use and water demand in municipal service sector

2.2.1. Public services: education, culture and health sectors

The capital city of Ulaanbaatar, the centre of public administration, science, culture, education and etc, is located in the Tuul River Basin. As of 2010, there have been over 100 universities, colleges and professional education centres, 230 general education schools and 260 pre-school education organisations.

As of 2010, there were more than 800 health organisations in the cities of Zuunmod and Ulaanbaatar that included in the basin. Of these, some 96% and 300 drug stores are located in Ulaanbaatar.

Except public administration, culture and scientific organisations number of international organisations are located in the capital city. There are approximately 300 public administrative organisations in the basin.

Public service organisations located in Ulaanbaatar and Zuunmod are connected to the centralized water supply pipelines network whereas organisations in soum centres are supplied from own wells and by transported water.

In connection with the increasing number of those involved in public services, a framework to expand and newly establish social infrastructure constructions is being performed by the state budget on annual basis.

The number of people who received service from public service organisations and their water consumption as of 2010 are shown in Table 8.

Table 8. Water consumption by public services in the cities (2010)

City	Education organisation, *thous. children*				Health organisation, *thous. children*			Offices	Water consumption, *thous. m³/year*			
	Kindergarten	General education school	University	Vocational training centre	Employees	Outpatient	Inpatient		Education organization	Health organization	Office	Total
Ulaanbaatar	54.2	184.6	181.0	19.0	18.3	676.1	313.6	72.1	2116.3	7764.0	349.0	3241.7
Zuunmod	3.6	14.3	1.0	1.3	1.1	19.2	15.7	3.9	58.4	21.9	18.9	99.2
Total	57.8	198.9	182.0	20.3	19.4	695.3	329.3	76.0	2174.7	7983.0	367.9	3340.9

In calculating water consumption of public service organisations, the water consumption norm approved by the resolution No.153 of Environmental minister in 1995, data and information on admission for academic year 2010-2011 by the Ministry of Education, Culture and Science (MECS), result of data and information on population disease and mortality by the end of 2010 by the Ministry of Health (MoH) have been used. Water demand of public service sector has been calculated based on population growth and shown in Table 9.

Table 9. Water consumption and water demand by public services in the cities

City	Water consumption, *thous. m³/year*			
	2008	2010	2015	2021
Ulaanbaatar	3079.9	3241.7	3475.0	3777.3
Zuunmod	94.2	99.2	106.3	115.5
Total	3174.1	3340.9	3581.3	3892.8

Water consumption has not been calculated due to incomplete data and information of those who are involved in public services located in soum centres included in the Tuul River Basin.

2.2.2. Commercial services

Commercial services include shops, restaurants, hotels, baths, hairdressers, laundry services, etc. Water consumption of these has been included in water consumption of the commercial service sector.

Hotels and restaurants: As of 2010, there were 15,000 economic entities and 800 hotels and restaurants that were running trade and service in Ulaanbaatar. There are approximately 100 trade and service centres, hotels and restaurants running activities in aimag and soum centres in the basin.

Laundry and dry-cleaning service: Laundry service is not common in Mongolia and citizens mostly wash at their home, because of their domestic culture. Also negative occurrences such as washing clothes and cars in the river water are still seen in summer. Hotels and clinic hospitals have their own laundries. Some few laundries such as Metro Express, etc have been started in Ulaanbaatar, but can't be commonly used by the citizens due to its high price and location, etc.

But dry-cleaning is commonly used by citizens and there are approximately 60 dry-cleanings in Ulaanbaatar. These places are mostly connected to the centralized water supply and sewerage network. There is no laundry and dry-cleaning in soum centres that included in the basin so far. Its water consumption calculation is included in water consumption of service sector.

Hairdresser and beauty salon: Hairdresser and beauty salon occupies a significant percentage in commercial service sector of Mongolia. There are 500 hairdresser and beauty salons in Ulaanbaatar and 100 in soum centres in the basin. Water supply for hairdresser and beauty salons in Ulaanbaatar and Zuunmod are connected to the centralized water supply and sewerage network while salons located in soum centres are supplied by transported water. It was included in development programme for aimags in the basin to establish and operate utility service centres and points in aimag centres and some soum centres.

Water consumption of hairdresser salons in Ulaanbaatar, Zuunmod and soum centres has been calculated and integrated into the water consumption of commercial service sector.

Car wash: is one of services that use and pollute water at large amount. Recent years, household living standard improvement leads to increasing number of car. As of 2010, there have been 254.5 thousand cars at national level and of these, some 64.0% or 162.7 thousand cars registered in Ulaanbaatar. In terms of calculating number of cars per 100 citizens in the basin, it amounts to 3.3 thousand cars. In other words, total number of cars in the basin amounts to 166.0 thousand.

There are over 40 car washes in the capital city while this service is provided by car parking and car workshops. Besides that, some citizens run their own car wash service. Economic entities permitted to provide car wash service are mostly connected to the centralized system and have water meter. But individuals mostly discharge their used water into soil directly and openly.

Due to difficulties to determine water consumed for car wash by each organisation and individual and unset water consumption-usage norm, water consumption for car wash has been determined as below based on studies. According to polls carried amongst Ulaanbaatar citizens who have car and in car wash centres, when they wash their car by themselves they may use only 5-15 l water. If they go to car wash, 25-40 l water is used for mini-cars, and 80-100 l water for large cars. And it has been reported that car wash is done 4-5 times in summer and 1-2 times in winter. If average water consumption for washing one car is calculated to be 40 l and 2 times a month, in total 159.3 thousand m^3 water have been consumed in 2010 at the basin level.

Baths: As of 2010, there were approximately 210 baths with a capacity of serving 1.200 persons at the same time in Ulaanbaatar, Zuunmod and soums of the basin (Table 10). Clients of baths are ger area residents in Ulaanbaatar, Zuunmod and soum centres. Water supply for baths in Ulaanbaatar and Zuunmod is connected to the centralized water supply and sewerage network and it is supplied from own wells and transported water in rural areas. Baths in soum centres discharge their wastewater into boreholes and infiltrate into soil.

As it is stated in the 'Temporary water usage norm for utility services' approved by the resolution No.153 of Environmental minister in 1995 that average water consumption in baths per person is 180 l, and according to calculation in terms of baths operating in their full capacity, total water consumption for baths amounted to 2173.3 thousand m3 as of 2010.

According to calculation in terms of complete supply for baths demand of population and water consumption per person to be 120 l, it would require 3932.3 thousand m^3 /year by 2015 and 4968.4 thousand m3/year by 2021, respectively.

A utility service centre has just opened its door in Khoroo 25 of Songinokhairkhan district within the framework of 2nd Project for Improvement of Public Utility Service in Ulaanbaatar which is being implemented by finance of the World Bank.

This service centre was established by grant aid from the government of Japan to provide services such as baths, sauna, massage, hairdresser, beauty salon, dry cleaning, internet and canteen, etc to 500 households domiciled in Khoroo No.9, 10 and 25 of the district. Now it has created some 12 vacancies and enabled citizens to receive quality services at one-point. This utility service centre has a borehole with a capacity of 30 m^3 which is connected to the centralized pipeline and it was constructed by Terkhiin Undraa LLC.

In the scope of this project, the same centre was established in Khoroo 18 of Chingeltei district as well as some 8 baths connected to fresh water pipeline have been established in Bayanzurkh, Bayangol, Chingeltei, Sukhbaatar and Songinokhairkhan districts.

Source: http://ulaanbaatar.mn/

Table 10. Baths in the Tuul River Basin (as of 2010)

№	Aimag	Quantity of baths	Capacity, person/one time
1	Arkhangai	1	4
2	Bulgan	5	40
3	Uvurkhangai	1	4
4	Selenge	1	4
5	Tuv	21	94
6	Ulaanbaatar	183	1029
Total		212	1175

Water consumption of the commercial service sector in the basin amounted to 3591.7 thousand m^3 in 2010. According to calculation in terms of service sector production to grow 6.9% on an average annually in the future as it included in regional development programme for Ulaanbaatar, water consumption is projected to be 5180.4 thousand m^3 in 2015 and 8039.6 thousand m^3 in 2021 (Table 11).

Table 11. Water consumption and water demand for commercial service sector in the cities

City	Water consumption, m^3/year			
	2008	2010	2015	2021
Ulaanbaatar	3410.6	3590.1	5178.1	8036.0
Zuunmod	1.5	1.6	2.3	3.6
Total	3412.1	3591.7	5180.4	8039.6

2.3. Water supply, water consumption and water demand for tourism and green areas

2.3.1. Tourist camps

Picture 9. Tourist camps established in Tuul-Terelj national park

According to registration of tourists passed by the passport control of the General Authority of Border Troops, number of inbound tourist visit Mongolia has been increasing year by year is tended to increase in the future (Figure 10).

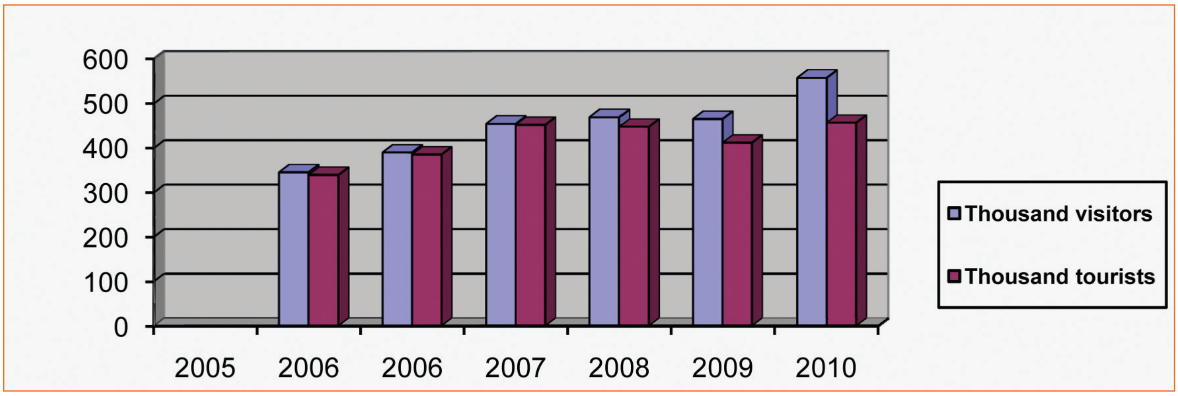


Figure 10. Visitors and tourists visited Mongolia

Transit passengers and tourists temporarily stay in Mongolia for 5 days and tourists stay for 8-12 days. Due to number of tourist visit Ulaanbaatar amounts to half population of Ulaanbaatar, it is necessary to calculate their water consumption. Tourists mostly visit during warm seasons.

Tourist camps established based on historical monument areas with a special natural formation. According to study based on data and information of MNET in 2010, there were around 70 tourist camps in the basin. Of these, some 70% is based in the vicinity of the Khan-Khentii protected area and Gorkhi-Terelj national park. Tourist camps are capable to receive 4000 tourists per day and over 90% of these camps run tourism activities on quarterly basis.

The Tuul River Basin includes number of beautiful areas such as Bogd Khan Mountain, Gorkhi, Terelj, Ar Janchivlan, Sand Dune, Khugnu Khan Mountain, Khustai Mountain, etc and historical and monument areas such as cave painting in Ikh Tenger Valley, Hunnu period graves in Belkh Valley, many graves in Songino Mountain, rock with a coin painting in Gachuurt Valley, cave inscription in Nukht Valley, ruin of Khereed's Tooril King's Palace, Bogd Khan Palace Museum, Choijin Lama Temple Museum, Geser Temple, Dambadarjaa Monastery, Megjid Janraisag Monastery, Gandantegchilen Monastery, etc. These are the basis of a tourism sector development.

Picture 11. Tourists visiting Mongolia

One of main conditions to provide tourists with amenity is a drinking water supply and sanitation. Most camps establish their own wells and consume water by delivering it to kitchen and sanitation facilities in an open network.

The water consumption for tourist camps which is based on capacity, service period, number of tourists visiting the camps in the basin and water consumption norm was calculated at 43.9 thousand m^3 in 2010. If it calculates that tourism sector growth is 6.9% annually according to regional development programmes, projection of water consumption will amount to 90.8 thousand m^3 in 2015 and 209.8 thousand m^3 in 2021, respectively.

2.3.2. Green areas

According to Metropolitan statistics, there were 7139.3 thousand m^2 park, 3625.9 thousand m^2 lawn areas and 2828.1 thousand pieces of trees and bushes in Ulaanbaatar as of 2010.

Picture 12. Landscape of green area and garden/park

According to data and information received from Nature, Environment and Tourism Department in Tuv aimag, there were 2.5 ha green area in Zuunmod in 2008 while no registered green area in 2010.

Green areas in the capital city are supplied from the same drinking water sources for people as there is no specific water source for green areas. At present, some parts of garden/park and lawn areas are irrigated by irrigation system. But some organisation use mini-portable sprinkling irrigation equipment by using domestic water or they manually irrigate their surrounding lawn and green areas.

Tsetserlegjilt LLC is responsible for care service of green areas in Ulaanbaatar while Tokhijilt service LLC is responsible for care service of green areas in Zuunmod.

According to calculation of 'Temporary irrigation norm for lawn areas' approved by the resolution No.153 of the Environmental minister in 1995, lawn and garden irrigation norm is amounted to 4 l/m^3 at once. If it is calculated to irrigate the areas for 50 days during warm seasons, it would amount to 2000 m^3/ha per year. Based on above, calculation of water consumption for green areas irrigation in 2010 amounted to 2153.0 thousand m^3.

According to calculation of water consumption for green areas in the basin is expected to amount to 2160.1 thousand m^3 in 2015 and 2169.6 thousand m^3 in 2021 based on size of green areas planned to newly establish within a year (an average growth of 4900 m^3) as it is included in mid-term targeted programmes of New Creation (Table 12).

Table 12. Irrigated lawn and green areas in the cities

Indicator	2008		2010	
	Green area, ha	Irrigated forest area, ha	Green area, ha	Irrigated forest area, ha
Ulaanbaatar	706.7	335.6	713.9	362.6
Zuunmod	0	2.5	0	0
Total area	706.7	338.1	713.9	362.6
Water consumption (thousand m^3/year)	1413.4	676.2	1427.8	725.2

2.3.3. Tourist camps, sanatorium and resorts

Picture 13. Tourist camp, sanatorium and resorts

There are plenty of spas and mud in Mongolia which are able to provide spa and mud treatment for various diseases. There are approximately 100 sanatorium and resorts based on them. Of these, but only 27 sanatorium and resorts are accredited as of 2010. Accredited sanatorium and spa resorts in the basin are:

- Ar Janchivlan spa resort and Takhilt treatment centre based in Tuv aimag.
- Orgil national balneology centre, Ulaanbaatar sanatorium, Traditional treatment medical science, technology and industrial corporation, Arga Bileg, Amarsanaa Gunj, Saikhan Gazar, EMJJ, Erdenet Khun, Enkh-Undraga, Unu-Enkh, Jargalan, Khasu Khandgait sanatorium and spa resorts based in Ulaanbaatar.

Whereas overall sanatorium and spa resorts in Ulaanbaatar are connected to the centralized network, sanatorium and spa resorts in rural areas are supplied from their own wells as they are not connected to the centralized water supply network. Water consumption for clients of the sanatorium and spa resorts is considered unnecessary to re-calculate as it is included in the water consumption for people.

2.4. Water supply, water consumption-use and water demand in agricultural sector

2.4.1. Water supply, water consumption and water demand of pastoral farming

Water supply for livestock is directly associated with pasture use. The way of dealing with animal husbandry is being changed due to socio-economic conditions and climate change, etc in recent years. In this connection, the state policy and trend of activities are being changed, too. There has been growth in number of livestock, and that's why the products of animal origin and food industry are being increased in recent years.

Overall livestock owned by citizens in 29 soums of Arkhangai, Uvurkhangai, Bulgan, Tuv, Selenge aimags and 7 districts of Ulaanbaatar and Zuunmod of Tuv aimag has been included in the basin. Burd soum of Uvurkhangai aimag, Mogod and Khishig-Undur soum of Bulgan aimag, Orkhontuul soum of Selenge aimag are subject to forest steppe zone and others are subject to steppe zone. Water supply and water availability for Buren, Bayankhangai and Argalant soums of Tuv aimag are dependent on only groundwater resources they do not have surface water network.

Picture 14. Borehole in pasture area for water supply of both people and livestock

As of 2010, there were 355 rivers, 389 springs, 2583 wells, of these, 1519 boreholes and 584 short-tube wells, 1314 wells with a concrete ring, 480 hand dug wells and 3 ponds, etc in use of water supply for people and livestock in pasture area of the basin. Open water bodies are frozen in winter causing difficulties with livestock water supply and livestock is watered from snow. Pasture use is limited due to water supply condition and livestock is concentrated near surface water bodies and wells in warm season. These are leading to loss of vegetation growth, grazing intensity and domination of stipa (feather grass), santonica (wormseed), wild leek and ramson.

According to researchers, vegetation is able to be restored if its 50% is used by livestock, but use of 70% leads to degradation. Number of livestock in Ulaanbaatar, Zaamar, Lun and Altanbulag soums of Tuv aimag is exceeded 3-4 times that standard grazing capacity. Livestock density in the Tuul River Basin is more than other basins due to its relatively well developed infrastructure and close location to the capital city.

Picture 15. Livestock watering in warm season

According to socio-economic study of the Tuul River Basin, national average livestock per 100 ha amounted to 49 livestock in terms of sheep head while it amounted to 114 livestock in the Tuul River Basin which means as much as two times than the national average.

It has been recently noted by researchers that increasing number of livestock, reduction of water bodies, sharp dependence of pasture use on water supply, loss of herdsmen's traditional nomadic-habit, their permanent settlement at one point such as winter and summer camps and its impact on water resource-forming habitat, etc are associated with the animal husbandry and the breeding.

Livestock population around rivers, streams, springs and surface water bodies is exceeded than ecological grazing capacity and a sign of water pollution is being detected.

Natural law requires optimal organisation of livestock breeding and artificial selection that meets the regional ecology. However, livestock has been privatized and its population is being increased. Cattle, a marketable/tradable livestock merely consisting of 5.2-5.9% of the total livestock at the basin level and this is a very low indicator.

Compared to the livestock structure of 2008, the number of cattle increased by 0.7% and sheep increased by 2.3% while goat decreased by 3.2% at the basin level in 2010 (Figure 16).

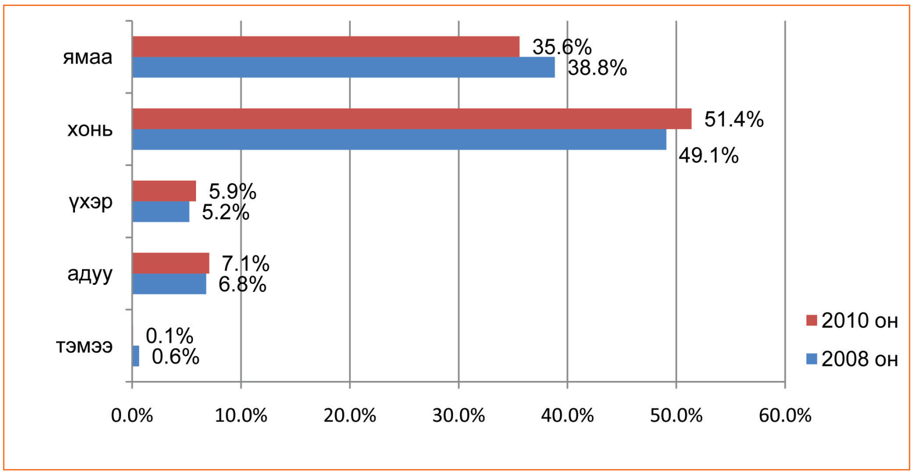


Figure 16. Livestock structure in the basin as of 2008 and 2010

It has been calculated to increase large cattle by 3.1-6.3% and decrease sheep and goat by 0.3-3.9% than their amount at the end of each year in 2015 and 2021. This is according to, on one hand, a necessity to develop marketable/tradable field of livestock as a priority and to have intensified animal husbandry by using advantage of infrastructure and demand, and on the other hand, according to reflection in projects and programmes approved by the government.

Number of livestock and water consumption in soums subject to the Tuul River Basin has been calculated by livestock water consumption norm based on the result of national census on livestock conducted by the National Statistics Committee in 2008 and 2010, and projection of livestock number in 2015 and 2021. An average calculation has been made depending on average age of livestock and duration of cold and warm seasons. This is due to their water consumption depends on their ages and seasons of the year.

In total, 2951.2 thousand livestock were registered in the Tuul River Basin in 2008 and their water consumption amounted to 6407.5 thousand m3. While this number has been decreased by 97.7 thousand amounting to 2853.5 thousand in 2010 and water consumption also decreased at 6389.5 thousand m3, respectively. In 2021, increase in number of large cattle is tended to increase and their water consumption is also to increase by 17%. However, total number of livestock in the basin is expected to decrease by 1% in 2021 (Table 13).

Table 13. Number of livestock, water consumption and water demand in the Tuul River Basin

Livestock population, thousand heads				Water consumption, thous. m^3/year			
2008	2010	2015	2021	2008	2010	2015	2021
2951.7	2853.3	3329.4	3297.5	6407.5	6390.0	8805.9	10315.4

Except above livestock, there are 12.0 thousand pigs and 300.0 thousand chickens as well as rabbit and pets in the Tuul River basin and interest of breeding such animals amongst community in the future is increasing.

As of 2010, some 48 non-functioned wells have been restored and 54 new wells have been established in the result of organizing restoration work of old wells from 1998 and establishment of new wells from 2004 within the framework of a policy of the Ministry of Food, Agriculture and Light Industry (MFALI) on improvement of water supply for herdsmen and pasture on their request in recent years.

In order to improve pasture use, herdsmen group has been established and they are organizing frameworks to enable herdsmen to own winter and summer camp areas, to jointly use the surrounding pasture areas, to establish wells that meet the herdsmen's requirements and to have the wells owned by the herdsmen, etc. Also in order to improve water supply and pasture use for livestock, number of new wells with an engineering design have been established by finance from the Millennium Challenge Account, Sustainable Living Standard II projects and World Vision organisation.

According to study carried out by Geoecological Institute of Mongolian Academy of Science, it has been concluded that 'water points with an engineering design established so far and water points restored and newly established between 2006 and 2008 in the Tuul River Basin have been chartered. When determining irrigated areas by radius of water points in its scope, area with 2081.6 thousand ha or 48.4% of a total pasture area in the basin are found able to be irrigated. But currently, 32.5% or 1396.9 thousand ha pasture areas are being irrigated'. In other words, it means that a new pasture area can't be used as new wells have been established near non-functioned wells, but not in non-irrigated areas, and hydrogeological investigation is not carried out covering a particular groundwater area.

Number of mining industries cause water pollution and damage the Tuul River Valley in Zaamar soum of Tuv aimag. Consequently, 10-12 thousand ha area in meadow and valley are unable to use for pastoral purpose due to absence of restoration.

It is said that many projects and programmes are implemented regarding improvement of water supply for herdsmen and their livestock, and number of new wells are established with the financial support from the state budget, international organisation, foreign loan and grant aids. But there is no integrated data and information on name of the related aimag, soum and area, address of economic entities conducted performance, hand over/receipt of wells, and technical specification of wells, etc.

2.4.2. Farming

Due to necessity of providing urban people with safe foods, the government of Mongolia has been significantly focusing on development of intensified animal husbandry. In this connection, number of farmers in the field of meat and milk livestock is increasing in recent years.

According to data of Small-Medium Enterprise Development Fund of the MFALI, bidding for projects of breeding meat and milk livestock, pig and poultry, production of animal feeds and planting animal feed has been carried out. As of 2010, loan amounted to MNT 705.0 million has been granted to some 90 economic entities and citizens. And 13.6% of the farms are based around Ulaanbaatar. As of the end of 2010, there have been 211 dairy cattle farms in Ulaanbaatar with some 259 cattle of pure breed and 14,000 cattle of crossbred.

Intensified farming is differentiated from the pastoral farming by warm shelter, complete supply of water and animal feeds (seeds, silage and roughage/fiber) and breeding livestock in settled way. For water supply of farms, as they have own wells and there is no different water consumption norm, it has included in water consumption norm for pastoral farming.

While settled livestock breeding is developed, also pig and poultry farms are at inception level of their development.

2.4.3. Irrigated areas

Tuul River originates at confluence of the Nomin and Nergui Rivers which are elevated at 1878 m height, continues about 770 km through the valleys between mountains and flows into the Orkhon River. Due to upstream part and its basin are surrounded by high mountains, its climate characteristic is a big difference between air temperatures of the day and night, relatively longer cold seasons, short summer and most precipitation falls during warm seasons.

Perennial average precipitation is 233.8 mm as the basin is located in insufficient moisture zone in terms of natural moisture provision. Due to some parts of the basin included in steppe zone has a lack of studies water resources as a whole, it is considered that possibility of establishing irrigated area is limited. Duration of period continues above 10 degrees of air temperature lasts about 110 days on an average.

Picture 17. Sprinklers for irrigation

For agriculture and water melioration, the Tuul River Basin and its tributaries are subject to central zone or 2nd zone with insufficient natural moisture. Therefore, the basin necessarily requires irrigation use in crop farming.

Some irrigation schemes have been established in the basin since 1990 such as Daliin Bulag (57 ha) in Bayannuur soum of Bulgan aimag, Guna (70 ha) and Dund Urt (57 ha) in Bayantsogt soum, Ar-Urt (125 ha) in Zaamar soum, Uubulan (36 ha) in Erdentsogt soum of Tuv aimag, Uvurbayan (74 ha), Khar Usan Tokhoi (95 ha) and Uliastai Am (240 ha) in Bayanzurkh district, and Bukhug-1 (150 ha) and Bukhug-2 (189 ha) in Khan-Uul district of Ulaanbaatar, etc in total 10 irrigation schemes with engineering design in 1135 ha area are financed from state budget. And 50 irrigation schemes with normal design in 1300 ha area are financed from then-soum commune/cooperative budget. Of these irrigation schemes, Guna, Dund-Urt, Khar Usan Tokhoi and Bukhug-2 have been restored between 2005 and 2009 with the support of investment by the state budget.

Since 2005 new 26 irrigation schemes with 1339.2 ha areas have been established with a support of the state budget (Annex 2). Of these systems, some 87% is subject to groundwater use. Water source used in these irrigation schemes is from the Bukhug and

Turgen Rivers, tributaries of the Tuul River. However, the source is recently turning into wells that established in the river floodplain due to interruption of runoff.

Main seedling planted in irrigated area is vegetables, animal feeds, seabuckthorn and fruit bushes.

In recent years, economic entities and citizens plant tomato, cucumber and leaf-vegetables in protected soil and it leads to foundation of green-house industry development.

Picture 18. Green house

In implementing goals/objectives included in the State Policy on Food and Agriculture and Water National Programme, there is a possibility to bring irrigated areas in the Tuul River Basin at 3.0 thousand ha in 2021 by restoring old irrigation schemes and establishing new irrigation schemes in potential areas.

Water use and water demand for irrigated areas have been calculated by irrigation norm (Table 14).

Table 14. Water use and water demand for Irrigation

Irrigated area, *ha*				Water use, *thousand.m³ /year*			
2008	2010	2015	2021	2008	2010	2015	2021
1132.6	1346.0	2149.0	3296.0	2992.1	3535.7	6083.4	9341.6

Irrigation norm and quantity is determined for irrigated areas depending on structure and moisture of soil, type of sown/seedling, air temperature and precipitation. In the event of irrigated area is irrigated from groundwater, water use has been calculated by small indicator of irrigation norm, due to this can't reach irrigation norm depending on energy cost.

