GOVERNMENT OF MONGOLIA

Kingdom of the Netherlands

ORKHON RIVER BASIN

INTEGRATED WATER RESOURCES MANAGEMENT ASSESSMENT REPORT

GOVERNMENT OF MONGOLIA

MINISTRY OF ENVIRONMENT AND GREEN DEVELOPMENT

УСНЫ НЭГДСЭН МЕНЕЖМЕНТ

ORKHON RIVER BASIN INTEGRATED WATER RESOURCES MANAGEMENT ASSESSMENT REPORT

Ulaanbaatar 2012

DDC
555.7'015
O-489

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

ORKHON RIVER BASIN
INTEGRATED WATER RESOURCES MANAGEMENT
ASSESSMENT REPORT

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ISBN 978-99962-4-536-7

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Preface

Within the framework of the cooperation between the Governments of Mongolia and the Kingdom of the Netherlands, implementation of the "Strengthening Integrated Water Resources Management in Mongolia" project commenced on November 17, 2006 by the Water Authority (the former Government Implementing Agency for water) on the basis of the cooperation agreement signed by the Minister of Nature and Environment of Mongolia (old name) and the ambassador of the Kingdom of the Netherlands in Beijing. The project implementing agreement was concluded on November 15, 2007 between the Ministry of Nature and Environment[1] of Mongolia and the Ministry of Development Cooperation of the Kingdom of the Netherlands.

According to the project implementing agreement one of the main outputs from the project is the Orkhon River Basin Integrated Water Resources Management Plan which is to act as a "model" basin plan to be approved and implemented by the competent authority. The renewed "Law on Water" approved by the Parliament in 2012 makes several references to river basins including: '... develop integrated water resources management plan for Mongolia and each water basin; the plan needs to be approved and implemented by the competent authority.'

The Orkhon River Basin is a very important economic development zone of Mongolia. Animal husbandry, farming and tourism are the dominating economic activities in the basin, which also includes: the Erdenet industry, a major representative of the mining industry; Erdenet and Kharkhorin cities which are basic centers of the Khangai zone; the centers of Arkhangai, Bulgan and Selenge aimags. The population density is 2.5 times the national average; out of the 29 basins it is second in respect of water use after the Tuul Basin. There are many water users and consumers.

The Orkhon River Basin Integrated Water Resources Management plan is a mid-term policy-planning document based on usable water resources within the basin. The following issues will be addressed within the framework of the policy-planning document: supply the water required by the socio-economic sectors by 2015 and 2021; solve the water related issues; maintain the ecological balance of the basin. These complex water management issues are included. The plan will form the framework for aimag and soum development policies and programs within the basin.

To collect the required data for the development of the Orkhon River Basin Integrated Water Resources Management Plan, researches were conducted in the assessment of: basin natural condition, surface water and groundwater resources and regime, water quality and ecology, fauna, land use, socio-economic development and current situation of the basin water demand and use. The future trends were defined and reports were prepared for each topic and are published as a separate volume named "Orkhon River Basin Integrated Water Resources Management assessment Report".

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 Orkhon River Basin Integrated Water Resources Management Plan.

The compilation contains 7 parts. The first part of the compilation is about the Orkhon River Basin's natural condition, fauna, land and use; the second part is about the Basin's surface water resources and regime and impacts from climate change; the third part adresses groundwater resources assessment; the fourth part presents the assessment and conclusion of water quality and some relevant ecological issues; part five is the analysis

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

of the current condition of the basin's socio-economic development and estimates for the future development trends of the economic sectors; the sixth part assesses the current condition of water supply, sewerage, flood protection construction, which is a basic information for the development of Orkhon River Basin Integrated Water Resources Management Plan. The current condition of water demand and use was estimated for the years 2008 and 2010 for each sector; future trends were estimated to estimate the levels in 2015 and 2021 and these results were integrated; recommendations for necessary measures are included along with integrated results in part six. Part seven includes one of the project's main results: the Orkhon River Basin Council, its formation, structure, legal environment, finances, human resources capacity, basic trend of activities and recommendations of main issues to be addressed in the near future.

Water sector researchers, project senior consultants, national and international consultants and the national project team closely cooperated on the integration and analysis of the results of research work for the development of Orkhon River Basin Integrated Water Resources Management Plan and in the preparation of the reports. Their contribution to the compilation has been very valuable.

On behalf of the project team, I would like to express my gratitude to the Embassy of the Kingdom of the Netherlands in Beijing, Ministry of Development Cooperation, the Government of the Kingdom of the Netherlands who sponsored the publication of the compilation and research works conducted within the framework of the "Strengthening Integrated Water Resources Management in Mongolia" project.

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
GDP	Gross Domestic Production
GEI / IGE	Institute Geo-Ecology
GIS	Geographical Information System
GoM	Government of Mongolia
GWP	Global Water Partnership
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
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
ORB	Orkhon River Basin
PPP	Public Private Partnership
PUSO	Public Urban Services Organization
RB	River Basin
RBC	River Basin Council

SPC	State Property Committee
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Program
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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[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 Orkhon River Basin there are 3 main sources of digital information:

- Census information on unified land fund
- Information on pastureland state and quality control confirmation
- Annual report on unified land fund

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 on 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 basins, mapping the drainage network in the Orkhon River Basin. For the evaluation the remote sensing research methodology, geographical information system (GIS) and standard model methods were used.

2. Topography

The Orkhon river basin is covered by 53 soums of 8 aimags. Bulgan, Tuvshruulekh, Khotont soum of Arkhangai aimag, Bayan-Undur soum of Orkhon aimag, Khujirt soum of Uvurkhangai aimag are fully included in Orkhon river basin.

Table 1 shows the area of aimag and soums which are included in the Orkhon river basin. Of the Orkhon River basin area 38.2% is occupied by Arkhangai aimag, 22.1% by Bulgan, 18.4% by Selenge, 15.9% by Uvurkhangai, 1.9% by Tuv aimag, 1.6% by Bayankhongor, 1.6% by Orkhon and 0.4% by Darkhan-Uul aimag.

The length of the Orkhon River is 1066 km, it is calculated by GIS methodology using topographical map with scale 1:100,000. Figure 1 and Figure 2 show the location of the Orkhon river basin.

The geographical coordinates of the origin of the Orkhon River are 101°20'13" E, 47°03'07" N. The Orkhon confluence with the Selenge River is at 106°08'55"E, 50°14'42"N. The geographical coordinates of the edges of the Orkhon River basin area:

West:	100°20'25"
East:	106°37'31"
North:	50°21'15"
South:	46°26'05"

Three natural zones occur in the Orkhon River Basin: the forest-steppe zone occupying 71.4%, the steppe zone occupying 26.0%, and the high mountainous zone covering 2.6% of the basin (Figure 3).

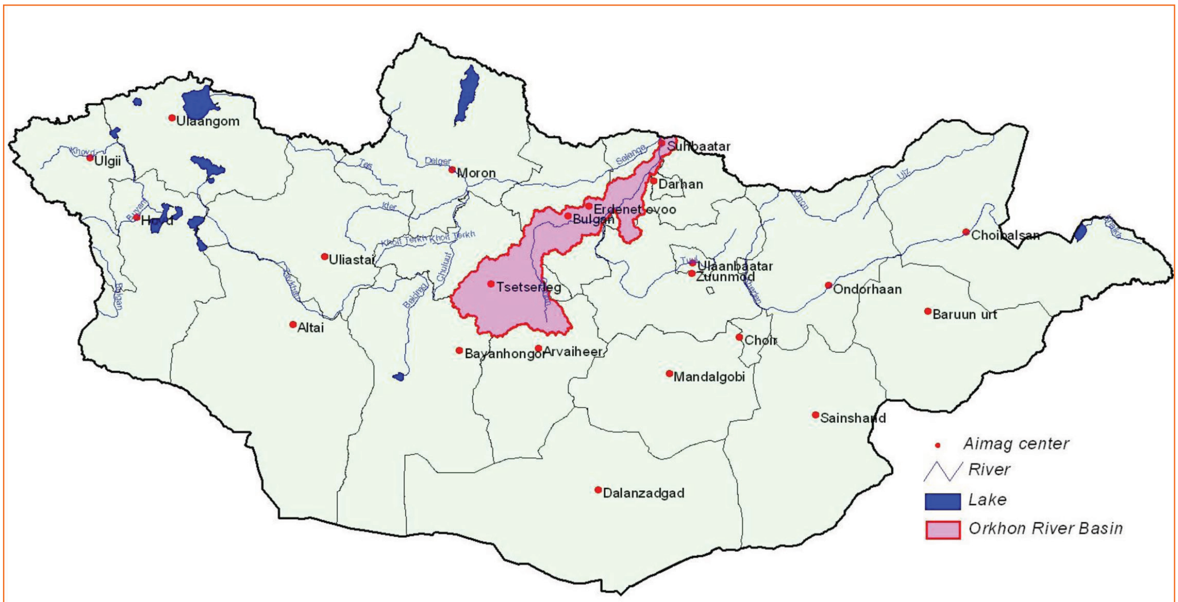

Figure 1. Location of the Orkhon river basin

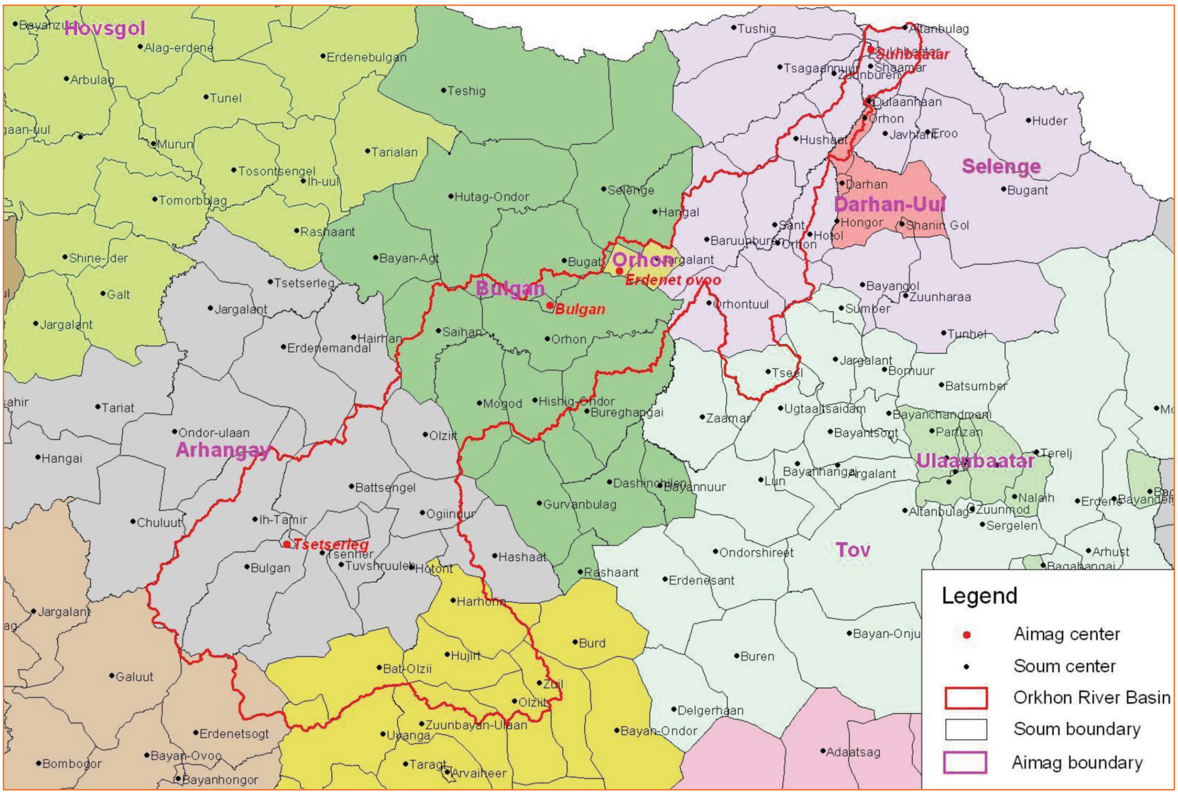

Figure 2. Aimag and soums in Orkhon river basin

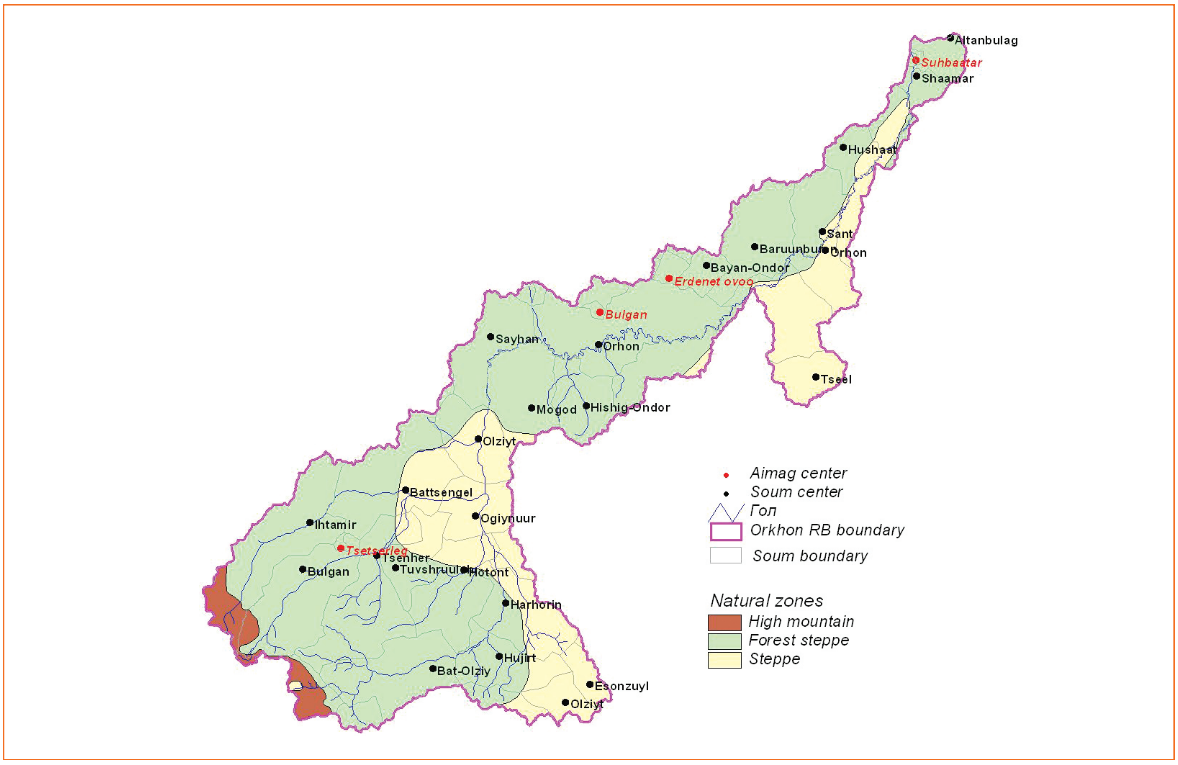

Figure 3. Natural zones of Orkhon river basin

Table 1. Area of soums in Orkhon river basin

No	ID	Aimag	Soum	Area in basin, *km²*	Total soum area, *km²*	Percentage (area in basin)	Percentage (of basin area)
1	201	Arkhangai	Battsengel	3,378.52	3,519.29	96.0	6.3
2	202		Bulgan	3,218.81	3,218.81	100.0	6.0
3	204		Ikhtamir	3,591.82	4,873.57	73.7	6.7
4	205		Ogiinuur	1,385.92	1,681.94	82.4	2.6
5	206		Olziit	1,717.54	1,717.54	100.0	3.2
6	207		Undur-Ulaan	0.05		0.0	0.0
7	209		Tuvshruulekh	1,185.41	1,185.41	100.0	2.2
8	211		Khairkhan	72.85	2,512.07	2.9	0.1
9	212		Khashaat	424.93	2,591.04	16.4	0.8
10	213		Khotont	2,343.07	2,343.07	100.0	4.4
11	214		Chuluut	6.87	3,435.00	0.2	0.0
12	216		Tsenkher	3,147.09	3,147.09	100.0	5.9
13	218		Erdenebulgan	62.68	62.68	100.0	0.1
14	219		Erdenemandal	0.45		0.0	0.0
15	412	Bayankhongor	Galuut	6.33	6,330.00	0.1	0.0
16	420		Erdenetsogt	836.75	4,061.89	20.6	1.6
17	503	Bulgan	Bugat	476.82	3,200.13	14.9	0.9
18	504		Bulgan	88.76	88.76	100.0	0.2
19	505		Buregkhangai	1,468.35	3,487.77	42.1	2.7
20	506		Gurvanbulag	0.06		0.0	0.0
21	508		Mogod	2,199.26	2,819.56	78.0	4.1
22	509		Orkhon	4,080.08	4,092.36	99.7	7.6
23	511		Saikhan	1,849.19	2,759.99	67.0	3.4
24	512		Selenge	18.60	4,650.00	0.4	0.0
25	514		Khangal	91.87	1,640.54	5.6	0.2
26	515		Khishig-Undur	1,476.71	2,436.82	60.6	2.8
27	516		Khutag-Undur	113.39	5,669.50	2.0	0.2
28	802	Darkhan-Uul	Orkhon	214.33	461.92	46.4	0.4
29	1302	Orkhon	Jargalant	562.94	567.48	99.2	1.1
30	1301		Bayan-Undur	273.00	273.00	100.0	0.5
31	1403	Uvurkhangai	Bat-Ulzii	2,579.14	2,586.90	99.7	4.8
32	1407		Burd	24.37	2,707.78	0.9	0.1
33	1409		Esonzuil	566.74	1,961.04	28.9	1.1
34	1410		Zuunbayan-Ulaan	540.17	2,512.42	21.5	1.0
35	1412		Olziit	733.71	1,967.05	37.3	1.4
36	1416		Uyanga	405.27	3,047.14	13.3	0.8
37	1418		Kharkhorin	2,043.52	2,301.26	88.8	3.8
38	1419		Khujirt	1,661.41	1,661.41	100.0	3.1
39	1701	Selenge	Altanbulag	674.59	2,435.34	27.7	1.3
40	1702		Baruunburen	2,334.34	2,805.70	83.2	4.3
41	1706		Zuunburen	609.05	1,191.88	51.1	1.1
42	1708		Orkhon	1,040.87	1,264.73	82.3	1.9
43	1709		Orkhontuul	2,001.72	2,935.07	68.2	3.7
44	1710		Saikhan	546.27	1,306.87	41.8	1.0
45	1711		Sant	1,337.48	1,350.99	99.0	2.5
46	1712		Sukhbaatar	46.47	46.89	99.1	0.1
47	1714		Khushaat	856.88	2,002.06	42.8	1.6
48	1717		Shaamar	474.53	617.88	76.8	0.9
49	1816	Tuv	Jargalant	7.36	1,840.00	0.4	0.0
50	1817		Zaamar	1.90	1,900.00	0.1	0.0
51	1823		Sumber	4.22	527.50	0.8	0.0
52	1824		Ugtaal	1.68	1,680.00	0.1	0.0
53	1825		Tseel	1,002.75	1,641.16	61.1	1.9
			Total	53,786.89			100.0

3. Climate

3.1. Climate condition

B.Jambaajamts (1989) divided Mongolia into 3 climate zones. A humid-cold zone, which is elevated more than 1800 m, a subhumid-cool zone - elevated between 1300 m and 1800 m, and a semidry-cooler zone - which is elevated between 700 m and 1300 m above sea level. The Orkhon River basin area is divided in 45.0% of the subhumid-cool climate zone, 27.3% of the semidry-cooler climate zone and 27.7% of the humid-cold climate zone (Figure 4).

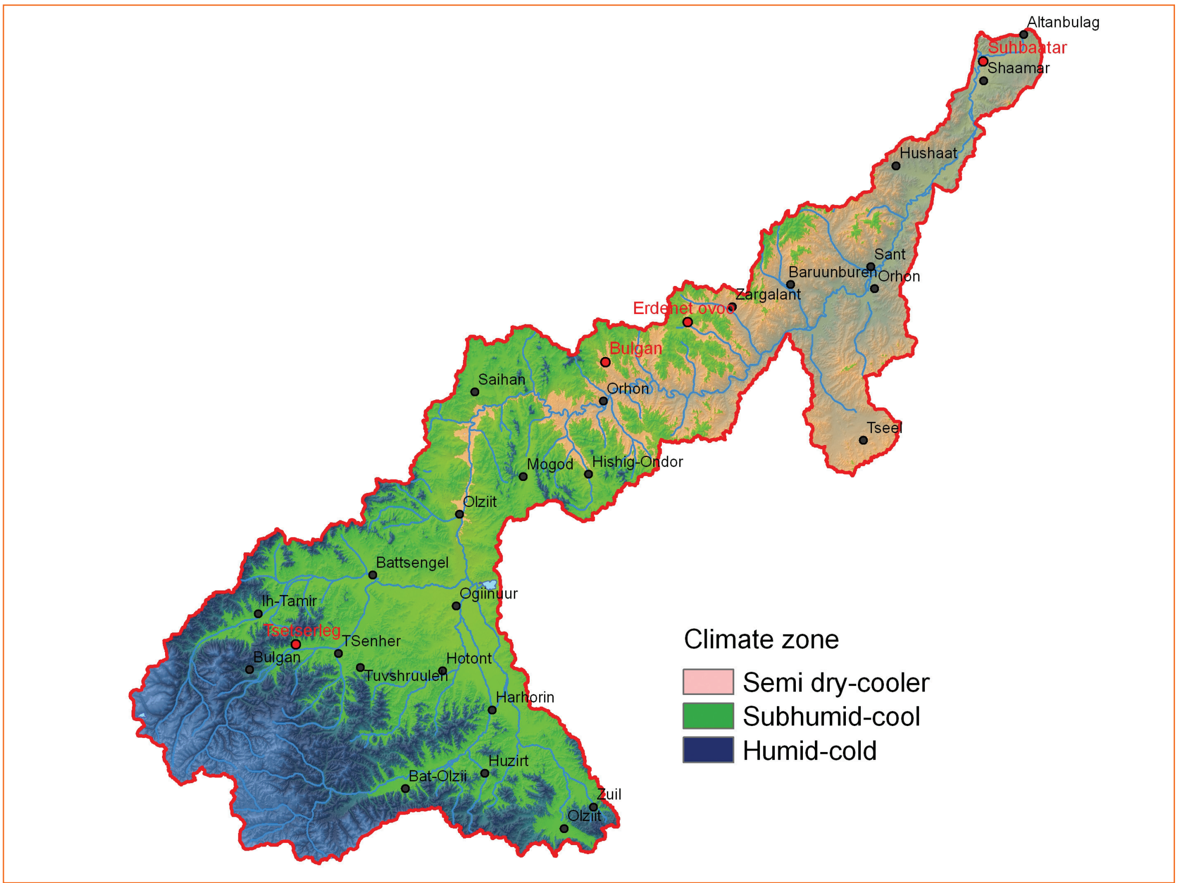

Figure 4. Climate zones of Orkhon river basin

The Khangai mountainous region is located in the humid-cold zone and the mean monthly temperature in the warmest month, July does not exceed 15˚C. During the summer it is possible to observe a sudden drop of temperature. The duration of the warm period is about 30-50 days. The heat resource with temperature more than 10˚C is less than 1250˚C, and the total annual precipitation is more than 350 mm.

The Khangai−Khentii middle elevated mountains are located in the subhumid-cool zone and consist of valleys between mountains and basins of rivers. The zone is characterized by mountain taiga and mountain steppe region landscape. The mean monthly temperature in July is 15-17˚C; the duration of the warm period is about 70-80 days. The heat resource with temperature more than 10˚C is 1250-1750˚C, and the total annual precipitation is 300-350 mm, but 250-280 mm in mountain steppe area.

The forest steppe region is located in the semidry-cooler zone. Here, the heat resource is sufficient for vegetation and soil humidity. The mean monthly temperature in the warmest month July is 17-20˚C. The duration of the warm period is about 80-100 days. The heat resource accumulates 1750-2250˚C during the vegetation period. For that period the total annual precipitation is 250-300 mm.

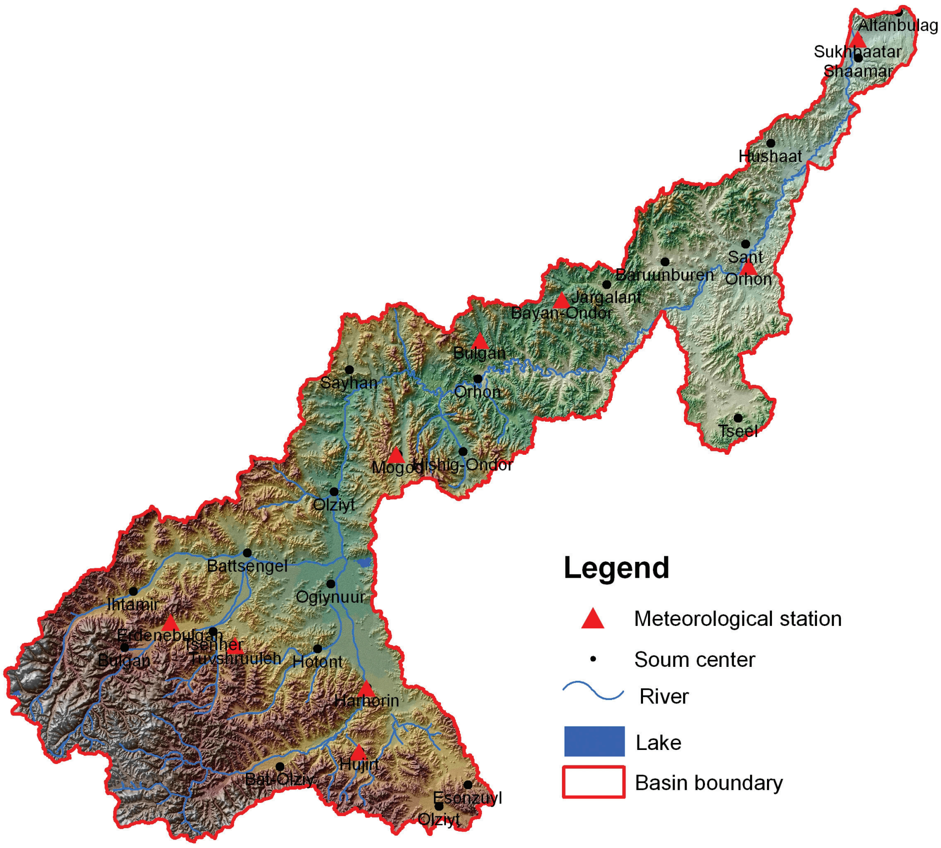

Figure 5. Location of the meteorological stations

Table 2. Mean monthly air temperature at meteorological stations, ^0C

Station name	Month												Annual
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
1. Khujirt	-20.8	-18.2	-8.7	0.6	8.2	13.0	14.5	12.8	6.9	-0.8	-11.1	-18.3	-1.8
2. Tsetserleg	-14.9	-13.6	-6.8	1.1	8.7	13.0	14.3	12.8	7.5	0.6	-7.6	-12.9	0.2
3. Bulgan	-20.3	-18.2	-8.6	1.1	9.1	14.2	16.0	13.9	7.2	-0.9	-10.9	-17.9	-1.3
4. Erdenet	-16.8	-14.8	-7.7	1.1	9.0	13.8	15.5	13.9	8.3	0.8	-8.7	-14.6	0.0
5. Orkhon	-24.9	-21.4	-9.0	2.8	10.7	16.6	18.6	16.2	9.2	0.5	-11.3	-21.0	-1.1
6. Sukhbaatar	-23.1	-19.3	-7.4	3.0	10.9	17.0	18.9	16.8	9.8	1.0	-10.7	-18.9	-0.2

Table 3. Precipitation, mm

N	Station name	Month												Sum
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
1	Tsetserleg	2.0	2.8	6.1	16.9	32.7	69.0	90.4	82.6	27.3	13.5	6.0	2.8	352.1
2	Tuvshruulekh	2.1	2.1	5.8	6.8	23.0	49.0	67.4	39.8	17.5	8.8	4.5	2.2	229.0
3	Bulgan	1.4	2.1	3.2	10.7	25.5	57.7	108.0	81.8	32.4	12.5	3.9	2.0	341.2
4	Mogod	0.3	0.2	1.2	4.4	10.7	35.2	62.9	42.2	16.6	3.9	1.9	0.6	180.1
5	Erdenet	2.0	1.7	5.0	13.8	23.7	70.7	100.5	81.3	41.2	13.0	7.6	3.3	363.8
6	Khujirt	1.2	2.0	3.9	10.1	24.9	53.5	91.5	73.4	25.6	7.4	3.5	2.2	299.2
7	Kharkhorin	3.9	3.0	7.4	13.2	28.9	60.0	79.7	49.8	24.4	13.2	5.6	4.0	293.1
8	Orkhon	3.4	1.9	3.2	6.1	19.2	69.0	77.2	72.0	41.8	8.3	5.8	4.5	312.4
9	Sukhbaatar	3.2	2.6	3.1	11.6	18.9	49.0	84.7	74.7	35.9	14.3	6.1	3.1	307.2

3.2. Climate change

Air temperature

The warming of the air is increasing depending on the geographical location of Mongolia caused by the global warming pattern and especially there is high intensity value in the Orkhon river basin. By observation data of meteorological stations in Orkhon river basin, mean annual air temperature increased by 0.8-1.3˚C from norm, especially at high places it increased more.

Warming in winter time is less, some places became colder and in summer warming is active. Due to the global warming, the number of hot days is increasing and the observed maximum air temperature since 1940 happened in the last few years.

Precipitation

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

The total precipitation and the duration of rainfall during the summer season is decreasing in the Orkhon River Basin. Figure 6 shows the total precipitation duration during the summer season at Tsetserleg station.

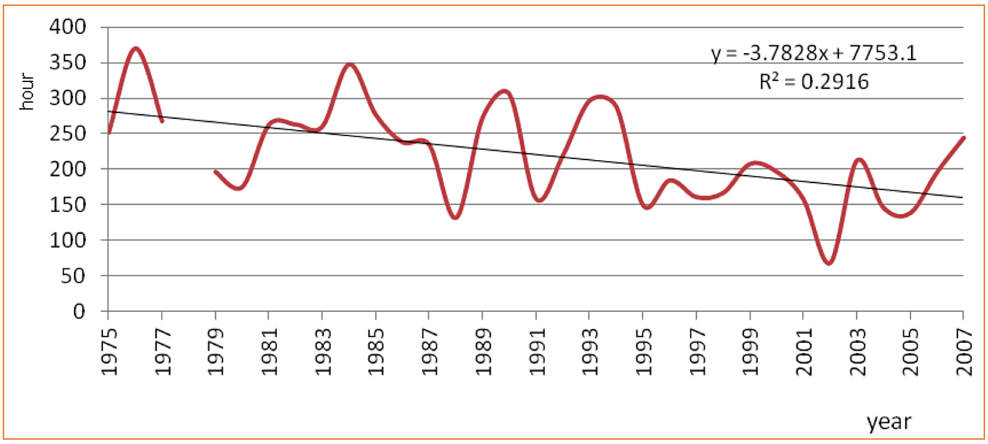

Figure 6. Precipitation duration during the summer at Tsetserleg

Figure 6 shows an average precipitation duration during the 3 month summer of 220 hour but since 1975 the duration decreased by about one third. Another change is the increased frequency of thunderstorms during the summer (L.Natsagdorj, 2009).

Evaporation

The main reason of the aridity in the Orkhon 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 30-40% in the runoff forming area of Orkhon river basin.

The change in evaporation and precipitation affects the river discharge. The discharge in the upper part of the Orkhon River was 24.8 mm between 1961-1990 at Khujirt gauging station data. However, the discharge was reduced to 16.6 mm between 1991-2008.

4. Soil, Vegetation, Forest

4.1. Soil

The soil-geography in the basin is dominated by mountain soil and steppe-valley soil. The soil types in the basin are shown in the table below.

Table 4. Soil types

no	Soil types	Area, [km^2]	%
1	Mountain soil	35,056.58	65.2
2	Low mountains and rolling hills soil	3,390.12	6.3
3	Soil of steppe valley and depression	8,686.28	16.1
4	Soil of humid areas	5,309.86	9.9
5	Riparian soil	809.77	1.5
6	Saline soil	384.71	0.7
7	Other soils and bare land	148.14	0.3

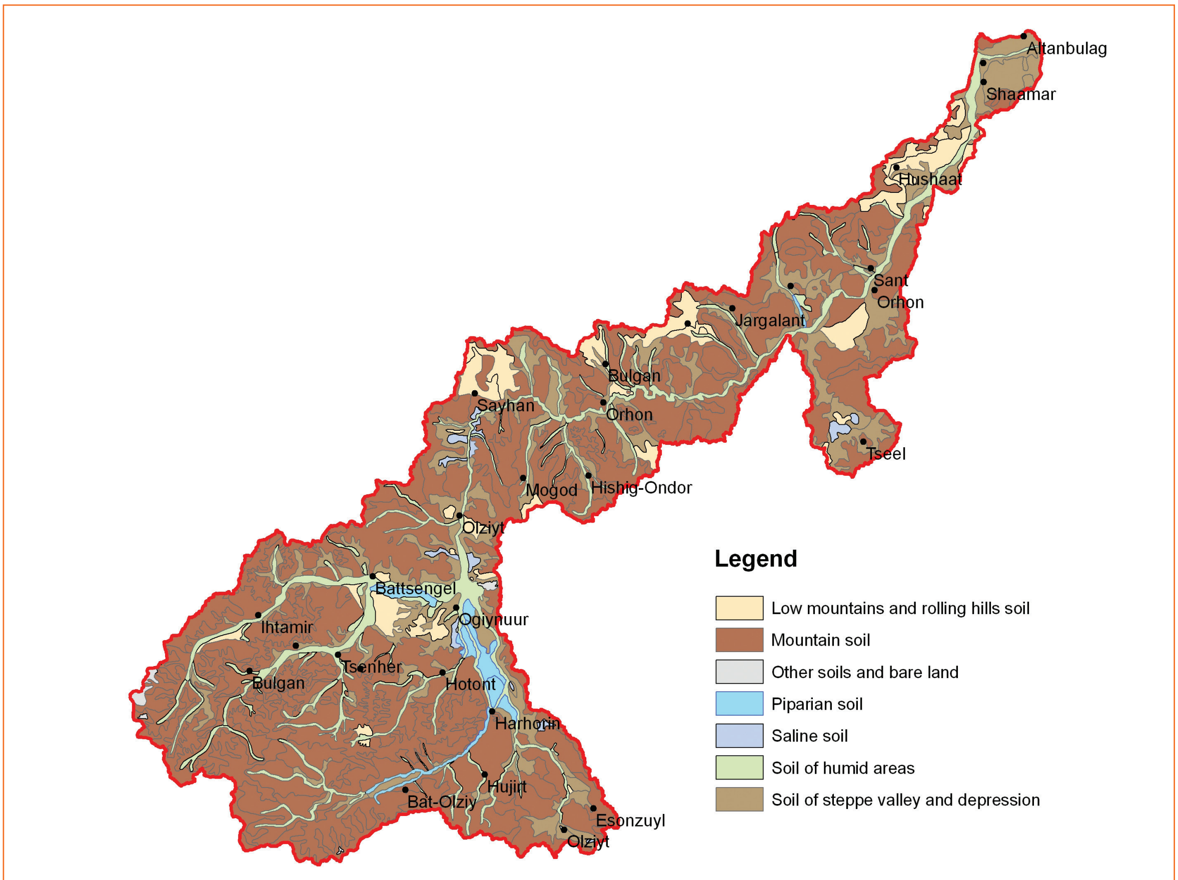

Figure 7. Soil type

4.2. Vegetation

More than 40% of the basin is covered by mountain steppe vegetation and the downstream part has a high occurrence of bushes, swamps and spotted grass. The distribution of the vegetation types in the basin is shown in Figure 8 and table 4.

Table 5. Vegetation types

No	Vegetation type	Area, *[km²]*	%
1	High Mountain	2,480.5	4.6
2	Mountain forest steppe	19,722.7	36.7
3	Mountain taiga	169.1	0.3
4	Mountain stepppe	2,217.4	4.1
5	Mountain desert steppe	574.9	1.1
6	Steppe and dry steppe	10,529.5	19.6
7	Desert	1,748.4	3.2
8	Desert steppe	6,820.4	12.7
9	Bare land	9,522.6	17.7
	Total	**53,786.9**	**100.0**

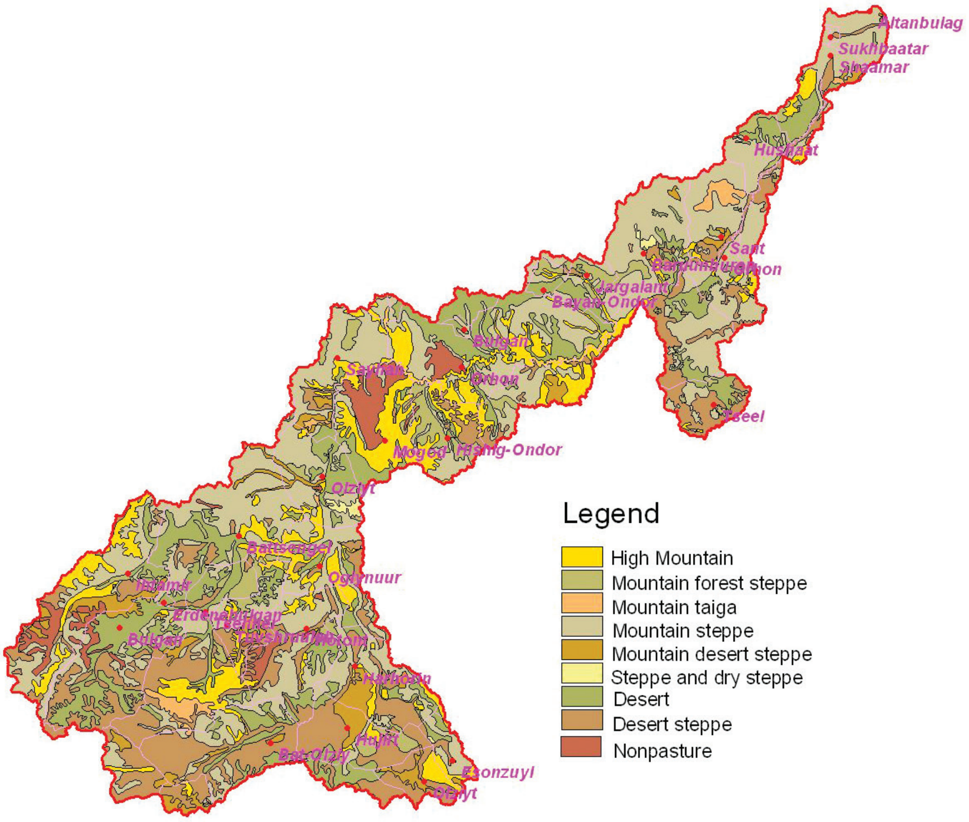

Figure 8. Vegetation

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”. The forest distribution of the Orkhon basin is shown in Figure 9. Of the total forest area: 76.6% is larch, 11.3% is birch and aspen, 5.8% is pine, 3.1% is cedar and 3.1% is burnt and destroyed forest.

The upper part of the Orkhon River basin is dominated by larch and cedar, the middle part by birch and aspen and the lower part of the basin is dominated by pine forest.

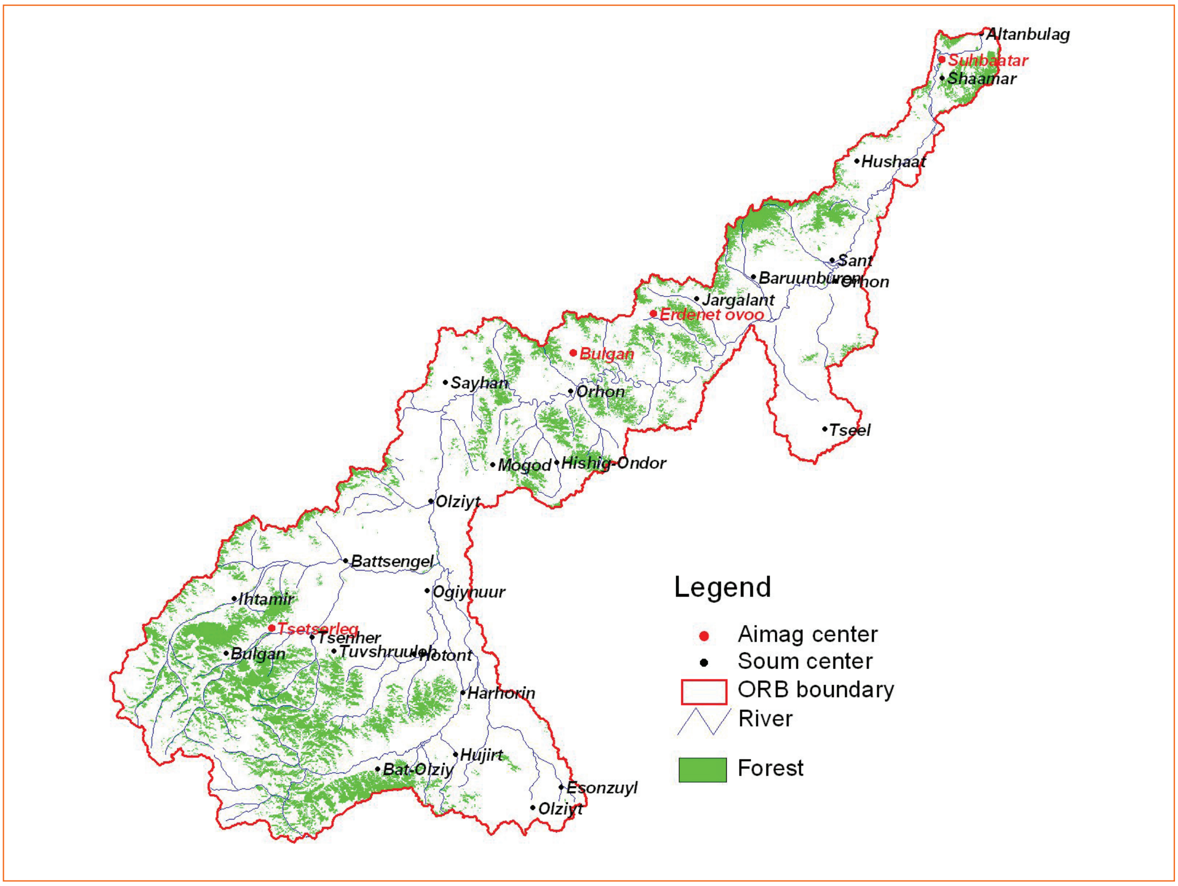

Figure 9. Forest in Orkhon River basin

5. Land use

5.1. Land cover

The digital elevation model of the Orkhon River Basin is shown in Figure 10.

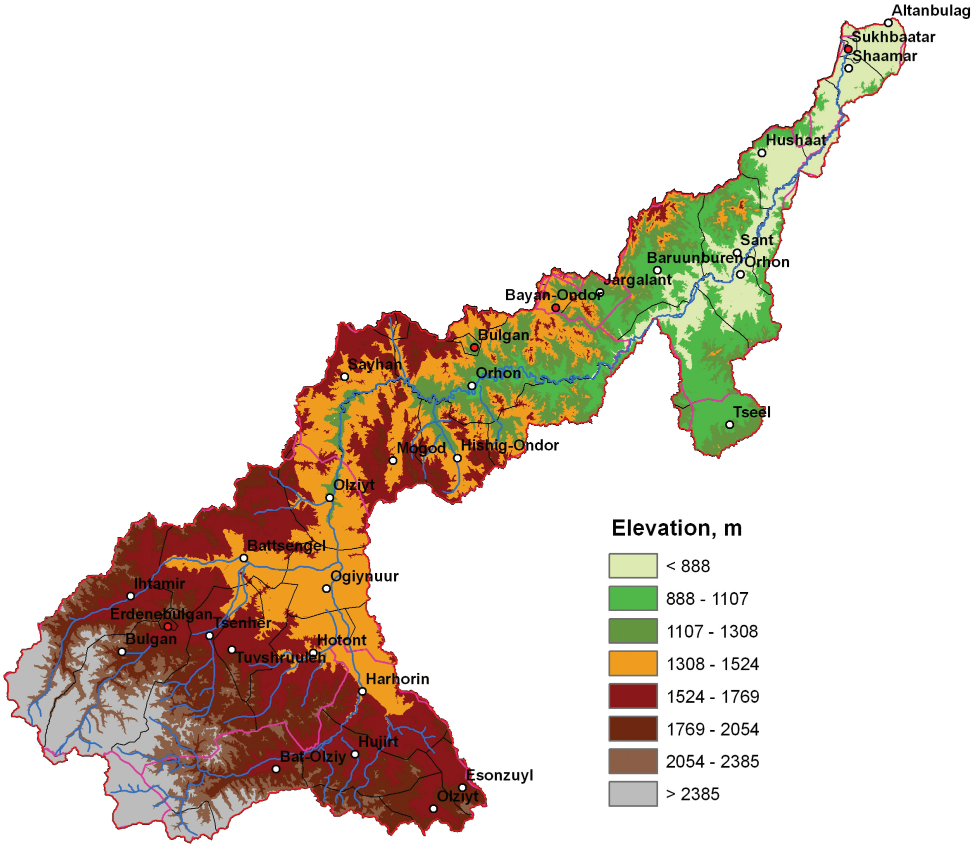

Figure 10. Digital elevation model

In 2008, EIC MNET produced a landcover map using MODIS satellite imagery (figure 11). By that map 18% of the Orkhon River basin is covered by forest, 43.7% by pasture land and about 35% of the basin area is covered by desert steppe class.

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. Analysis of the data reveals that 32% of the grassland steppe has changed into desert-steppe during this period. The maps clearly show that the desertification process is moving from the south to the north (figure 12).

Source: EIC

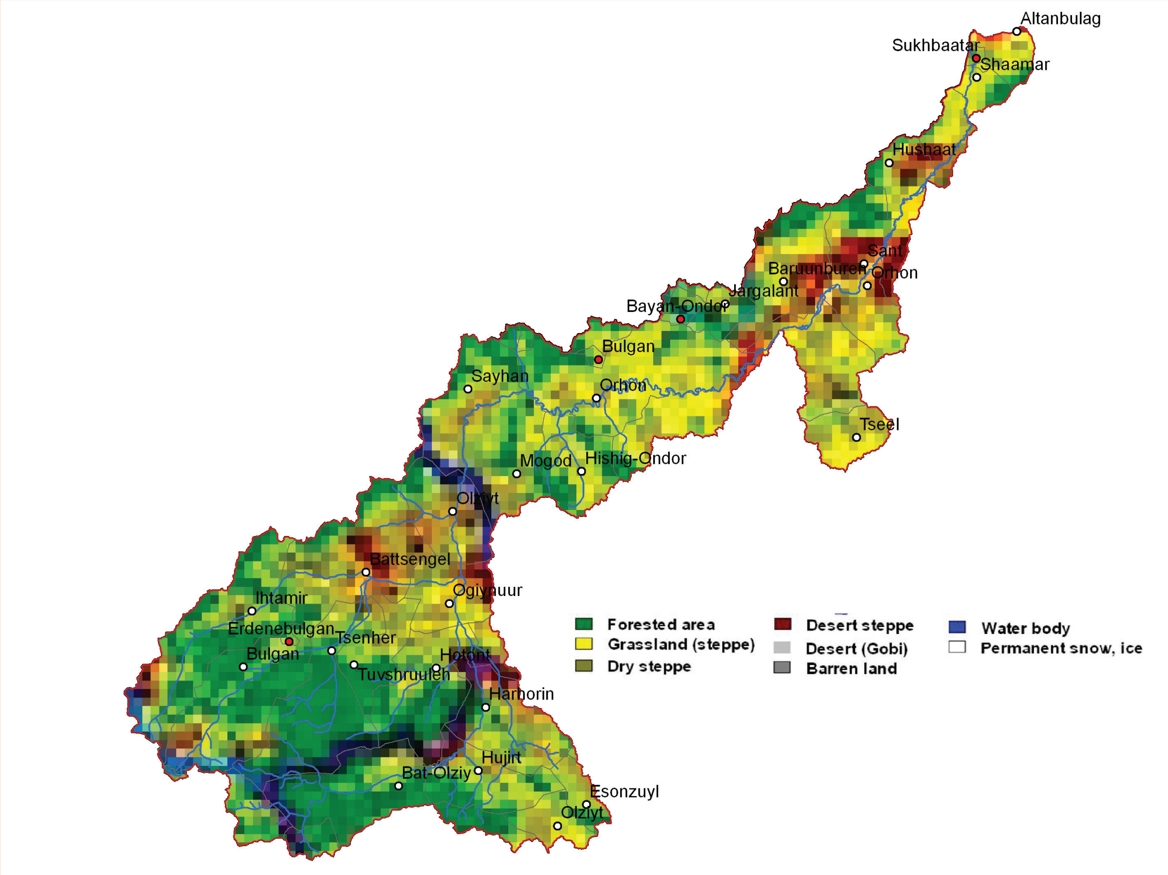

Figure 11. Land cover (by MODIS data, 2008)

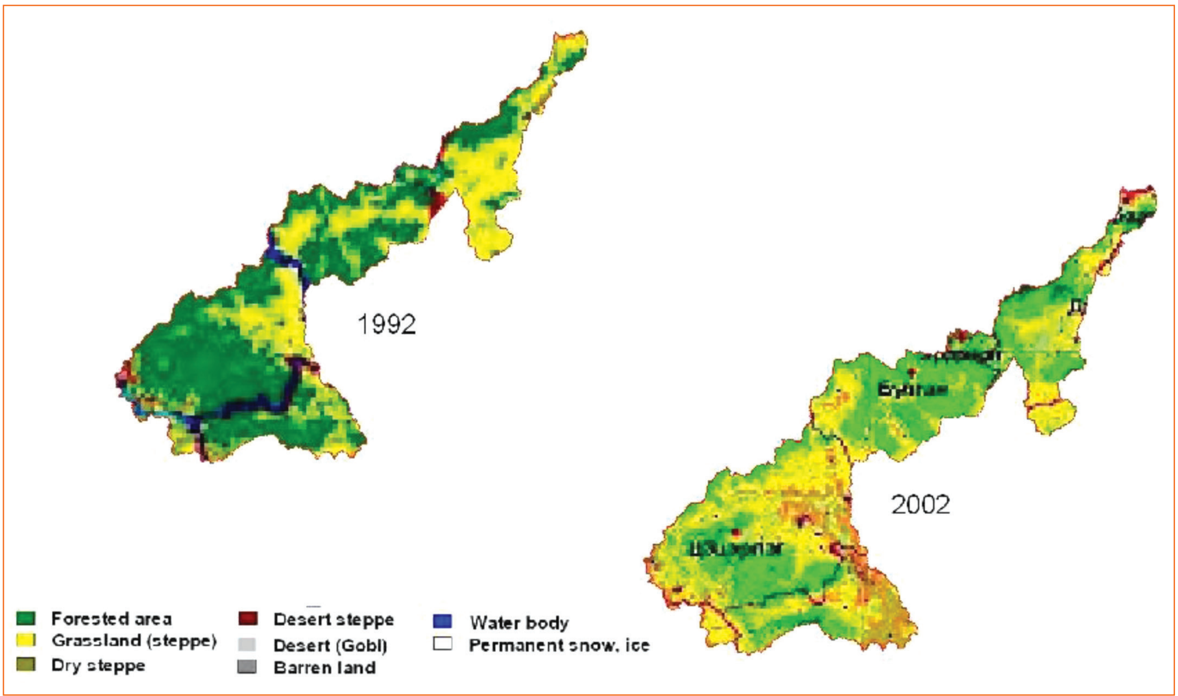

Figure 12. Land cover by MODIS data (1992, 2002)

The Orkhon River Basin includes the “Tujiin Nars”, the “Khangain Nuruu” mountain range and the “Orkhon valley” Natural Parks, and the “Khuisiin Naiman Nuur” and “Bulgan Uul” Natural Historic Monuments. The total of special protected areas occupy about 7460 km^2 of land, which amounts to about 13.8% of the Orkhon River Basin (Figure 13).

Table 6. Area of Protected Areas

Protected Area	Area *[km^2]*
Tujiin nars NP	425,3
Khangai mountain NP	5995,7
Orkhon valley NP	912,2
Naiman lake NHM	108,2
Bulgan mountainNHM	20,0

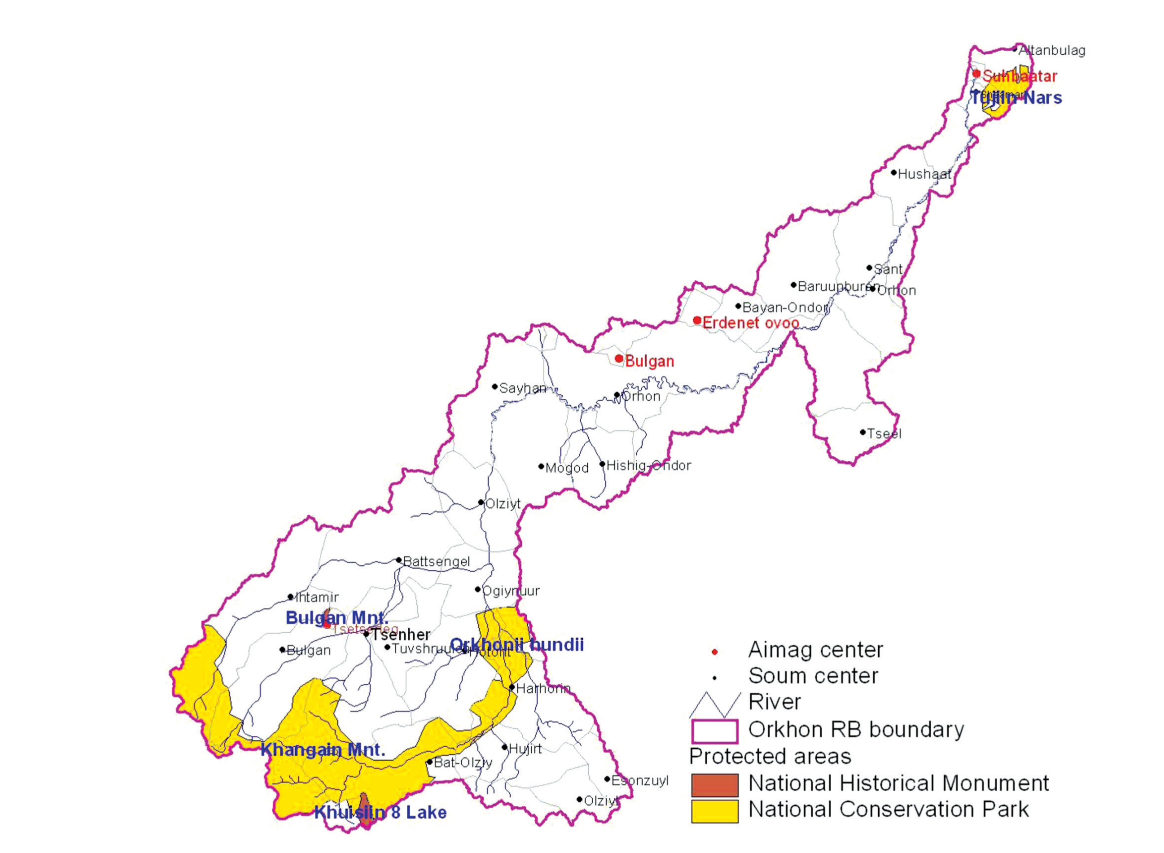

Figure 13. Location of Protected Areas

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

1. Pasture
2. Abandoned land
3. Hayland
4. Crop 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 41572.0 km^2 or 77.3% of the total basin area. Cultivated crop area, settlement, road and forest area occupy areas between 0.2-14.9%. River and lake areas occupy in total 392.8 km^2 from which 356.3 km^2 is occupied by rivers and 36.5 km^2 by lakes. The land use map of the Orkhon River Basin is given in Figure 14.

Table 7 presents the detailed distribution of the land use types in the Orkhon River basin.

Table 7. Land use types

No	Land use type	Area, *[km^2]*	%
1	Pasture	41,572.0	77.3%
2	Abandoned land	1,658.6	3.1%
3	Bare land	99.6	0.2%
4	Crop	298.5	0.6%
5	Forest	8,005.3	14.9%
6	Urban	408.8	0.8%
7	Water	392.8	0.7%
8	Road	132.6	0.2%
9	Industry/Mining	153.9	0.3%
10	Hay land	1,064.9	2.0%
	Total	53,786.9	100%

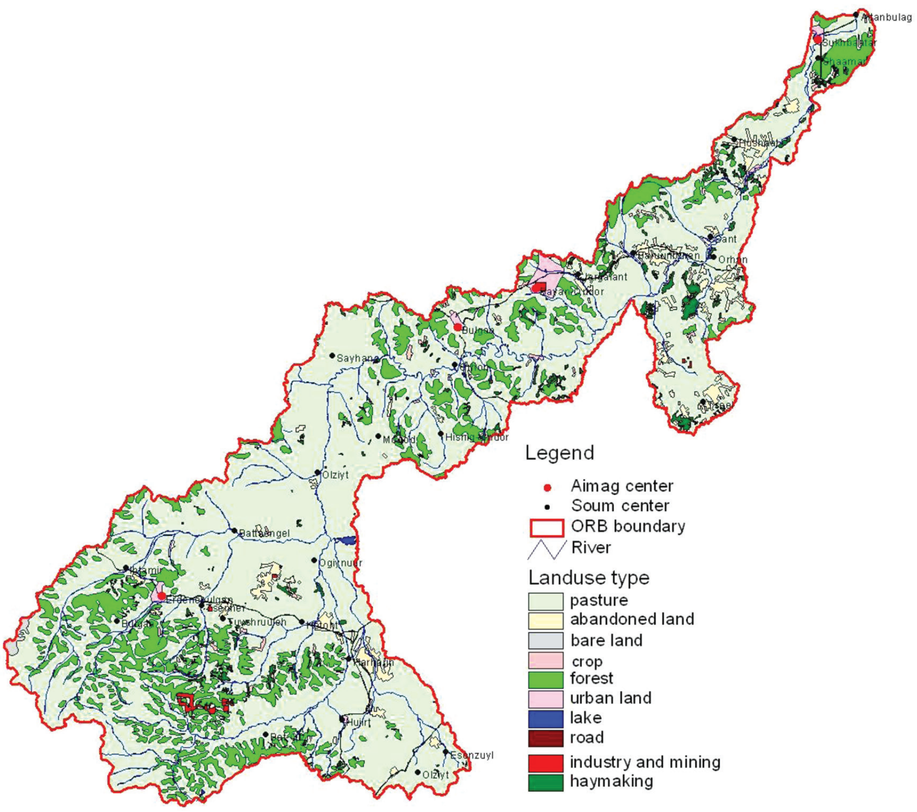

Figure 14. Land use

5.2. 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 8000 citizens in the Orkhon River basin owned land totaling about 11.2 km^2.

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 3000 km^2 have been implemented such as pasture rotation in about 700 km^2, extermination of rodents on 1800 km^2, planting new trees and bushes on 500 hectares of land and restoration. On other lands steps were taken to remove household waste, implement 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 59.8%. However, holes and destroyed land caused by mining or private activities are not included in the plan for rehabilitation work, because they do not comply with the legal specifications as stated in the report.

5.3. Land use approaches

From the general plan trends of land utilization can be derived of the land organizational structure of the aimags (Bulgan, Uvurkhangai) as covered by the Orkhon river basin:

- Increase crop land that is reflected in the plan to be grown as irrigated plant.
- Transfer hay land to citizens or entities for ownership and improve ecological control, to increase harvest output, to increase land area for integrated livestock needs to increase acre land in a way to cut hay on pasture and forest fund lands.

- Increase exploration area to a total of 6000 km^2 to completely use lands for mining operation with a special permission license that are working at the present.
- Provide necessary rehabilitation works in relation to the negative effects in forest fund land caused by fire, decay by rodents, or use for fire wood.

5.4. 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 resulting from various factors, including climatic variations and human activities". The researcher D.Dash 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 Orkhon river basin covers a total of almost 24.700 km^2 of land or 45.9% of the total territory of the river basin. About 3% or 1560 km^2 is severely degraded.

Used data was of the raster type and the areas were calculated for each category of desertification by image processing technique. The areas for each category of desertification are presented in table 8. The spatial distribution is shown in Figure 15.

Table 8. Desertification rate

Desertification rate	Area, *km^2*	%
Slightly	13,717.7	25.5
Moderately	9,403.4	17.5
Severely	1,561.2	2.9

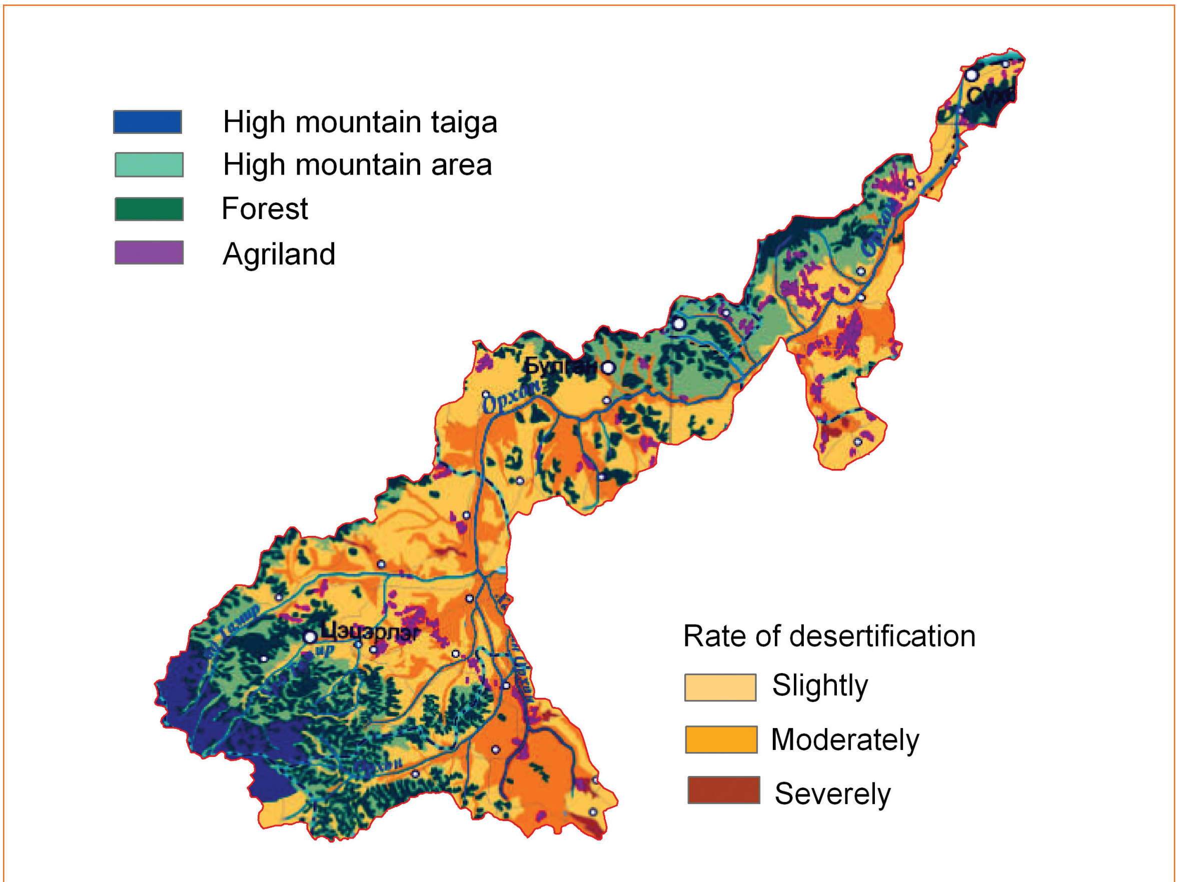

Figure 15. Desertification rate in Orkhon river basin

Land degradation

Land degradation is closely related to population density, livestock density, overgrazing of pastureland, the desertification process, and mining exploration and exploitation.

Around 10% of the total population of Mongolia lives in the Orkhon river basin. The distribution of the population density in the Orkhon river basin is shown in Figure 16.

According to the livestock census held in 2008, there were 3.9 million heads of livestock in the Orkhon river basin. The distribution of the livestock density in the Orkhon river basin is shown in Figure 17.

Due to natural and climate changes and the numbers of livestock, the pasture land is subject to overgrazing.

According to the Law on Land of Mongolia, pastureland should be inspected on pattern and quality every 5 years. From the results of such inspections over the period 2002-2005 years the map presented in Figure 18 of overgrazed pastureland in Orkhon river basin has been prepared. From this figure, it can be concluded that overgrazing occurs mainly in the Orkhon river valley. In general overgrazing is less in the upstream sections and more in middle sections of the river. About 23% of the basin or 10 thousand km^2 of pastureland is overgrazed.

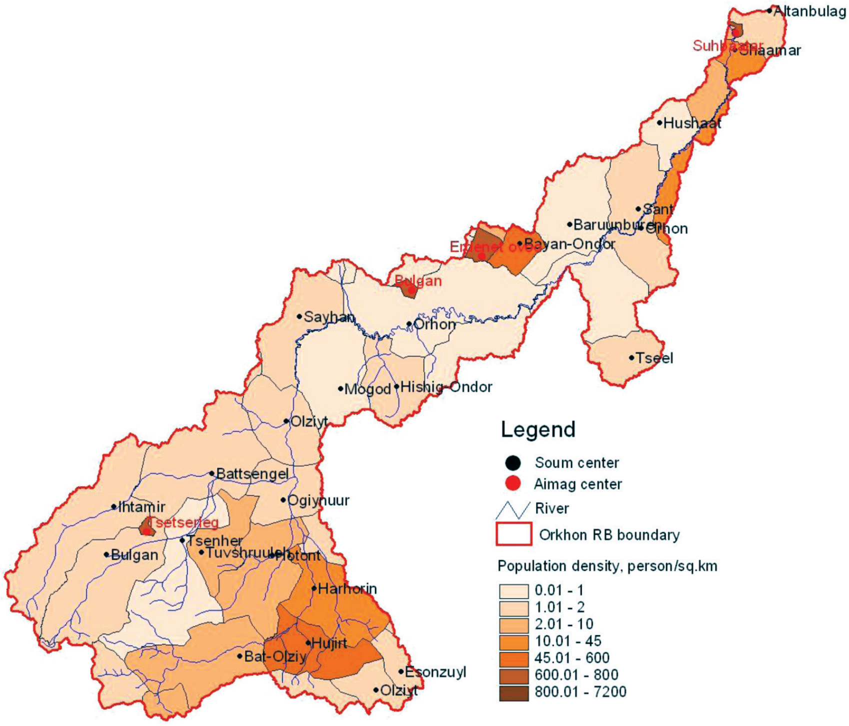

Figure 16. Population density

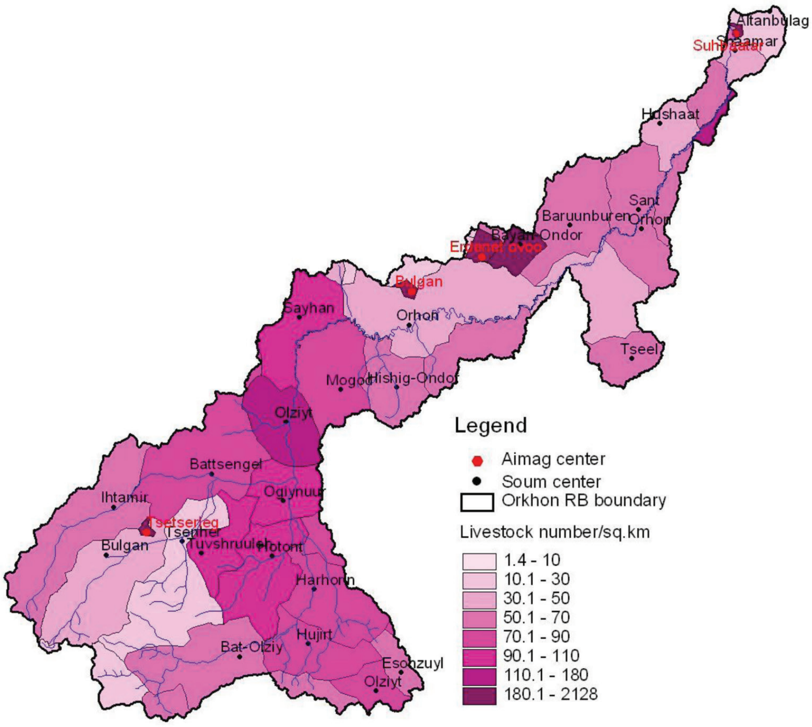

Figure 17. Livestock density

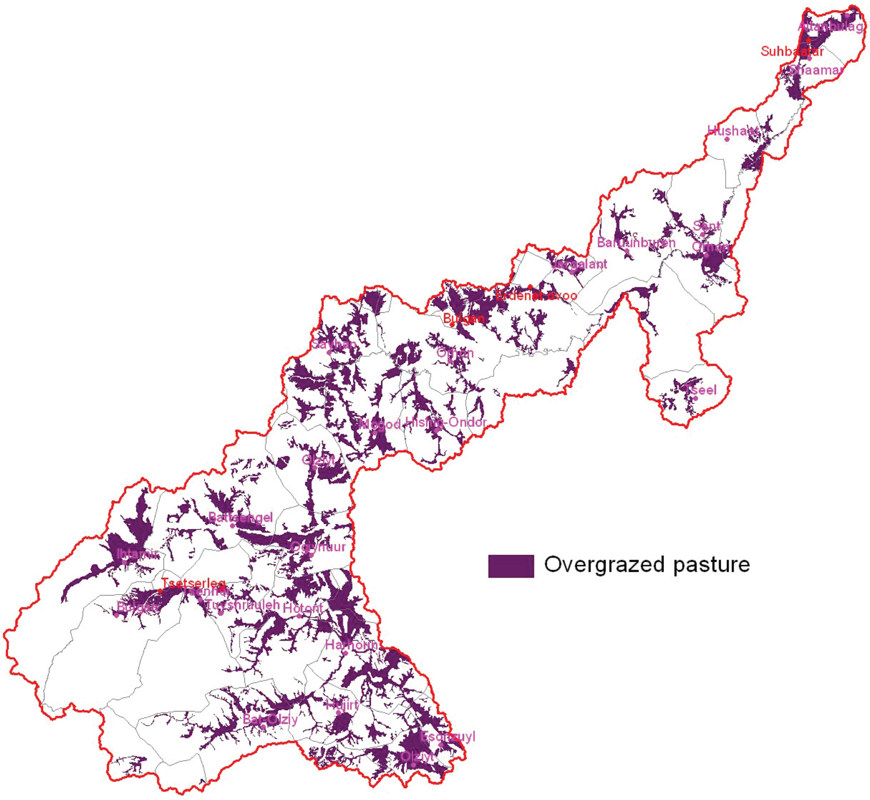

Figure 18. Overgrazed of pastureland

By data received from the Mineral Resources Authority in 2009 (sent to the Water Authority) it is clear that mineral resource exploration particularly gold mining by citizens and entities cover a broad area of industrial activities in the upper catchment of the Orkhon River. The exploration concessions in this basin total about 6200 km^2 or 11.5% of the total basin. The mining area is about 184 km^2 or 0.15% of the total basin. Most mining activity is in the upper section of the catchment, but in the middle section of the catchment, within Bulgan Aimag, the mining activities are sharply increasing. The locations of the areas for exploration of mineral resources and the mining exploitation areas are shown on the maps presented in Figure 19 and Figure 20.

Surveys by the Water Authority carried out in the context of enforcing the Law on "Prohibition of Mineral Prospecting Exploration in Water Basin Areas and Forest Areas" revealed that the total area of exploitation of mineral resources is 10% or about 630 km^2 from the total exploitation area of Orkhon River Basin; 71,8% of the mining area or 132.3 km^2 is included in river flow formation and water protection zones (Figure 21).