In the scope of "Atar-3" campaign, new irrigation schemes have been established and put into operation in Danikhuu Hill and Shar Usnii (Yellow Water) Channel in Orkhontuul soum of Selenge aimag. Water source for these irrigation schemes is a groundwater and this violates clauses of some documents related to concept. However, this groundwater-based irrigation scheme is a good activity aimed at improving food supply for people. Therefore, it would be appropriate to comply with the clause of 'limitation of groundwater use in irrigated areas' of the National Security Concept.

Picture 19. Agro-park based on green house

Only way to harvest constantly by reducing impact of continental climate and extreme difference between day and night in Mongolia is to develop green-house as well as improve vegetable supply and availability for people in urban areas. Number of entities and citizens in this field is increasing from year to year.

Establishment of new agro-parks and using them as training and public awareness centre in soums included in the basin is favoring improvement of local citizens' knowledge about crop, increase their income, improve their living standard and accustom themselves with use of new vegetables in their daily food.

There are two types of green-house: glass-rooted green house surrounded by brick wall to be used in winter and green-house covered by double-synthetic film. Seedling that completely grows 150 days is planted in winter type green-house and 120 days grown-one is planted in the latter one. The best way of irrigation in green-house is drip irrigation and fog irrigation. However, above green house vegetables are irrigated from groundwater that warmed up by solar energy. Main seedling of green house is appropriate to be a tomato, cucumber and leaf-plants that grow in a short period of time.

According to study of Metropolitan Agricultural Authority in 2010, there were 33 organisations and citizens that have planted vegetables in greenhouses with 21.2 ha area and took regular harvest.

Water use for greenhouse has been calculated by irrigation norm for greenhouse seedlings (Table 15).

Table 15. Greenhouse water use and water demand

Year	Greenhouse				Water use, *thous.* m^3*/year*	
	Summer		Winter			
	Qty	Area, ha	Qty	Area, ha	Summer	Winter
2008	27	8.7	11	10.8	22.3	24.5
2010	27	9.0	15	12.2	23.1	30.0
2015	-	10.6	-	14.4	27,0	36.7
2021	-	12.2	-	19.5	31.1	49.7

2.4.4. Recommendations on agricultural water supply

- By making conclusion on non-increasing pasture use due to establishment of new wells near non-functioned wells that were established prior to 1990, it needs to identify location of wells based on protection of pasture area and recommendations of herdsmen group with a participation of their assets, and to assign ownership and ownership of wells to them,

- By making conclusion on number of livestock per 100 ha area in the Tuul River Basin is as much as twice than national average, it needs to implement a policy to make changes in livestock structure and to maintain livestock with a high productivity that is suitable for grazing capacity,
- To establish large irrigation scheme with a runoff regulation and to completely use the expected irrigated areas based on the rivers with a constant runoff,
- To take measures such as enabling farmers who run activities on irrigated areas to make the correct selection of seedlings and protection of soil from wash-out, salt accumulation and becoming marshy,
- In the event of groundwater use is necessary in irrigated areas, its recharge regime and water resource are required to be determined by a complete hydrogeological investigation,
- To teach household farmers the method of how to establish green house by using synthetic plastic and glass material to create a warm and humid environment, how to plant vegetables by covering holed-synthetic film/plastic and how to regularly take a good harvest by keeping a proper warmth and soil moisture and protecting from weeds.

2.5. Water supply, water use and water demand for industries

2.5.1. Food industry

As the capital city of Ulaanbaatar is located in the Tuul River Basin, it becomes the largest consumer of products of food industry.

A new era of industrialization in Ulaanbaatar started from 1960s. High-capacity meat factory, flour and feed factory, milk and dairy products factory, etc were established with the support of partner countries that cooperated at technical development and mechanization level. And these factories used to significantly contribute to Mongolia's socio-economic development. Amongst these factories, light and food industries were dominated. Then-wells established for technological demand of the factories and apartments' water supply are being used at present day.

Water supply source for food industries is supplied from groundwater in the floodplain of the Tuul River through the centralized water supply network.

Water use for food industries has been calculated based on data and information by the Metropolitan Statistics Authority on products produces by the factories in Ulaanbaatar and water usage norm per unit product (Table 16).

Food industries in Ulaanbaatar not only supply food demand of the capital city, but supply whole demand throughout the country with products including spirit, beer, beverage drinks, juice and conserved meat, etc and export abroad some products.

Water use for the industries has been calculated by converting into unit of water use in the event of measuring unit for products doesn't match the measuring unit for water usage norm.

Table 16. Water use for food industry

№	Product	Measuring unit	Product quantity		Water use, *thous. m³/year*	
			2008	2010	2008	2010
1	Milk and dairy products	*mil l*	7.1	27.6	57.5	232.3
2	Meat	*thous. ton*	9.4	9.8	203.0	211.2
3	Canned meat product	*ton*	22.1	25.6	0.3	0.3
4	Wurst/sausage	*ton*	1500.0	1521.4	57.8	58.6
5	Spirit	*thous. ton*	1127.7	1337.5	16.9	20.1
6	Vodka and wine	*thous. l*	7800.0	16754.4	170.0	365.2
7	Beer	*thous. l*	32444.1	44878.5	275.8	381.5
8	Beverage drinks	*thous. l*	25080.2	67551.0	175.6	773.9
9	Flour	*thous. ton*	55.1	128.6	259.0	604.6
10	Noodle	*ton*	2314.2	2001.5	5.1	4.4
11	Bread	*thous. ton*	21.1	16.7	67.5	53.4
12	Bakeries	*thous. ton*	10.0	9.5	28.0	26.7
13	Biscuits/cookies	*thous. ton*	0.6	0.7	1.6	1.9
14	Confetti/candy	*thous. ton*	0.1	0.1	0.9	0.9
Total			-	-	1319.0	2735.0

Soum centres and urban areas in the Tuul River Basin themselves produce bread, beverage, milk and dairy products on their own and supply local demand as well as lunch of school children and kindergartens. Due to absence of data and information on number of small factories run activities locally and quantity of their products and their operation is not permanent, this is not included in water use for the industries.

2.5.2. Light industry

As Mongolia was a member country of then-Association of Economic Mutual Assistance prior to 1990, locally produced products not only supplied its national demand, but it was responsible for solely producing one type of product in order to supply demand of other countries based on its development level, natural resources and raw materials. And it often required increase of quantity of such products year by year. Light industry was dominant among them. After 1990, these factories have been privatized and divided into many number of factories such as initial stage leather, wool and cashmere processing factories, spinning/yarn mill, knitting factory, etc.

Main goal of light industries operating in the capital city is to process raw materials from livestock by using industrial method, to produce products and to supply demand of the country. Light industries not only supplied from the centralized water supply, but use groundwater as additional water source through wells established nearby.

There are some individuals, cooperatives and small workshops in soum centres included in the Tuul River Basin which produce sewn, knitted, felt and hand-crafted products. But no data and information related to quantity of their products and also their operation is not permanent. Therefore, this is not included in water use for the industries.

Picture 20. Leather, wool and cashmere processing factories

Table 17. Water use for light industry

№	Product	Unit	Product quantity		Water use, *thous. m³/year*	
			2008	2010	2008	2010
1	Combed cashmere	*ton*	752.7	824.7	45.2	49.5
2	Washed cashmere	*thous. ton*	0.5	1.6	0.0	0.1
3	Yarn	*ton*	120.2	123.3	15.0	15.4
4	Carpet	*Thous. m²*	108.8	42.2	25.0	9.7
5	Felt	*thous. m*	20.5	40.4	1.7	3.4
6	Knitted wool and cashmere products	*thous. pc*	1139.7	795.8	33.0	23.1
7	Shevro*	thous. pc	812.0	588.8	224.1	159.0
	Total		-	-	344.1	260.2

According reflection of light and food industry in regional economic development programmes to grow by 6.9%, water use and water demand has been calculated as follows (Table 18).

Table 18. Total water use and water demand of food and light industries

Industry	2008	2010	2015	2021
Food industry	1319.0	2735.0	3810.8	5687.0
Light industry	344.1	260.2	370.5	553.0
Total water use, thous. m³/year	1663.1	2995.2	4181.3	6240.0

2.5.3. Construction and construction material industries

Except Mongolians, Chinese and Soviet Union (former name of Russia) constructors were involved in construction work in Ulaanbaatar, and many constructions such as apartment districts, factories, schools, hospitals, hotels, public catering establishments and sport centres, etc have been established with the financial and technical assistance from China and Russia. All the construction materials required for constructions such as brick, block, remicon, concrete and ferro-concrete are produced in the capital city. Before 1990, construction factories used to produce and assemble construction structure/ frame and other parts by using industrial method on construction site. Since 2000, old method changed into a new technology which directly moulds remicon into prepared part of the construction.

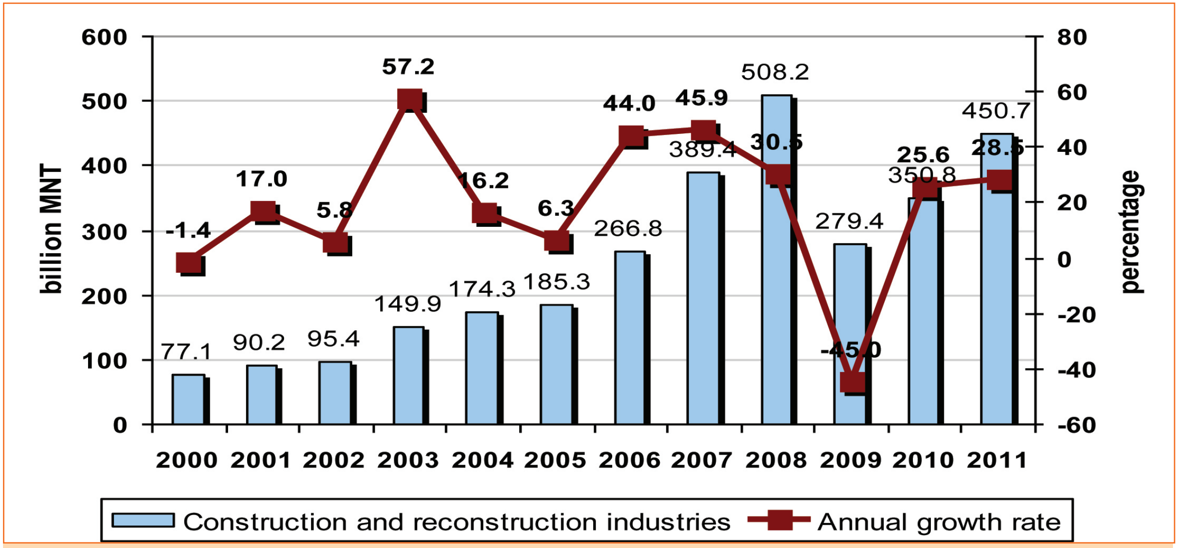
Picture 21. Construction work

The Remicon industry intensively started in Mongolia since 2007. Remicon is produced in the factory, transported by mixer truck and delivered to the construction site, and moulding machine automatically moulds into imprints of a construction column, cross backbone, ceiling and wall which assembled by reinforcing. This is implementation of a modern construction technology and it improves the quality of construction and accelerates the construction work.

Picture 22. Remicon factory

There are some 30 remicon companies such as Remicon LLC, JKS LLC, MKI LLC, Premium Concrete LLC, Arga Baril LLC< San Industrial LLC, West LLC, CFC LLC< Someone Dreamwork LLC, Ulaanbaatar Management LLC, etc in Ulaanbaatar (capacity to produce 70-120 m^3 remicon per hour). Also many companies such as Bluestarlit LLC, Baiguulamj Od LLC, Gungervaa LLC, etc produce concrete, ferro-concrete, brick and block. These companies mainly use groundwater through their own wells established along the floodplain of the Tuul River in producing construction materials and Remicon.

Within the framework of '100,000 household apartments' programme approved by the government in 2010, it is planned to build 75,000 household apartments in Ulaanbaatar until the end of 2016. It means construction sector industry is increasingly growing and it is followed by trend of increasing water demand for both construction industry and people.



Construction and overhaul work reached MNT450.7 billion in 2011. Of these, MNT427.9 billion or 94.9% is subject to national construction companies and MNT22.8 billion or 5.1% is subject to foreign construction companies. Construction work performed by national companies increased by MNT101.4 billion or 31.1% and it mainly affected increase of MNT99.9 billion or 28.5% of construction and overhaul work compare to the previous year.

Source: National Statistics Committee, 2012.

Water use for construction and construction material industries has been calculated in the following Table 19 based data and information of the Metropolitan Statistics Authority on products produced by construction companies and water usage norm per unit product.

In the event measuring unit for products included in the statistics book doesn't match the measuring unit for water usage norm during calculation of water use, it has been calculated by converting into unit for water usage norm.

Table 19. Water use of construction material industry

№	Product	Measuring unit	Product quantity		Water use, *thous. m³/year*	
			2008	2010	2008	2010
1	Cement	*thous. ton*	27.8	32.9	69.5	82.3
2	Lime	*thous. ton*	0.3	1.5	0.2	0.8
3	Concrete product	*thous. m^3*	43.7	46.6	183.5	195.7
4	Gravel and sand	*thous. m^3*	12.1	16.5	8.5	11.6
5	Rock debris	*thous. m^3*	123.4	101.1	86.4	70.8
6	Red brick	*Million .pc*	16.9	18.4	30.6	33.3
Total					378.7	394.5

Renovation and expansion work for old water supply pipeline is included in annual budget plan of the People's Representative's Khural and Governor's Office and is being implemented as new apartments are expanding from its central area towards suburban area and drinking water demand is increasing.

Water use and water demand which coordinated with water use of construction industry in 2008 and 2010, the sector's industry growth and development programmes is tended be as follows (Table 20).

Table 20. Water use and water demand of construction industry

Year	2008	2010	2015	2021
Water use, thous. m^3/year	378.6	394.3	550.3	821.3

In suburban areas of Ulaanbaatar and soum centres, some citizens and cooperatives produce concrete products such as block, brick, curb, concrete board and transom, etc on their own site. As there is no data and information on water use for producing remicon that required for construction, this is not included in the calculation.

Due to unclear amount of widespread construction materials such as gravel and sand which are being mined, water volume for washing such materials is not included in this calculation.

In connection with construction and housing process for citizens of the capital city, many clauses of Mongolian Laws on Nature Conservation are violated by increase in number and capacity of construction material industry, and mining of gravel and sand for producing remicon, concrete and ferro concrete. Therefore it needs to:

- Establish carrier that uses eco-friendly technology and does not pollute environment for mining gravel and sand which are main materials for construction industry in areas not less than 500 m from river bank permitted by local administrative authority,
- Use rock debris instead of gravel which is a filling material of concrete product,
- Use surface water or treated grey water in producing concrete and remicon as this production is occurred in warm seasons.
- Prohibit drinking water use in caretaking and other cleaning work of concrete moulded on construction site.

2.5.4. Mining and processing industries

The Government of Mongolia has officially selected mining industry especially gold mining industry since 1993 for the purpose of rapid recovery its economy and contribution of its development. And the government approved and implemented the ‘Gold’ programme. In the meantime, many national and internationally cooperated companies have been involved in those progresses. Shijir Alt LLC, Altan Dornod-Mongolia LLC, Mongol Gazar LLC, Jump LLC, Mongolrostsvetmet LLC, Zaamirin Ikh Alt LLC, Khotu LLC, Uyangan LLC, Datsan Trage LLC, Bud-Invest LLC, Tod-Undraga LLC, Monjump International LLC, Khuslemj LLC, Platum LLC in total 14 companies operating in only the Tuul River valley in Zaamar soum of Tuv aimag.

Picture 23. Gold mining in the Tuul River Valley in Zaamar soum, Tuv aimag

According to data and information of the Ministry of Natural Resources and Energy in 2010, gold mining activities occurred in some 40 deposit areas in the Tuul River Basin.

Picture 24. Illegal placer miner

For mining industry, only gold mining and gravel and sand carriers are now operating in the Tuul River Basin. Water source used for gold mining is supplied from the Tuul River, its small tributaries and streams, and their drinking water consumption is supplied from wells that established in floodplains of above rivers and streams.

Gold-contained sand is washed by highly pressured water and wastewater is collected in ponds for reuse. 30% of water for washing gold is replaced from rivers, streams and groundwater. Water use for mining industry has been calculated according to annual mining work plan of mining entities based on 'Conclusion on water use' by the Water Authority, Government Implementing Agency (Table 21 and Table 22).

Picture 25. Gravel and sand mining in floodplain of the Tuul River

In order to enforce the 'Law on prohibiting exploration and mining of natural resources in river runoff-forming areas, protection zone of reservoir areas and forest resource areas' approved by the State Great Khural (Congress) in 2009, the Water

Authority organized framework to set/determine protection boundaries in 2010 in collaboration with local administrative authorities according to right/power specified in 16.1.5 of Mongolian Law on Water. And the government of Mongolia verified it by making resolution of 'Partially Setting the Boundaries' which will result in suspending exploration licenses of 246 companies included in protection zones. Consequently, some 43 licenses of 26 companies which were running gold mining activities in the Tuul River Basin have been suspended.

Table 21. Water use by mining industries in 2008

№	Aimag	Soum	Natural resource	Deposit	Water use, thous. m³/year
1	Bulgan	Buregkhangai	gold	Baruun /west/ Zakhtsag	276.0
2		Buregkhangai	gold	Baruun /west/ Zakhtsag	56.5
3	Tuv	Zaamar	gold	Bayangoliin Golidrol	1476.0
4		Zaamar	gold	Tosongiin Golidrol	1328.3
5		Zaamar	gold	Ar Naimgan	720.8
6		Zaamar	gold	Dund Arnaimgan	462.5
7		Zaamar	gold	Baga Khailaast	429.3
8		Zaamar	gold	Tuul Goliin Zuun Denj /east embankment/	336.7
9		Zaamar	gold	Bayangoliin Altnii Uusmel Ord / Derivative gold deposit in Bayangol/	187.0
10		Zaamar	gold	Zaamariin Ekh	172.2
11		Zaamar	gold	Tuul Denj	123.0
12		Zaamar	gold	Tsagaan Chuluut	87.8
13		Zaamar	tin /Sn/	Avdrantiin Tsagaan Tugalga /tin deposit/	59.0
14		Zaamar	gold	Urd Delengiin	50.1
15		Zaamar	gold	Tuuliin Zuun Denj /east embankment/	27.9
16		Zaamar	gold	Tosongiin Zuun Denj	3.0
17		Zaamar	gold	Tuuliin Khundii /valley/	2550.0
Total					8346.1

Table 22. Water use by mining industries in 2010

№	Aimag	Soum	Deposit	Water use, thous. m³/year
1	Bulgan	Buregkhangai	Baruun /west/ Zakhtsag	98.4
2		Zaamar	Zaamariin Ekh	239.0
3	Tuv	Zaamar	Toson River downstream	25.6
4		Zaamar	Khadat Tolgoi /hill/	162.6
5		Zaamar	Bayangoliin Denj	31.6
6		Zaamar	Urd /south/ Delen	49.2
7		Zaamar	Zuun Shand Burkhantiin Am /valley/	32.6
8		Zaamar	Toson River-1	35.1
9		Zaamar	Tuul east embankment-1	17.1
10		Zaamar	Tuul Valley	2706.0
11		Zaamar	Dund Galt	24.8
12		Zaamar	Baga Khailaast valley	175.7
13		Zaamar	Bayangol Denj-6	46.6
14		Zaamar	Toson embankment	65.2
15		Zaamar	Ulaan Mountain	147.6
16		Zaamar	Toson Golidrol /channel/	1878.7
Total				5735.8

Compare to 2008, water use for mining industries in 2010 has been decreased by 31.3%. This is not due to decrease of mining, but enforcement of the related legislation issued by the government over natural conservation.

Due to trend of many mining licenses are going to be suspended and amount of mining production is going to be decreased, water use for mining industry is not tended to be increased in the future than the current volume (Table 23).

Table 23. Water use and water demand of mining industry

Year	2008	2010	2015	2021
Water use, thous. m^3/year	8346.0	5735.8	7396.4	6952.3

For placer deposit, gold is extracted by washing method. But for main deposit, gold-contained rock is crushed and milled, then extracted by method of dissolving it in acid. These methods both negatively impact the environment. In the Tuul River Basin, gold is mostly extracted from placer deposit.

It is necessary to take the following measures which included in the Comprehensive National Development Policy and the State Policy on Ecology over elimination of a negative impact on the environment from gold mining industry based on the Mongolia's Millennium Development Goals.

- To suspend special mining licenses of mining industries based in placer deposit area with a small gold resource and protection zones of watershed, basin and forest resource areas, and to completely stop mining activities,
- To enforce restoration by mining companies in the Tuul River Basin based on economic assessment of damages caused by them on the environment,
- To improve the quality and result of the detailed environmental impact assessment, to control its performance and to increase participation of a public control,
- To take measures for the purpose of improving living condition of citizens based on principle in which complete and efficient use and restoration of natural resources and equal sharing/distribution of their benefits for people,
- Mining companies to take measures such as tight enforcement of a technological regime in extracting gold from placer deposit, reduction of a negative impact on the environment and restoration of the environment on a regular basis,
- To use wastewater collection and recycle system in gold washing, to discharge excessive wastewater into the river after treatment and to treat sediments before starting mining operation in spring.

2.5.5. Energy and heat industries

Population growth and intensive increase of building in Ulaanbaatar is followed by increase of energy and heat use. As the city rapidly expanded and many industrial, social and apartment buildings were built, energy and heat demand was increasing and the 3rd thermo-power plant was established. So far, expansion and innovation have been repeatedly carried out. Water supply for technological demand of the existing thermo-power plants is from some 44 wells established in alluvial aquifer of the Tuul River floodplain.


Picture 26. Thermo-power plant No. 3 and 4

In 1980, the Industrial and Scientific Institute for Civil Engineering Investigation of the Construction Committee of Soviet Union (former name) carried out investigation on water in the Tuul River Basin which required for energy and heat production by thermo-power plants in Ulaanbaatar. According to the Natural Resources Commission of two countries, the related water resource was verified amounting to 70.6 thousand m^3 per day.

Picture 27. New thermo-power plant which is planned to establish in Ulaanbaatar

Thermo-power plants not only re-use their excessive steam through facilities to cool and liquefy steam after energy production. Also plants supply heat for the Devshil green-house which is responsible for fresh vegetables supply for Ulaanbaatar. The government of Mongolia has planned to establish a new thermo-power plant and to increase energy and heat supply in Ulaanbaatar by 2015.

Energy and heat produced throughout the year and water use have been calculated based on data and information of the National Statistics Committee of Mongolia and thermo-power plants in Ulaanbaatar (Table 24).

Table 24. Water use volume for energy and heat industries in the Tuul River Basin

City	Product	Measuring unit	Product quantity		Water use, thous. m^3/year	
			2008	2010	2008	2010
Ulaanbaatar	energy	*mil kwt.hour*	2 924.5	3 650.3	11.5	14.3
	heat	*thous. Gkal*	5 024.1	435.8	25 100.0	22 500.0
Zuunmod	heat	*thous. Gkal*	255.0	279.5	256.0	279.5

Energy produced in the cities of Ulaanbaatar, Darkhan and Erdenet is called 'Central Power System' and it supplies the central part of Mongolia through the mains.

Picture 28. Boiler/Steam generator used for heating of soum centre

In Zuunmod, heat is supplied from boiler/steam generator for offices, school, kindergarten and apartments in winter. Based on perspective of energy sector, energy and heat demand, a projection of water use as follows (Table 25).

Table 25. Water use and water demand of energy and heat industries in the Tuul River Basin

Year	2008	2010	2015	2021
Water use, thous. m^3/жил	25355.0	22779.5	30484.1	43242.3

Heat for administration buildings, schools, hospitals and cultural centres in soum centres are supplied from wood and coal burning stoves while some others are supplied their own low pressure stoves. Due to absence of data and information on heating of public service and other buildings, its water use has not been calculated.

2.6. Total water consumption-use and water demand in the Tuul River Basin

Tuul River has become the most overloaded river which has a frequent polluter and lost its ecological balance in Mongolia.

Population of aimag and soums included in the Tuul River Basin amounts to 1191.3 thousand and it consists 42.8% of Mongolia's total population. Of these, 95.7% is inhabited in Ulaanbaatar and Zuunmod. The largest factories are based in the capital city using huge volume of water and causing water pollution at the same volume.

Compare to water consumption-use in 2010 which is the first year of the Integrated Water Resource Management (IWRM) plan of the Tuul River Basin, water consumption-use in 2021, a final year of the IWRM plan is tended to increase by 53%.

Water management is not only about existence of water resources, but the appropriate organisation of issues on how to efficiently use water resources and protect from scarcity and pollution. This is the policy with a technical and technological view.

Water security is future of Ulaanbaatar and it is expected to comply with the ideology/ concept of urban expansion based on its water resources. It needs to calculate actual economic benefit which may result from protection of the Tuul River upstream part, limitation of domestic activities, stabilisation of water use in the downstream part and reduction of water scarcity and pollution.

Water consumption-use and water demand in the Tuul River Basin has been calculated and shown in Table 26 and Figure 29.

Table 26. Water consumption-use and water demand in the Tuul River Basin

№	Water consuming and using sector	Water consumption-use and water demand							
		2008		2010		2015		2021	
		thous. m^3/year	%	thous. m^3/year	%	thous. m^3/year	%	thous. m^3/year	%
1	Ulaanbaatar population	34,223.9	38.6	38,400.7	42.7	51,126.9	42.5	51,084.6	35.6
2	Zuunmod population	341.4	0.4	368.7	0.4	604.2	0.5	696.6	0.5
3	Soum centre population	56.0	0.1	74.1	0.1	87.4	0.1	132.7	0.1
4	Rural population	67.6	0.1	86.9	0.1	107.0	0.1	164.9	0.1
5	Public services	3,174.1	3.6	3,340.9	3.7	3,581.3	3.0	3,892.8	2.7
6	Commercial services	3,412.1	3.9	3,591.7	4.0	5,180.4	4.3	8,039.6	5.6
7	Food industry	1,319.0	1.5	2,735.0	3.0	3,810.8	3.2	5,687.0	4.0
8	Light industry	344.1	0.4	260.2	0.3	370.5	0.3	553.0	0.4
9	Construction and construction material	378.6	0.4	394.3	0.4	550.3	0.5	821.3	0.6
10	Mining	8,346.0	9.4	5,735.8	6.4	7,396.4	6.1	6,952.3	4.9
11	Energy and heat	25,355.0	28.6	22,779.5	25.3	30,484.1	25.3	43,242.3	30.2
12	Livestock	6,407.5	7.2	6,390.0	7.1	8,805.9	7.3	10,315.4	7.2
13	Irrigation	2,992.1	3.4	3,535.7	3.9	6,083.4	5.1	9,341.6	6.5
14	Tourism	38.8	0.0	43.9	0.0	90.8	0.1	209.8	0.1
15	Green area	2,150.6	2.4	2,153.0	2.4	2,160.1	1.8	2,169.6	1.5
	Total	88,606.8	100.0	89,890.4	100.0	120,439.5	100.0	143,303.5	100.0

Now it's time to take measures step by step such as setting boundaries of the Tuul River runoff-forming upstream part and water source recharge area, enforcement of protection procedure, bringing the runoff-forming part under protection, complete wastewater treatment, strict enforcement of the standard for discharging treated wastewater into environment, moving tanneries/wool washing factories from drinking water source area if they don't properly treat wastewater, river flow regulation, and increasing surface and groundwater resources, etc.