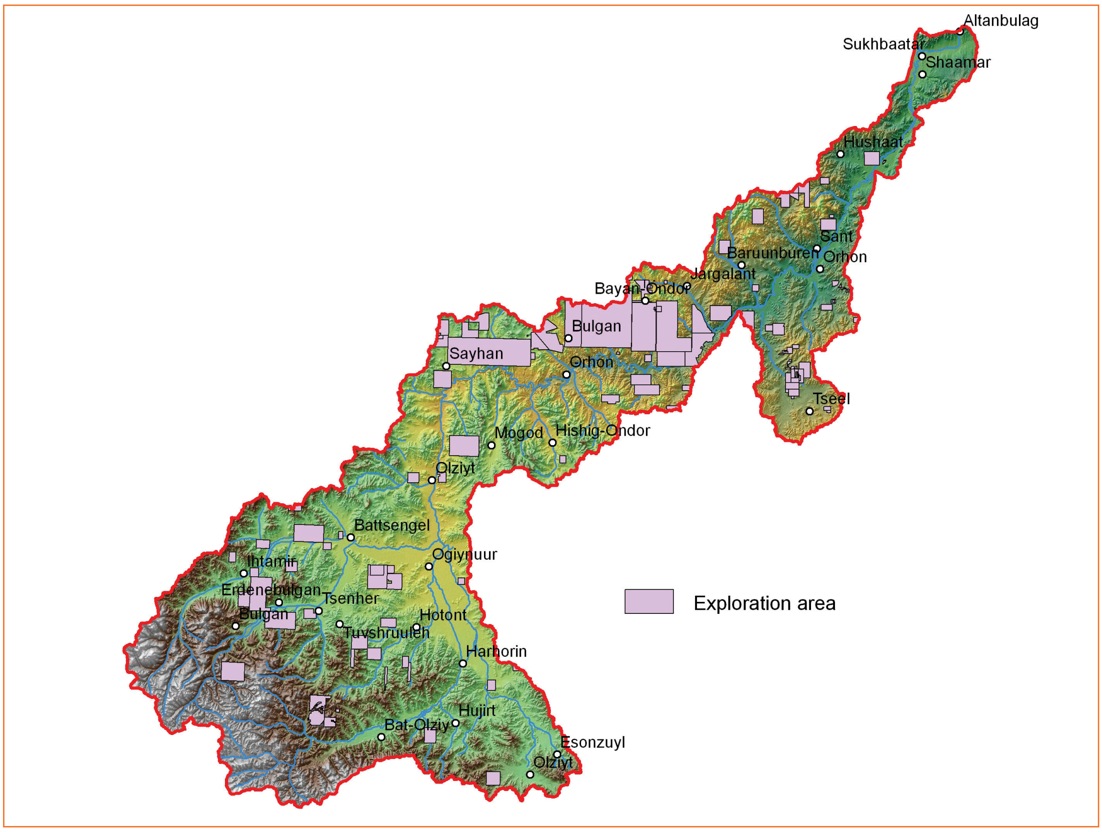

Figure 19. Exploration area

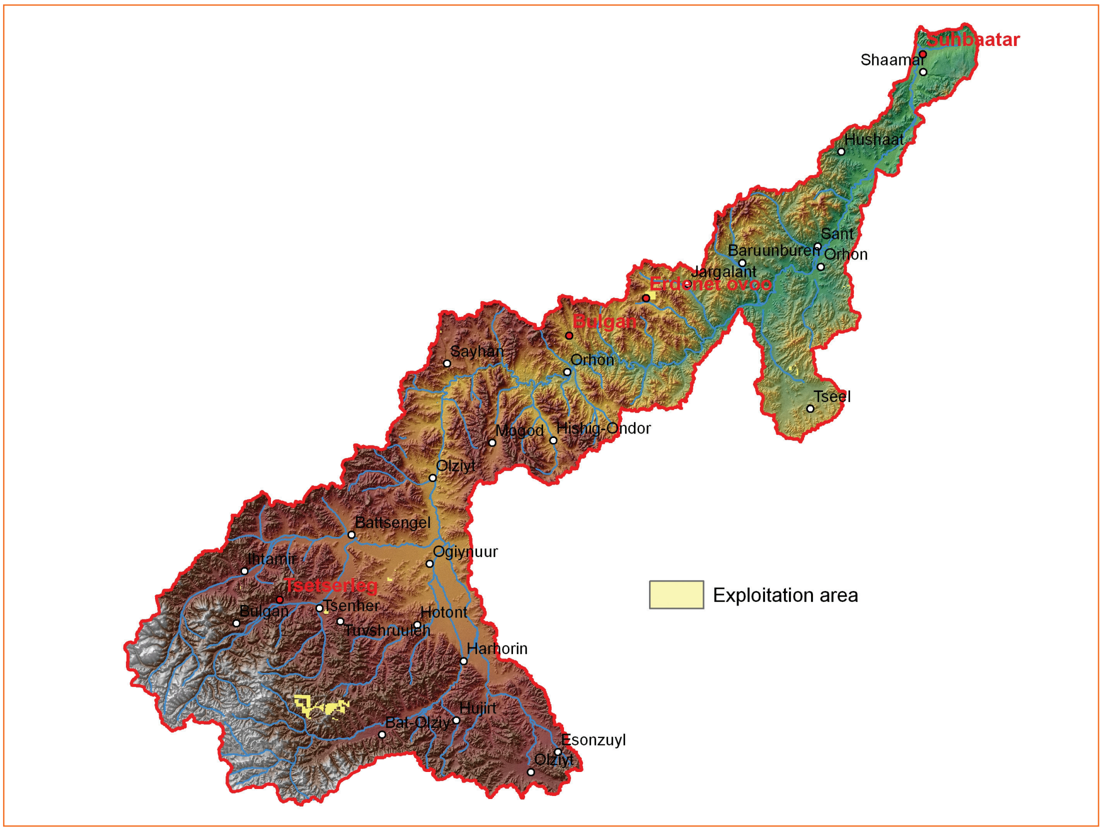

Figure 20. Mining exploitation area

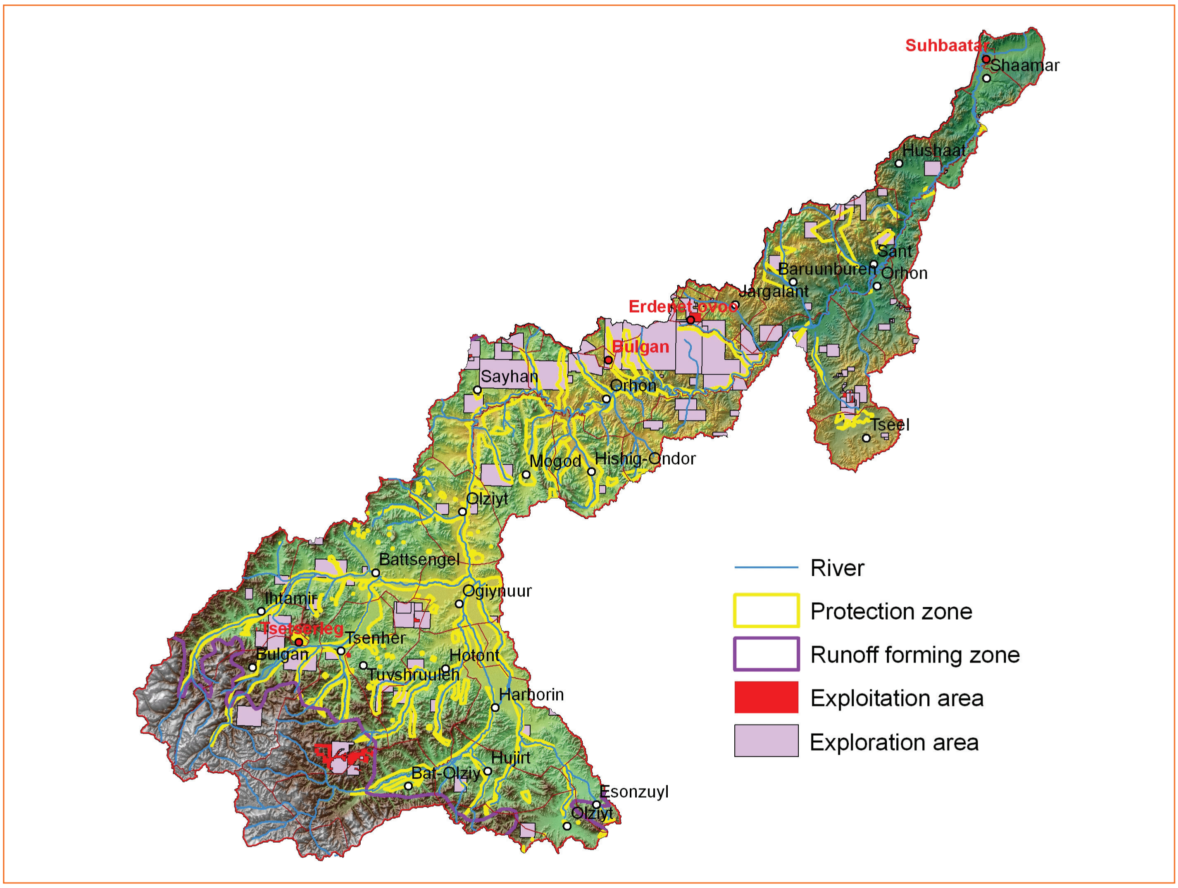

Figure 21. Exploration and exploitation area in runoff forming and protection zones

6. Wildlife

6.1. Introduction

There is no specific study on wildlife at Orkhon 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 Orkhon River Basin have been selected and included in this report. In order to determine distribution of animals in the basin, the basin is divided into the following three parts and determined by fauna location in each part by considering the basin's natural zones, population settlement along the river, tributaries, distribution of fauna and their habitats, etc.

1. Orkhon River upstream – Kharkhorin (Orkhon River upstream part)
2. Kharkhorin – Orkhon-Tuul confluence (midstream part)
3. Orkhon-Tuul confluence – Orkhon-Selenge confluence (downstream part)

A biodiversity database has been created and published online by the Steppe Forward Program implemented under the National University of Mongolia /NUM/ in cooperation with 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 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.

There are 8 fish species, 44 mammal species and 1 amphibian species in upstream part, 12 fish species, 51 mammal species and 3 amphibian/reptile species in midstream part, 17 fish species, 50 mammal species and 3 amphibian/reptile species in downstream part of the basin.

As we can see from above fauna distribution in three parts, approximately 70% of fish species and 60% of mammal species are overlapped.

6.2. Fauna

Fish. Depending on geographical location, living habits and characteristic of habitats, variety of fish species is differentiated from one another. There are 17 fish species of 12 families in the Orkhon River basin in total.

Fishing started in Ugii Lake located in the basin many years ago. Then-food factory and small enterprises in Arkhangai aimag and some organisations of Ulaanbaatar used to fish in the Ugii Lake between 1932 and 1947. Later on, then-meat factory of Ulaanbaatar had solely fished in the Ugii Lake from 1955 until late 1980s. Then since 1990, only locals started to fish on their own. There are 16 fish species of 10 families in the Ugii Lake - Old Orkhon River basin and 9 species are mainly caught for commercial purpose [6].

Taimen (Hucho Taimen), lenok (Brachymystax Lenok), grayling (Thymallus), common minnow (Phoxinus phoxinus), Siberian stone loach (Barbatula toni) and burbot (Lota lota) are distributed in upstream part located fast-flowing downstream of Ulaan Tsutgalan waterfall which is a confluence of Ulaan, Khyatruun and Tsagaan Azarga Rivers.

Some 30% of all the fishes in this basin (Siberian sturgeon (Acipenser bearii), ide (Leuciscus idus), lenok (Brachymystax lenok), taimen (Hucho Taimen) and arctic grayling (Thymallus arcticus)) are rare and endangered species according to the Mongolia's Red List of Fishes and included in the Mongolian Red Book as well. Main cause of a scarcity of these fishes is active gold mining activities based in the Orkhon River and its tributaries, change in the river bed, increase of suspended solids in the river water and change in the river bed morphology. Due to above causes, there is a change in variety of fish species in the Orkhon River and decline in population and growth of salmonids such as taimen, lenok and arctic grayling which hunted for recreational purpose. Instead, population of non-hunting cyprinids which are tolerant to any habitat change is being increasing.

Amphibians and reptiles. Variety of reptile and amphibian species is found few in the basin and is distributed along areas with a convenient habitat condition on a limited scale. Amphibian and reptile species such as Mongolian toad (Bufo Raddei), steppes rat snake (Elaphe dione) and Asian viper (Gloydius Halys) have been reported in the basin [1].

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 [4]. Also it has been reported in Khangai Mountain's Baidrag, Tui, Taats and Ongi River's upstream, and Shargaljuut, Tsagaan Sum, Khukh sum and Tsenkher hot springs, and Orkhon River basin as well [5].

There is a probability that its population might become rare recently due to degradation of its habitats, water pollution, mining of natural resources, 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. [4]

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.

Asian viper (Gloydius Halys). This is one of the most widespread in Mongolia. It has been reported in the Orkhon River basin of Khangai Mountain, Mogoi and Khyatruunii River valleys, and Shargaljuut and Tsagaan Turuut River gorges, respectively [5]. Asian viper is mainly fed by various small rodents. When this species in steppe zone it is fed by field mouse (or gerbil) and in Gobi desert fed by young wall-creeper and dwarf hamster. As we see from above, this species is mainly fed by rodents especially pests widespread in pasture and crop field, it certainly plays a particular role in limiting population of variety of rodents. Due to exploration and mining of natural resources (mining industry, hay harvesting, wood cutting, crop activity, etc), scarcity and degradation occur in its habitats and this is the main cause of decline in distribution and population of Asian viper.

Mammals. There are 128 'Endemic' mammal species, 4 'Invasive' mammal species and totally 132 mammal species in Mongolia. Of these, some 70 mammal species of 17 families of 7 orders are in the Orkhon River basin. These include some 8 insectivore species, 21 species of simple toothed rodents, 5 species of double toothed rodents, 8 species of winghanded animals, 16 carnivore species and 9 artiodactyla orders.

Some 30% of overall 70 mammal species in the Orkhon River basin are included in the Mongolian Red List of Mammals as rare, near rare and endangered classes, as well as in Mongolian Red Book and Mongolian Law on Fauna as rare and very rare classes. A brief introduction of some representatives of these rare animals as follows:

Eurasian otter (Lutra lutra). It is inhabited in the vicinity of the rivers of Khangai and Khentii Mountains and Khuvsgul Mountain of northern Mongolia, Ikh Khyangsan Mountain in the east, north-west taiga forest mountain of Mongol Altai, Khalkh River basin, Tes River basin of northern part of Khangai Mountain, Eg and Khurimt River basins of Khuvsgul Mountains, and this species is also seen in the Orkhon River basin downstream.

Since 1930 it was prohibited to hunt Eurasian otter and included in the Red List as very rare. 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 [2].

Red deer (Cervuis elaphus). Red deers inhabited in the middle and downstream of the basin. According to census in 1986, there were 130'000 populations in 115000 km square of territory. But in 2004, only 8000-10000 population of 15 orders were counted and it was dramatically decreased by 92% in 18 years time. Therefore red deer is included in the Mongolian Red List of Mammals as critically endangered as its population was decreased by 80% due to uncontrolled hunting and habitat scarcity. Also it has been included in rare animals' class according to Mongolian Law on Fauna [2].

Siberian ibex (Capra sibirica). It is mainly inhabited in south-eastern and eastern parts of Gobi Altai, Orkhon River upstream part, Khangai and Khuvsgul Mountain ranges. Siberian ibex is currently found in east of Northern Gobi, distributed in Khurkh Mountain in Alashan Gobi Desert and rock mountains of Altai. However there are some separated population in central and eastern parts of Mongolia. An operation to introduce its population at Bogd Khan Mountain strictly protected area in Khentii Mountain was successfully completed in 1980s.

It was protected and listed as rare class under the Mongolian Law on Hunting in 1995. The Government of Mongolia has set fees rate to get hunting permission at US$800 for Altai ibex and US$720 for Gobi ibex, respectively. Siberian ibex has been included in two editions of the Mongolian Red Book of Mongolia as rare class in 1987 and 1997 [5].

Siberian musk deer (Moschus moschiferus). It is found in upstream and midstream parts of the basin. Siberian musk deer is the smallest in deer family. This animal is inhabited in forest area as well as rocks and dead wood area near boundary of the forest which is difficult to access. It was listed as very rare in the Mongolian Red Book in 1997. Illegal hunting for musk in order to get its must is considered as main threat [5].

Birds. Approximately 245 bird species have been reported in the Orkhon River basin. Some 42 bird species of them are non-migratory and 203 species are migratory birds. Totally 205 bird species lay eggs in the basin. Also some 8 bird species such as bean goose (anser albifrons), mute swan (Cygnus olor), ferruginous duck (aythya nyroca), smew (mergus albellus), red necked grebe (podiceps grisegena), hooded crane (Grus monacha) and terek sandpiper (xenus cinereus) stopover here in summertime. But 11 bird species winter here such as Japanese quail (coturnix japonica), mallard (anas platyrhynchos), goosander (mergus merganser), merlin (falco amurencis), rough legged buzzard (buteo lagopus), solitary snipe (gallinago megala), dark throated trush (turdus ruficollis), arctic redpoll (acanthis hornemanni), yellow bunting (emberiza citrenilla), Lapland bunting (calcarius lapponicus), snow bunting (plectrophenax nivalis) [7]

Two reasons of why 203 bird species or 82.8% of total birds are migratory birds is firstly, main migration way of migratory birds in Mongolia is passed by the Orkhon River basin and secondly, some areas such as Ugii Lake and Sangiin Dalai Lake with a good shelter and habitat for birds to nest and lay eggs are located in the basin.

There are 17 rare species, 5 very rare species such as whooper swan (Cygnus Cygnus), Siberian crane (Grus leucogeranus), white naped crane (Grus vipio), hooded crane (Grus monacha), black winged (himantopus himantopus) in this basin. As we see from here, some 8.98% of overall birds that found in the basin are subject to rare and very rare species.

Changes in quantity, regime and quality of surface water not only affect the habitats of aforementioned fauna but certainly affect their population and species at a particular amount.

6.3. Conclusions on wildlife

- There are 17 fish species of 12 families, 4 amphibian species, 70 mammal species of 17 families of 7 orders, and 245 bird species in the Orkhon River basin. Of these, some 4 fish species and 8 mammal species are listed as near rare, 1 fish species and 3 mammal species are as critically endangered, 2 mammal species and 17 bird species are as rare, and 2 bird species and 5 bird species are as very rare, respectively.
- There are more than 20 mining companies such as Erdenet mining industry, Altandornod Mongol LLC, Altan Yondoi LLC, Mongol Gazar LLC and Gatsuurt LLC, etc which run gold mining operation on Mongolian large deposits in the basin as well as coal mining operation in Ereenii mining site in Saikhan sum of Bulgan aimag. Due to these mining activities, the Orkhon River water is polluted and it negatively affects the basin ecosystem degrading habitats of wild animals in the basin such as fish and aquatic microorganism, and changing variety of these species.
- To stop gold mining activities in the upstream part of the Orkhon River and to oblige those mining companies to restore used land and recover environmental damages.
- Due to changes in population and habitat condition of wild animals, birds, fishes and aquatic microorganisms in the basin, it is necessary to carry out the detailed study on their location, population, species and possibility to improve their habitat conditions, and to make actions clear to take in the future.
- It would be appropriate if especial attention is paid on completely providing the required habitats to regional wild animals, birds and fishes, etc when organising any manufacturing and operational activity in the territory of the basin.

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Part 2.
SURFACE WATER ASSESSMENT

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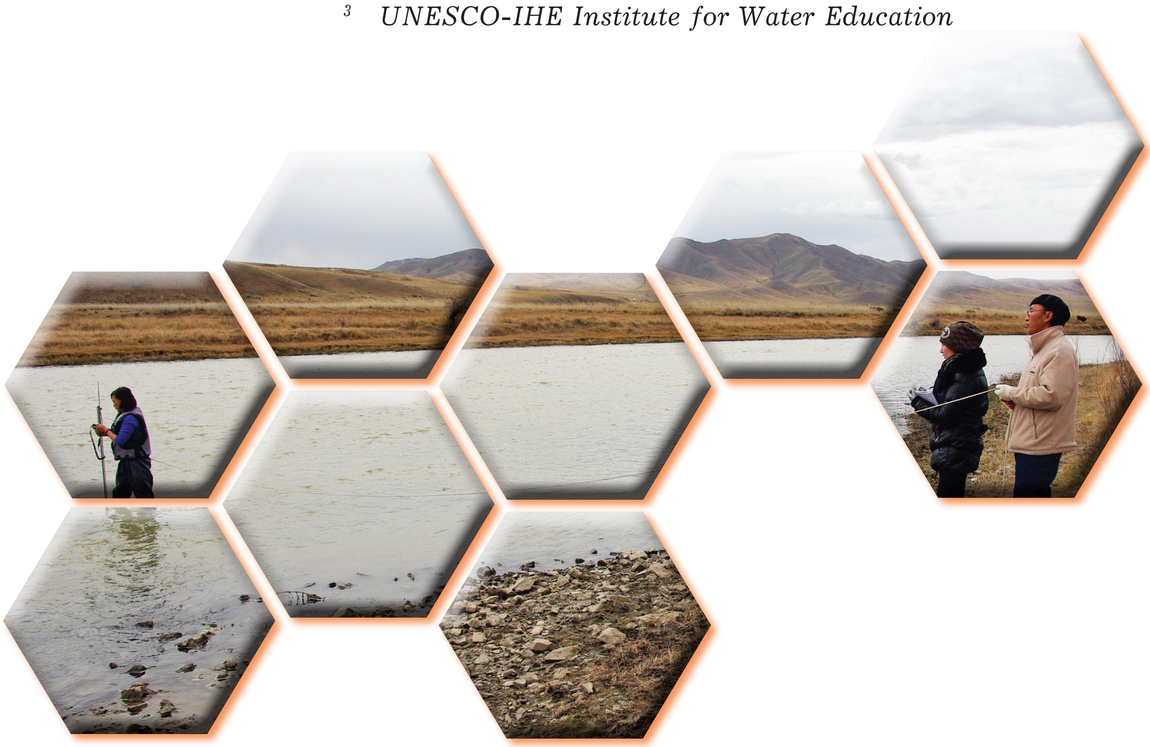

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Introduction

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 funded by Government of the Netherlands and implementing at Water Authority of Mongolia.

The Orkhon River rises in the Khangai Mountain Range and flows northwards to join the Selenge River in the northern part of Mongolia. The main tributaries of the Orkhon River are the Tamir, Tuul, Kharaa and Eroo Rivers which rise in the Khentii and Khangai mountain ranges.

The Orkhon River is the main surface water resource and source of Central Mongolia and the most affected river basin in terms of human influences such as agriculture, mining, forest cut and urbanization. There is a clear tendency of a decline in surface water resources and flow regime changes in the Orkhon river basin under climate change and human impacts.

1. Used data, information and data base

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 Orkhon 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.

Water resources and flow regime data collection of the Orkhon River began in 1942 by establishing a hydrological gauging station at Orkhon soum. The hydrological gauging station network of the Orkhon basin consists of 10 gauging stations along the Orkhon River and at some tributaries including Bat Ulziit, Kharkhorin, Orkhon (Bulgan), Orkhon (Selenge), Sukhbaatar, and Urd Tamir, Khoit Tamir, Achuut, Zuunturuu, Khangal.

1.2. Data and information from field trips, expeditions

Different research and professional organizations have done hydrological and water resources related studies in the Orkhon River basin in different periods. For example, field trips and measurements conducted by the Institute of Meteorology and Hydrology, joint Russian-Mongolia expeditions (1970th), joint Mongolian-Japanese measurements, field studies 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 water resources and flow regime of the Orkhon River basin such as the Map of climate and surface water of Mongolia (1985) and the National Atlas of Mongolia (1990) and (2009).

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 Orkhon River and to study the effect of a dam on the flow regime of the Orkhon River. The model is a water allocation model enabling to compare the water use with the available surface water and groundwater resources.

3. Water resources and flow regime of the Orkhon River

3.1. Flow regime and description of the river basin

The Orkhon River is the biggest tributary of the Selenge River and its basin area is 131105.6 km^2 with a length of 1124 km. The basin area of the Orkhon River occupies 47% of the Selenge river basin. The biggest waterfall of Mongolia-Ulaantsutgalan is located in the upstream basin of the Orkhon River.

The flood discharge of the Orkhon River significantly increases at the lower end of the river due to the Eroo river inflow. Due to flooding of the Selenge River, a backwater effect is observed at the end of the Orkhon River and the water level of the Orkhon River remains stable in many days during the flooding.

The order of the Orkhon is 6 and there are 1806 small rivers with order 1 in the Orkhon river basin. Similarly, there are 468 rivers with order 2, 117 rivers with order 3, 30 rivers with order 4 and 8 rivers with order 5 in the Orkhon river basin and the channel density in the river basin varies from 0.18 to 0.35 km/km^2.

According to the flow regime classification, the Orkhon River belongs to the rivers with spring and rainfall floods. A typical flow hydrograph of the Orkhon River is presented in the Figure below.

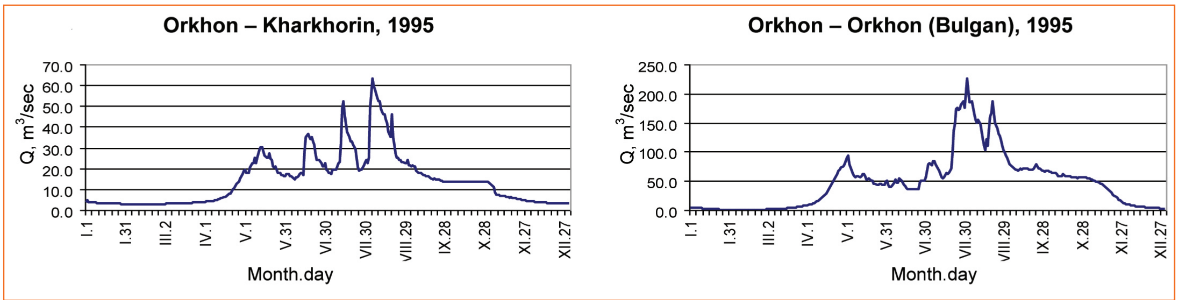


Figure 1. Typical annual hydrograph of Orkhon River

About 80% of the annual runoff forms during the spring and summer seasons and the remaining portion in autumn period and only 0.8-3.0% belong to the winter season.

There are two clear low flow periods observed in the flow regime of the Orkhon River in the winter and summer periods. The lowest runoff of the winter low flow period is 0.069 m^3/sec while the summer low flow varies around 0.258 m^3/sec. The low value runoff decreases along the river in downstream direction and in some cases the river freezes up to the riverbed cutting runoff around the Orkhontuul site. A slight increase of low flow can be observed after entering of the Eroo River.

The specific runoff of the river or drainage rate per unit area increases with increase of basin elevation (Figure 2). Such phenomena define the spatial and temporal distribution of the runoff in the river basin.

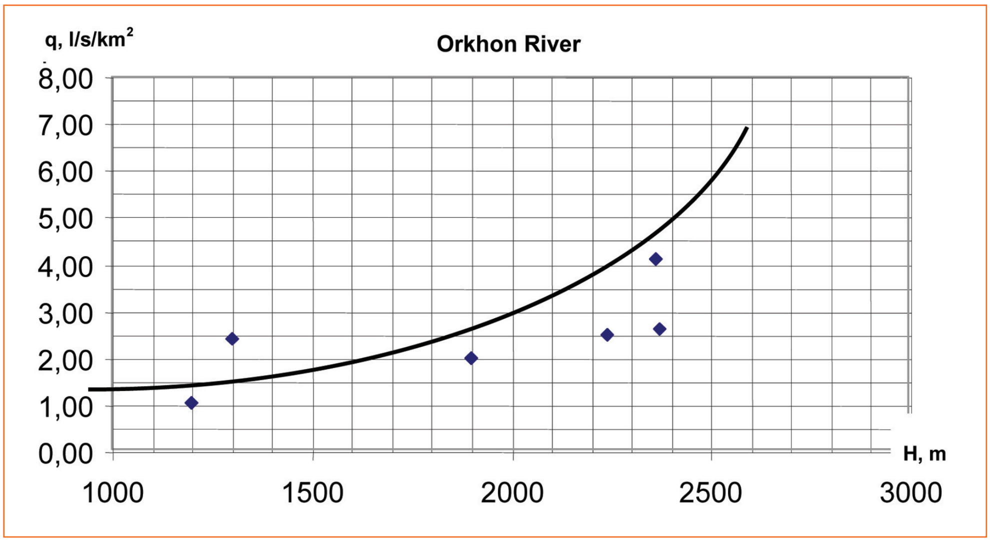


Figure 2. Relationship between mean basin altitude (m) and runoff (l/sec km2) in the Orkhon basin

3.2. Hydrological monitoring network in the Orkhon river basin

Systematic continuous and instrumental observation of water resources and flow regime in the Orkhon River began from 1942 by establishing a first hydrological gauging station at Orkhon-Orkhon site. Since, 25 hydrological gauging stations are operating in the Orkhon river basin including the Tuul river basin (Figure 3 and Table 1). Today there are 5 stations operating along the Orkhon River at Bat-Ulzii, Kharkhorin, Orkhon (Bulgan), Orkhon (Selenge) and Sukhbaatar.

Table 1. Description of hydrological gauging stations in the Orkhon river basin

No.	River	Station	Coordinates		Period of observation	
			Lat.	Long.	Open	Closed
1	Orkhon	Bat-Ulzii	46.87583	102.19056	2006	
2	Orkhon	Kharkhorin	47.20222	102.80000	1967.VI.14	
3	Orkhon	Orkhon	48.66000	103.56778	1942.X.20	
4	Orkhon	Orkhon	49.15178	105.38522	1970.X.01	H
5	Orkhon	Sukhbaatar	50.23986	106.18211	1973.XI.01	
6	Khoit Tamir	Ikh Tamir	47.65694	101.26833	1959.VIII.16	
7	Urd Tamir	Tsetserleg	47.44722	101.5025	1973.VIII.10	H (49 km)↑
8	Achuut	Bulgan	48.82917	103.50306	1991.V.01	
9	Zuunturuu	Bulgan	48.82917	103.54583	1991.V.01	
10	Khangal	Jargalant	49.28722	104.4825	1997.VI.20	
23	Khuiten	Sharyn gol	49.48402	106.55181	2005.V.01	
24	Eroo	Eroo	49.76058	107.53614	1958.V.28	H
25	Eroo	Dulaankhaan	49.77761	107.51586	1981.VII.15	

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 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 Orkhon River basin. The highest priority is to consider the possibility to extend the hydrological network in the river basin.

According to WMO standards, in the Orkhon-Tuul river basin must operate at least 80-85 hydrological gauging stations for surface water in order to meet the accuracy of estimation and assessment of water resources and flow regime and operational service.

The National program on Water states installation of 7 new hydrological stations in the Orkhon and nearby river basins by 2015-2020. For example, plans exist to establish stations at Boroo-Bornuur, Orkhon-Ulziit, Orkhon-Saikhan by 2015 and Tuul-Zaamar 2015 and Khugshin-Orkhon, Kharbukh-Dashinchilen, Eroo-Bugant by 2016-2020.

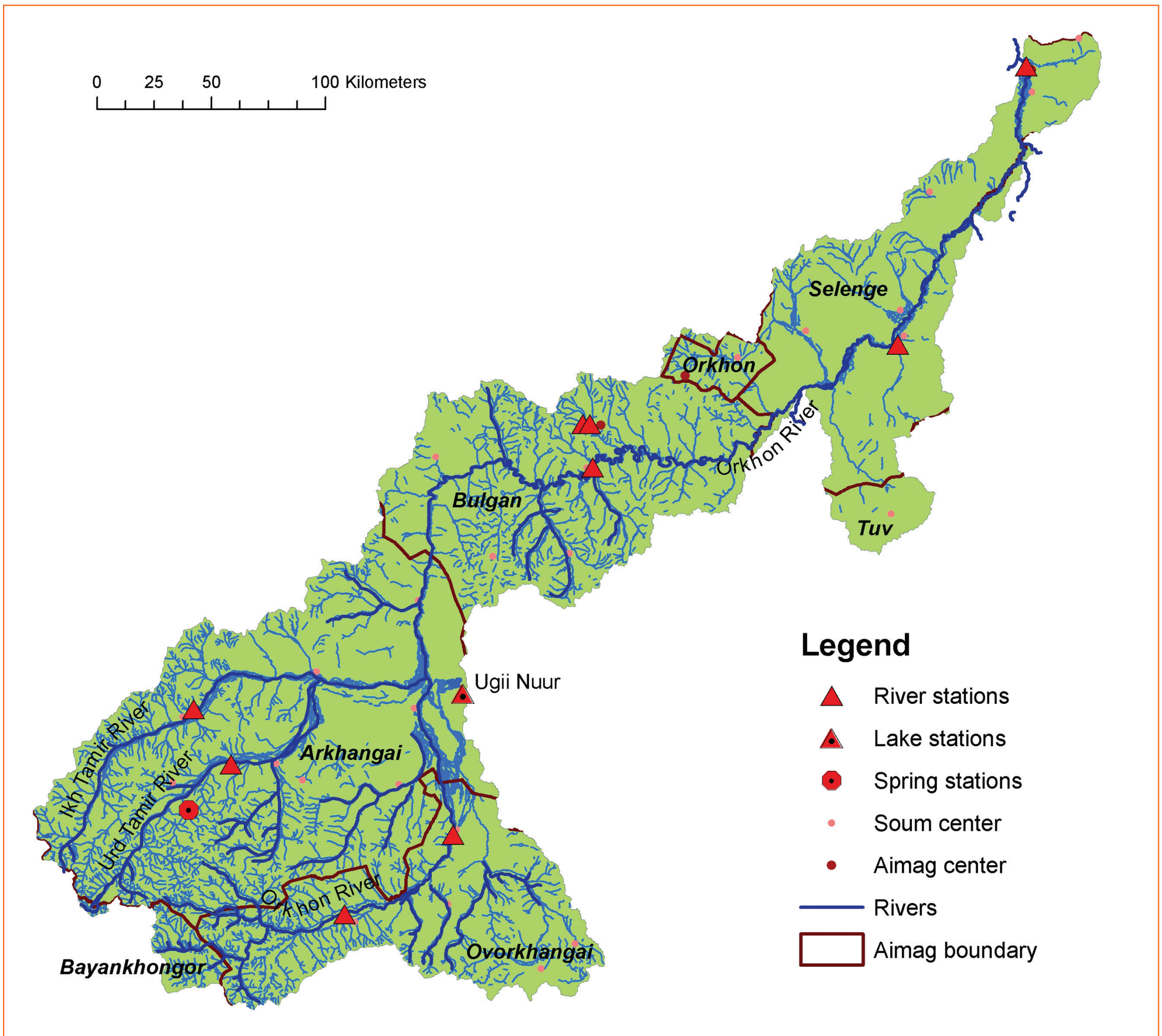


Figure 3. River and hydrological gauging station network in the Orkhon river basin

3.3. Long term mean runoff

The monthly and annual mean runoff is a key and basic parameter or information for water resources related issues including research, design, use and protection etc.

The period for estimation of the long term mean runoff should cover several entire wet and dry cycles such as two or four and the accuracy of estimation increases with the length of record. The long term mean runoff is a stable and consistent parameter of runoff and also forms the basis for the estimation of the potential water resources of the basin. The long term mean runoff is estimated as arithmetic mean of statistical series.

The long term mean runoff of the Orkhon River at Kharkhorin site is 13.3 m^3/sec and this value increases by three times at Orkhon station (Bulgan) and by 9 times at the end station at Sukhbaatar. Such increase of the mean runoff along the Orkhon River is due to the basin area increase and the inflow of tributaries along the river.

Table 2. Long term mean runoff of the Orkhon river basin

No	River-station	Period of observation	Period of estimation	Basin		Observed mean			Estimated mean			Cv	Cs
				area	Basin elevation	Q m^3/s	q l/s sq.km	h mm	Q m^3/s	q l/s sq.km	h mm		
1	Orkhon-Kharkhorin	1970-2008	39	6257	2115	13.2	2.13	67	13.3	2.112	66	0.47	0.95
2	Orkhon -Orkhon	1945-2008	64	37177	1480	41.5	1.12	35	41.6	1.119	35	0.62	1.54
3	Orkhon -Orkhontuul	1971-2008	38	96000	1880	76.04	0.84	27	81.1	0.792	25	0.60	1.21
4	Orkhon -Sukhbaatar	1950-2008	59	131691	1080	124.5	0.98	31	129.4	0.945	30	0.40	0.80
5	Acguut-Bulgan	1993-2007	15	138.7	1410	0.23	1.64	52	0.23	1.64	52	1.56	0.78
6	Zuuntutuu-Bulgan	1992-2008	17	136	1350	0.19	1.38	43	0.19	1.38	43	0.97	1.45
7	Khangal-Jargalant	1998-2008	11	647	1200	0.62	0.96	30	0.62	0.96	30	0.30	0.60
8	Urd Tamir-Tsetserleg	1967-2008	42	3058	2370	6.45	2.09	66	6.39	2.11	67	0.56	1.12
9	Khoit Tamir-Ikh Tamir	1969-2008	40	2507	2580	8.49	3.39	107	8.5	3.39	107	0.49	0.89

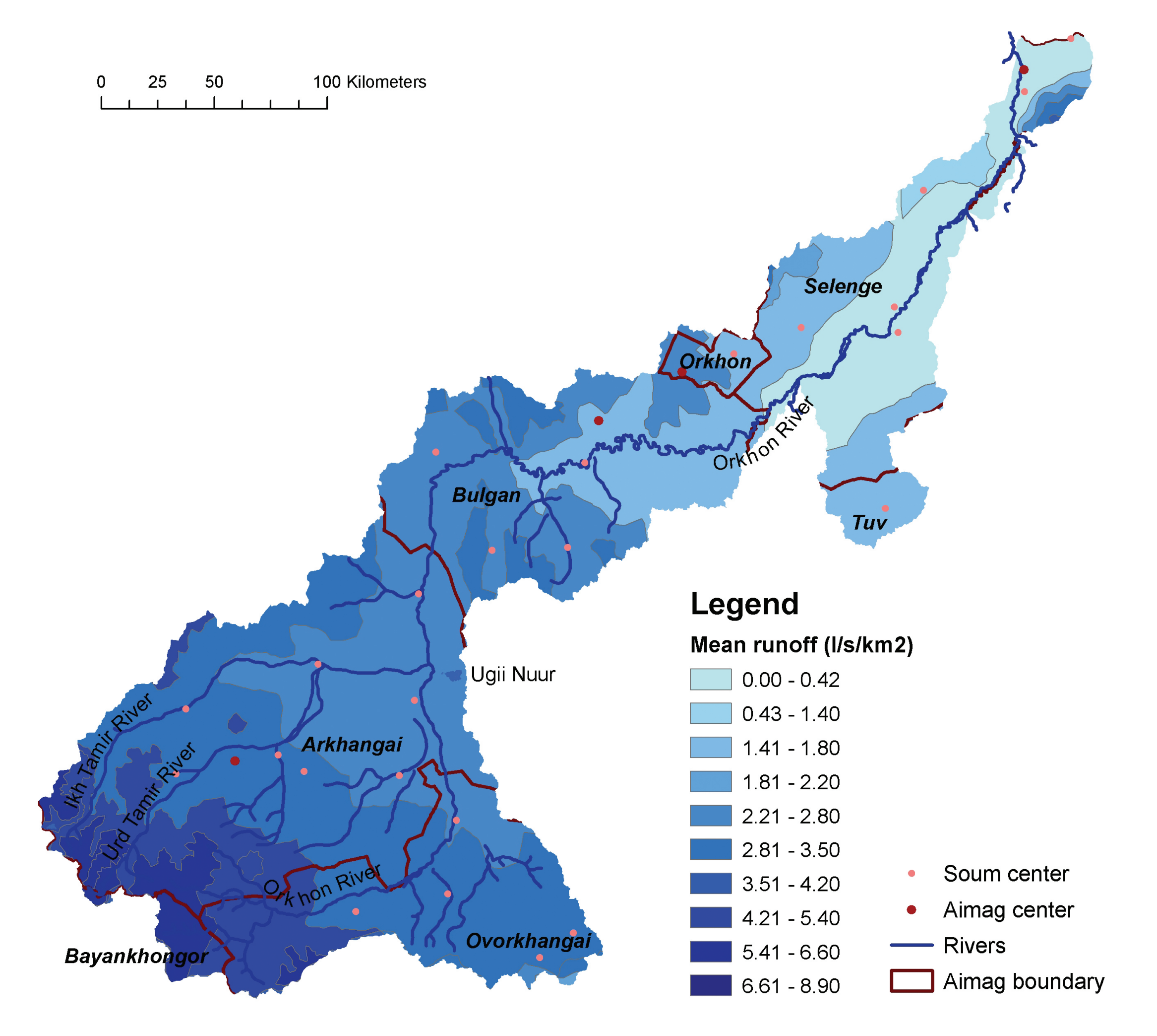


Figure 4. Long term mean runoff map of the Orkhon River basin

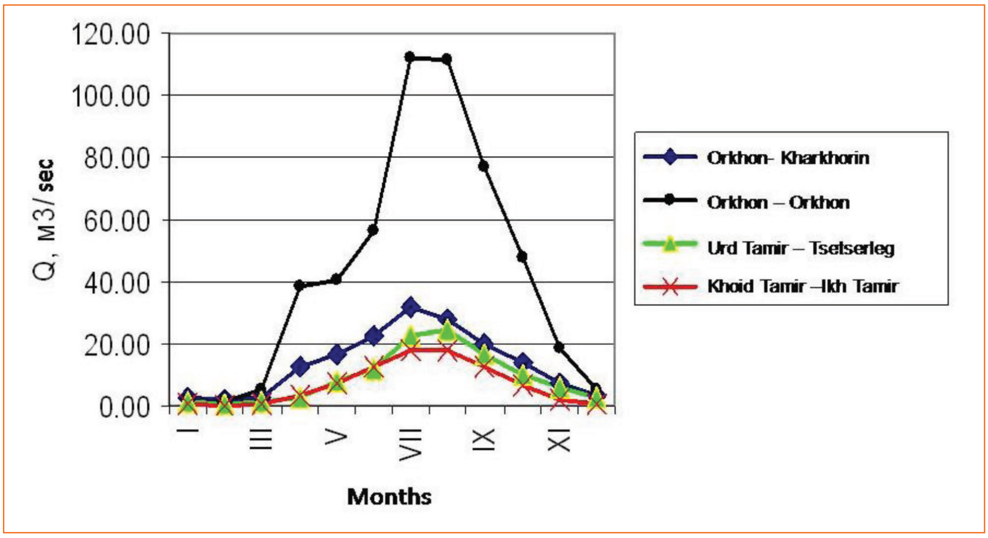


Figure 5. Monthly mean runoff of some rivers in the Orkhon river basin, m^3/sec

3.4. Annual runoff distribution and runoff variation

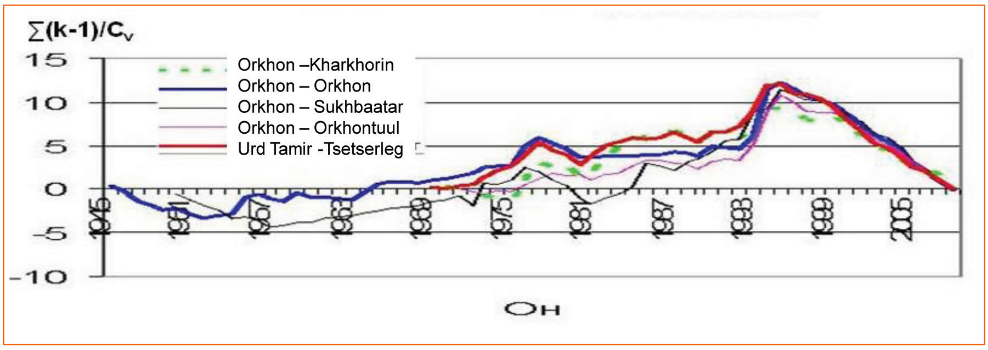
The annual distribution of the river runoff is defined by the flow regime of the river and it determines the water use condition. About 80% of the annual runoff forms during spring and summer seasons and the remaining portion in the autumn period and only 0.8-3.0% belongs to the winter season. The monthly and seasonal distributions of the runoff in the Orkhon River are presented in Table 3.

The portion and percentage of the monthly and seasonal runoff differ, depending on basin altitude and also flow situation. The number of days with flow exceeding the long term mean runoff varies from 120 to 150 days in the biggest tributaries of the Orkhon River and this number becomes longer with the increase of basin area.

The long term runoff variation shows that from 1952 to 1966 for 14 years high flow years continued in the Orkhon river and then up to mid 1980s 18 low flow years have been observed. Since mid 1990s up to today low flow years continue in the Orkhon river basin (Figure 6).

Table 3. Annual runoff distribution in the Orkhon river basin

River-station	Spring-Summer						Autumn		Winter			
	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II	III
Orkhon-Kharkhorin	6.46	11.06	11.35	16.70	18.81	13.05	10.5	5.47	2.08	1.62	1.25	1.64
Orkhon -Orkhon	7.88	9.31	9.91	18.81	21.45	16.78	9.73	3.57	0.94	0.32	0.21	1.09
Orkhon -Orkhontuul	8.67	9.73	9.79	15.09	18.67	15.66	10.8	5.57	2.35	1.23	0.97	1.71
Orkhon -Sukhbaatar	7.69	10.99	11.09	17.35	21.18	15.29	9.48	4.02	1.22	0.54	0.36	0.78
Khangal-Jargalant	11.80	11.92	9.32	12.25	10.67	9.80	9.66	6.67	4.87	4.04	3.68	5.30
Achuut-Bulgan	14.42	12.00	11.01	16.73	13.99	16.12	9.99	3.73	0.68	0.21	0.21	0.91
Zuunturuu-Bulgan	15.09	12.33	9.14	11.90	13.50	11.16	9.46	4.78	2.76	4.14	2.13	3.61
Urd Tamir-Tsetserleg	2.51	7.55	10.43	17.36	23.59	16.59	10.4	6.41	2.31	1.08	0.86	0.93
Khoit Tamir-Ikh Tamir	4.77	10.73	13.15	20.81	24.19	13.53	7.15	2.75	1.01	0.74	0.46	0.72
Tuul-Bosgo	2.90	13.97	19.32	21.94	16.29	13.47	9.36	2.27	0.32	0.00	0.00	0.17
Tuul –Ulaanbaatar	1.77	12.26	13.11	26.71	23.96	14.74	5.71	1.52	0.18	0.01	0.01	0.03
Tuul –Altanbulag	5.21	13.37	16.41	23.03	16.36	12.04	9.47	2.98	0.34	0.02	0.08	0.71
Tuul -Lun	5.29	12.23	13.22	15.33	18.52	18.39	11.7	4.05	0.66	0.00	0.01	0.58
Terelj-Terelj	2.49	8.23	15.20	20.73	23.85	17.01	9.21	2.80	0.40	0.00	0.00	0.09
Selbe-Sanzai	14.16	27.47	18.79	7.55	16.63	8.97	4.81	0.42	0.00	0.01	0.05	1.13
Selbe-Damba	15.96	19.57	18.57	17.00	11.53	11.37	5.39	0.20	0.00	0.00	0.00	0.41
Uliastai-Uliastai	4.20	14.62	15.64	13.38	29.87	16.66	4.28	0.78	0.00	0.00	0.01	0.55
Sugnugur- Sugnugur	3.88	16.30	15.06	18.34	23.17	13.81	7.27	1.69	0.25	0.00	0.00	0.22
Kharaa-Baruunkharaa	7.93	12.55	11.26	17.58	17.04	13.71	8.81	4.43	1.81	1.17	1.19	2.50
Kharaa-Darkhan	7.94	14.94	14.47	14.25	16.29	14.75	11.5	3.50	0.55	0.21	0.19	1.40
Sharyn gol-Jimsny stants	10.03	14.95	17.33	13.07	15.18	14.76	11.3	2.75	0.02	0.00	0.01	0.63
Eroo-Eroo	6.72	9.40	13.45	15.78	20.67	18.04	9.21	3.83	1.35	0.61	0.36	0.56
Eroo-Dulaankhaan	5.15	13.34	11.55	20.25	18.01	17.34	8.03	3.56	1.18	0.44	0.27	0.89



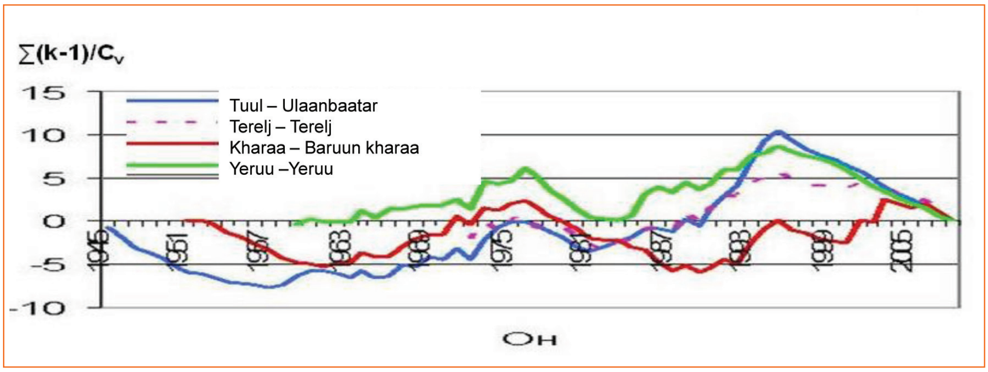


Figure 6. Long term runoff variation in the Orkhon river basin

The flow regime and runoff of the biggest rivers in the Arctic Ocean basin are much affected due to negative human impacts in the river basins such as wood logging, forest fires, pasture degradation and as a consequence reduction of forest resources, negative changes of soil and vegetation cover, and desertification.

The runoff coefficient is an integral indicator of the change in flow regime.

The moisture content is reduced in the surface layer of the soil cover due to the long dry season, the compaction of the soil cover and the sparse vegetation cover. Such a change reduces the infiltration of rain water in the soil and to the groundwater and increases more direct runoff. Also the frequency of heavy rainfall has increased. Thus, the values of the runoff coefficient are increasing in the Tuul, Kharaa and Eroo rivers and at the same time, the groundwater recharge rate is decreasing in the river basins.

So far, possibilities to quantities distinguish influences of each mentioned human impacts to the flow regime and water resources in the river basin have yet to created.

3.5. Maximum flow and floods

According to the flow regime, the Orkhon River belongs to the rivers with spring snow melting and summer rainfall floods. The maximum discharge of the rainfall floods always exceeds the maximum of the spring floods. The natural condition of the river basin increases the risk of rainfall and flash flooding in the river basin and threats to the population and properties.

Winter precipitation (October to April) plays a key role in the formation of spring floods and the water content of the snow cover reaches 20-30 mm in the northern slope of the Khangai Mountain. The runoff coefficient of the spring flood varies around 0.30.

When the daily rainfall amount varies from 40 to 120 mm then it generates the rainfall flooding in the Orkhon river basin. During the flooding, the amplitude of the water level variation reaches 100-150 cm.

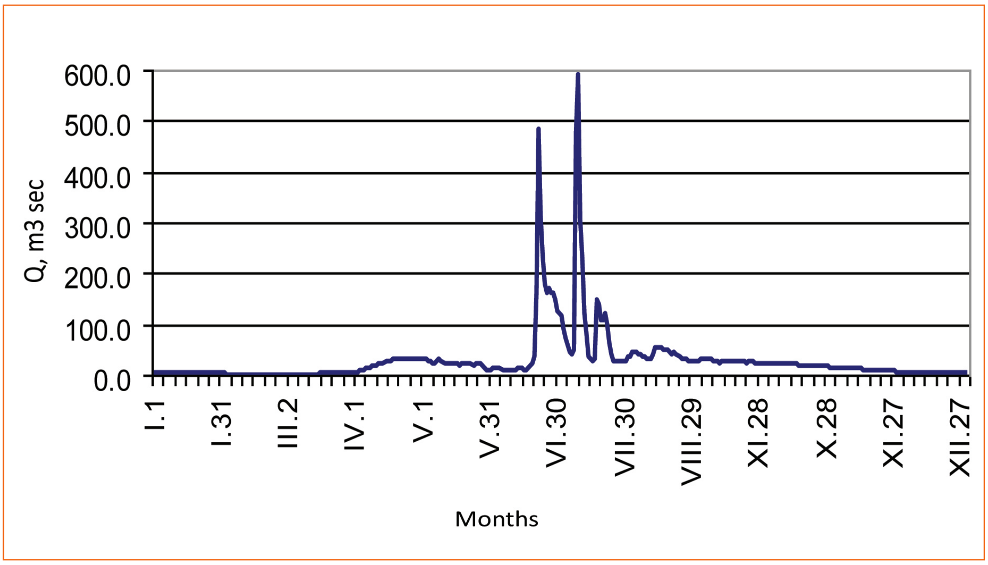


Figure 7. Flow hydrograph during the high flow year (Orkhon-Kharkhorin, 1994)

Rainfall flood peaks are observed 2-4 times during the summer season and the magnitude of the rainfall flood always exceeds the maximum of the spring floods.

The maximum discharges of the rainfall and spring floods with different probability of occurrence of some selected rivers in the Orkhon River are presented in Table 4 and 5. The probability of occurrence of 1, 2, 5, 10 and 20% corresponds with a return period of 100, 50, 20, 10 and 5 years.

Table 4. Maximum discharge of spring flood with different probability of occurrence

River-station	Percent of probability of occurrence					
	0.1	1.0	2	5	10	20
Tuul –Ulaanbaatar	443.5	361.9	272.6	221.8	179.6	136.7
Tuul-Bosgo	158.3	125.3	101.1	83.6	70.0	55.7
Terelj-Terelj	209.1	174.0	122.2	95.6	74.9	53.0
Orkhon-Kharkhorin	168.2	117.2	101.1	79.6	64.8	47.8
Khoit Tamir-Ikh Tamir	62.8	44.2	38.5	31.1	25.3	19.2
Urd Tamir-Tsetserleg	69.3	49.3	43.3	35.3	29.1	22.5
Orkhon -Orkhon	755.6	625.5	453.6	363.5	289.1	213.2
Orkhon -Sukhbaatar	1101.2	771.5	684.3	563.0	473.0	376.5
Kharaa-Baruunkharaa	125.6	101.5	78.1	63.5	52.2	40.3
Kharaa-Darkhan	141.7	98.9	85.8	68.3	55.9	42.1
Eroo-Eroo	883.2	711.7	548.8	446.4	366.7	282.8
Eroo-Dulaankhaan	565.7	409.3	361.5	299.0	250.4	199.1

Table 5. Maximum discharge of rainfall flood with different probability of occurrence

River-station	Percent of probability of occurrence					
	0.1	1.0	2	5	10	25
Orkhon-Kharkhorin	807.65	532.98	471.36	353.91	280.31	185.84
Orkhon -Orkhon	2215.11	1199.91	1024.22	709.23	540.03	346.86
Orkhon -Orkhontuul	2120.69	1240.30	1080.82	789.96	627.63	433.25
Orkhon -Sukhbaatar	2370.16	1677.00	1514.89	1201.85	995.02	715.52
Achuut-Bulgan	11.85	9.01	8.24	6.70	5.57	3.85
Zuunturuu-Bulgan	6.37	5.27	4.93	4.22	3.62	2.59
Urd Tamir-Tsetserleg	564.55	375.82	331.29	245.10	187.91	113.56

River-station	Percent of probability of occurrence					
	0.1	1.0	2	5	10	25
Khoit Tamir-Ikh Tamir	451.36	298.80	264.56	199.20	158.16	105.36
Tuul-Bosgo	1739.32	1040.76	899.16	637.20	486.16	304.44
Tuul –Ulaanbaatar	2146.30	1384.11	1215.11	895.70	697.97	447.85
Tuul-Lun	1030.88	612.27	527.95	372.10	282.61	175.44
Terelj-Terelj	937.93	526.21	451.48	318.38	254.36	169.76
Selbe-Sanzai	18.29	12.00	10.59	7.91	6.23	4.09
Uliastai-Uliastai	40.13	24.23	21.12	15.38	12.08	8.04
Sognogor-Sognogor	212.84	128.52	112.03	81.60	64.09	42.67
Kharaa-Baruunkharaa	914.08	456.25	379.03	241.92	171.78	96.14
Kharaa-Darkhan	267.48	154.57	134.21	97.88	79.02	56.45
Eroo-Eroo	1633.92	1088.82	972.56	752.10	614.79	436.08
Eroo-Dulaankhaan	726.07	518.76	471.64	382.14	324.13	244.93
Sharyn gol-Jimsny stants	32.17	23.43	21.25	16.97	14.03	9.84

The estimated maximum rainfall flood discharge of the Orkhon River with 100 year return period varies from 500 to 1700 m^3/sec.

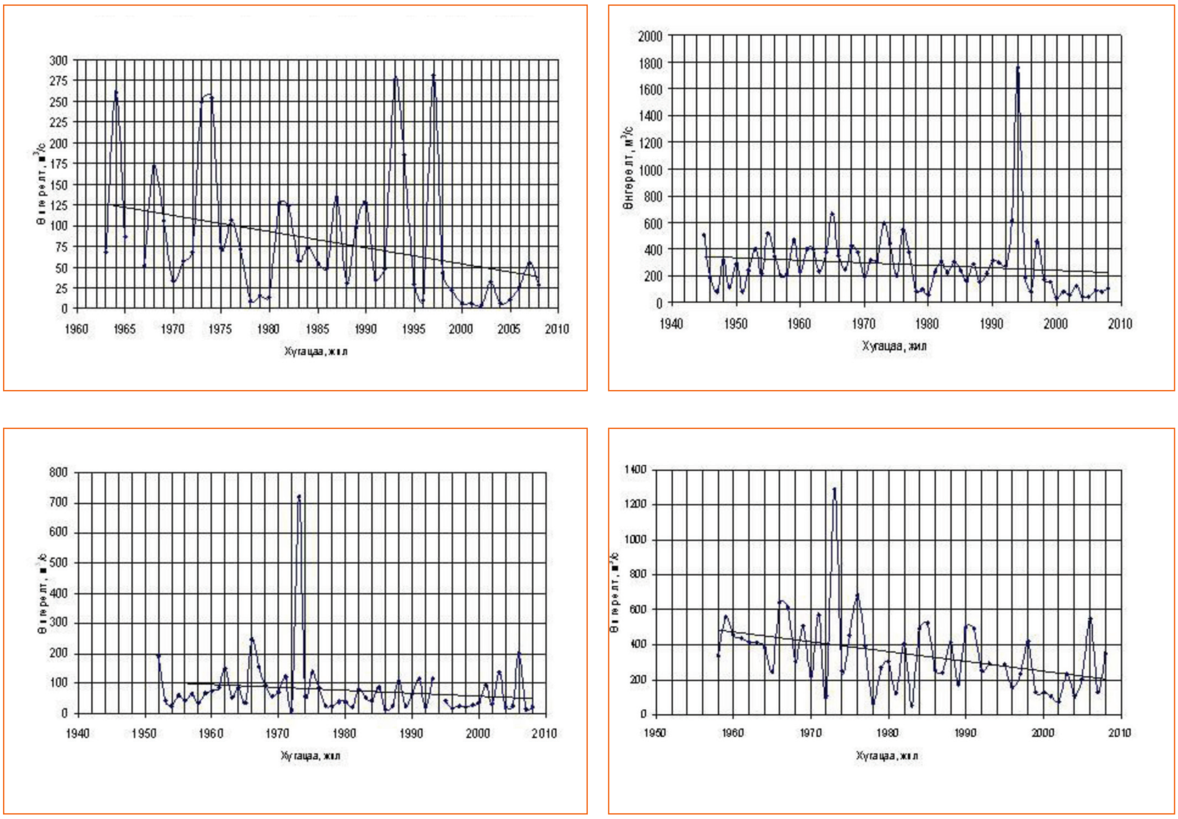


Figure 8. Trend of maximum discharge of rainfall floods at a) Urd Tamir-Tsetserleg, b) Orkhon-Orkhon, c) Kharaa-Baruunkharaa, d)Eroo-Eroo

There is a clear decreasing trend in the maximum discharge of floods in the Orkhon river basin mainly due to the occurrence of the low flow years in the last 20 years. This affects the estimated values of the maximum discharge by the different mathematical-statistical methods.

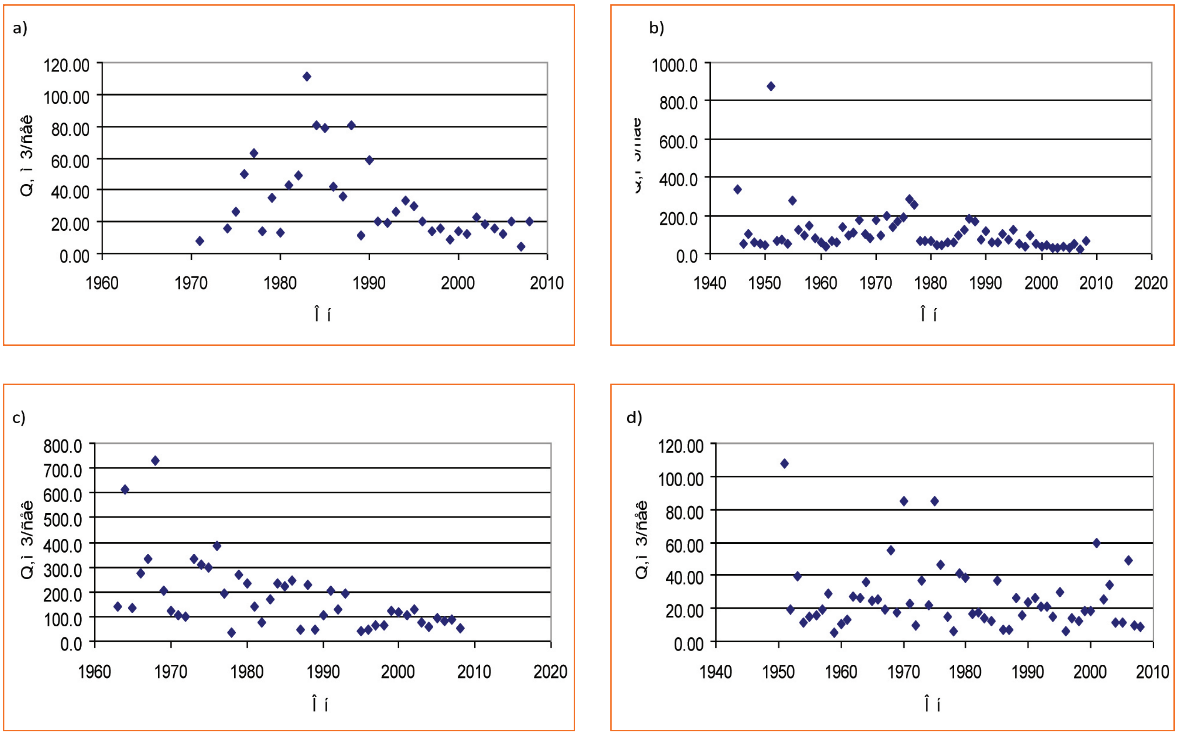


Figure 9. Changes of maximum discharge of spring floods at a) Orkhon-Kharkhorin, b) Orkhon-Orkhon, c) Eroo-Eroo, d) Kharaa-Baruunkharaa

Estimated values of the maximum rainfall flood discharge with different return periods (1000, 100, 50, 20, 10 and 4) are very important and useful for flood protection issues, designing practice etc.

3.6. Low flow

Due to the intermittent pattern of summer rainfall and the freezing of rivers in the winter season, two low flow periods are observed in between the mentioned periods in the Orkhon. The observed lowest discharge in the winter season at Orkhon-Kharkhorin station is 0.76 m^3/sec and at Orkhon-Orkhon is 6.98 m^3/sec. The summer low flow at Orkhon-Kharkhorin station is 6.83 m^3/sec and at Orkhon-Orkhon is 22.9 m^3/sec. As for the mean of the lowest 30 days low flow, it varies between 1.04-8.67 m^3/sec along the Orkhon River in the winter season and between 10.0-33.8 m^3/sec in the summer season (Table 6).

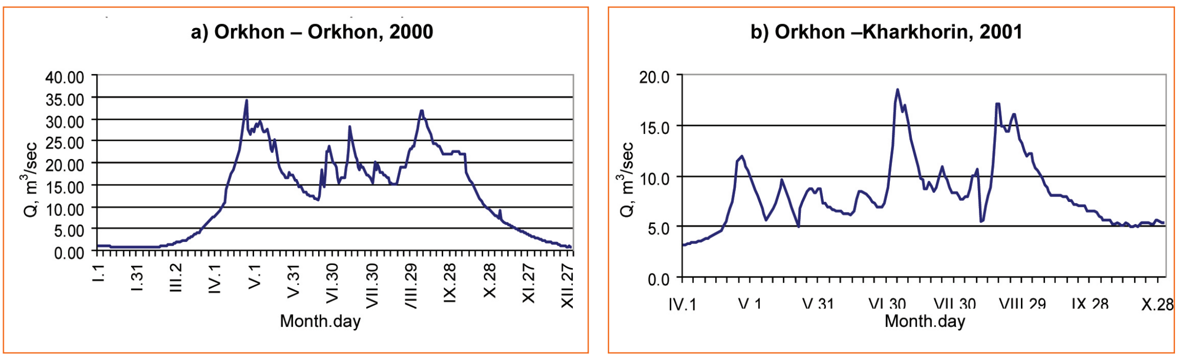


Figure 10. Typical hydrograph during the low flow year; a) Orkhon-Orkhon 2000 b) Orkhon-Kharkhorin 2001

The duration of the summer low flow period continues for about 50-80 days in the rivers of Orkhon, Urd Tamir and Khoit Tamir. The winter low flow duration varies from 160 to 170 days and even longer for the small rivers reaching 190-200 days.

Table 6. Low flow discharge with different probability of occurrence

River-station	Flow periods	Percent of probability of occurrence					
		50	75	80	90	95	97
Orkhon-Kharkhorin	warm	1.82	0.94	0.83	0.61	0.32	0.30
	cold	0.14	0.07	0.05	0.029	0.012	0.0
Orkhon-Orkhon	warm	0.83	0.59	0.53	0.38	0,30	0.26
	cold	0.016	0.007	0.005	0.002	0.00	0.00
Urd Tamir-Tsetserleg	warm	2.43	1.58	1.46	1.01	0.73	0.62
	cold	0.24	0.11	0.09	0.05	0.03	0.02
Urd Tamir-Tsetserleg	warm	1.67	1.00	0.90	0.64	0.50	0.43
	cold	0.07	0.04	0.03	0.02	0.01	0.00

3.7. Water temperature and changes

The water temperature of the rivers in the Orkhon river basin warm up after spring ice phenomena and exceed the value of 4˚C in the middle of May. The monthly mean water temperature in the river basin varies from 10.2 to 19.6˚C. After equilibrium of the air and water temperature around mid August, the water temperature cools down following the air temperature decrease. By September, the water temperature cools to 6-8˚C and goes below 0.2˚C in the first half of November. Usually, the water temperature is cooler than the air temperature in the spring-summer season while it exceeds the air temperature in the autumn season.

The mean water temperature of the Orkhon River in May is 10.1-10.9˚C and the maximum of the water temperature is observed in July with a mean value of 19.0-20.1 ˚C.

Table 7. Water temperature

	Date of 0.2°C in spring	Monthly mean							Date of 0.2°C in autumn	Maximum	
		IV	V	VI		IV	V	VI		IV	V
					Orkhon-Kharkhorin						
Mean	4/20	2.6	7.7	13.6	15.7	14.7	9.5	3.6	10/31	22.6	7/22
Max	3/1	10.2	15.2	17.9	19.5	17.4	18.0	6.1	10/9	29.4	6/10
Min	5/12	0.1	0.1	6.0	7.3	7.7	4.8	1.7	11/24	16.0	8/31
					Orkhon -Orkhon						
Mean	4/20	1.7	10.1	16.8	19.0	17.3	11.1	3.3	10/25	24.3	7/17
Max	3/29	7.2	16.8	19.6	21.7	20.3	18.7	6.0	10/6	29.0	6/13
Min	5/7	0.1	2.1	14.1	16.2	14.6	8.2	1.4	11/13	21.3	8/21
					Orkhon -Orkhontuul						
Mean	4/14	3.4	12.3	18.9	21.6	18.8	12.7	4.6	11/1	25.0	7/19
Max	4/8	10.5	20.4	26.2	29.9	24.9	18.9	9.3	10/1	28.4	6/22
Min	5/10	0.1	0.3	12.8	16.6	10.2	4.3	0.6	11/15	17.4	8/23
					Orkhon -Sukhbaatar						
Mean	4/12	3.0	10.9	17.5	20.1	18.1	11.5	3.9	11/1	24.4	7/18
Max	4/1	18.6	21.7	22.3	24.1	22.2	22.7	7.0	10/19	28.0	6/14
Min	5/11	0.1	3.0	11.7	10.7	4.9	1.5	0.9	11/30	18.3	8/21
					Khoit Tamir-Ikh Tamir						
Mean	4/6	1.2	5.5	9.8	12.4	11.7	8.6	3.9	10/27	18.2	7/28
Max	3/1	7.1	16.0	14.9	16.7	18.0	13.5	7.7	9/4	23.9	6/8

	Date of 0.2°C in spring	Monthly mean							Date of 0.2°C in autumn	Maximum	
		IV	V	VI		IV	V	VI		IV	V
Min	5/1	0.1	0.2	0.6	4.1	3.8	0.6	0.1	11/20	11.0	8/25
Urd Tamir-Tsetserleg											
Mean	4/8	1.2	4.1	7.8	10.7	11.0	8.2	4.4	11/8	16.2	7/28
Max	3/1	3.8	9.8	11.0	14.2	13.9	10.1	7.0	9/12	19.0	6/12
Min	5/5	0.1	0.4	5.1	7.3	7.3	2.6	1.8	12/6	11.0	8/30
Achuut-Bulgan											
Mean	4/7	1.7	6.5	11.6	14.0	12.3	6.9	2.2	10/27	22.0	8/3
Max	3/17	5.5	12.0	15.3	18.1	16.5	11.7	4.2	10/14	26.9	6/21
Min	4/25	0.1	1.8	9.7	11.8	9.8	1.5	1.0	11/18	17.6	8/31
Zuunturuu-Bulgan											
Mean	3/31	1.0	5.8	10.9	13.1	11.8	6.7	1.7	10/25	19.6	7/11
Max	3/1	2.8	11.3	12.8	14.4	13.6	8.2	2.8	9/17	25.8	6/17
Min	4/24	0.2	1.4	9.5	12.0	10.8	5.3	1.0	11/20	15.2	8/8
Khangal-Jargalant											
Mean	3/27	2.8	8.6	14.7	16.3	14.9	9.1	2.7	11/3	24.7	7/13
Max	3/6	6.0	14.5	16.2	18.4	17.1	10.6	4.3	9/24	29.8	6/13
Min	4/10	0.1	4.2	13.3	15.6	13.7	8.0	1.1	11/28	21.6	8/7
Kharaa-Baruunkharaa											
Mean	4/5	2.5	8.2	13.4	16.0	14.4	8.3	3.1	11/1	27.2	7/14
Max	3/13	11.1	18.4	19.6	22.0	20.7	14.3	6.8	10/11	37.4	6/7
Min	5/12	0.1	0.4	10.0	12.9	11.6	5.4	0.8	11/18	15.7	8/19
Kharaa-Darkhan											
Mean	4/10	4.0	12.2	18.5	20.7	18.6	11.8	4.9	10/28	26.1	7/11
Max	4/1	10.1	16.5	21.6	22.2	20.4	14.2	12.8	10/1	28.5	6/10
Min	4/23	0.2	6.3	15.6	17.0	13.6	4.7	3.4	11/24	20.0	7/28
Eroo-Eroo											
Mean	4/17	3.4	9.4	15.5	17.7	16.0	9.8	3.5	10/27	22.8	7/19
Max	3/28	7.0	21.0	26.9	25.4	20.4	16.0	9.2	10/7	32.2	6/28
Min	5/4	0.1	1.4	12.0	12.7	8.7	2.7	0.3	11/13	16.7	8/30
Eroo-Dulaankhaan											
Mean	4/15	3.3	9.3	13.7	17.0	14.8	10.8	3.1	10/24	22.4	7/20
Max	3/30	10.4	15.6	18.4	25.2	21.0	15.4	6.4	9/28	28.1	6/17
Min	4/29	0.1	2.5	6.2	7.2	5.5	3.3	0.7	11/14	16.5	8/19
Khuder- Khuder											
Mean	4/21		5.3	11.1	13.5	12.0	7.5	2.3	10/30	18.1	7/16
Max	4/6		16.3	18.2	22.0	19.4	11.3	4.6	10/5	27.1	5/21
Min	5/16		0.7	7.5	9.5	7.4	2.6	0.9	11/30	11.3	8/19

The mean water temperature in the warm season (May-October) of the Orkhon River has increased by 1.6oC in the last 60 years. According to the greenhouse emission scenario of A1B, the mean water temperature of the warm period is expected to increase by 1.7-1.9oC in 2020 and further continue to increase by 2.2-2.5 oC and 2.7-3.1 oC by 2050 and 2080, respectively.

Table 8. Water temperature changes (˚C) at Orkhon-Orkhontuul station

	V	VI	VII	VIII	IX	X	IV-X
1945	9.1	15.1	18.2	15.2	9.2	3.1	12.2
2008	10.2	16.2	19.6	16.3	10.2	3.5	13.8

3.8. Ice depth and ice phenomena and changes

The maximum ice depth of the biggest rivers in the Orkhon River reaches 150-200 cm and in case of a small river it varies around 90 cm. The variation of the mean ice depth by decades is presented in the Table below.

Table 9. Ice depth, cm

	XI			XII			I.31	II.28	III			IV.10	Maximum	
	10	20	30	10	20	31			10	20	31		cm	Date
Orkhon-Kharkhorin														
Mid	20	28	37	46	54	59	77	88	88	87	84	65	96	3/2
Early	57	57	59	67	80	80	135	155	145	170	149	108	170	3/20
Late	6	15	12	20	28	30	28	27	32	15	10	22	37	3/31
Orkhon -Orkhon														
Mid	18	26	39	55	68	79	108	128	136	136	135		135	3/6
Early	41	53	90	85	91	104	145	166	184	186	187		187	3/31
Late	5	5	7	17	25	44	60	68	83	78	76		89	3/10
Orkhon -Orkhontuul														
Mid	33	35	41	49	54	63	83	91	90	85	75	88	99	2/15
Early	100	104	109	109	107	107	149	162	152	152	125	100	162	2/28
Late	12	12	15	20	16	28	12	10	21	30	30	75	53	1/31
Orkhon -Sukhbaatar														
Mid	13	24	35	44	56	66	86	96	93	91	86	76	99	3/15
Early	32	48	66	82	85	143	124	135	136	122	136	110	136	3/31
Late	5	10	2	22	28	30	52	65	59	50	19	38	62	1/31
Achuut-Bulgan														
Mid	9	16	24	32	37	41	38	38	48	45	43	27	43	2/4
Early	26	32	40	70	84	84	77	75	83	89	90	43	90	3/31
Late	2	2	2	2	6	5	6	7	13	14	16	10	10	3/10
Zuunturuu-Bulgan														
Mid	8	13	16	22	28	34	61	52	54	47	38	38	68	2/11
Early	11	28	30	58	65	70	125	118	110	125	60	50	125	3/20
Late	4	5	10	10	10	15	10	10	15	10	10	10	15	3/10
Urd Tamir-Tsetserleg														
Mid	10	12	15	18	28	39	81	108	115	114	108	99	121	3/6
Early	22	30	25	55	63	84	155	195	198	228	235	233	235	3/31
Late	5	3	3	5	5	17	21	31	27	24	20	19	44	1/31
Khoit Tamir-Ikh Tamir														
Mid		5	7	13	16	19	32	38	37	32	27	23	44	2/22
Early		9	10	29	31	40	73	71	81	52	45	40	82	3/10
Late		3	5	5	8	7	4	4	12	14	10	15	4	1/31
Khangal-Jargalant														
Mid	22	31	44	57	67	82	105	118	111	108	94	54	134	2/22
Early	42	60	80	92	100	130	150	186	176	170	156	56	186	2/28
Late	9	5	15	39	47	49	65	67	49	48	41	52	67	2/28
Kharaa-Baruunkharaa														
Mid	18	23	29	39	45	52	68	70	66	62	56	56	58	2/5
Early	39	43	60	80	90	92	104	132	119	117	120	108	135	2/20
Late	7	5	5	5	8	10	15	11	10	10	8	5	15	1/31
Kharaa-Darkhan														
Mid	24	31	41	53	65	74	96	102	93	76	53	35	110	2/13
Early	49	45	60	80	80	100	131	180	185	189	187	40	190	3/20
Late	9	17	24	33	42	46	60	60	55	30	10	26	60	1/31

	XI			XII			I.31	II.28	III			IV.10	Maximum	
	10	20	30	10	20	31			10	20	31		cm	Date
Eroo-Eroo														
Mid	22	28	40	49	61	72	97	111	105	101	103	75	118	3/24
Early	44	60	65	84	93	105	175	200	200	190	176	120	200	2/28
Late	5	7	11	11	12	19	56	40	27	46	53	40	63	2/28
Eroo-Dulaankhaan														
Mid	12	26	30	42	56	65	92	93	81	72	53	48	100	2/18
Early	15	37	48	72	90	108	142	148	122	135	90	70	149	2/28
Late	8	10	10	15	18	29	49	61	47	35	20	16	65	12/30

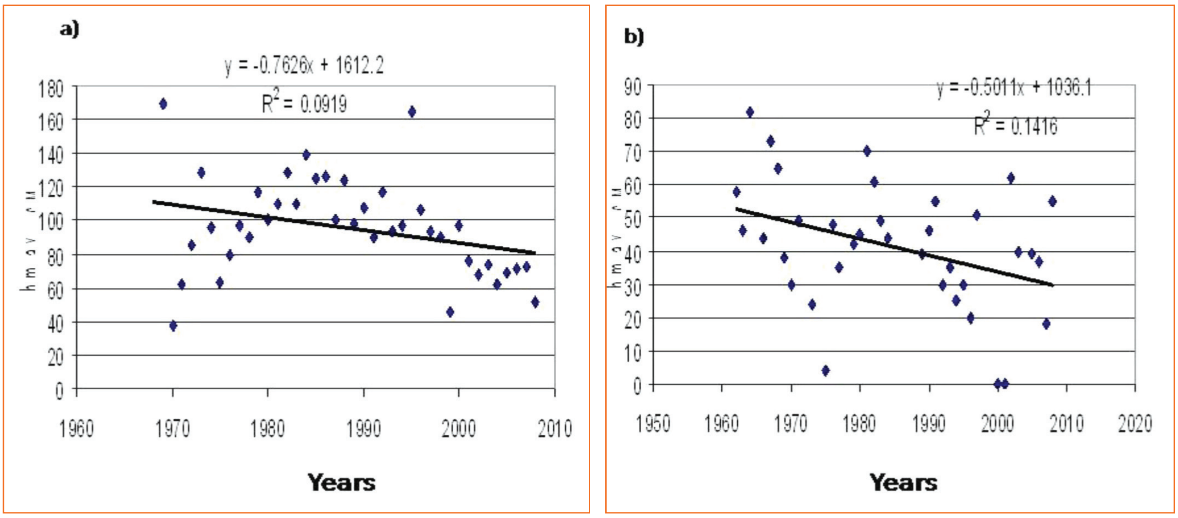


Figure 11. Changes of maximum ice depth in the Orkhon river basin a) Orkhon – Kharkhorin b) Khoit Tamir –Ikh Tamir

The maximum depth of the ice cover has a decreasing tendency and in recent years or from the mid 1990s, the maximum ice depth of the Orkhon River has decreased by 10 cm, on average.