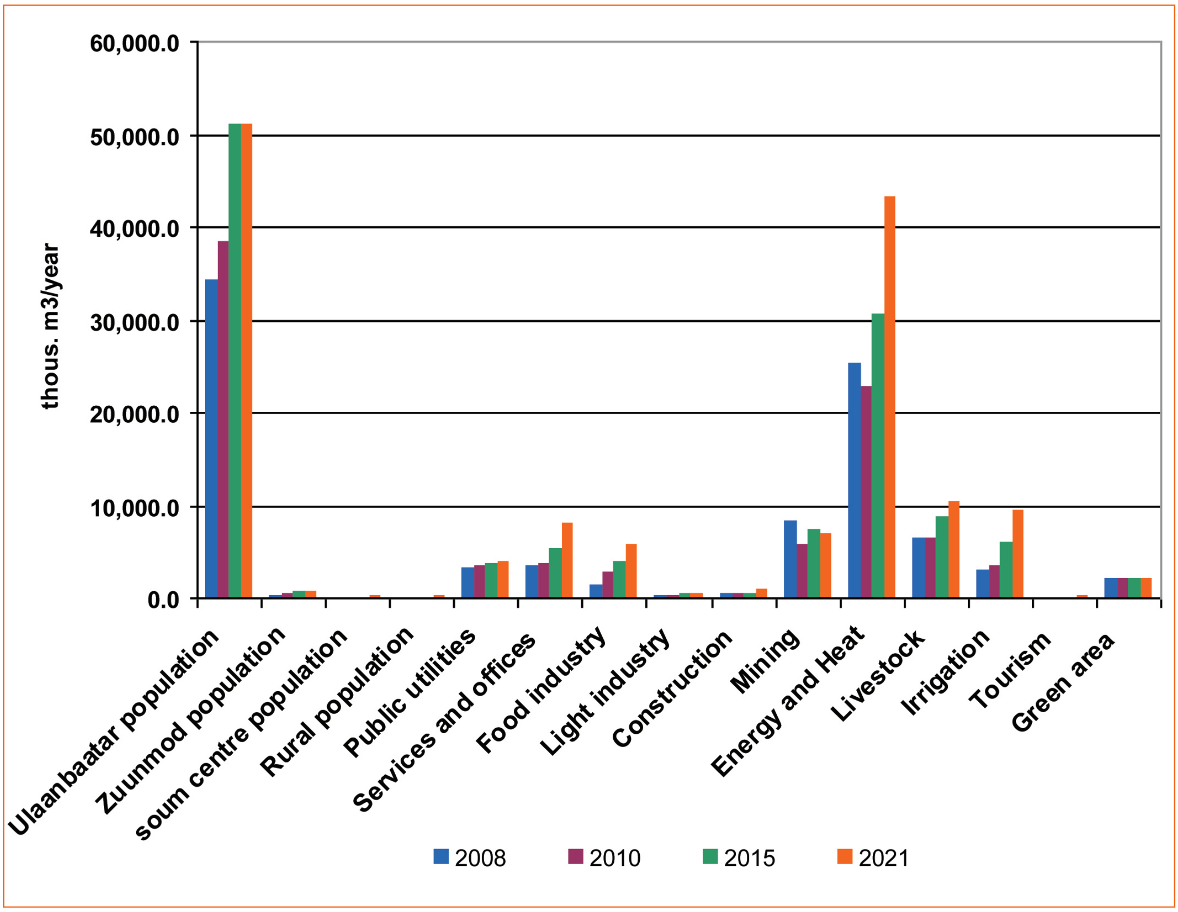


Figure 29. Total water consumption-use and water demand of the basin

3. Hydro–constructions

It is stated in the Mongolian Law on Water that hydro-constructions include ordinary and engineering constructions to regulate water discharge, water collection, water storage, water transfer, water distribution, provision, sterilization, purification and water treatment, exploration of ground water and protection from water disasters.

There are all kind of types of hydro-constructions in the Tuul River Basin and especially, large water supply and sewerage facilities and flood protection dykes in Ulaanbaatar. Wells and irrigation schemes are playing a significant role in the existing hydro-constructions.

Water supply and sewerage facilities in rural and urban areas of the basin, agricultural water supply facilities as well as flood protection system, etc are briefly mentioned in this chapter.

3.1. Hydro-constructions for water supply

3.1.1. Hydro-constructions for cities

Hydro-constructions for water supply in Ulaanbaatar city

The Ulaanbaatar water supply system consists of hydro-constructions that abstract, lift, collect and transmit water from water sources and of auxiliary water lifting and transmission pump stations, reservoirs, and main and branch pipelines.

As of 2010, the Ulaanbaatar water supply system included 176 boreholes from 4 main water abstraction sources, 6 transmission and pump stations, 4 pressure-regulating reservoirs, 350.3 km fresh water pipeline, 301 water kiosks connected to the centralized pipeline and 256 water kiosks not connected to the centralized pipeline. Also the system partially used some 29 boreholes from water supply sources at the Airport and Bio-combinat area for the city's thermo-power plants.

Picture 30. Pipelines used in Ulaanbaatar water supply

In connection with land privatization, citizens and economic entities have established and are using a number of wells on their own land. It's been reported that in recent years inhabitants in Ulaanbaatar suburban areas have established 800 new wells within their own fences for their own consumption.

The Water Supply and Sewerage Company (USUG) of Ulaanbaatar is responsible for the water supply system that supplies water to the Water and Heat Transmission Centres of the House and Public Utilities Company (HPUC) as well as industrial and office water consumers in urban areas of the city. USUG also supplies water to inhabitants in Ulaanbaatar ger areas through the centralized network and not-connected water kiosks.

Water sources: There are 4 water sources: Central, Upper, Meat Factory and Industrial which are being used for water supply in urban areas of Ulaanbaatar (Figure 31). Also there are water sources for water supply of thermo-power plants and a new water source is recently started in Gachuurt village with the support of the government of Japan.

Structure and operation of all the sources are similar. Water is supplied to primary reservoirs by pumps and the city is supplied by water through auxiliary water pumps and pipelines.

Central source: the largest source located in a wide area south-east of the city's constructed area consisting of 82 boreholes (22 wells in east part or between Gachuurt village and Khujirbulan, 45 wells in central part or between Khujirbulan and Central pump station, and 15 wells in west part or between Central pump station and central stadium). Of these, some 78-80 wells are functioning on a regular basis and 104-105 thousand m^3 fresh water is abstracted per day.

These wells were established by renovation programmes of Russia, Mongolia and Japan during certain phases since 1961. The most recent renovation has been carried out and was completed by project of JICA, Japan. Some installation of new pumps, control system and chlorination equipment and system maintenance were carried out under this project.

Water is delivered from the central source to the city centre and Tasgan reservoir through 3 main pipelines and it supplies the 3rd and 4th sub-districts and east part of the pipelines.

Industrial source: established in 1964 for the purpose of water supply to the industrial area located in south-west constructed area of the city and expanded in 1973 and 1976, respectively. This source is located 8 km to the west from the central source. There are 16 wells and 4 water pump stations: 2 of them non-function and 11-14 wells are functioning on a regular basis; 25-28 thousand m^3 water is abstracted per day.

USUG carried out an innovation on water pump station of industrial source in 2001. A new pump, control equipment of variable-speed engine (frequency converter) and discharge measurer and chlorination system were installed.

Meat factory source: was established in 1964 for the purpose of water supply to the meat factory and military compounds in the west of the city. It is located 1.5 km in downstream direction of the industrial source. There are in total 11 wells with a capacity of 19.000 m^3 water abstraction per day.

In the scope of a project implemented with a grant aid from the government of Denmark, all the new wells of the auxiliary water pump stations, well sites, the auxiliary pump and discharge measurers have been updated in 2002. The transmission pipeline of the meat factory source is not separate from other pipelines. The source is important in supplying the current water demand of the city. As the groundwater at this source is in pollution risk in the future, this demand need to be supplied from other sources as quickly as possible.

Upper source: is the second largest water source located 47 km to the east of the city. The well field is located in a stretch with a length of 20 km and occupies 45 km^2 area. There are in total 39 boreholes in this source.

Water is delivered to the equalizing reservoir located 7 km from the city's built-up area through two main pipelines with a length of 50 km and with a diameter of 600 and 800 mm. These pipelines were established for the water supply of the main pipelines and reducing the pressure.

The Upper source was put into operation in 1989 and went through innovation in 2004 and 2005 with the support of the government of Japan.

Thermo-power plant sources: three sources established for the purpose of water supply for thermo-power plants No.2, 3 and 4 are located in south-east of the city. These sources are under the control of the Energy Authority and are established based on groundwater in the alluvial aquifer of the Tuul River floodplain.

Reservoirs: The Ulaanbaatar main pipeline has five large reservoirs. These are West District, the 3rd and 4th Sub-District, Tasganii Ovoo, North-East Regional and the Equalizing reservoirs. In the framework of 'Project-2 for Improvement of Ulaanbaatar Utility Service', one reservoir with a capacity of 1500 m^3 was established in Khailaast for the purpose of water supply for people in Khailaast and Denjiin Myanga areas (water supply is available for people in Chingeltei and Dambadarjaa areas in the future). The reservoir was built by ferro-concrete and covered by soil in order to prevent from freezing during winter. The location of the Ulaanbaatar water supply sources, main pipelines and reservoirs is shown in Figure 31 and the main reservoir indicators are shown in Table 27, respectively.

Table 27. Main reservoirs in Ulaanbaatar

№	Reservoir	Quantity	Capacity of each reservoir, *thous. m^3*	Total capacity, *thous. m^3*
1	North-East Regional	2	3.0	6.0
2	Tasganii Ovoo (hill)	3	6.0	18.0
3	III, IY Sub-Districts	2	3.0	6.0
4	West District	2	3.0	6.0
5	Equalizing	2	3.0	6.0
	Total	11		42.0

The current status of the reservoirs and pump stations for Ulaanbaatar water supply are as follows:

West Districts' reservoir: alternatively named as North-west regional reservoir with a capacity of 3000 m^3 and consists of two parts which stabilize the pressure. The reservoir was established in 1995 and used in water supply for Tolgoit and Bayankhoshuu ger areas.

The 3rd and 4th sub-district reservoir: established in 1969 for the purpose of water storage and pressure stabilization of sub-pipeline of the 3rd and 4th sub-districts. The reservoir consists of two water tanks with a capacity of 3000 m^3 of each. Water is delivered to the distribution pipeline and reservoir of the 3rd and 4th sub-districts from the reservoir of Tasganii Ovoo through Tasganii pump station.

Tasganii-Ovoo reservoir: consists of three water tanks with a capacity of 6000 m3 of each and the largest reservoir in Ulaanbaatar. It was established in 1969-1971 for the purpose of water storage and pressure stabilization of middle part of Ulaanbaatar pipeline network. Water is also supplied from this reservoir to the 3rd and 4th sub-districts.

North-East Regional reservoir: wasn't put into operation until 1990 even though it was established by then-Soviet Union's construction team in 1984 for the purpose of water storage and pressure stabilization. The reservoir is consisted from two water tanks with a capacity of 3000m^3 of each. Within the framework of the Project-1 for Improvement of Ulaanbaatar Utility Service, North-East Regional reservoir was revamped as one part of water supply complex in Khailaast ger district in 2009.

Equalizing reservoir: is located separate from the main central system and is a part of water supply system of the Upper source. It wasn't put into operation until October 2003 however, it was established in 1989. This is for the purpose of reducing pressure of main pipeline that comes from the Upper source. When this reservoir wasn't operating, main pipeline near Uliastai used to operate under pressure of 200 m. Due to water supply system covers/doors under capacity of only 16 bars pressure (approximately 160 m), there was a dangerous situation in which the pipeline covers could have damaged if the pipeline was full of water while transferring from the lowest area to highest. This situation led to limitation of maximum discharge which is permissible in the pipeline and it represents half of the estimated capacity of the main pipeline. The Equalizing reservoir located on medium height between the highest and the lowest areas and it leads to reduction of permissible maximum pressure down to 100 m (10 bars).

Pump station for lifting water:

West District pump station: is aimed at increasing the pressure in west part of Ulaanbaatar pipeline. Therefore, the West District reservoir is enabled to be filled with water. The station was established in 1990 for the purpose of increasing the pressure of water received from the Central source. Although now it is being used for transmitting water from the Upper source to the West District pipeline through the South pipeline by using the West District pump station. There has been neither innovation nor improvement since the West District pump station was established. Currently, only one of four pump stations is in use. This station is going to be used in water delivery to Tolgoit and Bayankhoshuu ger areas through the centralized water supply network in the future.

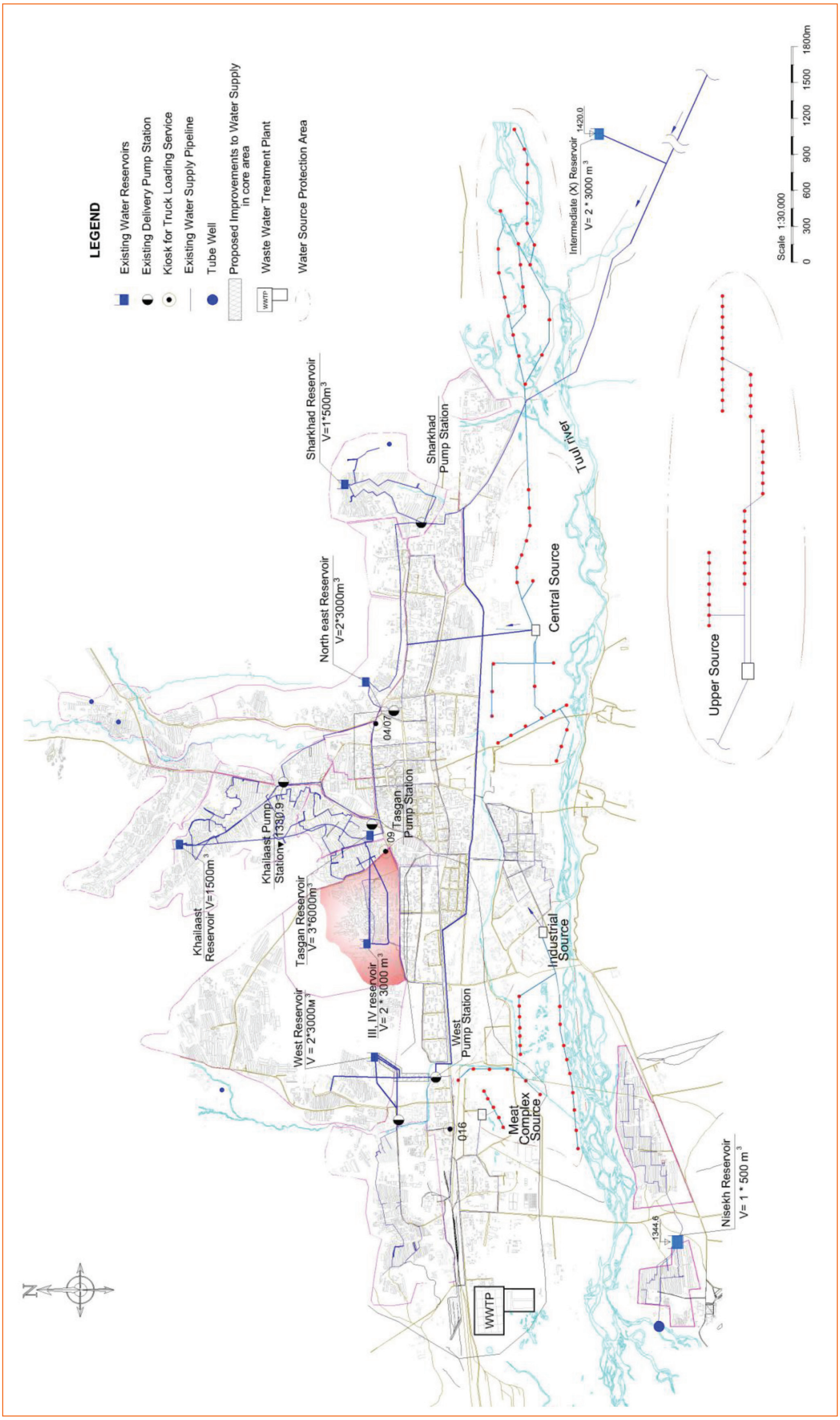


Figure 31. Location of water supply sources, main pipeline and reservoirs in Ulaanbaatar

Tasgan pump station: was established in 1972 for the purpose of water supply for 3rd and 4th sub-districts and water delivery to the 4th sub-district reservoir from the Tasgan Ovoo reservoir. The station consists of some 4 pumps which are all functioned.

Circle/Ring (Road) pump station: is a mini-pump station and established for the purpose of increasing the pressure in water supply for apartments in the 12th sub-district.

Branch pipeline: branch pipeline of central part of the city started to establish since 1959 and completed at certain phases. The pipeline had undergone maintenance and few additional pipelines have been installed since 1992. But so far, expansion and improvement haven't been carried out on a large scale. Even though all construction work was stagnant in 1990, but business construction work has been restored in the end of 1990 and these activities are being increased so far. All New Creation works are being carried out in the scope of or in the vicinity of the currently used pipeline network.

Pipeline network consists of 83.3 km cast-iron and 241.7 km steel pipes, respectively. Cast iron used in relatively earlier established pipelines with a diameter of 250-300 mm and without any internal layer. Most cast-iron pipelines need maintenance as their joints have been depreciated and their pressure capacity has been decreased. Steel pipes have 150-900 mm diameter, without internal layer, but outside is covered by bitumen.

Picture 32. Pump station

New water supply source of Ulaanbaatar or Tuul Complex: As construction in Ulaanbaatar was booming and all the national factories used to operate to their full capacity prior to 1990, water demand was expected to increase. But since 1990, due to the transition from a centrally planned economy to a market economy, the issue over funding a new water source has not been tackled and was left behind. On the other hand, there was a decline in water consumption/use due to stagnation of construction works and bankruptcy of most national factories, etc. It enabled the Ulaanbaatar water demand to be supplied from the above mentioned 4 sources so far. But now water consumption/use is increasing as the city is expanding, population is growing and the number of buildings is increasing according to the general plan for urban development.

Beyond 2015 it won't be able to use the Industrial region and the Meat Factory sources for drinking water. We are facing the necessity to collect and use surface water by carrying out flow regulation in the Tuul River which is a new water supply source of Ulaanbaatar.

A feasibility study for a new water supply source of Ulaanbaatar was executed in 1981-1983 with the assistance of then-Soviet Union's experts. This feasibility study suggested a scenario to use 11 sites with groundwater resources in a 200 km circle around Ulaanbaatar: 6 in the Tuul River valley, 2 in the Kharaa River valley, 2 in the Orkhon River valley and 1 in the Kherlen River valley. Also 5 dam sites: 3 in the Tuul River and 2 in the Terelj River have been studied. And according to comparison of these sources, one scenario to establish dam 2.5 km upstream of the Gachuurt village and to supply water to Ulaanbaatar from open reservoir was selected as the most beneficial one. Therefore, investigations and designs have been carried out in 1989.

Monhydroconstruction LLC implemented a 'pre-investigation work for formulating the feasibility study to establish hydro-construction on the Tuul River' between Nov 2007 and Apr 2008 upon request of the Ministry of Nature, Environment and Tourism and the Water Authority (Figure 33). Under this project some three dam sites have been selected. The 1st dam site selected to be in Khar Us, bend of the river in Gachuurt and it overlaps with the dam site which was previously selected by the Soviet Union's experts (this is considered the most convenient site to construct dam for tackling Ulaanbaatar water supply issue). And the 2nd dam site has been selected to be 2 km downstream of the 2nd site which was previously selected by Soviet Union's experts. The 3rd one selected to locate 70 km upstream of Ulaanbaatar or 4km downstream of Tuul-Terelj confluence.

Also Prestige Engineering LLC studied the Tuul Water Complex in 2010-2011 for the purpose of making regulating the Tuul River runoff, safe water supply for Ulaanbaatar in the future, hydro-power production, establishing complex hydro-construction including water refreshing facilities, solution of water supply for large factories and objects, and creating a convenient environment of ecosystem in the Tuul River Basin. A preliminary feasibility study has been carried out and dam sites to establish dam were selected.

In doing so, 2 sites have been selected to build a dam at initial stage. The 1st one is located 80 km upstream of Ulaanbaatar and 4.3 km downstream of Bosgiin bridge (river valley is 1367 m wide according to the standard level of reservoir, average perennial discharge is Q_0=9.6 m^3/sec, discharge is W=305.8 mil.m^3, watershed area is F=2253 km^2, the basin is 2037 m high on average, flood discharge with 1% probability, and discharge is $Q_{1\%}$=1107 m^3/sec). And the 2nd dam site is located 63 km upstream of Ulaanbaatar and selected to overlap with the 3rd dam site selected by Monhydroconstruction LLC or downstream of Tuul-Terelj confluence in lower boundary where brushwood, aspen, larch and spruce forest is the most widespread (river valley is 1667 m wide according to the standard level of reservoir, average perennial discharge is Q_0=27.4 m^3/sec, discharge is W=872.83 mil.m^3, watershed area F=4164 km^2, the basin is 1778 m high on an average, and flood discharge with 1% probability is $Q_{1\%}$=1548 m^3/sec) (Figure 34).

The preliminary feasibility study considered that one or both dams are possible to be constructed and used at the same time. The 1st scenario for a reservoir is considered to be solely used until 2030 and the second one is to be used after 2030, additionally.

The Tuul River Water Complex is intended to become an important multifunctional project creating a reliable water supply source for Ulaanbaatar, hydro-power use of Tuul River water, flood protection, river ecology conservation, condition for aquatic sports, tourism and aquatic animal breeding, etc.

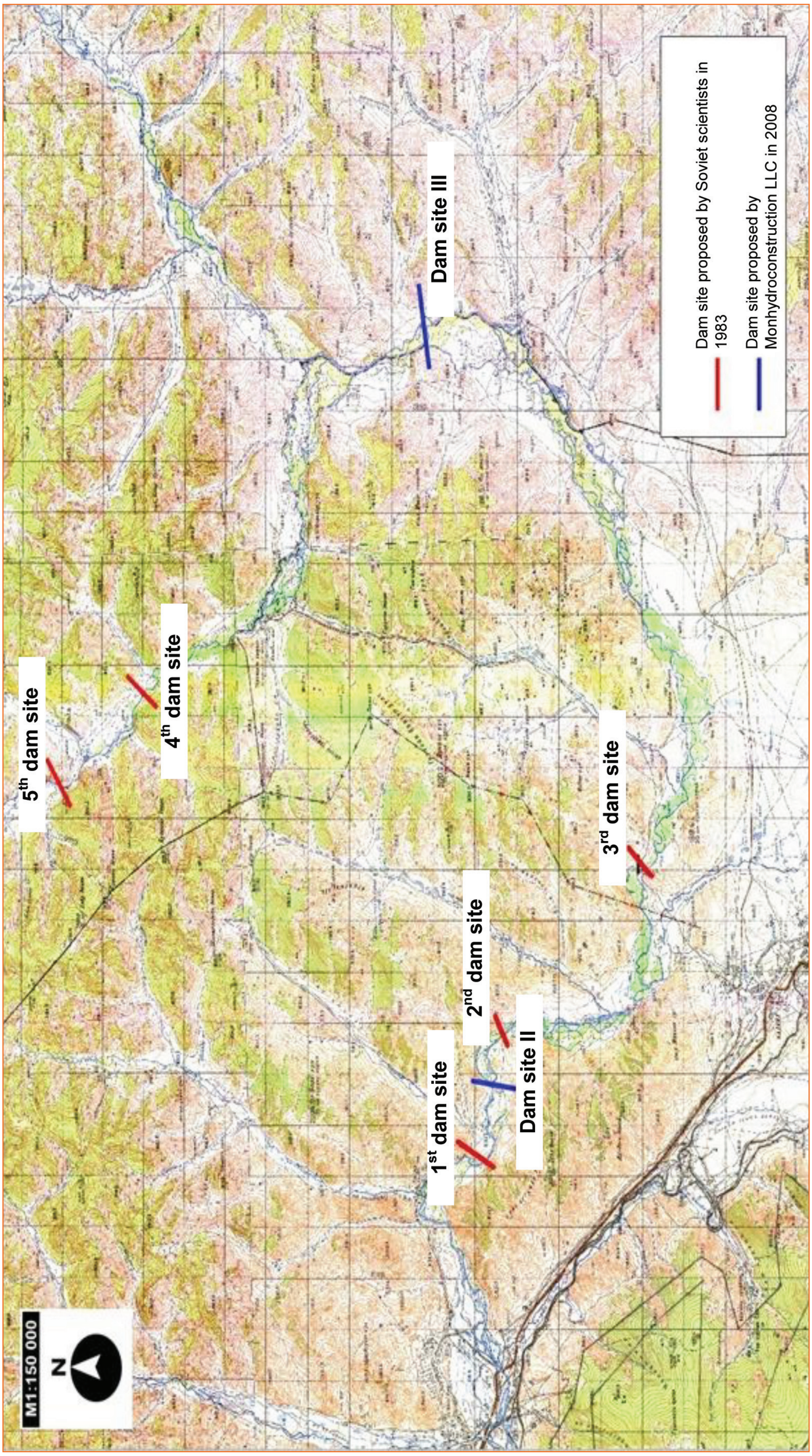


Figure 33. Dam sites selected by Soviet Union's experts in 1983 and by Monhydroconsturction LLC in 2008 on the Tuul River

Figure 34. Dam sites selected by Prestige Engineering LLC in 2010 on the Tuul River

Hydro-constructions for water supply in Zuunmod city

The water source of the centralized water supply of Zuunmod is groundwater. It uses a hydro-construction consisting of 3 wells, 2 pump stations and water transmission pipeline with a length of 15 km in Khushig Valley located 12 km to the south-west of the aimag centre.

Picture 35. Replacement of old fresh water pipes

Water supply for residents in ger districts is delivered through 2 water kiosks connected to the centralized water supply network and 15 water kiosks supplied by water truck.

Service centres and citizens in Zuunmod established some 11 wells and are using them for their own drinking water demand.

3.1.2. Hydro-constructions for water supply in rural area

The Tuul River Basin includes in total 19 soum centres of 5 aimags: Sergelen, Altanbulag, Erdenesant, Undurshireet, Lun, Argalant, Bayantsogt, Zaamar, Ugtaal, Bayankhangai, Bayan-Unjuul soum centres of Tuv aimag, Burd soum centre of Uvurkhangai aimag, Khashaat soum centre of Arkhangai aimag, Rashaant, Bayannuur, Dashinchilen, Gurvanbulag, Buregkhangai soum centres of Bulgan aimag, and Orkhontuul soum centre of Selenge aimag, etc.

Picture 36. Boreholes for water supply in soum centre

Boreholes are commonly used in water supply for soum centres. And water softening equipment has been installed in some wells with a high hardness and mineralization. But they are not being used due to high operating cost and lack of maintenance.

Hydro-constructions for water supply in soum centers

There is no centralized water supply network in soum centres in the basin (except connection of some soum centre wells with boiler, school, hospital and administration building through pipes). Instead, 2-3 boreholes are being used. Design of this well is similar to design of pastoral well. As soum centres are connected to the mains, electric water pump is used in their wells.

List of boreholes used in drinking water supply for soum centres of the basin is shown in Annex 1.

Hydro-constructions for water supply in rural area (pasture)

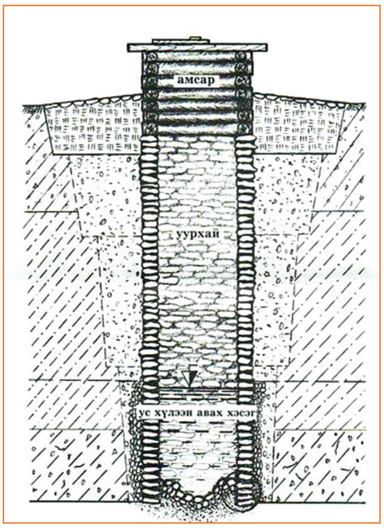
Rural wells are not specifically established for the purpose of water supply for rural people (herdsmen and farmers), but mainly established for irrigation and livestock watering. Drilled (borehole), short tube, concrete ring and hand dug wells are being used in water supply.

On one hand, there is no detailed study of well construction, reservoir and status of their use and on the other hand, the basin boundary crosses the territories of soums. Therefore, it's difficult to come up with clear figures in this regard. But there is data and information that 355 rivers, 389 springs and 3897 wells are used for livestock water supply. Of the wells, some 1519 boreholes, 584 short tube wells, 480 hand dug wells and 3 ponds.

Wells are divided into two classifications: well with traditional design and with engineering design (drilled, concrete ring and short tube).

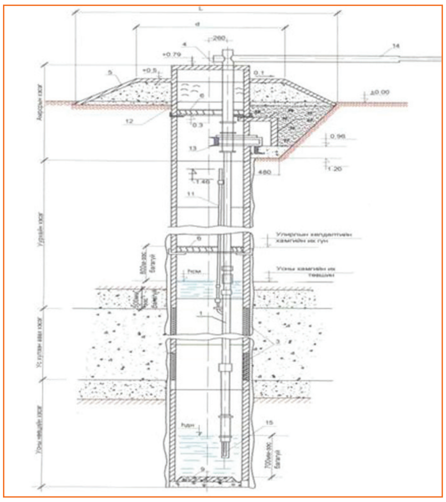
Traditional (dug) well: is a hand-dug well and its inside wall is built with stone and wood. Its average depth is 3-5 m and the deepest is 6 m. Bucket is used in drawing water from the well.

Engineering wells: these are wells established according a special design, technical specification and standard for the purpose of groundwater use for livestock water supply based on calculation adapting to natural and climate conditions. An engineering well is different from the traditional one by its design: not to freeze in winter, not to pollute the groundwater, not to decrease well yield, not to change water quality and mechanization of water lifting, etc.



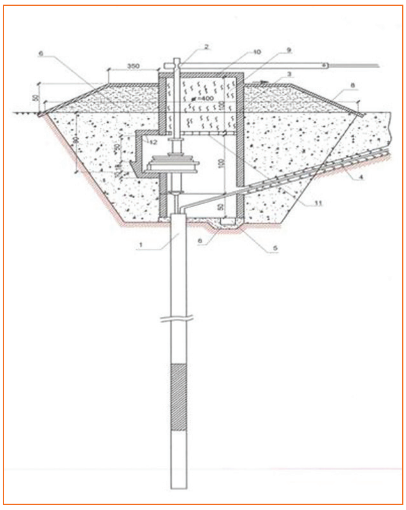
Picture 37. Design and use of a hand dug well

Concrete ring well (Pit well): well drilled 30 m by KShK-30 drilling rig and concrete ring with 1 m in diameter installed inside the well and equipped with NV-3M pump which is mechanically operated. This well was built with an engineering design such as insulation, sanitation stoop, square and trough with a length of 9-12 m.




Picture 38. Design and appearance of concrete ring well

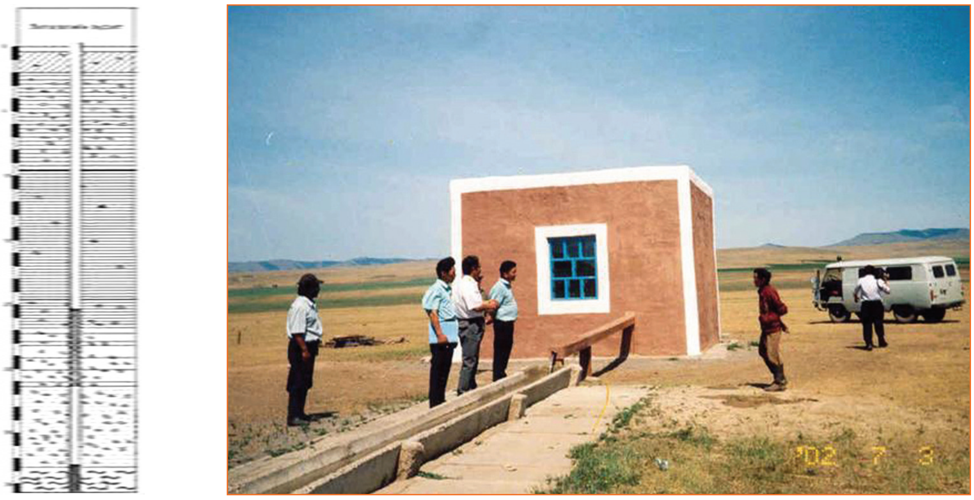
Short tube well: is 30 m deep drilled by drilling rigs such as UGB-50A, URB-2A, URB-3AM and tube with 6-8 inches in diameter installed inside the well and equipped with NV-3M pump on the well. It has a stoop, enough area and trough with 9 m in length as well. Its appearance is similar to and confused with the hand dug well. But the well water is only able to be lifted by pump. Because it's impossible to draw water from the well by using a bucket.




Picture 39. Design and appearance of Short tube well

The NV-3M pump was used in concrete ring well and short tube well by using man and animal power for drawing water from the well. As this pump is no longer manufactured since 1990, concrete ring wells are non-functioning. So this type of well is used as hand dug well or a borehole is established nearby.

Borehole: Groundwater resources in artesian and pressureless aquifers are investigated by geophysical and drilling methods. URB-2A, URB-3AM and 1BA-15B rotary drilling rigs, etc and UKS-22 percussion drilling rig drilled 30-300 m deep. A 6-10 inch tube was installed inside the well, filter installed adapting to aquifer, VL-3M pump installed in combination with T-62 mini-power generator with one cylinder. A small building is built to protect these equipments of the well with a water tank. A 12 m trough was built outside the construction.



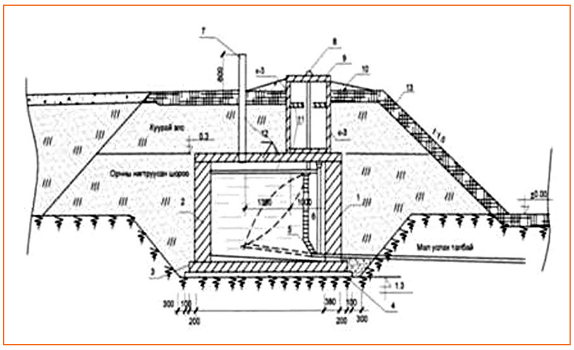
Picture 40. Design and appearance of a borehole

The drilling rigs, pumps and engines were manufactured in the former Soviet Union.

Above pumps and engines are rarely found in recent years and their operating cost is too high. And in establishing new borehole and restoring old wells, some pumps: DBZ, QGD, QDX, QJ manufactured in China, VRD, UQN manufactured in German Democratic Republic, electric pump manufactured in Grundfos LLC of Denmark, some power generators: ET-950, EF-1600 manufactured in Yamaha and Honda LLC of Japan, and X170F, 5EF, R185 manufactured in China, etc have been installed.

Since 2000, many boreholes have been established in pasture areas by loan and grant aid from the state budget, foreign countries and international financial organisations, and above various models of water lifting devices /pumps/ and power generators have been installed. Consequently, technical policy has been lost and making it very difficult to provide maintenance.

Reservoir: was established in prefabricated and mould ferro-concrete half dump and half hole with a capacity of 8-16 m3 in winter and spring camps. Water is delivered into the reservoir by water truck and it flows into livestock watering area without any external force. Agricultural socialist cooperatives collapsed after 1990 and water trucks were privatized. Therefore this sort of reservoir is almost abandoned and unused.



Picture 41. Reservoir

Pond: is a construction with an engineering design consisting of a soil dam, pond excavation and excess water drainage that is established for the purpose of watering livestock (hay, crop and trees) by collecting rain and snow water.

In recent years ponds have been established in the Tuul River Basin by state budget and are being used for irrigation and livestock watering by collection and use of rain and snow water in accordance with the Comprehensive National Development Policy based on Mongolian Millennium Development Goals, Water National Programme and Mongol Livestock National Programme (Table 28).

Picture 42. Pond to collect snow and rain water

Table 28. Ponds established in the basin for collection of snow and rain water

№	Aimag	Soum	Area	Source	Pond capacity, m^3
1	Tuv	Altanbulag	Shireekhuush	snow and rain water	1000
2	Tuv	Altanbulag	Khuurai Am	snow and rain water	1710
3	Tuv	Erdene	Bayantsogt Am	snow and rain water	9472

Irrigation schemes: a complex system established for the purpose of irrigating hay, crop and pasture areas consisting of hydro-constructions and equipments for collection, transmission, distribution and allocation of groundwater and drainage of excess water.

Picture 43. Main channel and sprinklers of an irrigation scheme

In the Tuul River basin, some 4 old irrigation schemes (Guna, Dund-Urt, Khar Usan Tokhoi and Bukhug-2) with engineering design and the projected initial capacity of 411 ha have been restored for irrigation of 284.7 ha area since 2005. And 26 new irrigation schemes with 1339.2 ha area have been established (Annex 2).

3.1.3. Conclusion on hydro-constructions for water supply

- Some parts of hydro-constructions and equipments such as central water supply pipelines in the cities of Ulaanbaatar and Zuunmod, and soum centres have been largely depreciated and outdated. Therefore, maintenance and expansion are really needed.
- A technical policy is not implemented at national level on standardization of water lifting equipment /pumps/ and power generators as variety of types is being installed on boreholes located in soum centres and pasture area.
- Groundwater scarcity is occurring locally as boreholes used in water supply for urban areas doesn't meet the natural groundwater regime.
- Due to NV-3M pump that installed in concrete ring and short tube wells in pasture area is not manufactured, this sort of well is no longer used. That's why boreholes are newly established by the side of such wells. But this can't be a substantial measure to prevent from pasture use in uninhabited area as well as grazing intensity.
- In recent years, there is a particular support from the state budget in establishing ponds. But ownership and use of the ponds are still unclear.
- It is necessary to carry out the detailed study on area where irrigated crop is available and to establish irrigation schemes in possible area. Therefore, it needs to launch water-efficient equipment which limits groundwater use in crop irrigation.

3.2. Sewerage and wastewater treatment

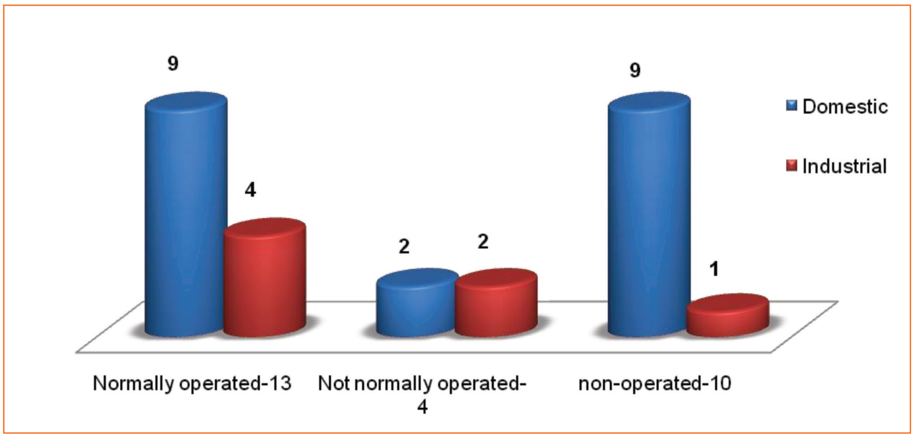
In Mongolia, urban areas' wastewater treatment was generally started in 1964 by introducing science-based advanced technologies and operating control systems on a regular basis with the assistance from developed countries. It was an important measure to prevent from negative impact on environment and ecology.

In this scope, all the factories and service units in the basin that used to produce wastewater were supplied by large and mini wastewater treatment plants /WTTP/ and the related systems were put into operation. After the transition period of Mongolia's new economic and social system, many WWTPs were out of service, abandoned and unused.

Now average wastewater discharged to the Tuul River from WWTPs in the basin amounts to 168300 m^3 per day. As a result, the river's self-purification possibility is being lost and this is negatively affecting its water environment. Therefore, it leads to loss of healthy and safe environment for human and livestock.

There are 27 WWPTs in 7 districts of Ulaanbaatar, Zuunmod city and 9 soum centres of Bulgan, Selenge and Tuv aimags. One WWTP is respectively located in Rashaant soum of Bulgan aimag, Orkhontuul soum of Selenge aimag, Erdenesant, Bayantsogt, Zuunmod, Bayankhangai Sergelen and Ugtaal soums of Tuv aimag. And 2 WWTPs in Zaamar soum, 6 in Songinokhairkhan district, 3 in Bayanzurkh district, 6 in Khan-Uul district and 2 in Nalaikh district.

Of these 27 WWTPs, some 13 plants are normally operating and 4 are not normally operating and 10 are non-operating (Picture 44).



Picture 44. Operating levels of wastewater treatment plants

Amongst above WWTPs, there are 18 domestic WWTPs and 9 hospital and industrial wastewater pre-treatment plants. And 5 plants of each are non-operating, respectively.

Table 29. Type of wastewater treatment plants in the basin

Type of wastewater	Wastewater treatment plant	Wastewater pre-treatment plant
Domestic wastewater	15	-
Hospital wastewater	-	2
Mining camp domestic wastewater	1	-
Tannery, wool and cashmere industrial wastewater	-	5
Meat processing industrial wastewater	-	2
Skiing camp domestic wastewater	1	-
Children's camp domestic wastewater	1	-
Total	18	9

For domestic WWTPs in the Tuul River Basin, a list of currently used domestic WWTPs are shown in Table 30.

Table 30. Domestic wastewater treatment plants operating in the basin

№	City and aimag	Soum and district	Wastewater treatment plant	Type of treated wastewater	Type of WWTP	Date put into operation	operation	Type of treatment	Capacity, m³/day		Where to discharge wastewater	Owner	Geographic coordinates	
									Projected	Current				
1	Ulaanbaatar	Songino-khairkhan	Central wastewater treatment plant	domestic		1963	normal	mechanic, biological	230000	160000	Tuul River	UB Water Supply and Sewerage Company	47.9036	106.763
2			Bayangol WWTP / Nairamdal/	domestic		1978	normal	mechanic, biological	200	200	Bayangol	UBUSUG	48.0063	106.7298
3		Khan-Uul	Airport WWTP	domestic		1985	normal	mechanic, biological	1000	2200	Tuul River	UBUSUG	47.8578	106.7523
4		Bayanzurkh	National Centre of Contagious Disease WWTP	domestic	pre-treatment	1986	normal	mechanic, chemical	3000	600	Central Pipeline	Ministry of Health	47.9144	106.9486
5			Psychiatric Clinic WWTP	domestic	pre-treatment	1986	normal	mechanic, chemical	280	280	Central WWTP	Ministry of Health	47.9343	107.0153
6			MCS Sky resort WWTP	domestic		2009	normal	mechanic, biological, chemical	30	30	reused	MCS LLC		
7		Nalaikh	Nalaikh WWTP	domestic		1976	normal	mechanic	2000	4500	Tuul River	Chandmani Nalaikh	47.779	107.2648
8		Khan-Uul	Bio WWTP	domestic		1989	normal	mechanic, biological	700	1300	Tuul River	UBUSUG	47.8388	106.6774
9	Tuv	Zuunmod	Soum WWTP	domestic		1995	not normal	mechanic, biological	2700	2100	soil	Tuv Chandmani	47.6859	106.9423
10		Erdenesant	Soum WWTP	domestic		1971	not normal	mechanic	200	200	soil		47.3134	104.4935
11		Zaamar	Shijir Alt LLC WWTP	domestic		2006	normal	mechanic, biological	100	100	Tuul River	Shijir Alt LLC	49.2969	104.4098

3.2.1. Domestic wastewater treatment plants

There are in total 18 domestic WWTPs in the Tuul River Basin. Of these, some 8 plants are located in Ulaanbaatar, 4 in Tuv aimag and 1 in Selenge aimag, respectively. And 5 plants are completely out of service.

Ulaanbaatar city

61% of Ulaanbaatar ger area households reside in houses and 38% reside in gers. And 92.8% of total households have their own pit latrine in their fences. Most pit latrines are unable to use from last months of the winter due to full of solid and liquid wastes.

As of 2010, 42% of Ulaanbaatar population are connected to the centralized pipelines network or have an access to improved sanitation.

Table 31. Sanitation availability of Ulaanbaatar population

Coverage	Population	Remark
Population have an access to the centralized sewage network	411 062	Subject to people who have an access to flush toilet connected to sewage system and WWTP.
Population have an access to improved sanitation	50 000	Subject to people who have an access to septic tank, flush toilet, improved pit latrine with air conditioner and eco-toilet.
Population have an access to non-improved sanitation	600 000	Subject to people who have an access to pit latrine, borehole, public toilet and open field.

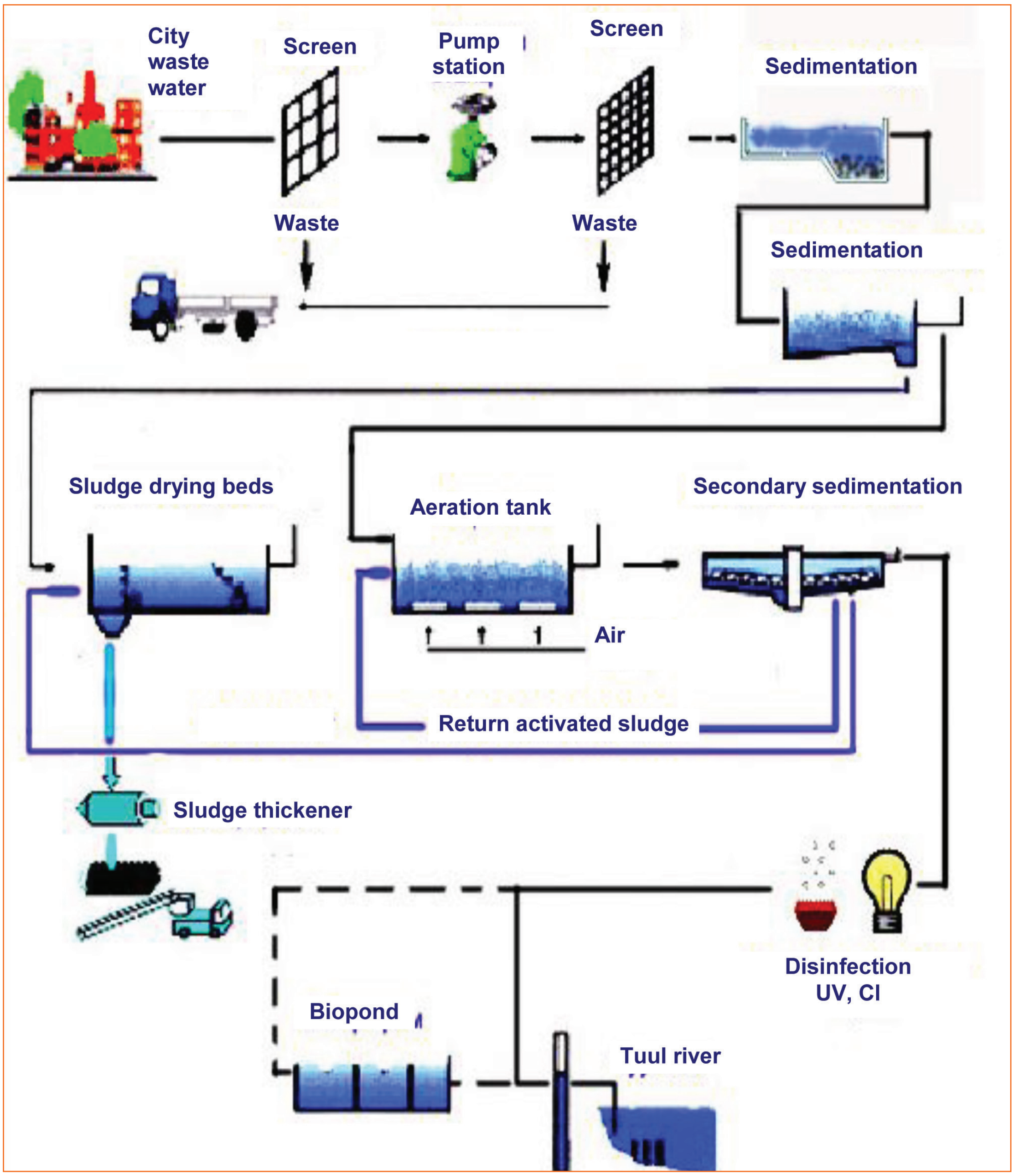
Ulaanbaatar Central WWTP: receives pre-treated domestic and industrial wastewater from Ulaanbaatar and treats the wastewater through mechanical and biological treatment plants. The plant was established in 1964 according to a design prepared by Hydrocommunvodacanal Institute of Soviet Union based on the mission of Mongolian side. Its capacity is to receive normally 45,000 m^3 wastewater per day and treats it up to 50% by using mechanical treatment. In connection with the capital city's development, the Central WWTP was expanded in 1979 and 1986 with a capacity to receive normally 200,000 m^3 wastewater per day and to treat the pollution up to 90-92%.

In principle, current wastewater treatment method hasn't been changed than it was initially planned. But sludge is drained in its sludge bed by natural method without processing. This is due to sludge and residue processing digester system wasn't built according to plan. In order to improve land use and accelarate sludge drainage process by expanding the WWTP, sludge bed has been reconstructed as a sludge thickening area.

Today WWTP receives 155-165 thousand m^3 wastewater per day, treats it by mechanical and biological treatment and delivers it into the Tuul River. Wastes, fat, oil, sand and sludge in wastewater are treated by mechanical treatment. And organic pollution is treated by biological treatment with the support of air and activated sludge by fermenting and mineralizing it, and disinfecting it by ultraviolet radiation.

From 600 to 700 m^3 sludge is pumped into 44 small fields with a total area of 14.7 ha per day and drained by natural method. And 14-15 thousand m^3 drained sludge is collected and loaded on trucks, then transported and dumped into specifically prepared landfill area.

Liquid chlorine is poured into channel of treated wastewater with the support of weight measurer Superior.



Picture 45. WWTP's technological conveyer

Pump station: when this pump station was firstly put into operation to receive wastewater from industrial region/district, there were only 5 SDV-2700/23.5 pumps and 3 RMU-4 screens. The pump station was additionally equipped with 5 AFP 5004 pumps and 3 ER screens. Today the station receives over 100 thousand m^3 wastewater per day and pumps it into the screening.

Pump station that receives domestic wastewater: firstly started its operation with GrUL-12 pump, 2 10F12 pumps and 2 MG-8 screens. Now it operates with 4 Cornell pumps and 2 ER screens. The station currently receives over 50 thousand m3 wastewater per day and pumps it into the screening.

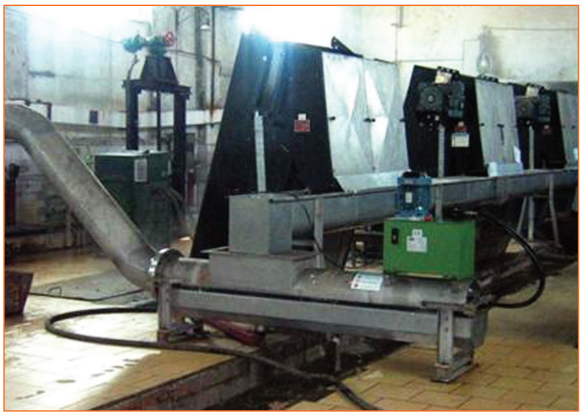
AFP 5004 pump

Cornell pump

Picture 46. Pumps

Screening: was put into operation with 4 MG-10 screens and 1 comminutor. During the operation, the comminutor was out of service and 2 screens were replaced with different screens manufactured in Mongolia. Currently, the screening is operating with some 4 ER screens and waste pump.

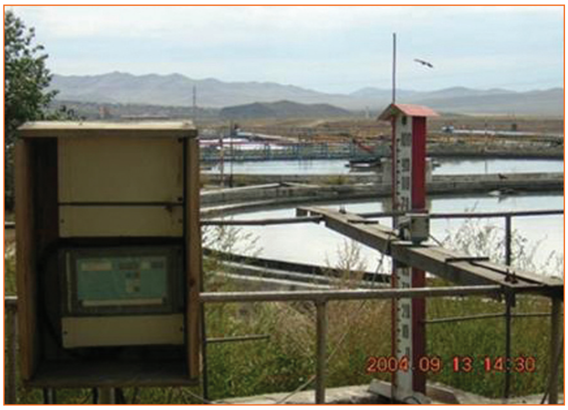
Screening



ER screening and waste pump

Picture 47. Screening

Grit chamber: there are four chambers in use. Each chamber has hydro-elevator for delivering sand into sand field/site. Previously, water level in Parshall channel used to be measured by rake and received water here was determined by normal calculation. But now it is measured by Ultrasonic automatic measurer at high accuracy.



Grit chamber   Discharge measurer /ultrasonic/

Picture 48. Grit chamber

Primary clarifier or raw residue pump station: 2 5F12 pumps (40 kW) and 1 SD-250/22.5 pump (37 kW) have been installed for the purpose of pumping sludge and raw residue into sludge bed. Also 4 radiation clarifiers (Sh40m) with 8Sh12 pump (55kWt) are being operated to empty the clarifier. Automation work has been carried out in pump station for pumping raw residues such as sludge, fat, grease and oil. And this is considered as a technical and technological innovation in a mechanical treatment conveyer. Consequently, it not only enabled to control, to regulate and to change operation of the station, but mechanical treatment level has been improved and safe operation has been provided.

Primary clarifier   Pump station for raw residue

Picture 49. Primary clarifier and pump station for raw residue

Aeration tank: 5 aeration tanks are being operating in four chambers. Previously, air used to be delivered to each chamber of aeration tanks with the support of grid boards. During the operation, these boards were cracked and air was largely lost. But now each aeration tank has been equipped with membrane diffuser and aeration has been improved.

Aeration tank

Aeration tank diffuser

Picture 50. Aeration tank construction

Aeration station: started operation in 1979 with 3 N-750-23 compressors and 2 K45/30 pumps for pumping water used in machines and equipments. In 1984 the station was additionally equipped with 3 N-750-23 pumps at 2nd expansion level. Since 1992, the operation started with 5 pumps. Now the station is operating with 3 KA22S compressors and 3 N-750-23 compressors.