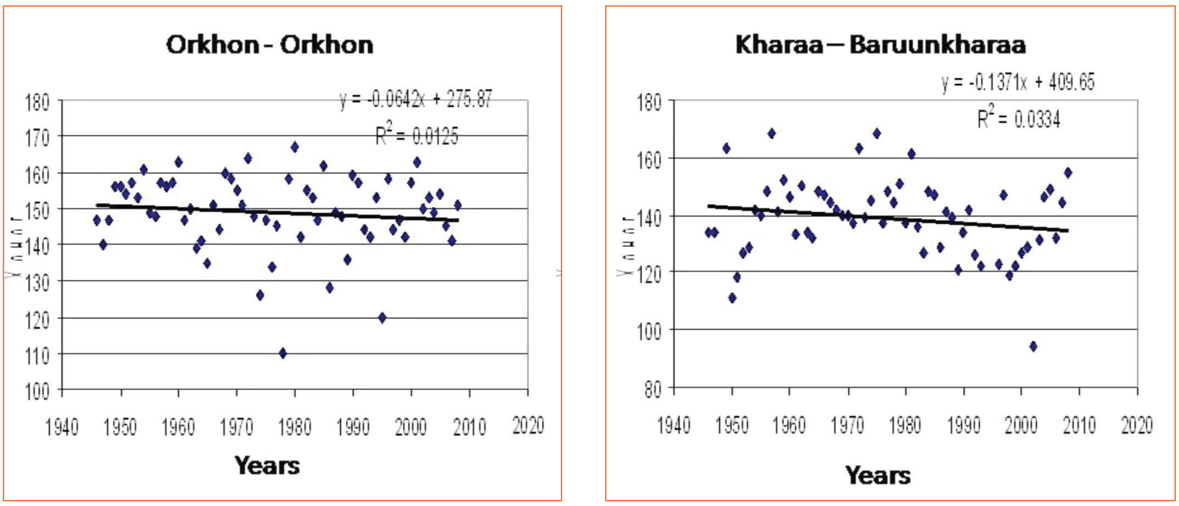


Figure 12. Changes of duration of ice cover in the Orkhon river basin

The duration of the ice phenomena in the rivers originating from Khangai Mountain has a tendency to reduce and it is expected to be shorter by 5-15 days. On the other hand, in rivers located above 2100 m, the duration of the ice phenomena tends to be even longer by 5-10 days. Generally, there is a clear tendency to decrease the duration of icing in the Orkhon river basin (Figure 13).

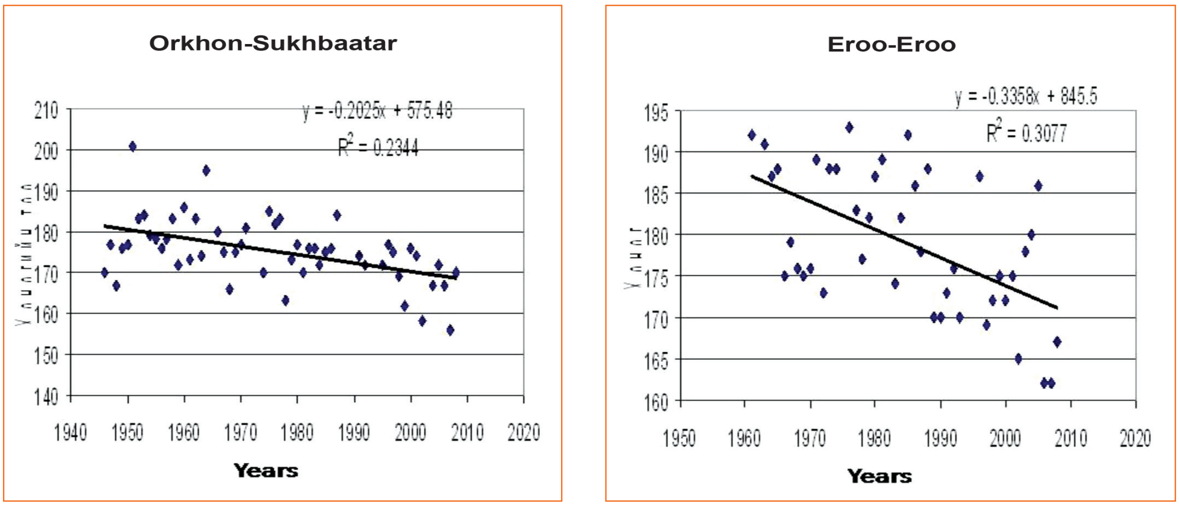


Figure 13. Changes of duration of ice phenomena in the Orkhon river basin

3.9. Water quality, chemical composition and hydrobiology

The water quality and composition of the Orkhon River around Kharkhorin is classified as "Very clean" and "Clean" and the lowest mineralization of the river water is observed during the spring and rainfall floods with a value of 110-240 mg/l and it increases till 380-450 mg/l in low flow periods.

Most of the river water belongs to the hydro carbonate class with dominating ions ratio of HCO3- >SO42- >Cl- and ions of hydro-carbonate dominating in upstream direction reaching 41-47% eqv. and percentage of SO42-, CL- not exceeding 10% eqv. The mineralization of the river water increases along the Orkhon River. After entering of the Kharaa and Eroo River, the mineralization of the Orkhon River slightly decreases. The concentration of hydro carbonate dominates (36-44% eqv.) after the confluence with the Tuul River and the concentrations of other ions do not exceed 10%. The concentration of calcium (Ca2+) dominates among cations with a percentage of 31% and magnesium (Mg2+) of around 10% eqv.

The hardness of the river water depends on the mineralization and it is very soft during flooding periods /0.90-2.00 mg-eqv/l/ and slightly increase in low flow periods. According to the pH values, the Orkhon river is weak alkaline with pH 7.10-7.80.

The mean concentration of nitrogen ammonium (NH4) is 0.28-0.31 mg/l, of nitrite (NO2) is around 0.007-0.019 mg/l and of nitrate (NO3) is 0.40-0.55 mg/l, and the concentration of phosphor is about 0.029-0.046 mg/l in the Orkhon river water.

The concentration of nitrogen ammonium and phosphor has an increasing tendency in downstream direction since the 1980s.

There are many diverse aquatic organisms living in the Orkhon River. For example: Mollusks (Anadontha sp, Radix auricularia, Sphaerium sp, Planorbis sp), Leech (Herpobdella octoculata, Glossiphonia complanata), Aquatic beetles (Rhantus frontalis, Coelambus urgensis, Dytiscus marginalis), Water bugs (Corixa sp), Mayflies (Potamanthus luteus, Baetis sp, Heptagenia werestchagini, Heptagenia kibunensis, Siphlonurus lacustris, Rhithrogena kurenzovi, Caenis macrura, Baetis fenestratum, Ephoron virgo, Ephoron nigridorsum, Ephemerella trispina, Cynigmula sp), Stoneflies (Nemoura arctica arctica, Phasganophora undata, Paragnetina identata, Taenionema japonica, Allocacrys reticulata, Eucapnopsis brevicauda), Dragonflies (Lestes dryas, Sympycna fusca) True flies (Simulium sp, Tabanus sp, Chironomus sp, Conchapelopia sp), and Caddisflies (Apatania majuscula, Lepidostoma hirtum, Hagenella sp, Brachycentrus americanus). The water quality of the Orkhon River is estimated using the Biotic index at upstream and downstream sites. Upstream the index shows "Good", downstream the water quality was "Fair" at two sites.

Table 10. Mechanical composition of suspended sediment

River and stations	Loss of HCl,% during the processsing	Diameter of particles, grains /mm/,								
		1-	0.25-	0.10-	0.05-	0.01-	0.005-	0.001	Sum of grain particles	
		0.25	0.10	0.05	0.01	0.005	0.001		>0.01	<0.01
Orkhon-Kharkhorin	3.2	3.2	31.13	25.19	2.48	1.4	4.4	11	80	16.8
Tuul –Ulaanbaatar	2.96	6.37	34.27	25.2	15.48	2.32	3.92	9.48	81.32	15.72
Tuul-Terelj	2.87	5.8	33.19	23.34	14.91	1.12	3.76	8.45	76.32	14.47
Terelj-Terelj	1.83	2.49	9.48	19.34	2.4	0.95	0.85	5.48	59.41	12.17

3.10. Hydrograph separation of the Orkhon river

Due to a lack of research studies and monitoring network for groundwater it is hard to estimate the groundwater resources and the portion of groundwater sources in the Orkhon river runoff. The groundwater component of the river runoff can be estimated by the hydrograph separation method (linear and trend methods). The results of the hydrograph separation by the linear method according to the runoff at Orkhon-Kharkhorin, Orkhon-Orkhon and Urd Tamir-Tsetserleg are presented in Table 11.

Table 11. Runoff components of the Orkhon River, (by percent)

River-station	Units	Groundwater	Spring melting	Rainfall sources
Orkhon-Kharkhorin	%	32.3	9.3	58.4
	m3	404533440	116568557	732842803
Orkhon-Orkhon	%	25.2	15.0	59.8
	m3	100822752	60104399	238946737
Urd Tamir-Tsetserleg	%	37.7	7.4	54.9
	m3	95997744	18812304	139619808

The contribution of groundwater to the river runoff varies from 25 to 37% in the Orkhon River depending on the flow regime condition. Such studies are needed to continue in the near future in the Orkhon river basin to get more accurate information on runoff sources.

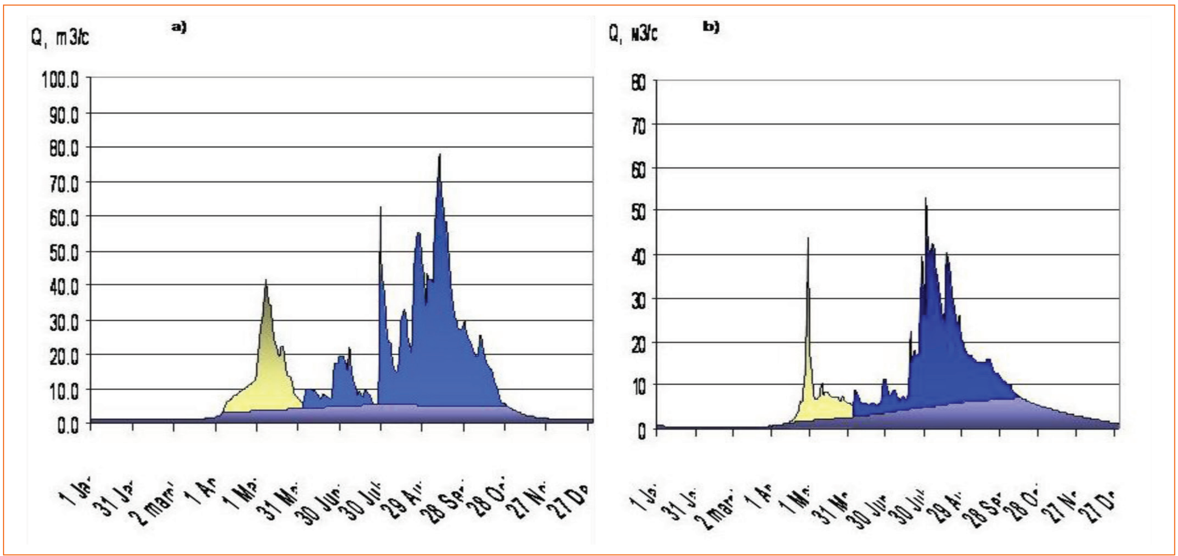


Figure 14. Hydrograph separation according to the runoff sources at a) Orkhon-Kharkhorin, b) Urd Tamir-Tsetserleg

4. HBV MODEL

The HBV model originally developed at the Swedish Meteorological and Hydrological Institute (SMHI) is a well-known conceptual distributed model in Northern Europe and became a daily tool for the runoff modeling (Bergstrom, 1992). HBV is abbreviation of Swedish word “Hydrologiska Byrrens Vattenbalansavdelning” which means Hydrological Bureau Water balance-section in English. In different model versions HBV has been applied in more than 40 countries all over the world. Input data for the model are meteorological, hydrological data in daily time steps. In this research, the version of the HBV spreadsheet model was developed by Jaap Kwadijk as described by Killingtveit and Salthun [1995].

4.1. Input data

In the Orkhon river basin, there are 10 meteorological stations located (Table 12). Six stations data is used for calculating the potential evapotranspiration according to the mean annual precipitation and elevation relationship. Because the mean annual precipitation from two meteorological stations, Khujirt and Mogod, is very low compared to their neighboring stations (Table 12) these two stations data was not used.

Table 12. The meteorological stations located in the Orkhon river basin.

Station name	Longitude	Latitude	Elevation	Mean annual precipitation	Data records
Bulgan	48.4800	103.3300	1210	309	1995-2004
Erdenet	49.1100	104.1300	1310	317	1995-2004
Kharkhorin	47.2000	102.7900	1480	282	1995-2004
Khujirt	46.9000	102.7700	1662	152	1995-2004
Mogod	48.1700	102.5700	1440	176	1995-2004
Orkhon Se	49.1500	105.4000	748	275	1995-2004
Orkhontuul	48.82	104.87	674	254	1995-2004
Sukhbaatar	50.2500	106.2100	632	284	1995-2004
Tsetserleg	47.2700	101.2800	1691	288	1995-2004
Tuvshruulekh	47.4800	101.5300	1541	213	1995-2004

The Thiessen weightened method is used for areal value of precipitation and evapotranspiration (Figure 15).

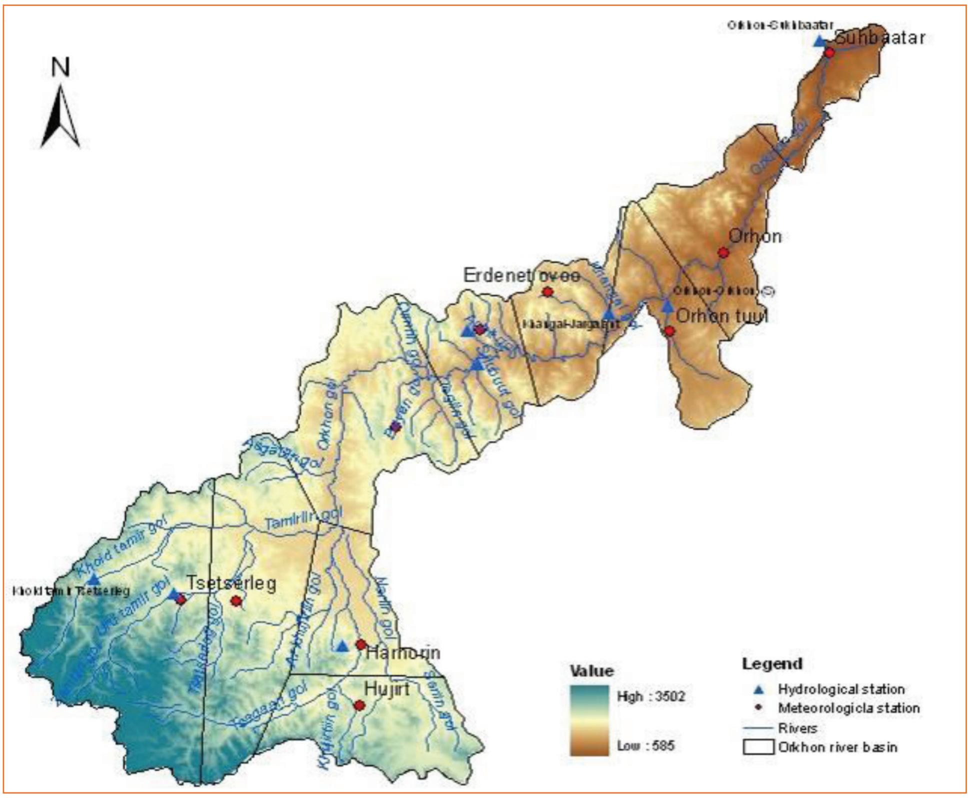


Figure 15. Polygons divided by Thiessen method at the Orkhon river basin.

Potential evapotranspiration

Areal potential evapotranspiration (Figure 16) was calculated using daily precipitation, temperature and relative humidity data from above 6 meteorological stations in 1995-2004.

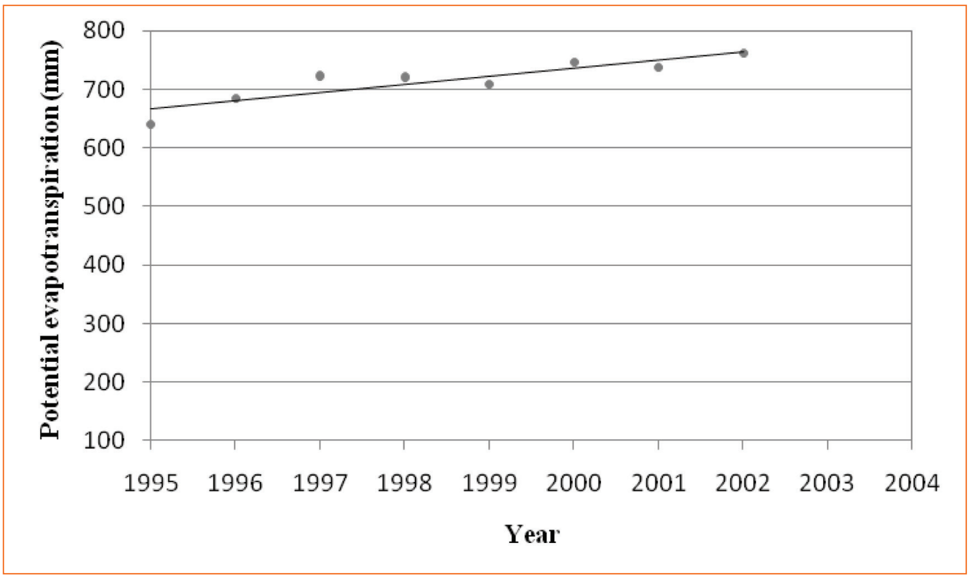


Figure 16. Calculated annual potential evapotranspiration in the Orkhon river basin between 1995-2004

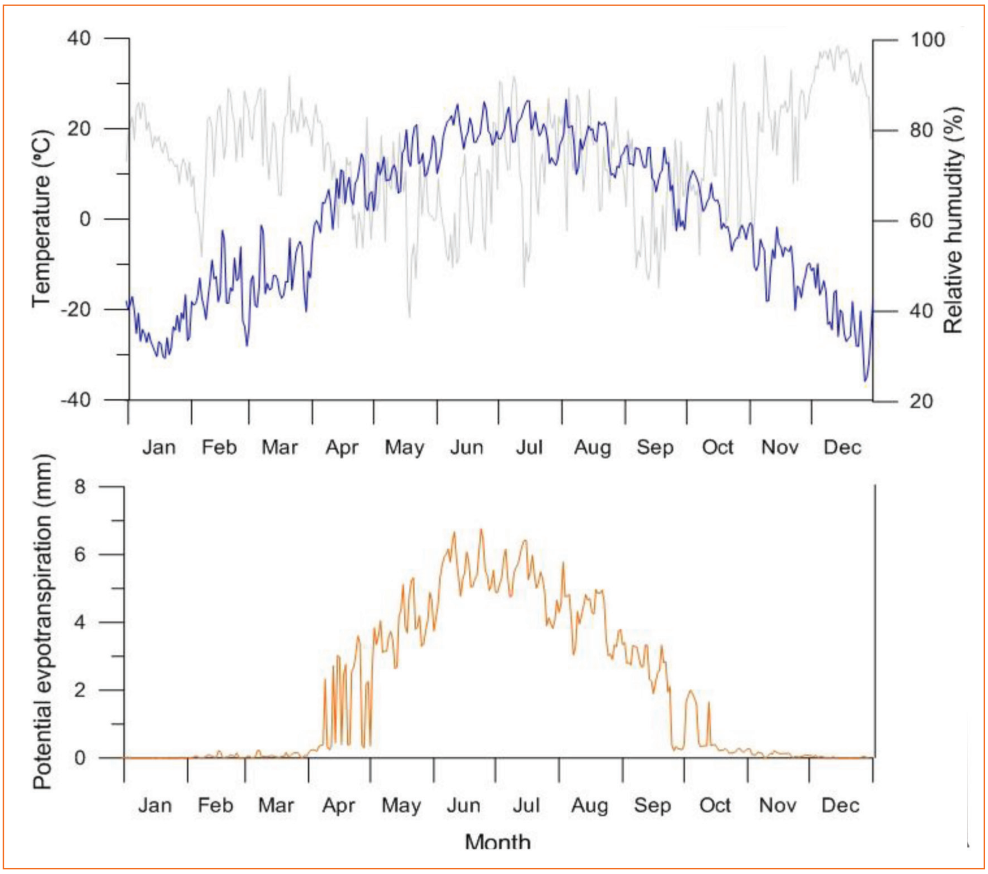


Figure 17. Calculated potential evapotranspiration at Orkhontuul meteorological station in the Orkhon river basin in 2004.

Precipitation

Areal precipitation is computed by meteorological station data which is shown in Figure 15 based on Thiessen polygon method.

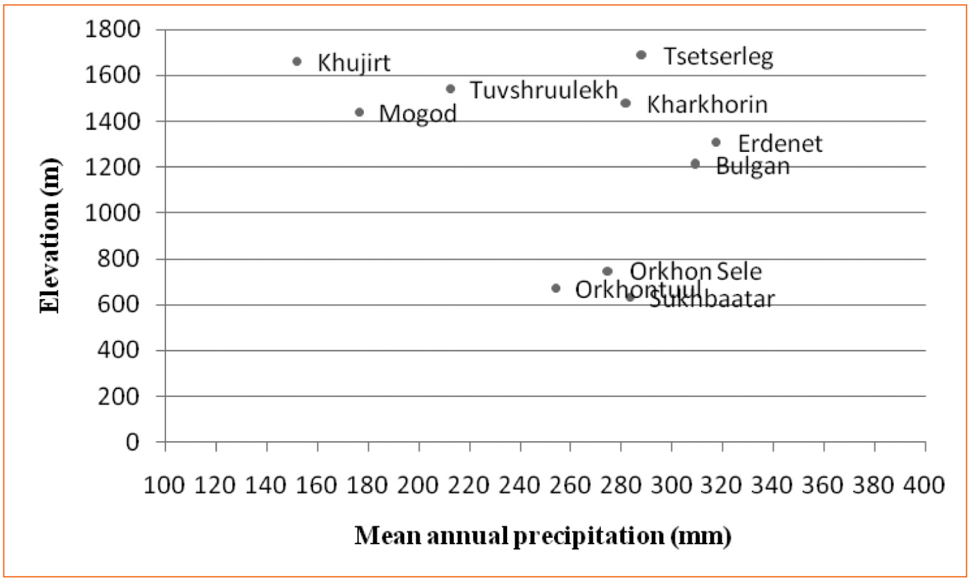


Figure 18. Relationship between annual precipitation and elevation of the meteorological stations in the Orkhon river basin.

Temperature

Areal temperature (Table 13) is described by average value of daily air temperature data which measured in Tsetserleg, Kharkhorin, Bulgan, Erdenet, Orkhontuul and Orkhon meteorological stations in 1995-2004.

Table 13. Areal monthly temperature at the Orkhon river basin, ˚C

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1995	-18.9	-14.7	-6.3	1.9	7.9	15.2	18.0	16.8	8.5	2.1	-7.3	-18.5
1996	-22.2	-19.7	-8.5	2.4	12.0	14.5	19.3	16.4	8.5	-1.3	-14.2	-16.7
1997	-23.2	-18.7	-3.8	6.3	11.3	16.9	18.2	16.2	8.4	1.1	-10.3	-18.1
1998	-23.9	-13.5	-5.3	5.7	11.1	14.7	19.2	16.8	10.7	1.8	-9.6	-15.9
1999	-19.9	-12.6	-12.1	3.9	12.8	16.2	20.6	16.4	8.2	0.4	-8.2	-15.3
2000	-26.5	-19.3	-4.1	4.4	13.2	20.6	18.6	17.4	10.5	-2.3	-15.8	-20.5
2001	-28.5	-19.9	-6.0	3.6	11.4	19.3	19.6	17.7	11.3	1.3	-8.9	-23.0
2002	-17.2	-13.1	-2.5	2.3	12.1	19.2	22.5	20.0	10.6	-2.8	-15.2	-25.6

4.2. Result of the HBV model

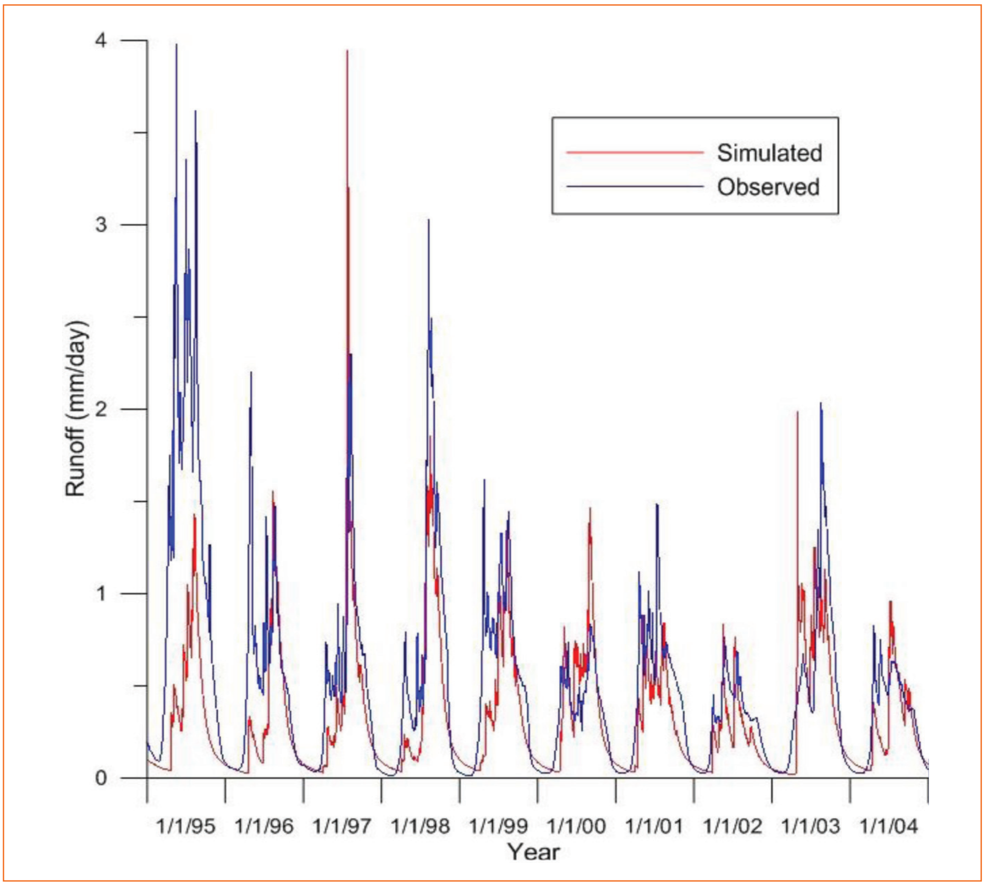


Figure 19. Computed and observed runoff at the Orkhon-Sukhbaatar hydrological station.

The calibrated parameters of the HBV model are shown in Table 14 for the Orkhon river basin.

Table 14. Parameters of the HBV for Orkhon river basin.

snow routine			
Tx	0	°C	Critical temperature below snowfall occurs
Ts	0	°C	Critical temperature above snow melt starts
TL	0.6	*°C/100m*	Temperature lapse per 100m
Cx	4	*mm/°C*	Melt constant in temperature-index
Cr	0	-	Refreezing efficiency constant of free water
CP	0.1	-	Fraction of Snow volume that can store water
soil routine			
Beta	2	-	Exponent in soil runoff generation
Fc	400	*mm*	Soil moisture capacity
Tm	0.6	-	Fraction of Field capacity above which evaporation equals potential evaporation
runoff routine			
Pm	0.6	*mm/day*	maximum percolation from Upper to Lower zone
Kq	0.3	*day-1*	recession constant upper zone very quick flow
Kl	0.04	*day-1*	recession constant upper zone quick flow
KLZ	0.03	*day-1*	Recession constant base flow
UZ1	50	*mm*	threshold for very quick flow

According to the sensitivity analysis, if current air temperature is not changed and precipitation increases by 20% the runoff of the Orkhon River is increasing by 67.0%. However if air temperature is increasing by 5°C and precipitation decreases by 20% than the runoff of the Orkhon River decreases by 57.0% (Table 15).

Table 15. Change in Orkhon river runoff (dQ) in 2100 according to climate change scenario of HadCM2

Month	dP	dT	dQ	Month	dP	dT	dQ
1	1.50	3.63	1.02	7	1.12	5.55	0.77
2	1.14	2.71	1.02	8	1.23	6.27	0.94
3	1.34	5.06	5.51	9	1.06	4.12	1.00
4	1.15	4.46	1.32	10	0.91	3.94	1.00
5	1.15	4.10	0.72	11	1.27	5.42	1.07
6	1.02	5.20	0.67	12	1.39	3.16	1.08

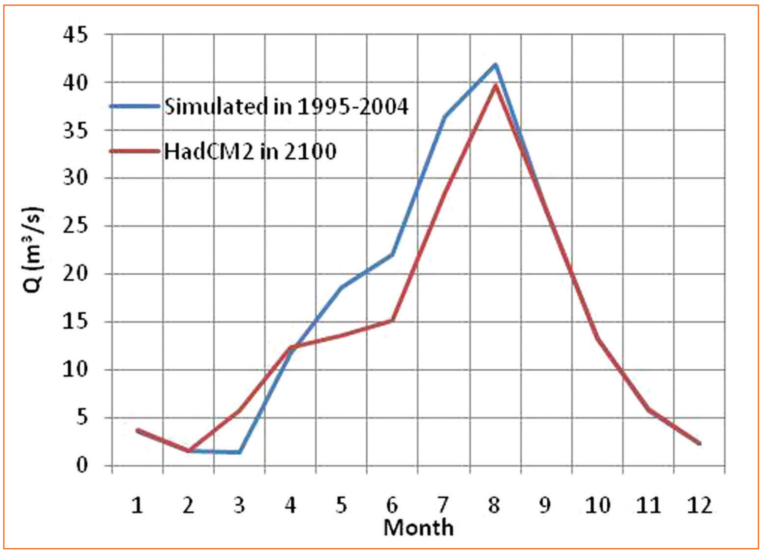


Figure 20. Runoff change according to the climate change scenario HadCM2 in 2100 and monthly mean simulated runoff in 1995-2004 at location of Orkhon-Orkhon gauge

The simulated runoff in 2100 shows a decrease in runoff in the months May-Aug of more than 20%.

5. Surface water allocation model RIBASIM

5.1. RIBASIM model

RIBASIM (River Basin Simulation Model) is a generic model package for analyzing the behavior 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
- Analyze the outputs and make graphs

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 visualized on the relevant stretch itself using different colours and thicknesses.

5.2. Set up of the RIBASIM model for Orkhon 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 analyze 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 Orkhon basin (Figure 21):

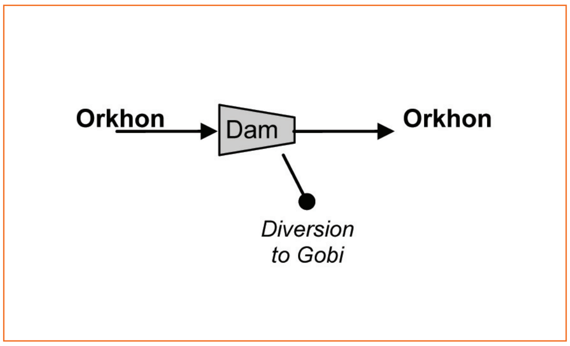
Model 1: a simple model including the proposed dam (Orkhon-Gobi diversion dam)

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

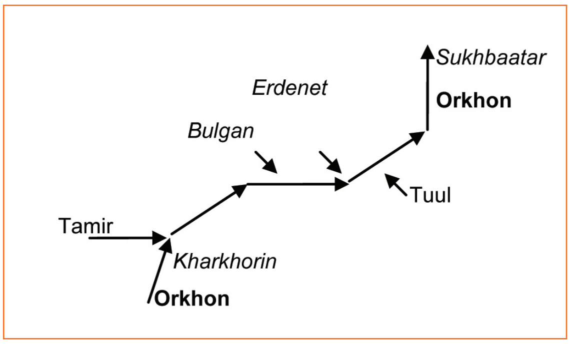
Model 3: a model including all water use and surface water discharge in two model versions:

- with a dam
- without a dam

Model 1



Model 2



Model 3

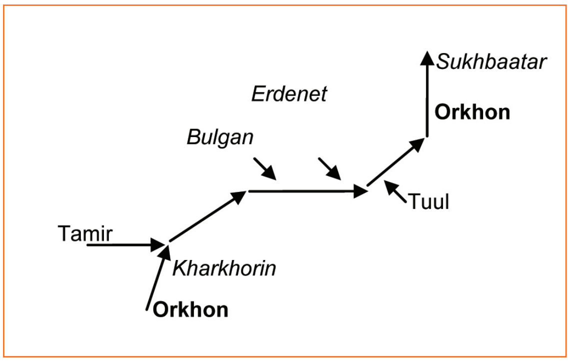


Figure 21. Design of RIBASIM models of the Orkhon River

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

5.3. Orkhon Basin: Model 1

In order to apply the RIBASIM water resources management model, the study area needs to be represented in a schematization that faithfully reproduces the dominant flow processes in the area. It is important to find an optimum for the level of detail of such a schematization taking into account the scarce knowledge that is normally available in terms of water fluxes, location of demand groups, etc.

For the surface water system, the schematization for the Orkhon basin is rather straightforward. The Orkhon-Tamir basin consists of the large Orkhon River and the Tamir River, an upstream tributary to the Orkhon River. Two rivers join the Orkhon River downstream by cutting its watershed boundaries, viz. Kharaa and Tuul rivers. Kharaa and Tuul rivers are not part of the Orkhon basin modeling. As far as no demand groups or control structures are present affecting the stream flow, the tributaries of the Orkhon river can be lumped into one (sub) basin and represented by one stream flow series.

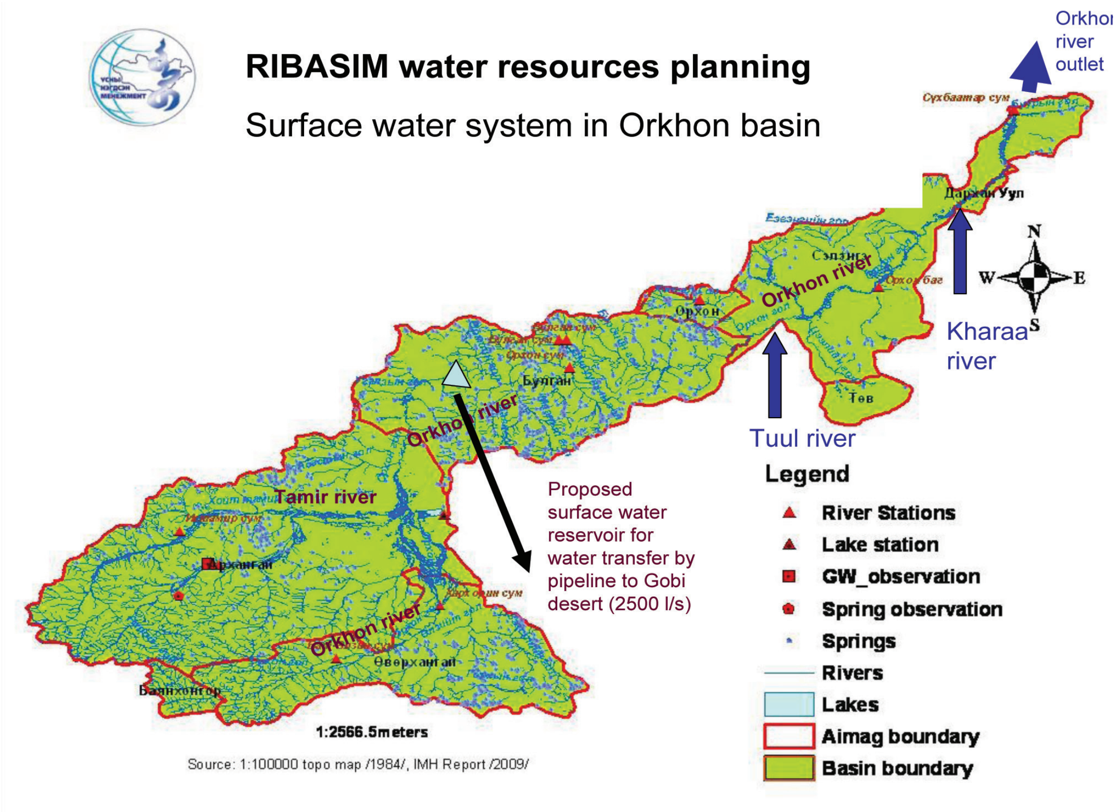


Figure 22. Surface water system Orkhon basin including proposed future water transfer

One of the most difficult aspects of the hydrology of the Orkhon River is the amount of water that is most likely being lost to the groundwater along its course. In general in most of the Mongolian regions, rivers are fed from their tributaries in the upper subbasins and lose water during their course in the drier lower areas depending on the groundwater table and the (no ice) season during the year. Although there is no direct evidence available, it is very likely the case that the aquifer under the river bed is fully replenished within one year, since the abstraction rate of water from the aquifer for water supply is very low compare to the average monthly discharge (less than 1%).

In addition, hardly anything is known about the behaviour of the aquifers in the basin. From a practical point of view, detailed schematizations are useless as it is evident that it will prove to be impossible to quantify the characteristics of each aquifer (water level, volumes, extension, etc.), and, especially, the fluxes between rainfall, water bodies and other aquifers for realistic modeling in RIBASIM. Moreover, field experiences show that in practice water supply for drinking water, livestock and irrigation depends on the available and operational infrastructure and is not limited by the abstraction rates of the aquifers. It is necessary to find a comprise in terms of detail, available data and physical reality. In this project we have chosen to refrain from modeling the behaviour of the aquifers. Instead we use the concept of constant or fixed flow rates abstracted from groundwater that equal the calculated water use.

Set-up of the schematization

The RIBASIM model makes use of a combination of nodes and links to draw a schematization of an area of study. The nodes represent four groups of items:

- (natural) water availability;

- water demand;
- low flow;
- Control structures.

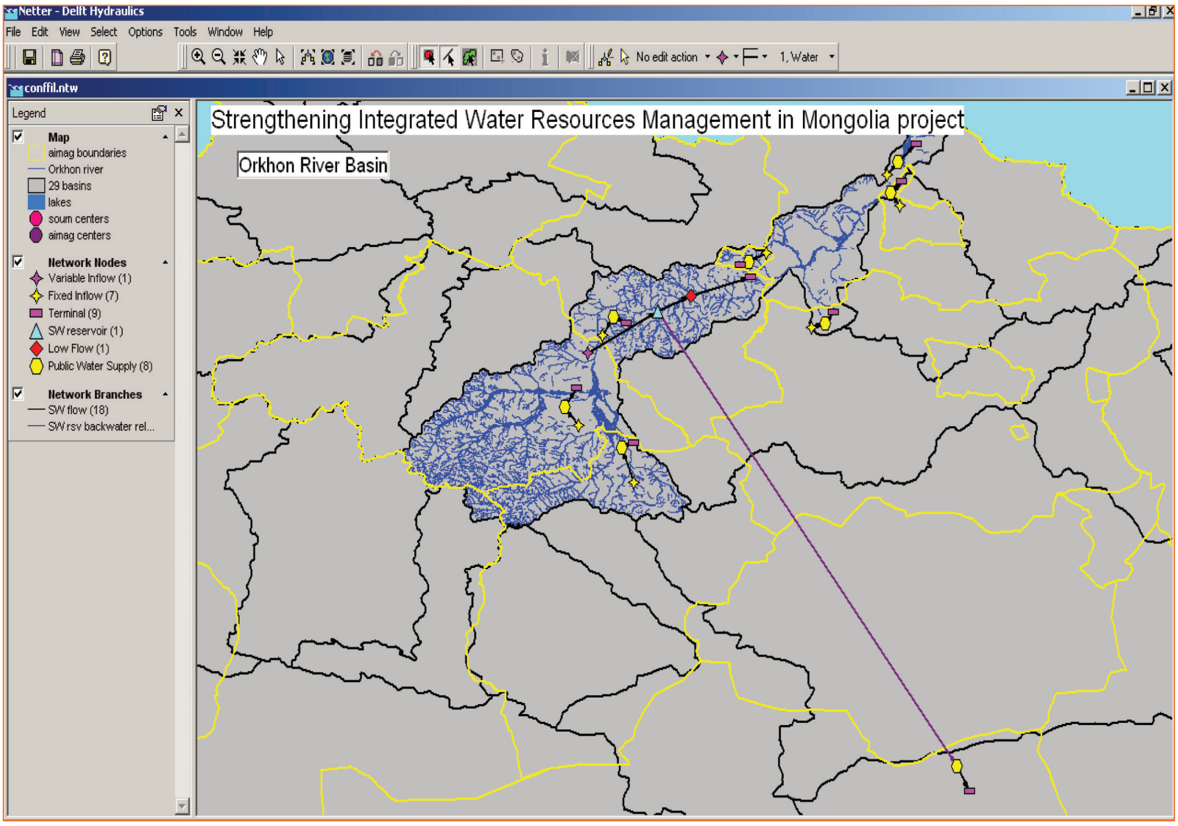


Figure 23. Schematization of the Orkhon-Tamir basin in RIBASIM nodes and links

It is important to know that both present and future infrastructure have to be included in the schematization. For the present situation only the public water supply and irrigation schemes are active. In case optional future situation are explored and the impact of a surface water reservoir is studied, the surface water reservoir node is activated.

Results of simulation

Although the data for the new reservoir was very limited and the operation rules are chosen by the project unit, some first results are presented below and show interesting results.

Two scenarios were selected for environmental flow. One scenario with a constant environmental flow of 10 m^3/s during 6 months May-October and a second scenario with the environmental flow equal to 88% of the mean monthly flow during May to October. The percentage used in the second scenario is equal to the environmental flow proposed by Davaa & Myagmarjav [1] for the midstream part of the Orkhon River.

Figure 25 and Figure 26 show the diversion from the reservoir (2.5 m^3/s) for the Gobi pipeline, the inflow from the Orkhon river catchment upstream (based on historical discharge series), the outflow from the reservoir and the simulated water level in the reservoir. The maximum water level in the reservoir was set at 1160 m+MSL. For each timestep the water balance for the reservoir was simulated: inflow + targeted abstraction = storage + outflow.

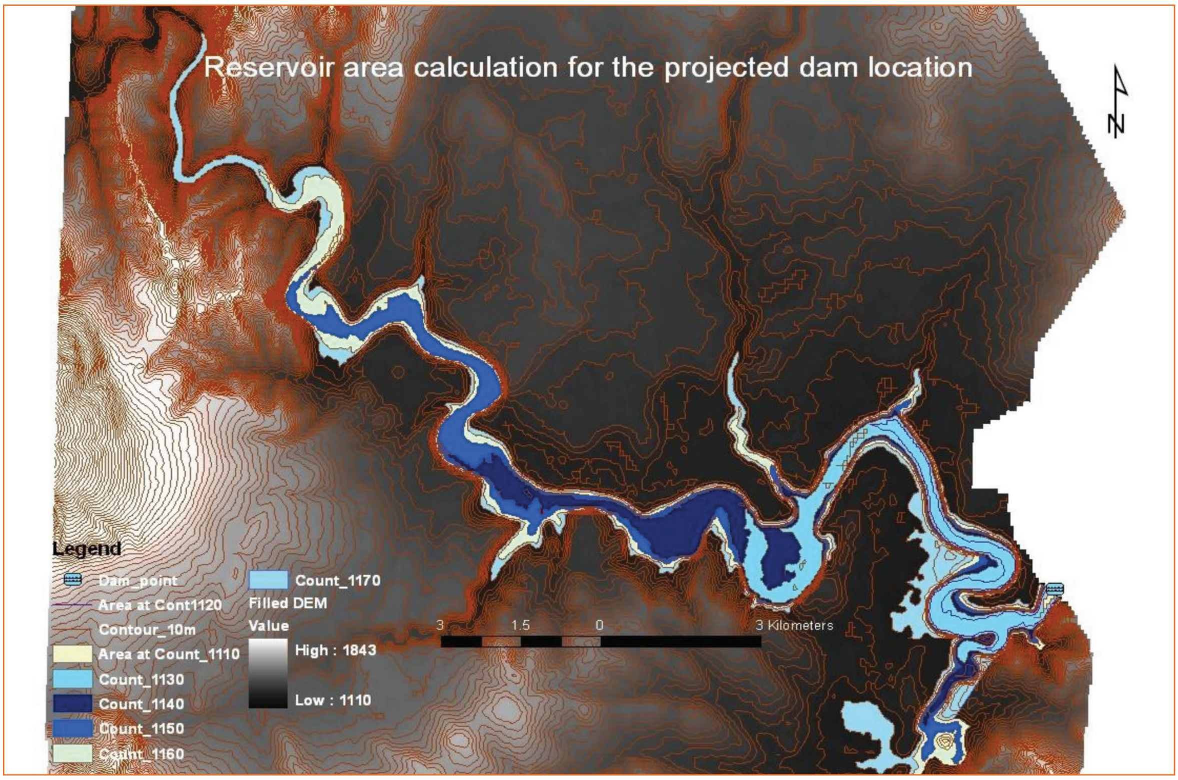


Figure 24. Reservoir level and related areas

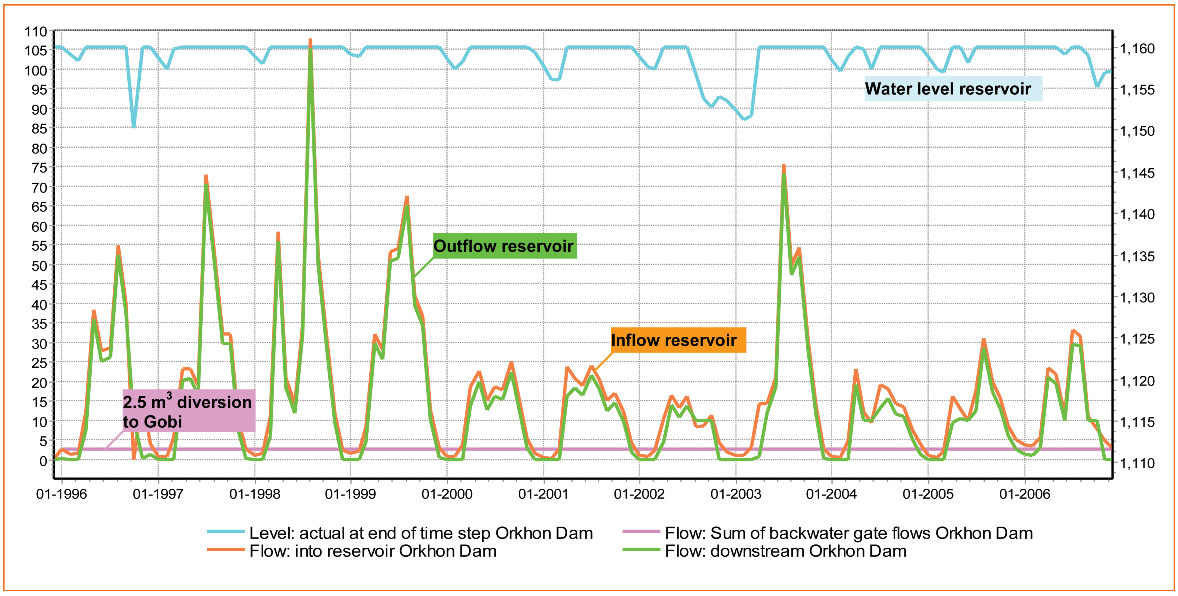


Figure 25. Orkhon-Gobi reservoir simulation - with constant environmental flow 10 m^3/s during May-October

The first scenario shows a situation in which the reservoir is full most of the time (Figure 25). When the reservoir is full, the outflow is equal to the inflow minus the abstraction for the Gobi. The reservoir is overflowing. The reservoir level drops during December-April period, when the runoff is insufficient to supply the Gobi pipeline. However, the reservoir level fluctuates in most years less than 5 meter; a simple weir would be sufficient instead of the current design storage of 50 m water level.

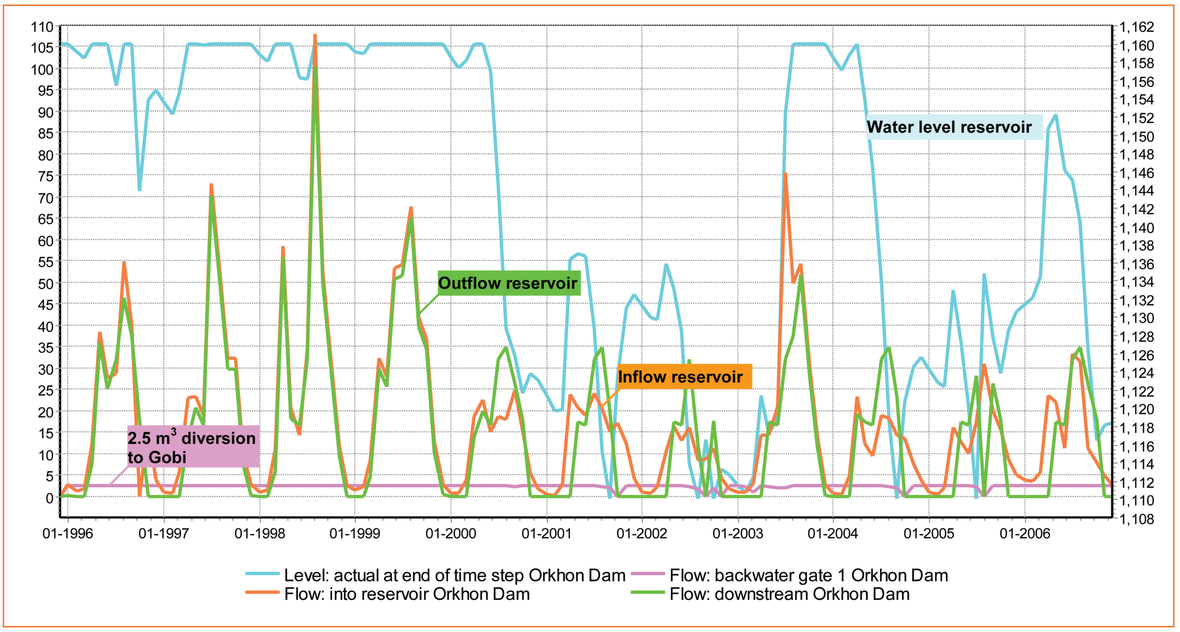


Figure 26. Orkhon-Gobi reservoir simulation - with environmental flow at 88% of mean monthly flow during May-October

In case the environmental flow is according the percentage of 88% as proposed by Davaa&Myagmarjav [1] then the reservoir is empty in successive years with low flows and the diversion to the Gobi may not be guaranteed in such years unless the environmental flow is reduced. This is illustrated in Figure 26. In the years 1996 – 2000 the reservoir is sufficiently full to supply the demand but in the dry years 2000 - 2002 the reservoir level has dropped and the required demand for both diversion and environmental flow cannot be supplied in 2001 and 2002. The situation recovers in the year 2003 when river flows are higher again.

The RIBASIM model runs may be improved once more detailed technical data become available of the Orkhon-Gobi diversion dam and reservoir.

5.4. Orkhon Basin: Model 2

Orkhon model 2 includes the simulation of the Orkhon River surface water system only. The model includes the inflow from gauged tributaries like Urd Tamir and Khoit Tamir.

The objective of the model is:

1. Analysis of the observed river runoff
2. Analysis of changes in river runoff along the Orkhon 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 Orkhon River)
3. Terminal node (at downstream end of Orkhon River)

The simulation period is 1996-2006. 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 10 active gauging stations on the Orkhon River and it's tributaries. There are 5 stations on the Orkhon River but Orkhon – Bat-Ulzii station is not included because of short observation period.

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

- Variable Inflow Node:

  Upstream: Orkhon - Kharkhorin (1996-2008)

  Tributaries: Khoit Tamir - Ikh Tamir (1996-2008)

  Urd Tamir - Tsetserleg, (1996-2008)

  Achuut - Bulgan (1991- 2008)

  Zuunturuu - Bulgan1991 -2008)

- Recording Nodes:

  Orkhon – Orkhon soum (since 1996-2008)

  Orkhon –Orkhon bag (1996-2008 1970)

- Terminal Node: Orkhon - Sukhbaatar (1996-2008)

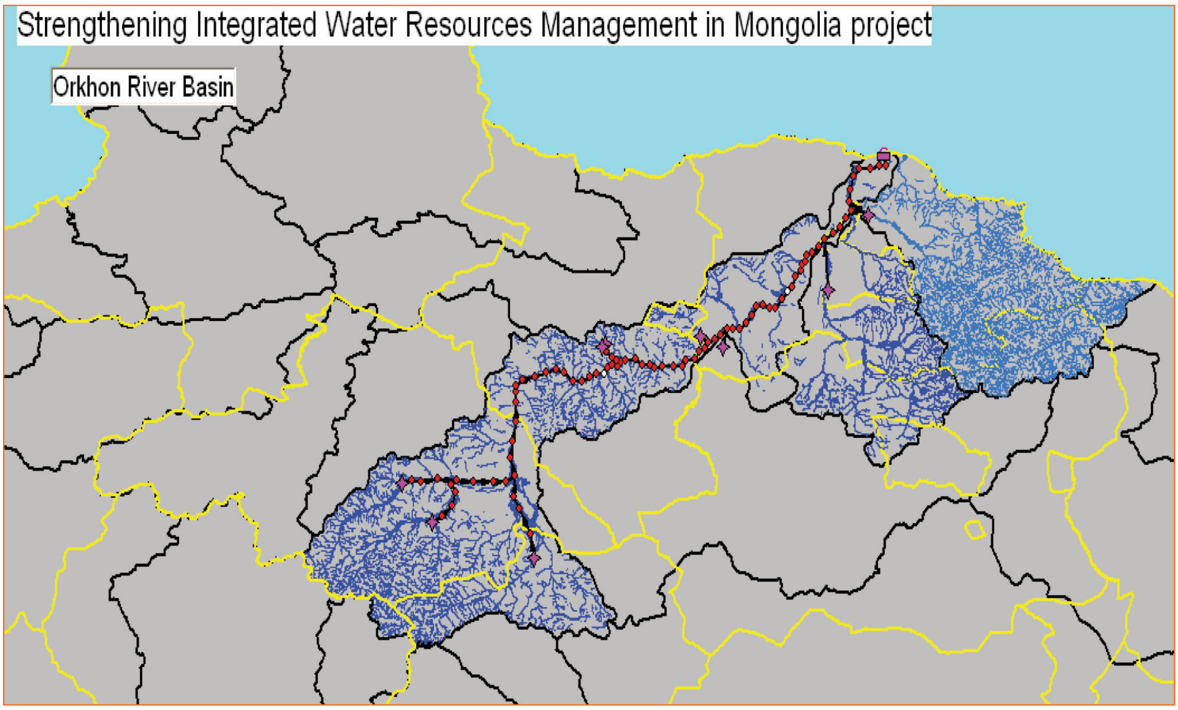


Figure 27. Schematic map of modeling

Model results

From hydrological analysis it is expected that Orkhon River is gaining water in downstream direction. Ungauged small tributaries exist in the upper part of the basin and in the lower and middle part of the Orkhon River contributing varying but unknown volumes of inflow. The difference between simulated and observed flow is equal to the unknown inflow minus possible water loss to the groundwater (which is expected to be minimal as there are no large abstractions). The comparison of simulated and observed flow is best done by calculating the average difference for the simulated period excluding years with a large unknown inflow.

Simulated runoff was compared with observed runoff at Orkhon-Orkhon /Selenge/ (1996-2006). Orkhon-Orkhon (Bulgan) station has no flow records in 1998, 1999.

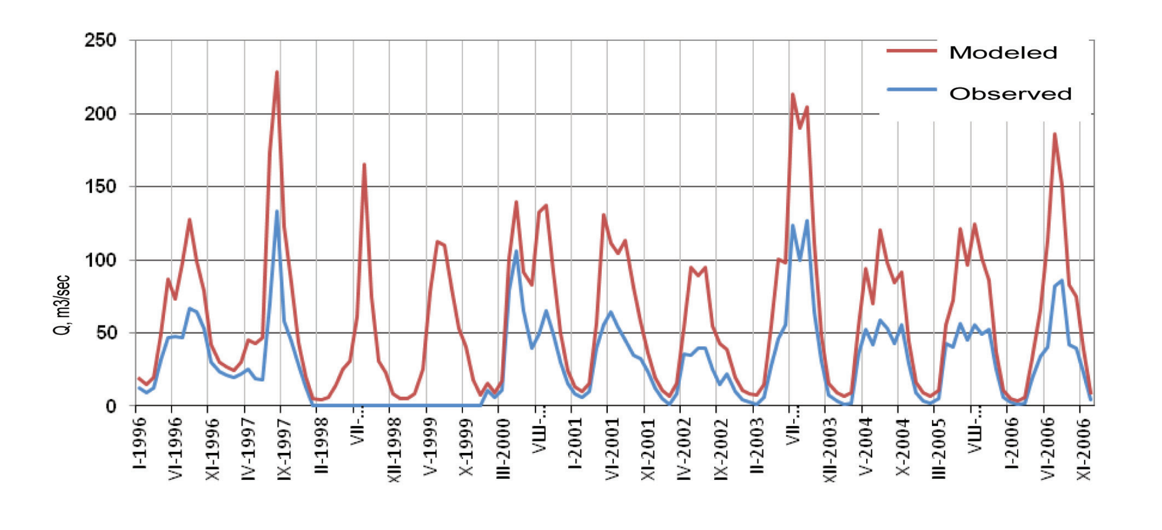


Figure 28. Simulated and observed runoff at the Orkhon-Orkhon (Selenge) station (1996-2006)

According to the correlation between simulated and observed flow the correlation coefficient at Orkhon-Orkhon (Selenge) (1996-2006) is 0.67 and it is 0.69 at Orkhon-Orkhon /Bulgan/ (1996-2006) station (Figure 29).

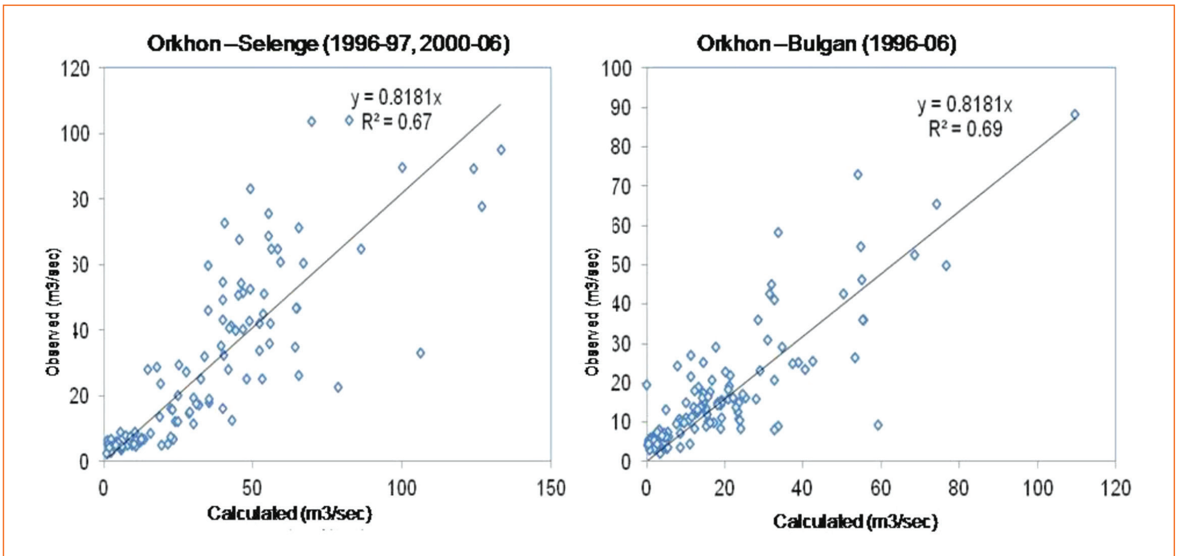


Figure 29. Correlation between calculated and observed flow

6. Conclusions and suggestions

1. The Orkhon River is the main surface water resource and source of Central Mongolia and the most affected river basin in terms of human influences such as agricultural, mining, deforestation and urbanization.

2. Due to climate change and human impacts, the water resources of the Orkhon River are decreased and its natural flow regime is changed.

3. The valley of the Orkhon River is the main agricultural area of Mongolia and the development of agricultural activities in recent years requires paying more attention to IWRM issues. Especially irrigated agricultural is intensively developing in the river basin. Therefore, it is recommended to manage direct use of fresh water for agriculture and other purposes and to encourage reuse of water which is vital important part in the planning and development of IWRM in the Orkhon river basin. Even can serve criteria of appropriate use and protection of water resources in the basin.

4. 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.

   One of the urgent issues in the Orkhon river in terms of monitoring network is the extension of the network in space and time. These concern installation of new stations, improving equipment which allow to conduct high floods and continuous measurement. According to WMO standard, in the Orkhon-Tuul river basin must operate at least 80-85 hydrological gauging stations for surface water in order to meet accuracy of estimation and assessment of water resources and flow regime and operational service. The National programme on Water states installation of 7 new hydrological stations in the Orkhon river basin by 2015-2020. For example, plan to establish following stations Boroo-Bornuur, Orkhon-Ulziit, Orkhon-Saikhan by 2015 and Tuul-Zaamar 2015 and Khogshin-Orkhon, Kharbukh-Dashinchilen, Eree-Bugant by 2016-2020.

5. Modeling, water balance studies and interrelation between surface and groundwater are key research topics in the Orkhon river basin in order to achieve better prediction assessment and estimation of water resources and flow regime

6. Valuing water principles as – balancing should be between pricing water as commodity and cost of providing good quality water and reducing expansion rates for water users and employing improved technologies. Nationwide campaign for water saving.

7. Enforcement of existing legislative bases on protection, use of water resources

8. Provide full participation of all related stakeholders at all levels of the IWRM and to make real outputs for clear end-users

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ANNEX 1. Morphometric characteristics of Orkhon river basin

The precise catchment of Orkhon River was defined manually on 1:100,000 scale topographic map with 20 meter interval of contour lines using spatial analyst tools in GIS. The catchment of Orkhon River basin is 53786.8 sq km and 143379.1.7 sq km including Tuul, Kharaa, Eroo, Khuder, Minj River basins (Figure 30).

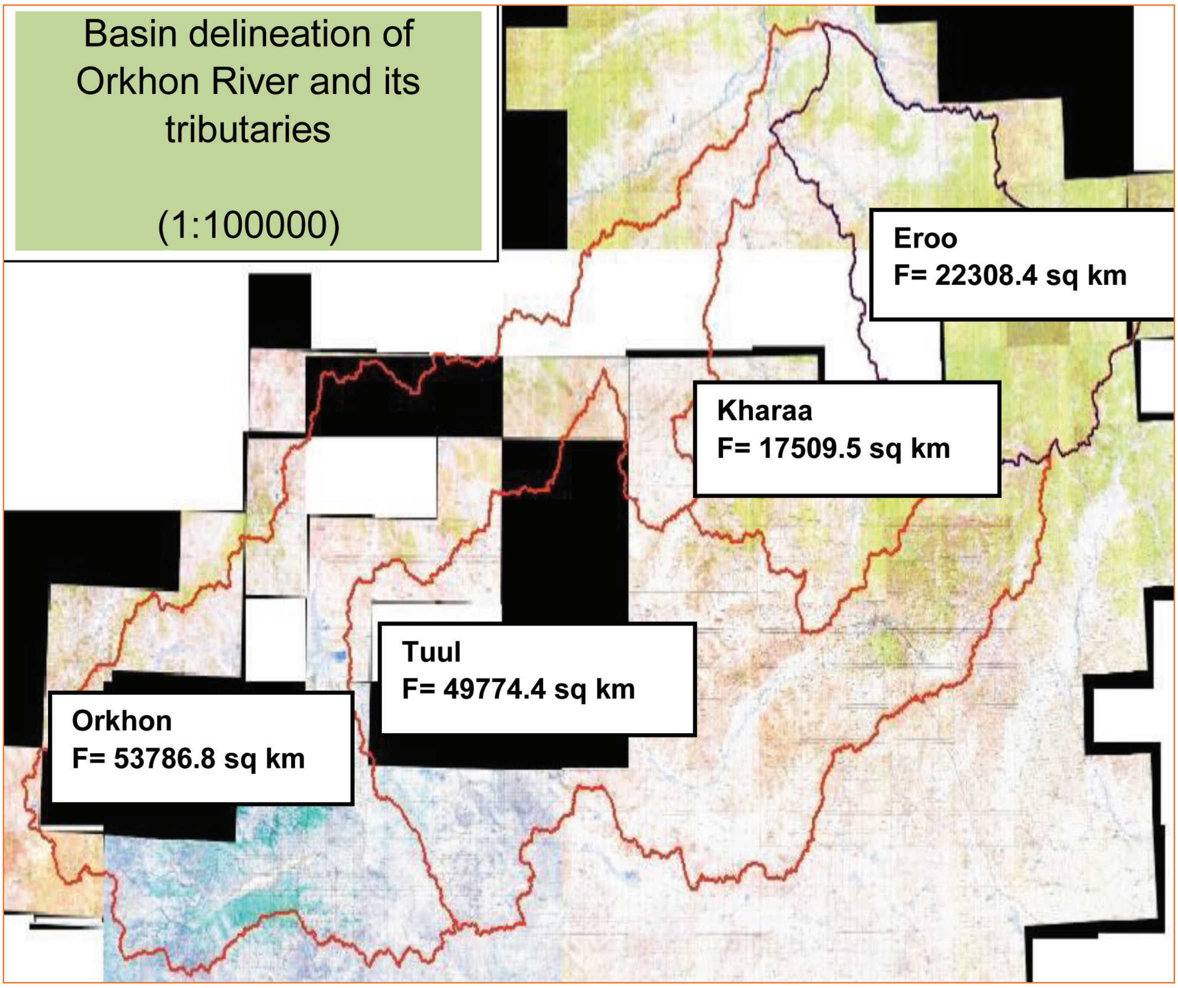

Figure 30. The catchment delineation of Orkhon, Tuul, Kharaa Eroo basins

ANNEX 2. Hydrological monitoring network in Orkhon river basin

In the Orkhon River basin 13 hydrological gauging stations are operating including 10 river stations, 3 spring stations, 1 lake and 1 groundwater observation station. At Orkhon –Ulziit it is proposed to build new river station as shown in Figure 31.

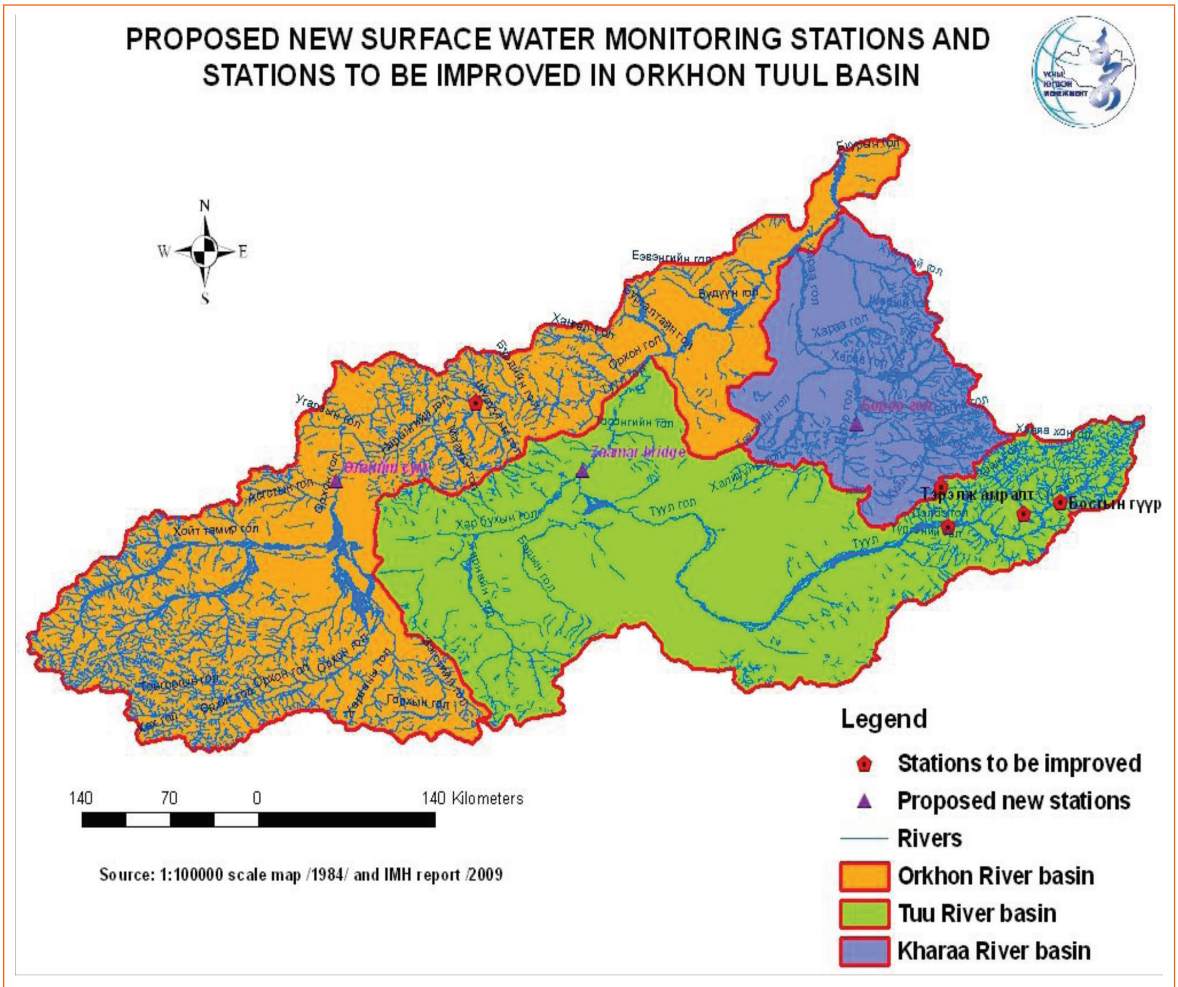

Figure 31. Locations of proposed new and to be improved stations

ANNEX 3. Surface water resources changes in Orkhon basin

By the average of recorded run off data from 1978 to 2008 years, Orkhon River has 12.7 cubic m/sec discharge at Kharkhorin, 36.9 cubic m/sec at Orkhon (Bulgan), 73.4 cubic m/sec at Orkhon (Selenge) and 126 cubic m/sec at Orkhon -Sukhbaatar station.

From the dynamic of flow changes it is able to see that water resources of Orkhon River basin are below average after 1996.

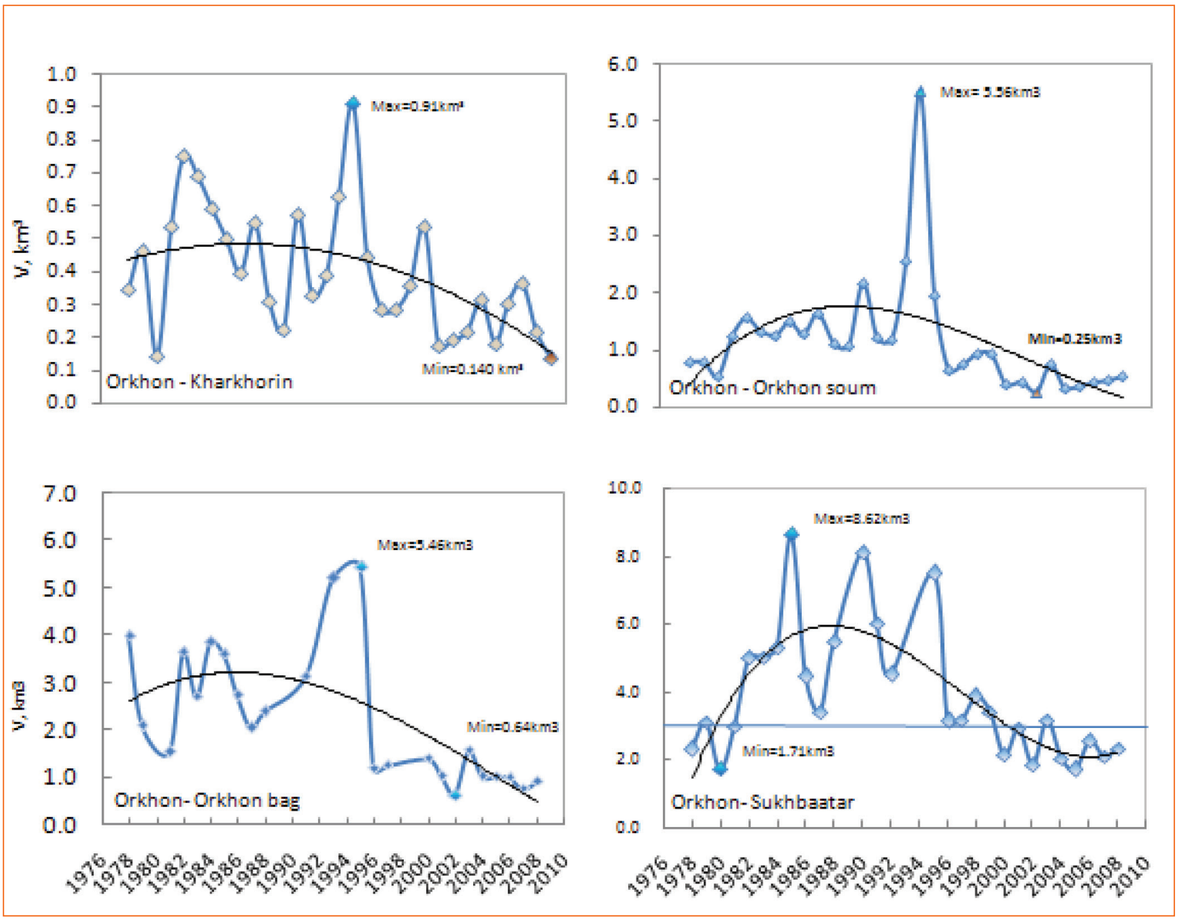

Figure 32. Annual flow changes in the Orkhon River Basin

ANNEX 4. Main issues related to surface water the Orkhon 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 water regime and resources of the Orkhon River basin. Due to the limited amount of available information the map was not fully completed.