KA22S compressor

N-750-23 compressor

Picture 51. Aeration tank

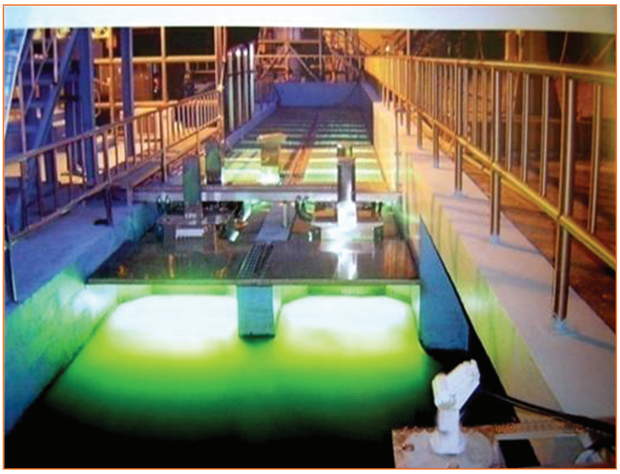
Secondary clarifier and return sludge pump: there are 5 radiation clarifiers with a diameter of 40 m in operation. Pump station for activated sludge was firstly started with 5 10F12 pumps for pumping activated sludge into aeration tank, 1 5F12 pump for pumping excessive sludge, 2 D320/50 pumps for pumping water used in machine and equipments and 1 8F12 pump to empty the aeration tank and clarifier. Currently, 4 KX and CM pumps are being operated.

Return sludge pump

Second clarifier

Picture 52. Second clarifier and return sludge pump station

Disinfection: UV/Air disinfection system of DOOHAP LLC, Korea has been installed in 2010. It aerates wastewater and rays/beams it with UV lamp. That's why this system is cost-efficient and can kill bacteria without large facilities.



Picture 53. Disinfection facilities

Central WWTP Sludge processing equipment: its location was determined in connection with Ulaanbaatar population density, development and settlement in 1960-1970. As the city expanded, now the location is almost in the middle of the city. And gas and odour emission from sludge which drained on open field might negatively affect the human health and hygiene. As the drained sludge is dumped into landfill, there is a risky condition of pollution in soil and water of that area. Therefore, it is necessary to launch a technology that completely processes the sludge from the WWTP.

There were 2 old clarifiers with a diameter of 28 m in 2008. But they have been newly equipped and now used as the sludge thickening equipment. Also 2 BS-25 filter-presses have been installed within the framework of a project implemented by the government of Spain. The sludge thickening equipment pumps 3122 m^3 sludge and raw residue mix with 98.5% moisture from the primary clarifier per day according to its operation mode. Sludge pump station has been restored and two pumps have been installed, additionally. Then thickened sludge is dehydrated by 2 BS-25 filter-presses. In the result, sludge moisture becomes less than 80%, volume becomes 234 m^3 and the treated sludge is enabled to be directly transported and dumped into landfill.

Picture 54. Sludge dehydration equipment

Picture 55. Sludge thickening equipment

Bayangol WWTP /Nairamdal children's camp/: was established in 1979 under UBUSUG for the purpose of carrying out mechanical and biological treatment by technology of the Soviet Union and located in Songinokhairkhan district. In 1996 the plant was expanded and 2 KU-100 equipments were installed. Now it is consisting of pump station, currently used KU-100 equipment as well as sludge bed. Treatment capacity is 400m^3 domestic wastewater. The plant receives 350-450 m^3 wastewater per day or 140,000 m^3 per year wastewater from Nairamdal international children's camp and premises for treatment and discharges the treated wastewater into environment. According to data and information from accredited Central Water Laboratory analyses, treatment level is 88%.

Picture 56. Bayangol WWTP

Airport WWTP: established in 1971 for the purpose of filter area under UBUSUG and innovated in 1973 for the purpose of carrying out mechanical and biological treatment by equipments and technology of Soviet Union. In 1989, the plant was expanded by installing 3 KU-200 equipments and establishing 3 sludge beds. Treatment capacity per day is 1000 m^3, but the plant currently receives 2000-2200 m^3 wastewater which is as much twice and treats wastewater by mechanical and biological treatment and delivers the treated wastewater into the Tuul River. According to data and information of the Central Water Laboratory analysis, treatment level is 86.4%.

Picture 57. Sludge bed and pump station at Airport WWTP

National Centre of Contagious Disease (NCCD) pre-treatment plant: was established in 1986 with a projected treatment capacity 3000 m^3 wastewater per day and treats 600 m^3 wastewater from the hospital and 219,000 m^3 per year. It carries out mechanical and chemical treatment in the wastewater and delivers it to the centralized wastewater pipeline. The plant has 5 technicians. Sludge from the WWTP is treated once a year and 42 ton sludge is discharged and dumped into the sludge bed of the Central WWTP. In 2008, technical innovation has been carried out and now the plant is being normally operated.

Picture 58. NCCD Wastewater Pre-Treatment Plant construction

Psychiatric Hospital Wastewater Pre-Treatment Plant: was established in 1986 under the Ministry of Health within the scope of cooperation between Mongolia-Czechoslovakia. Mechanical treatment is daily carried out in 280 m^3 wastewater per day and in total 102,200 m^3 wastewater is treated per year. Some 60 m^3 wastewater is transported 12 times a day and delivered to the centralized wastewater pipeline. Sludge from the WWPT is treated and discharged once a year and dumped into the sludge bed of the Centralized WWTP.

Nalaikh District WWTP: was established in 1976 with a projected treatment capacity of 2000 m^3 wastewater per day. Currently, mechanical and biological treatment is carried out in 1450 m^3 wastewater and the treated wastewater is delivered to the Tuul River. Owner of this plant is Chandmani Nalaikh state owned company. The plant construction has a monitoring laboratory inside. Chemical analysis is carried out in raw and treated wastewater to/from the plant once a week.

Picture 59. Wastewater pipeline and sludge bed at Nalaikh District WWTP

Bio Factory WWTP: was established in 1990 under UBUSUG for the purpose of carrying out a mechanical and biological treatment using equipments and technology of Soviet Union with a treatment capacity of 600m^3 per day. As of today, the plant receives and treats 290-320 m^3 wastewater per day from buildings with 60, 25 and 48 apartments, schools and kindergartens located in the territory of Khoroo 12 of Khan-Uul district, and the plant delivers the treated wastewater into the Tuul River. Treatment level was 50-76% in 2007, 54-82% in 2008 and 78-87% in 2009, respectively. Buildings of 60, 52 and 68 apartments in Khoroo 12 of Khan-Uul district don't have an access to hot water supply and it causes difficulties in operation of WWTP in winter and makes it impossible to carry out a biological treatment.

Picture 60. Bio Factory WWTP's clarifiers

"Sky resort" skiing camp WWTP: Sky Resort was established in 2009 by MCS LTD and its domestic WWTP was built. The plant treats 30 m^3 wastewater per day by using mechanic, biological and chemical methods and reuses the treated wastewater as an artificial snow.

Zuunmod city

Zuunmod WWTP: was established in 1995 with a capacity of carrying out a mechanical and biological treatment in 2700 m^3 wastewater per day. During its normal operation, 2100 m^3 wastewater is treated per day. A technical innovation has been carried out in 2010-2011 and equipments manufactured in Poland have been installed. And 1 OZ-B/500/2 automatic screen installed in screening part, 1 OH 1/N9 manual screen installed for use while maintenance and treatment are carried out, and automatic discharge measurer, grit chamber and old hydro-elevator have been replaced and 2 MF404D underwater-operating grit pumps installed in water measuring channel, a new sludge stabilizer installed in old sludge mineralizing facilities, 2 IFRA 1F2 100T pumps installed for improving operation of primary clarifier, aeration system with a special aeration nozzle /254 pieces/ and 2 LDO Lange light sensors to determine oxygen content and 2 temperature sensors installed in aeration tank, AFP 1032.IM60/40 pump installed in the secondary clarifier, 70*70*1.9 m sized 4 bio ponds with soil dam and other auxiliary equipments, and fresh and wastewater and heating systems have been newly established. Also Russian Lonii-100 disinfection equipment has been replaced with CMP10-TEKNA disinfection equipment manufactured in Poland.

Shijir Alt LLC WWTP: the company runs gold mining activity in Zaamar soum of Tuv aimag and established mini-WWTP in 2003. The plant carries out mechanical and biological treatment in 150-200 m^3 domestic wastewater from mining camp and dumps the treated wastewater into the Tuul River.

Other domestic WWTPs

There are approximately 20 mini-WWTPs for the purpose of carrying out mechanical treatment with a capacity 15~2500 m^3 in the basin. General status for wastewater treatment technologies of such plants are shown in Table 32.

Table 32. Technology used in domestic WWTPs

Capacity, m^3/day	Total	Qty	Technology used in domestic WWTP
10 ~ 200	11	2	Mechanical screen to filter wastes, wastewater pipeline and wastewater is delivered to the Central WWTP in Ulaanbaatar.
		6	Mechanical screen to filter wastes, wastewater pipeline and wastewater is dumped into soil.
		3	Mechanical screen to filter wastes, comminutor, grit chamber, primary clarifier, aeration tank, secondary clarifier, wastewater is dumped into nature.
200 ~ 500	4	1	Mechanical screen to filter wastes, wastewater pipeline and wastewater is delivered to the Central WWTP.
		1	Mechanical screen to filter wastes, wastewater pipeline and wastewater is delivered into nature and soil.
		1	Mechanical screen to filter wastes, comminutor, grit chamber, primary clarifier aeration tank, secondary clarifier, chlorine disinfection equipment and wastewater is delivered into the Central WWTP.
		2	Mechanical screen to filter wastes, comminutor, grit chamber, primary clarifier, aeration tank, secondary clarifier and wastewater is dumped into nature.
500 ~ 1000	2	1	Mechanical screen to filter wastes, wastewater pipeline and wastewater is dumped into nature and soil.
		1	Mechanical screen to filter wastes, comminutor, grit chamber, primary clarifier, aeration tank, secondary clarifier, chlorine disinfection equipment and wastewater is delivered into the Central WWTP.
1000 ~ 5000	3	3	Mechanical screen to filter wastes, comminutor, grit chamber, primary clarifier, aeration tank, secondary clarifier, chlorine disinfection equipment and wastewater is dumped into nature.
> 300000	1	1	Mechanical screen to filter wastes, comminutor, grit chamber, primary clarifier, aeration tank, secondary clarifier, disinfection equipment with ultraviolet radiation and wastewater is dumped into nature.

3.2.2. Industrial WWTPs

Wool and cashmere processing factories and tanneries are concentrated in the floodplain of the Tuul River or in the territory of Khan-Uul district of Ulaanbaatar. These factories produce a significant amount of heavy metals and toxic substances. However, some of these factories have WWTPs but their operation is not normal. Industrial WWTPs in the Tuul River Basin are shown in Table 33.

Table 33. Large Industrial WWTPs in the Tuul River Basin

№	City	District	WWTP	Date put in operation	Capacity, m^3/day	Current capacity, m^3/day
1	Ulaanbaatar	Songinokhairkhan	Makh Impex shareholding company	1968	7000	7000
2			Mon Noos LLC	1982	1200	1200
3			Cashmere Holding LLC	1978	3000	3000
4		Khan-Uul	Gobi shareholding company	2009	50	50
5			Goyo LLC	2001	10	10
6			Khargia Ulaanbaatar-owned company	1972	13000	5300

Makh Impex shareholding company wastewater pre-treatment plant: Makh Impex LLC was established in 1972. And the pre-treatment plant's equipments and technology are now outdated and damaged. Nowadays 164 m^3 wastewater from the sausage factory and butchering factory is treated per day and treated wastewater is delivered to the Central WWTP. Oil parshall equipments are already outdated and damaged and factory operation is deficient.

Mon Noos LLC wastewater pre-treatment plant: was established in 1979 and used to carry out pre-treatment in industrial wastewater from the factory and deliver it into the Khargia pre-treatment plant. But now wool factory operation is completely out of service. And domestic wastewater from Orkhon University and Kherchsen Guril (chomped/prepared noodles) Factory is delivered to the Central WTTP through this pre-treatment plant.

Cashmere Holding LLC wastewater pre-treatment plant: established in 1980 and previously owned by Eermel shareholding company. Mechanical treatment is carried out in 60-75 m^3 industrial wastewater from wool processing, washing and dying factory and the treated wastewater is delivered into the Central WWTP. Its clarifier capacity is 6.6 m^3. Sludge after treatment is treated on weekly basis and 18 ton sludge is dumped into landfill monthly. The company has the plant's technological innovation project formulated by Us Borgio LLC and is preparing for its implementation in the future.

Goyo LLC wastewater pre-treatment plant: established in 2001 and located in the territory of Khan-Uul district of Ulaanbaatar. It treats industrial wastewater produced during the operation of wool and cashmere processing factory and delivers it into the Central WWTP. And its treatment capacity is 50 m^3 per day. There are two separate pre-treatment plants to treat industrial wastewater from washing and dying workshops. The wastewater is analysed by the industrial wastewater laboratory of the Central WWTP on regular basis.

Gobi shareholding company wastewater pre-treatment plant: established in 2009 and located in Khan-Uul district. Pre-treatment is carried out in industrial wastewater from washing and dying workshops of wool and cashmere processing factory and the treated wastewater is delivered into the central wastewater pipeline. Its treatment capacity is 10 m^3 per day. Before the pre-treatment plant was established, industrial wastewater used to be delivered into the Central WWTP. At that time, industrial wastewater exceeded than the treated wastewater standard. Since the pre-treatment plant was established, it has been normally operating.

Khargia wastewater pre-treatment plant (Ulaanbaatar-owned company): established in 1972 as a part of manufacturing factories with main function to pre-treat industrial wastewater from tanneries up to a particular composition content and deliver the treated wastewater into the Central WWTP.

The plant was expanded in 1975 with neutralizing station, reservoir to receive wastewater with a chemical composition, stabilizing reservoir, pump station and horizontal clarifier for wastewater contains both chrome and other chemical composition, respectively. The plant has been updated with a capacity of 13865 m^3 wastewater.

Picture 61. Khargia Industrial Wastewater Pre-Treatment Plant

There are over 20 factories and economic entities which connected to the plant through 2 special pipelines with a diameter of 300-500 mm. Depending on old and depreciated equipments and outdated technology used in chemical treatment of the plant, wastewater treatment operation basically stopped. And it was negatively affecting treatment level of the Central WWTP. Technology to neutralize trivalent chrome by calcimine has been used and wastewater contains alkali and chrome has been received in two separate pipelines.

Picture 62. Expansion of the Khargia wastewater pre-treatment plant: Newly established construction with a capacity of 200-400 m^3

Khargia wastewater pre-treatment plant has been restructured as Khargia shareholding company according to the resolution No.43 of the Privatization Commission of the Government of Mongolia in 1993. Due to deficiency in its operation, the plant has been also restructured as the Pre-treatment plant Ulaanbaatar-owned company according to the resolution by the Citizens' Representatives' Khural (City Council) in 2010. The plant has been renovated by the investment of MNT1.5 billion from the state budget and put into operation in April 2011. Currently, the plant treats 5400 m3 industrial wastewater from 4 tanneries and delivers to the Central WWTP.

Mini-Industrial WWTPs

There are over 50 mini-industrial WWTPs in the basin which established by economic entities for the purpose of industrial wastewater treatment. Mini-WWTPs are shown in Annex 3.

It's good that these companies treat their industrial wastewater on their own costs. It has been considered that it needs to put non-operating treatment plants back into operation, to renovate and improve them and to stabilize their operation.

It is necessary to make analysis on the current situation of treatment plants except plants of Arildii LLC, Future LLC, Lora Piana Mongolia LLC and Ikh Ergelt LLC. And to take certain measures which might suitable for their own technologies over improvement of wastewater treatment level.

Picture 63. Newly established wastewater pre-treatment plant of Future Holding LLC

Picture 64. Newly established wastewater pre-treatment plant of Arildii LLC

3.2.3. Non-operating WWTPs

As of 2010, there were 9 non-operating domestic WWTPs and 1 non-operating industrial WWTP in the Tuul River Basin (Table 34).

It needs to carry out the detailed study on current status of WWTPs in soum centres in the basin, to make a new design for the plants, to provide maintenance and to launch operation of the related equipments.

Also it needs to charge Khan-Uul, Songinokhairkhan and Nalaikh districts to take measures such as carrying out the detailed study on current status of WWTPs in Poultry and Pig farms and Gorodok area included in the territory of Ulaanbaatar and putting the plants into operation.

Table 34. Non-operating wastewater treatment plants in the basin

№	City and aimag	Soum and district	WWTP	Date put into operation	Type of treatment	Projected capacity, m^3/day	Geographical coordinates		Measure to take in the future
1	Ulaanbaatar	Khan-Uul	Poultry farm WWTP	1981	Mechanical and biological	500	47.77	106.65	To put into operation
2		Nalaikh	Gorodok area WWTP	1989	Mechanical and biological	2800	47.79	107.41	To put into operation
3		Songino-khairkhan	Pig farm WWTP	1980	Mechanical	270	47.91	106.80	To study and use
4	Tuv	Bayantsogt	Soum WWTP	1973	Mechanical	200	48.12	105.81	To put into operation and renovate
5		Zaamar	Soum WWTP	1968	Mechanical	240	48.21	104.77	To put into operation and renovate
6		Bayan khangai	Soum WWTP	1989	Mechanical and biological	200	47.95	105.54	To put into operation
7		Ugtaal	Soum WWTP	1983	Mechanical and biological	200	48.07	105.44	To put into operation
8		Sergelen	Soum WWTP	1973	Mechanical and biological	560	48.32	107.71	To put into operation
9	Selenge	Orkhontuul	Soum WWTP	1974	Mechanical	450	48.83	104.80	To put into operation and renovate
10	Bulgan	Bayannuur	Soum WWTP	1976	Mechanical	100	47.37	105.95	To put into operation and renovate

3.2.4. Sanitation in sanatorium and spa resorts

Table 35. Sanitation in sanatorium and spa resorts that have been involved in the study

№	Sanatorium and spa resorts and their owners	Type of treatment / waste water handling
1	Bayanbuural (of Railway in Batsumner soum)	Mechanical and biological treatment is carried out and wastewater is dumped into Kharaa River.
2	Bayangol (of the Ministry of Construction in Batsumber soum)	Mechanical and biological treatment is carried out and wastewater is dumped into Bayangol River.
3	Ar Janchivlan (of Administration of Livestock Fattening Area in Erdene soum)	Mechanical and biological treatment is carried out and wastewater is dumped into soil.
4	Terelj Saran Travel hotel (in Nalaikh district)	Wastewater is stored in ferro-concrete tank with capacity of 200 ton and dumped by carrying it.
5	Ulaanbaatar-2 camp (of Ulaanbaatar hotel)	Wastewater is stored in ferro-concrete tank with capacity of 40 ton and dumped by carrying it.
6	Terelj Suikh camp (of Gachuurt LLC)	Mechanical and biological treatment is carried out in summer and wastewater is dumped into soil; Wastewater is pumped into pit with capacity of 24 ton in winter
7	Gorkhi Melkhii Khad camp (of Customs General Authority)	Wastewater is stored in ferro-concrete tank with capacity of 100 ton and dumped by carrying it.
8	Gorkhi camp of (of the government)	Wastewater is pumped into pit with capacity of 10 ton
9	Ar Khuvch camp (of Ulaanbaatar hotel)	Wastewater is pumped into pit of Ulaanbaatar-2 camp
10	Other camps and children's camps	Public toilet

3.2.5. Recommendations on WWTPs

It is stated in Article 24 and Clause 1.1 of the Mongolian Law on Water that water using citizens and economic entities need 'to have own WWTP to treat wastewater produced during water use up to the standard level' and stated in Article 24 and Clause 1.2 of the law that it is necessary to have a technology to reuse and efficiently use water, respectively.

- Industrial WWTP availability is insufficient in the Tuul River Basin.
- To renovate WWTP equipments, to improve monitoring activities on treatment level of treated wastewater and to make it constant;
- To make amendment and alteration in the relevant legislation having a condition which will grant a permission for running production in case of industrial wastewater meets the standard level, doesn't have a negative impact on the nature and ecology, and meets the hygienic requirements;
- To enforce Mongolian Law on Water Pollution Fee;
- To improve operation and use of Khargia pre-treatment plant;
  - To enable biological treatment
  - To create opportunity to collect the treated wastewater in specifically designed ponds and reuse it for industrial purpose without delivering it into the Tuul River and the Central WWTP
- To process sludge from WWTP and to put it into domestic circle. To take systematic measures: abstract a flammable gas and energy from sludge pumped by conveyer and use it in producing fertilizer and curb, etc;
- To launch a technology that collects the treated wastewater in ponds for reuse without dumping into natural water sources and soil;
- To draw up and enforce a general technical requirement standard and instruction for using a septic and mini WWTPs for the purpose of domestic wastewater treatment;
- To bring the wastewater pipeline closer to ger area and to establish a new one;
- To carry out an inventory on pollution point sources of the Tuul River and to precisely determine boundaries of the river's self purification;
- To organize framework to protect the Tuul River from pollution and scarcity in the scope of activities of the Tuul River Basin Council;
- To draw up and enforce a technological solution for wastewater treatment which is suitable for Mongolian natural and climate conditions, households, organizations, soum and settled areas;
- To train professional personnel and familiarize with imported sanitation equipment and technology in providing normal operation of the equipments that carries out treatment, disinfection and processing and monitoring of wastewater and its sludge. And to properly deal with the financial sources for carrying out investigations.

3.3. Constructions for flood protection and rain and soil water drainage

3.3.1. Flood protection system

Tuul River Basin includes large factories, economic entities and important state objects in Ulaanbaatar city 1191.9 thousand population/ and Zuunmod city /15.3 thousand population/ which are influential on the country's economy. Therefore, over 100 km dam and channels; and 70 km underground pipelines with different coordinates for 18 collectors and 40 water filtration constructions to drain rain and soil water have been established and are being used for the purpose of protecting the important objects from the river, pebble and flash floods.

Picture 65. During flood in Ulaanbaatar in 2009

In order to make assessment and conclusion on current situation of flood protection constructions, some flood protection systems in Ulaanbaatar have been considered.

After flood took place in Ulaanbaatar in 1966, first investigation on Flood protection system was started, design work was formulated and construction performance started. Construction for flood protection which flows through pebbles was additionally built after flash flood disaster due to heavy shower in August 1982 near Chingeltei Mountain of Ulaanbaatar.

Flood protection systems in the vicinity of Ulaanbaatar which are independent from one another can be considered as follows:

Flood protection system of West Mountain: involves flood protection channels in Denjiin Myanga, channel from 32 circle and Nogoon Lake to Dund River, flood protection systems in the 3rd and 4th sub-districts and Tolgoit River.

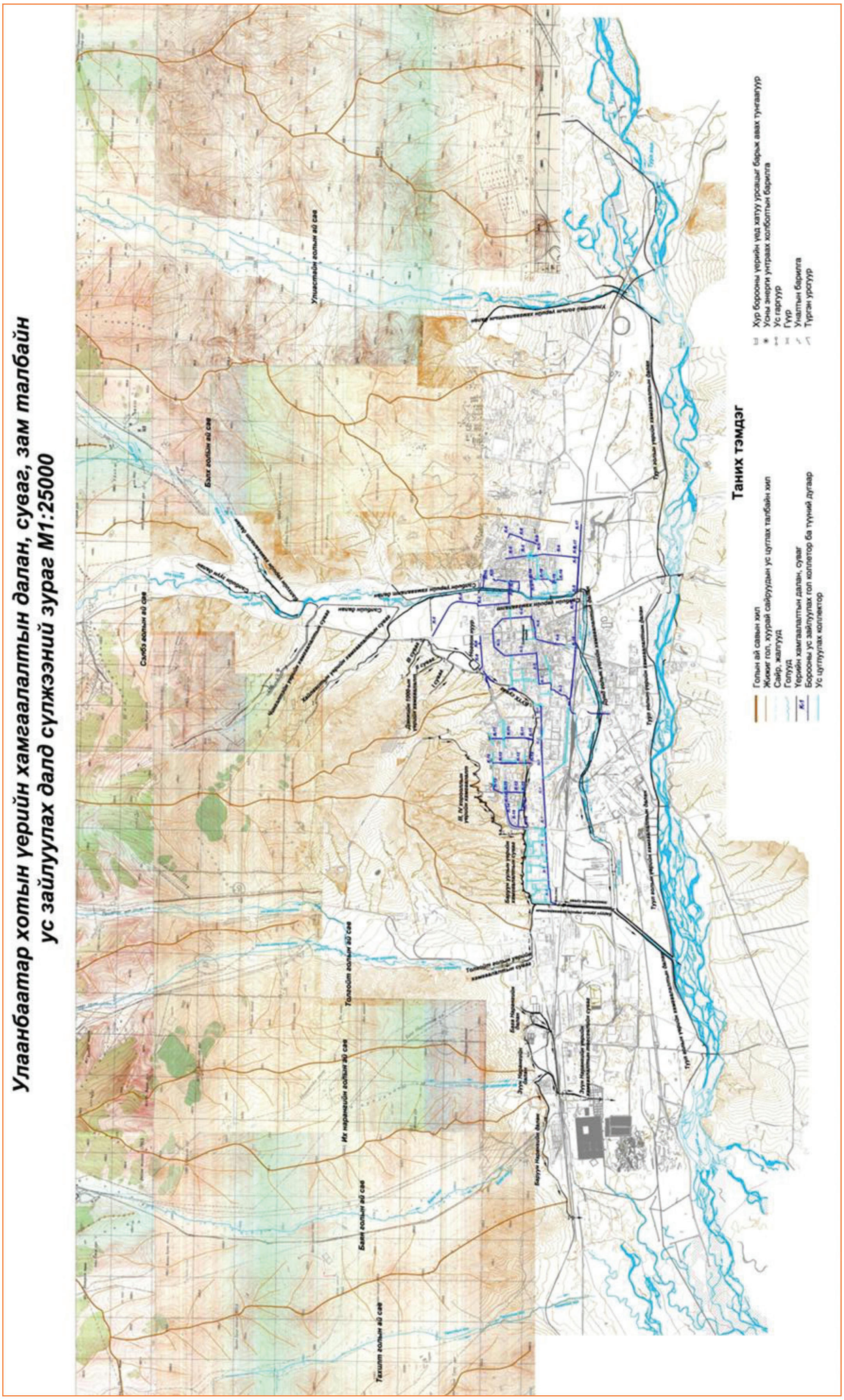
Flood protection channel was built in 1965 with a length of 23.7 km in order to protect the central Ulaanbaatar from flood from south and south-west ravines of the Chingeltei Mountain. This channel was built not only for protecting Ulaanbaatar from flood but for the purpose of improving water environment in downstream part of Nogoon Lake and creating micro climate.

This channel collects flood water from all pebbles and ravines of Denjiin Myanga and the West Mountain, rain water from the 3rd and 4th sub-districts, water from flood protection channel and all the pebbles and ravines of north hill of the 1st sub-district. Then the channel joins with flood protection channel of Tolgoit River and flows into Dund River.

The West Mountain channel not only delivers flood water but represents a channel which drains /shallow/ groundwater or spring, water loss from heavy and engineering pipelines and wastewater from ger area, etc. Therefore, under-road water drainage facilities are full of ice and frozen in winter and large amount of ice coverage appears along the channel. It makes the channel incapable to carry spring flood.

Picture 66. Appearance of flood protection channel filled with snow and ice

As the flood protection channel and trench are filled with ice and frozen, spring snow and ice water overflows the channel and flood disaster strikes the city's roads, squares and buildings. Except that, ice significantly degrades the quality of concrete products. Due to this situation, city of Ulaanbaatar suffers from melt snow and ice runoff or spring flood and it caused huge damage repeatedly in both direct and indirect ways. Considerable amount of sediment is collected in the West Mountain channel by flood water from the roads, squares and side pebbles during summer rain.