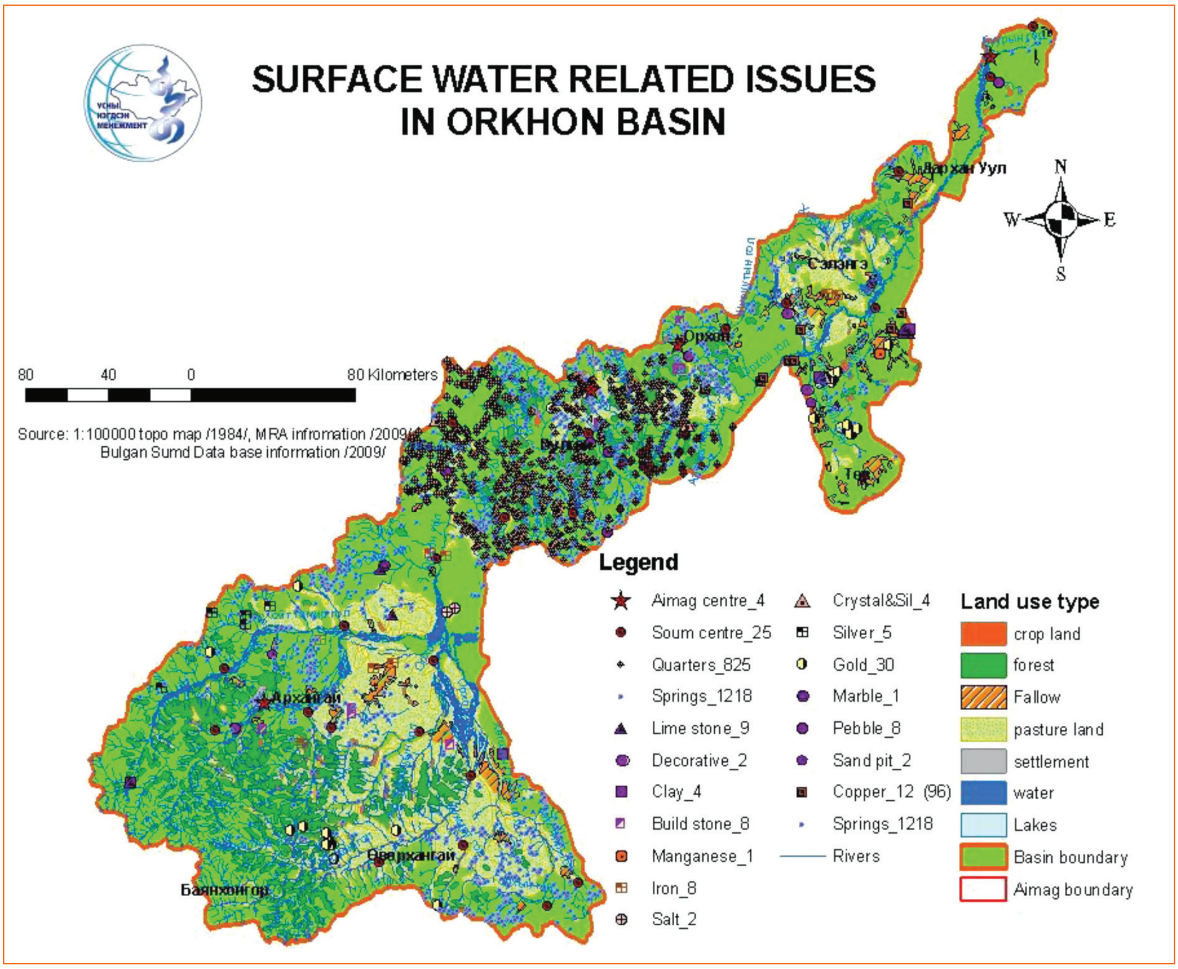

Figure 33. Issues in Orkhon basin

ANNEX 5. Defined sub basins in Orkhon basin

Sub basins in the Orkhon River basin were defined in Terrain pre-processing in Arc Hydro using SRTM DEM with the resolution of 90 meter. The number of the automatically derived sub basins will be depending on the accuracy of altitude data as DEM or contour map and river network data their thresholds for the software. In this case it was delineated 70 sub basins in Orkhon River basin.

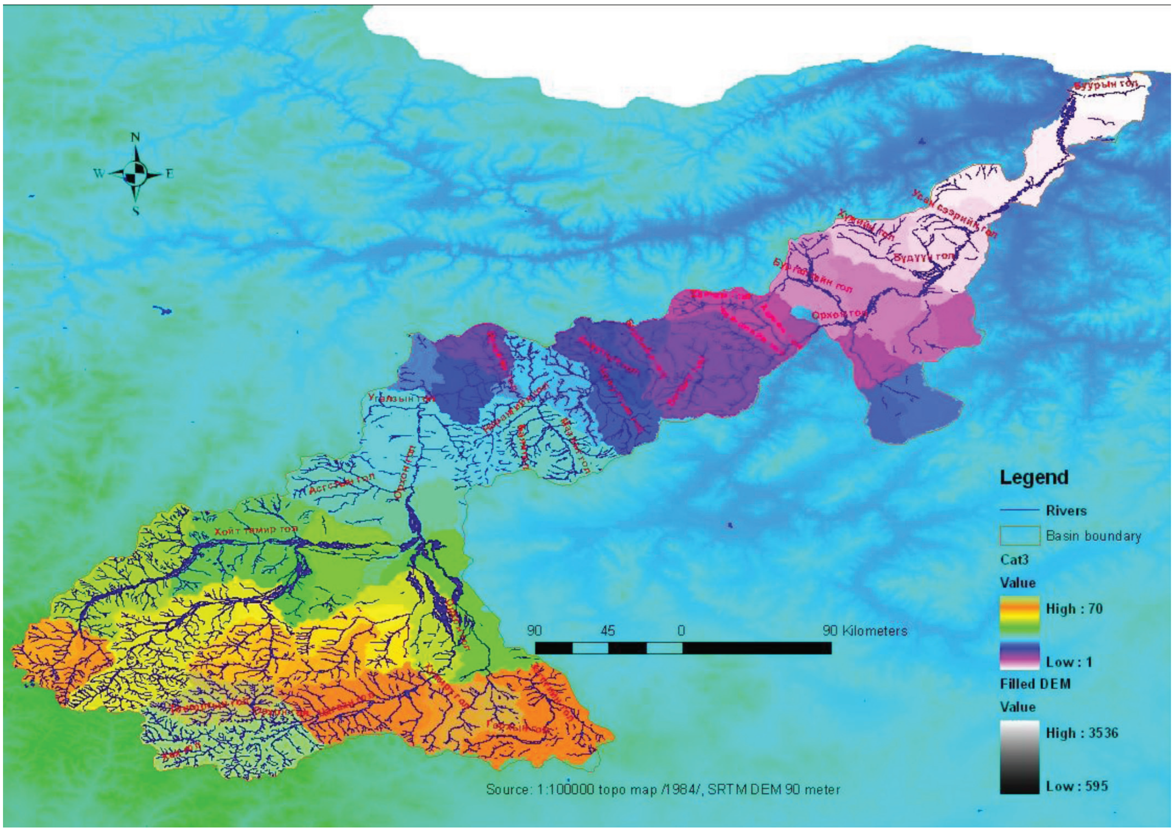

Figure 34. Sub catchments in Orkhon basin

PART 3.
GROUNDWATER RESOURCES

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1. Introduction

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

- To assess the present level of groundwater study in the Orkhon river basin, to list the direction to develop groundwater study in the Orkhon river basin to be reflected in integrated water resources management plan
- To improve processing rate in access of data document about ground water
- To improve the groundwater assessment studies in the Orkhon 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
3. Borehole information from "Hydrogeological map of the Northeastern part of Mongolia at scale of 1:500,000" developed in Moscow in 1991 with the participation of following people: R.Ya Koldishyeva; D.V Yefimova; A.P Grishina; A.F Boishenko; T.P Corolyeva; I.A Tumanova; T.N Sherbakova; U.Borchuluun and N.Sharkhuu.

In this methodology and other documents associated with hydrogeology and groundwater resources are used some terminologies like aquifer, intergranular 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 intergranular 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.

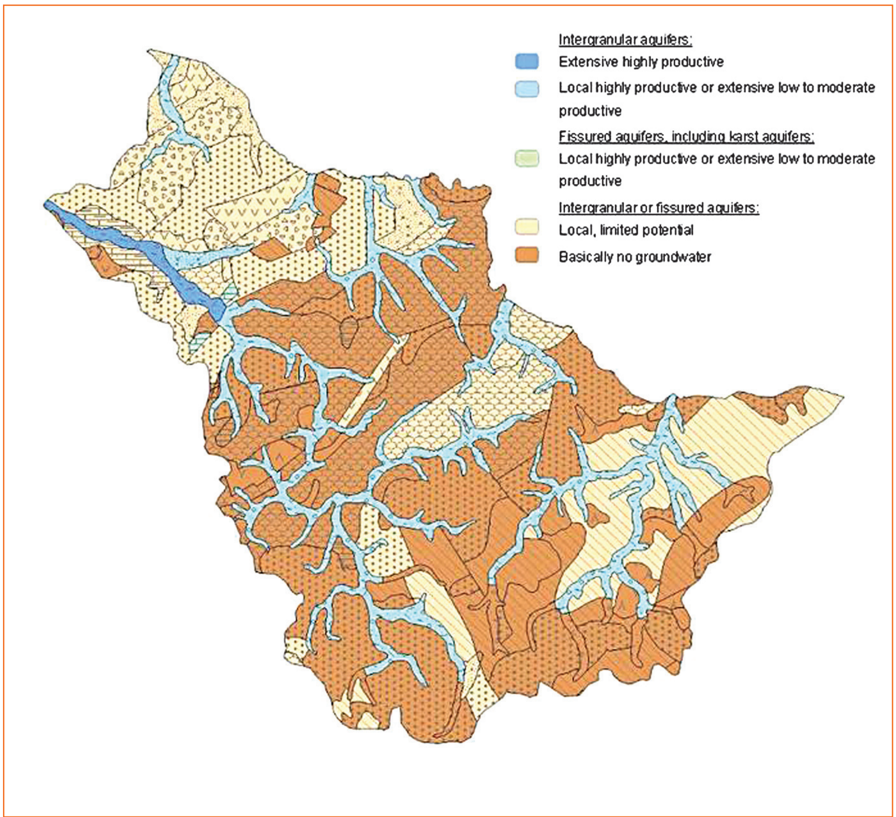

Figure 1. Example (Eroo Basin) of part of Regional Hydrogeological Map of Mongolia 1:1,000,000 (Jadambaa N., Grimmelmann W., Kampe A, 2003)

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.

For example, the exploitable groundwater resources of the water containing Holocene (Modern Quaternary) aged intergranular alluvial aquifer, located in the area of the confluence of the Selenge and Orkhon Rivers are approximated as averaging 10 l/s from 1 km^2 area and this is applied to the area where exploration work was conducted. If the groundwater resources are estimated by a hydrogeological 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.

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). Areas with mixed groundwater recharge indicate the aggregate of infiltration from precipitation and surface water and lateral groundwater flow.

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).

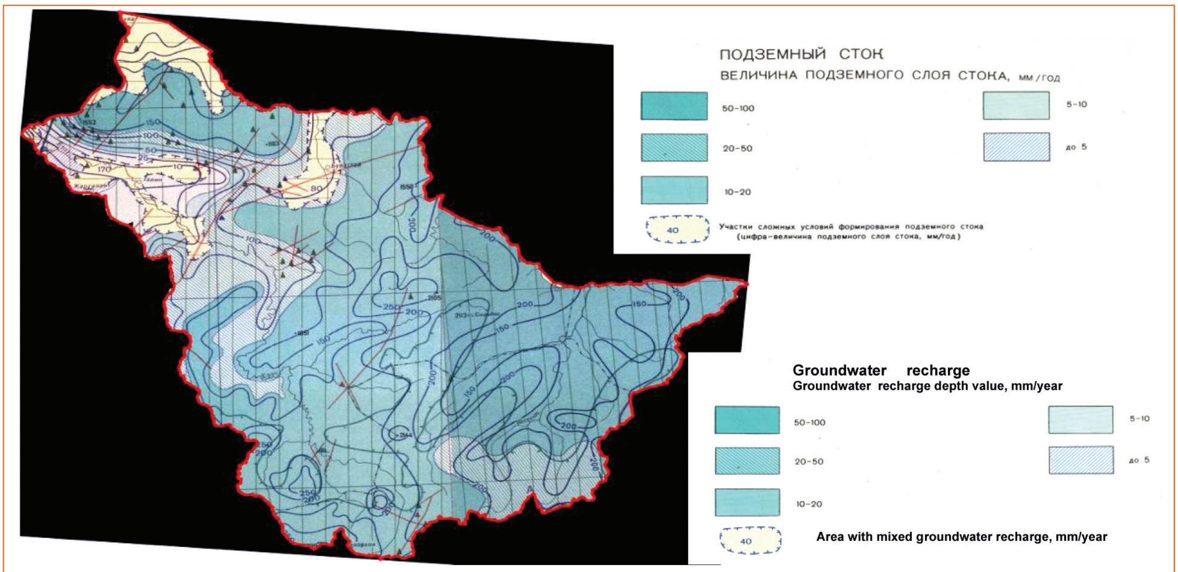

Figure 2. Example (Eroo Basin) of part of the “Multi-year average flow of surface and groundwater” Map 1:1,000,000 (1981)

The digital version of the “Multi-year Mean Flow of Surface Water and Groundwater” Map is combined with the Hydrogeological Map of Mongolia to determine the renewable groundwater resources for each aquifer.

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. 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

The objective is to prepare the map on "Groundwater natural renewable resources and potential exploitable resources" scaled at 1:1,000,000 for each river 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.

3.1. 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 [3] 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 Mongolian total renewable groundwater resources will be estimated as sum of each river basins renewable groundwater resources.

3.2. Methodology to calculate the exploitable groundwater resources in river basin

The potential exploitable groundwater resources of river basins are identified based on 3 methodologies and are shown on the map of each basin at scale 1:1,000,000:

1. The main methodology which is used in the Project "Strengthening Integrated Water Resources Management in Mongolia" 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 –
    2. more than 10 l/s (> 315000 m^3/year/km^2) or "large resources",
    3. 3-10 l/s (averaging 6.5 l/s = 204984 m^3/year/km^2) "larger than medium resources",
    4. 1-3 l/s (averaging 2 l/s = 63072 m^3/year/km^2) "medium resources",
    5. 0.3-1.0 l/s (averaging 0.65 l/s = 20498.4 m^3/year/km2) "lower than medium",
    6. 0.03-0.3 l/s (averaging 0.165 l/s = 5203.44 m^3/year/km^2) "low resources",

7. 0.003-0.03 l/s (averaging 0.03 l/s = 946.1 m^3/year/km^2) "very low resources",
8. < 0.003 l/s (< 94.6 m^3/year/km^2) "basically no water resources"

A map is created with a proper scale and the total potential exploitable groundwater resources for each basin are estimated.

The methodology of calculation by water balance equation. This methodology is used for calculation of potential exploitable groundwater resources in alluvial aquifers distributed in big river valleys of the Northern Mongolian Hydrogeological System. The potential exploitable groundwater resources is calculated from [4, 5] $Q_a = Q_n + \frac{\mu V_e}{t}$ 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 third methodology to calculate the potential exploitable groundwater resources is based on the methodology which is used by hydrogeologists from the Japanese JICA organization and from Australian "Aquaterra" Consulting Pty Ltd. This methodology is used for calculation of potential exploitable groundwater resources of intergranular aquifers distributed in basins in Southern Mongolian Hydrogeological System. In these basins the intergranular aquifers are composed of Holocene- Pleistocene-, Neogene-, Paleocene-, Cretaceous-age sand, sandy loam, sandstone, conglomerate, coal and other unconsolidated sediments. The area of these unconnected aquifers distributes usually over more than 200 km2. The methodology is illustrated in Table 1.

For calculating the potential exploitable groundwater resources in water containing fault complexes and fault zones, the sum of the safe yields as presented on the 1:1,000,000 scale Hydrogeological Map of Mongolia is taken. If it is necessarily considered that this data is not sufficient for calculation, then the data of a few safe yields of water exploration and exploitation can be added from the groundwater databases of governmental and/or private institutions in the geological and water sector.

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 ($S_б$=0.5 m, 50% of aquifer thickness for unconfined aquifer, or $S_б$=0.5(m+h), 50% of aquifer thickness + head for confined aquifer), potential safe yield ($Q_б$=qx$S_б$).

4. Geomorphology, geology and hydrogeology of the Orkhon river basin

The Orkhon river basin is stretched from southwest to north in terms of geology and geomorphology. The formation of the basin's geomorphology and geology is very complex. The peak of Tarwagtai nuruu is 3540 m Angarkhai mountain; Erkhet khairkhan (3535 m) of Khangain nuruu; Suvarga khairkhan (3179 m) and Zuun khairkhan (2408 m).

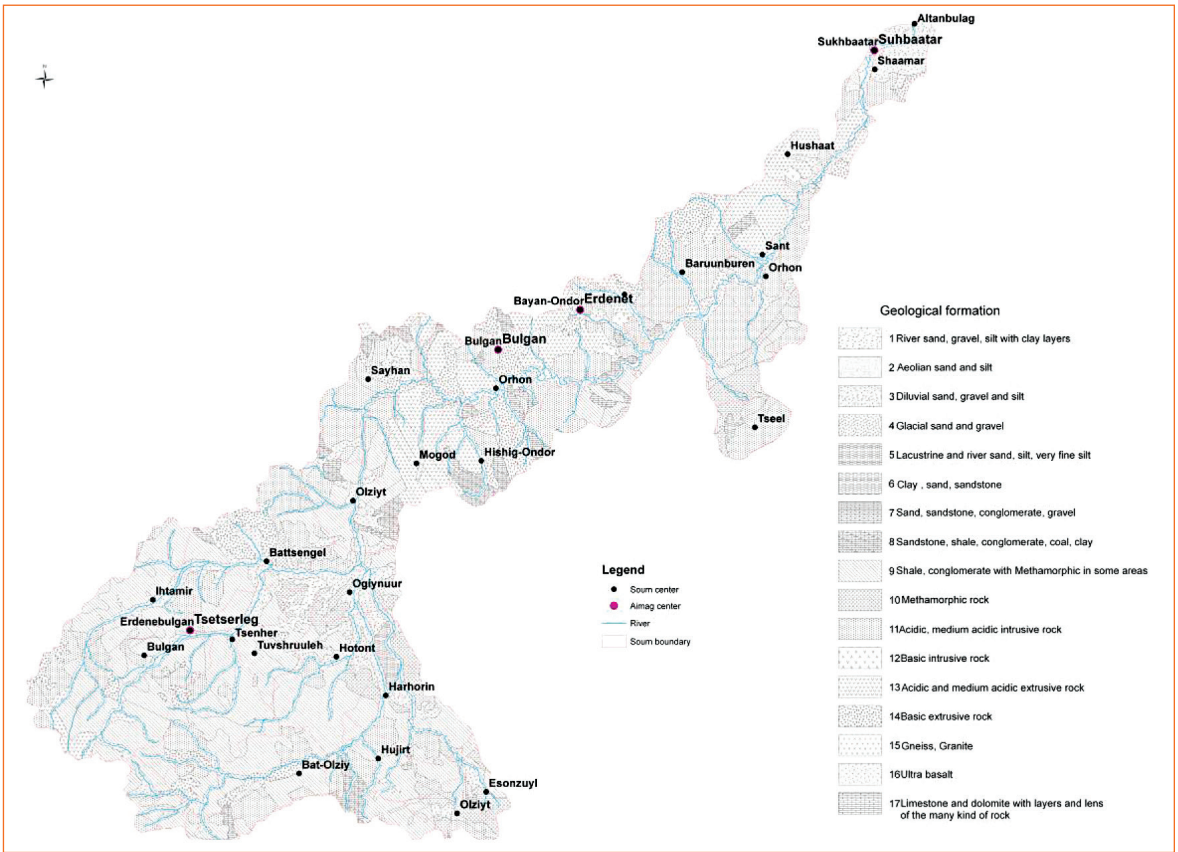

Figure 3. Geological Map Orkhon Basin (for legend see also Figure 6)

4.1. Geomorphology

The geomorphological basic elements of the Orkhon river basin are mountains and river valleys among the mountains. The southeast source of the Orkhon river basin include Munkh bulgiin river, Sariin river and Zegst river which start from Zuun khairkhan mountain, Ulziit and Zuil soums of Uvurkhangai. The south and west source of Orkhon include: Baruun khairkhan, Angaliin tsagaan ovoo, Dukh ovoo, Dolgoon uul, Jargalant davaa, Jargalant uul, Tsetseg mod, Baruun dugnen, Khetsuu davaa, Jargalantiin davaa, Tavan ulaan chuluu, Ulaan chuluunii davaa, Urtiin davaa, Zaluurtiin shovkh, Emgediin davaa, Uvtiin davaa, Khamariin davaa, Ulaan nuruu, Khar hushtiin nuruu, Salhit uul, Erkhet khairkhanii baruun hyar, Angarhai uul, Khan undur davaa, Shar bulag davaa, Chingeltei uul, Rashaant uul, Saikhan uul, Bulgan nuruu, Khats hash uul, and Ikh zaluu uul-the following rivers have source from above mentioned mountains: Dukh Chuluut, Khuush, Joroogiin sairuud, Kharznii gol, Tsuvria, Bunkhant, Khujirt, Khavtsgai, Tsagaan sum, Uliastai, Tongorog, Tamch, Urkhit, Ulaan, Shireet, Bukhiin shar, Ar aguit, Ar uwt, Mogoit, Moilt, Khamar and Khonog.

The Khoid Tamir and Urd Tamir rivers are a big source at the west side of the Orkhon River. The geomorphological elements of the middle Orkhon river basin influx parts consist of the following on the west hand side: Angarkhai uul, Khan Undur davaa, Shar bulag davaa, Chingeltei uul, Rashaant uul, Saikhan uul, Bulgan nuruu, Khats khash uul, Ikh zaluu uul and Burengiin nuruu.

The following elements are found in the Orkhon river basin along the above mentioned mountains, Orkhon River and its branch rivers and Gorhiin valley: alluvial flat and steep valley; glaciations; holes and hills caused by frozen ground. Also there are small concentrations of sand dunes formed by erosion in the Orkhon valley.

4.2. Geology

The geological structure of the Orkhon river basin is very complex. The followings are pervaded as well: Quaternary alluvial, proluvial, dilluvial sedimentary rock, terrestrial and lacustrine sedimentary rock of Neogene and lower Cretaceous age, Neogene-Quaternary valley rock, Permian and Triassic sediment, Paleozoic and Mesozoic effusive and intrusive rock.

These geological aquifers and formations constitute intergranular aquifers and fissured aquifers and possibility of unconfined and confined groundwater distribution.

4.3. Hydrogeology

There are 5 intergranular aquifers and 2 fissured aquifers in the Orkhon basin.

4.3.1. Granular aquifer formation in Holocene aged alluvial sediment

The granular alluvial aquifer is located along the whole length of the Orkhon river as shown on the 1:500,000 Mongolian hydrogeological map. The granular aquifer formation in Holocene aged alluvial sediment and metamorphic rock-fissured aquifer were found in the borehole number 43 which was drilled near Kharkhorin. The Holocene aged granular aquifer formation in alluvial sediment was found at a depth of 2.0 meters and the yield was 6.8 l/sec at a drawdown of 1.8 m.

The Holocene aged granular aquifer formation in alluvial sediment indicators were as follows in the boreholes of Khutul city water supply: groundwater yield was 11.9-33.4 l/sec; intergranular aquifer depth was 50-60 m in the field of Bajgar Ulaan where hydrogeological surveys were conducted; borehole yield was 0.3-6.8 l/sec; hydraulic conductivity is 4-26.4 m/day; aquifer transmissivity is 123-776.4 m^2/day. The groundwater composition was hydrocarbon-calcium-sodium-magnesium; chemical composition was 2.6-3.7 mg/l and pH was 7.9-8.4.

The Enkh-tal groundwater deposit found in the Orkhon river valley and the Sukhbaatar city water supply source has large resources with high yield. The alluvial aquifer located along the Orkhon valley is composed of gravel, sand, poor cemented conglomerate and rocks. The aquifer has a high storativity and transmissivity. In winter time, it does not freeze beyond 2.0 meters and has low risk of evaporation. The resources and yields are plentiful. The Holocene aged granular aquifer formation located in the Orkhon valley has much economical importance.

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

The Pleistocene granular aquifer formation is located in separate areas and consists dominantly of debris. The aquifer may be 65-meter thick and comprises boulders, gravel, sand, sandy clay and clay.

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

The survey is conducted for the purpose of using groundwater as a source for the cement-chalk factory water supply of Khutul city. According to the survey results, the aquifer is composed of Holocene-Pleistocene age alluvial, proluvial, proluvial-alluvial sediment. The groundwater was found at a depth of 5 m and pumping tests were done in 7 boreholes. The yield was estimated at 43.5-83.3 l/sec for a drawdown of 1.3-5.6 m. The water composition is hydrocarbon-calcium-magnesium.

The hydrogeological survey was conducted in 1980 on the granular aquifer formation in alluvial-proluvial sediment of Holocene-Pleistocene. During the survey, a groundwater aquifer was found in the Achuut river valley (a branch of Orkhon River) which can be used as water supply source of Bulgan aimag. The aquifer consisted of different types of sand, gravel with boulder and clay. The thickness of the aquifer was 14.9-54.9 m and the water level was 0.7-5.8 m. The hydraulic conductivity was 12.4-37.8 m/day and diffusivity was $4.6*10^4$-$1.2*10^5$ m^2/day.

4.3.4. Granular aquifer formation in Cretaceous age land-lake origin sedimentary aquifer

Its distribution is very limited in the Orkhon basin. This aquifer was surveyed in the coal mine of Saikhan ovoo. N.F. Chemodanova did a survey on mine hydrogeology and it was defined as Jurassic age. Ts. Khosbayar, J. Byamba and Ts. Maksbadar confirmed that Saikhan ovoo coal-containing sedimentary aquifer has lower Cretaceous age (geological figure at scale of 1:1,000,000, 1996). As for geomorphology, Saikhan ovoo mine is located in the basin of Khanui and Orkhon rivers. Most of the area is in the Orkhon basin. The mine came to light at the end of 1960s and beginning of 1970s due to geological researches.

Between 1971 and 1973, a survey to make geological mapping was conducted in the basin between Orkhon and Selenge rivers as well as Saikhan ovoo minefield. As B.Adyaa mentioned in his report on survey work results of Saikhan ovoo coal mine, main groundwater aquifer is Cretaceous age land-lake origin sedimentary aquifer (it is possible to have 0.01-0.3 l/sec yield from 1 square kilometer area).

In 1973, N.F. Chemodanova made an estimation on basic hydrogeological indicators and water amount to flow into the mine during the survey on western and eastern parts of Saikhan ovoo coal mine. She did short term pumping on boreholes number 122, 12 and 133. The yield was 0.02-0.2 l/sec and drawdown was 0.6-5.4 m.

During the 1989 pre-survey of Saikhan ovoo coal mine, B.Adyaa used 45.7 m-deep 220th borehole and drilled at the diameter of 112 mm to the 37.4th m. He did pumping in a method of airlifting. The yield was 0.8 l/sec; drawdown was 6.72 m and own yield was 0.12 l/sec.

N.F. Chemodanova and B.Adyaa defined leakage index. The permeability was K_2=1.75 m/day (it was estimated by measured level recovery after the pumping). It is (K_3) 4.53 m/day by Dupuit continuity formula and 0.95 m/day by N.K. Grinski's formula used for continuous, free surface-low pressure condition. It was 7.03 m/day by Dobrovolski's formula used for continuous, free surfaced-low pressure condition. The average for the whole mine was 3.38 m/day.

The following was solved by graphic-analytical method-transmissivity (KH), Diffusivity (A_y).

A. Drawdown: KH = 21.03, A_y=19.5*1440 = 2.8*10^4 m^2/day

B. Recovery: KH = 14.05 m^2/day, A_{y2}= 3.91*1440 = 1.28*10^4 m^2/day.

The average transmissivity was KH=17.54 m^2/day and average diffusivity was A_y = 2.04*10^4 m^2/day. The aquifer near Saikhan ovoo coal mine consists of coal, conglomerate, sand and shale. The static level of groundwater is revealed between 14.6 m and 168.0 m. The aquifer thickness in the coal of Saikhan ovoo mine is 8.0 m on average as B.Adyaa predicted.

The water which revealed in the borehole number 220 has composition of hydrocarbon-magnesium-sodium. The general water hardness is 2.95 mg-equiv/l and nitrite (NO_2) was not revealed. Nitrate (NO_3) was 1.9 mg/l; fluoride 0.71 mg/l; lead 0.03 mg/l; zinc 0.032 mg/l; molybdenum 0.033 mg/l; copper 0.01 mg/l; permanganate 0.005 mg/l and oxidation 5.4 mg/l.

As for the 4^{th} pit of coal of Saikhan Ovoo mine, 50 m^3 water is accumulated per hour. For the main mining place, water level decreased by 0.4 m when pumping out water by portable pumps at 9000 l per hour. The water level reached its previous level after 48 hours. The groundwater is fed by precipitation saturation. There is discontinuous permafrost near Saikhan ovoo coal mine. When making water management plan, permafrost issues should be considered in Orkhon basin scale.

4.3.5. Fissured aquifer formation in Triassic – Jurassic aged sediments and Permian

It is located in following areas. They include: the upstream part of the Achuut river which flows through Bulgan aimag center; Toiloviin davaa; downstream of Teeg river and Bayanzurkh mountain (1851 m)-east part of Shuvuut river.

The free-surface water is revealed between the depth of 3 m and 28 m. The yield of boreholes was 0.2-4.0 l/sec. Fissured aquifers in sedimentary, sedimentary mafic, effusive, effusive-mafic, mafic rocks of Paleozoic age have broad distribution in the Orkhon basin, but water amount is basically low. The fissured aquifer water was found in 400 boreholes in this basin. It usually has hydraulic connections with Quaternary and other aquifer water.

4.3.6. Fissured aquifers in intrusive sediments

This type of aquifer is widely distributed in the Orkhon basin and the water quantity is not high. The water quality is good in most cases, so local people use it for water supply by drilling wells. The groundwater level is between a depth of 0.7 m and 40 m. The yield fluctuates between 0.06 and 4.0 l/sec.

Table 2 Hydrogeological indicators of the Orkhon basin intergranular aquifers and fissured aquifers

№	Name	Number of boreholes used	Static level [m]	Yield [l/sec]
1	Holocene alluvial sediment	180	1-55.0	0.2-28.4
2	Granular aquifer formation in Pleistocene aged proluvial, alluvial-proluvial sediment	100	0.7-38	0.8-18
3	Granular aquifer formation in alluvial, proluvial sediment of Holocene-Pleistocene age in side valleys	80	2-40	0.5-11.0
4	Neogene aquifer	0	-	-
5	Cretaceous aquifer	30	4-29	0.15-1.4
6	Fissured aquifer formation in Triassic – Jurassic aged sediments	45	3-28.0	0.3-4
7	Fissured aquifers in sedimentary, effusive, mafic rocks of Paleozoic age	280	0.4-96	0.02-11.7
8	Fissured aquifer in intrusive sediment	120	0.7-40	0.06-4

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.

5. Groundwater resources of the Orkhon river basin

5.1. Natural renewable groundwater resources

The maximum of the renewable groundwater resources in the whole Orkhon river basin is 190 mm/year*km^2 in the upper part of Tamir river valley and near Ugii lake. The renewable groundwater resources are 110 mm/year*km^2 near the confluence of the Orkhon river and the Selenge river; 100 mm/year*km^2 near Khishig-undur; 10-50 mm/year*km^2 near the northeastern part of Burengiin ridge and Bayan-undur mountain near Erdenet city and 5 mm/year*km^2 in alluvial, proluvial sediment intergranular aquifers and fissured aquifer which located near the mountains on the left and right sides of the Orkhon river valley. The renewable resources per 1 square kilometer are estimated as follows and it is focused on 6 different types of area.

1. 50-100 mm/year or 75000 m^3/year*sq km on average
2. 20-50 mm/year or 35000 m^3/year*sq km on average
3. 10-20 mm/year or 15000 m^3/year*sq km on average
4. 5-10 mm/year or 7500 m^3/year*sq km
5. 0-5 mm/year or 5000 m^3/year*sq km
6. Mixed or 10-190 mm/year*sq km

Table 3. Estimate of Orkhon river basin renewable groundwater resources

	Classification of renewable resources (mm/year/km^2)	Area *(km^2)*	Average flow *(mm/year)*	Renewable resources *(mln m^3/year)*
1	Extremely low (0-5)	21,809	5	107
2	Low (5-10)	10,072	7.5	76
3	Low to average (10-20)	8,544	15	128
4	Average (20-50)	5,625	35	197
7	Average to high (50-100)	1,591	75	119
9	Mixed (10-190)	6,145	150	819
	Total	53,786		1,448

From this table it is clear that extremely low renewable resources cover an area of 21,809 km^2 or 40.1% of the total area of the Orkhon river basin containing 7.5 percent of the total renewable groundwater resources. An area of 6,145 km^2 or 11.4% of the total basin area with mixed renewable resources of 10-190 mm/year contains 56.5 percent of the renewable groundwater resources. The most renewable groundwater resources are formed and recharged in the granular alluvial deposits of the river valley.

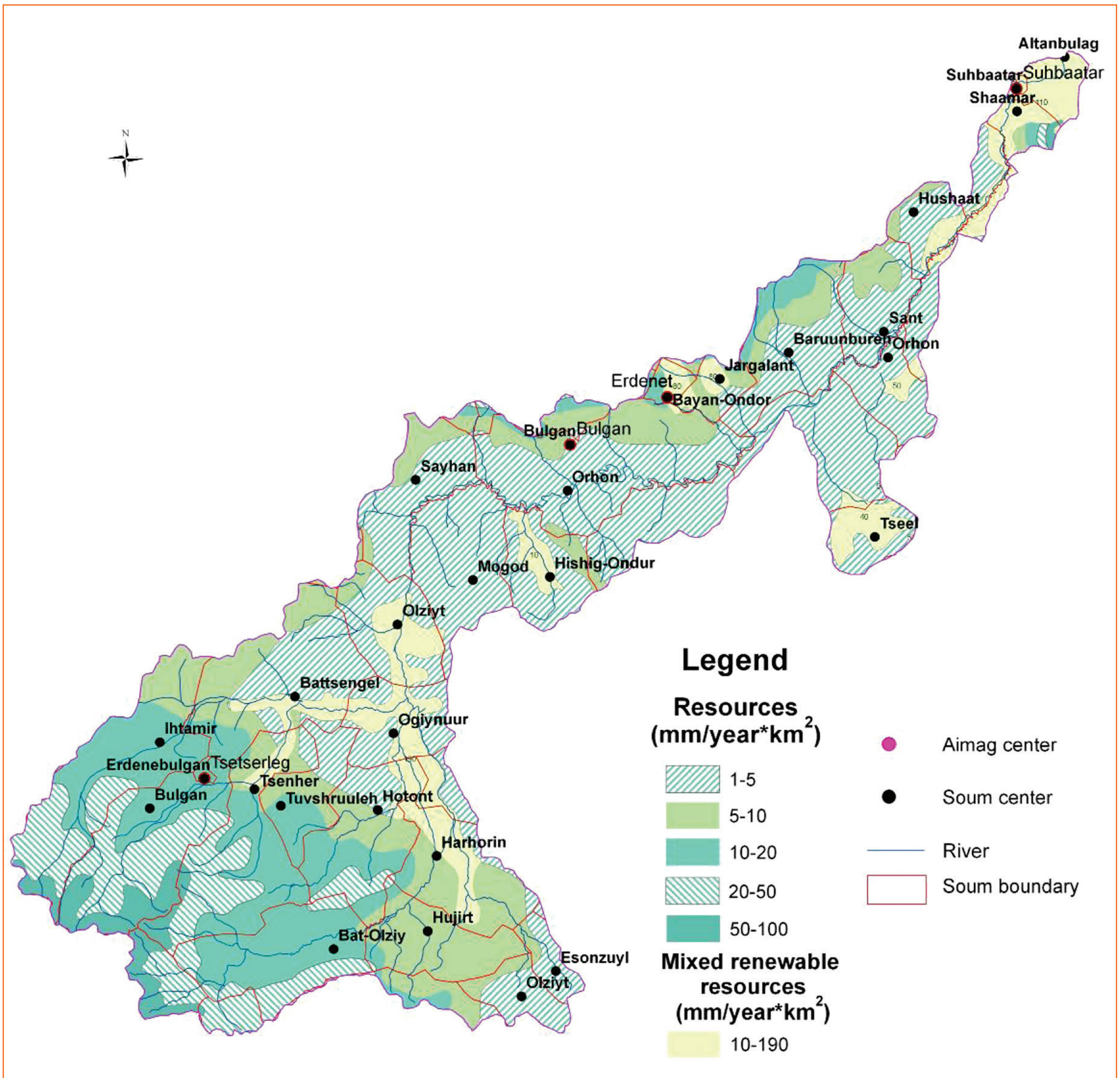

Figure 4. Renewable groundwater resources map of the Orkhon River Basin

5.2. Potential exploitable groundwater resources

On the basis of the Hydrogeological Map of Mongolia at scale 1:1,000,000, the potential exploitable groundwater resources per 1 square km are divided into the following 7 classifications:

1. 10 l/sec*km^2
2. 3-10 l/sec*km^2
3. 1.0-3.0 l/sec*km^2
4. 0.3-1.0 l/sec*km^2
5. 0.03-0.3 l/sec*km^2
6. 0.003-0.03 l/sec*km^2
7. < 0.003 l/sec*km^2

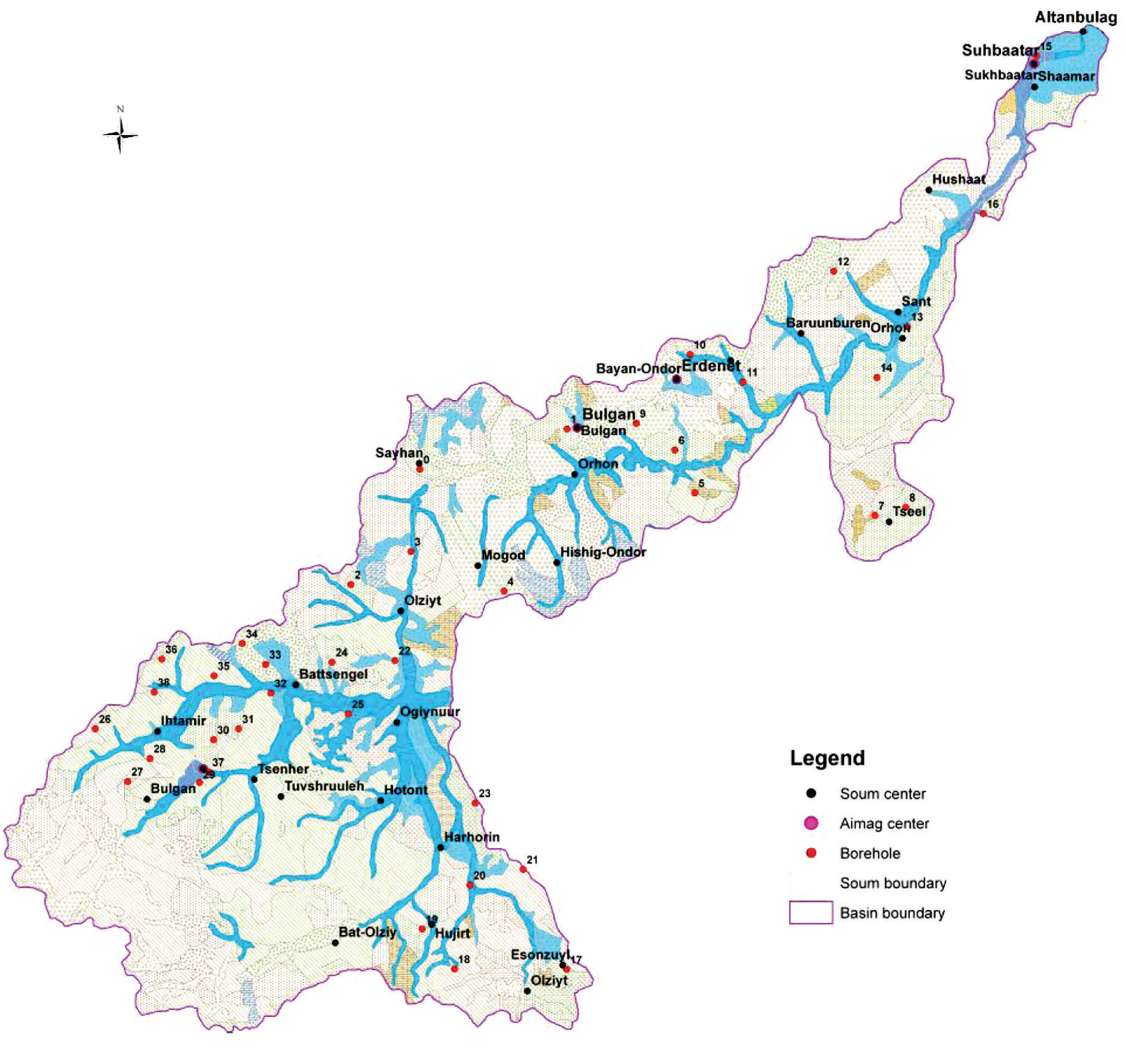

Figure 5. Potential exploitable groundwater resources map of the Orkhon River Basin

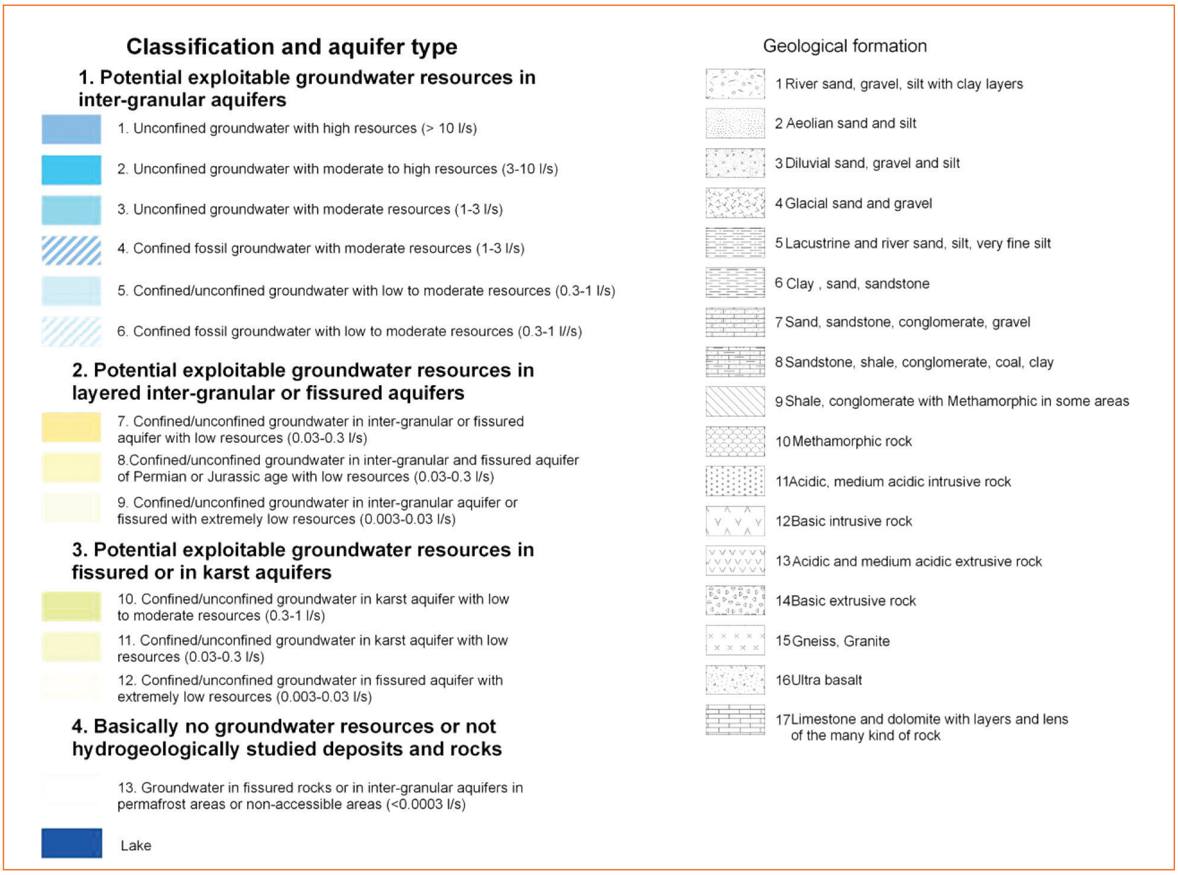

Figure 6. Legend of potential exploitable groundwater resources map

Borehole data is presented in *Table 4* which reflected on exploitable groundwater resources map.

Table 4 Borehole data

№	Static level [m]	Mineralization *[mg/l]*	Drawdown *[m]*	Yield *[l/sec]*	Depth of water encountered *[m]*
0	58.0	0.3	11.0	1.3	
1	17.0	0.2	3.0	2.0	
2	6.0	0.2	1.0	0.4	
3	10.0	0.3	10.0	1.0	
4	3.0	0.3	1.0	3.0	
5	21.0	0.3	2.0	1.3	
6	30.0	0.3	4.0	0.7	
7	53.0	0.6	29.0	5.1	60
8	26.5	2.2	1.5	2.0	70
9	15.0	0.7	4.0	10.0	
10	24.0	0.3		1.6	
11	5.0	0.4	20.0	10.0	
12	11.9	0.3	2.5	5.0	
13	27.5	0.5	2.3	2.0	
14	20.0	0.4	16.0	1.5	
15	1.3	0.5	1.5	4.8	
16	35.0	0.7	1.8	1.4	
17	7.3	0.8	3.3	2.0	
18	20.0	0.8	3.2	1.6	

№	Static level [m]	Mineralization [mg/l]	Drawdown [m]	Yield [l/sec]	Depth of water encountered [m]
19	6.0	0.3	12.0	2.0	
20	18.0	0.2	3.0	4.0	24
21	2.5	0.5	4.0	1.3	
22	0.2	0.3	3.0	0.4	
23	10.6	0.2	17.0	0.1	28
24	8.0	0.6	4.0	2.0	20
25	0.1	0.3	12.0	1.0	
26	11.0	0.2	0.4	3.0	
27	14.0	0.3	2.0	2.5	
28	1.1	0.2	6.0	6.0	
29	1.3	0.1	6.8	3.5	
30	3.0	0.3	18.0	2.5	
31	15.0	0.4	5.6	1.4	
32	38.0	0.5	8.2	2.8	
33	14.0	0.3	1.6	1.0	
34	29.0	0.3	6.0	16.0	
35	23.0	0.3	17.0	1.0	
36	46.0	0.2	3.0	3.5	

Table 5. Estimate of Orkhon river basin potential exploitable groundwater resources

Number of aquifer	Area [km²]	Potential exploitable groundwater resources per unit area		Resources [mill m³/year]
		[l/sec*km²]	[m³/year* km²]	
1	487	10	315000	153
2	5825	3	94600	551
3	3142	1	31500	99
4	41	1	31500	1
6	890	0.65	20500	18
7	181	0.165	5203	1
8	1123	0.165	5203	6
9	239	0.0165	520	0
10	37	0.65	20500	1
12	18216	0.0165	520	9
13	23605	0.003	94.6	2
Total	53,786			842

Some aquifer numbers (5, 11) are missing in the table. It means that kind of aquifers are not distributed in the basin. These numbers define what kind of aquifers they are (*Figure 6*).

According to the Table 5, there are 842 million m^3/year potential exploitable groundwater resources in the total area of 53,786 km^2 in the Orkhon river basin. 153 million m^3/year or 18.1 percent of total resources are in 0.9 percent of total area. The alluvial aquifers 1, 2, 3 are the most important and contain 803 million m^3/year or 95.3 percent of the total potential exploitable groundwater resources.

It is possible to extract 10 l/sec groundwater from 1 km^2 from the area where Orkhon river (downstream) meets Selenge river. The possibility is that 3-10 l/sec yield water can be extracted from 1 km^2 area where granular alluvial aquifers are distributed in the valley of Orkhon, North and South Tamir, Tsenkher and Khugshin Orkhon rivers.

5.3. Exploitable groundwater resources

Some 25 soum centers of 6 aimags and Sukhbaatar, Bulgan, Tsetserleg and Orkhon aimag centers are located in the Orkhon basin. Hydrogeological surveys were conducted to estimate the groundwater volume of Sukhbaatar, Bulgan and Tsetserleg's centralized water supply sources.

Orkhon aimag center supplies its drinking water demand from the Selenge basin. For soum centers water supply no specific groundwater survey was done. 10 soum centers are located in or near the flood plain of the Orkhon River and soum center population uses surface water and groundwater. The other 15 soum centers do not have rivers, springs, ponds nearby and they use groundwater only. Each soum center has 2-3 boreholes. Some 64 boreholes are used for the water supply of these 25 soum centers.

Table 6. Water sources used for Orkhon river basin-soum center population water supply

№	Aimag	Soum center	Water source	Soum center borehole numbers	Yield *[l/sec]*
1	Arkhangai	Ikh Tamir	North Tamir river and boreholes	4	0.7
2		Ugiinuur	Orkhon river, boreholes	3	3.6
3		Battsengel	North Tamir river and boreholes	3	5
4		Bulgan	Zuunmod river, boreholes	3	2
5		Ulziit	Orkhon river, boreholes	2	4
6		Khotont	Jarantain river, boreholes	3	3.1, 1.3
7		Tsenkher	Urd Tamir, boreholes	2	2.5, 8
8		Tuvshruulekh	Boreholes	3	1, 1.5
9	Bulgan	Khishig Undur		2	3
10		Saikhan	Boreholes	2	0.45, 1.5
11		Orkhon	Orkhon river, boreholes	2	2
12		Mogod	Boreholes	2	
13	Orkhon	Jargalant	Boreholes	6	3
14	Uvurkhangai	Yusunzuil	Springs, borehole	1	3.5
15		Ulziit	Khuisiin river, boreholes	2	2.2
16		Bat ulzii	Boreholes	3	1, 5, 4
17		Khujirt	Khujirt river, boreholes	3	5.5, 2.4, 2.7
18		Kharkhorin	Orkhon river, boreholes	6	5
19	Selenge	Altanbulag	Springs, boreholes	3	0.7
20		Khushaat	Orkhon river, boreholes	2	
21		Baruunburen		3	3.3
22		Orkhon	Orkhon river, boreholes	1	0.7, 3
23		Sant	Boreholes	3	1, 3.3
24		Shaamar	Orkhon river, borehole	1	1.5
25	Tuv	Tseel	Boreholes	2	5
	Total			67	

5.3.1. Groundwater aquifer of Sukhbaatar city

The city of Sukhbaatar has much surface water and groundwater resources, especially along the Orkhon and Selenge rivers. Alluvial and alluvial-proluvial sediment aquifers have much water in a large area. The boreholes can be drilled and used without doing any pre-hydrogeological surveys.

In 1983, R.Byambadorj did survey on centralized sources of Sukhbaatar city. He revealed that there are sufficient resources that can supply Sukhbaatar city water demand for many years in terms of hydrogeology. He did it with the aid of only 2 boreholes.

According to the survey of Sukhbaatar city centralized water supply sources, boreholes number 3 and 4 were drilled with a small diameter.

The yield of the boreholes was 38.4-48.2 l/sec; drawdown was 2.45-3.73 m; hydraulic conductivity was 42.5 m/day; diffusivity was $1x10^4$ m^2/day and aquifer thickness was over 100 m.

The groundwater is easy to be polluted because the groundwater level is shallow.

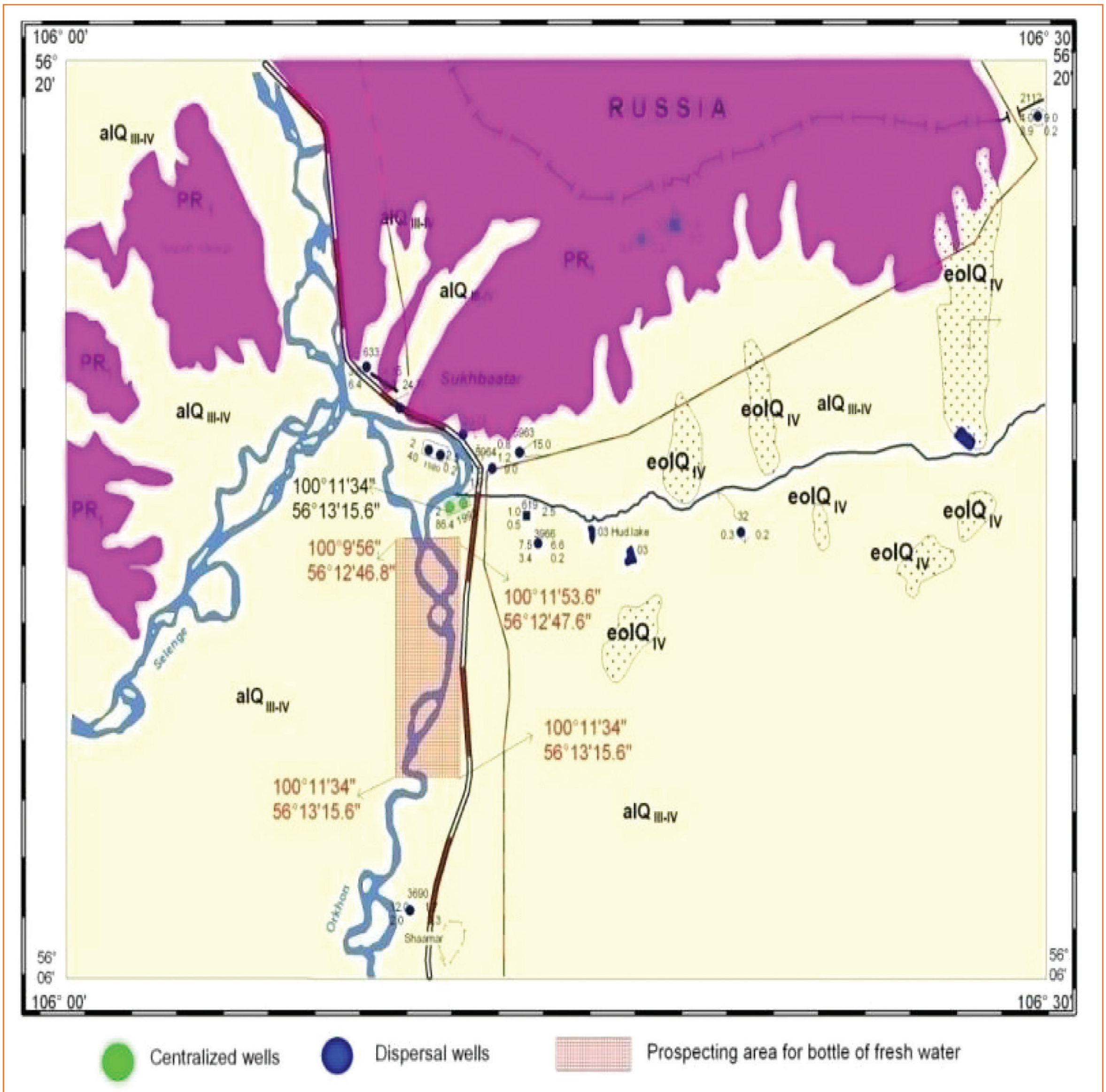

Figure 7. Sukhbaatar area hydrogeological map

The groundwater exploitable resources at Sukhbaatar city were recalculated in 2008 at 17,280 m^3/day.

5.3.2. Groundwater aquifer of Tsetserleg city

N.Munkhbaatar estimated that the alluvial sediment aquifer in the Urd Tamir river valley gives 19.9-31.2 l/sec yield and groundwater exploitable resource is 10,082.8 m^3/ day.

The groundwater exploitable resources at Tsetserleg were recalculated in 2012 at 5,702.4 m^3/day.

5.3.3. Groundwater aquifer of Bulgan city

The Quaternary-proluvial origin aquifer lies on top of Permian age metamorphic (layered and compressed) and effusive rocks near Bulgan city. Intrusive rocks are distributed near this area as well. D.Khatanbaatar did groundwater survey work between 1983 and 1984. During the survey work, 11 boreholes (1, 2, 3, 4, 5, 6, 7, 8, 10, 13, 16) with a depth of 27.2-77 m were drilled. Additional 11 boreholes (9, 11, 12, 14, 15, 17, 18, 19, 20, 21, 24) were drilled during the survey And test pumping was done in 17 boreholes (1-8, 16, 10, 13, 19, 15, 11, 12, 14, 9) with the help of 6 observation boreholes. The yield of borehole number 24 was 12.5 l/sec and drawdown was 11.09 m. Borehole numbers 17, 18 and 21 had a relatively high yield among other boreholes. In borehole number 17, the water level drawdown was 17.5 m and the yield was 6.3 l/sec; as for borehole number 18, drawdown was 24.0 m and yield was 5.3 l/sec. As for borehole number 21, water level drawdown was 14.9 m and yield was 10.2 l/sec. The groundwater exploitable resource is 4,907.6 m^3/day.

5.3.4. Erdenet city water supply sources

Erdenet city water supply source is located 61 km from the city. It is in the Selenge river valley and relevant data is put into the National groundwater report. The deposit's exploitable groundwater resources are total 247500 m^3/day, divided in A category 112000 m^3/year and C_2 category 135500 m^3/year as calculated by PNIIS institute.

5.3.5. Groundwater aquifer of Khutul

Khutul is one of the Mongolian important cement producing areas. The main water supply sources are located in the downstream part of the Nelge river which flows into Orkhon river.

The groundwater aquifer was first explored by a Russian hydrogeological expedition in 1980. They drilled 7 exploratory boreholes and the yield was 42.5-83.3 l/sec for a drawdown of 1.3-5.6 m (pumping). The groundwater exploitable resources of Nelge were estimated at 7,000 m^3/day [Borovikova, 1981].

5.3.6. Groundwater aquifer of Barjgar ulaan

This aquifer is located on the east bank of the Orkhon River in Selenge aimag and it is 2-2.2 km from the river bed. It is an alluvial intergranular aquifer composed of gravels and sand. The thickness is 30-60 m; permeability is 4-26.4 m/day or 19.6 m/day on average; transmissivity is 123-776.4 m^2/day or 388.4 m^2/day on average and diffusivity is $7.6x10^3$ m^2/day. The groundwater is found at a depth of 1.5-4.5 m in the boreholes. The yield is 2.5-15 l/sec for a drawdown of 4.0-8.9 m. The specific yield is 0.6-3.8 l/sec. The mineralization is 0.3 g/l and the water composition is hydrocarbon-calcium-natrium-magnesium. The water hardness is 2.6-3.7 mg-equiv/l. The groundwater exploitable resource is 1.98 thousand m^3/day (Nyatdari,1989). The level is $A+C_1$.

5.3.7. Groundwater aquifer of Enkh tal

Enkh tal is the source of Orkhon aimag's fruit and vegetable farms and Gombosuren conducted aquifer survey works [1985]. The borehole's yield was 28 l/sec and permeability was 57 m/day. The water composition is hydrocarbon-calcium-sodium. The mineralization is 0.2-0.3 g/l and hardness is 3.1-5.9 mg-equiv/l.

The potential exploitable resource of Enkh tal's groundwater aquifer is 5,500 m^3/day.

5.3.8. Other approved groundwater deposits

The information on the deposits not described above is included in Table 7.

Table 7. List of approved groundwater deposits

№	Aimag	Name of aquifer	Location		Resource [m^3/day]
			X	Y	
1	Uvurkhangai	Orkhon	102.796278	47.155389	10,800
2	Arkhangai	Shivert	101.5	47.6	432
3	Arkhangai	Urd Tamir river	101.366667	47.416667	10,545.3
4	Arkhangai	Del bag	102.241667	47.625	910.87
5	Bulgan	Maidar river	103.55	48.841667	4,907.5
6	Bulgan	Maidar river	103.425	48.783333	4,907.5
7	Orkhon	Upper part of Chingeliin river basin	104.006944	48.935	2,073.6
8	Orkhon	Middle part of Chingeliin river basin-1	104.001944	48.877222	1,028.16
9	Orkhon	Middle part of Chingeliin river basin-2	104.127778	48.968056	2,021.76
10	Orkhon	Lower part of Chingeliin river basin	104.168056	48.936111	2,073.6
11	Orkhon	Govil river valley	104.088056	49.076111	1,696.8
12	Orkhon	Erdenet river	104.0075	49.0075	2,109.5
13	Selenge	Orkhon	106.033333	49.716667	4,600
14	Selenge	Orkhon	106.187083	50.22175	17,280
15	Selenge	Narstiin hudag	105.602222	49.109444	501
16	Selenge	Sukhbaatar	106.188889	50.222222	9,208.5

6. Groundwater monitoring

Within the framework of "Strengthening Integrated Water Resources Management in Mongolia" project, 11 groundwater monitoring boreholes are equipped and observed in the Orkhon river basin. Data loggers are installed in these boreholes and measuring data is collected at intervals of 3-6 months. Both groundwater quality and groundwater level monitoring will be conducted in these monitoring boreholes.

Figure 8. Location of monitoring boreholes in the Orkhon river basin

NAMHEM conducts monitoring in one groundwater monitoring borehole in Tsetserleg city. But measurement is not continuous, in some years the measurement is not done. The groundwater level is measured by hand in the borehole.

Table 8. List of groundwater monitoring locations in Orkhon basin

№	Aimag	Soum	Well depth, m	Start date	Coordinate	
					X	Y
1	Bulgan	Orkhon	12	11.06.03	48°38'10.1"	103°33'00.4"
2	Orkhon	Bayan-ondor	52	11.06.04	48°58'46.3"	104°06'26.4"
3	Selenge	Orkhon-Tuul	25	11.06.04	48°57'14.6"	104°58'23.0"
4	Selenge	Eroo	34	11.12.06	106°37'30.9"	49°46'40.1"
5	Selenge	Orkhon	31.5	11.08.25	105°22'11.4"	49°07'07.9"
6	Selenge	Altanbulag	44	11.08.24	106°28'46.3"	50°16'12.8"
7	Selenge	Sukhbaatar	16	-	50°13'03.3"	106°10'54"
8	Ovor-khangai	Kharkhorin		-	102°47'52.1"	47°10'08.6"
9	Ar-khangai	Khotont	65	11.01.20	102°28'38.8"	47°22'02.6"
10	Ar-khangai	Battsengel	40	11.01.21	101°59'27.1"	47°48'05.5"
11	Ar-khangai	Olziit	40	11.01.21	102°33'15.3"	48°06'06.2"

Summary

1. The groundwater resources are distributed unequal in the Orkhon river basin. The sedimentary rocks in the valley of the Orkhon River and it's tributaries have the highest potential for groundwater. The hills and mountains in the Orkhon river basin have the lowest potential for groundwater.
2. For planning purposes the estimate of the exploitable groundwater resources is derived from the Potential exploitable groundwater map. However if the exploitable groundwater resources have been determined by a hydrogeological survey then result of the survey should be used.
3. The potential exploitable groundwater map shows the areas with highest groundwater potential. In case the groundwater is to be abstracted for the purpose of industrial or urban center water supply then a hydrogeological detailed survey is required.

7. Used publications

1. Reports and materials of groundwater deposits which their usage resources have been determined, or some reports on hydorgeological study which kept in geo-data centre fund of the Mineral Resource Authority and unpublished in scientific and cognitive publications, 1932-2009.
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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 9.

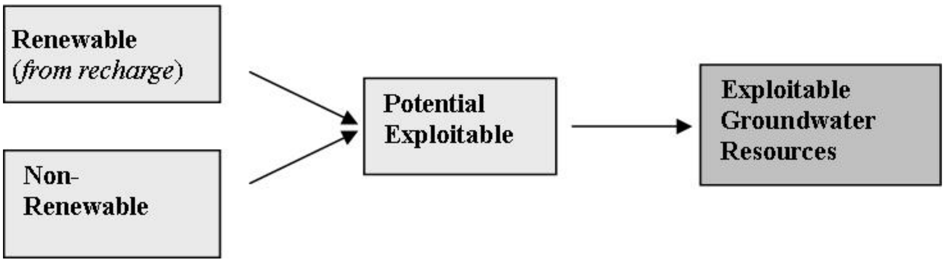

Figure 9. Sequence considered in the assessment of the groundwater resources

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.

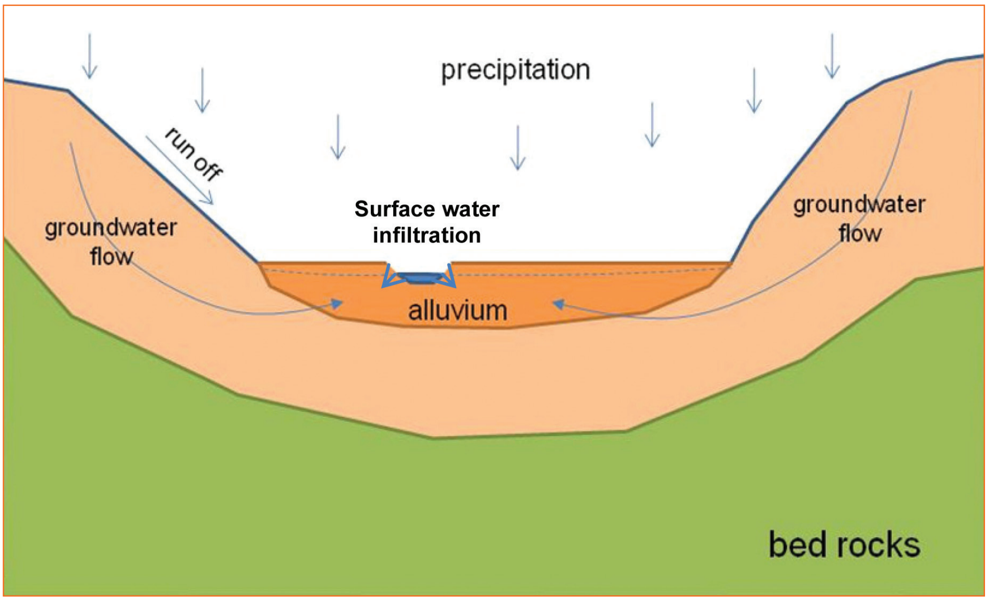

Figure 10. Renewable groundwater resources in an unconfined alluvial aquifer: recharge by infiltration of surface water and precipitation and groundwater flow from adjacent areas

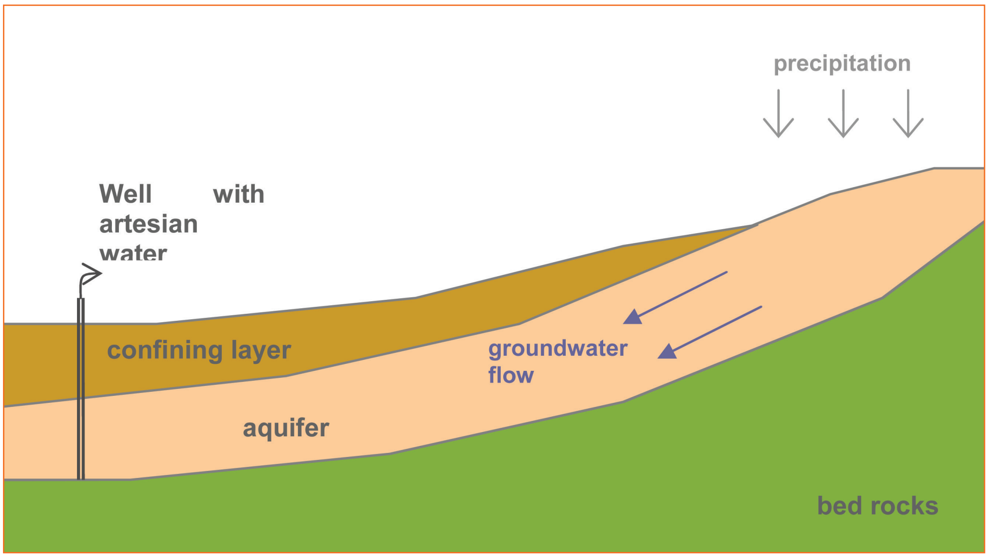

Figure 11. Groundwater resources in a confined aquifer: recharge by infiltration of precipitation in distant elevated area and groundwater flow to aquifer in low lying area

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.

C. 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.

D. 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

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Introduction

The Orkhon River basin concentrates simultaneously a diversity of ecosystems and a diversity of valuable human uses. Good environmental conditions and water quality are an asset for the human activities so far, but recent changes of practices and economic development may degrade this situation.

The main objectives of this report are to describe the recent changes related to water quality and ecological conditions, to determine the main causes of environmental degradation, and to propose recommendations to limit the loss of ecological services in the Orkhon River basin.

1. Research on surface water quality

1.1. Research purpose

Purpose of this research is to make an assessment on current situation of water quality, chemical composition and pollution in the Orkhon River and its tributaries, to identify its pollution source and to determine the way of protecting water quality. The Orkhon is the longest river with the freshest water in our country.

1.2. Research object

It covers the Orkhon River and its tributaries fed by the Khangai Mountain ranges and it passes through Arkhangai, Uvurkhangai, Bulgan, Orkhon, Darkhan-Uul and Selenge aimags as well as some lakes.

1.3. Research status

Research work on chemical compositions and property of river water in Mongolia so far has been repeatedly carried out by researchers of Mongolia and Soviet Union (former Russia). And the results from such research works have been included in some literature by Bespalov (1951), Kuznetsov (1959), N.Tsend (1963, 1982), N.Tsend and Sh.Sodnombaljir (1964), G.Tuvaanjav (1978), Myagmarjav and G.Davaa (1999) and Ch.Javzan (2006), etc. A complete research work on chemical water composition of large and small rivers in the Selenge river basin (RB) was firstly done since 1973 and consequently, natural being of above rivers has been firstly identified. Therefore, research work has been carried out on water pollution, environment and ecology. In this regard, it's been reflected on number of literature released by national and international researchers and the literature includes the "Hydro-chemistry of Selenge River" released by A.Munguntsetseg, teacher and PhD of NUM. In this literature, the results from the research works carried out during in 1974-1975, 1981-1982, 1988-1989 and 1998-1999 have been precisely noted. Also, some research work on surface water in Mongolia was carried out by the Central Hydro-Chemical Laboratory of the Scientific Institute for Water Exploration (1966-1997), the Central Geological Institute, and the Water laboratories of the Geo-ecological Institute. For example, it's been clearly reflected on the "Some geo-ecological issue in Mongolia", literature released by scientist and researchers of the Geo-ecological Institute over the rivers' water quality research in the Orkhon RB, and some materials released by the Central Laboratory for Environmental Measurement over issue of water quality and chemical composition of the Orkhon River.

1.4. Research methodology

A research as widely as possible was carried out on the rivers to collect previous results and materials and to make the related analysis and assessment, comparison was needed with the related standard and normative which is currently adhered in our country. According to the "Surface water standard: MNS 4586-98" and the "Normative to classify purity class of surface water" (NCPCSW), it is classified by six classes when making assessment on the river's water quality.

- I class – very pure water
- II class – pure water

- III class – slightly polluted water
- IV class – polluted water
- V class – largely polluted water
- VI class – extremely polluted water

When we deal with wastewater which is being dumped into natural water and soil, we have used the "MNS4943:2011 standard for effluent to the environment of treated wastewater". It is difficult to make an assessment on water quality due to there is no standard or normative in our country which indicates the accepted maximum volume of heavy metal contained in sediments on the bottom of river. Therefore, we have used the "pollution level of heavy metal which is contained in aquifer on the bottom of surface water" released by researchers of the Federal Republic of Germany on the Elbe River [6].

Table 1. Muller's classification which sorted out the microelements' volume contained in aquifer on the bottom of surface water, mg/kg

Class	As	Cd	Cr	Pb	Hg	Ni	Zn	Cu
0	0.0195	0.00045	0.135	0.030	0.0006	0.102	0.1425	0.0675
1	0.039	0.0009	0.270	0.060	0.0012	0.204	0.285	0.135
2	0.078	0.0018	0.540	0.120	0.0024	0.408	0.570	0.270
3	0.156	0.0036	1.080	0.240	0.0048	0.816	1.140	0.540
4	0.312	0.0072	2.160	0.480	0.0096	1.632	2.280	1.080
5	0.624	0.0144	4.320	0.960	0.0192	3.264	4.560	2.160

For a chemical composition, surface water is classified based on some principles below. It is classified as the 1st and 2nd dominant ions by anion majority and they are separated from each other. If ion contained in chemical composition is more than 50 mg-equivalent (%), it is subject to the 1st dominant ion. If it is not less 10 mg-equivalent (%) rather than the 1st dominant ion, it is subject to the following dominant and classified as below:

- HCO_3 (hydrocarbonate water class includes river, lake and groundwater with a small mineralization)
- SO_4 (sulfate class includes all kinds of water which have a chemical property between hydrocarbonate and chlorine classes)
- Cl (chlorine class includes mostly ocean and sea water, as well as ground water with a large mineralization)

If interaction between these ions is very close (less than 10 mg-eqv (%)) it is subject to the mixed class. By cation, it is divided into 4 groups such as Ca (calcium), Mg (magnesium), Na (sodium) and mixed. In view of anion and cation, it is divided into the following types:

- if $HCO_3^- > Ca^{++} + Mg^{++}$ mg-eqv/litre, it is subject to the 1st type of water
- if $HCO_3^- < Ca^{++} + Mg^{++} < HCO_3^- + SO_4^{--}$ mg-eqv/l, the 2nd type of water
- if $HCO_3^- + SO_4^{--} < Ca^{++} + Mg^{++}$ mg-eqv/l, the 3rd type of water
- if $HCO_3^- = 0$, it is subject to the 4th type of water.

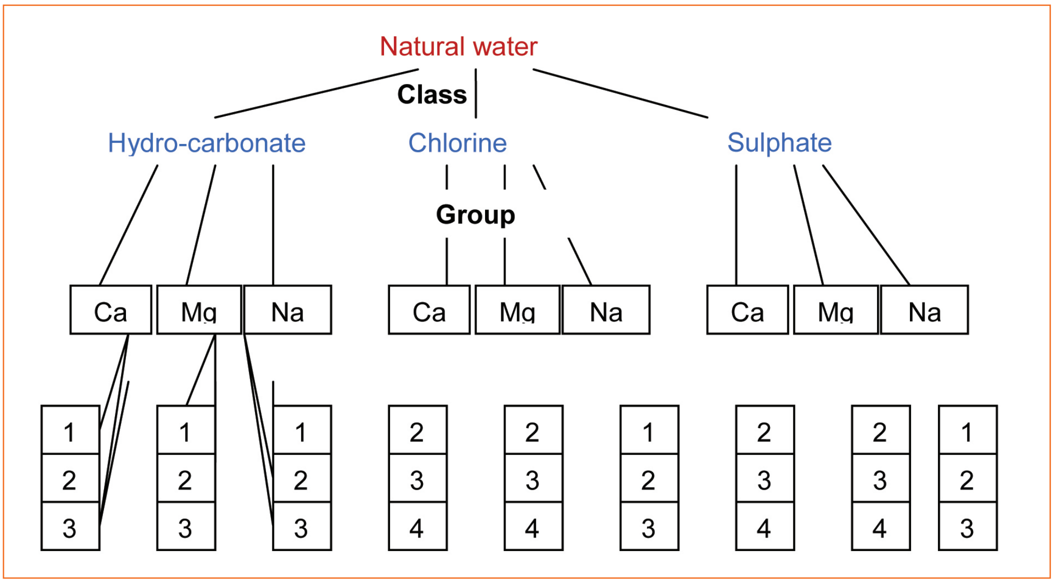


Figure 1. Natural water class / according to O.A.Alekin's

As there are many number of water classes by its mineralization, our classification below is generally based on the classification by A.M.Ovchinnikov considering the related normative for drinking, domestic and livestock water. Please see table below:

Table 2. Classification of natural water by its mineralization

No.	Mineralization level	Mineralization, g/l
1	Very fresh or with a low mineralization	< 0.20
2	Fresh or with a medium mineralization	0.21-0.50
3	Quasi-fresh or with a relatively substantial mineralization	0.51-1.00
4	Quasi-salty or with a large mineralization	1.01-3.00
5	Salty	3.01-7.00
6	Very salty	>7.01

There are many classifications of water hardness and we usually classify as below based on the classification by O.A.Alekin, Russian scientist and hydro-chemist by comparing it to the related standards in our country:

Table 3. Classification of water hardness

No.	Hardness level	Hardness, mg- equivalent/liter
1	Very soft	<1.50
2	Soft	1.51-3.00
3	Slightly soft	3.01-5.00
4	Slightly hard	5.01-7.00
5	Hard	7.01-9.00
6	Very hard	>9.01

2. Results from research of surface water quality

2.1. Quality and chemical composition of surface water

2.1.1. Orkhon River.

It is a large tributary of the Selenge River which joins from its right side and the longest river (1125 km) in Mongolia. The river is provided by water from 133.000 km^2 which is some 47% of the Selenge River watershed. And its width at its source is 40-60 m, at its mouth is 120-150 m, average depth is 1.5 m and the deepest is 4 m. Average discharge near Sukhbaatar soum is 101 m^3 per second and the largest discharge is 891 m^3/sec. The Orkhon River originates in the Suvraga Mountain in Tsenkher soum, Arkhangai aimag and flows into the Selenge River before Russian boundary (in Sukhbaatar soum centre) by passing through Arkhangai, Uvurkhangai, Bulgan and Selenge aimags. According to research, water mineralization in the rivers in the Orkhon RB, is typically very low (50-300 mg/l) and it ranges from very fresh to fresh. For hardness, it mostly ranges from very soft to slightly soft. In ion structure in the river water, hydro-carbonate (HCO_3), is dominant rather than other anions, anion ratio $HCO_3^- > SO_4^{2-} > Cl^-$, cation ratio $Ca^{2+} > Na^+ + K^+ > Mg^{2+}$. Tributaries (except small rivers in valley of the Ult River) flowing into the Orkhon River are considered mountain rivers with fresh water which still keep their original form. From midstream to downstream of the Orkhon River, it is largely affected by the human activities of urban areas, manufacturing and mining. This is due to tributaries such as Khangal, Tuul, Kharaa, Shariin and Eroo Rivers which are relatively polluted in our country. Therefore, this pollution significantly affects water quality in the Orkhon River.

2.1.2. Upstream Orkhon River

The upstream part of the Orkhon River basin covers the upper parts of the South and North Tamir, Tsenkher and Tsetserleg Rivers which originate from the Khangai Mountains with clean, fresh, clear and soft water. It is considered that the Orkhon River source is the Ikh Teel River which originates in the Suvarga Mountain and its tributary the Ult River.

The Ult River's tributaries are Ulziit Teel, Budant Teel, Khargui, Shiirt, Zuun Sudut, Baruun Sudut, Guut rivers and gold mining activities are likely centralized in the valleys of these tributaries. A total of 1106 hectare land with a fertile soil and plant cover has been badly affected until it became unable to settle down, herd livestock and even unable for wild animals to live there. Also base soil with a long years' permafrost has been removed away, small river bed has been changed, surface and groundwater resources have been sometimes reduced by 50%, and it's been polluted by suspended substance [2]. The Ult River is not having runoff generally as small tributaries have become dry and flow underground. There is a high risk of possible pollution into the Orkhon River. This is due to intentional wrong actions by human, and flood-caused polluted and turbid water flows into the Orkhon River through the Ult River bed. Water quality research carried out on the tributaries near the Orkhon River in 2005-2006 is mainly included here [4]. The Ikh Teel River was a mountain river with very soft (hardness 1.00mg-eqv/l) and very fresh water (mineralization 148.7mg/l). But it's been affected by domestic pollution due to the growing number of population and livestock here. According to hydro-chemical study in May 2006, the Ikh Teel River included in the *polluted* class as it was tested by surface water purity classification.

Pic - Ikh Teel River, source of the Orkhon River

Pic - Pollution in the Ult River

<u>*Ulziit Teel River:*</u> This is a tributary of the Ult River and runoff here is basically disappeared. Man-made lakes are commonly found here due to mining activities. For chemical composition, the river water is subject to the mixed class, Na group, 2nd type and its mineralization is 164.2 mg/l or very fresh, its hardness is 1.40 mg-eqv/l or very soft and the river is included in the "Polluted" class according the ammonium ion.

Pic - Ulziit Teel River (gold mining)

Pic - Pebble of the Ult River

<u>*Bodonch River:*</u> This is a tributary of the Ult River and its water is very fresh (mineralization 122.0 mg/l) and soft (hardness 1.60mg-eqv/l). Unfortunately, its runoff was dried and blocked due to gold mining. The river has been turbid and polluted as Salnik LLC used to directly dump its wastewater into it. So, it is subject to "Largely polluted" class by volume of ammonium ion and the suspended solid according to the Normative to classify purity level of surface water (NCPLSF).

Pic -. Pollution in the Bodonch River

Gold mining activities near the Orkhon River source are likely centralized and riverbeds of the related tributaries have been changed along the length of 21 km. Moreover, river runoff, forest resources, fertile soil and green land have been largely affected by ecological damage and consequently, high risk of pollution in the Orkhon River exists. Before joining the Ulaan River in Bat Ulzii soum, Uvurkhangai aimag, the river is subject to hydrocarbonate class, Na and Ca group, 1st type, carbonate (HCO_3^-) is solely dominant rather than anion, anion ratio $CO_3^- > SO_4^{2-} > Cl^-$ and cation ratio $Na^+ + K^+ > Ca^{2+} > Mg^{2+}$. For quality, its mineralization 148.7mg/l, hardness 1.00 mg-eqv/l, neither turbid nor polluted and it is subject to “pure” class according to the NCPLSW [1]. Near Ulaan Tsutgalan waterfall, the Orkhon River water is found fresh and swift-flowing passing through rocky cliffs. Large and dark coloured rocks/stones creating rapids are found in the middle of the river.

Pic - Orkhon River in Bat-Ulzii soum

Pic - Near headwork of irrigation system, Orkhon River in Kharkhorin soum

Further downstream the Orkhon river, according to research at the irrigation system headwork near Kharkhorin soum, the river is subject to hydrocarbonate class, Ca group, 1st type, hydrocarbonate is dominant than anion (HCO_3^-), anion ratio $HCO_3^- > SO_4^{2-} > Cl^-$, cation ratio $Ca^{2+} > Na^+ + K^+ > Mg^{2+}$. For quality, its mineralization raised up to 167.3 mg/l, hardness up to 1.75 mg-eqv/l, respectively. As mud and pollution is largely found here, it is subject to the “largely polluted” class according to the NCPLSW and its water quality and chemical composition have been changed [1].

There are two river stations involved in the environmental monitoring programme on the Orkhon River. The first river station in the highest part conducts observations between May and Oct and was established on the Orkhon River in Bat Ulzii soum in 2006. Another one has been working since 1977 on the Orkhon River. Data and information received from these river stations are analyzed by the Environmental Analysis Laboratory of Uvurkhangai aimag and its result is sent to the Central Laboratory for Environmental Measurement (CLEM), below result was made by CLEM based on the data received from the Orkhon-Kharkhorin river station according to long years’ average indicator of the river’s upstream [8].

Source: Data from the Kharkhorin monitoring station

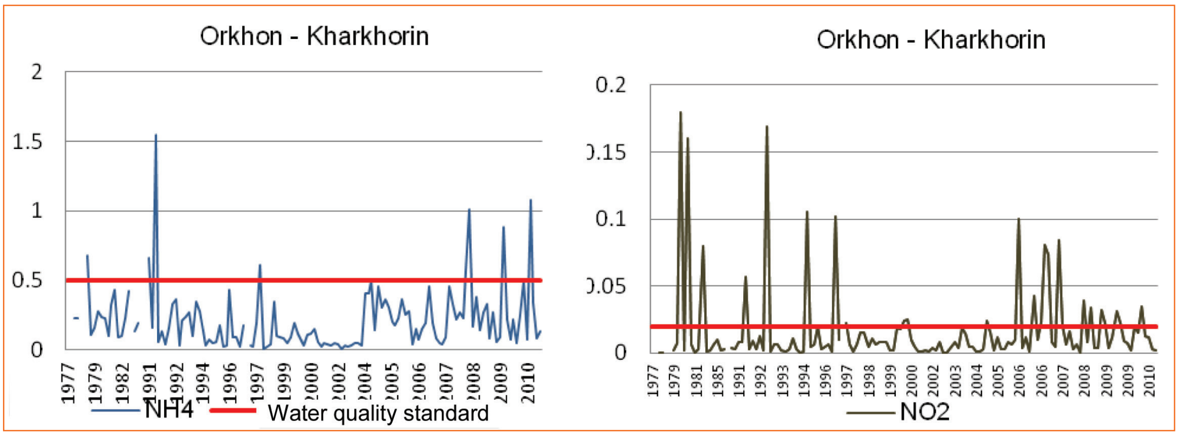


Figure 2. Ammonium and nitrite ion contained in water of the Orkhon River, mg/l

Source: Data from the Kharkhorin monitoring station

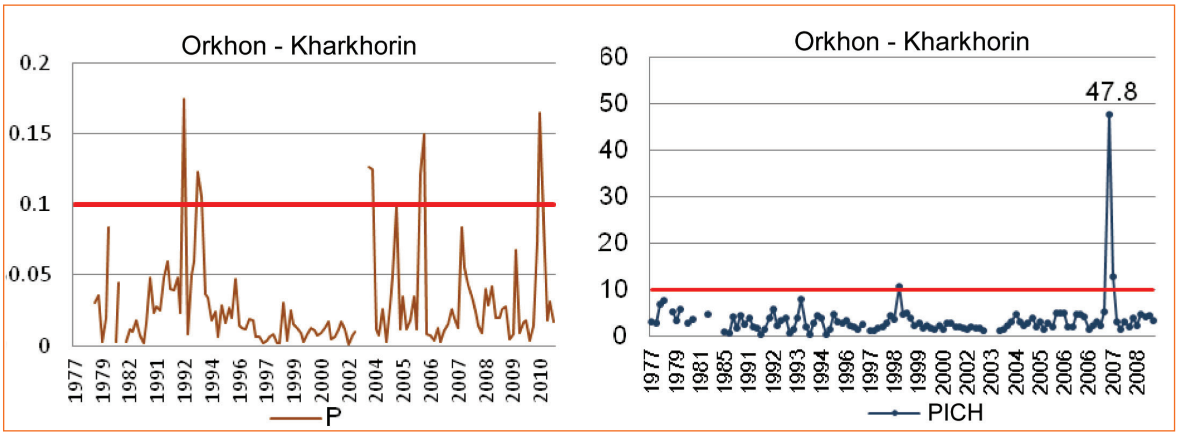


Figure 3. Phosphorus and organic oxide, permanganate oxidation contained in water of the Orkhon River, mg/l

As we can see from above, water pollution in the Orkhon River in the vicinity of Kharkhorin soum is substantial and it corresponds to the result from previous research. Especially the ammonium ion component indicating a new pollution tends to increase in recent years.

Most rivers originating in the Khangai Mountains and located in the basin near the Orkhon River source have the purest and freshest water in our country and there is no negative ecological impact on them. These are swift-flowing mountain rivers and they are all subject to hydrocarbonate class and most are subject to Ca group and type 1-2. Some rivers are not affected by human activities except some small rivers in the valley of the Ult River which is a tributary joining the Ikh Teel River from the east side, as well as Nariin Khamar River [4].

2.1.3. Tributaries which flow into source of the Orkhon River

While the Orkhon River passes through Bat Ulzii soum, Uvurkhangai aimag, some small rivers flow into it from its right side. These are mountainous rivers with fresh water and their ecosystem is not damaged generally. These include: <u>Gorkhiin River</u> (C^{Na}_{II}, mineralization 189.4 mg/l, hardness 1.50 mg-eqv/l, pure and fresh, and its tributaries are Khurvuulgu /C^{Na}_{II}, mineralization 141 mg/l, hardness 1.1 mg-eqv/l, pure and fresh/, Jimger, Khoshgit, Tongorog /C^{X}_{II}, mineralization 170 mg/l, hardness 1.6 mg-eqv/l/), *Uliastai River* (C^{Ca}_{II}, mineralization 198.8 mg/l, hardness 1.85 mg-eqv/l, pure and fresh), *Ulaan River* (C^{Na}_{I}, mineralization 87.4 mg/l, hardness 0.55 mg-eqv/l, pure and fresh and its tributaries are Khurment and Biluut), *Khunug River* (C^{Ca}_{II}, mineralization 115.6 mg/l, hardness 1.2 mg-eqv/l, pure and fresh), *Tsagaan River* (C^{Na}_{II}, mineralization 90.0 mg/l, hardness 0.80 mg-eqv/l, pure and fresh and its tributaries are Khamart / C^{Na}_{I}, mineralization 100 mg/l, hardness 0.5 mg-eqv/l, pure and fresh/, Moilt /C^{Ca}_{I}, mineralization 127 mg/l, hardness 0.7 mg-eqv/l, slightly polluted/, Uvt / C^{Na}_{I}, mineralization 196 mg/l, hardness 0.9 mg-eqv/l, slightly polluted/, Ar aguit), *Adag Turuu River* (C^{Ca}_{II}, mineralization 258.6 mg/l, hardness 2.2 mg-eqv/l, slightly polluted), *Khujirt River* (C^{Na}_{I}, mineralization 460.9 mg/l, hardness 3.0 mg-eqv/l, slightly polluted, the river is included in the "polluted" class after joining the wastewater from Khujirt camp).

Ulaan River: before joining the Orkhon River in Bat Ulzii soum. The chemical composition is subject to hydrocarbonate class, Na group, 1st type, hydro-carbonate is dominant rather than anion (HCO_3^-),anion ratio $HCO_3^- > SO_4^{2-} > Cl^-$, cation ratio $Na^+ + K^+ > Ca^{2+} > Mg^{2+}$. For quality, its mineralization is 87mg/l or very fresh, hardness 0.55 mg-eqv/l or very soft, mountainous fresh water, and its aquifer and rocks are different from others by round-shape and red colour. Many local and tourists visit here as it is considered the waterfall. In some summers, the waterfall of the Ulaan River disappears due to runoff reduction and underground flow.

Pic - Ulaan Waterfall /Aug 2006/

Tsagaan River: The chemical composition is subject to hydrocarbonate class, Na group, type 2, and for quality, its mineralization is 90.0 mg/l or very fresh, hardness 0.8 mg-eqv/l or very soft and mountainous fresh water. The river is largely polluted downstream after passing through Bat Ulzii soum before reaching the Orkhon River. It clearly shows that the river is in domestic pollution caused by local residents and livestock.

2.1.4. Midstream Orkhon River and its tributaries

The midstream Orkhon River covers the South Tamir River from Tsetserleg, the North Tamir River from Ikhtamir soum center, the Khaluun Usnii gol from Tsenkher hot spa and the Orkhon River from the Hujirt tributary. Of all the tributaries in this part, the Tsagaan soum and Khukh soum rivers, which firstly flow into the Orkhon River from its left side via southern soums of Arkhangai aimag, are subject to hydrocarbonate class, Ca group, type 1, and for quality, its mineralization 366.-372 mg/l or fresh, hardness 3.45 mg-eqv/l or very soft water. These rivers are in "polluted" class in summer time due to local herdsmen summer camps in valleys of these small rivers.

The most mineralized, polluted and hardest river amongst the tributaries which flow into midstream of the Orkhon River is the Khugshin Orkhon River and its hardness near Kharkhorin soum is 3.70 mg-eqv/l and considered the hardest compared to other

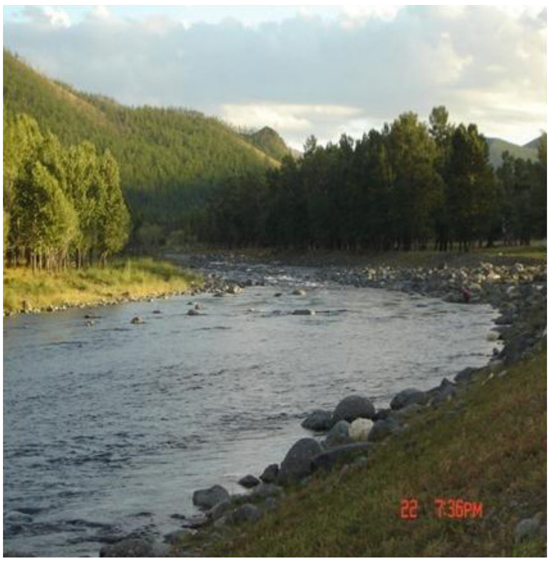
Pic - Khugshin Orkhon River near Kharkhorin

rivers around. The Khugshin Orkhon River is alternatively called Nariinii River after passing through west part of the Ugii Lake. But its pollution is almost the same however there is a reduction in hardness (2.50 mg-eqv/l). Even though it is a small river, it is largely polluted and turbid during warm seasons. It will substantially impact on water quality of the Ugii Lake and the Orkhon River.

Khundlun River (C^{NaCa}_{I}, mineralization 516 mg/l, hardness 4.0 mg-eqv/l and slightly polluted) flows into the Khugshin River. Kharz River (C^{Ca}_{I}, mineralization 127 mg/l, hardness 0.7 mg-eqv/l) and Khavtsal River flow into the Khundlun River._

Tamir River, a large tributary of the Orkhon River's midstream, is the only river with the freshest and softest water amid rivers around this area. In the South Tamir River's upstream near Bulgan soum, Arkhangai aimag, its water is subject to hydrocarbonate class, Ca group, type 1, hydrocarbonate is dominant rather than anion (HCO_3^-), anion ratio $HCO_3^->SO_4^{2-}>Cl^-$ and cation ratio $Ca^{2+}>Na^++K^+>Mg^{2+}$. For water quality, its mineralization is 96.5mg/l or very fresh, hardness 0.85mg-eqv/l or very soft, and it consists fresh water according to the NCPLSW. In the vicinity of Tsenkher soum, there is a slight change in water quality and chemical composition of river water such as hydrocarbonate class, Na group, type 1 and no change in anion ratio. But there is a change in Na ion and moved to the 1st and became $Na^++K^+>Ca^{2+}>Mg^{2+}$. For quality, its mineralization and hardness have been increased /mineralisation 137.6mg/l and hardness 0.90 mg-eqv/l/, but it still has very fresh and very soft water. But according to the NCPLSW, it has moved to the *polluted* class. There are a number of large and small tributaries which flow into the South Tamir River such as *Tsenkher, Tsetserleg, Mogoi, Teel, Jargalant, Bugat, Khoshigt, Nariin, Chandmani, Khukh Davaa and Khavtgai Modot, etc* [4].

North Tamir River's chemical composition is similar to the South Tamir River's and it divides into South and North rivers on its upstream part. Both South and North rivers both have the same fresh, soft, swift-flowing and mountainous water. There are many large and small rivers which flow into the North Tamir River such as *Khujirt, Ikh Shivert, Emt, Dood (down) and Deed (up) Nariin, Jargalant, Delgerekh Bulag, Dood Khavchig, Shar Bulag, Ust Tag, Khukh Nuur, Maraan Tag, Ekhen Khavchig, Khatuu, Angarkhai and Davaanii Gol, etc* with a fresh, pure and soft water. The South River has the same fresh, soft and swift-flowing water as the North River's. It is called typically the South River after joining *Zamt (C^{CaNa}_{I}, mineralization 88.4mg/l, hardness 0.75mg-eqv/l, pure) and Uliastai (C^{CaNa}_{I}, mineralization 95.4mg/l,*



Pic - The South Tamir River

hardness 0.75mg-eqv/l, pure) rivers with a large stones and mountainous, fresh and soft water. *Duganiin Shivert River (C^{Ca}_{I}, mineralization 65.3mg/l, hardness 0.50mg-eqv/l, extreme pure)* flows into the South River as its tributary from its left side [4]. The North and South rivers and their tributaries are very soft, very pure, non-polluted and swift-flowing, and contain rain/snow water. The South and North Tamir rivers haven't affected by human activities and still keep their original form. By joining each other and flowing into the Orkhon River, it positively affects the river water quality and runoff.

While the Orkhon River pass through the territory of Saikhan soum, Selenge aimag and Baruunburen soum, Selenge aimag, some tributaries flow into it from its left side such as *Ugalz River* (C^{Na}_{I}, mineralisation 309 mg/l, hardness 2.65 mg-eqv/l, "very largely polluted"), *Khuremt River* (C^{Na}_{I}, mineralisation 601 mg/l, hardness 4.3 mg-eqv/l, "polluted"), *Dundat River* (C^{Ca}_{I}, mineralisation 500 mg/l, hardness 4.65mg-eqv/l, "slightly polluted"), *Burgaltai River* (C^{Ca}_{I}, mineralisation 322 mg/l, hardness 2.9 mg-eqv/l, "slightly polluted").

2.1.5. Downstream Orkhon River and its tributaries

The downstream part of the Orkhon Basin stretches from Erdenet to the junction of the Orkhon and Selenge rivers.

Khangal River is included in a list of rivers which significantly affect water quality and chemical composition of the Orkhon River. Quality and component in the Khangal River have been changed and increasingly polluted year by year. The Orkhon River was polluted due to influence by the Khangal River, there have been several cases in some months such as change in its chemical composition and sulphate ion was dominant. Under most events, all macro, micro and bioactive elements' volume contained in water have been increased and consequently, the Orkhon River has been polluted [3]. Erdenet River which flows through south part of Erdenet city (17.6 km in length), Govil River on the east of Erdenet (15.5 km in length), Zunii River on the north-east of Erdenet (now there is a wastewater lake created by processing plant) altogether originate the Khangal River and it flows around 70 km and flows into the Orkhon River from its left side. This region was undergone the water research by organisations such as (teacher/scientists of) NUM and Geological Institute, etc in 1975 before Erdenet's mining operation and in 1982 after the mining operation, respectively [3]. According to the research, water mineralization has been changed depending on a seasonal condition and Erdenet River water mineralization was 519-829 mg/l, hardness 6.96-7.20 mg-eqv/l, Govil River's average mineralization was 503 mg/l, hardness 7.89 mg-eqv/l, Zunii River's mineralization was 372 mg/l, hardness 4.60 mg-eqv/l and Khangal River's mineralization was 585 mg/l, hardness 5.44 mg-eqv/l. As we can see from above, these rivers' mineralization and hardness were high, generally. This region's water is slightly alkaline (pH 7.3-8.3), organic substance permanganate oxidation 0.5-8.7 mg/l, dissolved oxygen (DO) 9.46-11.71 mg/l, solute carbonic gas 13.8-14.5 mg/l, non-organic phosphor 0.014-0.070 mg/l from bioactive elements, ammonium ion 0.01-0.07 mg/l, silicon oxide 1.08-1.89 mg/l, total iron 0.12-1.26 mg/l, fluoride ion 0.9-1.0 mg/l, copper 0.002-0.082 mg/l from microelements and molybdenum 0.2-0.33 mg/l, respectively.

Table 4. Chemical water composition of the Khangal River as of 1975

Date, month	Σ_{ion} mg/l	Hardness mg-eqv/l	pH	Main ions, mg/l					
				Ca^{2+}	Mg^{2+}	$Na^{+}+K^{+}$	HCO_3^-	SO_4^{2-}	Cl^-
III/17	432.5	5.56	7.80	60.1	31.1	63.2	366.1	8.21	13.8
IY/10	480.1	5.31	7.60	60.1	28.0	63.0	305.1	13.25	10.6
IY/14	557.3	4.96	7.40	60.1	28.7	59.9	305.1	8.97	13.8
YII/15	453.5	4.26	7.80	48.1	22.5	24.1	305.1	8.1	4.5
Average	480.7	5.02	7.65	57.1	27.4	52.5	320.3	9.6	10.7

In 1975, before the Erdenet's mining operation, the Khangal River water was fresh (average mineralization 480 mg/l), slightly hard (average hardness 5.02 mg-eqv/l), and for a chemical component, hydrocarbonate ion was dominant, anion ratio HCO_3^- $>Cl^->SO_4^{2-}$, cation ratio $Ca^{2+}>Na^++K^+ >Mg^{2+}$. Please see average indicator of some 18 researches carried out on the Khangal River along its length in 1998-1999 from table below.

Table 5. Average chemical indicator along the length of the Khangal River, 1998-1999

Sampling point/ distance, km	Σ_{ion} mg/l	Hardness mg-eqv/l	Alekin's index	Main ions, mg/l						
				Ca^{2+}	Mg^{2+}	Na^+	K^+	HCO_3^-	SO_4^{2-}	Cl^-
Train bridge / 5	576.2	6.34	SCCall	81.6	27.7	43.3	3.8	208.0	181.1	28.5
Khuurain am /15	566.1	6.42	SCCall	85.4	26.3	40.9	3.6	200.8	180.9	26.0
Taria brigade /35	567.1	6.08	SCCall	79.6	25.7	40.9	3.4	212.8	175.5	26.2
Pioneer camp/55	536.5	6.11	CSCall	73.1	27.5	38.5	2.9	211.9	156.0	23.8
River mouth / 75	517.7	5.78	CSCall	73.9	25.4	38.1	2.7	207.3	146.7	20.2

Table 6. Other indicator along the length of the Khangal River, mg/l (1998-1999)

Sampling point	Bioactive element						Microelement				Solute gas		
	NH_4^+	NO_2^-	NO_3^-	Fe	SiO_2	P	Cu	Mo	Cr	F	O_2	Permanganate Oxidation /PO/	Biochemical Demand Oxygen /BDO/
Train bridge	0.64	0.31	2.14	0.43	19.01	0.342	0.07	0.077	0.030	0.611	8.05	3.76	4.55
Khuurain am	0.59	0.16	1.60	0.36	18.94	0.296	0.07	0.071	-	-	8.15	3.43	4.05
Taria brigade	0.48	0.15	1.37	0.34	18.33	0.189	0.07	0.068	-	-	8.17	2.54	3.94
Pioneer camp	0.47	0.09	1.12	0.34	18.31	0.137	0.06	0.059	0.029	0.645	8.19	2.46	3.17
River mouth	0.46	0.05	1.01	0.33	18.07	0.108	0.05	0.057	-	-	8.41	2.07	3.11

For chemical composition, the river water is subject to hydrocarbonate class, Ca group, type 1-2, and sometimes sulphate ion is dominant rather than anions in water of the Erdenet River. After wastewater which percolates down through the dam of the Erdenet mining plant, dumped into the Khangal River, its manganese 0.41 mg/l, copper 0.32 mg/l, zinc 0.066 mg/l, molybdenum 0.2 mg/l and solute oxygen volume decreased. In reverse, contained bioactive elements, nitrogenous composition, micro and macro elements have been increased. The Khangal River joins the Orkhon River without purification. However, solute elements tend to decrease along the river in downstream direction.

According to research by the Geo-ecological Institute, the Erdenet River water is subject to relatively high mineralization (average mineralization 730 mg/l), hardness (average hardness 7.20 mg-eqv/l), polluted (NO_2^- 0.3 mg/l), and for a chemical composition, sulphate ion is dominant, anion ratio $SO_4^{2-} >HCO_3^- > Cl^-$, cation ratio $Ca^{2+} > Mg^{2+} > Na^++K^+$ by ions structure. Compare to the NCPLSW, the Erdenet River water is subject to "largely polluted" class. Zunii River is usually disappeared and it percolates through the Erdenet plant's dam by joining wastewater from the Erdenet plant and flows into the Orkhon River. According to recent research, the Khangal River water mineralization is constantly high or 600-800 mg/l, hardness 6.50-7.50 mg-eqv/l [2], and it is polluted by nitrogenous composition and heavy metals such as copper and nickel, etc. For a chemical composition, sulphate ion is prevailed, and anion ratio $SO_4^{2-}>HCO_3^->Cl^-$ and cation ratio $Ca^{2+}>Mg^{2+}>Na^++K^+$ by ion's structure. The Khangal River is the only river subject to type 3 amid tributaries which flow into the Orkhon River.

In the framework of Mongolian-Russian joint biological expedition, research team of US, Russia and Mongolia carried out research on water quality, river bed materials, as well as water animals in the Selenge RB. According to research carried out on water quality in the Khangal River on Aug 29, 2010, the river water was slightly polluted (NH_4^+ 0.3 mg/l), brownish coloured. But next morning the river's colour has been changed into auburn colour and there were some white bubble along the river bank. So, we decided to take sample again and pollution indicators were increased, for example, ammonium ion was sharply increased (NH_4^+ 6.0 mg/l). During this observation, this unexpected river's change was gradually disappearing and turned into its normal situation after half an hour. It shows that wastewater is probably dumped into the river from any pollution source in the night time. If it proceeds in this way, there could be a risk that the river might flow into the Orkhon River without getting purified [7].

Pic - Khangal River as of 14:15 Aug 29, 2010

Pic - Khangal River /as of 09:30 Aug 30, 2010/

There are three river stations involved in an environmental monitoring programme in the midstream part of the Orkhon River and environmental monitoring laboratory in Orkhon aimag makes analysis on data and samples received from these two monitoring locations in which before and after the Khangal River joins the Orkhon River on a monthly basis. These two river stations were established in 1991 and another one is Orkhon-Orkhon river station which has been operating since 1978 in the territory of Sant soum, Selenge aimag. Data and information received from these monitoring stations is analysed by the environmental monitoring laboratory in Orkhon and Selenge aimags. Using this data, the Environmental measurement laboratory released the following result based on the average long years' indicators in the Orkhon River's midstream [8].

Source: Data from Orkhon-Khangal downstream monitoring station, 1991-2010

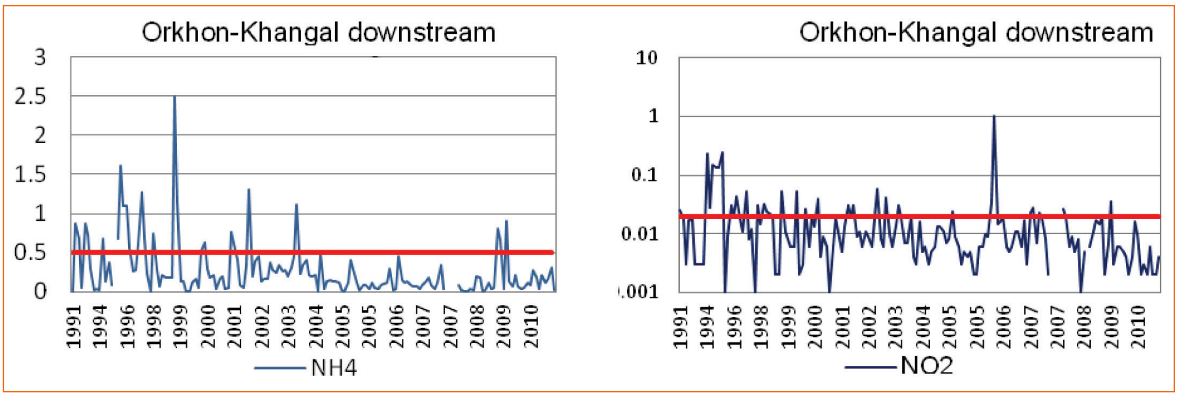


Figure 4. Ammonium and nitrite ion contained in water of the Orkhon River, mg/l

Ammonium nitrogenous contained in water near the Orkhon River-Khangal downstream monitoring station ranges 0.00- 2.50 mg/l and 0.29 mgN/l on an average, nitrite contained in the water ranges 0.000- 1.039 mg/l and 0.027 mg/l on an average. The indicator shows that there is a reduction in some cases of exceeding the MNS4586-98 water quality standard in recent years. Mineral phosphorus contained in the water ranges 0.001- 1.408 mg/l and long years' average is 0.074 mg/l [8].

Before joining the Tuul River /in territory of Orkhontuul soum, Selenge aimag/, according to research in 2006, the Orkhon River water is subject to hydrocarbonate class, Ca group, water type 1, hydrocarbonate is dominant rather than anion /HCO_3^-/ anion ratio $HCO_3^- > SO_4^{2-} > Cl^-$ and cation ratio $Ca^{2+} > Na^+ + K^+ > Mg^{2+}$. For water quality, its mineralization 240.7mg/l, hardness 2.45mg-eqv/l and "slightly polluted" class by ammonium volume (NH_4^+ 0.1 mg/l) according to the NCPLSW. Indeed, its water was fresh here. But after joining *the Tuul River*, there is a change in water of the Orkhon River and main ions' volume and turbid were increased /mineralization 283.1mg/l, hardness 2.60mg-eqv/l, suspended solid volume 78 mg/l/ and included in the "polluted" class according to the NCPLSW. This pollution is due to strong impact by the gold mining activities in the Tuul River and its water has been largely become turbid. In this sense, there might be a risk to increase the microelements.

Pic - Orkhon River before joining the Khangal River

Pic - Orkhon River after joining the Tuul River

Small river which flows into the Burgaltai River from its right side near Burgaltai bridge on Erdenet's main road is largely turbid and this is obviously due to influence by mining industry.

Pic - Burgaltai River as of Aug 2010

Chemical water composition of the tributaries which flow into the downstream Orkhon River is subject to hydro-carbonate class, Ca and Ca-Na groups and type 1-2. The chemical composition of the Eroo River water is very fresh, very soft water and other rivers have fresh and soft water. But heavy metals have been accumulated in the river water and in the river bed material, and it affects ecosystem of the river water. This is due to long year's gold mining activities in the valleys of the Eroo River and its tributaries such as Yalbag, Mogoi, Tsamkhag, Ikh Kharganat, Ikh Ajir, Baga Ajir, Bugant, Nariin and Tolgoit, etc. Some elements such as arsenic, zinc, aluminium, iron, etc have entered in the turbid water in a colloidal manner due to gold mining activities. These elements have been penetrated into sediments on the bottom along the river. That's why these elements are substantially contained and very largely polluted. Therefore, relatively large number of elements found in the sediment and mud on the bottom of the Kharaa and Shariin Gol rivers. Besides, heavy elements which contained in sediments on the bottom the Orkhon River along the downstream direction is high. So it can be concluded that the Orkhon River is polluted by heavy metals [7].

Pic - Buur River's pollution by oil leakage, 2001

Pic - Buur River's pollution, down from Ger area, 2010

The last tributary of the Orkhon River is Buur River which flows through Sukhbaatar soum, Selenge aimag. While the Buur River flows through households live in ger area, it is polluted by organic and domestic pollution and it is subject to "Very polluted" class. Except that, it has relatively high mineralization and hardness (mineralization 600-800 mg/l, hardness 6.50-7.50 mg-eqv/l).

For a chemical composition, according to research in 2001, it is subject to hydrocarbonate class, Na and Ca groups, type 1, and for quality, slightly pure, slightly soft and polluted in downstream part from the maintenance centre for train. And chemical composition has been changed such as Mg and Ca group for cation in upstream part from the maintenance centre for train. In 2001, some fuel and lubricant material were leaked from the Oil supply base of Ulaanbaatar Railway in Sukhbaatar city, Selenge aimag and consequently, it was percolated into the soil and then entered into the Buur River which flows into the Orkhon River. The river was polluted by organic substance. On the other hand, Khiagt River which flows through Altan Bulag soum centre is largely polluted while it flows through Mongolian border from Russian and this might substantially affect water quality of the Buur River. According to research on Aug 28, 2010, there hasn't yet been change in water quality and chemical composition of the Buur River and it was subject to still polluted, contained ammonium ion NH_4^+ 0.7 mg/l, permanganate oxidation which is an organic pollution 13,4 mg/l and "very largely polluted" class according to the NCPLSW, Ca and Mg ions and hardness have been increased (hardness 7.10 mg-eqv/l).

Before joining the Selenge River, the Orkhon River water is subject to hydrocarbonate class, Ca group, type 1, hydro-carbonate is dominant rather than anion (HCO_3^-), anion ratio $HCO_3^{-}>^{-}Cl^{-}>SO_4^{2}$, cation ratio $Ca^{2+}>Mg^{2+}>Na^{+}+K^{+}$. For quality, mineralization 175.6mg/l, hardness 1.8 mg-eqv/l, "slightly polluted" class by volume of suspended solid according to NCPLSW.

There are 2 river stations involved in environmental analysis programme in the downstream part of the Orkhon River. First one is Orkhon-Shaamar river station which was established in 1981 and conducts measurement and takes sample once in a month. Another one Orkhon-Sukhbaatar river station was established in 1978 and conducts measurement and takes sample twice in a month. Please see the following result by Central Laboratory for Environmental Measurement (CLEM) on pollution indicator for a period of long years in downstream part of the Orkhon River using data and record from Orkhon-Sukhbaatar river monitoring station [8].

Source: Data from Orkhon-Sukhbaatar river monitoring station, 1977-2010

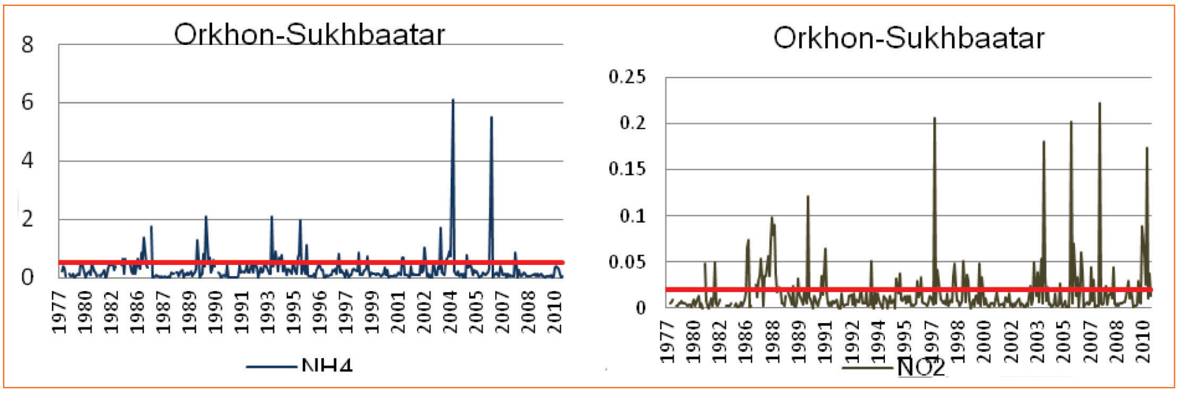


Figure 5. Ammonium and nitrite ion component in water of the Orkhon River, mg/l

As we can see from the above graph, ammonium nitrogenous component in water of the Orkhon River around Sukhbaatar river station ranges from 0.00-6.12 mg/l and 0.30 mgN/l on an average. There have been some cases that exceeded the MNS4586-98 water quality standard which were observed in 2004 and 2006. But there have been many cases which exceeded the standard even though contained nitrite ion ranged 0.000-0.222 mg/ and 0.018 mg/l on an average. And there were some five cases compared to the MNS4586-98 water quality standard that mineral phosphor contained in water ranged 0.000- 0.514 mg/l and average of 0.044 mg/l for long years, total contained iron ranged 0.00-0.77 mg/l and average of 0.11 mg/l for many years [8].

Research on water micro elements in downstream part of the Orkhon River was carried solely out by researchers of the Geo-ecological Institute of the Academy of Science, as well as jointly with International research team. Accumulation of heavy metals in water is mostly related to mining activities. Micro elements or heavy metals are originated in deep underground as a subsidiary element of any deposit. While digging and quarrying the ground, these elements appear on the ground and are processed in a chemical reaction and oxidation. Consequently, the elements are changed and affect near soil and water. Due to external influence, the heavy metals which appeared on the ground are accumulated in sediments on the bottom of surface water while it is transported in downstream direction. That's why we have taken sample from the sediments on the bottom except water. Then the sample was dried and sifted. We have used ICP device to identify heavy metals which might be contained in the sample [7].

Table 7. Micro elements contained in the Orkhon River along its length, mg/l

Sampling points	Cr	Mn	Fe	Co	Ni	Cu	Zn	As	Cd	Pb	Ag	Mo
Result from the Natural Resource Institute, the Buriat, Russia, 2002												
Orkhon River (midstream)	0.0057			0	0	0.0843	0		0.0009	0.0125		
Orkhon River (downstream)	0.0044			0.0050	0.0002	0.0281	0		0.0016	0.0195		

Sampling points	Cr	Mn	Fe	Co	Ni	Cu	Zn	As	Cd	Pb	Ag	Mo
Result from the Natural Resource Institute, the Republic of Korea, 2009												
Orkhon River (upstream)	0.0005	0.0051	0.0799	0.0001	0.0010	0.0015	0.0222	0.0074	m	0.0005		
Orkhon River (midstream)	0.0028	0.0236	0.427	0.0009	0.0042	0.0026	0.1131	0.0125	m	0.0004		
Orkhon River (downstream)	0.0005	0.0183	0.8802		0.0007	0.0006	0.0154	0.0014	m			
Geo-ecological Institute (USUG laboratory), 2011												
Orkhon River (before joining Kharaa River)	0	0	0.0146	0.001	0.001	0.006	0	0.001	0	0	0.006	0.012
Orkhon River (after joining Eroo River)	0	0	0.1744	0	0.001	0.006	0.014	0	0	0.001	0.012	0.001

Figure below shows the result from tested micro elements contained in the samples taken from water and sediments in the Orkhon River and its tributaries in 2010.

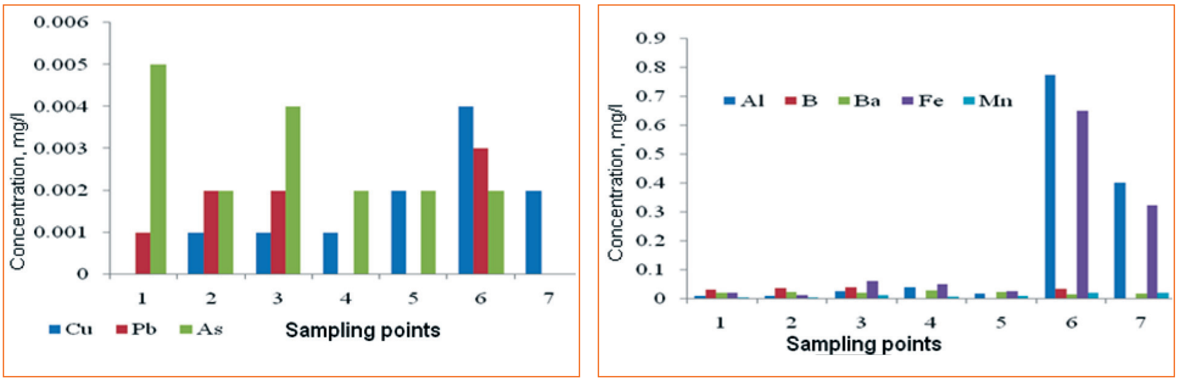


Figure 6. Heavy metals contained in water of the Orkhon River and its tributaries

Sampling points:

1. Orkhon River before joining Kharaa River;
2. Kharaa River, before joining Orkhon
3. Orkhon River after joining Kharaa River;
4. Shariin River before joining Orkhon
5. Orkhon River, after joining Shariin River;
6. Eroo River, before joining Orkhon
7. Orkhon River after joining Eroo River

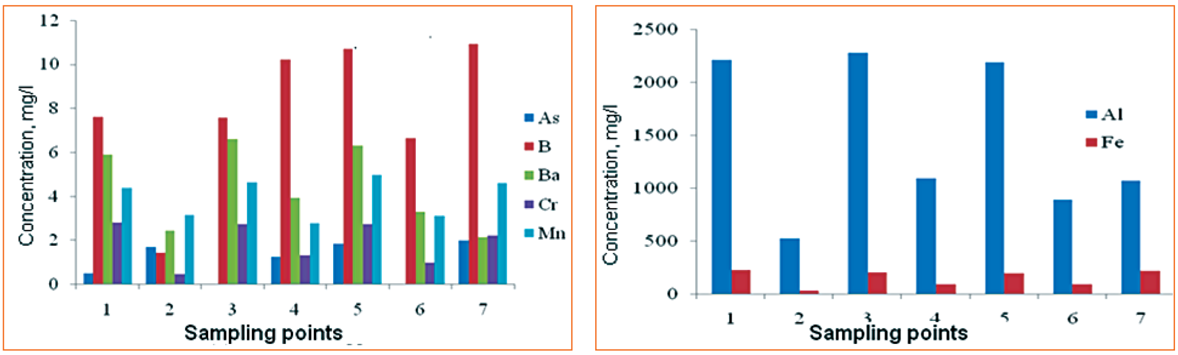


Figure 7. Heavy metals contained in sediments of the Orkhon River and its tributaries (sampling points are same as above)

According to test result of microelements contained in water of the Orkhon River and its tributaries, aluminum and iron contained in water of the Eroo River high and it affects the Orkhon River water. These are main elements of ground layers and these elements typically enter into water from mining activities in turbid /colloid/ form and are accumulated in sediments on the bottom during downstream process.

Water pollution of the Orkhon River and its tributaries tends to increase year by year.

2.2. Change in water quality in the Orkhon River

Change in water quality in the Orkhon River along its length

As mentioned above, water quality of the river changes along the length depending on the water quality of the tributaries which flow into the Orkhon River.

As we can see from Figure 8, some rivers such as Ulaan River in upstream part, Tamir River in midstream part and Eroo River in downstream part have the minimum mineralization. But Khugshin Orkhon in midstream part and Buur River and Khangal Rivers in downstream part have the maximum mineralization. The Khangal River water has the highest sulfate ion component. The Orkhon River water mineralization and hardness volume increases along its downstream direction. After joining the Eroo River which has very pure and large water (mineralization 70-110 mg/l, hardness 0.70-1.00 mg-eqv/l), its mineralization decreases below 200 mg/l and becomes very pure and soft water. Then it flows into the Selenge River.

Table 8. Water quality and chemical composition of the Orkhon River along its length, 2005-2010

Sampling points	Σ_{ion} mg/l	hardness mg-eqv/l	Main ions, mg/l					
			Ca^{2+}	Mg^{2+}	Na^{+}+ K^{+}	HCO_3^-	SO_4^{2-}	Cl^-
Orkhon River, before joining Ulaan River (Bat Ulzii soum, Uvurkhangai)	148.7	1.00	18.0	1.2	20.9	91.5	10.0	7.1
Kharkhorin soum, Uvurkhangai	167.3	1.75	22.0	7.9	10.0	109.8	10.0	7.1
Orkhon River, before joining Khangal River (Orkhon soum, Bulgan)	263.6	2.25	30.1	9.1	35.5	131.2	18.9	8.9
	190.6	1.85	27.1	6.1	15.4	122.0	13.0	7.1
Orkhon River, before joining Tuul River (Jargalant soum, Orkhon)	240.7	2.45	36.1	7.9	16.0	161.6	12.0	7.1
Orkhon River, Orkhon bridge (Sant soum, Selenge)	244.6	2.60	38.1	8.5	14.2	160.1	13.0	10.7
	208.6	2.00	26.1	8.5	18.0	134.2	11.0	10.7
Orkhon River, before joining Kharaa River (Orkhon soum, Darkhan Uul)	238.7	2.45	32.1	10.3	16.4	155.6	10.0	14.2
	283.5	2.40	36.1	7.3	35.6	167.5	12.0	24.9
	266.2	2.80	40.1	9.7	18.9	170.6	16.0	10.7
Orkhon River, before joining Shariin River (Orkhon soum, Darkhan Uul)	285.8	2.50	33.1	10.3	28.3	186.1	13.0	14.2
	286.0	3.20	40.1	14.6	19.4	173.6	15.0	21.3
	296.2	2.40	32.1	9.7	37.3	190.8	20.0	14.2
Orkhon River, before joining Eroo River (Shaamar soum, Selenge)	286.2	2.85	35.1	13.4	22.0	189.1	10.0	10.7
	300.1	3.30	42.1	14.6	19.2	192.0	16.0	16.0
	305.2	2.60	36.1	9.7	32.6	189.0	28.0	7.1
Orkhon River, after joining Eroo River (Shaamar soum, Selenge)	126,4	1,20	17,0	4,3	10,6	79,3	8,0	7,1
	189.6	1.80	24.0	7.3	17.4	112.8	17.0	10.7
	160.4	1.60	20.0	7.3	12.4	97.6	9.8	10.7
Orkhon River, before joining Selenge River (Sukhbaatar soum, Selenge)	175.6	1.80	22.0	8.5	12.5	109.8	12.0	10.7
	183.4	1.95	21.0	10.9	12.2	115.9	16.0	7.1

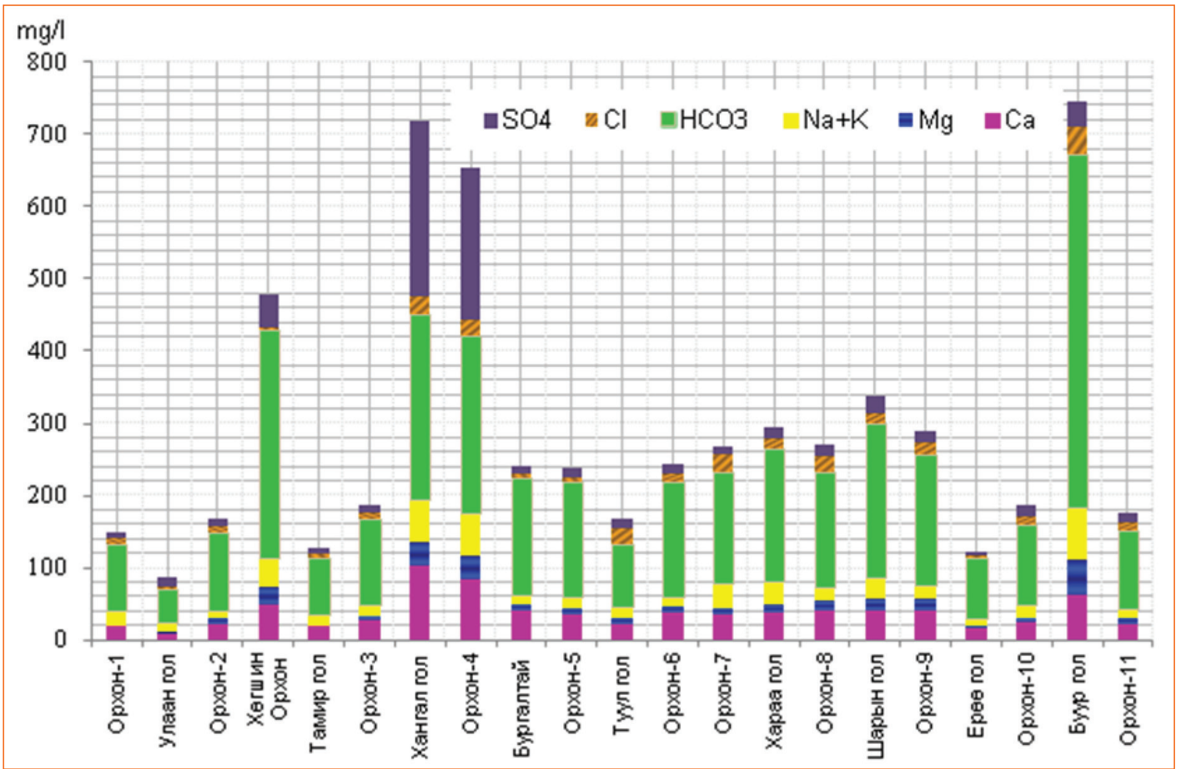


Figure 8. Water mineralization and main ions contained in the Orkhon River and its large tributaries

1. Orkhon-1. Before joining Ulaan River;
2. Ulaan River, before joining Orkhon;
3. Orkhon-2, Headwork of irrigation system in Kharkhorin;
4. Khugshin Orkhon River, Kharkhorin;
5. Tamir River;
6. Orkhon-3, Orkhon soum, upstream before joining Khangal River;
7. Khangal River, before joining Orkhon River; 8. Orkhon-4, 500 m after joining Khangal River;
9. Burgaltai River, Baruunburen;
10. Orkhon-5, before joining Tuul River,
11. Tuul River, before joining Orkhon River;
12. Orkhon-6, Orkhon bridge;
13. Orkhon-7, before joining Kharaa River;
14. Kharaa River, before joining Orkhon;
15. Orkhon-8, junction with Kharaa River;
16. Shariin River, before joining Orkhon River;
17. Orkhon-9, downstream after joining Shariin River;
18. Eroo River, from south of Dulaankhaan;
19. Orkhon-10, downstream after joining Eroo River;
20. Buur River, Sukhbaatar soum;
21. Orkhon-11, Orkhon River, before joining Selenge River

2.3. Change in time of water quality in the Orkhon River

Surface water quality changes within a year depending on the season. Scientists and researchers of NUM conducted research on hydro-chemical monthly regime of the Orkhon River in 1974-1976 in 2 km before Orkhon River joins the Selenge River in south part of Sukhbaatar soum, Selenge aimag. At that time, a total of main ions or mineralization of the Orkhon River ranged 164-340 mg/l and maximum volume was high mostly in winter when it's covered by ice (mineralization 339.8 mg/l in Dec, 330.5 mg/l in Jan, and hardness 3.0 mg-eqv/l), and it was the minimum in spring when there is a spring flood (mineralization was 226.0 mg/l in Apr 1974, and 164.0 mg/l, hardness 2.0 mg-eqv/l in Apr 1975) [4]. Hydrocarbonate ion was dominant rather than main ions 70 mg-eqv% (93-195 mg/l), sulfate ion 10-12.7 mg-eqv% (13.9-23.0 mg/l), chloride ion 6.1-8.5 mg-eqv% (5.7-7.9 mg/l) or anion ratio $HCO_3^- > SO_4^{2-} > Cl^-$, but cation ratio was mostly $Ca^{2+} > Na^+ > Mg^{2+} > K^+$ and $Ca^{2+} > Mg^{2+} > Na^+ > K^+$ in few cases. And Ca ion was dominant 37-69 mg-eqv% (20.4-61.2 mg/l), Mg ion 9.2-40.1 mg-eqv% (1.8-31.7 mg/l), Na ion 14.2-43.0 mg-eqv% (6.7-28.9 mg/l), kali ion wasn't almost changed 1.8-5.0 mg/l, respectively. For chemical composition, the water is subject to hydrocarbonate class, Ca group and type 1-2. In view of above, quarterly change in the Orkhon River water is relatively high while change in chemical composition is low. According to research, volume of solute oxygen is an adequate for water animal and plants to survive in any season of the year. Depending on water temperature increase and oxygen spends to oxide an organic substance which entered into water during rain etc, the oxygen volume declines 6.60 mg/l or saturated by 87% in summer time. Beginning from the end of autumn, it starts to oxide and reaches its maximum volume in winter 11.70-13.10 mg/l (saturated 101-107%), and declines again 7.30-9.30 mg/l or saturated 61-74% in Dec and Jan in which oxygen is unable to solute from air into water. When the ice melts down, it increases again and maximum volume reaches at 14.00 mg/l or saturation level 112%. There are two times of each maximum and minimum within year. For annual change regime of solute carbonic gas, it was 1.1-1.4 mg/l in summer. Starting from ice cover on the river water, it increased and reached maximum level at 18.8 mg/l. By permanganate oxidation, volume of organic substance was 1.28-4.60 mgO/l in times of ice cover and 11.20 mgO/l in times of spring flood. Ammonium ion 0.1-0.4 mg/l, nitrate nitrogen 0.01-0.24 mg/l, phosphor 0.01-0.09 mg/l, zinc oxide 2.4-8.0 mg/l, total iron 0.1-0.4 mg/l appeared from nitrogenous non-organic state. Changes in quarterly and monthly regime of bioactive elements showed almost the same property. Weak alkalinity pH near the river water was ranging 7.4-8.8 [4].

Table below shows the summary of research on same points of the Orkhon River (carried out in summer) by researchers of all time.

Table 9. Chemical water composition near the Orkhon River's downstream

Period	Σ_{ion} mg/l	Hardness mg-eqv/l	pH	Main ions, mg/l					
				Ca^{2+}	Mg^{2+}	Na^++K^+	HCO_3^-	SO_4^{2-}	Cl^-
1973.07.16	191.1	1.32	8.10	20.6	3.4	17.3	122.0	20.2	7.8
1974.08.12	210.9	2.93	7.90	22.6	9.3	27.0	107.4	38.7	5.9
1975.05.20	192.5	2.00	8.00	24.0	5.0	20.9	128.1	10.0	5.6
2002.07-08	185.7	1.80	7.60	24.0	7.2	30.9	100.0	5.2	18.4
2006.05.25	175.6	1.80	8.00	22.0	8.5	12.5	109.8	12.0	10.7
2010.08.28	183.4	1.95	8.40	21.0	10.9	12.2	115.9	16.0	7.1

There hasn't been any special change in water mineralization, hardness and main elements contained in water of the Orkhon River for many years.

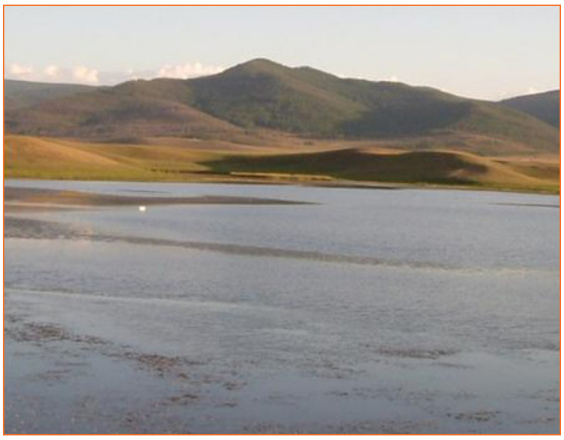
2.4. Some lakes in the Orkhon River Basin

Khukh Lake and Duut Lake have been chosen as an example amongst the lakes in the Orkhon RB upstream.

Khukh Lake. This beautiful lake is elevated at 2680 m from sea level on a mountain peak as the river source, located in the territory of Ikh Tamir soum, Arkhangai aimag. For a chemical composition, the lake's water is subject to hydrocarbonate class, Ca group, type 1, anoin ratio $HCO_3^- > SO_4^{2-} > Cl^-$, cation ratio $Ca^{2+} > Na^+ + K^+ > Mg^{2+}$ and fed by rain/snow water. For quality, its mineralization 69.6 mg/l or fresh, hardness 0.50 mg-eqv/l or very soft, with a neutral environment pH-7.14, very fresh water according to the NCPLSW. This is due to far distance from influence by human and livestock [4].

Duut Lake. It is located in the territory of Khan Undur bag, Ikh Tamir soum, Arkhangai aimag. Compared to the Khukh Lake, it has relatively large mineralization, sand on the bottom and it's slightly warm. There are many water birds gather here and it's been substantially affected by human and livestock. For chemical composition, its water is subject to hydrocarbonate class, Na group, type 1, and for ion structure anion HCO_3^- $>CO_3^{2-}>SO_4^{2-}$ or carbonate ion is dominant and cation ratio $Na^++K^+>Ca^{2+}>Mg^{2+}$. For quality, its mineralization 340,4 mg/l fresh, hardness 1,50 mg-eqv/l or soft, *polluted* class according to the NCPLSW and alkalinity pH-9,14 [4].

Pic - Duut Lake, Ikh Tamir soum



Pic - Khukh Lake, on the mountain peak

As we see from above two lakes, the Khukh Lake, located on a high mountainous region, is not affected by human and livestock, and still keeps its original nature. While the Duut Lake is relatively polluted as there are many local families summer around here.

Ugii Lake has been chosen as an example amongst the lakes in the Orkhon RB midstream.

Ugii Lake. The midstream part locates at relatively lower altitude than the upstream part and mineralization in the Ugii Lake tends to increase. The Ugii Lake is the largest and ecologically important lake in this midstream part. This lake was created as a result of water accumulation and erosion processes in the east part of the Orkhon River valley. Its location is really close to the upstream part of Asgat, Tarnai and Kharbukh rivers in south part of the Orkhon River valley. Lakes in the river valley such as Ugii, Tsaidam and Jargalant-Tarnain lakes were created in the vicinity of watershed line of the Orkhon and Tuul Rivers as a result of erosion-accumulation processes. Due to the Ugii Lake has only one inflow (Nariinii River) and outflow (Ugiin Channel) in its west part at present time, water exchange process is relatively slow.

For the Ugii Lake, its mineralization ranges 210-274 mg/l and it is subject to "fresh" class according to classification by A.M.Ovchinnikov. There are two small lakes on the east of the Ugii Lake, big one's mineralization is 312 mg/l and another one 620 mg/l. The Ugii Lake's water hardness ranges 2.70-3.20 mg-eqv/l and Mg ion is dominant in its hardness. And this is different from other lakes with fresh water.

The tributaries become one of main sources to create/form the chemical water composition of the lake. But mineralization gradually decreases starting from the inflow part and a new classification was created in the lake's area in horizontal direction. And runoff with the same mineralization and composition flows not so far distance from the inflow. Therefore, it can be concluded that influence in the lake's hydro-chemistry and ecological balance by the inflow is unstable. For the area, the Ugii Lake is not large, and its quality and composition are easily changed depending on environmental and climate impacts. E.g. according to research in 1990, Na ion ($Na^{+}+K^{+}$) decreased along the depth in negative relationship with Mgs^{2+}, Ca^{2+}, while dominant anion /HCO_3^-/ increased in negative relationship with SO^{2-}_4 CO^{2-}_3.

Pic - The Ugii Lake

Table 10. Water quality and chemical composition of the Ugii Lake, 2003

Points	Water ^{0}C	NH_4^+ mg/l	pH	Mineralization mg/l	Hardness mg-eqv/l	Main ions mg/l						
						$Na^{+}+K^{+}$	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	CO_3^{2-}	HCO_3^-
1st	18,1	0.3	8,85	342.0	2.76	42.9	24.5	18.8	12.4	22.6	16.0	208.0
2nd	19,0	0.0	8,15	358.6	2.68	49.9	24.7	17.6	14.2	29.8	13.8.	210.9
3rd	16,9	0.0	8,45.	345.4	2.80	45.6	23.4	19.9	12.4	28.0	18.0	198.2
4th	17,2	0.0	8,85	343.6	2.59	48.8	22.3	18.0	13.0	25.2	17.0	199.3
5th	25,0	0.4	7,53	256,1	3,20	50,8	26,0	23,1	14,2	35,0		262,3
6th	17,3	0.2	8,80	312,2	3,90	48,8	30,1	29,2	31,9	46,9	27,0	198,2
7th	22,8	0.4	8,85	620,3	4,20	168,6	20,0	38,9	35,5	97,9	72,0	372,1
8th	17,8	0.4	8,88	347.1	2.55	50.0	23.9	16.5	14.2	27.0	18.6	200.8
9th	24,0	0.0	9,13	371.4	2.75	53.0	29.0	15.8	15.1	37.5	13.5	207.4
10th	23,1	0.0	9,16	375.6	3.00	48.0	36.1	14.6	14.4	44.0	12.0	205.9
11th	22,8	0.2	8,91	209,6	2,60	32,2	22,0	18,2	10,6	36,0	21,0	137,2
12th	18,4	0.2	8,90	243,7	2,70	45,1	20,0	20,7	14,2	37,0	18,0	176,9
13th	16,9	0.2	8,52	223,3	2,50	38,9	30,1	12,2	10,6	32,9	12,0	170,8
14th	16,4	0.2	8,05	378,9	3,70	82,1	40,1	19,5	17,7	78,2	6,0	301,9

Sampling points:
Point 1. North part of the Ugiin channel /outflow/
Point 2. North part of the lake /south from point 1/
Point 3. Point shaped north part of the lake
Point 4. East part of the lake
Point 5. Small spring on east part of the lake
Point 6. Small lake at east edge of the lake /north/
Point 7. Small lake at east edge of the lake /south/
Point 8. South-east edge of the lake
Point 9. South part of the lake
Point 10. South-west part of the lake
Point 11. Ugii Lake. Between inflow and outflow
Point 12. Ugiin channel, south part of the outflow
Point 13. Khugshin Orkhon /Nariinii River/
Point 14. Khugshin Orkhon. Near Kharkhorin

Tsagaan Lake and Dardai Lake have been chosen as an example amongst the lakes in the Orkhon RB downstream part. These salty lakes are located in the territory of Orkhon soum, Darkhan Uul aimag (mineralization >11000 mg/l), slightly hard and polluted, and the chemical composition is subject to Chlorine class, Na group and very polluted class which means different from the lakes in the upstream and midstream.

Pic - Tsagaan Lake in Darkhan Uul aimag

Pic - Dardai Lake in Darkhan Uul aimag

As we can see from above, the lake's mineralization tends to increase as the surface region becomes lower and transmits into a steppe region.

2.5. Conclusion on water quality and chemical composition of surface water

Natural water quality and chemical composition are the sophisticated compound (system) which is evolved and changed depending on number of factors such as geographical feature, condition, soil, plants, rock, animal and human activities, etc of the related region.

The following conclusion has been made on what level the Orkhon RB water quality and chemical composition really are, what factors are affecting water quality of the river in comparison with previous research materials.

- The tributaries in the Orkhon River's upstream part mostly originate in the Khangain Mountain and its branches, relatively not largely affected by human activities, keeping their original form, and having mountainous fresh, pure and soft water. That's why its impact on the Orkhon River water is positive.
- The Ikh Teel River is the Orkhon River source and still keeping its main natural composition. Due to gold mining activities in the Orkhon River's upstream part or its tributary Ult River valley, there are many small rivers have been blocked and consequently, runoff disappeared in riverbed of the Ult River. But there is a high risk of pollution in the Orkhon River's upstream if polluted and turbid water joins the river through the riverbed due to both intentional and sudden actions by human, as well as flood. Also there is a possibility that heavy elements in the turbid water which caused by the gold mining activities, then these elements might enter into the river water in colloid manner and affect the ecosystem of water environment.
- The Khujirt River is polluted by wastewater which is dumped by the Khujirt

camp and it is likely to substantially affect the water environment of the Orkhon River at certain volume.

- The Tamir River, tributary in the Orkhon River's midstream part and its tributaries, originating in the Khangain Mountain are not affected by human activities and these rivers keep their original form and have mountainous fresh, pure and soft water. Impact on the water quality in the Orkhon River is obviously positive.
- The Khangal River, tributary flows in the Orkhon River's downstream part from its left side, has the most polluted water with the largest mineralization and hardness. There have been many cases in which mineral nitrogen components contained in water of the downstream after junction of the Orkhon and Khangal Rivers, exceeded than the standard and polluted. Moreover, water mineralization in the Orkhon River has been increased and there have been some changes in hydro-chemical composition e.g. anion ratio in water changed and contained sulphate ion volume has been increased.
- Of large tributaries in the Orkhon River's downstream part, there are number of centralized settlements alongside of the Tuul RB which originates from the branches of Khentii Mountain. Consequently, the Tuul River has been largely affected by domestic pollution and there has been ecological change in its valley due to gold mining activities are being ran in centralized form. Therefore, the Tuul River is negatively affecting the water quality in the Orkhon River. Of small rivers in this part, tributary of the Burgaltai River from its right side has been observed that it was largely turbid according to research in Aug 2010 and there might be a gold mining on this river.
- Tributaries in the Orkhon River's downstream part are Kharaa, Shariin Gol and Eroo rivers are originated in the branches of the Khentii Mountain. These rivers are affected by gold mining activities, turbid and polluted by heavy metals. The Buur River is affected by domestic pollution. And this pollution negatively affects the water quality in the Orkhon River. Even though Eroo River has the freshest and very soft water, it's been mostly polluted by heavy metals in connection with gold mining activities are being ran in centralized form along its riverbed and in valleys of its tributaries.
- Water mineralization, hardness and main elements contained in the Orkhon River haven't been seriously changed for the period of long years. However, the river water is being polluted.
- According to research on water quality of lake, lake's mineralization tends to increase as the surface elevation becomes lower and transmits into steppe region.

3. Research on groundwater quality

3.1. Research purpose

Purpose of this research is to make an analysis on current status of water quality in wells with a variety of design, as well as springs located in soums in the Orkhon RB and to identify the ways of improving the related quality.

3.2. Research object

The research object includes wells, spa and springs in the territory of Bulgan, Ikh Tamir, Erdenebulgan (Tsetserleg city), Tsenkher, Tuvshruulekh, Khotont, Ugii Nuur, Battsengel, Ulziit soums of Arkhangai aimag; Bat Ulzii, Khujirt and Kharkhorin soums in full, north part of Ulziit soum, west and north-west part of Yusun Zuil soum, north-east part of Zuunbayan Ulaan soum of Uvurkhangai aimag; south part of Mogod, Shaikhan, Khishig Undur, Orkhon, Bulgan and Bugat soums of Bulgan aimag; Erdenet, Jargalant and Bayan Undur soums of Orkhon aimag; Tseel soum of Tuv aimag; Baruunburen and Orkhon soums almost in full, half east of Orkhontuul soum, most part of Sant soum, south part of Khushaat and Zuunburen soums, Shaamar and Altanbulag soums of Selenge aimag.

3.3. Research status

Research on well water quality was carried out by researchers of “Hydro-chemical Central Laboratory” (1966-1997) of Scientific Institute for Water Exploration, the Water Laboratory of Geo-ecological Institute, other water laboratories, scientific institutes and universities. And they have clearly reflected the results of the research on their own literature. Concerning the research on spa, it’s been reflected on the literature by researchers of all time.

3.4. Research methodology and used materials

Groundwater in the related soum and aimags in the Orkhon RB has been classified the same as the surface water, such as upstream, midstream and downstream parts. To make assessment on water quality in settled areas, some materials from the laboratory analysis and archives have been used. But it was impossible to make assessment on water/irrigation point by micro elements. That’s why the assessment has been made by using some indicators of the main elements and pollution. Chemical composition, mineralization and hardness in groundwater have been calculated as the same as surface water. When assessing the water quality, it’s been compared to the “MNS 6148:2010 standard of the accepted maximum level of substance and elements to cause pollution in groundwater” and the “MNS 900:2005 standard for the Environment, Health Safety, Defense, Drinking Water, Hygienic Requirements and its monitoring”. There have been amendment and alteration in these standards in 2010 and it’s been also considered.

4. Results from research on groundwater quality

4.1. Groundwater quality and chemical composition of the Orkhon RB

Groundwater resources in Mongolia are not equally distributed and their quality is relatively different from one another. For the territory, there has been observed that mineralization tends to increase from west to east and from north to south. This is related to climate change such as precipitation volume, air temperature and evaporation increase, as well as basic property (or main feature) of aquifer rock which contains the water. Shallow groundwater which is being used for the purpose of water supply in any region is affected by extreme continental climate especially, hot and cold air, quarterly changes in precipitation. In the result, its water resource, quality and composition have been changed not only regionally, but there is a constant change within the same geographical region. This climate condition leads to erosion, absorption and salt accumulation of soil and stone/rock, and it becomes main factor which affects the formation of chemical composition of natural water in the related region.

Although there are not few materials about research in the field of identifying groundwater quality and chemical composition, some drawbacks/disadvantages have been commonly observed such as water sample was taken at random; water quality and composition were not closely related to geographic formation, soil, rock/stone and climate feature in the related region; chemical analysis was limited by only identifying main element and pollution indicators; research on microelement and bacteriology were put aside, etc.

Water mineralization in total water/irrigation point in Arkhangai, Uvurkhangai, Bulgan, Darkhan Uul and Selenge aimags included in the Orkhon RB in Central and Khangai region is less than 1.0 g/l and compared to Gobi region, it shows relatively fresh water.

In northern Mongolia, fresh water subject to hydrocarbonate class, Na and Ca group, ($HCO_3^- > SO_4^{2-} > Cl$, $Ca^{2+} > Mg^{2+} > Na^+$) is dominantly distributed.

4.1.1. Groundwater quality and chemical composition of the Orkhon RB upstream part

The upstream part covers some south and south-west soums of Arkhangai aimag such as Bulgan, western of Ikh Tamir, Erdenebulgan (Tsetserleg), Tsenkher, western area of Tuvshruulekh and Khotont; some soums of Uvurkhangai aimag in full such as Bat Ulzii and Khujirt, as well as north part of Ulziit soum, west and north-west part of Yusunzuil soum, north-east part of Zuunbayan Ulaan soum, respectively.

The chemical composition of the water in the wells in the region included in the Orkhon RB upstream part, hydrocarbonate ion solely prevails, calcium ion is mostly dominant rather than cation, water type 1-2, Na group is 5.8% or in few cases, mixed group is 3.5%, and there hasn't been any water in which Mg ion solely prevails.

Table 11. Mineralization in well water located in the Orkhon RB upstream part

Total water points	Mineralization level and classification, mg/l					
	I	II	III	IV	V	VI
	<200	201-500	501-1000	1001-3000	3001-7000	>7001
84	20	59	4	-	1	-
	23.8%	70.2%	4.8%		1.2%	

Considering mineralization in well water in the upstream part, 98.8% meets the quality standard and remaining 1.2% is subject to more mineralization than the standard. Besides, water drawn from the well with a tube in the Musun zoorit channel (grid: $46^0$859722, $102^0$20333) in the territory of Bat Ulzii soum in 1979 was subject to salty (mineralization 4040 mg/l), very hard (hardness 29.2 mg-eqv/l), and for a chemical composition, it was subject to chlorine-sulphate class, Na group and type 3. It's different from other wells in this part and this well water is not suitable for any water use.

Table 12. Hardness in water well in the Orkhon RB upstream part

Total points of water	Hardness level and classification, mg-eqv/l					
	I	II	III	IV	V	VI
	<1.5	1.51-3.0	3.01-5.00	5.01-7.00	7.01-9.00	>9.01
84	7	32	43	1	-	1
	8.3%	38.1%	51.2%	1.2%	-	1.2%

Water drawn from the well which was deeply drilled in the north-west part of Khotont soum centre, Arkhangai aimag was hard and therefore, water softening equipment has been installed. One water point in the territory of Kharkhorin soum has hardness that exceeded the related standard.

Nitrogenous compounds which are mostly originated by disintegration of nutritious substance (NH_4^+, NO_2^-, NO_3^-) have been substantially detected in the regional water point. But ammonium (NH_4^+) and nitrite (NO_2^-) are dominant. These ions have been not slightly detected in the water points in Khangai region. Consequently, plant cover makes nitrogenous compounds as nutrition and this might be associated with small damage and percolation in soil cover. This property is also seen from volume of permanganate oxidation.

In this region, some 95.8% of water/irrigation points have an oxidation ranging from 1.5-5.6 mg/l which is an indicator of organic pollution and meets the standard. But some 6 water points with exceeded oxidation (oxidation 12-30 mg/l) are in the territory of Bat Ulzii, Kharkhorin and Khujirt soums of Uvurkhangai aimag [9].

The pH of water points in this part ranges (pH 6.4-8.2) from weak acidity to weak alkalinity environment.

Iron ion, one of biological active compound, has been not slightly detected in total regions. Iron contained in mountain stone/rock is different from one another, but most one is muddy/clay aquifer (5.5-8.5%) [5]. Therefore, iron content may be associated with stone/rock which contains water in the related region. In view of iron, zinc and oxide, etc which have been identified in relatively few water points in the region, SiO2 6.0-16.0 mg/l [5] and some 6 water points (0.5-1.2 mg/l) exceeded the standard have been detected by iron content, and free carbonic gas content 4.4-13.2 mg/l [5].

Free carbon dioxide (CO_2) 2.2-13.2 mg/l is in water of settled area in the central region. By considering mineralization at regional level, of 269 points of water, there were some 34 points with very fresh water and slightly mineralization, 180 points with fresh water and medium mineralization, 48 points with relatively large mineralization and 7 points with large mineralization, respectively. For hardness, there were some 19 water points with very soft water, 78 with soft water, 180 with slightly hard, 25 with relatively hard, 3 with hard and 4 with very hard water, respectively [5].

4.1.2. Groundwater quality and chemical composition of the Orkhon RB midstream part

In this part, we have made analysis and processing of the results from researches on

108 wells in the territory of eastern of Ikh Tamir, Erdenebulgan (Tsetserleg), Tsenkher, Tuvshruulekh and Khotont, Ugii Nuur, Battsengel and Ulziit soums of Arkhangai aimag, Mogod, Saikhan, Khishig Undur, Orkhon, Bulgan and southern part of Bugat soum of Bulgan aimag.

Water mineralization and hardness towards south direction in the region tends to increase if it is considered at level of total territory. If considering total well water in the midstream part by their *mineralization*, 93.4% have fresh water which meets the required standard and 6.6% or some 10 water points have water with large mineralization. And from wich 2 wells located in Kharkhorin of Uvurkhangai (mineralization more than 1820 mg/l), 6 points are located in the territory of Mogod soum, Bulgan aimag (mineralization 1004-1746mg/l), one is located in Orkhon soum (mineralization 2101mg/l).

Table 13. Mineralization in well water in the Orkhon RB midstream part

Total number of water points	Mineralization level and classification, mg/l					
	I	II	III	IV	V	VI
	<200	201-500	501-1000	1001-3000	3001-7000	>7001
108	6	76	17	6	1	-

For mineralization, 5.5% of water/irrigation points is subject to very fresh or level I, 70.4% is subject to fresh or level II, 15.7% is subject to slightly fresh or level III, 5.5% is subject to slightly salty or level IV and 0.9% is subject to salty level.