Picture 67. Layout of flood protection systems in Ulaanbaatar

After flood, some 20-30% of cross section in some parts is covered by mud and sometimes the West Mountain channel is completely covered by gravels (sediments) transported by flood water from the side channels, pebbles and ravines. It causes flood disaster surrounding area. For instance, considerable amount of waste, gravel and sand are transported by flood water through the 3rd channel of Denjiin Myanga and deposited in confluence of the West Mountain channel. As it encloses the channel and flood water overflows, city of Ulaanbaatar is suffered from flood disaster.

Ulaanbaatar suffers from melt snow and ice runoff or spring flood and it causes considerable amount of damages many times in direct and indirect ways. Flood water from the roads, squares and side pebbles dumps large amount of sediments into the West Mountain channel during the flood caused by summer rain.

Another important part of flood protection systems of the West Mountain is a channel with internal prefabricated ferro-concrete layer and with a length of 4.36 km located in the 3rd and 4th districts.

Picture 68. Wastes dumped into the flood protection channel

People dump their wastes into the channel and some fences were built very close to the connection construction in the end of ravine which joins the channel. And it makes unable to clarify and collect solid wastes transported by flood water before entering the channel. In other words, gravels and stones transported by flood water along the pebbles directly enter and deposit in the channel. It not only reduces the channel's capability of water drainage, but also covers/clogs main channel (which water flowed through) by gravels and stones in several events. And there have been two flood disasters nearby.

It needs to build a clarifier to screen solid runoff in the beginning of constructions connected to channel in the end of dry pebbles and to clean the clarifier on regular basis. It is impossible to maintain a normal operation of the flood protection system in the 3rd and 4th sub-districts without establishing such clarifier.

As we can see from the study, this main channel was built with a drainage capacity of 5.7 m^3/sec flood water in its upstream part. But flood discharge in 2003 and July 2009 was 7.5-9.5 m^3/sec which is two times much more than the channel capacity. During the floods, flood water overflowed the dam which collects sediment and flood disaster has been caused.

In the West Mountain flood protection, number of hydro-technical constructions such as dyke, channel, tunnel, trough channel, clarifier, underground water transmission pipeline, water inertia-reducing well, sediment parshal, chute, etc are used in combination. This can possible lead to a loss of normal operation and flood disaster if waste is dumped there and they are clogged by construction wastes, etc. So it needs to provide citizens with public awareness in this regard.

Flood protection system in Selbe River: involves flood protections of Chingeltei, Khailaast and Belkh rivers, the tributaries of the Selbe River. It was planned to build the combined system of a dam and channel along the Selbe River channel from the Dund River upstream part to the Khailaast River downstream part or the bus station II. The channel's inside wall was built with stones mixed with remicon. This construction still existing in upstream of the bridge on the Selbe River of Ikh Toiruu (big ring) and has been used for more that 4 decades. But recently the stones have been peeled off and used for other purposes. Consequently, there is a condition that brittles the dam and to be washed by water runoff.

Increasing water environment site within the city of Ulaanbaatar by using Selbe River water has a multi-lateral importance such as creation of a micro-climate in such environment and improvement of the city's appearance, etc.

Systems in the Selbe River really can't meet current demand in terms of its design suitability, appearance and damage. Along the river channel, weir collects 40-50 cm sediments in thickness and decreases the river's flood passing capacity. In some parts of the river, flood water with 1% probability is incapable to be passed by.

It is necessary to update design of flood protection systems in the Selbe River and to increase the bridge's capacity to pass river water and to remove currently damaged concrete weir.

Picture 69. Flood protection channel in the Selbe River

Flood protection system of East Mountain: collects snow and rain water through open natural pebbles near Tsagaan Davaa and Shar Khad areas and the water flows through underground pipelines. It is connected to ravine that protected by soil dam located in the west of Police Department of Bayanzurkh district through water inertia-reducing well. Then it is delivered into the Tuul River through tunnels under Narnii Zam /road/ and railway. Currently, ger area and buildings are being built on watershed area of dry pebbles. This leads to tricky situation which causes flood disaster.

Hydro-construction locally owned company under the Ulaanbaatar Meyer's Working Office is responsible for improvement of the city's infrastructural engineering constructions, renovation of flood protection systems and pipelines, lawn and trees irrigation using soil water, establishment of park consisting of irrigation systems, fountains and ponds as well as its operation and maintenance.

***Flood protection system in the Tuul River*:** involves the west flood protection dykes in Uliastai and Tuul Rivers.

Dam in west bank of Uliastai River was continuously established as a soil dam 24.5 km in length with internal stone layer along the north bank of the Tuul River until the Songsolon Bridge. Due to human activities, the flood protection dyke was cracked and partially damaged in its several parts during the long period of use and became unable to pass the flood water through it. Even Standard apartment block was just built in the flood protection dyke of the Tuul River.

***Zuun (East) Naran flood protection system*:** involves soil/ channel dug in the west and east of the existing oil base and the channel located in the end of Baga /small/ Naran pebble.

***Baruun (West) Naran flood protection system*:** involves soil dam which directs the flood water from Ikh Naran and Bayangol valley and drainage pipes under railway and the roads.

Hydro-Construction Ulaanbaatar-owned company in charge of operation and maintenance of the flood protection and snow/rain water drainage systems in Ulaanbaatar needs to focus on taking measures for protection from the flood disasters mentioned in this report.

Re-planning of Zuun and Baruun Naran flood protection systems included in the general development plan for Ulaanbaatar until 2020. But implementation of measures became unable due population settlement area appeared in its watershed area and land has been privatized.

3.3.2. Conclusion on the flood protection systems

- Complex measures to protect Ulaanbaatar from flash flood, river flood, soil water and rain water have been planned in the general development plan for Ulaanbaatar until 2020. But its implementation is insufficient.
- During the flood, flood protection channel and clarifying lake near Denjin Myanga and Nogoon Lake is full of sludge and wastes from ger area. As fly, mosquito and pests are bred here, it leads to a condition of contagious disease which has a negative impact on social hygiene.
- Due to low drainage capacity of flood water passing channel, it can't pass a particular part of the flood water. And this may lead to condition in which Ulaanbaatar suffers from flash flood. Renovation is required in the flood protection dyke and channels in Khailaast and Chingeltei areas.

- As there is no flood protection system in the vicinity of Yarmag, Airport and Bio factory, it needs to be newly established.
- If it rains near Dari-Ekh and Maakhuur Tolgoi /hill/ flood water flows towards the 13th and 14th sub-districts and blocked by road and railway. As a result, puddle is created and soil is polluted. This possibly has a negative impact on social health. Therefore, it needs to take measure on flood water drainage.
- It needs to successfully pass and prevent from possible flash flood in Ulaanbaatar. Location and number of engineering construction is lack and unprepared to operate in summer.
- It needs to clearly determine the maximum runoff of unstudied small rivers, springs and dry pebbles which have small watershed area in the vicinity of the city centre, and to build a robust hydro-construction with a high quality which will survive for 100 years, by design with the most rational technical solution. This is for the purpose of a successful pass of the largest flood which possibly can occur once-in-hundred years and safe protection of the city from the flood disaster.
- Tuul River dam urgently needs a complete renovation and maintenance.
- Large amount of flood water is unable to pass by the Arslantai Bridge on the Selbe River, but only 70% of a flood with 1% probability is able. Therefore, it needs to renovate the Arslantai Bridge, flood protection dyke and channel in the Selbe River.
- Migrant from rural areas to the city settle down on ravine mouth and dry pebbles without permission and disregard the resolution of local administration. Consequently, they may largely suffer from flood disaster and it causes big damage during the flood. Therefore, it is necessary to create a legal system to completely stop old practice in which sufferers receive the state grant and aid.

3.3.3. Rain and snow water drainage system

Due to global warming and degradation in ecological condition of Ulaanbaatar environment, annual precipitation and its in-year distribution have been significantly changed. And rainfall in and around the city has been likely turned into type of heavy shower in recent years and risk of flood disaster is being increased. Meanwhile, paved roads and squares in the city have a low drainage capacity and are clogged in some parts. Consequently, the city streets and squares are likely to repeatedly suffer from flood disaster.

There are currently 18 collectors consisting of ferro-concrete pipelines with a length of 30 km (with a diameter of Ш500, Ш600, Ш800, Ш1000 and Ш1500) for rain and snow water drainage in Ulaanbaatar. Each collector consists of own water collection pipeline. Total length of water collection pipeline is more then 50 km. These water collecting pipelines are the constructions consisting of underground network with a special function to drain water from rain/snow and water filtrated from groundwater in the territory of 6 districts of Ulaanbaatar. Drainage capacity of these collectors' pipelines ranges between 0.1-4.0 m3/sec.

Picture 70. Clogging of rain water drainage pipeline during the flood

Pump station was put into operation in 1987 for underground pipelines to drain rain/snow water from surface of paved roads and asphalt squares. Capacity is 14000 m^3/hour (Q=3500 m^3/hour per pump). This station is located in the west of Kharkhorin market in Songinokhairkhan district.

3.3.4. Soil water level drainage system

Many numbers of systems, communication, electricity and other engineering networks are damaged in the city of Ulaanbaatar due to impact of soil water. And these systems are unable to use.

A system to provide safe flood protection in Ulaanbaatar, to lower impact of soil water and to drain rain water from the road and squares will be a guarantee of providing the city's sustainable development and protecting the citizens' peaceful life and their properties.

There are number of cases such as erosion of construction basement by water, the basement and cellar suffer from flood water, subsidence of the construction basement and crack on the construction wall, and damage in electric cable and other underground engineering pipeline networks in some parts with a high soil water fluctuation such as central part of Ulaanbaatar (along the old West Selbe River channel), Bayankhoshuu, Khaniin (wall) material ger area, ger area from school No.17 to the east of Doloon Buudal (bus station 7), Gandangiin Khur, 16th sub-district, Dari-Ekh ger area and Dambadarjaa ger area, etc.

There is crack on walls and putrefaction on floor of the first store of some 20 buildings such as building No.14, 44, 16 and 13 in the city centre and Baga Toiruu (small circle), some building of the 1st Duchin Myangat (40,000) and Tavin Myangat (50,000), and the State Palace, Property Authority building, expansion of National History Museum, Art Museum, etc. And it has a negative impact on working and living conditions of citizens. Also swamp in the basement/cellar of some buildings in both summer and winter and it creates humid environment. As a result, fly, mosquito and pests are breeding and it leads to outbreak of contagious disease. One of two Gandan children's hospital buildings is completely collapsed, and Tolgoit road is damaged and it is unavailable for cars.

Except that, some 40% of buildings in the central part of Ulaanbaatar are suffered from the impact of soil water to some extent.

The first project for protecting Ulaanbaatar from (shallow) groundwater water regarding the impact of groundwater in the north and central parts of Ulaanbaatar and measures to protect from this impact was formulated by Gyprocommunstroi institute of Soviet Union in 1959. Ever since the first project, several Mongolia's Investigation and Design Institutes carried out investigations, formulated projects and made a particular proposal. However, it wasn't implemented.

As Ulaanbaatar is located in the floodplain of the Tuul River and its tributaries, soil water level is often fluctuating depending on changes in the river water level and amount of precipitation falls on land surface. This situation still continues due to soil water lowering construction wasn't built in Ulaanbaatar so far.

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ANNEX 1. Location and technical specification of wells used in water supply for aimag and soum centres included in the basin

Aimag	№	Soum	Owner	Year put into operation	Location		Depth, m	Well yield, l/sec
					Longitude	Latitude		
Arkhangai	1	Khashaat		1959	103.08.56	47.26.59	30	0.9
	2			1974	103.08.50	47.26.50	56	4.0
Tuv	3	Zuunmod	New school	1973	106.56.35	47.42.55	36	1.8
	4		Technical base and construction	1977	106.57.00	47.41.15	35	6
	5		Material and technical basis	1981	106.56.15	47.41.20	46	8
	6		Stadium and park	1983	106.56.49	47.41.49	62	2.7
	7		Military unit No.078	1986	106.27.15	47.41.40	31	1.51
	8		Military unit No.256	1986	107.02.30	47.40.45	60	4.0
	9		Nomt	1987	106.56.50	47.42.00	56	1.1
	10		Construction military unit	1988	106.57.50	47.12.50	60	2.5
	11		Sanatorium	1988	106.57.38	47.43.07	77.8	2.5
	12		Water sector park	1990	106.56.00	47.40.45	30	2.5
	13		in Commune	1990	106.57.05	47.41.25	38	11.05
	14	Sergelen		1980	107.00.00	47.37.00	58	1.3
	15			1980	106.59.10	47.37.00	56	1.4
	16			1986	107.01.58	47.36.30	61	8.0
	17			1988	107.02.00	47.36.50	65	2.5
	18	Altanbulag		1974	106.23.45	47.41.10	61	2.0
	19			1989	106.25.40	47.40.58	53	2.0
	20	Bayan-Unjuul		1975	105.56.50	45.51.55	50	1.0
	21			1984	105.56.40	46.52.00	60	3.0
	22			1986	105.54.30	46.52.50	65	1.5
	23			1994	105.57.20.	47.02.22.		
	24			1995	105.57.50.	47.02.11.		
	25	Buren			105.03.09	46.55.29		
	26				105.03.06	46.55.56		
	27	Undur Shireet		1978	105.07.00	47.35.10	125	1.2
	28				105 03 17	47.27 14		
	29				105 03 25	47.27 08		
	30	Erdene Sant		1980	104.29.10	47.21.30	81	2.0
	31			1983	104.29.58	47.19.49		
	32	Zaamar		1974	104.16.00	48.12.50	52	2.0
	33				104.46.32	48.12.39		
	34				104.46.16	48.12.52		
	35				104.47.01	48.12.47		
	36	Tseel		1977	105.21.30	48.50.00	107	1.0
	37			1990	105.18.00	48.27.30	114	2.0
	38	Ugtaal		1977	105.21.00	48.50.00	85	3.0
	39			1979	105.23.45	48.15.40	109	1.6
	40				105.25.33	48.15.39		
	41				105.24.33	48.15.27		

Aimag	№	Soum	Owner	Year put into operation	Location		Depth, m	Well yield, l/sec
					Longitude	Latitude		
	42	Lun		1975	105.15.00	47.52.00	50	7.0
	43			1989	105.16.35	47.52.00	29	2.5
	44			1988	105.15.00	47.51.55	40	2.5
	45				105.15.18	47.51.57		
	46				105.15.17	47.52.09		
	47	Bayantsogt		1986	105.54.30	46.52.50	65	1.5
	48		Animal feed factory		105.48.57	48.07.17		
	49		Cow farm	1972	105.49.08	48.07.35		
	50		Governor's Office / GO/		105.48.48	48.07.50		
	51		For stock		105.48.49	48.07.52		
	52	Bayan khangai			105.32.44	47.57.02		
	53				105.32.49	47.57.11		
	54			1993	105.33.49	47.55.37	120	
	55	Argalant			105.53.36	47.56.33		
	56				105.53.35	47.56.37		
	57		vegetable	2007	105.54.12	47.57.08		
Bulgan	58	Bayannuur	GO	2007	104.26.39	47.49.22	58	1.5
	59		GO	2009	104.26..24	47.49.43	25	1.2
	60		GO	2010	104.26.24	47.49.52	55	0.8
	61		GO	2004	104.26.48	47.50.11	110	0.8
	62		Monsoft	2010	104.27.14	47.50.35	80	1.0
	63		GO	1998	104.26.32	47.49.50	25	1.0
	64		school	2009	104.26.35	47.49.52	50	1.0
	65		GO	2008	104.31.47	47.54.11	40	1.0
	66	Rashaant	centre	2006	103.56.50	47.22.52		
	67		Rural	2004	103.57.21	47.23.06		
	68		Livestock	2008	103.57.21	47.22.15	90	
	69		For stock	1985	103.57.17	47.22.14	65	
	70		For stock	1986	103.57.07	47.22.12	65	
	71				103.57.00	47.22.09	65	
	72		Soum centre	1960	103.29.06	47.44. 29	72.8	
	73		Soum centre	1973	103.28.50	47.44.15	50	1.2
	74				103.29.04	47.44.28		
	75				103.28.43	47.44.14		
	76		Agriculture	1984	103.58.12	47.22.30	162	1.0
	77			1974	104.02.45	47.51.00	55	1.30
	78				104.04.45	47.50.42		
	79			1982	104.28.25	47.49.20	67.5	3.0
	80				104.26.24	47.49.21		
	81				104.26.36	47.49.38		
	82				104.26.12	47.49.32		
	83				104.26.45	47.49.36		
	84	Buregkhangai	Tractor maintenance	1988	103.53.00	48.15.00	40	2.0
	85				103.52.43	48.14.56		
	86				103.52.17	48.15.10		
	87				103.52.43	48.15.25		
	88			1976	103.48.50	48.13.00	10	1.0

Aimag	№	Soum	Owner	Year put into operation	Location		Depth, m	Well yield, l/sec
					Longitude	Latitude		
	89	Gurvanbulag	GO	2006	103.47.87	47.73.73	130	2.0
	90		GO	1996	103.48.46	47.741	40	1.5
	91		hospital	2009	103.48.32	47.746	38	1.0
	92		GO	2005	103.48.37	47.7443	35	1.8
	93		GO	2007	103.70.30	47.63.66	96	1.2
	94		GO	2008	103.52.50	47.72.52	30	1.0
	95	Dashinchilen	GO		104.07.89	47.84.48		
	96		Chuluut lake	2002	104.33.66	47.81.70	30	
	98		GO		104.07.89	47.84.48		
			GO	2007	104.52.44	47.95.44	10	1.0
	99		GO		104.04.80	47.84.69.		
	100		GO		104.04.22	47.85.06		
	101		GO	2007	103.95.86	47.80.28	30	1.0
	102		GO	30	103.52.52	47.72.52	30	0.8
	103	Mogod	GO	2010	102.99.53	48.28.05		
	104		GO	1980	102.98.50	48.28.19		
	105		GO		102.98.45	48.27.89	50	
	106	Khishig-Undur	GO	1989	103.26.46	48.31.30	32	3.0
	107		GO		103.25.54	48.17.30		
	108		GO		103.26.11	48.18.00		
	109		GO		103.26.10	48.18.03		
	110		GO		103.25.34	48.18.12	45	
	111		GO		103.25.45	48.17.36		
	112		GO		103.25.29	48.14.36		
Selenge	113	Orkhon-Tuul	Soum centre		104.48.23	48.49.55		
	114		Soum centre		104.48.22	48.49.43		
	115		Ger area		104.49.15	48.49.21		
	116		Ger area		104.49.02	48.50.26		
	117		Soum centre	1961	105.23.10	49.09.00		
	118		Soum centre		105.24.09	49.08.35		
Uvurkhangai	119	Burd	Soum centre		103.47.06	46.58.59		
	120				103.47.06	46.58.50		
	121				103.46.39	46.58.42.		
	122				103.46.46	46.58.56		

ANNEX 2. Irrigation schemes in the Tuul River Basin

№	Capital city and aimag	Soum	№	Area	System design	Year put into operation	Projected initial capacity, ha		Restored					Newly established		
							engineer	ordinary	engineer	ordinary	year	qty	ha	year	qty	ha
1	Arkhangai	Khashaat	1	Tsaidam	ord.			130.0								
2	Bulgan	Bayannuur	2	Daliin Bulag	eng.	1983	57.0									
			3	Shar Tal	ord.			560.0								
			4	Borbulan	ord.			350.0								
		Buregkhangai	5	Jajiin Bulag	ord.			6.0								
		Gurvanbulag	6	Sain Turuu	ord.			13.0								
		Dashinchilen	7	Myalangiin River	ord.			4.0								
		Mogod	8	Urt Tariat	ord.			7.0								
		Khishig-Undur	9	Shand	ord.			30.0								
3	Uvurkhangai	Burd	10	Borigdoi	ord.			50.0								
4	Selenge	Orkhontuul	11	Tsagaan Ereg	ord.			5.0								
			12	Shar Usnii Khooloi										2008	1	129.2
			13	Emeelt Uuliin Uvur										2008	1	5.0
			14	Danikhuu Tolgoi										2009	1	390.0
			15	Bichigtiin Eruu										2009	1	10.0
			16											2010	1	30.4
			17	Salkhit										2008	1	80.0

№	Capital city and aimag	Soum	№	Area	System design	Year put into operation	Projected initial capacity, ha		Restored					Newly established		
							engineer	ordinary	engineer	ordinary	year	qty	ha	year	qty	ha
5	Tuv	Altanbulag	18	Bukhug River	ord.			6.0								
			19	Bayariin Sanaachlaaga										2008	1	7.3
			20	Akhmad										2008	1	9.0
		Argalant	21	Sagzai Tolgoi										2008	1	55.6
		Bayan-Unjuul	22	Bayanbulag	ord.			3.0								
		Bayankhangai	23	Buduundugar	ord.			3.0								
		Buren	24	Drilled well	ord.			1.0								
		Bayantsogt	25	Guna	eng.	1978	70.0		1		2008	1	62.0			
			26	Dund-Urt	eng.	1983	57.0		1		2005	1	57.0			
			27	Khetsiin Bogino										2008	1	98.0
			28	Sarlag Tolgoi										2009	1	63.0
			29	Drilled well	ord.			1.0								
		Zaamar	30	Ar-Urt	eng.	1976	125.0									
			31	Zaamar River	ord.			2.0								
		Zuunmod	32	Tavan Khumst										2009	1	10.0
		Lun	33	Enkhiin khudag/well/	ord.			4.0								
		Undurshireet	34	Uyangiin khudag	ord.			4.0								
		Sergelen	35	Khushigiin khudag	ord.			3.0								
			36	Uvurbayan-Ulaan										2007	1	60.0
			37	Bayanburd										2008	1	10.0
			38	Uguumuriin Am										2008	1	100.0
			39	Oortsog										2009	1	10.0
			40	Khushigiin Khundii										2008	1	10.0
		Ugtaaltsaidam	41	Borkhujir	ord.			4.0								
			42	Manz										2008	1	150.0
		Erdene	43	Uubulan	eng.	1974	36.0									
			44	Bukhun River	ord.			17.0								
		Erdenesant	45	Urtiin River	ord.			5.0								

№	Capital city and aimag	Soum	№	Area	System design	Year put into operation	Projected initial capacity, ha		Restored					Newly established		
							engineer	ordinary	engineer	ordinary	year	qty	ha	year	qty	ha
6	Ulaanbaatar	Bayanzurkh (Gachuurt)	46	Uvurbayan	eng.	1983	74.0									
			47	Khar Usan Tokhoi	eng.	1977	95.0		1		2008	1	79.2			
			48	Uliastain Am	eng.	1988	240.0									
			49	Uliastai										2009	1	10.0
			50	Bayantukhum										2008	1	8.0
		Nalaikh	51	Enger Shand										2010	1	5.0
		Khan-Uul	52	Bukhug-1	eng.	1984	150.0									
			53	Bukhugiin River downstream										2010	1	3.0
			54	Bukhug-2 (Songino tree planting)	eng.	1989	189.0							Tsetserlegjilt LLC		
			55		2005	1	43.0	78.9	1		2009	1	43.5			
			56	Turgen										2008	1	1.7
			57	Turgenii River										2010	1	4.0
			58	Turgenii River downstream										2008	1	75.0
			59	Dulmaa's ownership										2009	1	2.0
			60	Bat's ownership										2008	1	3.0
TOTAL			60				1,136.0	1,286.9								1,339.2

2003	0	0.0	2003	0	0.0
2004	0	0.0	2004	0	0.0
2005	2	100.0	2005	0	0.0
2006	0	0.0	2006	0	0
2007	0	0.0	2007	1	60.0
2008	2	141.2	2008	15	741.8
2009	1	43.5	2009	6	495.0
2010	0	0.0	2010	4	42.4
Total	5	284.7		26	1,339.2

ANNEX 3. Industrial WWTPs in the Tuul River Basin

№	WWTP's owner and name	Relevant district	Operation	Type of treatment	Capacity, m^3/day	Issues to focus on in the future
1	VC LLC	Bayangol	normal	mechanical	614	Improve WWT level
2	New Space LLC	Bayangol	normal	mechanical	498	Improve WWT level
3	Arildii LLC	Bayangol	normal	mechanical, biological	847	New WWTP to put into operation in 2012
4	Future LLC	Bayangol	normal	mechanical, biological	617	New WWTP to put into operation in 2012
5	Monital Cashmere LLC	Bayangol	normal	mechanical	125	Improve WWT level
6	Tuya LLC	Bayangol	non-operating	mechanical	37	Improve WWT level
7	Talst Erchim LLC	Songino Kharkhan	normal	mechanical	198	Improve WWT level
8	Khan Bogd Cashmere LLC	Songino Kharkhan	normal	mechanical	1397	Improve WWT level
9	Monfiya LLC	Songino Kharkhan	normal	mechanical	300	Improve WWT level
10	Jinkorona LLC	Songino Kharkhan	normal	mechanical	1397	Improve WWT level
11	Capital Factory LLC	Songino Kharkhan	normal	mechanical	204	Improve WWT level
12	Lora Piana Mongolia LLC	Khan-Uul	normal	mechanical	1502	Improve WWT level
13	Altai Cashmere LLC	Khan-Uul	normal	mechanical, biological	1199	Improve WWT level
14	Mon Forte LLC	Khan-Uul	normal	mechanical	95	Improve WWT level
15	Zun Fen LLC	Khan-Uul	non-operating	mechanical	132	Improve WWT level
16	Khan Tuul Cashmere LLC	Khan-Uul	normal	mechanical	10	Improve WWT level
17	Mongol Gar Khivs LLC	Khan-Uul	normal	mechanical	443	Improve WWT level
18	Noos Trage shareholding company	Khan-Uul	non-operating	mechanical	180	Improve WWT level
19	Nekheesgui Edlel SC	Khan-Uul	normal	mechanical	202	Improve WWT level
20	Cashmere Holding LLC	Khan-Uul	normal	mechanical	4553	Improve WWT level
21	MDCP LLC	Khan-Uul	normal	mechanical	945	Improve WWT level
22	Susan LLC	Khan-Uul	normal	mechanical	1178	Improve WWT level
23	Noos Ireedui LLC	Khan-Uul	normal	mechanical	1246	Improve WWT level and with gravel clarifier
24	Altan Khargia LLC	Khan-Uul	normal	mechanical	932	Improve WWT level
25	Jilbo Leather LLC	Khan-Uul	normal	mechanical	1448	Improve WWT level
26	Ikh Asar LLC	Khan-Uul	normal	mechanical	1436	Improve WWT level
27	Sutain Devshil LLC	Khan-Uul	normal	mechanical	379	Improve WWT level and with fixed screen
28	Yarmag LLC	Khan-Uul	normal	mechanical	1339	Improve WWT level
29	Sutain Invest LLC	Khan-Uul	normal	mechanical	429	Improve WWT level
30	Mongol Shevro LLC	Khan-Uul	normal	mechanical	1179	Improve WWT level
31	Ikh Ergelt LLC	Khan-Uul	normal	mechanical	629	With water purification equipment

№	WWTP's owner and name	Relevant district	Operation	Type of treatment	Capacity, m^3/day	Issues to focus on in the future
32	Sodon Tsuurai Cooperative	Khan-Uul	normal	mechanical	21	Improve WWT level and with a fixed screen
33	Suudertiin Khundii LLC	Khan-Uul	normal	mechanical	34	Improve WWT level and with a fixed screen
34	Erdene Chandmani Cooperative	Khan-Uul	normal	mechanical	104	Improve WWT level and with a fixed screen
35	BSB SC	Khan-Uul	normal	mechanical	2416	Improve WWT level
36	Ue Impex LLC	Khan-Uul	normal	mechanical	147	Improve WWT level
37	Buligar SC	Khan-Uul	normal	mechanical	2275	Improve WWT level and with a fixed screen
38	Munkh Shine Od LLC	Khan-Uul	normal	mechanical	43	Improve WWT level
39	Tumen Sor LLC	Khan-Uul	normal	mechanical	38	Improve WWT level and with a fixed screen
40	Yalman LLC	Khan-Uul	normal	mechanical	149	Improve WWT level and with a fixed screen
41	MLTG LLC	Khan-Uul	normal	mechanical	115	Improve WWT level and with a fixed screen
42	Mon Ireedui LLC	Khan-Uul	normal	mechanical	781	Improve WWT level and with a fixed screen
43	Belon LLC	Khan-Uul	normal	mechanical	1759	Improve WWT level
44	Elite Fur LLC	Khan-Uul	normal	mechanical	564	Improve WWT level
45	Khatan Tugul LLC	Khan-Uul	normal	mechanical	37	Improve WWT level and with a fixed screen
46	Otgonsuren Sh LLC	Khan-Uul	normal	mechanical	583	Improve WWT level
47	Eruult International LLC	Khan-Uul	normal	mechanical	128	Improve WWT level and with a fixed screen
48	"Mongol Shir LLC	Khan-Uul	normal	mechanical	482	Improve WWT level
49	Khanpivon LLC	Khan-Uul	normal	mechanical	32	Improve WWT level
50	Davaabayar LLC	Khan-Uul	normal	mechanical	122	Improve WWT level
51	Bi Tse Trade LLC	Khan-Uul	non-operating	mechanical	89	Improve WWT level

Part 7.
TUUL RIVER BASIN COUNCIL

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[1] *Tuul River Basin Council*

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Content

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1. General introduction

One of the objectives of the “Strengthening Integrated Water Resources Management in Mongolia” project is to establish river basin councils in model basins including the Orkhon and Tuul River Basins; to support the councils’ activities; to improve human resources capacity and to support the development of basin water resources management plan.

In the context of these objectives, the project cooperated with Water Authority to establish the Tuul and Orkhon River Basin Councils. The two Councils’ also received support for their activities. This chapter discusses the Tuul river basin council, its organization, structure and activities as well as recommendations of future issues.

Figure 1. Beautiful valley of Khatan Tuul

1.1. River Basin Council

The “Strengthening Integrated Water Resources Management in Mongolia” project organized the first consultative meeting to establish the Tuul River Basin Council in Ulaanbaatar in March, 2010. Some 200 people, representatives from all aimags and soums within the Tuul River Basin, participated in the meeting. During the meeting, the number of representatives to be elected from aimags and soums that belong to the basin for the council was decided. This nomination issue for council members was confirmed by the Peoples’ Representative Khural. It was the first step to establish Tuul River Basin Council.

The Tuul River Basin Council was formally established with 17 members following order A-268 of August 31, 2010 of the Minister of Nature, Environment and Tourism on the basis of article 19.2.1 of Water Law (2004).

Basic objectives of the River Basin Council

The basic objectives of the basin council are:

- to give professional support for citizens and organizations to protect, use and rehabilitate water resources;
- to use water resources wisely and to protect and rehabilitate it in order to keep basin water resources ecological balanced;
- to develop an integrated water resources management plan, to have this approved and to organize its implementation;
- to conduct monitoring on water use.

Representatives from Ulaanbaatar city, Tuv, Selenge, Arkhangai and Bulgan aimags, are included in the Tuul river basin council organization.

In accordance with article 19.4 of the Water Law, representatives from environmental agencies, professional inspection agency, NGOs, scientists and professional water agencies are included as well.

Figure 2. Tuul river basin council members

According to article 19.6.2 of the Water Law (2004), river basin councils' stable activities, finances and member capacity are basic requirements for a River Basin Council to implement the mandates and duties as given by law and to develop a water resources management plan for the basin. When comparing the Tuul River Basin Council's representation to other RBCs, the advantages are the number of representatives from state organizations and public administration is less and number of representatives and from NGOs, citizens, environmental and water experts is higher than in other RBCs.

River basin council:

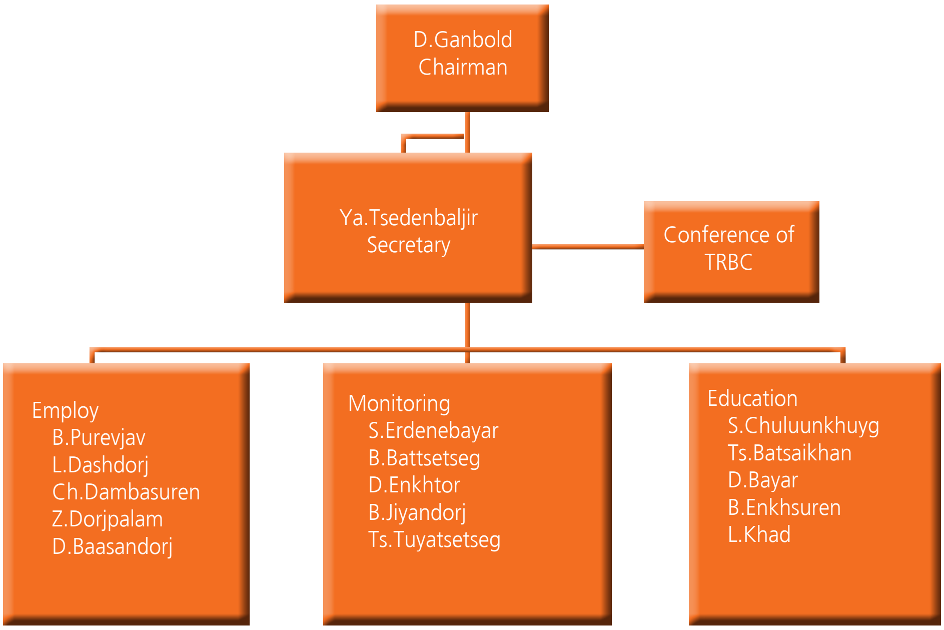

Figure 3. Tuul river basin council structure

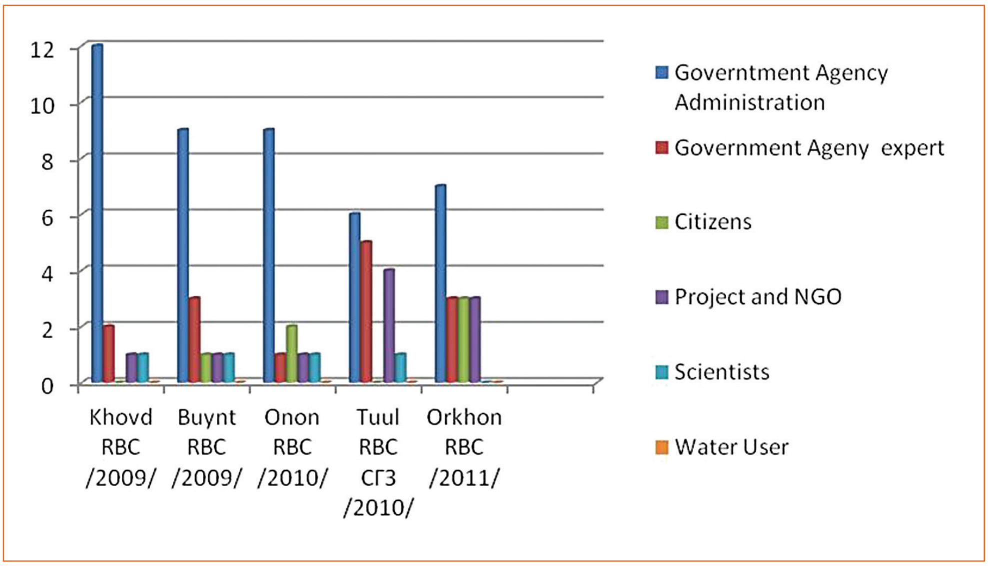

Figure 4. Representation in Tuul and other basin council structures

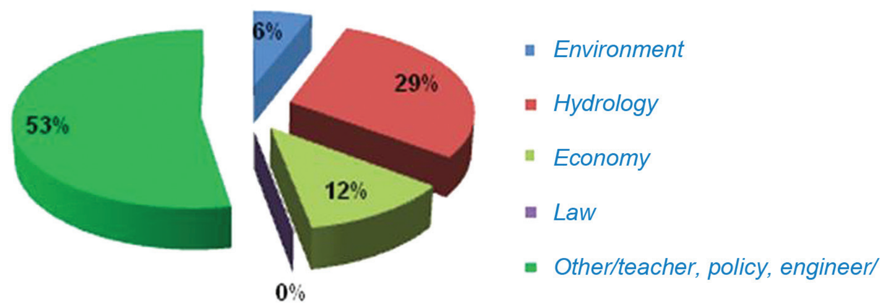

Figure 5. Professions of Tuul river basin council members

The Tuul River Basin Council consists of a director, a secretary and 15 members. There are 3 Phds, 3 consulting engineers, 3 MScs, 2 hydrologists, 3 local area governors and 4 NGO representatives in the river basin council. The experts in the field of environment, water and engineering are dominating the river basin council organization enabling it to execute the duties given by basin council rules and water law.

1.2. Mandates and duties of the river basin council

The Tuul River Basin Council's Internal Regulations were approved on November 10, 2010 by the plenary council meeting. The main subjects covered by the Internal Regulations are the basic principles of the council's activities, formation, common rights and duties of council's chairman, secretary and members as well as the financial sources. The Tuul River Basin Council included the following principles in its Internal Regulations for implementing its activities:

- Reporting is honest, democratic, open and transparent
- Public interests will lead along with respect for private or group, section and local residents' interests
- Land use and land use demand will be coherent to water resources management

According to article 3.7 of the Tuul River Basin Council Internal Regulations, an RBC will have three sections: one each for operation, monitoring, and training and public participation. Implementation of the mandates and duties given by the law will be conducted through these offices.

One of the mandates of the Tuul RBC given by law on water is stated in article 19.6.2: "Development of a plan with measures for wise use, protection, and rehabilitation of the basin's water resources; its approval by the relevant people's representative Khural and monitoring of its implementation".

The territories of (parts of) Tuv, Bulgan, Selenge, Arkhangai and Uvurkhangai aimags as well as Ulaanbaatar city are included in the Tuul river basin. When developing the water resources management plan for the Tuul River Basin, these aimags and soums will be included following article 3.10 of the Internal Regulations on approval of plans. It states: "The River Basin Council needs to have its Basin Integrated Water Resources Management Plan approved by each People's Representative Khural of the aimags that belong to the basin, the Water Authority and the Minister of Nature, Environment and Tourism".

According to the river basin council Internal Regulations the "Monitoring Office" will be operational. The basic function of the office is to monitor the Tuul River Basin Council activities. This office will have 5-7 representatives from citizens and NGOs. It is detailed in the Internal Regulations that the RBC can establish branch councils to implement its own tasks and functions along those rivers that discharge into the Tuul River or branch from it.

The River Basin Council's Secretary and his/her assistant conduct the daily activities of the Tuul River Basin Council. They communicate with the members daily by email and telephone. Their main focus is on the following activities:

- to have discussed and approved seasonal and annual reports of the RBC activities by RBC director;
- to implement the activities as detailed in the plan;
- to organize RBC meetings;
- to submit activity reports and collect data on river basin water resources use.

1.3. River basin council finances

The Tuul River Basin Council conducts its activities with the financial support of the "Strengthening Integrated Water Resources Management in Mongolia" project. In the Law on Water financial issues related to state duties and function on water are not included. The financial resources for implementing the integrated water resources management plan have not yet been resolved. One option would be to allocate funds form the water use fees collected. According to the Law on Re-Investment of Natural Resources Use Fees for the Protection of the Environment and the Restoration of Natural Resources, usually referred to as the "Short Law with the Long Name" a minimum of 35% of the water use fees collected will be spent on the protection and conservation of water resources and prevention of pollution. To implement this law requires the approval of the Government Regulation on this issue which has not been approved until now. In fact the water use fees that are presently collected (by the local governments) are used to fill the shortages on the local budgets.

This minimum of 35% of the collected water use fee could become the source for the Tuul River Basin Council's stable activities for implementing integrated water resources management in the Tuul River Basin once approved by the aimag and Ulaanbaatar Peoples' Representative Khural according to article 14.1.1 of the Water Law (2004).

The "Strengthening Integrated Water Resources Management in Mongolia" project, implemented at Water Authority under a Netherlands Government grant. The project is to develop a model integrated management plan for the Tuul River Basin. It is also financing the Tuul River Basin Council activities within the project period that end in December 2012.

River Basin Council members were involved in IWRM training conducted by the project and the project provides the salary for the RBC Secretary and his/her assistant, office facilities with furniture and equipment, operational costs for RBC meeting expenses and travel expenses of local area members. These became the main conditions to stabilize Tuul River Basin Council activities.

2. Brief introduction of the activities

2.1. 2011 activities

2.1.1. River basin council meetings

The first meeting

The first meeting of Tuul River Basin Council was organized on November 10, 2010 and the Council Internal Regulations as well as the 2010-2011 action plan were approved. The RBC was registered at the State Registration with the status of an industrial object with state budget on December 30, 2010. Its state registration certificate number is 9070003034 and it has its own stamp. By this the legal basis for the RBC activities was formed. The council proceeded to stabilize council activities, to make work schedules for river basin council members and to implement major planned activities with the participation of NGOs in the council organization.

The council mainly focused on defining measures to solve water related issues facing the Tuul River Basin and establishing a database on water resources and water use.

Figure 6. First meeting of river basin council

After the first meeting of RBC the "Strengthening Integrated Water Resources Management in Mongolia" project organized a short training to provide the river basin council members some basic knowledge and information on integrated water resources management.

Figure 7. Integrated water resources management training

Figure 8. International consultant taught a lesson on IWRM

The second meeting

The second meeting of the RBC was organized on April 18, 2011 and the action plan for the second half of the year was approved and its implementation organized.

According to the Internal Regulations that allow for branch councils under Tuul River Basin Council, a meeting to establish the "Yarmag-Sonsgolon-Khan-Uul" branch council was held on June 22, 2011 and branch council Internal Rules were approved by all members. Mr. Z.Dorjpalam, a member of the river basin council, will work as the branch council Director and M.Dash as Secretary.

Figure 9. Participants in the first meeting of branch council establishment

The branch council has the status of a civil rganization. According to article 19 of the Water Law (2004), its activity is to implement water resources management in the area to provide state, water users and citizens' participation; to protect water sources along the Tuul River; to protect pond and springs sources; to increase water resources by planting trees and to use water resources wisely.

The rule to establish a "Fund to Restore Tuuliin Khar Shugui" was developed and approved by the Khan-Uul district 9th khoroo citizens. This fund is established on the basis of citizens, public organizations and entity initiatives. The fund is for protecting and rehabilitating Tuul brushwood which is a part of Tuul River system. The Tuul RBC campaigned for the Khatan Tuul protection with the involvement of the Water Authority.

Figure 10. Opening of Tuul river protection campaign

The third meeting

The third meeting of the river basin council was held on November 01, 2011. The following issues were discussed:

- Methods to solve difficulties facing the Tuul River Basin
- Progress and future objectives of Tuul River Basin IWRM plan development
- Assessment of the water way inspection from 5 branches of Tuul River to Tuul-Orkhon confluence which was conducted by a team led by B.Jiyandorj, a river basin council member. It was conducted between July 24, 2011 and August 03, 2011.
- Action report on the first 9 months of 2011 of the RBC and the action plan for the 4th quarter of 2011.

As for the first issue: Issues for Tuul River Basin are classified as water resources, water use and water pollution. The issues for water resources protection and rehabilitation are divided as follows: in Tuul River upstream, Ulaanbaatar city settlement zone and other areas. The following issues were discussed: tourist camps' water sources; water use; waste water issues and its impacts on soil, grass cover and animal species; water supply source resources availability of Ulaanbaatar; water demand growth and future perspectives; Tuul river pollution; irrigation field water supply for livestock. To solve these issues the following was resolved:

- Monitoring tourist camps' environmental impact assessment fulfillment which operate in upper parts of Tuul river; conducting natural capacity research in the whole basin; conducting inspection on tourist camps' waste water treatment and waste points and monitoring their water use;
- As for Ulaanbaatar city settlement zone, conducting assessment (from Marshal bridge down to Songino camp) of groundwater resources including soil water; conducting groundwater hydrological research of Sharkhai valley which is located in Altanbulag soum of Tuv aimag; calculating usage resources;

- Conducting technical and economic basis of Tuul-Gachuurt water complex; these big measures related to water management will be projected in IWRM plan of Tuul river basin;

As for water use: for the water sources, tourist camps' water use perspectives are not clear. The general urban planning in Ulaanbaatar city settlement zone is not clear as well. Due to these unclear situations, water supply perspectives are unclear. As for other zones of the basin, water use technology level of mining industries is low and river channel is changed. The river channel sediments are increased due to gold-miners' influences. The damage on water ecology is not low. The above mentioned issues were discussed. To solve these issues to following was resolved:

- Tourist camps' water demand should be coherent to their development future perspective
- Ulaanbaatar city population water demand should be estimated in coherence with general city planning
- Determining water demand of districts of Bagakhangai and Nalaikh which do not have connection to centralized sources
- Estimating Ulaanbaatar city industries' water demand separately
- Draw a conclusion on mining industries' water use technological level; using water meter and pipes when using surface water; expanding re-use technological development; if river channel is changed, it should be rehabilitated according to layout
- It is required to determine water demand of population, livestock and irrigation field in whole basin

As for Ulaanbaatar city settlement zone, "Khargia" WWTP treatment level is low, central waste water treatment plant technology of Ulaanbaatar city is outdated, no sludge processing, ger district sanitation sealing is poor in Ulaanbaatar city ger district, including in the first hilltop of the flood channel or "Sensitive Zone", high soil water pollution, much construction, industrial and domestic solid waste in urban settlement zone and flood channel, sand and gravel stone-pits operating in settlement zones increase evaporation of water resources, increase air dust and damage water ecology. In order to solve above mentioned issues, following measures should be implemented:

- Inspecting environmental impact assessment fulfillment of tourist companies that operate in the upper part of Tuul River and if there are violations, those relevant companies will be charged and their activities will be stopped.
- Announcing international tender on "Khargia" pre-treatment facility technique and technology renovation
- Organize activities to develop technical and economic basis of "Emeelt" industrial park
- To stop the activities of industries that do not meet industrial waste water standard
- To improve central waste water treatment facility technology, constant monitoring on treatment level, stop discharging of poor-treated waste water into nature and reuse water according to Korean experiences
- Developing technical and economic basis that allows central waste water treatment facility capacity at 450000 m3 in 2030 in accordance with Ulaanbaatar city population growth and introducing membrane and Nano technology to the treatment technological pipes

- Conducting inspection and inventory at household sanitation in "Sensitive Zone", sanifying by chemical and biological methods and dislocating households that have bad or poor sanitation
- Halting/stopping the action to put construction, industrial and domestic solid waste in river channel and flood channel
- Conducting inspection at sand-gravel, brick mud stone-pits that operate in Ulaanbaatar city settlement zone, establishing resources future perspectives in accordance with road and construction future perspectives, using rules that allow mines to use resources only if they have environmental impact assessment and conducted geological research and estimated resources
- As for other districts of the basin, inspection should be conducted on mining industries' waste water discharge to nature, to have environmental impact assessment fulfillment submitted
- Conducting water inspection in areas where Tuul river channel is changed
- Conducting rehabilitation activity in special-permission-areas that were voided in accordance with "Law on Prohibiting Mining and Researching of Natural Resources in Areas Where There are Flow-Forming Sources, Protection Zone for Water Bodies and Forest Areas"

The following issues were discussed: activities to cut trees illegally in the green zone have not been stopped, possessions of residents and organizations increased in green zones nearby the city and camp site areas are being privatized. These issues are having negative impacts on water resources protection and rehabilitation. In order to solve these issues, following measures should be taken:

- Prohibiting to pick fruits and nuts from urban green zone; also prohibiting wood preparation from the green zones
- Including permafrost and green zone in Ulaanbaatar city ownership zone into water source recharge zone; protecting them and getting them out of ownership
- Organizing activities to plant trees and grass in the regions of Tuul river upstream and Ulaanbaatar city settlement zone where there are ecological balance disturbances
- Drawing a conclusion on activities of sand-gravel industries which operate in the part of Tuul river flood channel and stopping illegal activities
- Developing and implementing science-based project in accordance with rehabilitation activities in Zaamar district where river channel is changed

2nd issue: The following research reports were done in order to develop water resources management plan of Tuul river basin:

- Tuul river basin socio-economic condition, water fee, water sector investment
- River basin natural condition and land use
- Groundwater resources assessment
- Surface water resources assessment
- Water resources quality and ecological assessment
- Basin water supply, water demand-use, water constructions

The Tuul River Basin IWRM plan covers the following topics: Tuul river basin natural condition, river basin water resources, quality and ecology, river basin current socio-economic condition, sector development objectives, current water use condition and future perspectives, water resources use balance, issues facing the river basin, river basin IWRM strategy and main issues, measures and activities and risk management.

The Tuul River Basin IWRM plan will be developed within the 3rd quarter of 2012. It will be discussed by residents and authorities of other aimags and soums that belong to the basin. Their recommendations will be included and it will be supported by the relevant Peoples' Representative Khural and approved by the Minister of Nature, Environment and Tourism.

Cooperation with international organizations is intensified for the purpose of expanding RBC's international cooperation. The Council supported the implementation of the "Master Plan to Improve Ulaanbaatar City Water Supply and Pipelines" within the framework of developing a master plan for environmental protection which is being implemented under Korean Government grant.

2.1.2. River basin water resources management plan

The Tuul River Basin IWRM plan is being developed by the Netherlands Government supported project "Strengthening Integrated Water Resources Management in Mongolia" at the Water Authority. The project team will complete its work by the end of 2012.

The RBC is gathering issues related to water supply, water resources scarcity and pollution through its Ulaanbaatar city and local area members in order to support this management plan development. The measures to solve these issues will be put into the water resources management plan.

The Council is studying Mongolian and international scientific organizations' research works, environmental assessment and Ulaanbaatar and local area residents' recommendations on water resources, its change and ecological condition of the water.

The population, livestock water demand, borehole researches and figures in river basins of Ulaanbaatar, Uvurkhangai, Arkhangai and Selenge aimags are being collected and integrated. A plan is made to cooperate with Nature Conservation Agency of Ulaanbaatar city in order to decrease water damages or harm in Ulaanbaatar city zones within the activity framework of collecting research data of urban investment and organizations.

2.1.3. Monitoring of water resources use and protection

The following activities were conducted in a purpose of implementing decisions made by Municipal Office of Ulaanbaatar city and urban planning agencies on increase of Ulaanbaatar city water supply and sewerage usage level. Groundwater resources re-assessment of Ulaanbaatar city central sources will be developed and implemented with the participation of Water Authority. Gachuurt-Tuul water complex's technical and economic basis was developed by the metropolitan financial source in order to increase urban area drinking water sources. It was approved by river basin council director and the "Prestige" group executed it.

The residents and public organizations will participate in activities to combat against domestic and industrial waste disposal in river water in Ulaanbaatar city settlement zone. On May 17, 2011 cleaning was organized along the Tuul River with the participation of "Tungaa" NGO on a public cleaning day which was organized by Municipal Office of Ulaanbaatar city.

The cleaning also was organized in Yarmag-Nisekh ger districts of Khan-Uul district and along Tuul River with the participation of khoroo residents. The campaign to restore Tuul brushwood was organized by residents of the 9th khoroo of Khan-Uul district and some 3000 trees were planted. With the cooperation of “Tungaa” NGO, inspectors worked in areas from Marshal Bridge to Yarmag Bridge and they revealed that truckloads of construction material and soil used to be dumped in the flood channel.

The official document on “Standard House” company activities was sent to Ulaanbaatar city land agency. The reason is that “Standard House” company is constructing buildings next to flood water discharging channel and flood protection dam in the flood channel nearby Marshal Bridge. They requested that this company’s land use license should be terminated.

Figure 11. Activity progress of waste cleaning and tree planting

Figure 12. After cleaning Tuul river flood plain wastes

"Tungaa" NGO sends its activity report to the basin council every 10 days. They advise on safety to people who rest along Tuul River and advise not to wash their cars, not to litter and to collect garbage themselves. By taking these measures, it looks like the number of people who wash their cars, carpets, clothes in the river will decrease and people will not litter a lot when they rest alongside Tuul River.

The following people and organizations conducted a big inspection on entity activities along Tuul River like extracting sand, gravel and other business activities:

- Parliament members D.Batbayar, Su.Batbold, Ts.Batbayar, Ts.Sedvaanchig;
- Deputy governor of Ulaanbaatar city and Tuul river basin council director D.Ganbold,;
- RBC member and State Professional Inspection Agency Ch.Dambasuren;
- Nature Conservation Agency of Ulaanbaatar city
- Water Authority.

During the inspection, the following laws and regulations as well as standard implementations were inspected on site:

- "Law on State Inspection",
- "Law on Natural Resources",
- "Law on Underground Wealth",
- "Law on Land",
- "Law on Geodesy and Cartography",
- "Law on Water", "Law on Nature Conservation",
- "Law on Nature and Environment Impact Assessment" and
- "Law on Special Permission of Entities".

The recommendations were made on observed violations and these were very beneficial measures to protect the Tuul River.

Inspection results and recommendations:

1. The following law implementations are very poor in Tuul river protection zone: "Law on Nature Conservation", "Law on Land", "Law on Geodesy and Cartography", "Law on Water", "Law on Nature and Environment Impact Assessment" and other relevant laws and regulations.
2. Tuul River pollution is caused by following:
   - bad waste water treatment plant activities of tanneries and wool and cashmere industries;
   - domestic and industrial waste;
   - soil and soil water pollution caused by non-standard latrines in ger districts and camps;
   - illegal activities of people, organizations and entities that operate mining in Tuul river basin and Tuul river protection zone;
   - bad activity coherence of government organizations and NGOs.
3. Technological waste water pre-treatment plant activity of tanneries and wool-cashmere industries was not normal and they supply half-treated and chemical pollution water to Central waste water treatment plant. It causes negative impact

on Central waste water treatment plant's treatment level and it causes chemical polluted water discharge into Tuul River. It will pollute the Tuul River water and degrade the ecosystem along the river. It violates the rights of Ulaanbaatar city and Altanbulag soum citizens of Tuv aimag to live in safe and healthy environment.