If considering total well water in the midstream part by their *hardness*, 81.5% is subject to fresh water which meets the standard, 4.6% is in the accepted maximum level however, more than the appropriate level, and 10.1% is subject to hardness more than the standard.

Table 14. Hardness in well water in the Orkhon RB midstream part

Total number of Water points	Hardness level and classification, mg-eqv/l					
	I	II	III	IV	V	VI
	<1.5	1.51-3.0	3.01-5.00	5.01-7.00	7.01-9.00	>9.01
108	3	13	78	5	6	3
	2.8%	12.1%	72.2%	4.6%	5.5%	2.8%

A borehole at right side of Khotont soum center of Arkhangai aimag had hardness and was installed softener. A hardness water in one well of Kharkhorin soum of Uvurkhangai aimag is exceeded the standard. Hard water has been found in some 3 wells in Mogod soum, 2 wells in Orkhon soum and 2 wells in Khishig Undur soum of Bulgan aimag.

The chemical composition of the groundwater in the midstream part is mostly subject to hydrocarbonate class, and for cation, percent of Na ion is increased, Ca and Na ion is dominant, and water type 1-2 compared to the upstream part. There were some 2 water points in which Mg ion is dominant in Mogod soum.

4.1.3. Groundwater quality and chemical composition of the Orkhon RB downstream part

In this part, we have made analysis and processing on the results from researches on approx. 108 wells water by covering Bayan-Undur (Erdenet), Jargalant of Orkhon aimag; Tseel of Tuv aimag; eastern part of Baruunburen and Orkhobntuul soums, Shaamar and Altanbulag soums, most part of Sant soum, south part of Khushaat and Zuunburen soums of Selenge aimag.

If considering total well water in the downstream part by their *mineralization*, there is one water point, in which mineralization is exceeded the standard, located in Erdenet (mineralization 1450 mg/l).

Table 15. Mineralization in well water in the Orkhon RB upstream part

Total number of water point	Mineralization level and classification, mg/l					
	I	II	III	IV	V	VI
	<200	201-500	501-1000	1001-3000	3001-7000	>7001
108	8	63	36	1	-	-
	7.4%	58.3%	33.3%	0.9%	-	-

Table 16. Hardness in well water in the Orkhon RB upstream part

Total number of water point	Hardness level and classification, mg-eqv/l					
	I	II	III	IV	V	VI
	<1.5	1.51-3.0	3.01-5.00	5.01-7.00	7.01-9.00	>9.01
108	4	30	45	20	7	2
	3.7%	27.8%	41.7%	18.5%	6.5%	1.8%

Almost all the wells in the vicinity of Erdenet soum, Orkhon aimag have very hard water (hardness 6.85-14.80 mg-eqv/l), Mg ion is dominant in its hardness and mineralization 628.7-1459.6 mg/l or relatively high. But water in the boreholes which were drilled in valley of the Chingeltei River is slightly less than the wells around Erdenet (hardness 1.45-5.75 mg-eqv/l), Mg ion is dominant in its hardness and mineralization is 227-751 mg/l or high.

All 5 water points with hardness exceeded the standard were found in Altanbulag free zone. There have been some 4 points with slightly hard water in Altanbulag soum, 3 in Sukhbaatar soum, 1 in Khushaat soum and 1 in Shaamar soum, respectively.

For chemical composition, its water is subject to hydrocarbonate class. In Altanbulag region, there were 2 water points subject to sulphate and hydrocarbonate-sulphate classes. For cation, mostly subject to Ca class and type 1-3. Also there were 11 water points in which Na ion is dominant, 6 points with mixed class, 2 points in which Mg ion is dominant, 7 points in which Mg ion is dominant in its hardness and its 5 points exceeded the standard. Compare to the upstream and midstream parts, some water points with water type 3 have been detected substantially in this part.

Water environment pH relatively ranges 6.4-8.8 and there has been one case in which less than the standard in one water point (pH 6.4) in Sukhbaatar soum and more than the standard in one water point (pH 8.8) in Altanbulag soum, and others were in the standard level. According to pollution indicator, pollution of ammonium ion exceeded the standard in 2 water points in Sukhbaatar soum and 1 well in Altanbulag soum. Permanganate oxidation which is an organic pollution exceeded the standard in one well in Zuunburen soum and other points in the standard level.

4.2. Conclusion

- Water samples have been mostly taken at level of microelements and pollution indicators. However, there are some materials of researches which were carried out in the field of identifying the groundwater quality and chemical composition.
- Water mineralization in a total water points in Arkhangai, Uvurkhangai, Bulgan, Darkhan Uul and Selenge aimags included in the Orkhon RB is less

than 1.0 g/l. It shows that water in this basin is relatively fresh compared to the Gobi-desert region.

- Mostly fresh water subject to hydrocarbonate class, Ca and Na group (HCO_3^- $>SO_4^{2-}>Cl$, $Ca^{2+}>Mg^{2+}>Na^+$) is dominantly distributed in northern Mongolia and there are some water points with salty and hard water in few cases. By identifying the quality and composition of water points at regional level in such way, it enables us to pre-determine the guidelines on identifying water point in the future and how to use the existing water points.
- Wells and water points in the upstream part are mostly subject to fresh and soft water. But water softening equipment has been installed in some water points subject to relatively high hardness, e.g. in one well in soum centre of Khotont, Arkhangai aimag.
- There are some water points which do not satisfy the requirements in the midstream part. E.g. water points subject to high mineralization and hardness are (relatively) commonly found in Mogod soum Bulgan aimag.
- There are many water points with high mineralization and hardness in Erdenet and also some water points which do not satisfy the quality requirements within the Altanbulag free zone in the downstream part.

5. Mineral springs in the Orkhon RB

Research on mineral springs: About 60 literatures have been released by V.A.Smirnov in 1926-1927, by V.N.Popov in 1939-1940 and V.N.Popov and N.A.Marinov in 1944, respectively based on the researches which had been carried out on mineral springs in the territory of Khangai and Khentii Mountain. At that time, Ulaanbaatar and Khujirt mineral springs had been studied and used. Since 1947, chemist Sh.Tseren, Dr.Densmaa, geographer O.Namnandorj, Janchiv, Chultembayar and Budaev started their constant research on chemical composition and therapeutic quality in the related mineral springs. In 1960s, O.Namnandorj, Sh.Tseren and U.Naymdorj had carried out research covering all mineral springs in Mongolia. They made classification of main indicators for the mineral springs including chemical composition, mineralization, temperature, radioactive quality, bioactive element contained in the compound, acidity, alkalinity as well as gas in solution and combination states [10]. In 2009, framework of "research and certification of all mineral springs in Mongolia" had been organized at initiative by the Ministry of Nature, Environment and Tourism at national level and the related experts carried out research by appointing research team.

5.1. Mineral springs in the Orkhon RB upstream part

Some part of Arkhangai and Uvurkhangai aimags which included in the Orkhon RB has a plenty of surface water density and abundant mineral springs. This part is differentiated from others by its centralized hot spas and based in a sub-region of Khangai in hot spa region III.

Same as groundwater, this part includes 6 south-west and south soums of Arkhangai aimag such as Bulgan, Ikh Tamir, Erdenebulgan (Tsetserleg), Tsenkher, Tuvshruulekh and Khotont; north 3 soums of Uvurkhangai aimag such as Bat Ulziit, Khujirt and Kharkhorin, north part of Ulziit soum, west and north-west part of Yusun Zuil soum and north-east part of Zuunbayan Ulaan soum.

Mineral springs in Arkhangai aimag: Tsenkher hot spa

The Tsenkher hot spa is located in south part of the Hot water river which is a tributary of the Tsenkher River from its left side in the territory of Tsenkher soum in Arkhangai aimag on a grid of north latitude of $47^{0}19^{'}00.4$" and east longitude of $101^{0}39$'08.2" and elevated at 1784 m from sea level. This mouth in which the Hot water river flown is wide enough and there is a forest on the back of the river. Every mouth in this area has a beautiful nature and water as well. Some 5-6 very hot springs with relatively sufficient water here flows (blown out) from mafic blue schist in the south of the hot water mouth and then these springs flow towards north-east direction in 20 -30 m to join the spring in the hot water mouth. The hot spring/spa is indeed a hot water from deep underground and there are many aquifers from the Quaternary period in the deep underground. Its temperature is almost at boiled water which ranges 65-90^{o}C as it's not mixed with soil water. According to measurement in 1960s, its radioactivity was ranging from 16-22 by micro roentgen time/hour [10].

Main yield of the hot spa originates from 6 sources. In 1978, concrete wall was built surrounding the main yield and its water was blocked and accumulated in there. To deliver the hot spring to tourist camp, spa resort and green-house through pipes which have been equipped and trifurcated (divided into three part). Consequently, main yield was included in the accumulated spring. By building concrete wall, water temperature wasn't able to be measured, but temperature in upper section of the yield was 86.2^{0}C according to recent research. The wall was firstly built in order to protect the hot spring source but now it doesn't meet the requirements. And sanitarian zone needs to be newly established.

Pic - Main yield of the hot spa

Pic -.Water accumulation by blocking yield by concrete wall

There are some 3-4 hot springs which are closely located from one another in the territory of Tsenkher soum and these were included in the aimag's green area in 1970. Based on the Tsenkher mineral spring, then-soum governor Mr.Tumurbaatar initiated to plant vegetables accordingly, green house was built next year. Vegetables such as grape, tomato, chili, etc were grown/planted in the green house. This area became local restricted area in 1998 and it covers area of 30 km in radius. The area is protected, locally.

"Tsenkher Jiguur" Japanese-Mongolian joint tourist camp was firstly established in the hot spa area in 1993-1995, then "Shiveet Mankhan" tourist camp established in 2000-2001, "Altan Nutag" local tourist camp in 2008 and "Duut" tourist camp in 2009, respectively. A greenhouse gas is being developed by these camps at the same time. In order keep the balance of an ecological load here, it is no longer available to newly establish tourist camp in this area. The region is itself really beautiful and the camps mainly provide service including horse-trekking, hot spa pool, etc. Local inhabitants provide the camps with a meat, milk and dairy products, as well as horse rental and handcraft to improve their living standard.

Pic - Appearance of hot spa which was built as an open pool for tourists

According to laboratory test by the Geo-ecological Institute in 2003, 2005 and 2009, the hot spa had too hot water and weak alkalinity medium (pH 8.89), that's why carbonate ion has been substantially observed in the water and it is subject to carbonate class, Na group, type 1, fresh and very soft water. Test result is shown in table below.

Table 17. Test result of the Tsenkher hot spa

Sampled period	Mineralization *mg/l*	Hardness, *ng-eqv/l*	H_2S *mg/l*	SiO_2 *mg/l*	pH	T ^{0}C	Main elements' content (mg/l)					
							CO_3^-/ HCO_3^-	Cl^-	SO_4^{2}	Na^++ K^+	Ca^{2+}	Mg^{2+}
1957	239.9	0.20	11.6	60.6		90	-/24.4	24.9	48	83.7	3.0	0.6
Sep 2009	221.3	0.10	2.37	18.0	8.89	86.2	51/54.9	17.8	18	77.6	2.0	0.0

Above test shows a slight reduction in indicators of hydrosulphur and silica oxide, etc. However, there has been generally small change in a chemical composition of the hot spa last 50 years. This may refer to impossibility of taking sample from the main yield. For chemical composition, carbonate Na is prevailed, ion and anion ratio CO_3^{2-}>HCO_3^-> Cl^->SO_4^{2-}, cation ratio Na^++K^+> Ca^{2+}>Mg^{2+}. For quality, the spa is subject to fresh (mineralization 221 mg/l), very soft (hardness 0.10 mg-eqv/l), pure and too hot water and sulphur is slightly found here.

If these camps are not complied with the programme to preserve/protect the nature and environment while running the activities, there might be a reason that this will negatively affect the related environment. However, current activities by the camps are for amenity of their guests as well as for the benefit of local inhabitants in some ways. Even though wastewater is purified, accumulated and dumped into specifically prepared place, the way that wastewater is being dumped into the river from spa pool and hot shower is definitely not complied with the quality requirements.

When testing a sample which was taken from the Hot water river that flows in north-west of the hot spa, it was subject to temperature of 8.3^{0}C, weak alkalinity pH-7.87, hydrocarbonate class, Ca group, water type 1, ion structure HCO_3^->SO_4^{2-}>Cl^- and cation ratio Ca^{2+}>Na^++K^+>Mg^{2+}. For quality, its mineralization was 277.3mg/l or very fresh and hardness 2.50mg-eqv/l or soft water. But some mud/turbid and pollution have been detected after passing through the tourist camps. Temperature of the river which flows through the camps after junction of hot spa and cold spring was 22.2^{0}C, alkalinity pH-8.58, ion structure HCO_3^->CO_3^{2-}>SO_4^{2-}>Cl^-, cation ratio Na^++K^+>Ca^{2+}>Mg^{2+}. For quality, the river's mineralization 318.7mg/l or fresh, hardness 1.65mg-eqv/l or soft, slightly polluted water. This river flows into the Tsenkher River which flows into the Tsetserleg River which flows into the South Tamir River. Therefore, it's important to take action to protect this river from pollution.

Bor Tal hot spa

Bor Tal hot spa is located on a grid of north latitude of 47^{0}11'19.7" and west longitude of 101^{0}35'35.0" and elevated at 1772 m from sea level in south-west part of Bor Tal and west part from Tsenkher River in the territory of Tsenkher soum, Arkhangai aimag. The hot spa flows from an oval shaped land with size of 8-25 m from granite massive located on the relief which is embedded 5-6 m deep into a flat area in the bottom of Temeen Chuluut Mountain. Total yield ranges 3−3.5 l/sec. There is a flat area with few stones and abundant space around the hot spa.


Pic - Bor Tal hot spa (locals were washing their clothes)

On the hot spa the granite rock is not visible but the spa flows out from the bottom of granite rocks and conglomerate rocks and there are several outlets. There is a wooden house with two bathrooms in which only one bathtub is shared. When the wastewater comes out from the wooden house, locals wash their clothes. It might lead to risk which causes negative consequence such as impact on water quality in the hot spa and pollution in the related environment. Due to no sanitarian and protection zone was built to protect source of the hot spa, livestock easily intrude into the yield and pollute it. Chemical property in this hot spa is similar to the Tsenkher hot spa and only its temperature is slightly less. According to laboratory test, this hot spa is subject to carbonate class, Na group, type 1, very fresh and very soft water. The test result is shown in table below.

Table 18. Test result of the Bor Tal hot spa

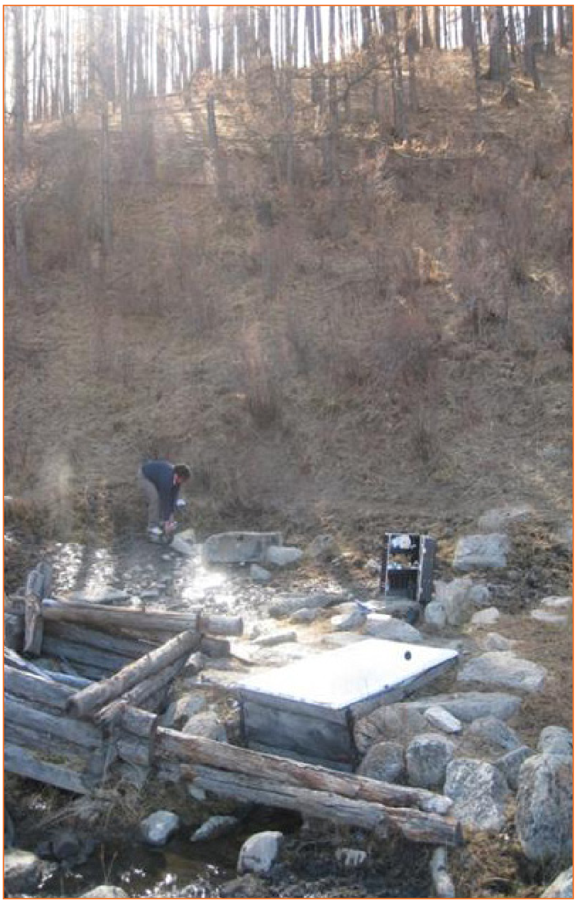
Sampled period	Mineralization mg/l	Hardness, mg-eqv/l	H_2S mg/l	SiO_2 mg/l	pH	T °C	Main elements' content (mg/l)					
							CO_3 HCO_3^-	Cl^-	SO_4^{2}	Na^++ K^+	Ca^{2+}	Mg^{2+}
1957.08	258.9	0.25	4.6	47.6	8.0	42	- / 73.2	25	51	80.7	5.0	0.0
2009.09	194.2	0.05		18.0	8.9	50	54 / 36.6	16	15	71.6	1.0	0.0

The spa's temperature and pH etc, indicators are slightly more than before 52 years ago and other indicators are slightly less. Typically, there hasn't been any large change in its chemical composition. According to measurement in 1957, radioactivity was ranging 16-32 by micro roentgen time/hour [10]. It is considered that the spa remedies the vitals.

Gyalaan hot spa (Gyalgar)

Gyalaanii hot spa is located on a grid of north latitude of $47^0$12'06.8-07.0" and west longitude of $101^0$30'14.8-16.4", elevated at height from 1805 to 1822 m from sea level in south part of Gyalgar River and north-east side of Ikh Ar Mountain in the territory of Tsenkher soum, Arkhangai aimag. It has many types of yields such as hot and cold springs in the bottom, middle side and many parts in the west and east of the mountain. The Gyalaan hot spa is surrounded by really beautiful taiga and mountains such as Yambil, Ikh-Arts, Ikh-Ar, Mankhan and Gyalaanii Mountain, etc. Many cold and hot yields located in distance of 5-100 m and these flow into the Gyalaan River from its right side. In ancient time, bathtub was made from grey granite with a channel in which hot spa flows through, but it was broken. After that it was re-made from wood such as wooden bathtub and channel and used for many years. As a result, now it's also broken. According to measurement on Aug 24, 1960, water temperature of main 4 yields ranged 22-50^{0}C while it was 51.8^{0}C as of Aug 20, 2006. And it means the temperature hasn't been decreased. Main yield of the hot spa was 0.5 l/sec and the yield of warm spa was 0.12 l/s. Every temperature of all yields is differed from one another as they have own dedication. For climate condition, this region has more humidity, softer climate, more leeward in winter and more precipitation in summer compared to the Tsenkher and Bor Tal hot springs. The Gyalaan River which passes by the Gyalaanii hot spa is originally fed by upstream on a high peak (2380 m from sea level) below the steep peak of the Khamar Mountain, and flows through a low area (2180 m from sea level) between the Gyalaanii gorge and the Mankhan Mountain. Then it continuously flows down through boulder stones in quasi-vertical direction by creating strong rapids and swift-flowing. Finally, it reaches down the mountainside (1800 m from sea level) and this section is called Oniin Borgio.

Based on the Gyalaan hot spa, a cornerstone of tourism here is being put by “Ulzii Teel” LLC as it has just established own tourist camp, as well as responsible for a security of the spa. According to measurement on Oct 14, 2009, temperature of this spa which flows out through narrow space on the rock was ranging 33.4-36^{0}C, upper yield 44^{0}C, mid yield 51^{0}C and down yield 54.3^{0}C, respectively. Chemical property of these springs is almost same and subject to carbonate class, Na group, type 1, very fresh and very soft water. Please see below test result.



Pic - Bathtub in the Gyalaan hot spa

Pic - Main yield of the Gyalaan hot spa

Pic - Cold spa for headache

Table 19. Test results of the hot springs

Name of hot spa	Mineralization mg/l	Hardness, mg-eqv/l	SiO_2 mg/l	pH	T ^0C	Alekin's index	Main elements' component (mg/l)					
							CO_3^-/ HCO_3^-	Cl^-	SO_4^{2-}	Na^++ K^+	Ca^{2+}	Mg^{2+}
Tsenkher	224.8	0.10	18.0	8.89	85-86.2	C_I^{Na}	51 / 54.9	21.3	18.0	77.6	2.0	0.0
Bor Tal	194.2	0.05	18.0	8.95	45.6-50.0	C_I^{Na}	54 /36.6	16.0	15.0	71.6	1.0	0.0
Gyalaan	186.8	0.05	18.0	8.68	44-54.3	C_I^{Na}	42 /48.8	14.2	15.0	65.8	1.0	0.0
Tsagaan soum	207.3	0.15	16.0	8.38	56.4-70.8	CC_I^{Na}	36 /85.4	5.3	12.0	65.4	3.0	0.0

The Tsenkher, Bor Tal, Gyalaan and Tsagaan soum hot springs are located in close distance. Their water quality and chemical composition is very approximate. Temperature ranges 44-86^oC, pH ranges 8.38-8.95, mineralization ranges 187-225 mg/l, and hardness ranges 0.05-0.15 mg-eqv/l. Tsagaan soum hot spring is subject to hydrocarbonate and carbonate classes, and others are subject to carbonate class, all subject to Na group and type 1 [6].

Borehole in the Gyalaan hot spa

Based on the Gyalaan hot spa, Mac LLC conducted drilling work of two boreholes and one borehole is for the purpose of exploration and another one, located on the north hilltop of Gyalaan River, is for the purpose of drinking water. There is no information about these two boreholes. But all we know is the drinking water borehole was sealed while another one wasn't. The latter is located near the spa on a grid of north latitude of $47^0$12'07.8" and west longitude of $101^0$30'17.1" and elevated at 1797 m from sea level. Pipe/chimney with a diameter of 168 mm and its 0.7 m is appeared from the borehole. Spring blows out through that chimney and this may negatively affect source of the Gyalaan hot spa. Water temperature in that borehole is 48.7^0C, pH 8.98, conductivity 350µS/cm, TDS 170 ppm, carbonate ion 48 mg/l, hydrocarbonate ion 48.8 mg/l, carbonate class, Na group, type 1, very fresh and soft water. And its chemical property is similar to the Gyalaanii hot spa. This hot spa which is blowing-out through its mount is being used by locals such as washing clothes and bath, etc. While this research was being carried out, a new tourist camp was being built behind the river [6].

Pic - Borehole near the Gyalaan spa

Pic - 2nd borehole behind the river

An image shows a state of being polluted by livestock around the Gyalaan spa. Source of the spa needs to be protected by building fence around and it needs to be improved.

Mineral springs in the Orkhon RB in Uvurkhangai aimag

Moilt mineral spring

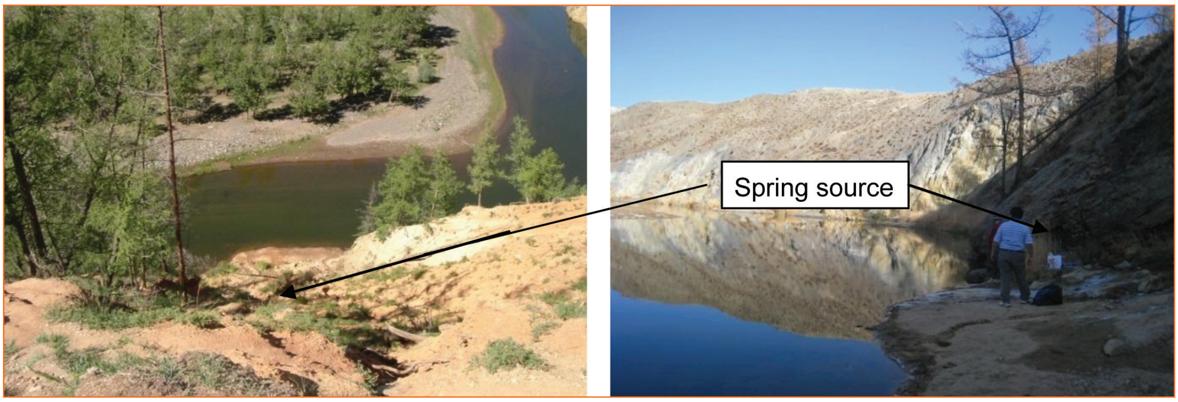
The Moilt springs is located on a grid of north latitude of $47^{0}12'11.8''$ and east longitude of $102^{0}47'38.5''$, elevated at 1436 m from sea level in the end of Baga Moiltiin valley behind Orkhon bridge in the territory of Kharkhorin. Monks of the Erdene Zuu monastery had used the spring for the purpose of nursing and therapy. This spring is used for diseases in stomach and internal organs. The water is odourless, flavourless, colourless and fresh and yield was 0.25 l/sec. According to test in Aug 1960, its temperature was 6^{0}C, radioactivity 20 by micro roentgen hour/time, pH-6.8, hydrocarbonate class, Ca group, water type 1, fresh (mineralization 492.2 mg/l) and slightly soft water (hardness 4.48 mg-eqv/l). When measurement was made on Oct 15, 2009, the spring's yield was disappeared and instead, there is a borehole/well and water is drawn from the well, manually. Typically, it's no longer used. The well was covered and closed and surrounded by stone wall. Temperature in the ell water was 7.2^{0}C, pH 7.48, conductivity 420 μS/cm, TDS 223 ppm, carbonic gas 22 mg/l, carbonate ion is undetected, hydro-carbonate ion 292.8 mg/l. The chemical composition is subject to hydrocarbonate class, Ca group, type 1, and for quality, fresh (mineralization 395.4 mg/l) and slightly soft water (hardness 4.70 mg-eqv/l).

Pic - General condition of the Moilt spring

Pic - Borehole/well of the Moilt mineral mineral spring

Uurtiin Tokhoin mineral spring

Uurtiin Tokhoin spring is located on a grid of north latitude of $46^{0}53'31.1''$ and east longitude of $102^{0}22'46.3''$, elevated at 1640 m from sea level, and located on 10 m height, under steep gorge/cliff in the bend of Orkhon River and it's about 12 km in the east of Bat-Ulzii soum centre. Uurtiin Tokhoi spring is similar to Kuko, Russian famous mineral water which is sold on the market and the spring is recommended to drink for stomach. According to measurement, some part of the spring which entered into the river bed is mixed with the river water and showed some changes in its quality and composition. But its source comes from deep underground through crack on the rock. Therefore, it is possibly not to lose its chemical property in the source section even it rains. Some yields of this spring are likely almost pressed due to slight change in riverbed of the Orkhon River as time goes by and gas was blowing out/gushing dispersedly around the river bank. The spring consists of huge volume of carbonic gas and this is a mineralized spring with a specific property.



Pic - Orkhon River, Uurtiin Tokhoi spring

The Uurtiin Tokhoi spring has several yields and bitter-tasted, fresh, cold, and temperature in main source/yield is 8.6^{0}C, weak acidity pH 7.48, mineralized, conductivity 1780 μS/cm, TDS 977 ppm, filled with too much gas, carbonic gas 1100 mg/l, carbonate ion is undetected, hydrocarbonate ion 1952 mg/l. For chemical composition, the spring is subject to hydrocarbonate class, Na group, type 1, and for quality, slightly salty (mineralization 2665 mg/l), very hard water (hardness 9.90 mg-eqv/l).

Pic - Measurement and research of the Uurtiin Tokhoi mineral spring

The Uurtiin Tokhoi spring is apparently included in a list of well-known springs in our country by its specific chemical composition and property. In fact, it is located in a place which is difficult to reach. On the other hand, its yield resource is small. Locals take and pack its water for the purpose of sale in warm seasons.

Khust mineral spring

Khust cold spring is located on a grid of north latitude of 46^{0}53'34.5" and east longitude of 102^{0}19'28.6", elevated at 1638 m from sea level in the valley of the Orkhon River in the territory of Bat-Ulzii soum. The spring's yield flows from 26 m diameter basalt rocks and it becomes also source of the Nariin River.

This spring is used in ways of drinking and bathing for all internal diseases, liver, heart, eye, gall bladder, etc. Many people visit here from neighboring aimag and soums however, this spring is locally used. Mr. Dashlonjid, local person assembles his own ger (tradition felt tent) here and personally serves the visitors. We were told by local herdsman that no tax is paid to local authority. The spring has many yields and identification mark is placed on source of each yield explaining which one is good at what disease.

Pic - Khust mineral spring

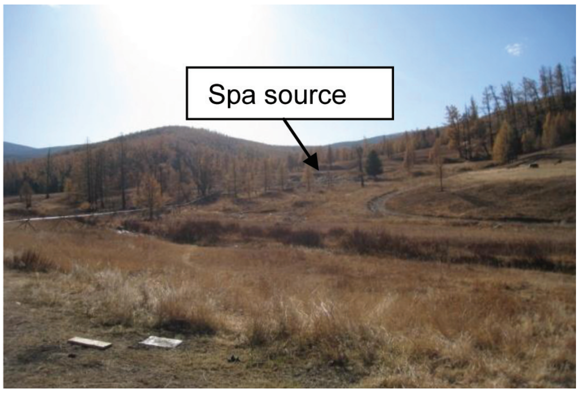
Chemical property of each yield is similar to one another and we have taken sample from main yield. The spring is very cold, it never freezes in winter, temperature was 3.8^{0}C, pH 7.49, conductivity 165 µS/cm, TDS 81 ppm, carbonic gas 22 mg/l, carbonate ion is undetected hydrocarbonate ion 91.5 mg/l, and for chemical composition, hydrocarbonate class, Na group, type 1, and for quality, very fresh (mineralization 134.0 mg/l) and very soft (hardness 0.60 mg-eqv/l) water.

Mogoit hot spa

The Mogoit hot spa is located on a grid of north latitude of 46^{0}44'50.7" and east longitude of 102^{0}13'56.3", elevated at 1865 m from sea level, 12 km in the south-west of Bat-Ulzii soum centre in its territory. It has many yields which blow out through cracks on boulder stone in the forest behind the rocky mountain in the east of Khangain Mountain. For natural condition, the Mogoit valley in which the hot spa located is a beautiful place. There are mountains such as Shar Buluu, Gol Khamar, Khetsuu Khavirga in the south and Rashaanii Nurangi, Khustiin Davaa, etc in the north of this valley. Khangai white rock (alternatively called Tsagaan Ovoo, as locals praised) in the forest in its south-east, there are plenty of wild animals as well as Zes Ulaan Mountain. Both sides are covered by steep-high mountains and forest. That's why it's not windy but leeward here. Hot steam is constantly steamed up from the hot string and plenty of environmental micro soft climate, precipitation, as well as constant fog found here. Due to above foggy condition, this area is called also Manangiin Tarkhi, Manangiin Gurvan Khovog.

Pic - Mogoit hot spa

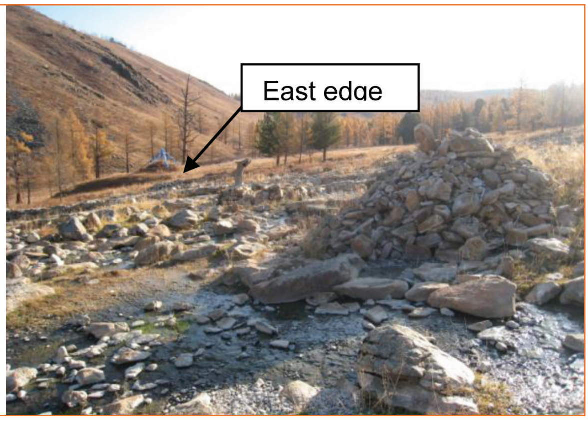
The area was being cleaned and some constructions were being built on the north hilltop of the hot spa in order to establish a new tourist camp and spa resort by Ombo LLC with a director Mr.Dash. Previously, there were some 4 bathe pools and 2 wooden houses and now they've been removed. Instead, the hot spa is taken to the opposite hillside of the spa through pipe and solution of bathing is due to complete here. This solution carries an advantage not to pollute the host spa.



Pic - It was planned to draw water from the hot spa through pipe and deliver it to the camp

It is necessary to improve road, improve environment and build fence due to plenty of mud/turbid here. However, environmental and climate conditions are very convenient to use this hot spa. According to measurement (by V.N.Popov) on May 29, temperature in some 11 yields ranged 33-72^0C, according to research by Sh.Tseren in 1957, temperature in total 16 yields ranged 45-72^0C, pH 8.0-8.2, carbonate ion 27-39 mg/l, hydrocarbonate 66-91.5 mg/l, total yield was 3.75 l/sec. In such research conducted some 50 years ago, each yield was clearly numbered and titled by specific human organs. But this numbering and title has become unclear now. We arrived at the Mogoit hot spa in the morning of Oct 13, 2009. The hot spa had over ten yields and it was 81 m from the very west yield to the very east yield.

Pic - Hot pot/craver



Pic - Main yield of the hot spa

Please see on-site measurement from table below.

Table 20. On-site measurement on some yields of the Mogoitiin hot spa

Yield	T⁰C	TDS ppm	pH
Down east yield	44.6	204	9.0
Up east yield	68.4	188	8.58
Big yield in south part (very rocky)	75.1	185	8.41
Middle yield	60.4	195	8.80
Up west yield	74.0	190	8.54
Crater yield	67.8	196	8.61
West small yield of Crater	57.7	197	8.97
Down yield of Crater	70.2	190	8.9
Down west yield	71.8	186	8.86
Very west and rocky yield	73.6	193	8.57

Our sample has been taken from the very west main yield and its temperature was 73.4^0C, pH 8.48, conductivity 320 µS/cm, TDS 186 ppm, carbonic gas is undetected, carbonate ion 54 mg/l, hydrocarbonate ion 61 mg/l, and for chemical composition, carbonate class, Na group and type 1, and for quality, fresh (mineralization 207.3 mg/l) and very soft water (hardness 0.05 mg-eqv/l). The yield of this hot spa consisted white algae divided into piece very similar to string.

Khamar hot spa

The Khamar hot spa is located on grid on north latitude of $46^0$44’35.1’’ and east longitude of $102^0$08’18.4’’, elevated at 1854 km from sea level. It’s 20 km in the west of Bat-Ulzii soum centre and 8 km from downstream of the Khamar River which is right-wing tributary of the Orkhon River. The hot spa is surrounded by the Shar Buluu Mountain in the south, Tsegeen Mountain in the west and the Shar Khamar Mountain is neighboring as well. The Khamar River flows through the valley of these mountains. In ancient time, kings had bathe by using this hot spa. The hot spa used to become hotter on the 3rd day of the first month in summer, spring and autumn according to the lunar calendar and sometimes this heat is continued until the 15th day. There is a history that some local people used to eat venison by pouring it into hot spa until it was cooked. The Khamariin hot spa was sulfur-tasted and flavoured, colourless and fresh, its temperature was 39^0C, yield 0.7 l/sec and it was able to be used only locally. Currently, this hot spa is mixed with water from the Khamar River and its chemical property is being changed and it was steaming from its yield. If we make a slight change in the riverbed and let it flow little apart from the hot spa, it will be able to restore the spa. We have taken sample from section in the river pebble which was fenced. The spa’s temperature was 24^0C, pH 8.74, conductivity 290 µS/cm, TDS 178 ppm, carbonic gas is undetected, CO_3^{2-}- 24 mg/l, HCO_3^-- 97.6 mg/l, and for chemical composition, hydrocarbonate class, Na group, type 1, and for quality, very fresh (mineralization 199.3 mg/l) and very soft (hardness 0.35 mg-eqv/l). The hot spa is polluted by livestock due to lack of fence except its entrance in the riverbed. The Khamar hot spa needs some care and protection.

There is a cold spring 65 m in the east of the Khamar hot spa and this cold spring is protected by “Tsegeen Nuur” Cooperative which was established by locals. The spring is surrounded by stone, and it was covered and closed. This cold spring is good at drinking for stomach and the related internal organs. Due to it never freezes in winter, locals drink in both winter and summer. Its temperature 5.4^0C, pH 7.47, conductivity 90 µS/cm, TDS 35 ppm, carbonate ion is undetected, hydrocarbonate ion 48.8 mg/l, and The chemical composition is subject to hydrocarbonate class, Ca and Na group, type 1, and for quality, very fresh (mineralization 72 mg/l) and very soft water (hardness 0.55 mg-eqv/l).

Gyatruun hot spa

The Gyatruun hot spa is located on a grid of north latitude of $46^0$38'41.8'' and east longitude of $101^0$56'49.7'', elevated at 2364 m from sea level on a boundary of larch, Siberian pine and birch forest in the beginning of the Gyatruun valley in up-east section of the Gyatruun Mountain in the territory of Bat-Ulzii soum. Many hot and cold springs' yields are gushed from the rock on upper edge of the forest of a high mountain. The hot spa was taken into water exploration in 1996. It is very difficult to reach there and it's impossible by car. It takes about 2 hours by horse as this area is 15 km elevated from the land.

Pic - General condition of the Gyatruun hot spa

Total yields of the hot spa is 2 l/sec, hydrocarbonate-Na class, temperature was 37^0C in 1944 (by Marinov and Popov), 39^0C in 1946 and 36^0C in 1957. There are 7-8 yields which blow out from the rock and it is unable to precisely identify the yields, it was approximately 4.0 - 5.0 l/sec. The Gyatruun hot and warm springs are similar to one another for chemical property. Small wooden houses with identification mark were built on each yield indicating name of some human organs. There are some images of gods and sutras in a wooden house which is stood in the beginning of the hot spa. While air temperature on Oct 11, 2009 was 10^0C what temperature of this hot spa was shown in table below.

Table 21. On-site measurement on the Gyatruun hot spa

Yield (by organ name)	T^0C	TDS ppm	pH
Uterus/womb	30.1	76	8.41
Anonymous	30.1	78	8.14
Kidney	38.0(35.2)	74	8.00
Liver	35.8	78	8.03
Gall bladder	37.0	78	8.13
Mind, brain	37.0	73	8.15
Heart and nerve	38.0(36.7)	80	7.80
Yield with a chant	34.8	82	8.21
Eczema	33.4	76	8.26

Except above yields, north two yields had slightly less temperature. The first one had temperature of 26^0C, pH 7.89, TDS 81 ppm and second one had 27.4^0C, pH 8.29, TDS 81 ppm.

Pic - Main yield of the Gyatruun hot spa

Pic - Sacred place on the source of the hot spa

There are a green algal in the Gaytruun hot spa. Main yield flows into container located in the house labeled 'heart and nerve' and whoever wants to be healed is recommended to bathe here. When we take sample from the main yield, its temperature was 37^0C, pH 8.47, conductivity 162 μS/cm, TDS 87 ppm, carbonate ion 6.0 mg/l, hydrocarbonate ion 73.2 mg/l, and for chemical composition, subject to hydrocarbonate class, Na group, type 1, and for quality, very fresh (mineralization 126.3 mg/l) and very soft (hardness 0.30 mg-eqv/l).

Gaytruun cold spring

The Gyatruun cold spring is located on a grid of north latitude of $46^0$38'47.5'' and east longitude of $101^0$56'51.1'', elevated at 2362 m from sea level. It's about 100 m distance in the north of the Gyatruun hot spa. The spring is flown out through crack on the rock and its yield is medium. Therefore, it is used by collecting in a wooden box which is located underneath. According to measurement, its temperature was 1.4^0C, pH 6.57, conductivity 38 μS/cm, TDS 14 ppm, HCO_3- 73.2 mg/l and it is similar to rain/snow water. We have taken sample from this spring and tested in a laboratory. The chemical composition is subject to hydrocarbonate class, Ca group and type 1, and for quality, very fresh (mineralization 32.1 mg/l) and very soft (hardness 0.30 mg-eqv/l).

Uvur Gyatruun mineral spring

Uvur Gyatruunii spring is located in the middle of rocks in front of the Gyatruun Mountain on a grid of north latitude of $46^0$33'32.4'' and east longitude of $102^0$03'009'' and elevated at 2225 m from sea level. To reach there it needs to pass through plenty of rocks towards north-east from the Bituunii spring. But many people visit there every year. However, it is very difficult to get there. At visitors' initiative, a new bridge was built on a small spring and improved the path leads to the spring. There are yields for each internal organ and it has also sacred place, natural pool and special place for a prayer. And it makes visitors spontaneously worshiped and prayed.

Pic - Uvur Gyatruun idol

Pic - Bathing pool

There are four large yields which gushed from the rocks and their property is similar. And we have taken sample from the main and idol yields. The spring is not cold, its temperature was 17^0C, pH 7.82, conductivity 150 μS/cm, TDS 74 ppm, carbonic gas and carbonate ion is undetected, hydrocarbonate ion 94.6 mg/l, and The chemical composition is subject to hydrocarbonate class, Ca group, type 1, and for quality, very fresh (mineralization 144.1 mg/l) and very soft (hardness 1.10 mg-eqv/l) according to laboratory test.

Bituut mineral spring

The Bituut spring is located in the middle of rocks on a front-side of the Gyatruun Mountain on a grid of north latitude of $46^0$32'27.4'' and east longitude of $102^0$03'34.2'' and elevated at 2226 m from sea level. The spring has a good yield and is not so cold, its temperature 14.6^0C, neutral medium (pH 7.527), conductivity 147 μS/cm, TDS 78ppm, CO_2 and CO_3 are undetected, and HCO_3- 94.6 mg/l. The chemical composition is subject to hydrocarbonate class, Ca group, type 1, and for quality, very fresh (mineralization 143.6 mg/l) and very soft (hardness 1.15 mg-eqv/l) according to laboratory test.

Pic - Main yield of the Bituut spring

Pic - The spring flows through rocks

Khujirt hot spa

The Khujirt hot spa is located 422 km in the west of UB, 110 km in the north of Arvaikheer and 54 km in the south-west of Kharkhorin in Khujirt soum centre, in the south ending section of the Khangai Mountain, in the south valley of the Orkhon River, on the east bank of Khujirt River (small), and surrounded by the Shiveet Mountain in the west and by the Gua Mountain in the east. Water vapour and humidness here is low and weather is clean and sunny in most seasons. According to mentioned in fable/

saga and history, this area was uninhabited but wild animals and surrounded by forest some 2000 years ago. At that time, hunter called Shunkhlai used to live here and while he was hunting around the Khujirt hot spa area, he saw one deer lying on a marshy land. When he approached the deer, it didn't move. So, he waited and observed for several days and the deer was still lying down there. And one day, the hunter decided to reach and got there. In reaction, the deer barely got up due to its legs were wounded and couldn't walk. Day by day, the deer was recovering and finally, ran away. As the hunter observed this natural healing process by the deer, he attempted to do the same as the deer did. As a result, pain in his legs and arms has gone away. So, he publicly declared that this spring was good at articulation. Since then, some 13 yields in the east bank of the Khujirt River have been used for a therapy. Branch hospital was established there in 1930s, complex construction with rooms started to build in 1933 and therapist/physician worked to provide advice to visitors on proper use of the spring and everything was made in a good order. In 1940, the first sanatorium with some 40 beds was established. By using the Khujirt hot spa, it is able to provide balneotherapy to patients who suffer from rheumatic, bone, muscle and joint aches, accessory nerve (end-bulb), womb, some stomach diseases and all kinds of skin/venereal disease.

The Khujirt hot spring has been widely researched. Russian-Mongolian joint research team kicked off their research in this area from the end of 1920s. A.S.Smirnov conducted research in 1926-1927, V.V.Dalikov in 1942, V.A.Chekhovsky in 1943, V.N.Popov in 1944 and national experts in 1957, respectively. As we see from the literature by these scientists, it suggested that there are 10 springs in this area and especially, soil formation here is substantially interesting [10]. Chemical property of these springs was similar. In 1944, V.N.Popov conducted test on several yields and determined it as hot spa which is weakly mineralised (mineralization 0.33mg/l), siliceous (H_2SO_3 18-40 mg/l) and it has sulfurous gas (H_2S 4.5-50 mg/l), weak alkalinity (pH 8.45), hydrocarbonated Na (by contained percent it was - CO_3^{2-} 44-45, HCO_3^- 21-23, SO_4^{2-} 20-24, Cl^- 12-13, Na^++K^+ 90-96, Ca^{2+} 2-4, Mg^{2+} 1) and temperature (T^0C 36.8-42). This test is similar to the test by A.S.Smirnov in 1927 and it was considered that there had been almost no change during 20 years. When analysis was made in Russian Spring Research Institute on some gas emitted from this spa, nitrogen consisted 93.94% of a total gas capacity, carbonic gas 0.44%, methane 1.77%, ethane 0.64%, propane 1.12%, butane 1.13%. Complete hydrocarbonic gas 0.96% above them and some rare gases haven't been identified. Also the spa was determined that it consists of slight radon and microelements such as gallium, tungsten (wolfram), molybdenum, copper, tin and silver [10].

Besides above 10 hot springs, sample was taken from borehole which was drilled and started to conduct research since 1963 as its temperature was 52^0C. Chemical composition of these yields was similar, but temperatures were quiet different. The yields consisted from alkalinity and different sulfurous hydrogen and it tends to increase in summer and decrease in winter. Due to the Khujirt spring is piquant-sulphur tasted, sulfurous-flavoured, bright-blue coloured and very soft, it feels like soapy when bathing and it makes skin very soft. According to research on water drawn from the borehole/well, it showed that it slightly consists of microelements such as aluminium, silver, copper, potassium (kali), germanium, lithium, manganese, molybdenum, nickel, white pin, tungsten (wolfram), iodine and brome, etc. And it consists of hydrocarbonate, sulphate, natrium-potassium, silicic acid, alkalinity, weak mineralization as well as quarterly-changed sulphur hydrogen [10]. Chemical composition of the sulphur hydrogen had been precisely analysed in 1964. As a result, thiosulphate ion was dominant/ majority and hydrosulphate ion was minority percent.

Pic - "Khujirt" spa resort

Pic - Borehole of the Khujirt hot spa

There is a greasy mud for a therapy in 8000 $м^2$ area near the Khujirt hot spa and chemical composition of the mud is described below by mg per 100 g:

Ca 1129.6, Mg 432.4, iron 904.9, aluminium 921.6, manganese 5.4, sulphate 59.2, silicic dioxide 640.0, aluminium oxide 1742.4, ironic oxide 1293.6, moisture capacity 32.0 and dead-weight 1.76. When cleaning the mud by fresh water and describing by chemical element, it suggested that it is not so strongly mineralised and it has an acidic environment [10]. Chemical composition is shown as below:

$$CO_2\ 0.017\ M\ 0.3\ \frac{SO_4 48\ Cl\ 35\ NO_2\ 12\ HCO_3}{(Na+K)\ 52\ Ca\ 42\ Mg\ 5}\ H_2SiO_3\ 35\ pH < 6.75$$

The mud is used as it considered that it's a good treatment of disease in such as bone and joints, accessory neural organs, stomach, liver, gall bladder and some skin/venereal disease. Therefore, hundreds of people visit here to get the appropriate mud therapy, as well as relax.

Except Khujirt spa resort, "Elma Khujirt" private camp is running its activities here in Khujirt. Some 3-4 wells are being used here and yield of old springs is disappeared now. The spa's temperature increases in upstream direction along the riverbed of Khujirt River. E.g. water temperature of newly drilled borehole by Elme Khujirt camp was 56.2^{0}C. As higher as temperature increases, hydrosulfuric acid smells deeper. In upper section, there is a good spring with soft and fresh water called 'Khundlun Bulag' which is adored and respected by locals.

We carried out research on the springs in this region in Sep 2009 and took sample for a complete analysis from the borehole on a grid of 46^{0}54'04.8'' and east longitude of 102^{0}46'22.1'', elevated at 1642 m from sea level, located on east bank of the river outside fence of the camp. Water supply for the camp is provided by drawing water from the borehole/well into the pool. While making measurement, water temperature was less than actual due to it was unable to slowly dump the water. According to on-site measurement, the spa's temperature was 47.2^{0}C, pH 8.725, conductivity 370 μS/cm, TDS 186 ppm, carbonic gas is undetected and found a little bit hydrosulfuric acid (odour increases as the temperature increases), carbonate ion 24.0 mg/l, hydrocarbonate ion 97.6 mg/l. According to the laboratory test the chemical composition is subject to hydrocarbonate class, Na group and type 1, and for quality, fresh (mineralization 239.8 mg/l), very soft (hardness 0.65 mg-eqv/l). The borehole of "Elma Khujirt" camp is located on upper part of old boreholes (south of the boreholes) and it is hotter than others. When taking sample, water was drawn from the borehole to the reserve pool and according to measurement, its temperature was 56.2^{0}C, pH 9.056, conductivity 390 μS/cm, TDS 201ppm, carbonic gas is undetected, hydrosulfuric acid is detected, carbonate ion 48.0 mg/l and hydrocarbonate ion 36.6 mg/l. The chemical composition is subject to carbonate class, Na group, type 1, and for quality, very fresh (mineralization 197.1 mg/l) and very soft (hardness 0.10 mg-eqv/l) water according to the laboratory test. From comparison of these two boreholes, it's seen that as closely as it approaches the river's upstream part, spa's temperature and alkalinity are tended to increase and mineralization is decreased.

Must cold spring

Must cold spring is located on grid of north latitude of 46^{0}42'22.0'' and east longitude of 102^{0}46'33.2'', elevated at 1819 m from sea level in an open place in the territory of Zuunbayan Ulaan soum in south of Khujirt soum. Its yield flows from the middle of mounds which originated by permafrost in the valley of the Must Mountain. Between 1980 and 1990, the spring was used for disease in liver, gas bladder and stomach, etc. Recently, it is being drought and became less. It appears lately in Sep, Oct in autumn and its yield became 0.011/sec and flows merely 15 m and disappears/percolates into soil. In order to protect the spring, a particular project is being implemented by local person E.Zolbayar of Khad brigade and now it is planned to build fence.

Pic - Must cold spring

During research, yield beside of the stony hillock wasn't appeared but it appeared from near ground. Unless protect this spring such as building fence, it might be polluted by livestock and its water may go underground. According on-site measurement, Must spring's temperature was 0.8^{0}C which is very cold, neutral medium (pH 7.15), conductivity 330 μS/cm, TDS 170 ppm, carbonic gas 8.8 mg/l, carbonate ion is undetected, hydrocarbonate ion 189.1 mg/l. The chemical composition is subject to hydrocarbonate class, Ca group, type 1, and for quality, fresh (mineralization 301.2 mg/l) and soft (hardness 2.75 mg-eqv/l) according to the laboratory test.

Seruun bulag spring

Located in the territory of Yusunzuil soum on a grid of north latitude of 46^{0}41'58.2'' and east longitude of 103^{0}42'03.1'' and elevated at 1795 m from sea level. The spring is 4 m in width, 16 m in length, its yield flows out from half-round shaped bank and there are 2 sources. Locals have been drinking it for internal disease and it also becomes source of Dulguun River. There is a black mud around its bank and the spring often used by livestock due to no fence around, its yield is low and risky to be polluted and lacked. Seruun bulag spring is mentioned in Mongolian popular song as its composer and poet are native people of this region.

Pic - Seruun bulag spring

According to on-site measure, its temperature ranged 3.3-3.6^{0}C, neutral medium (pH 6.9), conductivity 400 μS/cm, TDS 190ppm, carbonic gas 8.8 mg/l, carbonate ion is undetected, hydrocarbonate ion 222.7 mg/l. According to the laboratory test, it is subject to hydrocarbonate class, Ca group and type 1 for chemical composition, and fresh (mineralization 330.6 mg/l) and slightly soft water (hardness 3.65 mg-eqv/l) for quality.

Orkhonii Saikhan Bulag spring

The spring is on a grid of north latitude of 46^{0}56' and east longitude of 102^{0}30' and elevated at 1550 m from sea level. And its yield flows out from upper ending section of Khurdet on the north bank of the Orkhon River in the territory of Khujirt soum. And it flows into the Orkhon River. It is a fresh, soft, cold, flavourless, odourless and colourless spring.

Tavan Salaa spring

It is located on a grid of north latitude of 46^{0}53'52.5" and east longitude of 102^{0}21'34.6", elevated at 1624 m from sea level in the vicinity of Ulaan River waterfall, mouth of the Tsagaan River in the territory of Bat-Ulzii soum. It has a large five yields. Water is fresh and used for therapy of stomach disease. Not well-known yet but widely used, locally.

Pic - Tavan Salaa spring

Table 22. General indicators of chemical analyses in mineral springs in the Orkhon RB upstream part

No	Name of spring/spa	Location	Research year/ and researcher	Main ion index	Mineralization g/l	Hardness mg-eqv/l	pH	T°C	H_2S mg/l	Remarks
1	Tsenkher hot spa	47°19′00.4″ 101°39′08.2″	1955, Sh.Tseren	C^{Na}_{I}	0.24	0.20		90	11.6	Spa resort, sanatorium and entity
			1985, Genscheme	C^{Na}_{I}	0.33		8.8	86	10.0	Q-10.0 litre/second
			2005, Geoecology	CO^{X}_{II}	0.32	0.30	7.9-8.5	80-85		Q-3.8 l/s /main yield not included/
			2009, Geoecology	CO^{Na}_{I}	0.24	0.10	8.89	86.2	3.7	4 tourist camps
2	Bor Tal hot spa	47°11′19.7″ 101°35′35″	1957, Sh.Tseren	C^{Na}_{I}	0.26	0.25	8.0	42	4.6	
			1985, Genscheme	CCO^{Na}_{I}	0.26		9.0	46	12.0	Q-4.5 l/s
			2005, Geoecology	CCO^{X}_{II}	0.28	0.35	8.9	41-43		Used for daily wash by locals
			2009, Geoecology	CO^{Na}_{I}	0.19	0.05	8.95	45-50		
3	Gyalgar (Gyalaan) hot spa	47°12′07″ 101°30′16″	1957, Sh.Tseren	CO^{Na}_{I}	0.21	0.15	8.1	50		
			1985, Genscheme	CCO^{Na}_{I}	0.35		9.0	52	12.0	Q-1.0 l/s
			2005, Geoecology	C^{X}_{II}	0.34	0.25	8.9	40-52		Many hot and warm yields
			2009, Geoecology	CO^{Na}_{I}	0.19	0.05	8.7	44-54		Borehole near the spa and tourist camp is being built
4	Khujirt hot spa	46°54′04.8″ 102°46′22.1″	1927, V.A.Smirnov	CO^{Na}_{I}	256.6	0.74	9.4	39	9.37	H_2SiO_3-105.9 mg/l
			1934, expedition of Health Ministry	C^{Na}_{I}	256.3	0.42	7.9			H_2SiO_3-17.8 mg/l
			1944, V.N.Popov	CO^{Na}_{I}	209.5	0.15	8.4	45	3.9	H_2SiO_3-48.8 mg/l
			1945, V.N.Popov	X^{Na}_{I}	205.5	0.16	8.4	52	5.2	H_2SiO_3-98.8 mg/l
			1957, Sh.Tseren	CO^{Na}_{I}	163.3	0.26	8.0	40	4.4	H_2SiO_3-58.8 mg/l
			1957, Sh.Tseren	CO^{Na}_{I}	249.2	0.30	8.2	53	8.2	H_2SiO_3-100 mg/l
			1985, Genscheme	CO^{Na}_{I}	290.0		8.6	55	12.0	It has a therapeutic mud. Elma Khujirt camp's borehole T-56.2°C, pH-9.056
			2005, Geoecology	CO^{Na}_{I}	260.0	0.20	9.1	42-53	+	
			2009, Geoecology	C^{Na}_{I}	239.8	0.65	8.7	52	+	
5	Mogoit hot spa	46°44′50.7″ 102°13′56.3″	1957, Sh.Tseren	CO^{Na}_{I}	320.0		8.4	50		16 yields for each human organ
			2009, Geoecology	CO^{Na}_{I}	207.3	0.05	8.5	45-73		It's owned by "Ombo" LLC. There are 10 yields
6	Khamar hot spa	46°44′35.1″ 102°08′18.4″	2009, Geoecology	C^{Na}_{I}	199.3	0.35	8.7	24		T-5.4°C, pH-7.47, C^{CaNa}_{I}, mineralization 72 mg/l
7	Gyatruun hot spa	46°38′41.8″ 101°56′49.7″	1957, Sh.Tseren	CO^{Na}_{I}	210.6	0.15	8.2	50	6.1	H_2SiO_3-54.1 mg/l
			2009, Geoecology	C^{Na}_{I}	126.3	0.30	8.5	30-38		10 yields for each human organ
8	Gyatruun cold spring	46°38′47.5″ 101°56′51.1″	2009, Geoecology	C^{Ca}_{I}	32.1	0.30	6.6	1.4		Chemical composition is similar to rain water
9	Khust spring	46°53′34.5″ 102°19′28.6″	2009, Geoecology	C^{Na}_{I}	134.0	0.60	7.5	3.8		Number of yields for each human organ
10	Uurtiin Tokhoi spring	46°53′31.1″ 102°22′43.6″	2009, Geoecology	C^{Na}_{I}	2665	9.90	6.1	8.6		CO_2-1100 mg/l, yield resource is small and difficult to use
11	Uvur Gyatruun spring	46°33′32.4″ 102°03′00.9″	2009, Geoecology	C^{Ca}_{I}	136.0	1.00	7.8	17.0		There are 6-8 yields for each human organ

No	Name of spring/spa	Location	Research year/ and researcher	Main ion index	Mineralization g/l	Hardness mg-eqv/l	pH	T^{0}C	H_2S mg/l	Remarks
12	Bituut spring	46^{0}32′27.4″ 102^{0}03′34.2″	2009, Geoecology	C^{Ca}_{I}	135.2	1.15	7.5	15		Stomach and internal disease
13	Orkhonii Saikhan Bulag spring	46^{0}56′ 102^{0}30′					7.4			Fresh and cold spring flows 500 m and joins the Orkhon River
14	Tavan Salaa spring	46^{0}53′52.5″ 102^{0}21′34.6″	2005, Geoecology	C^{Ca}_{I}						Fresh and cold 5 springs flow into Orkhon River in a very short distance
15	Moilt spring	47^{0}12′11.8″ 102^{0}47′38.5″	1957, Sh.Tseren	C^{Ca}_{I}	492.2	4.87	6.8	6.0		Internal disease
			2009, Geoecology	C^{Ca}_{I}	395.4	4.70	7.5	7.2		Water is drawn manually from well as its yield reduced
16	Must spring	46^{0}42′22.0″ 102^{0}46′33.2″	2009, Geoecology	C^{Ca}_{I}	301.2	2.75	7.15	0.8		Yield is very small and unprotected
17	Seruun bulag spring	46^{0}41′58.2″ 103^{0}42′03.1″	2009, Geoecology	C^{Ca}_{I}	330.6	3.65	6.9	3.3		Yield is small and it flows into the Dulguun spring immediately after blowing out. Unprotected

5.2. Mineral springs in the Orkhon RB midstream part

This part covers Ugii Nuur, Battsengel and Ulziit soums of Arkhangai aimag; Mogod, Saikhan, Khishig Undur, Orkhon, Bulgan soums, south part of Bugat soums of Bulgan aimag; Tseel soum of Tuv aimag; Baruunburen, Orkhon soum and half east part of Orkhontuul soum of Selenge aimag.

Shart mineral spring

This cold spring is located on a grid of north latitude of 47^{0}01’41.8’’ and west longitude of 101^{0}39’ 20.9’’ and elevated at 1739 m from sea level on a slope (in south direction) in the beginning of the Shart mouth in the territory of Tsenkher soum, Arkhangai aimag. Its two small yields are gushed from the bottom of stone on a steep downhill (towards south-east direction) in the midst of black forest, west side of valley (towards south direction), north of Rashaantiin Asgat, west of Shar Khamar, south-east of Rashaant Mountain, north of Mankhan Mountain and in the source of Tsetserleg River [6]. This spring is well-known locally as it is used to therapy of liver and other internal organs especially, hepatitis, but not appropriate for gall bladder. In 1960s, this spring had been used by people such as bathe, drink, etc by using wooden channel/pipe. The spring is owned by Shartiin Nukhurlul Cooperative which was established locally, but there is no organization which is responsible for its maintenance and utilization.

Pic - Shart cold spring

The spring is odourless (no smell), colourless, flavourless and fresh water. According to measurement on Aug 123, 1960, its yield was

0.35 l/sec. It never freezes in winter time. In Oct 2009, temperature in its yield was 2.8^{0}C, pH 7.76, TDS 116 ppm, and east yield T- 2.1^{0}C, pH 7.82 and TDS 113 ppm. The spring contains a slight carbonic gas (CO_2 6.6 mg/l) and is subject to hydrocarbonate class, Ca group, type 1, fresh (mineralization 204.9 mg/l) and soft water (hardness 2.25 mg-eqv/l) [6].

Tsagaan Sum hot spa (Jarantain hot spa)

Tsagaan Sumiin hot spa is located on grid of north latitude of 47^{0}04'01.7'' and west longitude of 102^{0}05'56.4" and elevated at 1699 m from sea level in the valley of Tsagaan Sum (Jarantai) River in the midst of the Chonot, Khan-Undur, Gugesh, Tumur Khairkhan and Undursant Mountains with a forest in the territory of Khotont soum, Arkhangai aimag. Ancient city's ruin is located on north hillside 4 km from the hot spring and the White summer palace for the kings of ancient capital city of Kharkhorum was located 23-25 km from the spring. Also this spring is located to the Orkhon's black ruin of ancient Uigur State and the ancient capital city of Kharkhorum and it reveals that the spring is nationally well-known as it has been ceaselessly used from ancient time until today. The Orkhon's black ruin was the Uigur State's capital city of Ordubalik in the 9th century and Khar Balgas is the remains of Baliklik city. It was trade centre with a protected castle which was located on the way of the Silk Road. Khar Balgas and Kharkhorum cities were controlling the north branch of the Silk Road for 400 years. There are remains of the king's castle, handcraft manufacture, castle, horse fence, military and trade warehouses and administration building, etc. These remains were included in protection by the country in 1971 and registered in the UNESCO's world heritage in 1996 at level of "becoming remarkable cultural value". Sculpture Mr.Zanabazar of Erdene Zuu Monastery was born near Shine Usnii River, a tributary in upstream of the Tsagaan Sumiin River and he established the Tuvkhun Monastery.

Yields are originated from edge and central parts of the hilltop (98 m in length and 10 m in width) stood in the midst of Jarantai and Tsagaansoum River. There are 10 yields and main yield becomes Zurkh spring. According to measurement on Aug 26, 1960, temperature in one yield was 27^{0}C, other five yields ranged 42-69^{0}C, and an average yield ranged 2-3 l/sec. But according to measurement on Oct 13, 2009, yields' temperature ranged 56.4-70.8^{0}C. And signboards are put on the head of all springs explaining which spring is good at which organ. And each spring has a different colour of algae. The spring is capable to cure some diseases such as articulation, neural disease, etc. It is unable to identify the exact volume of each yield, but total yields are approximately 8-10 l/sec.

Pic - General condition of the Tsagaan Sum (Jarantain) hot spa (locals are doing some wash)

There were some camp and spa resorts based on the hot spa, but disappeared in recent years. And individuals usually come here on their own to have some spa therapy. As the river which tourists pass by is located on the main road, “Ikh Khaan Khubilai”, “Jarantai” and “Tsagaan Sum” tourist camps are running activities around there. So, we have taken sample from the main yield and its temperature was 70.8^{0}C, pH 8.38, conductivity 360μS/cm, TDS 193 ppm, carbonate ion 36 mg/l, hydrocarbonate ion 85.4 mg/l. The chemical composition is subject to hydrocarbonate and carbonate classes, Na group and type 1. For quality, it is fresh (mineralization 207.3 mg/l), very soft water (hardness 0.15 mg-eqv/l).

Khukh Sum spring (Bor Burgas)

Khukh Sum mineral spring is located on a grid of north latitude of 47^{0}15’ and west longitude of 101^{0}58’05” and elevated 2000 m from sea level in the territory of Tuvshruulekh soum, Arkhangai aimag. It flows towards south direction from the mountain in the west of Khukh Sum River. There are many yields in this spring and they are originated in the midst of black-blue coloured mafic slate/shale, rock and boulder stones. Also hazel granites are rarely found there.

Pic -Khukh Sum (Bor Burgas) mineral spring

This mineral spring is surrounded by Tumur Khairkhan, Ikh-Ar, Teleegiin Khairkhan, Gurvan Gets and Surt Ovoo mountains with larch (Blackwood) wood forest. Khukh Sum River valley is much wide and rich about grass and plants. Khukh Sum spring is alternatively called Bor Burgas spring. Bor Burgas valley is substantially narrow and its two mountain sides are steep, there are plenty of forest (jungle) and springs and it is really beautiful place. Due to this area is surrounded by forest and high mountains, wind here is not strong, warmly leeward, relatively cool in warm season and more precipitation. During summer, tourist visit here often to drink and bathe in order to get rid of many diseases in stomach, lungs and other internal organs. There are many small wooden houses here. The spring is colourless, flavourless, odourless, fresh water and subject to hydrocarbonate-Ca-Mg-Na [10]. Chemical property in many yields of the Bor Burgas mineral spring is similar to one another. Total springs’ temperature is 6.4^{0}C, pH 7.42, conductivity 230μS/cm, TDS 114 ppm, and carbonate ion is not appeared, hydrocarbonate ion 131.2 mg/l. The chemical composition is subject to hydrocarbonate class, Na group and type 1. For quality, it is fresh (mineralization 215.6 mg/l) and soft water (hardness 1.00 mg-eqv/l) [6].

Gants Mod mineral spring

The Gants Mod spring flows from the west of the Bulgan Mountain in Erdenebulgan soum, Arkhangai aimag and Jamgan spring flows from the east of the mountain and they have been used from generation to generation.

The Gants Mod spring is located on a grid of north latitude of $47^0$28',56.9" and east longitude of $101^0$25'24.7" and elevated at 1796 m from sea level in the west bottom of the Bulgan Mountain. There is an accustomed tradition that the spring should be drunk by whoever crosses over Tsagaan Davaa, the mountain pass. In order to protect source of the spring, fence was build surrounding the source and water is taken through pipe/channel. According to measurement on Oct 14, 2009, the spring's temperature was 4.7^0C, pH 7.39, conductivity 119 μS/cm, TDS 60 ppm, carbonic gas 8.8 mg/l, carbonate ion is not detected, hydrocarbonate ion 61mg/l. The chemical composition is subject to hydrocarbonate class, Ca group and type 1. For quality, it is subject to fresh (mineralization 91.6 mg/l) and soft (hardness 1.00 mg-eqv/l). This spring never freezes in winter and locals drink for therapy of and preventing diseases in stomach and internal organs.


Pic - Gants Mod mineral spring

There hasn't been significant change in water of the spring.

Jamgan mineral spring

Jamganii spring is located on west bottom of the Bulgan Mountain and on a grid of north latitude of $47^0$29'18.4" and east longitude of $101^0$27'16.0" and elevated at 1699 m from sea level. Surrounding the spring, iron fence was built and the spring is used such as drinking for diseases in stomach and internal organs. The spring's yield is slightly less than the Gants Mod spring. According to measurement on Aug 12, 1960 [10], the spring's temperature was 1^0C, radioactivity 40 by micro roentgen hour/time, hydrocarbonate class, mixed group, very fresh (mineralization 123 mg/l) and very soft water (hardness 1.10 mg-eqv/l). But according to measurement on Oct 14, 2009, its temperature was 4.0^0C, pH 6.86, conductivity 118 μS/cm, TDS 56 ppm, carbonic gas 8.8 mg/l, carbonate ion is undetected, hydrocarbonate ion 73.2 mg/l. For chemical composition, hydrocarbonate class, Ca group and water type 1. For quality, it is subject to very fresh (mineralization 102.5 mg/l) and very soft water (hardness 1.05 mg-eqv/l). As we see from the test, the spring's chemical property hasn't been typically changed during 50 years and it is similar to the Gants Mod mineral spring and it doesn't freeze in winter.

Pic - Jamgan mineral spring

Chuluun Davaa mineral spring

Chuluun Davaanii spring is located on the Chuluun mountain pass in the territory of Khotont soum, Arkhangai aimag on a grid of north latitude of $47^0$17’ and east longitude of $102^0$25’ and elevated at 1650 m from sea level. It’s about 10 km in the south-west from Khotont soum and 2 km from the forest. Mainly used for drinking for variety of disease such as stomach and other internal organs, locally used. The spring is odourless, flavourless, colourless and fresh water and it is subject to hydrocarbonate class and Ca and Na group.

Baishingiin Bulag mineral spring

The spring is located on a grid of north latitude of $47^0$13’30” and east longitude of $101^0$34’ and elevated at 1690 m from sea level. It’s about 20 km in the south-east of Khotont soum, Arkhangai aimag. The spring flows into Temeem Khuzuunii River in north-east direction about 1 km and green algal is commonly found in the spring. It is locally used and drinkable for disease in stomach and internal organs. The spring is odourless, flavourless, colourless and fresh and its yield is good. It is subject to hydrocarbonate class and Ca and Na group.

Shivert hot spa

Located on a bank of Shivert River in the north of Toom Mountain in the territory of Battsengel soum, Arkhangai aimag on a grid of north latitude of $47^0$38’30” and east longitude of $101^0$31’15”, elevated at 1710 m from sea level. It’s about 21 km from aimag centre of Tsetserleg, 38 km from Battsengel soum and 23 km from Ikh Tamir soum.

The Shivert hot spa is surrounded by branch forest mountains of Khangai Mountain such as Undur Shiveet, Atsat Gozgor, Toom, Khukh Chuluut, Galaviin Ulaan and Bulgiin Ovoo, etc. There are several yields which gush from the bottom of grass with yellow mire of the river which consisted of mafic slate, sandstone, sedimentary rocks and pebbles which based on granite, crystalline stone and marl from Hertsen age.

Yields of two main hot springs are 0.52 l/s, sulphur-flavoured and tasted, colourless and fresh water, and subject to sulphate-natrium group. Temperature of its yields as follows. Temperature of the 1^{st} hot spa was 60^0C, the 2^{nd} spa 39^0C, the 3^{rd} spa 18^0C, the 4^{th} spa 17^0C, the 5^{th} spa 16^0C and the 6^{th} spa 16^0C, respectively (as of Aug 22, 1957). According to research by geologists before 1957, the 1^{st} spa was 60^0C, the 2^{nd} spa 54^0C and the yield was 2.38 l/s. And it was considered that due to the yield was pressed by mud/rubbish and mixed with soil water, it might have shown different indicator. In Selenge RB scheme (genscheme), it was noted that water temperature was 47^0C and the yield was 1.0 l/s [10].

In times of communism, there was a centralized factory of the common union in Ikh Tamir soum and then-labour hero, Mr. R.Minjuur established local spa resort with a capacity of some 200 beds. And it used to serve patients who were suffering from articulation, womb and skin/venereal disease. Just recently, "Khasu Mandal" LLC has improved and furnished the spa resort at modern level and established national spa resort.

Tsats spring

Tsats (Ulgii-Khalzan) spring is located in the territory of Battsengel soum, Arkhangai aimag on a grid of north latitude of $47^0$59' and east longitude of $101^0$57' and elevated at 1650 m from sea level. It's about 65 km in north-east of Tsetserleg city and 24-25 km from Battsengel soum centre. There are 6 yields which blow out from the bottom of thick trap from ancient volcano and they never freeze in winter. The spring has no colour, flavour and its yield is good enough. It is subject to hydrocarbonate-Ca-Mg. It is drinkable for stomach and internal disease. Moreover, the spring is blocked in distance of 40 m by wooden dam in order to collect its water. And there are 3 pipes in which water gushes out strongly. And this is used for a therapy of articulation, nerve and rheumatic.

Sarlag spring

The spring is located 6 km in the south of Ugii Nuur soum in Arkhangai aimag on a grid of north latitude of $47^0$37' and east longitude of $102^0$34' and elevated at 1345 m from sea level. Its yield flows out underneath very thick aquifer from the Quaternary through grass on marshy mounds with small gravel. The spring is ironic-tasted, brownish-coloured and its yield 1.0 l/s, hydrocarbonate class Na-Ca groups. Locals use it by drinking for stomach disease, losing weight, dizziness and physical deterioration, etc.

Tamiriin Ulaan Khoshuu spring

The spring is located in valley of the Tamir River, 12 km from Ugii Nuur soum centre in Arkhangai aimag on a grid of north latitude of $47^0$44' and east longitude of $102^0$29' and elevated at 1348 m from sea level. Its yield flows out from underneath thick aquifer from the Quaternary and located in a green field of the river with a brushwood, mire and mounds. Local people use it by drinking for stomach and internal disease and the spring is odourless, flavourless, colourless and fresh. It is subject to hydrocarbonate class and its yield 1 l/s.

Tsats Tolgoin spring

The spring is located on a grid of north latitude of $47^0$48' and east longitude of $102^0$37' and elevated at 1340 m from sea level in the territory of Ugii Nuur soum. Its yield flows out from the middle of mafic slate/shale which a navy-coloured and knifegrinder-shaped from the bottom of the river bank in the bottom of Tsats hill near the Orkhon River. It is risky to be seized water from the river when flood takes place. The spring is considered to be good at internal disease and it's used locally. It is colourless, flavourless and odourless and subject to hydrocarbonate-Ca-Na.

Tsaidam Lake

Tsaidam Lake is located on a grid of north latitude of $47^0$52'30" and east longitude of $102^0$37'30", elevated at 1340 m from sea level, 25 km in the south-east of Ulziit soum and 4 km in the east of the Orkhon River. The lake is 15 m in diameter, 1.5 m in depth and very salty. Locals bathe here in the lake for therapy of skin/venereal disease, wound, articulation, kidney, spine and scurvy, etc.

Huge amount of saline, saltpeter and salt are mined/quarried from the lake, annually.

The lake water is salty, turbid, light-coloured, sulfuric silt-flavoured and subject to hydrocarbonate class and Na group.

Table 23. General indicators of chemical analyses in the mineral springs in the Orkhon RB midstream part

No	Name of spring/spa	Location	Research date/ Researcher	Main ion index	Mineralization g/l	Hardness mg-eqv/l	pH	T⁰C	H_2S mg/l	Remarks
1	Tsagaan Sum (Jarantai) hot spa	$47^{0}04'01.7''$ $102^{0}05'56''$	1957, Sh.Tseren	X^{Na}_{I}	0.18	0.20	7.6	59-69	9.2	It has 5-6 yields and each yield has different algae
			1985, Genscheme	CCO^{Na}_{I}	0.29		8.8	69	18.0	Q-8.0 l/s
			2005, Geoecology	C^{Ca}_{I}	0.25	0.30	8.1	65		There are 3 tourist camps
			2009, Geoecology	CCO^{Na}_{I}	0.21	0.15	8.38	56.-71		
2	Khukh Sum (Bor Burgas) spring	$47^{0}15'$ $101^{0}58'05''$	1957, Sh.Tseren	C^{Ca}_{I}	0.21	2.0	7.8	8		Stomach and internal disease
			2005, Geoecology	C^{Ca}_{I}	0.37	3.45	7.1	12	Main Q	Wooden houses for guests
			2005, Geoecology	C^{Na}_{I}	0.21	1.0	7.4	6.4		
3	Shart spring	$47^{0}01'41.8''$ $101^{0}39'21''$	1960, Sh.Tseren	C^{Ca}_{I}	0.26	3.2	6.8	4		Variety of stomach and internal disease
			2009, Geoecology	C^{Ca}_{I}	0.20	2.25	7.82	2.1		Not used for gall bladder disease
4	Jamgan spring	$47^{0}29'18.4''$ $101^{0}27'16''$	1960, Sh.Tseren	C^{X}_{I}	0.12	1.10	6.8	1		
			2005, Geoecology	C^{CaMg}_{I}	0.14	0.90	6.8	1-2		Internal disease
			2009, Geoecology	C^{Ca}_{I}	0.10	1.05	6.86	4.0		Source is protected
5	Gants Mod spring	$47^{0}28'57''$ $101^{0}25'25''$	2005, Geoecology	C^{CaMg}_{I}	0.14	0.80	7.2	1-2		Internal disease
			2009, Geoecology	C^{Ca}_{I}	0.09	1.00	7.4	4.7		Source is protected
6	Altan Ovoo spring	$47^{0}24'01''$ $101^{0}45'$	1957, Sh.Tseren	C^{Ca}_{I}	0.37	2.6	6.8	3		Variety of stomach and internal disease
7	Ulziit Tolgoi spring	$47^{0}37'$ $102^{0}00'$	1957, Sh.Tseren	C^{Na}_{I}	0.23	1.56	6.6	7		Stomach and internal disease
8	Ikh Teel spring	$47^{0}16'$ $101^{0}39'30''$	1960, Sh.Tseren	C^{X}_{I}	0.22	2.11	6.6	6		Stomach acid increase and decrease, headache and rheumatic
9	Baishin Bulag spring	$47^{0}13'30''$ $102^{0}34'$	1960, Sh.Tseren	C^{Ca}_{I}	0.30	2.57	6.8	3		Internal disease
10	Shivert hot spa	$47^{0}38'30''$ $101^{0}31'15''$	1957, Sh.Tseren	COS^{Na}_{I} S^{Na}_{I}	0.23	0.20	8.2	80	6.8	Spring with a sulfuric gas and mud is used
			1985, Genscheme	COS^{Na}_{I}	0.33		8.8	47		Q-0.1l/s

No	Name of spring/spa	Location	Research date/ Researcher	Main ion index	Mineralization g/l	Hardness mg-eqv/l	pH	T⁰C	H_2S mg/l	Remarks
11	Khuree Nutag spring	47⁰37/ 101⁰31/	1985, Genscheme	C^{Ca}_{I}	0.13		7.8	2.0	-	Internal disease
12	Sarlag spring	47⁰37/ 102⁰34/	1960, Sh.Tseren	C^{NaCa}_{I}	0.52	3.77	6.6	8		Digestive organ, against slimming and dizziness, etc
13	Tamiriin Ulaan Khosuu spring	47⁰44/ 102⁰29/	1960, Sh.Tseren	C^{X}_{I}	0.31	2.48	6.8	4		Stomach and internal disease
14	Tsats Tolgoi spring	47⁰48/ 102⁰37/	1960, Sh.Tseren	C^{Ca}_{I}	0.38	3.40	6.8	6		Digestive organ and internal disease
15	Tsaidam Lake	47⁰52/30// 102⁰37/30//	1960, Sh.Tseren	CO^{Na}_{I}	2.41	5.43	7.8	20		Skin disease, rheumatic, scurvy, 4 joints, kidney and spine disease
16	Saikhan Khulij hot spa	48⁰16/ 102⁰58/	1960, Sh.Tseren	S^{Na}_{II}	0.74	2.32	7.8	38	7.6	Sulfuric-tasted, Disease in kidney, spine, rheumatic and venereal disease
			1985, Genscheme	S^{Na}_{II}	0.77		8.7	52	6.0	Q-1.3 /s
17	Khulijiin Khar Lake	In the foot of spring	1960, Sh.Tseren	S^{Na}_{II}	1.09	3.23	7.8	24		Articulation, rheumatic kidney, spine and venereal disease
18	Khunt spring and lake	48⁰28/ 102⁰32/	1960, Sh.Tseren	The lake's temperature is 17⁰C and its mud is used for articulation therapy, and spring (T- 3⁰C) which flows out of the lake is used for stomach and internal disease						
19	Asgat spring	48⁰39/ 102⁰38/	1960, Sh.Tseren	C^{Na}_{I}	0.56	3.60	6.8	1		It consists of a slight CO_2 and iron. Mg is dominant in its hardness
20	Dalain Bulag spring	48⁰56/ 102⁰27/	1960, Sh.Tseren	C^{X}_{I}	0.33	3.03	6.8	5		Stomach and internal disease
21	Khugnu Khaan small spring	47⁰25/ 103⁰41/	1960, Sh.Tseren	CS^{Na}_{I}	0.13	0.55	Digestive organ, internal disease and good at eyes as it is leaked almost drop by drop			
22	Khundlun spring	48⁰19/ 104⁰00/	1956, Sh.Tseren	C^{Na}_{I}	0.49	2.72		0-5	8.8	All kinds of disease
23	Nomiin Bulag spring	48⁰12/ 103⁰40/	1955, Sh.Tseren	C^{Ca}_{I}	0.31	2.58	6.8	0.4		CO_2 88 mg/l. Stomach and internal disease
24	Orkhon spring	48⁰40/ 103⁰37/30//	1960, Sh.Tseren	C^{Mg}_{I}	0.34	3.13	6.8	5		Stomach and internal disease
25	Baishin spring	48⁰47/ 103⁰23/	1960, Sh.Tseren							Stomach and internal disease
26	Khuis Lake spring	48⁰47/30// 103⁰11/	1960, Sh.Tseren	ClC^{Na}_{I}	0.40	1.94	6.8	4		Stomach and internal disease
27	Zuun Turuun spring	48⁰52/ 103⁰32/	1960, Sh.Tseren	C^{Na}_{I}	0.54	3.20	6.8	4		Stomach and internal disease

Bayan Undur spring in Erdenet is mineralised and contains acidity/sourness.

5.3. Mineral springs in the Orkhon RB downstream part

Dalt spring

it locates on a grid of north latitude of $49^{0}51^{I}$ and east longitude of $105^{0}50^{I}$ and elevated at 850 m from sea level, on the east scarp which is the beginning of Uvur Urt mouth in the territory of the 1^{st} brigade of Zuunburen collective farm in Selenge aimag. Alternatively, it's called Urtiin spring. This spring is located 31 km in the south-west of the collective farm centre and 30 km in the south-east of Asmaljin spring.

This is nationally well-know spring which is full of local and other guests as its water and mud are used for a therapy of stomach and internal disease, as well as disabled joints. Unfortunately, the spring has only one yield in recent years as its many yields disappeared due to lack of respondent and protection, according to locals' say. Below picture reveals the current image in which neither protection nor improvement around the spring. However, local environmental staff has taken it into protection and a particular project has been implemented.

Pic - Current condition of the Dalt spring

Neighboring local families fetch drinking water from the spring and water their livestock here due to lack of drinking water source around. In doing so, they break the surrounded wooden fence which is not robust and pollute environment, according to introduction by local environmental staff. When we arrived there, incautiousness has seen very clearly.

Physical and chemical property of the Dalt spring:

According to research conducted at 15:00 on Sep 30, 1960 in outside temperature 16˚C, the spring's temperature was 3.5˚C, flavourless, odourless, colourless and fresh. And its yield was 14400 l per hour. A carbonic gas and iron of 2 percent have been slightly detected according to field research [10]. But researchers of the Geoecological Institute carried out research on the spring in Nov 2011 and when outside temperature was -18˚C, the spring's temperature was 4.5˚C, flavourless, odourless, colourless and fresh. There were black sediments and slight turbid in the bottom of flowing section. As we see from above, its temperature is almost constant in both summer and winter times.

Table 24. Compared results of chemical composition of the Dalt spring

Analysed		Chemical composition of the spring
Date	Person, organization	
Sep 30, 1960	Sh.Tseren	$CO_2 0.2\ M_{0.4} \frac{HCO_3\ 88\ SO_4 10}{Ca\ 51\ (Na+K)37.4\ Mg11}$ pH 6.4
Jun 21, 1969	Hydrochemical Laboratory	$M_{0.4} \frac{HCO_3\ 86}{Ca\ 61\ Mg36}$ pH 7.1
Nov 14, 2011	Water research laboratory of the Geoecological Institute	$CO_2 0.004 M_{0.4} \frac{HCO_3\ 93}{Ca\ 59\ Mg27\ (Na+K)13.4}$ T= 4.5°C pH 7.41

There has been almost no change in water mineralization in the Dalt spring for last 50 years. But sharp decline in carbonic gas, slight increase in water environment pH and converted from weak acidity into weak alkalinity. This cold spring consists of a slight carbonic gas and its water is fresh, slightly soft and slightly polluted.

Table 25. Compared results of chemical analyses in the Dalt spring

No.	Analysed indicators, mg/l	1960.09.30			1969.06.21			2011.11.22		
		mg/l	mg-eqv/l	mg-eqv%	mg/l	mg-eqv/l	mg/eqv %	mg/l	mg-eqv/l	mg/eqv %
1	Natrium+Kali	44,8	1,95	37,4	4	0,17	3	15.3	0.66	13.47
2	Calcium	53,6	2,68	51,3	68	3,4	61	58.1	2.9	58.89
3	Magnesium	7,2	0,59	11,3	24	2,0	36	16.4	1.35	27.41
4	Ammonium	Unidentified			Undetected			0.2	0.01	0.23
5	Chloride	36,5	0,1	1,9	7	0,2	4	3.6	0.1	2.03
6	Sulphate	25,0	0,52	10,0	20	0,52	9	10.0	0.21	4.23
7	Hydrocarbonate	280,6	4,6	88,1	299	4,8	86	280.6	4.6	93.41
8	Nitrite	Unidentified			Undetected			0.0	0.0	0.0
9	Nitrate	Unidentified			3	0,85	1	1.0	0.02	0.33
10	Carbonate	Undetected			Undetected			0.0	0.0	0.0
11	Mineralization	447,7			420			385.1		
12	pH	6,4			7,1			7.41		
13	Permanganate oxidation	Unidentified			3,52			1.92		
14	Dry remains	Unidentified			Unidentified			232.4		
15	Hardness, mg-eqv/l	3,27			5,4			4.25		
16	Carbonic gas	231,4			-			0.44		

There are 6-7 yields in the Dalt spring and total yield resource was 14400 l per hour according to measurement in Sep 1960 [10]. After 50 years, one yield was left and it has merely 86.4 l per hour (0.024 l/s) according to measurement in Nov 2011. It shows that this spring is almost in drought. Besides, environmental improvement is really bad and unprotected. Consequently, there is a risk that livestock of near local herdsman families can easily intrude into the spring and cause pollution. Scientist and researchers have already evidenced based on findings from their researches that any spring is itself a living nature when it's only in its original form as it gets some energy from earth, sun, moon and the stars unless it is not devastated by human activities as well as lack of protection, care and respect. Otherwise, it loses its living nature and its original structure is totally changed. For the Dalt spring, its carbonic gas which is the main feature has been reduced and it's been polluted due to lack of protection and respect by people.

Dulaankhaan spring

located 946 m from Dulaankhaan town centre on frontside of Dulaankhaan Mountain in Shaamar soum and the mountain is itself much leeward. The Eroo and Orkhon large rivers are here and infrastructure such as road and tourism can be highly developed in this area. An area around the spring has been improved and protected. Local senior Mr.Perenlei installed a pipe which enables to get water through it. This is to protect the spring's yield from pollution. On the other hand, lithograph of health god 'Manal' has been located in the beginning of the spring and it enables local people to respect the spring. At his initiative, a natural museum was established in just left side of the spring.

Pic - Manal god which was drawn on the mountain stone near the spring

Pic - Line pipe to protect the spring source

Pic - Natural museum established at Mr. Perenlei's initiative

Physical and chemical property of the Dulaankhaan spring

The spring has fresh water without any mixture and no specific odour or flavour. Table below shows the compared result of chemical analyses in the spring.

Table 26. Compared result of chemical analyses in the Dulaankhaan spring

Analysed		Chemical composition of the spring
Date	Laboratory	
May 1969	"Springs in Mongolia" by Sh.Tseren and U.Nyamdorj in 1966	$M_{0.2}\dfrac{HCO_3\ 73\ SO_4 15\ Cl11}{Ca\ 48\ (Na+K)33\ Mg20}$ pH 6.9
Nov 2011	Water Test Laboratory of the Geoecological Institute	$M_{0.2}\dfrac{HCO_3\ 89}{Ca\ 68\ Mg17\ (Na+K)15}$ pH 6.95

As we see from above analysis, almost no change in water quality and chemical composition of the spring. There is a slight increase in percent of hydrocarbonate ion and percent of Ca and Mg ions amid cation. On the contrary, there is a small decline in sum of sulphate, chlorine ion, Na and Ka. The spring is very fresh, soft and cold, and hydrocarbonate is dominant amid ions, Ca group and weak acidity.

Table 27. Chemical composition of the Dulaankhaan spring

No.	Analysed indicator	1969.05.21*			2011.11.22**		
		mg/l	*mg-eqv/l*	*mg-eqv %*	*mg/l*	*mg-eqv/l*	*mg-eqv %*
1	Na+Ka	27	1,16	33	8.1	0.35	15.04
2	Calcium	34	1,7	48	32.1	1.6	67.96
3	Magnesium	9	0,7	20	4.9	0.4	16.99
4	Ammonium			Undetected	0.0	0.0	0.0
5	Chloride	14	0,4	11	5.3	0.15	6.37
6	Sulphate	25	0,52	15	5.0	0.1	4.42
7	Hydrocarbonate	159	2,6	73	128.1	2.1	89.2

No.	Analysed indicator	1969.05.21*			2011.11.22**		
		mg/l	*mg-eqv/l*	*mg-eqv %*	*mg/l*	*mg-eqv/l*	*mg-eqv %*
8	Nitrite	Undetected			0.0	0.0	0.0
9	Nitrate	2	0,04	1	0.0	0.0	0.0
10	Carbonate	Undetected			0.0	0.0	0.0
11	Mineralization, mg/l	260			183.5		
12	pH	6.9			6.95		
13	Permanganate oxidation, mg/l	1.92			2.24		
14	Dry remains	Undefined			110.5		
15	Hardness, mg-eqv/l	2.4			2.0		
16	Carbonic gas, mg/ls	-			-		

*Remark: * Result by the Hydrochemical Laboratory, Scientific Institute for Water Exploration*
***Result by the Geoecological Institute of the Academy of Science*

Above two springs which involved in the research have different use and protection. However, their environmental and climate conditions are similar. *Dalt spring* has fresh and slightly soft water and it's slightly polluted. There has been a slight change in main elements in its chemical composition for last 50 years. On the contrary, there is a decline in carbonic gas which makes it special, slight increase in water environment pH and converted from weak acidity into weak alkalinity. The result is likely to be considered that this spring is basically in drought. According to measurement in Sep 1960, total 5-6 yields' resource was 14400 l per hour. While it's been reduced after 50 years and only one yield was found and it had merely 86.4 l/hour (0.024 l/s) according to measurement in Nov 2011. For environmental ecology, the Dalt spring is located in the south underneath section of the Khaliun Mountain in south ravine of the Dalt mountain pass. There is a high risk of pollution in the spring by washed water on the related environmental surface. For use, the spring has been remained unprotected and absent for many years. Also its environmental improvement is really bad and it will be risky if livestock easily intrude into the yield and pollute the spring. This spring is necessarily needed to be protected and improved, and its quality and yield need to be restored.

The Dulaan Khaan spring still has fresh, soft, weak acidity, pure and cold water which can be considered that there has been basically no change in water quality and chemical composition of the spring for last 40 years. For the yield resource, it is relatively small and merely 241.2 l/hour (0.067 l/s) compared to other springs with a good yield. However, this volume is three times as much than the Dalt spring's yield. For environmental ecology, it is specific as it is located mountainside of the Dulaankhaan Mountain and pollution risk here is relatively small. Its yield is protected and each visitor pays some respect to the spring by keeping its environment clean. As a result, the spring keeps its original structure and living nature. That's why its yield is relatively enough compared to the Dalt spring's yield. Still there is an opportunity to properly use the spring such as making fund, improving its environment and exemplifying at aimag level by developing tourism, regionally.

5.4. Conclusion

- There are many hot and cold springs in the Orkhon River Basin. In view of spring use, most springs are being used locally especially hot spa is used by locals such as merely wash and bathe. This can lead to a high risk of pollution in water quality and environmental ecological deterioration as well. In most events, spring pollution is caused by intrusion of livestock and its yield is reduced due to lack of protection.

- According to shown in image of springs in Mongolia which was updated in 1983, there are 6 spa resorts which are permanently operating at national level and some more 7 spa resorts are planned to be launched. At local/regional level, totally 11 spa resorts and sanatoriums are being operated. Furthermore, it is necessary to carry out more detailed research on those springs which are accustomed to be used by people.
- In order to prevent pollution and scarcity of water resource as well as change in water quality, the related professional authority determines the related limitation and configuration/form of spring protection zone/region by considering sanitarian condition of a particular section in which water source and soil water aquifer are existed, geological formation, hydrogeological nature, soil structure, runoff direction in groundwater, prevailed wind direction and pollution source, etc. By now, successfully implemented work is rarely found.
- In the future need to prepare detailed study on spas.

6. Pollution and scarcity in water resource and actions for prevention and protection

- The most polluted tributary in the Orkhon RB upstream part is the Ult River which is a left wing tributary of the Ikh Teel River. The Orkhon River is in a high risk to be polluted by soil sediments as it might transport soil eroded due to gold mining activities in valley of the Ult River near the Orkhon River's upstream. That's why it needs to filter and purify the turbid water in the Ult River before reaching the Ikh Teel River by establishing special dam in accordance with drawings of the related riverbed. In doing so, pollution risk is about to decrease in the Orkhon River from its very upstream part.
- Of the rivers in the Orkhon RB upstream part, the Khujirt River water is being polluted by the Khujirt camp. So, it needs to install water treatment equipment with a high capacity at spa resorts nearby and therefore, to improve monitoring in compliance with terms and condition of the "MNS 4943:2011" standard.
- Of the river in the Orkhon RB downstream part, the Khangal River is the mostly polluted river which negatively affects water quality in the Orkhon River. According to research, its pollution is increased annually and we observed that some wastewater is directly dumped into the river from an unknown source during the night time. Therefore, it needs to establish monitoring equipment to measure the related pollution on hourly basis and consequently, it will enable us to take timely action in the future.
- The rivers in the Orkhon RB downstream part are turbid and polluted at certain volume due to gold mining activities. Especially, there are accumulated heavy metals in sediments on the bottom of some rivers. And its needs to shut down any gold mining company which runs activities in the valley, to improve monitoring and to conduct remediation in compliance with the related standard.
- In the future, it is important to carry out research on how these heavy metals which accumulated in the river water affect ecosystem of the river.
- It's important to be scientifically based, when conducting research on the river water quality to identify heavy metal contained in both river water and sediments on the bottom, its impact on the river fish species, water animal, plant, livestock as well as human. And it needs to process the ground basis to take action in the future for reducing toxicity level of the already-accumulated heavy metals.
- Due to the ecological vulnerability of the Ugii Lake it would be appropriate to limit the number of tourist camps, fishing, sport and competition, etc around the lake. It needs to protect the lake such as building bridge on the Ugii channel and Nariin River, establish paved road around the lake and prohibit any car entrance onto the lakeshore section which is protruded into the lake.
- Increase the number of water monitoring research point, improve its quality, equip it with the latest equipment, prepare experts and have them trained, inform the result to the related authority and community in order to take the related action timely.
- Strengthen the Orkhon RB council, establish water quality and research laboratory and carry out monitoring and research, constantly.
- Tidy-up license issuance and it needs to transit into system in which selection

of technology and completion of the related Environmental Impact Assessment are done before getting license. In case of mining license issued, it needs to completely use the latest technology while conducting exploration or mining.

- Research on water quality and chemical composition needs to be carried out in connection with geology-geographical formation, soil, stone and weather feature. And chemical analysis needs to be made jointly with microelements, organic and bacteriological indicators.
- As we see from the result of material processing, it needs to conduct check-up in use and protection of water/irrigation points by hospital, sanitarian and other authorities, to input the location of water points in the map/picture sorting them soum and bag, to identify on what purpose they can be used, to update registration research, and to set scope and power of the related ownership.
- It's important to set up a sanitarian zone not to pollute well water and to use the already polluted water by purifying.
- It's necessary to improve design of water point and provide with the latest equipment.
- In way of processing water points by using the latest technology (to purify and soften) in some soums with a large mineralization and hardness, it needs to improve its quality and appropriation, and to use it for drinking water and daily use.
- Water quality and chemical composition of springs especially, solute gases and variable compound are changed easily. In order not to make change in and not to pollute the main chemical property, it needs to improve environmental appearance, to set sanitarian and protection zone, to carry out the detailed research, to increase number of spa resort by identifying therapeutic ability and it enables to identify whether or not it's possible to use for other purpose.

7. Ecological conditions

7.1. Habitats

The Orkhon 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 temporary torrents recharged by snowmelt and rainfalls.

The main valley is wide and the Orkhon River is composed of braided channels. This offers a valuable area for herders' activities especially in summer with easy access to surface water for livestock. Morphogenetic flows occur after summer rainfall, and floods regularly occur, increasing soil moisture in the floodplain.

The physical assessment carried out by the Asia Foundation from 2007 to 2009 contains too few points to be representative of the different stretches of the river basin. However this type of assessment can be valuable if it is performed on a regular interval all along the river.

7.2. Fish

The list of fish species in the Orkhon River basin is reported in Annex 3.

Among them, the Siberian sturgeon is considered as Critically Endangered in the basin, the main threats being the degradation and loss of habitats due to mining activities and the degradation of water quality, according to [4], though available data do not show a significant degradation of water quality. The Taimen is considered as endangered for the same reasons.

7.3. Amphibians

The Siberian salamander and the Far Eastern tree frog are registered as vulnerable species according to [6]. Main threats reported are the loss of habitat and increasing dry conditions according to the red list of amphibians.

Other populations of amphibians, mainly Siberian wood frog and the Mongolian frog were found by Kuzmin [7] in different points of the river basin, but he reported a significant decline of abundance compared to previous studies carried out in the 1960s. He reported that the main reasons were the increasing land use for cultures and the concentration of livestock around water bodies, becoming then unsuitable for amphibians cycles.

7.4. Birds

The Orkhon River basin hosts important bird areas, most of them being located in the mountainous area in the southern edge of the basin.

The Ogii Nuur area is the most important site for water birds in the basin. Many endangered or vulnerable species occur in this site including the critically endangered Siberian crane, the endangered Swan goose, plus 8 vulnerable species of water birds [8]. Ogii Nuur is registered as Ramsar site [12] but not included in a nationally protected area. Threats to wildlife are detailed in the next paragraph.

7.5. Specific ecological sites

The Orkhon River basin is not widely covered by protected areas (Figure 9). The Khangai mountain national conservation park covers a small part the upstream catchment area of the river basin, whereas Tujiin Nars national conservation park is located at the end of the river basin. Khangai mountain national conservation park is composed of pine forest and steppes. Forest diseases, fires and overgrazing are the main threat to the ecological conditions in this area.

Tujiin Nars national conservation park is a pine forest stand that is widely distributed by flat plain sandy soil. Forest fires and illegal logging are the main threat. A better enforcement of protection resulted in a decrease of forest fires and illegal logging in the last years.

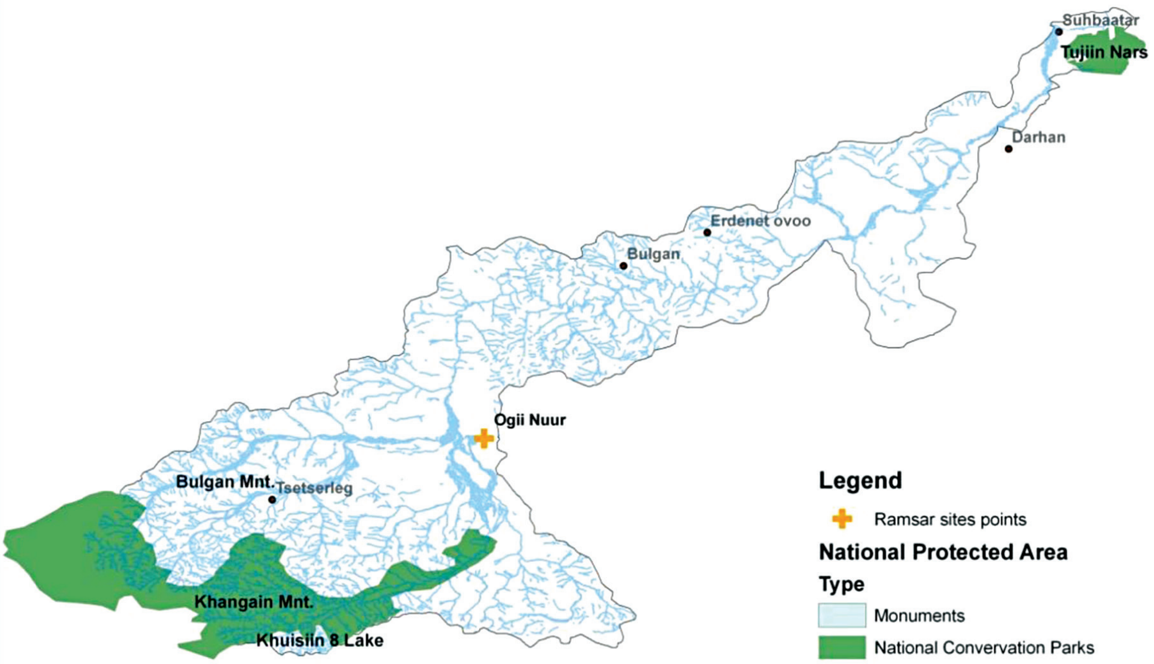


Figure 9. Location of National protected areas and Ramsar sites

The Ogii Nuur site is a Ramsar site but is not protected by a national status. The area is covered by a locally protected area, under the responsibility of Arkhangai aimag council, but little is known on the effective protection of the area. The lake is a mesotrophic, freshwater lake with an extensive alluvial area of grassland, river channels, pools and marshes at the western end. The maximum depth of the lake is 16m, but about 40% of the lake is less than 3m deep, and 50% supports macrophytes. It is recharged by the Orkhon River when floods occur. The surface water temperature in summer reaches 18 C. The lake is a very important breeding and staging area for a wide variety of waterfowls.

Main pressures on this site are overgrazing, destroying valuable habitats for waterfowls and fish, and increasing touristic pressure, mainly for recreational fishing and/or bird watching. The development of the tourist activities have been carried out without a specific plan regarding threats for ecological conditions and disturbance of wildlife.

8. Human uses

8.1. Domestic pollution

Domestic pollution is essentially concentrated in Erdenet city. Data shows that the efficiency of the waste water treatment plant is not good and in under capacity but the wash out of the urban area counts for a significant part of the pollution in the Khangal River as well.

The impact of Sukhbaatar city is difficult to asses because of the lack of data. Short term sampling in 2006 [1] showed a slight decrease of dissolved oxygen after the WWTP discharge but no other signs of pollution have been reported. The stretch of potential impact would be limited as the Orkhon River pours into the Selenge River after a few kilometers. It could limit the access and migration for fish population in the Orkhon River basin, but as most of the fish migration occurs when river discharge is medium or high, we can expect that the dilution factor will improve water quality and create suitable conditions for fish.

8.2. Pressure from livestock

Pressure from livestock has been reported to be low in the Khangai mountain national park but the increasing concentration of nitrate and phosphate in surface water at Kharkhorin could be due to a greater concentration of livestock around the surface water bodies.

No detailed information was found on the loss of functioning wells in the basin. The national trend is a significant decrease of wells in pasture area, which has for result a concentration of livestock around surface water bodies, increasing the threats of soil degradation, destruction of riparian vegetation and transfer of soil particles in the stream. Risks of bacteriological contamination in surface water increase as well.

A survey is needed to understand if the increasing concentration of livestock reported around water bodies is due to a loss of functioning wells. If so, a rehabilitation of functioning wells is needed but should be accompanied with a regulation of livestock number to ensure that the better water availability will not trigger greater soil degradation in new areas.

8.3. Irrigation and crops

Crops are spread in the river basin. Data on nutrients in surface water shows that the use of fertilizers is low and do not affect water quality so far. However the use of nutrients may increase in the next year with a better availability of fertilizers, and plans carried out to increase irrigated areas in the Orkhon valley. It would then necessary to control the use of fertilizers and to limit their transfer to the streams, for instance by preserving a strip of non cropped soil between the crops and the streams.

The current agricultural practices may however have an effect on erosion and transfer of suspended solids in streams. Furrows of arable land are often in direction of the steepest slope gradient and increase the erosion process, especially during heavy rainfall. This generates furthermore a loss of valuable soil for crops. Specific training is needed to change this general practice.

8.4. Industries

Industries are mainly located in Erdenet city. Sampling campaigns in 2005 and 2006 [1] did not show any signs of contamination by hazardous compounds such as chromium, used in tanneries. However analyses for heavy metals and other hazardous compounds in sediments in Khangal River are needed to assess if industries generate pollution. As the pH of water is alkaline, transfer of heavy metals in the water is low and molecules bind to sediments. There is then a greater risk of accumulation along the riverbed which might be the source of bioaccumulation in plants, wildlife or livestock.

8.5. Mining

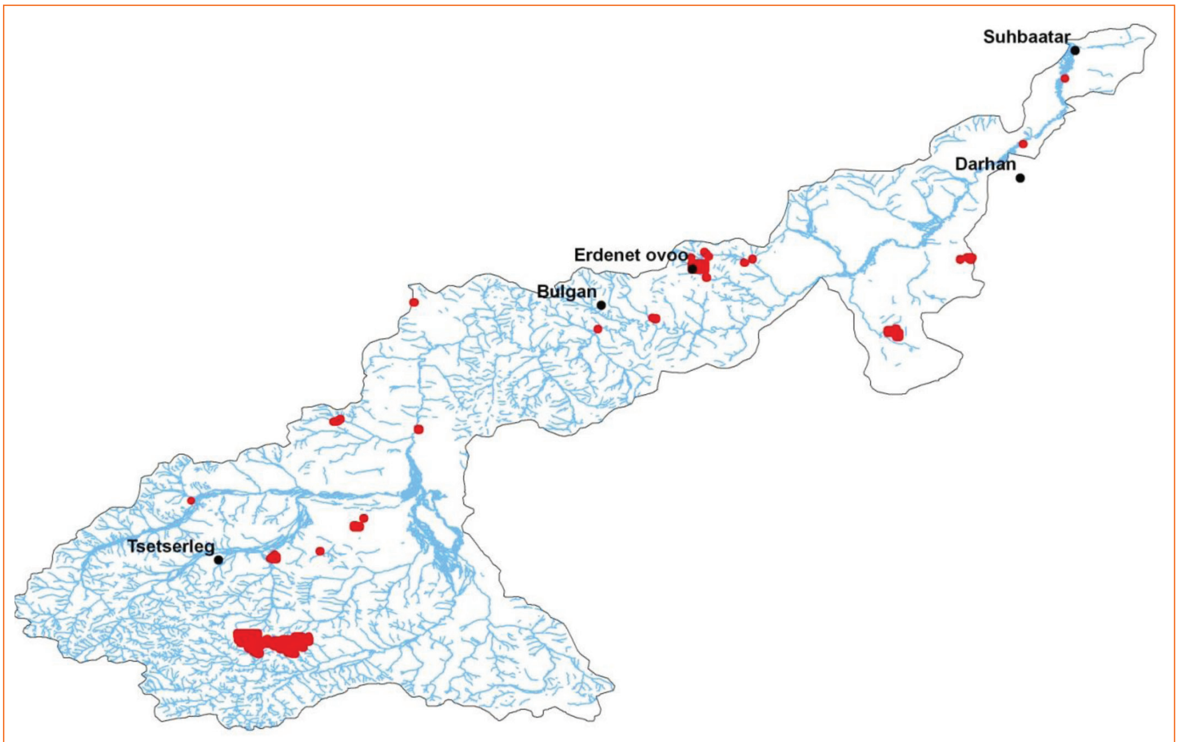


Figure 10. Mining sites in Orkhon River basin

Mining in the Orkhon River basin is mainly composed of small scale gold mining sites in the upstream part of the basin and the important open copper mine in the vicinity of Erdenet city.

Gold mining mainly occurs in the Khangai mountainous area. Impacts on water quality have been reported from the local population, especially regarding suspended solids concentration. As mentioned above monthly data at Bat Olzii station do not report any specific problem, but the time gap is too large to show peaks of suspended solids. A specific survey should be carried out to assess whether or not mining activities have an impact in the upstream part of the Orkhon River and its tributaries. If so, a better design and management of the settling ponds could be a cost effective way to reduce transfer of soil particles to the streams.

14,500 illegal miners (ninjas) have been reported in 2003 in Tsenkher soum, Arkhangai aimag and a couple of hundreds in Bat-Olzii, Ovorkhangai aimag [13]. No more recent data have been found on the presence of illegal miners or not in the area, or on the use of heavy metals for gold recovery. Valleys in this area are a valuable pasture area, especially during summer when mining activities occur. A degradation of surface water quality (e.g. by heavy metals) could have severe effects on human use. Contaminated sediments could travel downstream and deposit in the floodplain during floods. Transfer to grass and then livestock and/or humans could occur.

A survey on the intensity of illegal mining and their practices is needed in the upstream part of the Orkhon River and its tributaries.

The Erdenetyn-Ovoo copper ore deposit is located close to the town of Erdenet. The deposit was discovered and explored between 1960 and 1972. In 1973, the Government of Mongolia set up the Erdenet Mining Corporation. Water for mining processes is supplied by pipeline from the Selenge River. Processing of ore includes the use of quantities of sulfate, and the ore contains a high percentage of manganese [14].

Effluents from the tailing dam have high concentration of sulfate and manganese. Data showed that the dilution in Khangal River is high enough in summer to lower the concentrations under the surface water standards. But data are missing to assess their impact in winter and on sediments downstream of the discharge site. It is necessary to assess sediments quality downstream the dam, as they may contain much higher levels of toxic compounds than surface water.

There is a need to strengthen the maintenance and monitoring of the dam stability to avoid and/or manage contamination problems resulting from leaks, as the ore contains copper-sulfide minerals and pyrite, which cannot entirely be recovered.

8.6. Forest management

The upstream part of the basin is covered by pine forests that ensure the stabilization of the soil and play a role in the hydrology of the small tributaries. WWF [15] reported that forest pests and fires have an impact on forest cover in the Khangai mountain national conservation park. We can assume that those threats are present as well outside the national park in the mountainous region.

Loss of forest cover will increase soil degradation, especially in the part of the basin where slopes are important and erosive capacity higher. Associated with heavy rainfall in summer, deforestation will enhance the transfer of soil particles and organic materials in the streams.

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. Fires are often started due to left over campfires and cigarettes not completely extinguished by wanders in forests

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, public awareness in Khangai Mountain national conservation park should be reinforced in spring and autumn months, though due to the vast area covered by forests, control of access is not easy. The effective management work of the Tujiin Nars NCP showed good results in limiting illegal wood harvesting and reforestation.

8.7. Commercial and recreational fishing

Little is known on the impacts of commercial and recreational fishing in the river basin. Ogii Nuur is one of the renowned places for recreational fishermen, and had an organized fishery since 1938 [5]. From 1966 some protection of fish stocks was enforced, limiting the fishing to specified periods. This has led to decline in catches and eventually to their stabilisation during the period 1970-1985, but was followed by a considerable decline in fish catches in the following years. It is difficult to know however if this decrease is due to a net decrease of fish stocks or a lesser fishing pressure. A small-scale commercial fishery still operates in winter.

The recreational fishing pressure seems to have increased in the last decade. Many tourist camps have been implemented around Ogii Nuur. As tourism may represent an important source of income for local population under the form of accommodation, and fishing licences, it is necessary to assess whether or not fish population is declining. If so a proper enforcement of the regulations concerning fishing activities should be implemented. Public awareness and a control of fish size captured would be a cost effective way to limit recreational fishing pressure in Ogii Nuur.

8.8. Invasive species

Some fishes have been deliberately introduced in the Orkhon basin or in the Selenge catchment area and colonized the Orkhon River. However their population reached an equilibrium and does not have a strong impact on natural fish populations.

No other invasive species, such as plants or other fishes have been reported.

8.9. Tourism

Tourist activities are growing in the Orkhon River basin, especially in the upstream part of the river basin. The main attraction in the upper course is the Orkhon waterfall which is situated in Bat-Olzii soum. Also called Ulaan Tsutgalan, the waterfall was formed by a unique combination of volcanic eruptions and earthquakes about 20,000 years ago.

It seems that the tourist activities in the upstream part of the river valley have still a low impact on water quality but installation of tourist camps increased in the last years and should be limited and including proper techniques for waste management.

As mentioned above Ogii Nuur supports an increasing pressure from tourist activities, mainly related to fishing and bird watching. This can generate disturbances that could decrease the attractiveness of the site, and thus its economic value. The recent decrease of water levels in Ogii Nuur (approximately 100cm between 2004 and 2008) [10] reduced the area of aquatic habitats, and makes it even more sensible to local disturbance. Public awareness and implementation of a zone protected from human activities is needed to protect habitats that are necessary for the biological cycles of fish and birds.

8.10. Reservoirs and hydropower plants

One hydropower plant is located on the Orkhon River, in Kharkhorin soum. Its capacity is 528kW but it is currently out of order. There is no fishway installed and this can create a barrier for fish migration. During periods of high flow, the height of the barrier created is reduced and some fish, especially salmonids, can have the capacity to cross the dam. Their capacity of crossing and the impact of this dam on fish migration should be assessed. As the height of the dam is low, a fishway could be easily implemented to allow crossing for most species during periods of medium and high flows.

The Orkhon River is a promising location for bigger hydropower plants. It represents 7% of the hydropower potential of Mongolia. Five sites in the Orkhon River basin (Figure 11) have been proposed of which Ulaankhunkh and Khishigundur dam sites are the most preferred.

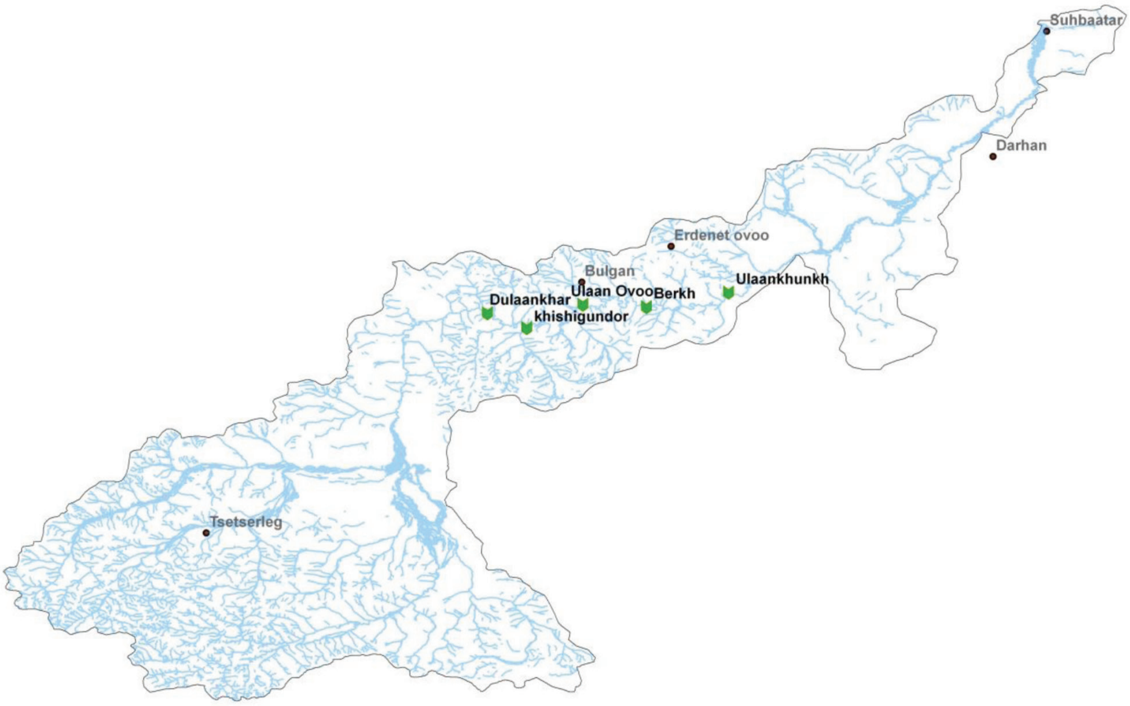


Figure 11. Location of studied dam sites

A feasibility study is planned for the Orkhon-Gobi diversion project. This project involves construction of a diversion dam at Khishigundur and a diversion of 2.5 m^3/s by pipeline to the Gobi mining area.

A dam has various effects on water quality and ecological conditions, on a significant stretch of the river upstream and downstream the dam site.

Impacts upstream the dam site:

Concerns about water quality can occur in the reservoir itself, where the stagnation of the water body increases the risk of eutrophication compare to a free flowing river. The eutrophication process is favoured by the immobility of the water body, allowing exchange between sediments containing nitrates and phosphate. The increase of the temperature in the uppermost layer of water is another factor.

Biological productivity of the Orkhon River is currently limited by its low phosphate concentration, so risks of eutrophication are still low. As the development of crops is planned in the valley, the use of fertilizer should be limited and concentrations of nutrients in water and sediments monitored. Soil degradation, increasing transfer of soil particles loaded in nutrients in the streams can be a factor of risk as well.

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 at term depletion of oxygen in the water. Colour, smell, and water treatment problems can occur in summer time, especially as temperature is expected to rise in the next decade. If 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 sediment load in the Orkhon River. In any case sediment transport will be impacted as well, with a greater sedimentation, especially of fine particles, in the upstream stretch of the dam, due to the deceleration of the flow. This process can occur on a long stretch, 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 kilometres upstream 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. Potential dam sites are all located upstream of Khangal River, and therefore will not be affected by potential pollution of sediments from Erdenet city. So far too little information is known on pollution sources in Bulgan soum that could affect sediments in Ulaankhunkh reservoir. If a dam is implemented on the Orkhon River, the quality of the water and sediments should be monitored in any case to assess if water quality is affected by sediments. A flushing gate is the best way to limit sediment deposition in the reservoir, but needs to be carefully designed and manage 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.

A dam will create a physical barrier blocking fish migrations. The predicted heights of the dams are important (Table 28) will not allow the implementation of 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.

Table 28 Details of proposed dams

Dam name	Maximum Head (m)	Average discharge (m^3/s)
Ulaan Ovoo	37	44
Khishig Undur	70	44
DulaanKhar	110	40
Berkh	110	44.5
Ulaankhunkh	100	44.6

Source: *(National Water Committee) [17]*

Impacts downstream:

The major impact downstream of the mining sites 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 diminution of the occurrence and intensity of morphological flows can be expected after the dam construction. 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 global morphology of the Orkhon may tend to lose it 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 benefic for grass productivity, hence livestock activities. Depending on the characteristics of the dams, a diminution of the frequency of floods could occur. This may decrease the vegetation cover in the floodplain, increase soil degradation, and diminishes available area for pasture.

Wetlands could suffer from this diminution of water afflux. These ecosystems significantly participate in the self-purification process, especially concerning the removal of ammonium and nitrate [17].

Design and management of the proposed dam(s) have not been defined yet; it is therefore difficult to carry out a detailed assessment of the impact of sediment flushing from the dams. The purpose is to discharge sediment accumulated behind the dam without affecting too much the reserve of water. The best period seems to be in summer, where the dam is full and overflow occurs.

The release of a high amount of fine sediments in a short period of time could result in 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 amount 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.

8.11. Impact of climate change on environmental services

Additionally to the impact on surface water quality described in 4.5, climate change can impact biology and environmental services. Water quality could be affected after heavier rainfall in summer, causing risks to livestock and human health. Increasing erosive capacity from precipitation could severely affect aquatic habitats, by clogging spawning sites. 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. Limitation of soil degradation and protection of forest cover is needed to compensate the effect of more erosive rainfalls, especially in the upstream part of the basin.

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 surface water is expected to increase in summer months. The eutrophication process is currently limited by nutrients and mineral availability and temperature of the water. But the augmentation of water temperature will diminish dissolved oxygen in surface water and enhance the risk of fish mortality. Riparian vegetation should be protected to ensure a shadow cover in order to limit the increase of water temperature.

Table 29 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	Erdenet	Untreated waste wash out from the urban area Insufficient treatment of domestic effluents	Organic pollution	Degradation of habitat conditions	Medium in Khangal River	Degradation of water quality	Improve water collecting network in Erdenet Improve treatment capacity of WWTP in Erdenet
Mining activities	Upstream part of the basin (Khangai)	Uncontrolled operation of mining activities	Possible release of suspended solids in the Orkhon	Degradation and loss of habitats	TBD (possibly low)	Degradation of water quality Threats to livestock and human health	Control the presence and practices of ninja miners in Orkhon tributaries in the upstream part of the basin Improve design and use of water storage
	Erdenet copper mine	Leakage of pollutants from reservoir	Transfer of Sulphates, Mn and other hazardous substances in Khangal River	Degradation and loss of habitats in Khangal River Transfer of pollutants to Orkhon river	TBD (possibly low)	Degradation of water quality in Khangal River Threats to livestock and human health along Khangal River	Improve design and management of mine water reservoir Monitoring of soil and water quality in Khangal River
Tourism	Ogii Nuur	Increase in use by tourists and recreational fishing	Organic pollution	Destruction of aquatic habitats and disturbance of wildlife Impact of recreational fishing on fishstock	Medium	Degradation of Ogii Nuur attractiveness	Control activities and development of tourist camps. Develop public awareness Define an area with restricted human access
Livestock	Near rivers, lakes and water points	Concentration of livestock near the water bodies	Risk of bacteriological contamination	Degradation of the floodplain cover and riparian vegetation	Medium	Degradation of water quality	Rehabilitate non functioning wells. Install new wells.

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
Dams and reservoirs	Middle part of Orkhon River	Change in river flow regime.	Eutrophication 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 loss diminution of valuable fishstock	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	Khangai region	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 forest area in spring and autumn
Agriculture	Middle and lower part of Orkhon River	Possible increase in use of fertilizer / pesticide: transfer of nutrients to the stream / shallow aquifers	Increase risks of eutrophication	Toxicity for fish	Low	Risk of degradation of water quality Toxicity for livestock downstream	Minimum distance between the crop area and the streams Change practices (ex : direction of furrows)

9. Conclusions

Water quality and ecological conditions remain in most cases good in Orkhon River basin. The locations of the monitoring stations can not give a detailed picture of the water quality especially in the northern part of the basin. High levels of suspended solids seem to be the biggest problem regarding water quality, but the sampling frequency is too low to correctly evaluate this issue. A more precise survey should be carried out to assess the occurrence of peaks of turbidity, and establish the part due to natural conditions and human impacts such as soil degradation and deforestation.

Erdenet urban area and its copper mine has an impact on Khangal River, modifying for instance the distribution of minerals in surface water. However other signs of pollution are not easily visible at the station located before the confluence with the Orkhon. Indicators show no clear signs of degradation of water quality since 1986. A survey on sediment content in Khangal River, including analyses on hazardous substances released from the tailing dam is needed to evaluate the impacts of the copper mine.

The Tuul River can significantly increase the content of suspended solids in the Orkhon, on a limited stretch. Once again detailed data are missing to properly evaluate the impact of Tuul, Kharaa and Eroo River on Orkhon water quality.

Construction of a dam on the Orkhon River could generate multiple effects on water quality and ecology on a wide stretch of the river upstream and downstream the reservoir(s) site(s). Eutrophication and degradation of water quality in the reservoir could become a major issue if the development of crops in the basin is associated with an increase of fertilizer use. Protection of the catchment area against organic pollution (especially phosphorus) is the most effective way to limit this risk. 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 floodplain downstream. Management of fine particles trapped in the reservoir shall try to imitate the natural sediment balance, and avoid a massive release of particles in a short period of time.

The Orkhon River basin concentrates a multitude of human activities, and may go through severe changes in the next years (installation of dam(s), increase of crop area, and development of tourism). In order to preserve benefits of the currently good water quality and ecological conditions, impacts of new practices and infrastructures should be carefully studied.

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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	NO_2-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
	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 <
	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 <
	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 <
	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
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
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 <
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. List of fish species in the Orkhon river basin

Fish species in the Orkhon 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
Acipenseridae			
Acipencer	baerii	Siberian sturgeon	Critically endangered
Salmonidae			
Hucho	taimen	Taimen	Endangered
Brachymystax	lenok	Lenok	Vulnerable
Thymallidae			
Thymallus	arcticus	Arctic grayling	Near Threatened
Coregonidae			
Coregonus	peled	Coregon	not assessed
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
Abramis	brama	Common bream	Least concern
Balitoridae			
Barbatula	toni	Siberian stone loach	Least Concern
Triplophysa	sp	Catfish-like 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

Part 5.
SOCIO-ECONOMIC CONDITION

Prepared by: J.Gerelchuluun[1]

Consultants: Ts.Baldandorj[1], Ph.D

[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.

In the Orkhon river basin are located the Khangai region pillar cities Erdenet and Kharkhorin and the Arkhangai, Bulgan and Selenge aimag centers. The economically important industry of the Mongolia Erdenet mining company is located in the basin, which produces about 30% of the total export of Mongolia. In addition, the Orkhon river basin is one of the important agricultural (crop) regions of Mongolia.

Accordingly, the socio-economic report for Orkhon river basin was prepared to assess, to make conclusions and to determine the importance of water use, as well as water demand, and the current and future development approach of the water sector. The following tasks have been performed in the scope of the project.

- I. Data collection and analysis for the Orkhon River Basin management plan;
- II. Analysis of the current socio-economic situation of the Orkhon River Basin;
- III. Data collection and assessment of water use and demand of the Orkhon 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 the Orkhon 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 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

[1] UNDP Mongolia Common Country Assessment, 2005

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

As noted in the project document, Tuul and Orkhon river basin management plans will be prepared. The Orkhon river basin is an important region, socio-economically and the basin is different from others due to the location of the Erdenet plant, the largest export producer of Mongolia.

Data and information required for the socio-economic assessment was obtained from official documents and websites. Except that, other data and information was obtained from research carried out by the project team on the Orkhon basin and from Orkhon, Bulgan, Selenge and Uvurkhangai aimags which are included in the basin. Table 1 shows a summary of the data sources and type of data used for the Orkhon 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, Ulaanbaatar 2007-2011, Population and Housing Census-2010 main results
Macroeconomic	WB, IMF. NSO, MF, MFALI, www.pmis.gov.mn, www.statistic.mn, www.bulgan.mn, www.erdenet.mn, www.tuv.mn	Statistical Yearbooks, NSO, Ulaanbaatar 2007-2011, The Budget Project of Mongolia 2009-2011, GoM 2008, Regional Development program of Khangai and Central region, Aimags' Development Programs
Agriculture	NSO, MFALI, MF, www.pmis.gov.mn, www.statistic.mn, www.bulgan.mn, www.erdenet.mn, www.tuv.mn	Statistical Yearbooks, NSO, Ulaanbaatar 2007-2011, Agriculture, NSO, Ulaanbaatar 2007-2010, Budget Project of Mongolia 2009-2011, GoM, 2008
Industry	NSO, MFALI, MF, www.pmis.gov.mn www.statistic.mn	Statistical Yearbooks, NSO, Ulaanbaatar 2007-2011, Budget Project of Mongolia 2009-2011, GoM, 2008
Water tariff and fee	MF, WA, ALACGC, PUSO, related web sites, government officers	Local Governments, PUSO's Orders

Besides data on water use and water tariffs in the region of the basin collected from official sources, this data was also collected from organizations and citizens using a questionnaire. A list of all collected data and information is presented in Annex 1.

By January 2011 data collection had been completed. The base year used for the methodology of the IWRM framework 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

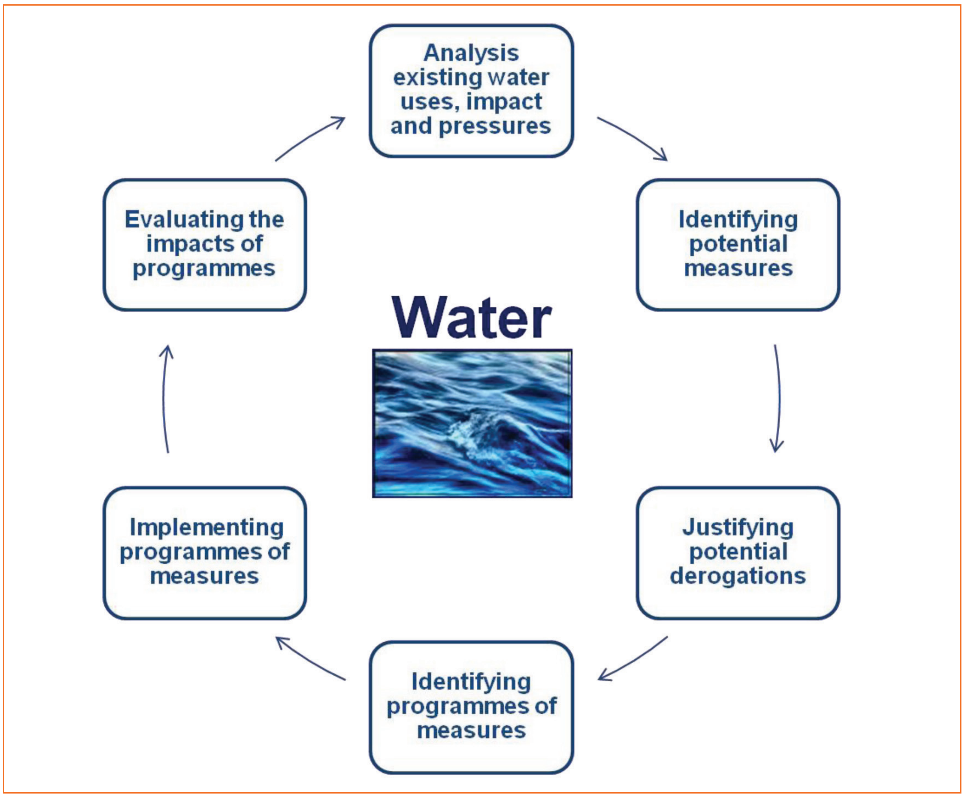

Figure 1. Economic elements are linked and must be integrated

The economic analysis consists of the following stages: [52]

- 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 program of measures;
- Evaluation of the impacts of the program.

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 programs 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:

$$P_t = P_0 * (1 + r * t) \qquad (1)$$

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 program", 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. [33]

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 [41].

In this report, 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. A summary of the approach is given in Figure 2. [67]

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;

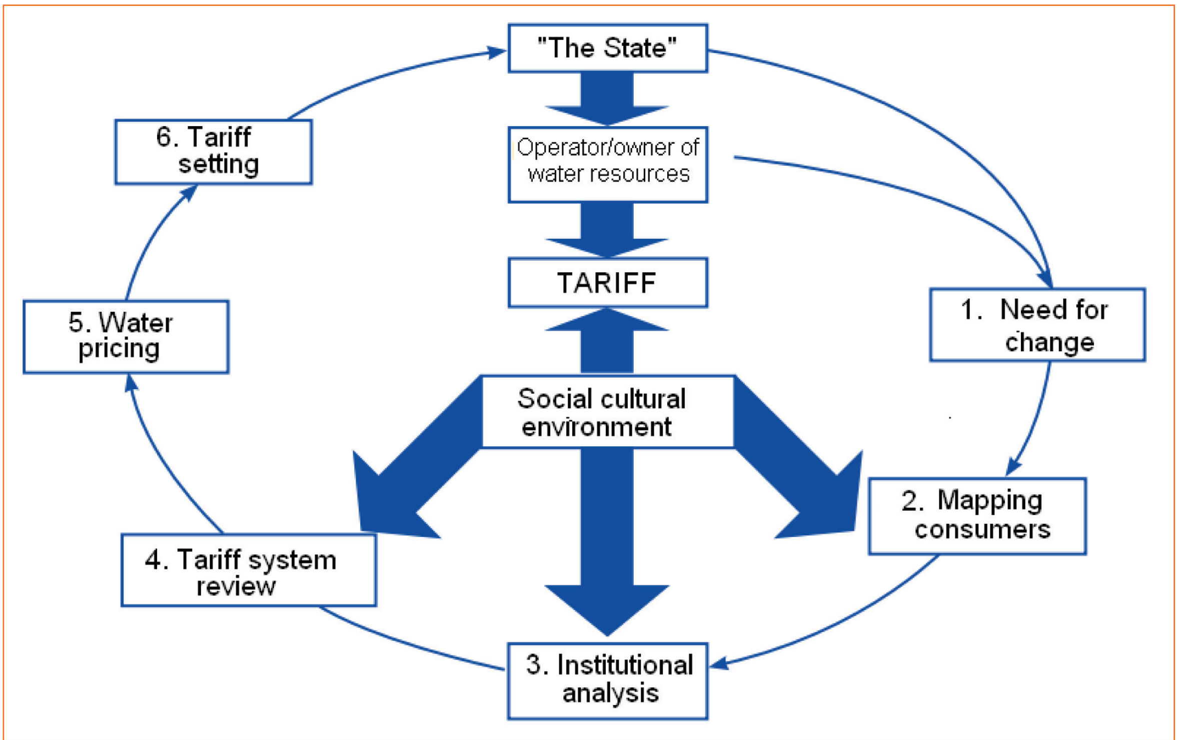

Figure 2. Framework for water tariff decision-making

- 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.

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. [67]

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]

g) 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".

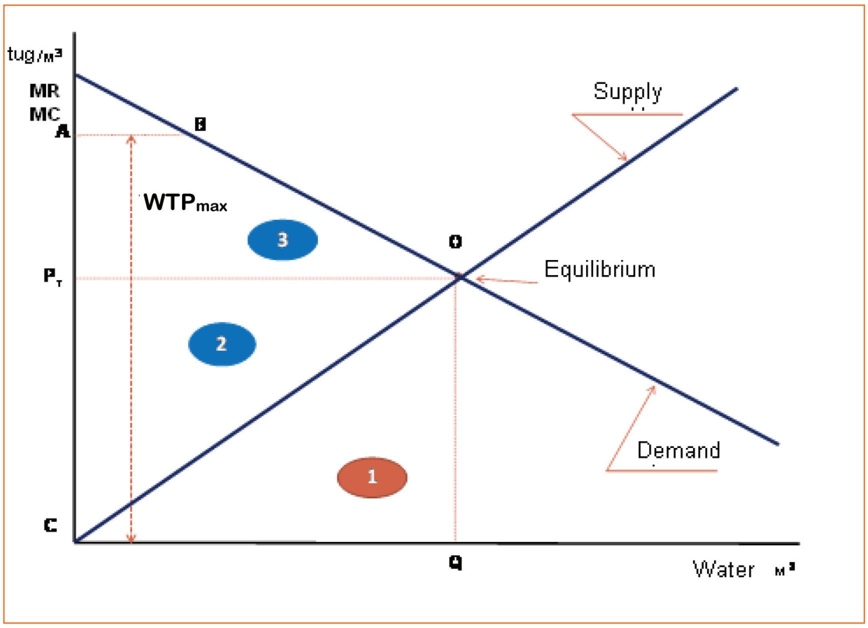

Figure 3. WTP and consumer and producer surplus

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 Orkhon river basin covers 3.4% of the total territory of the country and it spreads through the economic regions of Ulaanbaatar, Tuv and Khangai. Some 8 aimags including Arkhangai, Bayankhongor, Bulgan, Darkhan-Uul, Orkhon, Uvurkhangai, Selenge and Tuv partly belong to the Orkhon RB. Please see the location and administrative structure of the basin from Figure 4 and Table 2 below.

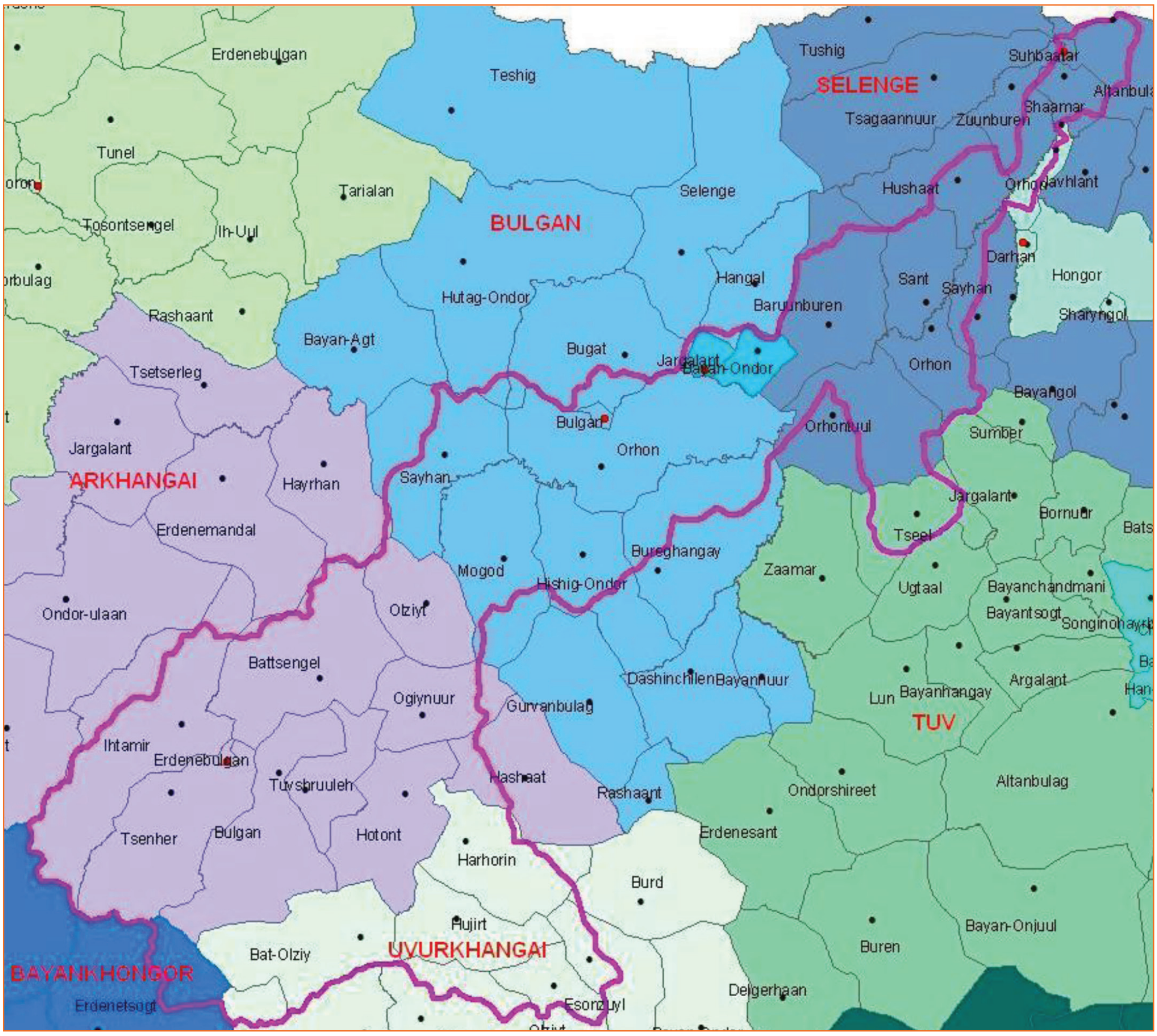

Figure 4. Location and administration of the Orkhon river basin

Of the river basin territory Arkhangai aimag covers 38.2% of the basin, Bulgan 22.1%, Selenge 18.4%, Uvurkhangai 15.9% and the 4 other aimags 0.4-1.9% (See Figure 5).

There are in total 53 soums of Arkhangai, Bayankhongor, Bulgan, Darkhan-Uul, Orkhon, Uvurkhangai, Selenge and Tuv aimags which partially or fully belong to the Orkhon river basin. Of these soums, the territory of some 8 soums is 100% covered in the basin, 32 soums 5.0%-99.9% and 13 soums up to 5%, respectively. And 4 aimag centers, 25 soum centers and 134 bags are altogether located in the basin. The differences in the boundary between the basin and the administrative units reveal clearly that, when calculating socio-economic indicators of the basin, it is necessary to focus on the specific conditions e.g. the location and population of the related administrative unit, the location of the economical subjects and the hydrological feature.

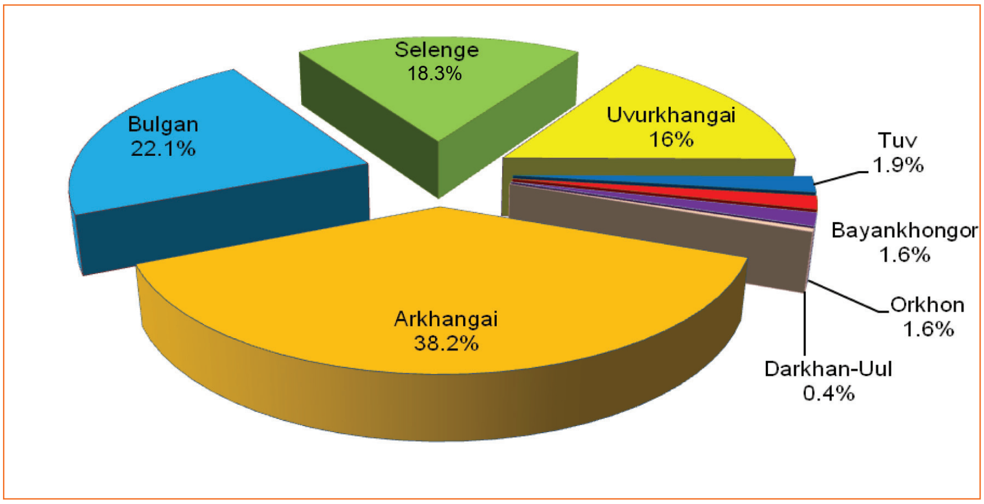

Figure 5. Structure of the ORB by aimag

Table 2. Administrative structure in the Orkhon River basin

	Aimag, soum	Aimag and soum center	Nr. of bag, khoroo	Percentage in Orkhon RB, %	
				from territory	from pasture
1	**Arkhangai**			**37.1**	**43.8**
1	Undur-Ulaan			0.0	0.0
2	Chuluut			0.2	0.0
3	Khairkhan			2.9	0.0
4	Erdenemandal			0.0	0.0
5	Battsengel	Battsengel	6	96.0	100.0
6	Bulgan	Bulgan	4	100	100.0
7	Ikhtamir	Ikhtamir	3	73.7	74.4
8	Ugiinuur	Ugiinuur	5	82.4	82.1
9	Ulziit	Ulziit	4	100	100.0
10	Tuvshruulekh	Tuvshruulekh	4	100	100.0
11	Khashaat		1	16.4	16.7
12	Khotont	Khotont	6	100	100.0
13	Tsenkher	Tsenkher	6	99.8	100.0
14	Erdenebulgan	Erdenebulgan	1	100	100.0
2	**Bayankhongor**			**0.7**	**0.9**
15	Galuut			0.1	0.0
16	Erdenetsogt		2	20.6	20.9
3	**Bulgan**			**24.3**	**36.1**
17	Gurvanbulag			0.0	0.0
18	Selenge			0.4	0.0
19	Khutag-Undur			2.0	0.0
20	Bugat		1	14.9	23.2
21	Bulgan	Bulgan	1	100	100.0
22	Buregkhangai		2	42.1	37.7

	Aimag, soum	Aimag and soum center	Nr. of bag, khoroo	Percentage in Orkhon RB, %	
				from territory	from pasture
23	Mogod	Mogod	4	78.0	74.0
24	Orkhon	Orkhon	4	99.7	100.0
25	Saikhan	Saikhan	4	67.0	67.0
26	Khangal		1	5.6	9.8
27	Khishig-Undur	Khishig-Undur	4	60.6	54.9
4	**Darkhan-Uul**			**6.5**	**11.7**
28	Orkhon		1	46.4	47.3
5	**Orkhon**			**100**	**100**
29	Bayan-Undur	Erdenet	19	99.2	100
30	Jargalant	Jargalant	3	100	100
6	**Uvurkhangai**			**13.6**	**12.0**
31	Burd			0.9	0.0
32	Bat-Ulzii	Bat-Ulzii	4	99.7	100.0
33	Yusunzuil	Yusunzuil	2	28.9	24.4
34	Zuunbayan-Ulaan		2	21.5	20.2
35	Ulziit	Ulziit	2	37.3	36.5
36	Uyanga		2	13.3	10.1
37	Kharkhorin	Kharkhorin	5	88.8	86.6
38	Khujirt	Khujirt	4	100	100.0
7	**Selenge**			**24.1**	**40.2**
39	Altanbulag	Altanbulag	2	27.7	36.5
40	Baruunburen	Baruunburen	3	83.2	100.0
41	Zuunburen		2	51.1	57.5
42	Orkhontuul		2	68.2	71.9
43	Orkhon	Orkhon	2	82.3	83.0
44	Saikhan		2	41.8	47.6
45	Sant	Sant	2	99.0	100.0
46	Sukhbaatar	Sukhbaatar	5	99.1	100.0
47	Khushaat	Khushaat	1	42.8	54.4
48	Shaamar	Shaamar	3	76.8	75.4
8	**Tuv**			**1.4**	**1.5**
51	Jargalant			0.4	0.0
49	Zaamar			0.1	0.0
52	Sumber			0.8	0.0
50	Ugtaal			0.1	0.0
53	Tseel	Tseel	3	61.1	65.0
	Total	**4 aimag centers, 25 soum centers**	**134**	**3.4***	**3.7***

** Share of total country area*

Arkhangai aimag. The territories of 14 soums belong to the basin. Of these, the territory of Erdenebulgan, aimag centre and Bulgan, Ulziit, Tuvshruulekh and Khotont soums are fully, and the territory of 9 other soums are partially included in the basin while 8 soum centres are included.

Bayankhongor aimag. The basin covers some part of Galuut and Erdenetsogt soums.

Bulgan aimag. Bulgan, the aimag centre and 11 soums are covered in the basin; one soum is covered fully and 10 soums are partially included.

Darkhan-Uul aimag. Of one soum, Orkhon soum, 46.4% is located in the basin.

Orkhon aimag. The basin comprises Jargalant soum 100% and Bayan-Undur soum 99.2%.

Uvurkhangai aimag. Of the aimag the basin covers one soum fully, Khujirt soum, and 7 soums partly. The soum centers of Bat-Ulzii, Yusunzuil, Ulziit, Kharkhorin and Khujirt soum are located in the basin. Burd soum has only 0.9% of its territory in the basin and is not included in the calculation of the economic indicators.

Selenge aimag. Part of the territory of Sukhbaatar, aimag centre and 9 soums are covered in the basin. In total 6 soum centres are located in the basin.

Tuv aimag. There are 5 soums included in the basin. Of these, 61.1% of the territory of Tseel soum belongs to the basin. For the other 4 soums, only 0.1-0.8% of each is located in the basin. Therefore, only Tseel soum is included in the socio-economic analysis estimation.

The number of population and livestock of the Orkhon river basin and the relevant socio-economic indicators have been calculated based on the 40 soums of 8 aimags which have more than 5% of their pasture area in the basin. Soums with less than 5% of the pasture area in the basin have not been included in the calculation.

When developing a management plan of the basin in the future, it is necessary to consider the following issues:

- Location of administrative centre in the basin;
- Percent of the territory of the soum included in the basin
- Water user using large water quantities
- Surface and ground water resource, and environmental status
- Impacts which may affect socio-economic sectors

Therefore, it is very important to develop the management plan also for those soums which co-exist in more than 2 basins without any omission and missing part.

4.2. Demography

4.2.1. Population Density and Growth

Population Density

The Orkhon river basin is different from other basins as the city of Erdenet is located here which is one of the largest and densely populated cities in the country. In 2010, Orkhon RB’s population was 235.6 thousand or 8.6% of the country’s population. From which, some 58.9% were living in urban area, 18.4% in soum centers and 22.7% in rural areas. Of the total basins’ population 37.3% is living in Orkhon aimag, 21.0% in Arkhangai, 17.8% in Selenge, 12.6% in Uvurkhangai and the remainder in other aimags (Figure 6).

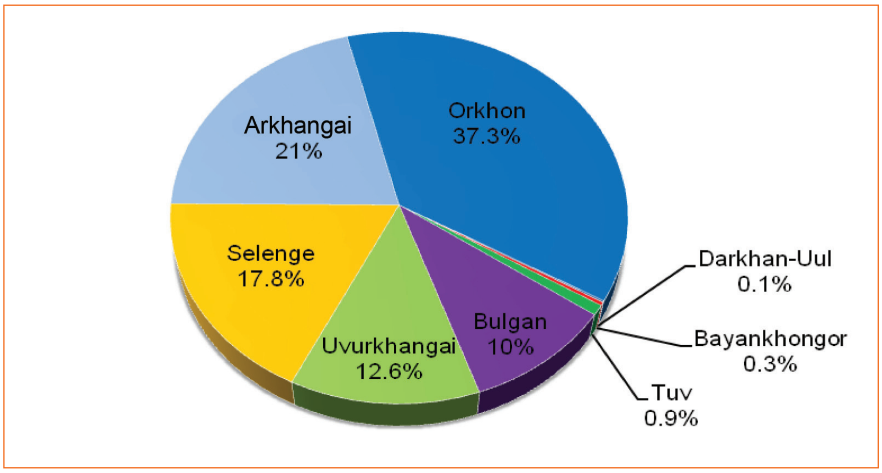

Figure 6. Population in the Orkhon river basin in percent

In the basin, there are 4.4 persons per square km which is 2.5 times more than the country's average (1.75). Whereas, the Orkhon aimag is the most densely populated with 106.3 people per square km and the least populated is Bayankhongor aimag with 0.9 person per square km.[3] Of the aimag and soum centers, Sukhbaatar city of Selenge aimag is the most densely populated with 484.3 people per square km and the least populated is Buregkhangai soum of Bulgan aimag with 0.4 person per square km The population density map is presented in Figure 19 of the Land use report.

Table 3 shows the population of the Orkhon RB by aimag. More detailed information is presented in Annex 2. From the total population of Orkhon RB 58.9% or 138.6 thousand persons were living in the aimag centers, 18.4% or 43.3 thousand in soum centers (including Kharkhorin) and the remaining 22.7% or 53.5 thousand were living in rural areas.

In 2006-2010 the average annual growth of Orkhon RBs population was 0.9%, which was lower than the country average. Although some big urban areas are located in the basin, population growth is low due to migration to the Capital.

Table 3. Population of ORB in thousand persons

Aimag	2006		2007		2008		2009		2010	
	Total	Rural	Total	Rural	Total	Rural	Total	Rural	Total	Rural
Arkhangai	48.6	21.8	48.0	21.8	48.0	21.3	47.7	22.1	49.5	22.0
Bayankhongor	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Bulgan	23.6	8.0	23.5	7.9	23.5	8.5	24.7	9.6	23.6	8.0
Darkhan-Uul	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3
Orkhon	86.3	4.0	88.2	4.0	89.9	4.3	91.2	1.3	87.9	1.8
Uvurkhangai	29.6	14.0	29.1	13.2	29.5	13.2	29.6	13.3	29.8	12.3
Selenge	36.5	5.1	38.8	8.4	37.9	6.4	41.8	8.0	42.1	7.2
Tuv	2.2	0.3	2.1	0.5	2.1	0.6	1.8	1.1	1.8	1.2
Total	227.7	54.1	230.6	56.7	231.8	55.2	237.8	56.3	235.6	53.5

Out of the total population of the Orkhon RB 51.1% are female and 48.9% are male. Figure 7 shows how the population is divided over the various age groups, showing that in total about 64% of the population is at present in the working age group. As about

[3] Only population density which included in the basin has been calculated.

83% of the people outside the working age group were children under 14 years old, it can be concluded that the labour force resource is high. Demographic burden on 100 working age population was 55, from which some 46 are children and 9 are elder people (for more detailed information see Annex 3).

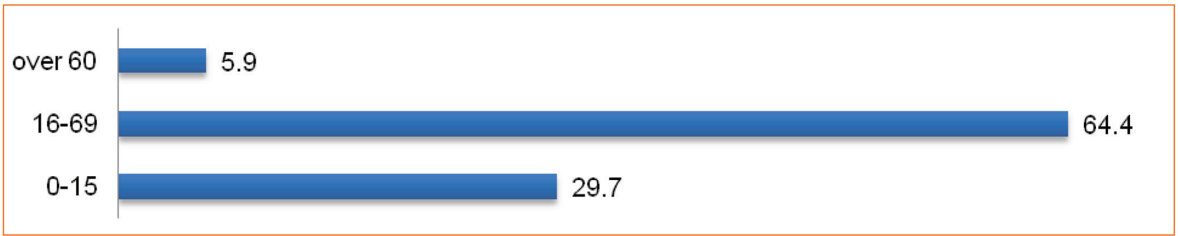

Figure 7. Population by age in percent, 2010

Urbanization

Due to the location of the Khangai regions pillar cities Erdenet, Kharkhorin and other aimag centers the Orkhon RB urbanization is comparatively high. In 2010, some 147.6 thousand persons were living in the cities and 34.2 thousand in soum centers. Erdenet (Bayan-Undur) city has 85.0 thousand people, Tsetserleg (Erdenebulgan) 20.1 thousand, Bulgan 11.6 thousand, Sukhbaatar 21.9 thousand and Kharkhorin city 9.0 thousand people.