4. There are some 168 pieces of land in drinking water centralized source protection zone of Ulaanbaatar city with permission from Ulaanbaatar and district governors. There are some 144 pieces of land without any specific permissions and it pollutes soil. It will probably pollute and downgrade the Tuul River surface water and groundwater. The following organizations did not fulfill their duties according to article 16, clause 2.1, and 2.4 of "Law on Nature Conservation": the Municipal Office of Ulaanbaatar city, the Nature Conservation Agency of Ulaanbaatar city, the Ulaanbaatar city Land Affairs Agency.
5. Some 312 illegal land-own permissions in Tuul River protection zone were denounced. The land-free activity was conducted. The relevant officers who did not fulfill official claims on Tuul river pollution decrease by state inspector will be punished according to relevant laws and regulations.
6. In order to provide implementation of Ulaanbaatar city governor regulation number 411 of June 21, 2010, the following measures should be taken:
   - to establish industrial park in Khuitnii Am just in front of "Emeelt" depot in the 20th khoroo territory of Songino Khairkhan district;
   - to establish infrastructure and solve budget and financial issues;
   - to move tanneries and wool-cashmere washing and processing industries out of settlement zone.
7. According to "Law on Natural Resources Search and Extraction Prohibition in Forested Areas and Water Body Protection Zone Where River Flow is Formed", the following measures will be taken:
   - to establish Tuul river protection zone and terminate special permissions of entities which mine natural resources in protection zone verified by Government regulation;
   - to estimate compensation for ecological damage and implement rehabilitation measures.
8. To take measure to include Tuul River in special protection status

2.1.4. River basin council function in local areas

Tuv aimag's People's Representative Khural organized its meeting in Altanbulag soum on August 10, 2011 and Tuul River pollution issue was discussed. D.Ganbold, RBC Director, gave a presentation on current condition of Tuul River water pollution, high and low solutions that decrease pollution, Hargia pre-treatment facility operation and technical renovation in Ulaanbaatar city.

Local residents presented the following issues and complaints during Tuv aimag's People's Representative Khural.:

- 70-80% of Altanbulag soum population lives in this part of Tuul River and river water is polluted in this part and water is stinking. It has been many years since this occurred. The local people made complaints and there are not any government organizations that take measures.
- Many people complained about skin diseases. The livestock and human disease is not decreasing. They required that these issues should be taken seriously and they should be solved.

- There is an opinion that following need to be included in Tuul river basin IWRM plan. They are: measures to solve difficult issues facing Tuul river basin; big objectives coherent to aimag and local area future perspectives and development.

During the meeting, they inspected sand and gravel extracting organizations' activities on site. The recommendations, to stop stone-pit/chalk-pit activities that did not conduct environmental impact assessment, were sent to relevant inspection organizations. It is important to take following measures: to provide citizens and public participation for protecting and rehabilitating nature and establishing Tuul river branch council in soums in Tuv aimag; punishing and charging compensation for people and organizations that inflicted damages in water resources and quality. During the meeting, they discussed about "Khargia" pre-treatment facility which pollutes Tuul River along Tuv aimag and Ulaanbaatar city and Ulaanbaatar city central waste water treatment facility's activity malfunction. They made basic guidelines of future activities.

In accordance with mining companies' activities, Tuul River protection zone was established at 200-1000 m in Zaamar district. The following issues were discussed and solved: termination of 37 natural resources special permissions in protection zone; estimation of water damages caused by mining and compensation calculation; professional assessment on Bukhug-Tuul River sand and gravel stone-pit/chalk-pit.

Tuv aimag's People's Representative Khural gave the following duties to Tuul RBC:

- To submit a measure plan "to use, protect and rehabilitate Tuul river basin water resources wisely" to Tuv aimag's People's Representative Khural within this year and cooperate in the activity to provide its implementation;
- To develop projects to protect Tuul river water resources and the basin, to use water resources wisely, to develop project with actual/real benefits; to finance these projects by state and local area budget, international projects and programs and fund assets;
- To intensify the activities to implement mandates and duties as noted in article 19.6, 28.1.6. of Law on Water; to organize and expand aimags' cooperation which belong to the basin;
- To inform the public about the assessment on waste water purification condition which is discharged to Tuul river from central waste water treatment facility every month, this assessment is made by Ulaanbaatar city Professional Inspection Agency;

2.1.5. Ulaanbaatar city water supply and sewerage management plan

Within the framework of Korean Government grant, Ministry of Nature and Environment of Mongolia and Ministry of Nature and Environment of Korea signed on cooperation agreement on May 20, 2009, it was signed by both countries' Ministers of Nature and Environment.

The "Improving Ulaanbaatar City Water Supply and Sewerage Management" project is implemented. Within the framework of cooperation, "Improving Ulaanbaatar city Water Supply and Sewerage Management" project was financed by the Korean Government grant. The project implementing organizations were selected by both sides. They include the Tuul RBC and Ulaanbaatar City Water Supply and Sewerage Authority from the Mongolian side and from the Korean side they include the Environmental Institute of Industry and Technology and construction engineering company "G-S".

Figure 13. Opening of Ulaanbaatar city water supply and sewerage management project

The project opening seminar was organized in Ulaanbaatar city on March 30, 2011. The project implementing cooperation agreement was signed. The project was implemented between April 01, 2011 and December 31, 2011. The following activities were conducted within the framework of the project:

- Ulaanbaatar city water supply and sewerage management plan was developed;
- Used-water treatment small size equipment was tested in Mongolian condition in a purpose of increasing technological level of Ulaanbaatar city treatment facility;
- Mongolian water supply and sewerage experts participated in short term training in Republic of Korea

The mid-term and final result reports were conducted during the project. These reports' discussions were made in Ulaanbaatar city at the end of June, 2011 and in Seoul, Korea at the end of December, 2011. The working group, led by Yu Kion Jan, Korean project manager, functioned in Ulaanbaatar city between April 25 and 28, 2011. They conducted inspection on Ulaanbaatar city water supply and sewerage condition and met relevant organizations' officers and experts in order to collect data and define facing issues. They made work contacts with relevant organizations' officers. It was agreed that used-water treatment small size equipment will be tested in Ulaanbaatar city central waste water treatment facility.

The working group received relevant data from Mongolian side on water policy law and regulations, natural condition, previous implemented projects, water supply and sewerage technical documents which are required for the development of environmental management master plan. The mid-term report seminar of the project was organized in Ulaanbaatar city between June 28 and 29, 2011. The Vice Minister of Nature and Environment of Korea, Jong Soo Yung, led the Korean delegates. He met Ch.Jargalsaikhan, Vice Minister of Nature and Environment of Mongolia. They discussed about cooperation between two countries' environmental sectors.

They discussed about further activity trends to implement the project. They agreed about testing small size treatment equipment in Ulaanbaatar city central waste water treatment facility. The customs tax for new equipment's transition through the border was freed and equipment installation and testing were conducted between August 12, 2011 and November 15, 2011. This equipment has capacity to treat 80 m^3 used water to the treatment level of 98 percent daily. It is a membrane technology which is world's advanced water treatment technology. Based on the equipment testing results, assessment/recommendation was made on improvement of Ulaanbaatar city central waste water treatment facility technology, using possibility in used water treatment of ger districts, aimag and soum centers and distant districts of Bagakhangai and Baganuur which do not have connection to centralized pipelines.

The Korean project working group operated in Mongolia between September 19 and 22, 2011 and they introduced preliminary report results of Ulaanbaatar city water supply and sewerage master plan until 2030. They met with representatives from Ulaanbaatar city Municipal Office, Ministry of Nature, Environment and Tourism, Water Authority, Ulaanbaatar city Urban Planning Institute and National Water Committee as well as water sector experts. They received recommendations related to the report.

The final report seminar of Ulaanbaatar city water supply and sewerage management master plan was organized in Seoul, Korea between November 30 and December 01. 11 representatives took part in the seminar including Ch.Jargalsaikhan, Vice Minister of Nature, Environment and Tourism; D.Ganbold, deputy governor of Ulaanbaatar city, Tuul river basin council director and project director; Ts.Badrakh, director of Water Authority, Government Implementing Agency; B.Purevjav, Ulaanbaatar city water supply and sewerage authority.

During the seminar, Ch.Jargalsaikhan, Vice Minister of Nature, Environment and Tourism of Mongolia, met with Jay Yong Song, Vice Minister of Nature and Environment of the Republic of Korea and they discussed about two countries' environmental sector cooperation. They also discussed about future cooperation. Ch.Jargalsaikhan, Vice Minister of Nature, Environment and Tourism of Mongolia, expressed his gratitude that two countries' cooperation is expanding, Government organizations and NGOs are cooperating in the fields of forestry, water, fauna, climate, dust storm and green wall. He also praised the results of "Ulaanbaatar city Water Supply and Sewerage Management Master Plan Development" project. He also noted that this master plan will have beneficial recommendations on determining Ulaanbaatar city water supply perspectives until 2030 and introducing advanced technology in sewerage, pipelines and central waste water treatment facility.

Jay Yong Song, Vice Minister of Nature and Environment of the Republic of Korea, stated that 5 meetings and seminars were organized within the project implementation period and small size equipment with membrane technology was installed and tested in Ulaanbaatar city central waste water treatment facility. He also introduced about Ulaanbaatar city water supply and sewerage master plan until 2030. 13 project ideas which can be implemented in the field of two countries' cooperation were stated by him.

Figure 14. Ulaanbaatar city water supply and sewerage management project seminar

The following presentations were made and discussed in the final report seminar of Ulaanbaatar city water supply and sewerage management master plan development project: "Water" national program basic implementation trend and future objectives, by Ts.Badrakh, Water Authority director, Government Implementing Agency; "Technological Level of Ulaanbaatar city Central Waste Water Treatment Facility and Methods to Improve It" by D.Ganbold, Ulaanbaatar city deputy governor and Tuul RBC director.

The representatives from Korean scientific and business organizations also participated in the seminar and they asked questions and discussed about them.

Figure 15. Ulaanbaatar city water supply and sewerage management project discussion

Ulaanbaatar city population will reach 2.3 million in 2030.Tuul river basin council and Ulaanbaatar city Water Supply and Sewerage Authority and Korean G-S Engineering Construction Corporation as well as Cheil Engineering company signed on a cooperation memorandum to cooperate when developing technical and economic basis to expand Ulaanbaatar city central waste water treatment facility until 2030 on October 24, 2011. The main objective of the cooperation is the technical and economic basis to develop sewerage systems and expand Ulaanbaatar city central waste water treatment facility.

2.1.6. Other activities

The council's website is working as it was included in the basin council activity plan. The Industrial-Technological Institute of Korean Ministry of Nature and Environment organized "Green Business Partnership" forum between June 22 and 23, 2011. D.Ganbold, RBC director and Ya.Tsedenbaljir, secretary participated in the forum and they had a presentation on Mongolian water resources management.

The Russian Baikal-Angar basin council meeting was held in Ulaan-Ude city on July 21. Ya.Tsedenbaljir, river basin council secretary, was invited and participated in the meeting. He had a presentation on Mongolian river basin council activities and facing issues of Tuul River. The RBC director and secretary had interviews at Mongolian Radio, National Television and Ecomony Magazine about river basin council activities in order to inform about river basin council activities to the public.

2.1.7. "Tsenkher Zamiin Erguul" inspection of Tuul river

As included in the river basin council activity plan, 11 people team led by B.Jiyandorj, RBC member and international water sport master, inspected along the 600 km water way from Tuul river 5 branches to Orkhon-Tuul confluence between July 24 and August 03. The main objectives of the inspection are: inspect water law implementation; inspect water pollution and geo-ecology balance along Tuul river channel; clear violations; introduction on water law and Tuul river basin council activities to the residents, entities and organizations; prepare for television and newspaper interviews.

"Tsenkher Zamiin Erguul" water way trip was organized for the first time and it started from Gachuurt to Orkhon-Tuul, 650 km; from Gachuurt to Altanbulag 120 km on water way, from Altanbulag to Undur Shireet on water way, by car to Lun (280 km), from Zaamar bridge to Orkhon-Tuul on water way (330 km). The following RBC members participated in the "Tsenkher Zamiin Erguul": Ch.Dambasuren, Z.Dorjpalam, L.Dashdorj, D.Enkhtor and S.Erdenebayar.

Figure 16. Water way patrols

The following violations were revealed during the inspection: residents wash their cars and litter garbage in the settlement zone of the city; apartment waste discharge near Zaisan Bridge; Tuul River waste flow from Sonsgolon bridge to Biokombinat; land degradation caused by mining industries in Zaamar district.

In order to provide the implementation of the law "Prohibition on Natural Resources Research and Mining in Forested Areas, Sources and Protection Zone of Water Bodies Where River Flow is Formed", the Tuul RBC initiated the following programs and projects: support the struggle/fighting of the public and civil society organizations; putting pressure on the Government; establish dedicatory areas and parking areas in the urban settlement zone where people can fish, relax, spend free time, sunbathe and swim. The river basin council initiated about how to solve financial sources of the above mentioned programs and projects and Tuul river protection administration establishment.

2.2. 2012 activities

Tuul RBC planned its activities to be conducted in 2012 in the first quarter. They introduced about the activity results conducted in 2011 and future objectives and contacted with council members via e-mails and received their recommendations. The required data for the development of Tuul River Basin IWRM plan was accumulated and integrated. The water management activity was conducted according to the duties and directions given by Ministry of Nature, Environment and Tourism as well as Water Authority.

2.2.1. Structure

- The river basin council 2011 activity report and activity plan project of 2012 were sent to the council members via e-mail and recommendations were integrated and approved by the river basin council director. Some 30 types of activities in the 5 fields are in the plan. They include: organizational issues; support for the approval of Tuul river basin IWRM plan; inspections; domestic and foreign cooperation; training-methodology; public relations.

- The river basin council logo was created. The official letter forms are published and are being used. The river basin council website was created and information on the website is regularly updated. They include: RBC director greetings, RBC introduction and activity directions.
- The branch council was created in Gachuurt village of Tuul River, which is a Ulaanbaatar settlement source with the cooperation of Environmental Institute of New Zealand. Enkhtuya was selected as branch council director who is Bayanzurkh district environment and service expert and Bulgan was selected as secretary of the branch council who is Gachuurt village's manager. They have created branch council laws and regulations and 2012 activity plan. They also inspected water use condition in Gachuurt village territory.
- They supported Tuul river basin IWRM plan development activities and Facing issues for Tuul river basin were revealed and submitted to the project team.
- They participated in the activities to develop project result report and Ulaanbaatar city water supply and sewerage management master plan within the framework of Mongolian environmental management master plan construction which is implemented by cooperation of Industry-Technology Institute of Ministry of Nature and Environment of the Republic of Korea and G-S Corporation.

2.2.2. "Khatan Tuul" program

Within the framework of the "Water" national program, working group formation, to develop activity plan project and "Khatan Tuul" program to be implemented in the field of protecting Tuul river water resources and decreasing pollution, was approved by the resolution A-495 of December 30, 2011 of Minister of Nature, Environment and Tourism. Tuul river basin council developed recommendations to include in "Khatan Tuul" program and submitted them to the working group.

D.Ganbold, RBC director and Ya.Tsedenbaljir, secretary worked in the program's working group. The program has 55 clauses and 6 chapters including demand for program implementation; legal basis to develop the program; principles to implement the program; program objectives; implementing activities; implementing period; program finances; implementing methods; program administration and organization. The activity plan to implement the program was specially developed.

The basic objectives of the program include:

- To intensify groundwater and surface water researches and confirm water resources, specially usage resources in order to provide social and economic stable development by providing Ulaanbaatar city, other urban areas, population and agro-industry with safe water sources;
- To protect Tuul River Basin water resources, provide all possibilities to form and keep one's freshness and rehabilitate naturally; increase surface flow by constructing reservoirs and conduct flow/water regulation;
- To establish Tuul River water resources and quality inspection and monitoring network based on new advanced technology; provide data and administration readiness;

- Taking measures to decrease pollution, provide Tuul River water cleanliness, decrease negative impacts for Tuul River water resources and pollution by 50 percent which caused by industries and entities; moving primary industries out of urban settlement zone which treat used water generated from tanneries, introducing advanced technology, conducting technological renovations of central waste water treatment facility and small size waste water treatment plants and increasing the capacity.

The "Khatan Tuul" program was approved by the Government of Mongolia at a meeting on May 17, 2012.

2.2.3. Water resources monitoring

- As included in Tuul River Basin Council activity plan, working group led by D.Enkhtor, RBC member, developed terms of reference to conduct monitoring on mining activities along Tuul River and terms of reference were approved. They worked in Zaamar part of Tuul River where it needs much mining rehabilitation. They prepared data on rehabilitation on site.
- According to the guidelines approved by D.Ganbold, Tuul River Basin Council director, the activity to inspect pollution and areas from Terelj to Sonsgolon Bridge along Tuul River was conducted on March 20, 2012. As a result, places where they need treatment and cleaning were chosen. According to the cooperation memorandum with Ministry of Defense of Mongolia, soldiers from military units 151, 013 and MOD staff members cleaned domestic and construction garbage in the flood channel part of 1200 he area from Sonsgolon Bridge to Songino camp and some 60 tons of waste was transported to the dump. The cooperation agreement was conducted with Gachuurt, Yarmag-Nisekh branch councils, Tungaa and Sain Uils NGOs. Also "Eco-Patrol" will operate in 4 parts including a) from Gachuurt to Bayanzurkh bridge, b) from Bayanzurkh bridge to Yarmag bridge, c) from Yarmag bridge to Sonsgolon bridge, and 4) from Sonsgolon bridge to Songino camp.

2.2.4. International cooperation

Environmental Industry and Technology Institute of Korea and construction engineering G-S company is discussing with Tuul River Basin Council about future cooperation. The representatives from G-S company visited Mongolia between June 2 and 4. They submitted result report, of the Ulaanbaatar city water supply and sewerage master plan which was conducted last year within the framework of environmental management master plan, to the basin council. According to the cooperation memorandum to develop technical and economic basis of Ulaanbaatar city central waste water treatment facility technical renovation and expansion, they agreed about activity plan to be conducted in 2012.

As a result of last year's project implementation, many new projects, on new construction of waste water treatment facilities of districts whether they have connection to Ulaanbaatar city water supply, ger district water supply or centralized pipelines, were offered. Many of it is included in "Khatan Tuul" program.

2.2.5. Cooperation with other river basin councils

- In accordance with the establishment of new Orkhon River Basin Council, Ts.Oyuntugs, river basin council secretary, was given advice on basin rules and activity trends. She was invited to the first meeting of the basin and given relevant advice.

- In accordance with the establishment of Kharaa river basin council, Ya.Tsedenbaljir participated in the first meeting of the basin and he had a presentation on groundwater resources and current condition of basin legal regulations in Kharaa river basin.
- Meeting with Russian delegates from Baikal Lake Basin Global Environmental Foundation project which is being implemented by the World Wildlife Fund. Data on Tuul River ecology was given and they agreed to cooperate in the relevant field.
- The secretary of Tuul RBC participated in the Khyargas-Zavkhan River Basin Council meeting and he gave data on groundwater resources in Khyargas-Zavkhan river basin and advice on basin management plan.
- On April 24, D.Tsogtbaatar, Mongolian Government member, Minister of Nature, Environment and Tourism went to Sonsgolon Bridge part where Tuul River is cut off and he discussed about natural and human factors that caused runoff cut with experts. He gave duties and directions to the authorities of Water Authority and Tuul River Basin Council to attract attention of parliament members who were elected from Ulaanbaatar for the required investment for establishing Tuul River protection administration, protecting Tuul River and rehabilitating flow. According to given duties and directions, the project on protection administration rules, vacancy and decision has been just finished.
- Water quality and digital information, from pre-treatment facility of industrial used water and Ulaanbaatar city central waste water treatment facility, are regularly received and they are put on the river basin council website. They initiated to inform through media.

2.2.6. Other activities

- The "River Basin Councils' Future Activity Framework" 2nd forum was held in Ulaanbaatar city on February 10, 2012 with the participation of Asia Fund and Water Authority. 18 river basin councils from 11 aimags participated in the 2nd forum. Ya.Tsedenbaljir, Tuul RBC secretary, D.Gan-Erdene, assistant and S.Chuluunkhuyag, RBC member also participated in the forum and expressed stance/position of river basin council on methods to manage water resources scarcity, unwise use of water and pollution in the basin.
- The Ministry of Nature, Environment and Tourism organized State conference of environment rangers in 2012. Tuul river basin council director and secretary participated in the conference and exchanged their opinions on Ulaanbaatar city ecological issues with the participants of the conference. The river basin council secretary participated in the administrators' conference of the Ministry of Nature, Environment and Tourism. He reported on Tuul RBC activities. The authorities from the Ministry of Nature, Environment and Tourism gave a "good" mark on the Tuul RBC activities.
- The Tuul River Basin Council representatives took part in the "Water-Human Rights" discussion in Government Palace hall B on March 22, 2012 and this discussion was organized by Ministry of Nature, Environment and Tourism, UN Children's Fund, Program Office of WWF in Mongolia and Water Authority.
- To improve protection activities and plant trees in the Tuul river bank protection zone with the cooperation of thermal power plant-3, thermal power plant-4, Sonsgolon-Khan-Uul branch council and "Sain Uils" NGO. Financial and organizational support was given to them.

3. Recommendations and future objectives

- The Tuul River Basin Council was established with the help of "Strengthening Integrated Water Resources Management in Mongolia" project. The council is a new and young organization since it has been a year. In order to have stable and fruitful operation, its members' capacity should be increased and council members should be participated in the activities evenly.
- The Tuul River is water supply source of Ulaanbaatar city which has very high economic pressures, ecological degradation, water and soil pollution. Every spring, Tuul River is cut off and groundwater level in the flood channel is decreased. The resources are decreasing. This basin has many issues. The council is short of capacity to solve all these issues itself. The reason is that there are only 2 people in the council including a secretary and an assistant. It is required to solve financial issues of the basin council in order to have stable and fruitful operation.
- The law on water is very important legal document for strengthening river basin council. It was reapproved by parliament in 2012. For article 17 of the law, mandates of the basin administration were legalized by 13 clauses. For example: the following mandates were legalized in the new basin administration mandates (in former law, these used to belong to the mandates of Water Agency): develop basin IWRM plan project; provide its implementation; conduct water inventory every year in the basin; charge water use and pollution fees (used to belong to the mandates of all level governors and People's Representative Khural); define spots where waste water is discharged; monitor water use; submit an idea about river basin council establishment; have evidence to include water bodies in the special protection. The river basin organizations' rights and duties are to be increased significantly.
- The Government member responsible for environmental issues is entitled to approve river basin administration director and formation. The river basin administration will operate under management administration of Water Authority. This opens possibilities to implement mandates of Water Agency through river basin administrations. As of reapproved water law, river basin administration mandates and duties as well as status increased significantly comparing to current river basin council.
- The "Ulaanbaatar City Water Supply and Sewerage Management Master Plan" project was implemented within the framework of Mongolian and Korean environmental sector cooperation. The Tuul River Basin Council Worked as a subcontractor of Mongolian side. This was a good example that river basin councils can participate and operate in international projects and programs.
- The River Basin Council will participate actively for the development and approval of Tuul River Basin IWRM plan.

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5. “Улаанбаатар хотын ус хангамж, ариутгах татуургын нэгдсэн менежмент төсөл”-ийн тайлан
6. Л.Жанчивдорж, Туул: Экологийн өөрчлөлт, усны менежментийн асуудал 2011 он

ANNEX 1. Order of Tuul River Basin Council establishment

МОНГОЛ УЛСЫН
БАЙГАЛЬ ОРЧИН, АЯЛАЛ ЖУУЛЧЛАЛЫН
САЙДЫН ТУШААЛ

2010 оны 11 сарын 04 өдөр   Дугаар А-341   Улаанбаатар хот

Тушаалын хавсралтад өөрчлөлт
оруулах тухай

"Усны тухай хууль"-ийн 19 дүгээр зүйлийн 19.2.1, 19.4, 19.6 дахь хэсэг, Усны газрын хүсэлтийг үндэслэн ТУШААХ нь:

"Сав газрын зөвлөл байгуулах тухай" Байгаль орчин, аялал жуулчлалын Сайдын 2010 оны 8 дугаар сарын 31-ны өдрийн А-268 дугаар тушаалын хавсралтад заагдсан Туул голын сав газрын зөвлөлийн гишүүдээс "З.Батбаярыг" "Д.Басандорж", "Х.Сэвжидмааг", "Б.Жияндорж", "З.Занданпүрэвийг" ,"Б.Энхсүрэн", "Ц.Дашдэмбэрэлийг", "Ц.Туяацэцэг" гэж тус тус өөрчилсүгэй.

САЙД Л.ГАНСҮХ

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ANNEX 2. Tuul River Basin Council organization

Байгаль орчин, аялал жуулчлалын сайдын
2010 оны 11. дугаар сарын 04-ний өдрийн
А-341.. дугаар тушаалын хавсралт

Туул голын сав газрын бүрэлдэхүүн

Сав газрын зөвлөлийн дарга	Д.Ганболд	Нийслэлийн засаг даргын орлогч
Сав газрын зөвлөлийн нарийн бичгийн дарга	Я.Цэдэнбалжир	Усны газрын усны нөөцийн хэлтсийн дарга
Сав газрын зөвлөлийн гишүүд	Б.Пүрэвжав	Ус сувгийн удирдах газрын дарга Нийслэлийн иргэдийн төлөөлөгчдийн хурлын төлөөлөгч
	Л.Дашдорж	Нийслэлийн мэргэжлийн хяналтын газрын байгаль орчин аялал жуулчлал, геологи уул уурхайн хяналтын хэлстийн усны асуудал хариуцсан ахлах байцаагч
	Ч.Дамбасүрэн	Нийслэлийн байгаль хамгаалах газрын ус, хөрс газрын хэвлийн асуудал хариуцсан мэргэжилтэн
	С.Чулуунхуяг	Чулуунхуяг Шинжлэх Ухаан Техникийн Их Сургууль, Барилгын инженерийн сургуулийн хүрээлэн байгаа орчны инженехийн салбарын эрхлэгч
	С.Эрдэнэбаяр	Сэлэнгэ аймгийн Орхонтуул сумын засаг дарга
	Б.Батцэцэг	Архангай аймгийн Хашаат сумын засаг дарга
	Ц.Батсайхан	Булган аймгийн Иргэдийн Төлөөлөгчдийн Хурлын төлөөлөгч, ЗДТГ-н хэвлэл мэдээлэлийн ажилтан

Д.Баяр	Төв аймгийн Аргалант сумын засаг дарга
Б.Энхсүрэн	Өвөрхангай аймгийн Байгаль орчин аялал жуулчлалын газрын Усны нөөцийн ашиглалт хамгаалалтын асуудал хариуцсан мэргэжилтэн
З.Доржпалам	"Туулын хар шугуй" -Буянт ухаа" нөхөрлөлийн гишүүн
Л.Ханд	Ханд Төв аймгийн Алтанбулаг сумын ИТХ-н төлөөлөгч, Хустайн цогцолборт газрын Алтанбулаг сум дахь орчны бүсийн төлөөлөгч
Д.Энхтөр	Тосонзаамар-Туул гол хөдөлгөөний тэргүүн
Д.Басандорж	Байгаль орчны хөгжлийн нийгэмлэг
Б.Жияандорж	Адал явдалт аялал жуулчлалын холбоо
Ц.Туяацэцэг	Экологийн боловсролын төв

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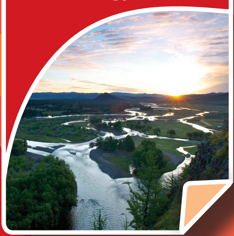
1. Natural condition and land use

2. Surface Water resources

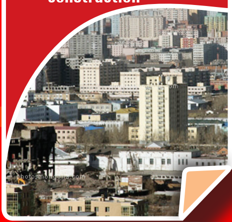
3. Groundwater resources

4. Water quality and ecology



5. Socio-economic condition

6. Water supply, water consumption-use, water demand and hydro-construction



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