From 25 soum centers 44% or 11 soum centers have 500-1000 persons, 36% or 9 soum centers have 1000-2000 persons and 20% or 5 soum centers have over 2000 persons. From these the most high population are in Bat-Ulzii soum center of Uvurkhangai aimag (4091 people), Altanbulag soum center (4067 people) and Shaamar soum center (3827 people) of Selenge aimag. And the most low population are in Ulziit soum center (560 people) of Uvurkhangai, Mogod soum center (579 people) of Bulgan and Tseel soum center (530 people) of Tuv aimag.

Table 4. Urban and soum center population of the ORB in thousand persons

City and soum center	2006	2007	2008	2009	2010	2015	2021	2021/2008 %
Arkhangai	26.8	26.2	26.7	26.0	27.4	27.0	27.8	103.9
Tsetserleg city	17.9	18.0	18.0	17.8	20.1	19.8	20.3	112.6
Battsengel	1.1	1.1	1.1	1.1	1.1	1.0	1.1	97.2
Bulgan	0.8	0.7	0.9	1.0	1.0	1.0	1.0	108.2
Ikhtamir	1.2	1.4	1.2	1.1	1.1	1.0	1.1	88.9
Ugiinuur	0.6	0.6	0.6	0.6	0.6	0.6	0.6	114.3
Ulziit	0.8	0.8	0.8	0.8	0.8	0.8	0.8	99.8
Tuvshruulekh	1.9	1.9	1.9	1.9	1.1	1.1	1.1	59.0
Khotont	1.2	0.9	1.3	0.8	0.8	0.8	0.8	62.0
Tsenkher	1.3	1.0	1.0	1.0	1.0	1.0	1.0	102.0
Bulgan	15.6	15.5	15.0	15.1	15.6	15.3	15.7	105.0
Bulgan city	11.0	11.6	11.2	11.0	11.6	11.4	11.7	104.6
Mogod	0.7	0.7	0.6	0.6	0.6	0.6	0.6	92.4
Orkhon	1.0	1.0	1.0	0.9	1.0	0.9	1.0	99.6
Saikhan	1.3	0.9	0.9	1.2	1.2	1.2	1.2	140.1
Khishig-Undur	1.6	1.4	1.3	1.3	1.3	1.2	1.3	95.6
Orkhon	82.3	84.1	85.6	90.0	86.1	96.4	109.3	127.7
Erdenet city	79.9	81.8	83.3	88.0	85.0	95.2	107.9	129.5
Jargalant	2.4	2.4	2.3	1.9	1.1	1.2	1.4	62.2
Uvurkhangai	15.6	15.9	16.3	16.4	17.5	17.4	17.8	109.4
Bat-Ulzii	2.1	2.2	2.2	3.7	4.1	4.1	4.2	186.8

City and soum center	2006	2007	2008	2009	2010	2015	2021	2021/2008 %
Yusunzuil	0.8	0.9	0.9	0.9	0.9	0.8	0.9	100.3
Ulziit	0.6	0.9	0.9	0.7	0.6	0.6	0.6	66.7
Kharkhorin city	9.3	8.8	9.2	8.3	9.0	9.0	9.2	100.3
Khujirt	2.8	3.1	3.1	2.8	2.9	2.9	2.9	94.9
Selenge	31.3	30.4	31.5	33.8	34.7	34.7	36.0	114.3
Sukhbaatar city	19.7	18.8	19.4	21.3	21.9	21.9	22.8	117.4
Altanbulag	3.4	3.5	3.6	3.8	4.1	4.1	4.2	117.4
Baruunburen	1.2	1.2	1.3	1.3	1.3	1.3	1.3	101.4
Orkhon	1.1	1.0	1.1	1.0	1.0	1.0	1.1	99.3
Sant	1.4	1.6	1.4	1.5	1.6	1.6	1.6	120.0
Khushaat	1.1	1.0	0.9	1.0	1.0	1.0	1.0	110.6
Shaamar	3.4	3.4	3.9	3.8	3.8	3.8	4.0	102.9
Tuv	1.8	1.6	1.5	0.7	0.6	0.6	0.6	40.2
Tseel	1.8	1.6	1.5	0.7	0.6	0.6	0.6	40.2
Total of basin	173.4	173.8	176.6	181.8	181.9	191.4	207.3	117.3
From which in the cities	137.8	139.0	141.2	146.5	147.6	157.3	172.0	121.8
In the soum centers	35.6	34.8	35.4	35.3	34.3	34.1	35.3	99.6

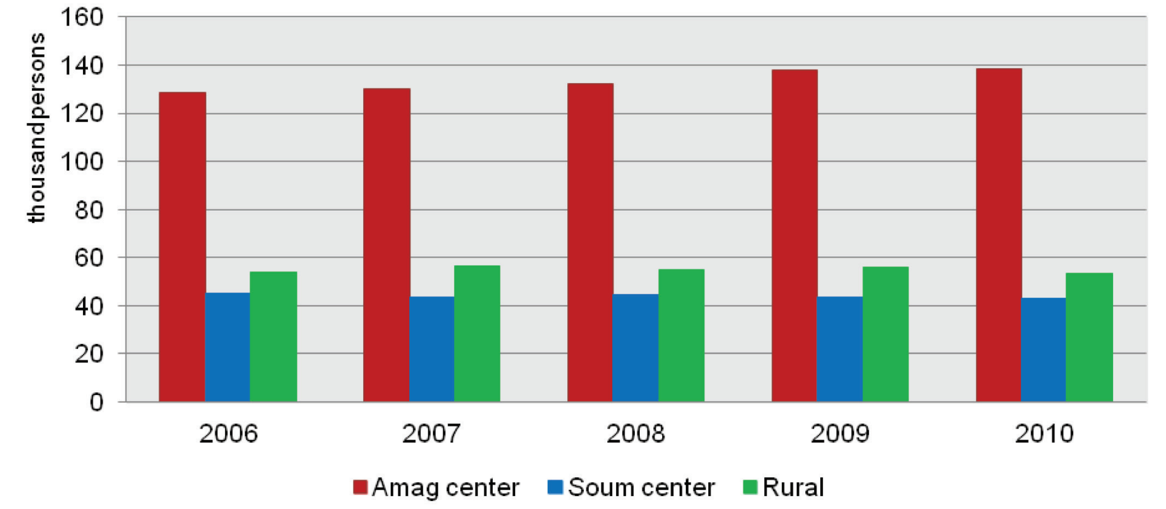

Figure 8. Population of the Orkhon river basin, by settlement

According to the medium scenario of the NSO forecasting of population, the population of urban and soum centers of the Orkhon RB will reach 191.4 thousand persons in 2015 and 207.3 thousand persons in 2021, an increase by 17.3% compared to 2008. From these in 2021, 172.0 thousand persons or 83.0% may live in the cities and 35.3 thousand persons or 17.0% may live in the soum centers. About 63% of the city's population will live in Erdenet.

The Khangai region development program aims to improve the living condition of the population by updating and implementing the regional pillar cities and urban development programs for the current market economy. Moreover based on population growth and apartment needs will increase apartment coverage and the percentage of apartment households will reach 70% in 2015.

The Orkhon aimag development program plans to improve land use in the urban area and to study the establishment of a new settlement between Erdenet and Bulgan. The development program of Uvurkhangai aimag aims to give more attention to creating work places and favorable living conditions for the residents, to update and implement

Kharkhorin city's master plan, to prepare and implement general development programs for the micro-region centers and large soum centers based on "Soum center" project and to improve environmental condition around cities and protect water and soil from pollution. The development programs of Arkhangai and Bulgan aimags plan to develop Tsetserleg and Bulgan cities based on their general plan and to develop big soum centers, to improve land use and to increase the housing supply level. The development program of Selenge aimag aims to improve environmental conditions around cities and to develop cities, to increase housing supply, and to create good living condition for the residents.

Population Growth Forecasting

Population growth is an essential indicator to calculate drinking water demand of the population in the future. In forecasting the population growth on a national scale the "Population prospect of Mongolia 2010-2040" issued by NSO used three scenarios: high, medium and low (Figure 9). Table 5 shows the medium scenario of calculating the population growth of urban areas. The total population of the Orkhon river basin is forecasted to reach 262.4 thousand by 2021 and to increase by 13.2% compared to 2008.

Table 5. Population growth forecasting in thousand persons

Aimag	2008	2010	2015	2020	2021
Arkhangai	48	49.4	48.6	49.6	50.0
Bayankhongor	0.7	0.7	0.7	0.7	0.7
Bulgan	23.5	23.6	23.2	23.7	23.8
Darkhan-Uul	0.3	0.3	0.3	0.4	0.4
Orkhon	89.9	87.9	98.5	109.0	111.6
Uvurkhangai	29.5	29.8	29.5	30.2	30.4
Selenge	37.9	42.1	42.1	43.4	43.7
Tuv	2.1	1.8	1.8	1.9	2.0
Total of the basin	231.8	235.6	244.7	258.9	262.4

Figure 9 shows the population prospect of Orkhon RB by low, medium and high scenarios.

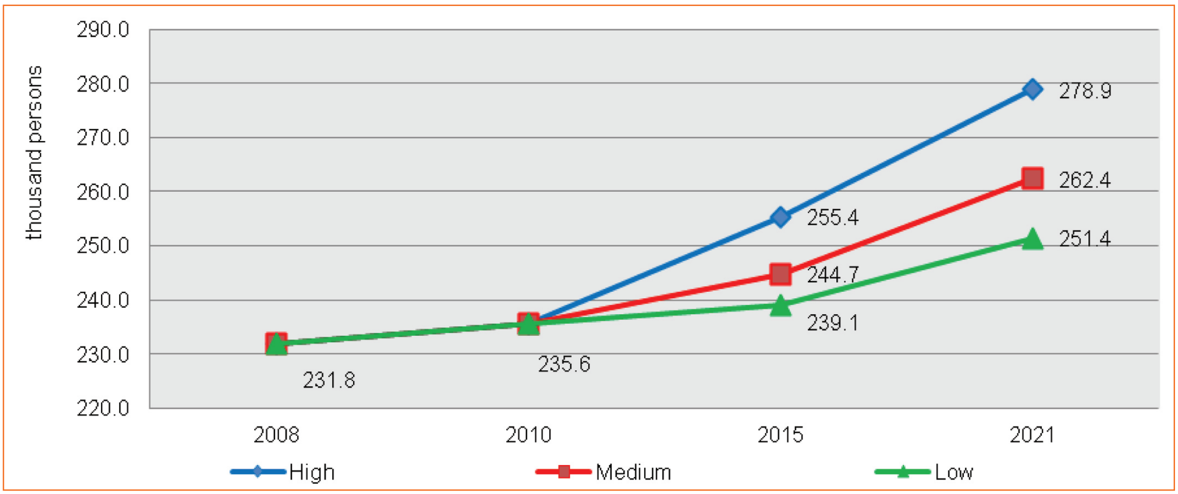

Figure 9. Population prospect of the Orkhon RB

4.2.2. Households in the Orkhon River Basin

In 2010, there were 64.7 thousand households in the basin which is some 8.7% of the total households of the country. Of the basin households, 75.7% live in urban areas and soum centre, and 24.3% live in rural areas (see Table 6).

Table 6. Number of households in the ORB, 2010

Aimag	Households in the basin, thous. households		Average number of family members per household
	Total	of which, rural	
Arkhangai	13.8	6.1	3.6
Bayankhongor	0.1	0.1	3.7
Bulgan	6.6	2.5	3.6
Darkhan-Uul	0.1	0.1	3.0
Orkhon	23.2	1.1	3.8
Uvurkhangai	8.6	3.9	3.4
Selenge	11.8	1.9	3.6
Tuv	0.5	0.2	3.6
Total of the basin	64.7	15.7	3.6

The average number of family members per household was 3.6, which is the same number compared to the national population census which was carried out in 2010. Orkhon aimag has the highest number of family members per household by 3.8 and Orkhon soum in Darkhan-Uul aimag has the lowest at 3.0 persons per family. Some 75.3% of total households in the basin live in Arkhangai, Orkhon and Selenge aimags.

4.2.3. Employment

As of 2010, there were 151.6 thousand working age people in the basin that is 9.6% of the country's economically active population and 9.2% of the country's employed population, respectively (see Table 7). Employment rate is lower than the country's average by 4 points due to the high level of unemployment in Orkhon aimag. However, labor force participation is higher than the country's average.

Table 7. Employment of the ORB in thousand persons, 2010

Indicators	Arkhangai	Bayankhongor	Bulgan	Darkhan-Uul	Orkhon	Uvurkhangai	Selenge	Tuv	Total of the basin	Total of the country	Percent in the country's total
Total population	49.4	0.7	23.6	0.3	87.9	29.8	42.1	1.8	235.6	2780.8	8.6
Working age population	32.2	0.4	15.9	0.2	54.7	18.4	28.6	1.2	151.6	1863.4	8.1
Economically active population	26.6	0.3	11.7	0.1	38.6	13.8	18.6	0.9	110.6	1147.1	9.6
Employees	24.8	0.3	9.9	0.1	28.0	13.1	18.2	0.8	95.2	1033.7	9.2
Unemployed	1.9	0.0	1.8	0.0	10.0	0.7	0.4	0.1	14.8	113.4	13.0
Registered unemployed	1.2	0	0.7	0	1.7	0.6	0.4	0	4.6	38.3	12.0
Labor force participation, %	82.6	74.9	73.3	61.7	70.6	75.2	65.1	71.2	73.0	61.6	-
Employment rate, %	93.0	96.4	84.8	89.0	74.1	95.1	97.9	94.0	86.1	90.1	-
Unemployment rate, %	7.0	3.6	15.2	11.0	25.9	4.9	2.1	6.0	13.4	9.9	-

In 2010, some 44.3% of all employees worked in the agricultural sector, 8.4% in the service sector and 17.3% in the industrial sector (see Table 8).

According to an employment study conducted in 2008 in Orkhon aimag, which is the most densely populated, some 67% of its population was of working age and 58.5% of its workforce resource were employees. There were 12.5 thousand unemployed and 59.2% is due to a lack of working premises. In view of the above, adherence to a policy of increasing job vacancies and encouraging small-and-medium businesses promises to be a significant influence to improve the living standard of the population.

Table 8. Number of employees in thousand persons, 2010

Sectors	Arkhangai	Bayankhongor	Bulgan	Darkhan-Uul	Orkhon	Uvurkhangai	Selenge	Tuv	Total of the basin	Percent in the basin total, %
Agriculture, forestry, hunting and fishing	17.0	0.3	5.9	0.1	3.5	8.3	7.0	0.4	42.5	44.3
Mining	0.1	0.0	0.0	0.0	5.7	0.5	0.9	0.0	7.2	7.5
Processing plant	0.9	0.0	0.5	0.0	4.3	0.7	2.2	0.1	8.6	9.0
Water supply, sewage and waste management and treatment activities	0.1	0.0	0.1	0.0	0.3	0.0	0.2	0.0	0.7	0.8
Trade, maintenance, transport and communication	3.0	0.0	1.2	0.0	6.5	1.7	2.9	0.1	15.5	16.2
Activities to provide housing and food supply service	0.2	0.0	0.2	0.0	0.5	0.3	0.3	0.0	1.6	1.6
Finance, insurance and real estate	0.1	0.0	0.1	0.0	0.7	0.1	0.3	0.0	1.3	1.4
Public and administration service	1.3	0.0	0.8	0.0	1.3	0.8	1.7	0.1	5.9	6.1
Education	1.0	0.0	0.8	0.0	3.2	0.9	1.1	0.0	6.9	7.2
Population health and social welfare	0.9	0.0	0.3	0.0	1.0	0.4	0.9	0.0	3.5	3.6
Other activities	0.2	0.0	0.1	0.0	1.0	0.2	0.7	0.0	2.2	2.3

4.2.4. Living Standard

Human Development Index

The Human Development index (HDI) is one of the socio-economic indicators that measure country's development by combining indicators of life expectancy, educational attainment 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".

The estimation of the human development index is based on average life expectancy, education level and GDP per capita. The index is shown by aimags of the basin in Table 9.

Orkhon aimag has the highest HDI with 0.845 which is 0.082 higher than the country's average while Bayankhongor and Uvurkhangai aimags have 0.07 lower than the country's average. The higher than the country's average GDP per capita of Orkhon aimag is due to the location of Erdenet, the leading copper mining company.

Table 9. Human development index of aimags in the Orkhon RB, 2010

Aimag	Life expectancy index	Education index	GDP per capita index	Human development index /HDI/
Arkhangai	0.711	0.917	0.536	0.722
Bayankhongor	0.685	0.916	0.477	0.693
Bulgan	0.739	0.901	0.575	0.739
Darkhan-Uul	0.679	0.985	0.554	0.739
Orkhon	0.716	0.966	0.853	0.845
Uvurkhangai	0.715	0.902	0.467	0.694
Selenge	0.732	0.907	0.611	0.750
Tuv	0.747	0.887	0.584	0.739
Country's average	0.718	0.928	0.648	0.763

Source: Statistical book of Mongolia-2010

Household Income and Expenditures

The NSO started conducting researches on population, household income and expenditures since 1966. In 2010, average cash income per household in Mongolia reached MNT448.0 thousand, MNT498.1 thousand in urban areas and MNT386.6 thousand in rural areas (Table 10).

Table 10. 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

According to the country's average, salary comprises 44.7%, household business 18.5% and the remaining is obtained from other income. But this indicator is extremely different between urban and rural areas. In urban areas, most income or 72% is from salary and allowances while in rural area this is 40% only. Rural household business and food produced by private farms and enterprises reaches 48%.

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 salary of employees was 341.5 thousand MNT 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 the "Survey on average wages and salaries of employees" of the Orkhon aimag were involved 9135 employees of 41 organizations like Erdmin, Stroi invest, Erdenet carpet, Medical clinic, Majaa hospital, Saving's bank and Khiimori CATV and Erdenet Khaan Suu LLC, etc. According to the survey, the average salary was MNT362.1 thousand which is MNT20.6 thousand more than the country's average salary. [109]

In 2010, household expenditure at national level amounted to MNT450.6 thousand on average with MNT501.0 thousand in urban areas and MNT387.9 thousand in rural areas (Table 10). Of a total monthly expenditure per household, cash expenditure is 89.1%, food expenditure is 33.8% and other products and services are 52.2% compared to the national level. Figure 10 presents the average household income and expenditure for urban and rural population.

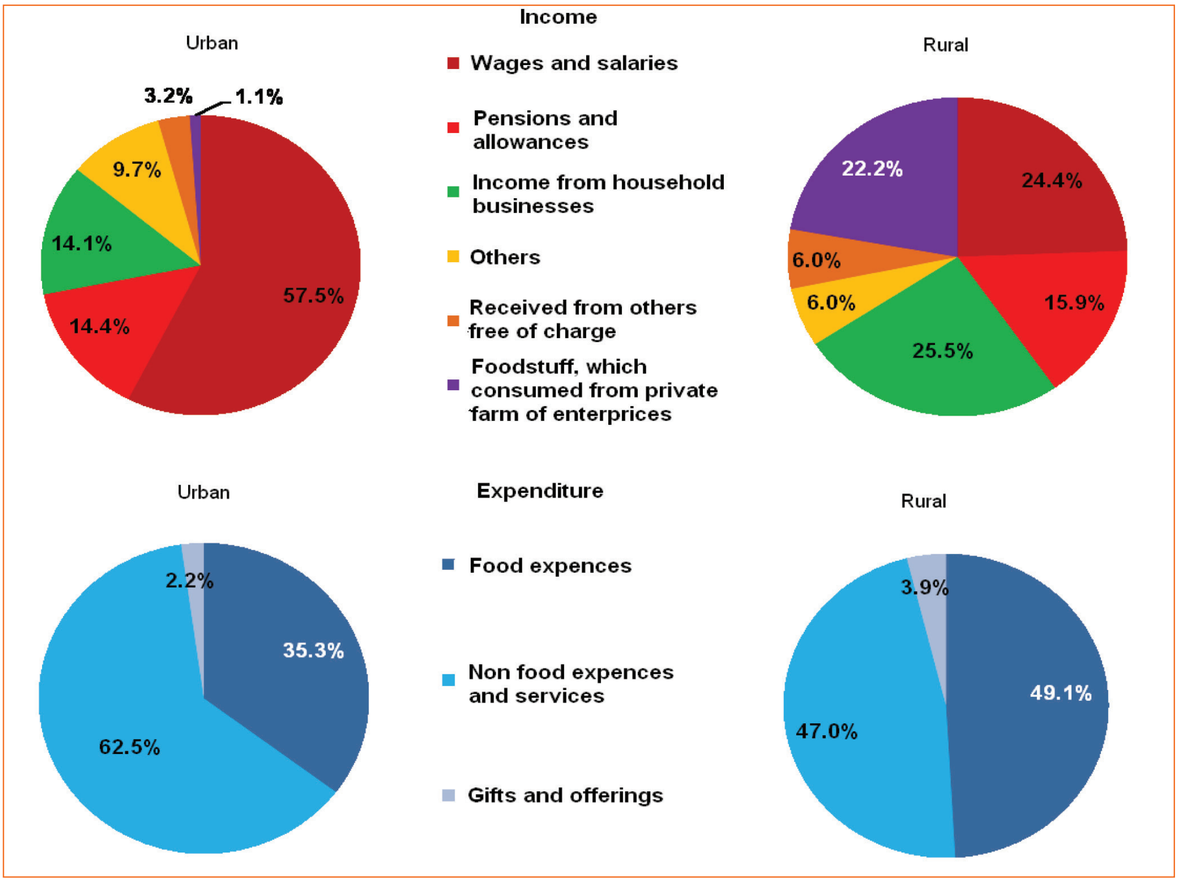

Figure 10. Composition of Household income and expenditure, 2010

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 MNT18.7 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 11 shows the minimum subsistence levels in 2006-2010.

[4] By recommendation from EBRD water and waste water expense have to be under 5% of household income.

Table 11. Minimum Subsistence Level of Population

Region	Minimum Subsistence Level, MNT/per month per person					
	2006	2007	2008.II	2008.X	2009	2010
Central: Darkhan-Uul, Tuv, Selenge	39 000	56 700	73 100	90 800	91 200	91 700
Khangai: Arkhangai, Bayankhongor, Uvurkhangai, Bulgan and Orkhon	38 300	54 600	70 600	89 000	90 600	91 500

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.

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 reduce poverty".

Table 12. 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	Khangai	38.7	46.6	55.2	51.9
	Central	34.4	30.7	29.3	29.3
Location	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 poverty of the population has certainly become an attention-drawing and crucial issue. However, there is an increase in Mongolia's economy and GDP per capita. Poverty level has reached 39.2% from 2006 to 2010 due to the dzud which took place in 2009 and 2010. Compared to 2007, the poverty level has increased by 4.5 points in rural area, 1.3 in aimag centres and 3.2 in soum centres, respectively.

Water Poverty Index (WPI)

In 2002, for the purpose to express an interdisciplinary measure 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 11).

Source: http://maps.grida.no/go/graphic/water-poverty-index-by-country-in-2002

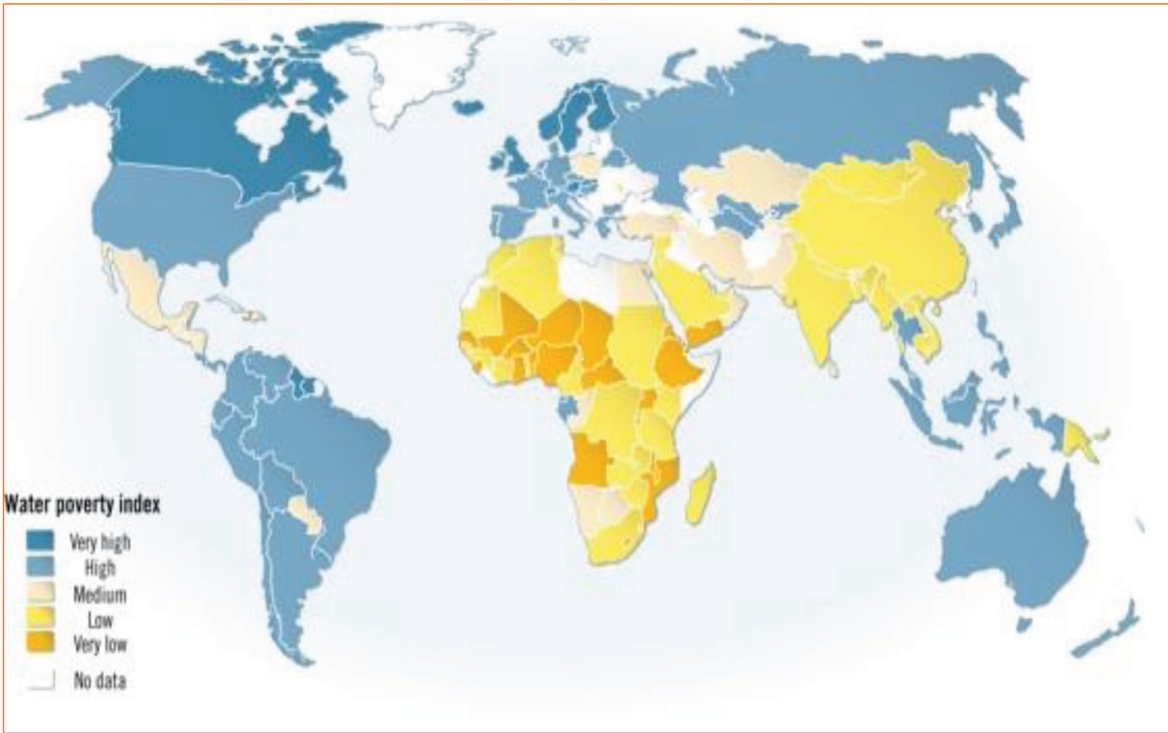

Figure 11. World WPI map

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 13 presents the WPI of various countries.

Table 13. 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

Drinking water supply

One of the indicators which shows the living condition of the country population is the drinking water supply level.

According to the water demand estimation, in 2010 33.4% of Orkhon RBs population was connected to a centralized water supply and sewerage system, 40.7% used other protected water sources and 25.9% used unprotected water sources. (Table 14)

Table 14. Drinking water supply connection

Water source		2008		2010	
		thousand persons	*share of the total, %*	*thousand persons*	*share of the total, %*
Connection to the centralized system	Apartment	45.6	19.6	47.7	20.2
	Kiosks	23.2	10.0	31.1	13.2
Kiosks by transport		73.3	31.6	63.8	27.1
Protected wells, springs		27.3	11.8	32.1	13.6
Other sources		62.4	27.0	60.9	25.9
Total		231.8	100.0	235.6	100.0

4.3. Society and Culture

4.3.1. Education

The education index[5] of Mongolia is relatively high: 0.925 in 2010. The education system of Mongolia consists of pre-school education, primary and secondary education and higher education. Erdenet, the country's second largest city is located in the basin and it has created good opportunities to develop centralized educational institutes.

[5] One component of HDI, that 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.

During the academic year 2010-2011, in total 11.5 thousand children have enrolled in approximately 80 kindergartens of aimags in the basin and they are receiving pre-school education. This is 23.0% of the country total. Food costs for children involved in state-owned kindergartens are fully covered by the government and this became a significant action towards improving the living standard of the population. At the same time, there are 47.3 thousand children studying at some 70 general education schools of which 38.2% in Orkhon aimag. Overall pupils studying at general education schools in the aimags and soums of the basin are 25.6% of the country total.

In the Orkhon river basin, there are in total 5.4 thousand students who are now studying at 6 universities and 7 vocational training centres. This is 2.5% of the total number of students in the country.

4.3.2. Social and cultural status

The Orkhon river basin is a rich region, historically and culturally and it is essentially related to Mongolian history. By now, there have been two cultural objects registered in the world heritage of UNESCO and one of them is historic monuments based in Orkhon valley. It includes number of historically significant places related to tradition culture and custom of nomadic Mongol nation.

Mongolians are one of the few nations in the world which still keep a traditional nomadic life and culture. And essential co-existence of nomadic life and nature has formed the tradition to preserve and respect our planet and local environment.

One demonstration of this tradition delivered hand to hand from ancient time is an inclusion of nature preserving procedures in its religion and traditional saga. Around the 18th century, a specific procedure for the protection of the nature and environment was released and it was prohibited to pollute environment/river or hunt during the season of breeding. Mongolians have a history in which they've been strictly following the procedure.

One sacred idol which has been kept so far related to fresh water is Luvaanjalbuu water god and whose image was created on a litho glyph located on a bank of the Orkhon River, Orkhon aimag. This place has become one of the favorite places for sightseeing and prayer as well. In 2007, Erdenezuu temple administration established a small temple on a ruin of an old temple in Kharkhorin soum for a chant by monks in order to praise the water god in Mongolia. Inside the temple, there is an icon of various animals headed by fish and instruction to preserve nature and environment in order to educate local community through their belief.

In Shamanism, the traditional religion has been keeping the precious tradition to respect the blue sky and preserve water, nature and environment.

Both Shamanism and Buddhism are an obvious closely-knitted part of our tradition and culture, and the religion has been enriched by a hereditary commitment/intention to hand over to next generation a pure nature by preserving and not polluting our planet, keeping it clean.

So far, nomad-style livestock husbandry has prevailed in the agricultural sector and herdsman families usually move by following rivers, lakeshores and good pastures. In conjunction with the nomad-style life, labour organization/schedule in a family has been already accustomed. Also there are many numbers of households who still live in a ger or house which is not connected to a water supply system, even when they are located in an urban area. There is much continued use of water directly from wells, rivers, springs, fountains, snow and ice depending on the related life and condition. However, centralized water supply and sewerage networks were launched in our country since 1960.

Figure 12. Luvaanjalbuu, the water god; Ulaan tsutgalan waterfall

While women are mainly responsible for water use in a family, men dominantly participate in fetching water as this is considered a difficult labour. Also there is plenty of participation by children in fetching water in ger districts of urban areas. It's been clearly confirmed according to a questionnaire carried out amongst ger districts of Ulaanbaatar, that some 45% of adult male, 29% of adult female and 26% of children do fetch water. According to another questionnaire carried out in Altanbulag soum centre, Tuv aimag, male is 62.7%, female is 20.9% and children are 6.3% and compared to a study named "Which family member how to fetch water?" [100] which was conducted in 2004, there seems to be an approach that male participation has been increased and female, especially children's participation has decreased. Currently, such study hasn't been conducted yet in the Orkhon basin.

How far is it to fetch water from? This question reveals the status of water supply for the population. As it is mentioned in "Urban poverty and migration" study conducted in 2002, of total households involved in the study, some 60.4% answered they fetch water from a distance up to 300 m, 28.0% from 0.3-1 km and 11.6% from above 1 km distance. But according to the "Readiness to process payment" study which was conducted in 2009 in the scope of the project among households inhabitants of ger districts in Ulaanbaatar, some 50% answered they fetch water from a distance up to 200 m, 43% from up to 1 km and 7% from above 1 km. Meanwhile, in soum centres, 22.9% from up to 200 m, 50% from up to 1 km and 27.1% from above 1 km. Therefore, 73% in Ulaanbaatar and 68.8% in rural area answered they spend up to 1 hour to fetch water. But 10% in Ulaanbaatar and 4.2% in rural area answered it takes above 2 hours to fetch water. Compared to the result of studies of "Urban poverty and migration" and "Which family member how to fetch water?", the result of our study shows some decrease. This is one important indicator to reveal the importance of measures taken over issues of water supply.

Recently due to rapid urbanization the lifestyle of the population has been changing. Rivers and water sources around the cities and industries become polluted from human activities. Therefore there is a need to improve public participation for the environmental protection and evoke national traditions and customs related to protect environment and water resources.

4.3.3. Health

It is stated in the policy on population development which is implemented by the government that its purpose is to provide sustainable growth of the population and create a convenient condition for long, healthy and productive life and development of the population.

Therefore, a number of actions have been taken and are being successfully implemented for the health safety of the population such as "The strategy to reduce maternal mortality 2005-2011", "The 3rd national program on reproductive health 2007-2011", order No.149 by Minister of Health on "action to reduce maternal mortality" in order to intensify the implementation of the 5th goal of the Millennium development, and "National strategy on safety and sustainable supply of pharmacy on for reproductive health", etc.

According to statistics, there have been about 2.3 thousand health institutes at national level as of 2010 and 50% or 1160 institutes are based in aimag and soums of the basin.

Maternal mortality which took place in aimag and soum of the basin consisted 10% of the total maternal mortality of the country in 2010 while infant mortality consisted some 9.4% of total infant mortality. Also number of patients suffered from infectious disease consisted 7.7% or 3.2 thousand of the country total. Of the patients in the basin, some 50% suffered from viral hepatitis, one of the infectious diseases caused by polluted water. [100]

Future Trend of Social Development

It is stated in the 1st guidance of six leading guidances of the integrated national development policy based on Millennium Development Goals that "it shall achieve the Millennium Development Goals and develop Mongolian citizens 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 programs of the region and aimags have been processed and approved based on the above guidance. The Central and Khangai economical regions are included in the Orkhon river basin. It is stated in the development program of the Central region that average life expectancy of the population is about to reach the age of 66 and the unemployment level as of 1998 is to decrease two times by 2015. But the development program of Khangai region aims at bringing average life expectancy to reach the age of 69 and increase the population growth by 1.8%, decrease the number of registered unemployed below 2% and bring 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. It is stated in the development program and integrated policy of the Aimags in the basin to aim for creating a convenient and permanently living condition for the population, bringing its average annual growth at average national level, encouraging employment and reducing unemployment.

5. Economic sectors

5.1. Economic development

5.1.1. Gross Domestic Product

The basin, itself, is a very important region, economically. The aimag and soums of the economic Central and Khangai regions, as well as Kharkhorin soum and Erdenet city are the base centres of the Khangai region located in the basin.

When calculating the GDP of the basin, the aimag centres located in the basin are considered. Please see Figure 13 for the GDP of the aimags in the basin, at current prices.

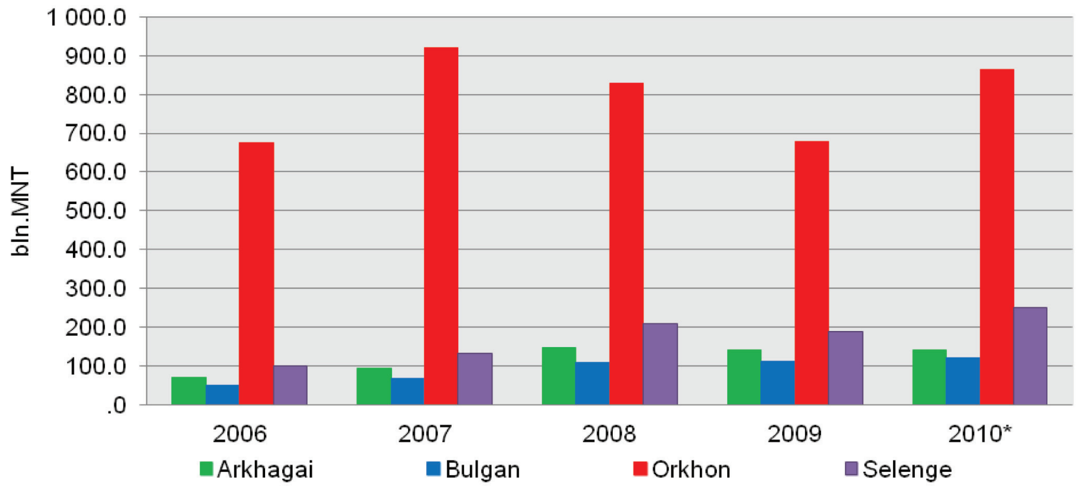

Figure 13. GDP produced in the Orkhon RB, at current prices

In 2010, the aimags that are located in the Orkhon RB produced in total MNT1456.1 billion at current price which is 16.7% of the total GDP of the country. This is a very high indicator compared to the 8.5% of the country's population living in this basin. Some 66.9% of the total GDP of the ORB was from the industrial sector. The GDP of the aimags located in the ORB is presented in Table 15.

Table 15. GDP produced in the Orkhon RB, at current price, 2010

Aimag	GDP, in billion MNT	Share of the sectors, %		
		Agriculture	Industry and construction	Services
Arkhangai	133.0	76.6	1.5	21.8
Bulgan	121.6	77.6	2.0	20.4
Orkhon	1 007.6	1.5	92.6	5.9
Selenge	193.9	62.2	19.1	18.7
Total	1 456.1	22.8	66.9	10.3

The Orkhon River basin is different from other basins as the industrial sector of its aimags contributes a relatively high percentage of the GDP. Compared to other basins, the percentage agriculture in the GDP of the basin is low. Orkhon aimag produced 69.2%

of the total value added products produced by the aimags of the basin while 13.3% is produced by Selenge aimag, the largest agricultural region.

Figure 14 shows the GDP per capita by aimag. In 2010, GDP per capita was the highest or MNT10054.8 thousand in Orkhon aimag, 3.4 times higher than the country's average while the lowest GDP per capita was in Uvurkhangai aimag with MNT1012.0 thousand, 2.9 times lower than the country's average. Whereas, only Orkhon aimag within the basin had higher GDP than the country's average, other aimags had lower. The GDP decreased in Orkhon aimag in 2009, which is due to the financial crisis of 2009 (Figure 14).

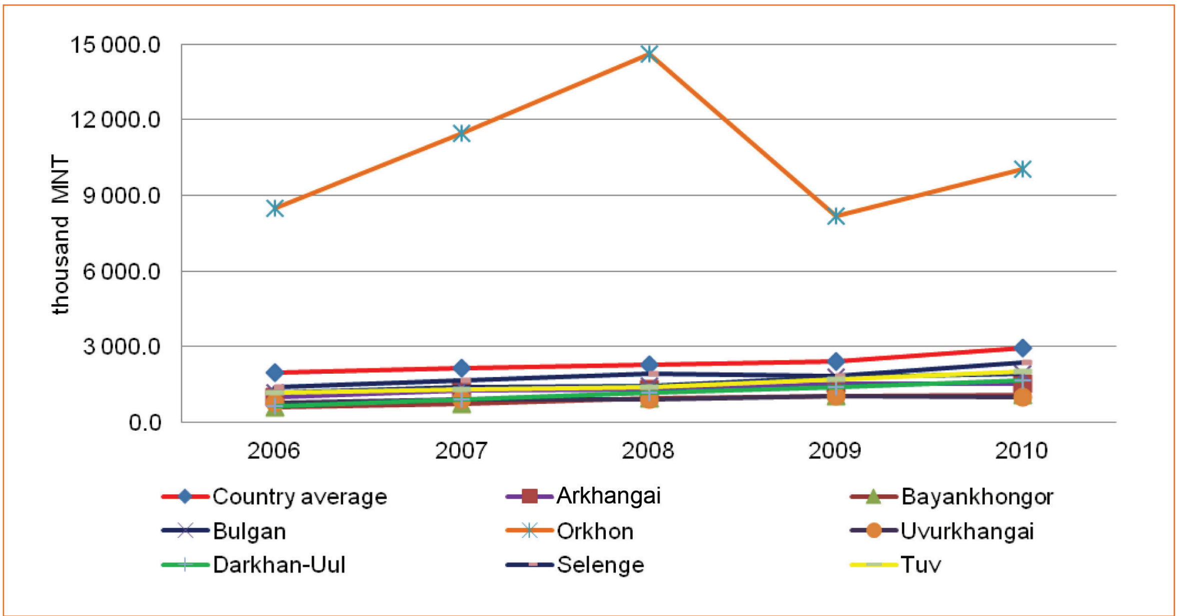

Figure 14. GDP per capita by aimag in the Orkhon RB

There are in total 2.4 thousand entities which run activities in the region of the basin and most of them are located in Orkhon aimag. Some 60% of all organizations are running business activities. Among these organizations, mostly provide sales and trade services.

Some factors which may affect the future development of the Orkhon river basin:[6]

Advantages:

- Located near the largest cities Ulaanbaatar, Darkhan and Erdenet, and therefore good market conditions,
- Sufficient human resources,
- A relatively high education level,
- Convenient soil and climate to run intensified livestock husbandry and crop farming,
- Relatively high developed infrastructure,
- Good conditions for industrial development related to mining,
- Good quantities of mineral resources,
- Excellent conditions for tourism.

[6] Consultant's report of Agricultural Policy

Disadvantages:

- Due to over grazing, there are some conditions deteriorating the ecological balance such as desertification and pasture degradation, etc.
- Due to influence by mining, pollution of water resource, etc.
- High level of poverty and unemployment.

5.1.2. Infrastructure

Transport

In this basin, one of our industrial centers, Erdenet is located as well as 3 aimag centers. The infrastructure is well-developed. The railway lines which connect Mongolia with Russia pass through this region. The cities of Erdenet and Sukhbaatar are connected with Ulaanbaatar via railway lines.

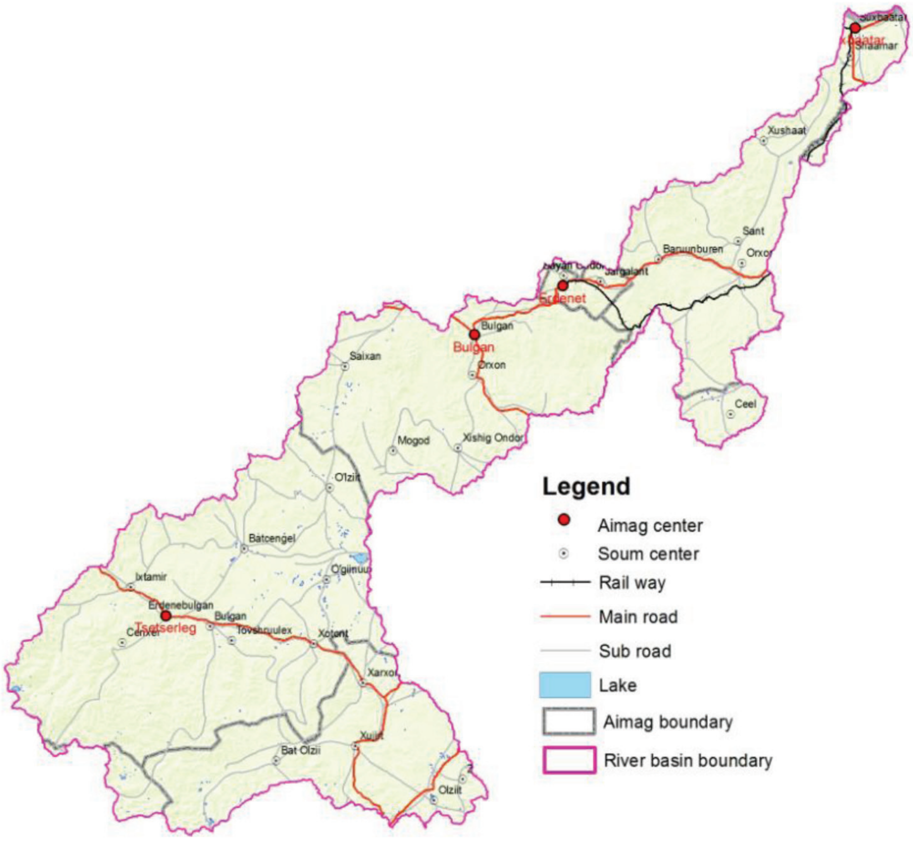

Figure 15. Road network in the Orkhon river basin

The aimag centers are connected with Ulaanbaatar city by 1550 km paved road. Bulgan, Orkhon and Sukhbaatar cities are connected with each other by state and local roads. Orkhon aimag is 420 km from Ulaanbaatar and connected with neighboring aimags by paved road. Orkhon aimag has 190 km auto road and 54 km is paved road and 135 km is pebbled road. Bulgan aimag has 1023 km improved pebbled road which connects aimags and soums. The black-top road is 27.5 km and state road is 477 km.

Energy

The aimags in the basin are connected to the central energy network. They have reliable energy sources. The central region energy systems occupy 90% of the energy networks.

It consists of Ulaanbaatar's power plants number 2, 3, 4; Darkhan power plant; Erdenet power plant; Central region electricity transmitting network and electricity transmitting network agencies of Ulaanbaatar, Darkhan, Erdenet and Baganuur.

The total installed electricity capacity is 712 MW and total installed thermal capacity is 1786 Gcal/hour. It distributes electricity to Ulaanbaatar, Khangai and Central region aimags (except Umnugovi) and Khentii's 270 soums' consumers using 35-220 KW-1300 km-long electricity transmitting lines.

Water supply and sewerage system

Erdenet city is located in the basin and has centralized water and thermal supplies. 50% of the population lives in apartments. Erdenet city water supply is carried from 64 km using 4 pump stations.

The average annual water loss is 4000.0 thousand m^3. This is due to unwise use of water and insufficient researches. 40 kiosks supply ger district consumers with drinking water.

The waste water treatment plant was constructed in 1978 with a capacity of treating 24.000 m^3 of wastewater per day. The deep cleaning facility was put into use in 1991. Since 2008 started renovation works of Erdenet waste water treatment plant by French aid. According this project the wastewater treatment plant capacity will increase 2 times and reach 40000 m^3 and level of treatment will reach 98%.

Tsetserleg city: 6.3% of the population lives in apartments connected to engineering pipelines. 93.7% lives in ger districts. The guaranteed water supply source is 8500 cubic meter/day. Total of 6 boreholes are used. The chlorination facility was built in 2000. But it is not in use. The city drinking water centralized system was built between 1988 and 1990. Total length is 39 km. The ger district drinking water is supplied from 13 kiosks.

The sewerage network was constructed in 1987 and waste water treatment plant was built in 1995. But both of them are not used completely.

Bulgan city: 9.2% of the population lives in apartments connected to engineering pipelines. 90.8% lives in ger districts. The centralized system and ger districts are supplied from 9 boreholes which were drilled between 1962 and 1987. The ger district households are supplied from 12 kiosks.

The centralized sewerage pipelines were constructed in 1987. But it is not used completely. The waste water treatment plant with biological treatment was constructed, but it is not in use. The collected waste water is discharged in special catchment area through pumping stations.

Sukhbaatar city: 10% of the population lives in apartments connected to engineering pipelines. 90% lives in ger districts. The water supply source is 2 km from the city. There is a 4-borehole-facility on the Orkhon river bank and the facility was put into use in 1991. Some 45 km long pipelines are used. The ger district households supply their drinking water demand from 40 kiosks. 12 of them are connected to centralized system. The waste water treatment plant with waste water pumping station and biological treatment, was constructed in 1985. The waste water treatment plant with a capacity of treating 6900 m3 waste water by biological methods, was put into use in 1992.

Kharkhorin: Currently the cities houses are not connected to the centralized system. Some organizations have connections to the water supply and sewerage network. Wastewater treatment plant with capacity of 360 m^3 was built in 1977. But currently there is used only 6% of capacity.

The Water National Program approved in 2010 planned to improve drinking water supply in the urban area, intensify surveys and investigation for water sources for cities and soum centers, and to protect water supply sources. In the new mid-term development program it is planned to improve the urban development and local infrastructure, to create comfortable living condition in the local area and to provide engineering infrastructure to local area residents. As a result of implementing these programs aimag and soum centers will solve some problems related to the water supply and *wastewater* of the cities and urban areas.

5.1.3. Entities and organizations

The Orkhon basin is a region in which industries and especially the mining sector has been highly developed.

In total 2.5 thousand entities and organizations are running activities in the territory of the basin and most of them are located in Orkhon aimag. 60% of all organizations, run business activities and most of the 60% run trade and services (Table 16).

Table 16. Organizations of the ORB

Aimag	Hospital	Business organization	Budgetary	NOG	Mining plant	Processing plant	Agricultural	Power, gas and heat production	Bank and finance
Arkhangai	16	145	68	14	2	65	40	6	14
Bulgan	10	16	18	12	1	4	10	1	5
Orkhon	113	1239	78	132	4	125	8	2	30
Uvurkhangai	15	40	29	9	2	17	37	4	19
Selenge	5	15	15	0	0	5	10	2	5
Tuv	1	2	3	-	-	1	2	-	2
Total of the basin	160	1457	211	167	9	217	107	15	75

5.2. Agriculture

5.2.1. Livestock husbandry

One of the important sectors in the country is livestock husbandry. For the basin, its GDP% reveals that the agricultural sector and especially livestock husbandry plays an important role in the economic development of all aimags and soums of the basin except Orkhon aimag. In 2010, the agricultural production comprised some 22.8% of the GDP of the Orkhon RB. In 2010, agriculture sector of Orkhon aimag produced 1.5% and other aimags 62.2%-77.6%.

Structure and Growth of Livestock and Influencing Factors on Livestock Husbandry

In 2010, there were in total 160.3 herder families and 327.2 thousand herders in the country. Some 11% or 17.5 thousand families and 9.7% or 31.9 thousand herders are living in the Orkhon river basin. The detailed number of herdsman family and herders is shown in Table 17.

Table 17 Number of herdsman family and herders in the Orkhon river basin

Aimag	Herdsman family, thousand families					Herders, thousand persons				
	2006	2007	2008	2009	2010	2006	2007	2008	2009	2010
Arkhangai	6.9	7.0	6.7	7.0	7.0	14.6	14.7	14.1	14.8	14.7
Bayankhongor	0.2	0.2	0.2	0.2	0.2	0.5	0.5	0.5	0.5	0.5
Bulgan	2.4	2.4	2.6	2.9	2.4	5.0	5.1	5.4	6.1	5.1
Darkhan-Uul	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3
Orkhon	0.9	0.9	1.3	0.3	0.4	1.7	1.9	2.3	0.6	0.9
Uvurkhangai	4.0	3.9	4.2	4.0	3.7	7.9	7.8	8.2	7.9	7.3
Selenge	1.0	1.1	1.4	1.6	1.4	2.2	2.2	2.5	2.9	2.7
Tuv	0.2	0.2	0.2	0.4	0.2	0.3	0.4	0.4	0.8	0.4
Total of the basin	15.7	15.8	16.7	16.6	15.5	32.4	32.8	33.6	33.9	31.9
Total of the country	170.8	171.6	171.1	170.1	160.3	364.4	366.2	360.3	349.3	327.2
Percent in total of the country	9.2	9.3	9.7	11.0	10.9	8.9	8.9	9.3	9.7	9.7

Livestock

As of 2010, there were 2.9 mln livestock in the basin comprising 8.9% of the total livestock number of the country.

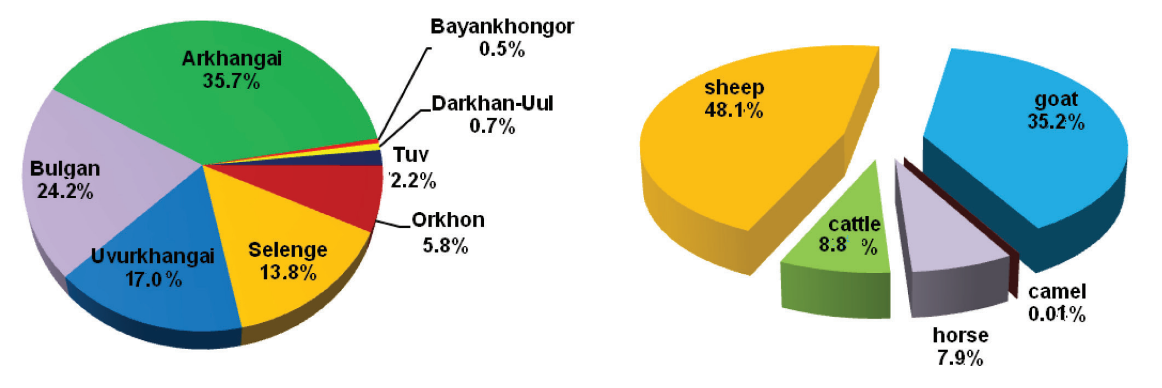

Figure 16. Livestock percentage of aimags and livestock structure in Orkhon RB

As we see from Figure 16, Arkhangai aimag contained 35.7%, the highest percentage of the total livestock of the basin while Darkhan-Uul aimag contained a mere 0.5%, the least percentage. The livestock density by soums presented in shows livestock density in terms of location and the most densely populated soums include Bayan-Undur, Orkhon aimag and Ulziit soum, Uvurkhangai aimag while Tsenkher and Bulgan soums, Arkhangai aimag are included in the least densely populated. The livestock density map is presented in Figure 20 of the Land use report.

Small cattle comprises 83.3% of the total livestock number and large cattle 16.7%. The decreased percentage of small cattle compared to 2008 is due to the dzud of 2009.

The percentage of goat heads in small cattle has been decreased from 45.6% to 42.3%. This is considered as relatively high than the appropriate percentage according to scientists view. Please see the detailed number of livestock by soum in Annex 4.

Table 18. Livestock of the Orkhon river basin, 2010

thousand head

Aimag	Camel	Horse	Cow	Sheep	Goat	Total
Arkhangai	0.5	84.8	98.6	487.8	369.3	1041.0
Bayankhongor	0.0	1.1	5.1	7.7	7.5	21.4
Bulgan	0.2	69.0	52.0	366.8	218.8	706.8
Darkhan-Uul	0.1	0.6	3.1	7.8	4.4	16.0
Orkhon	0.2	10.7	17.8	73.1	67.4	169.2
Uvurkhangai	0.3	33.5	26.5	190.5	150.4	401.2
Selenge	0.4	25.3	50.3	237.0	182.4	495.5
Tuv	0.0	4.6	4.3	31.1	24.8	64.9
Total	**1.8**	**229.6**	**257.6**	**1402.0**	**1025.0**	**2915.9**

In 2008 the livestock number of Orkhon RB was about 7 mln in terms of sheep head. Since 2004 the share of the cattle and horses decreased while the share of the small animals increased. Between 2004-2008 small animals number in terms of sheep head increased 2 times and cattle's increased 1.7 times. As of 2010, the basin had 4.3 million pasture/grazing and 5.5 million livestock in terms of sheephead. There are 129 sheephead per hectare which is 2.6 times more than the country's average and 1.4 times more than the average of Tuul river basin (Table 19, Table 20)

Table 19. Livestock of aimag in the basin in terms of sheephead

Type of livestock	Livestock, thousand sheephead			
	2004	2006	2008	2010
Camel	5.7	7.0	8.0	9.2
Horse	1488.8	1662.6	1965.8	1607.1
Cow	1058.3	1354.6	1835.5	1545.4
Sheep	874.2	1222.1	1790.2	1402.0
Goat	656.2	921.4	1364.9	922.5
Total	**4083.2**	**5167.7**	**6964.4**	**5486.1**

Table 20. Grazing capacity of the Orkhon basin, 2010

Aimag	Pasture area, km^2	In terms of sheephead	
		Total, thous. sheephead	On per 100 ha
Arkhangai	16656.3	2007.6	121
Bayankhongor	822.3	52.7	64
Bulgan	9572.7	1359.6	142
Darkhan-Uul	216.4	35.2	163
Orkhon	431.7	316.3	771
Uvurkhangai	6981.4	720.8	103
Selenge	7128.7	882.2	124
Tuv	827.4	111.8	135
Total	**42636.9**	**5486.1**	**129**

As of 2010, the number of newborn young animals in the basin was 800.1 thousand, which is 10.8% of the country total (Table 21). Of the total animal breeding, lamb are 53.0%, goatling 33.2%, calf 8.5% and remaining is colt and baby camel.

Table 21. Animal breeding of aimags in the basin, in thousand heads as of 2010

Aimag	Baby camel	Colt	Calf	Lamb	Goatling	Total
Arkhangai	0.1	12.7	23.2	133.8	78.5	248.3
Bayankhongor	0.0	0.2	1.2	1.9	1.7	5.0
Bulgan	0.0	16.1	14.6	137.4	85.5	253.6
Darkhan-Uul	0.0	0.1	0.9	4.5	3.4	8.9
Orkhon	0.0	2.3	5.8	30.0	17.1	55.1
Uvurkhangai	0.0	2.3	4.5	32.9	16.5	56.2
Selenge	0.1	7.8	16.4	74.0	57.7	156.0
Tuv	0.0	0.7	1.2	9.4	5.5	16.9
Total of the basin	0.3	42.2	67.7	423.9	265.9	800.1
Total of the country	36.4	274	541	3895.8	2652	7399.2
Percentage of country total	**0.9**	**15.4**	**12.5**	**10.9**	**10.0**	**10.8**

As Erdenet, the densely populated city is in the basin and it is located closely to cities of Darkhan and Ulaanbaatar, the biggest marketplace, it would be more convenient to develop an intensive livestock husbandry.

The administration of land affairs, construction, geodesy and cartography conducts "State inspection and guarantee on land status and quality" in all types of land subject to the integrated fund once in five years and most recently this inspection has been carried out between 2008 and 2010.

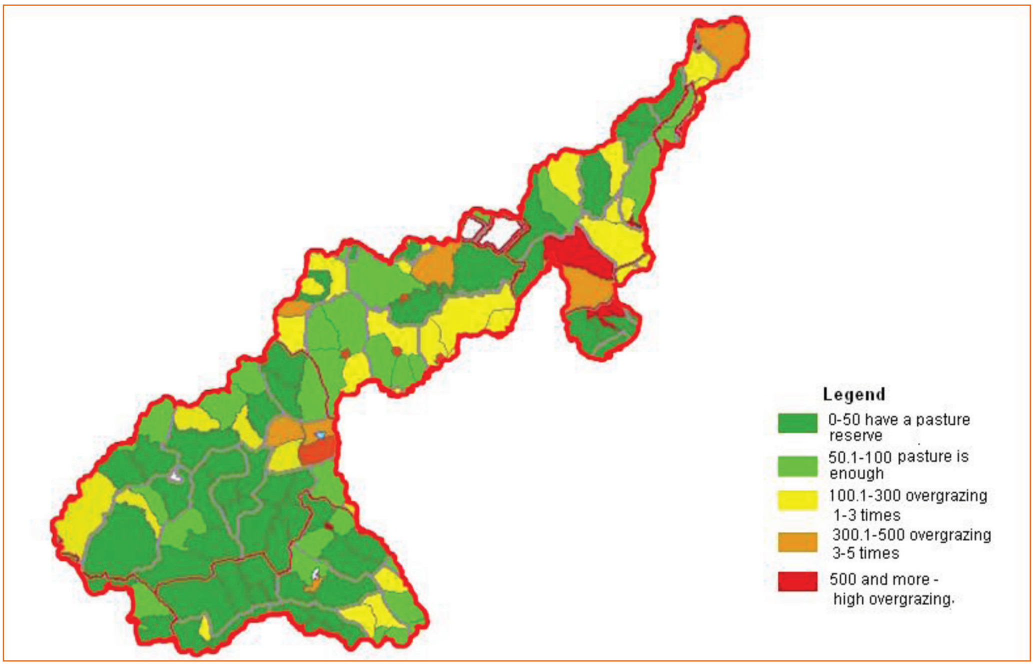

Figure 17. Grazing capacity in the Orkhon river basin, 2011

Also, National Meteorological Institute conducts calculating work of grazing capacity by the end of August every year. Please see Figure 17 for the related grazing capacity of the basin as of 2011.

According to the above figures, it's been considered that the grazing capacity in Orkhontuul soum, Selenge aimag has been exceeded strongly while the grazing capacity was exceeded 3 to 5 times in Ugiinuur soum, Arkhangai aimag and Orkhon soum, Bulgan aimag. The way to overcome these difficulties is to plant some additional animal food, to receive it from other aimags, or to graze livestock for fattening, etc.

Production of livestock husbandry

Meat production: As of 2010, in total 8.4 million livestock were used for food at the national level, whereas 665.1 thousand were used for food at the level of the basin (Table 22). This is 7.9% of the country total with 92.1% small cattle and 7.9% large cattle.

Table 22. Number of livestock used for food by type and head as of 2010

Aimag	Camel	Horse	Cow	Sheep	Goat	Total
Arkhangai	0.0	4.1	6.5	100.2	43.6	154.4
Bayankhongor	0.0	0.1	0.5	1.3	0.8	2.6
Bulgan	0.0	11.7	11.2	122.9	85.1	231.1
Darkhan-Uul	0.0	0.2	1.9	9.5	8.2	19.8
Orkhon	0.0	2.3	6.8	57.0	45.9	112.1
Uvurkhangai	0.0	0.0	0.0	39.2	9.6	48.7
Selenge	0.1	1.3	5.1	33.5	49.5	89.4
Tuv	0.0	0.5	0.4	3.5	2.6	6.9
Total of the basin	**0.2**	**20.1**	**32.4**	**367.1**	**245.4**	**665.1**

Remark: Above figure calculated by aimags is only subject to the Orkhon river basin.

According to calculation in terms of live weight, 468.4 thousand ton of meat was supplied for meat production at national level. And 8.2% of total meat production was supplied by the basin with camel meat 0.1%, horse meat 15.1%, beef 23.1%, mutton 38.4% and goat meat 23.1%. For more detailed information please see Table 23, Annex 5, and Annex 6.

Table 23. Meat production by aimag in terms of live weight in ton, 2010

Aimag	Camel	Horse	Cow	Sheep	Goat	Total
Arkhangai	7.8	1172.0	1768.3	4009.6	1569.4	8527.1
Bayankhongor	0.0	16.0	125.4	52.2	29.5	223.1
Bulgan	5.3	3380.5	3067.3	4917.2	3065.3	14435.6
Darkhan-Uul	8.9	49.1	515.2	378.5	295.4	1247.1
Orkhon	0.9	666.1	1866.5	2281.9	1654.0	6469.4
Uvurkhangai	9.0	0.0	0.0	1566.3	344.2	1919.5
Selenge	18.0	360.5	1395.0	1338.9	1783.5	4895.9
Tuv	0.1	141.4	101.8	138.8	92.9	475.0
Total of the basin	**49.9**	**5785.7**	**8839.5**	**14683.5**	**8834.0**	**38192.7**

Milk production: As of 2010, 338.4 million liter milk was produced at national level and 43.5 mil. liter or 12.9% was produced in the basin (Table 24). More detailed information is presented in Annex 7. In the basin it is very common to produce airag (fermented mare milk) and in total 7.1 million liter of airag was produced in the basin.

Table 24. Milk and dairy production of the Orkhon RB in thousand liters, 2010

Aimag	Horse	Cow	Sheep	Goat	Total
Arkhangai	2142.3	11318.8	642.3	376.9	14480.4
Bayankhongor	30.7	609.0	9.3	8.0	657.0
Bulgan	2721.1	7135.5	659.6	410.3	10926.5
Darkhan-Uul	20.8	431.5	21.4	16.2	489.9
Orkhon	384.5	2820.6	144.1	81.9	3431.1
Uvurkhangai	381.3	2202.1	157.8	79.4	2820.5
Selenge	1316.9	8000.3	355.0	277.2	9949.5
Tuv	119.5	594.3	45.3	26.5	785.7
Total of the basin	**7117.3**	**33112.0**	**2034.9**	**1276.3**	**43540.5**

Wool and cashmere: As of 2010, 23.5 thousand ton of sheep wool and 6.3 thousand ton of cashmere was produced in the country. The basin produced 2.1 thousand ton or 8.8% of total wool production and 6.5% or 407.1 ton of total cashmere production. Please see Table 25. More detailed information is presented in Annex 8.

Table 25. Wool, cashmere produced by the basin, in ton as of 2010

Aimag	Camel wool	Cattle soft wool	Birse of large cattle	Sheep wool	Cashmere
Arkhangai	1.7	15.1	20.6	832.4	168.3
Bayankhongor	0.0	0.3	0.4	9.0	1.9
Bulgan	0.9	7.2	9.9	499.5	78.2
Darkhan-Uul	0.4	0.3	0.4	14.4	2.6
Orkhon	0.6	1.8	2.5	124.7	31.2
Uvurkhangai	1.1	5.8	8.0	393.7	74.6
Selenge	0.8	2.8	3.8	181.1	45.3
Tuv	0.1	0.3	0.5	21.5	5.0
Total of the basin	**5.5**	**33.7**	**46.0**	**2076.3**	**407.1**

Leather: As of 2010, 16.8 million pieces of leather were manufactured at national level and 4.4% or 731.6 thousand were supplied from the basin. Cow and camel leather has the highest percentage at 8.1-8.6% of the country total. This is due to special meat supply from the basin to the cities of Ulaanbaatar, Erdenet and Darkhan. More detailed information is presented in Table 26 and Annex 9.

Table 26. Number of pieces of leather of the Orkhon RB, 2010

Aimag	Camel skin	Horsehide	Cowhide	Sheep skin	Goat skin	Total
Arkhangai	0.0	14.7	24.8	140.2	81.6	261.4
Bayankhongor	0.0	0.1	0.6	1.5	0.9	2.9
Bulgan	0.0	12.9	14.6	135.5	92.6	255.6
Darkhan-Uul	0.0	0.2	1.9	9.5	8.2	19.8
Orkhon	0.0	0.1	0.9	1.7	2.2	5.0
Uvurkhangai	0.0	5.0	10.6	66.1	32.3	114.0
Selenge	0.1	1.5	5.8	27.3	31.2	65.9
Tuv	0.0	0.5	0.4	3.5	2.6	7.0
Total of the basin	0.2	34.9	59.6	385.2	251.6	731.6

Future Development Trend of Livestock Husbandry

Livestock growth forecasting: In forecasting the growth of the livestock numbers, a proportion method has been used by comparing the forecasting by the Ministry of Food, Agriculture and Light Industry and the average livestock growth in the recent 5 years. This forecasting was calculated including changes in livestock numbers and the increase in food demand of the population of Mongolia.

According to the livestock growth forecasting of the Orkhon basin, livestock head is about to reach 3.8 million and sheep head to reach 3.5 million by 2021 (Table 27, and Annex 10).

Table 27. Livestock growth forecasting of the ORB in thousand heads

Aimag	2008	2010	2015	2021
Arkhangai	1508.4	1041.0	1245.4	1271.3
Bayankhongor	18.6	21.4	27.1	29.8
Bulgan	801.2	706.8	848.6	865.1
Darkhan-Uul	631.1	401.2	447.9	468.8
Orkhon	29.8	16.0	20.0	21.7

Aimag	2008	2010	2015	2021
Uvurkhangai	268.9	169.2	192.7	190.9
Selenge	576.7	495.5	584.6	590.7
Tuv	62.6	64.8	75.9	75.4
Total of the basin	**3897.3**	**2915.9**	**3464.5**	**3513.6**

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 of 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.

Table 28 presents the main agriculture farming development guidelines of the aimags that are planned in the Development program of the aimags. According to the table below, in the aimags were planned to develop intensive livestock and crop farming.

Table 28. Main development guidelines of aimags in the ORB

Development direction	City, aimag, soum
Intensive livestock farming	Erdenet, Kharkhorin, Tsetserleg; Khutag-Undur, Bulgan, Bugat, Orkhon, Buregkhangai of Bulgan; Uyanga of Uvurkhangai
Core herd of cattle, raise the male parent of an animal	Khotont of Arkhangai, Uyanga of Uvurkhangai
Cattle farm of Selenge breed	Khutag-Undur of Bulgan, Arkhangai
Intensive, model farms of crop and livestock	Arkhangai, Bulgan
Livestock Research Institute of Mountain area	Ikhtamir of Arkhangai
Farm of fine-woolen sheep	Buregkhangai, Khishig-Undur of Bulgan; Orkhon; Selenge
Fodder farm	Rashaant, Khutag-Undur, Khishig-Undur of Bulgan; Orkhon; Selenge
Slaughter plant, a cellar	Mogod, Dashinchilen and Khishig-Undur of Bulgan

5.2.2. Crop farming

An essential sector of the agriculture is crop farming. As the basin is closely located to the main marketplaces, it is possible to develop crop farming in terms of economy and climate. Most parts of the basin are convenient for crop farming and it belongs to a region with an assessment of 60 points[7] according to the assessment on soil quality.

7 Mongolian National Map-2009, page 122.

Therefore, the following regions have been determined as major agricultural region[8] for Mongolia. Some 8 soums located in the forest steppe zone in the north of Tuv aimag, another 3 soums of Bulgan aimag, the Orkhon aimag, and the territory of Selenge aimag. Of the aimags included in the Orkhon river basin, Selenge aimag was dedicated in 1931 with a specifically given name of “crop farming” and developed as a birthplace of botanic, livestock husbandry and crop farming. As of 1990, Selenge aimag used to provide 23.7% of the total crop in the country. In 2010, it reached to some 47% of total sown area at national level. Of this, the Orkhon river basin contributed 35%. As of 2010, 24.7% of the irrigation areas of the country are located in the Selenge aimag.

Aimags included in the basin have planted seed/grain, potato and vegetables on crop fields with 79.6 thousand hectare as of 2010 and comprised some 25.2% of the total crop field in the country. Some 28.6% of seed/grain, 16.6% of potato, 19.5% of other vegetables were planted in the basin. Please see figures of crops and harvests from Table 29 below in terms of aimag and in terms of soum in Annex 11 and Annex 12. Selenge aimag has 64.1% of the total crop/harvest planted in the basin.

Table 29. Size of crop field and crops in the Orkhon river basin

Aimag	Type of crop	2007		2008		2009		2010		
		Sown area, *ha*	Crop, *ton*	Sown area, *ha*	Crop, *ton*	Sown area, *ha*	Crop, *ton*	Sown area, *ha*	Crop, *ton*	Yield, *c/ha*
Arkhangai	Wheat	548.0	142.5	670.0	880.0	4000.0	2395.0	3515.0	2753.0	7.8
	Potato	401.8	2704.1	568.5	4234.8	551.7	1515.8	316.3	3861.6	122.1
	Vegetable	171.6	495.9	159.4	1037.6	162.9	1076.0	118.9	1218.8	102.5
	Fodder	-	-	-	-	39.0	95.0	1231.9	3208.7	26.0
Bulgan	Wheat	1271.0	1052.0	1781.0	3380.0	1121.0	1642.0	3166.0	3216.0	10.2
	Potato	158.2	1385.0	144.0	1494.0	154.0	1476.7	154.0	1635.5	106.2
	Vegetable	62.6	582.0	80.0	834.0	79.0	742.5	88.0	832.0	94.5
Orkhon	Wheat	2009.2	1349.8	2326.0	5134.9	4529.0	11322.0	4102.0	8491.2	20.7
	Potato	487.5	4465.2	561.0	5670.1	672.8	6519.4	479.1	5418.6	113.1
	Vegetable	323.6	3375.9	448.3	4220.8	436.7	4487.3	367.6	4517.9	122.9
	Technical plant	395.0	29.0	20.0	8.0			60.0	42.0	7.0
Uvurkhangai	Wheat	1145.0	4.4	570.0	150.3	980.0	702.0	1395.0	1088.0	7.8
	Potato	80.5	695.0	87.2	824.8	97.0	887.1	104.3	931.7	89.3
	Vegetable	72.0	435.4	45.8	511.7	60.3	457.0	55.3	406.8	73.6
Selenge	Wheat	14840.0	12284.9	26366.0	36020.5	44715.0	57743.0	49162.0	64526.0	13.1
	Potato	889.4	13498.5	1095.0	19071.0	1166.0	17814.0	1126.0	15771.0	140.1
	Vegetable	531.0	10685.3	596.0	10815.0	646.0	9789.0	724.0	10287.0	142.1
Tuv	Wheat	2183.0	2401.0	2861.0	2993.8	9907.0	20407.6	12885.0	26413.9	20.5
	Potato	110.0	550.0	115.0	575.0	110.3	880.0	113.5	1305.2	115.0
	Vegetable	13.6	54.4	10.0	45.0	14.0	92.1	15.8	208.5	132.0
	Fodder	-	-	-	-	-	-	150.0	265.6	17.7
	Technical plant	-	-	-	-	-	-	276.0	1337.6	48.5
Total of the basin	Wheat	21996.2	4949.7	34574.0	12539	65252.0	36468.6	74225.0	41962.1	14.3
	Potato	2127.4	9799.3	2570.7	12798.7	2751.8	11279	2293.2	13152.6	126.1
	Vegetable	1174.4	4943.6	1339.5	6649.1	1398.9	6854.9	1369.6	7184	127.6
	Fodder	0.0	0	0.0	39	39.0	1381.9	1381.9	43.7	25.1
	Technical plant	395.0	29	20.0	8	0.0	0	336.0	1379.6	41.1
	Total	25693.0	-	38504.2	-	69441.7	-	79605.7	-	-

Irrigation. As of 2010, there were some 20 irrigation systems in the basin with a capacity to irrigate of 4.8 thousand hectare of which 65% is located in Selenge aimag.

[8] Development program of Selenge aimag, page 14.

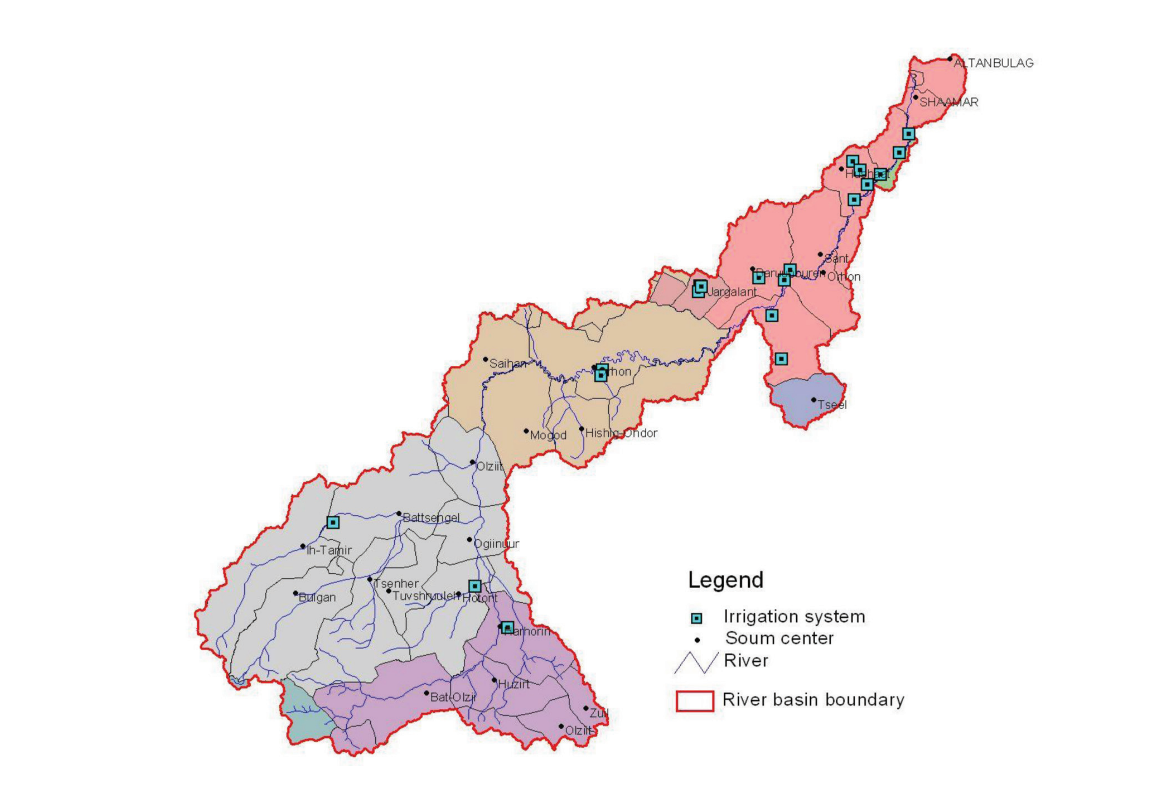

Figure 18. Irrigation systems in the Orkhon river basin

Table 30. Irrigation systems in the Orkhon river basin

N	Aimag	Soum	Irrigation system	Capacity, *ha*
1	Arkhangai	Battsengel	Suuntolgoi	136
2		Khotont	Tsagaan sumiin gol	122
3	Bulgan	Orkhon	Kheltgii nuga	52
4		Orkhon	Shuvuut gol	76
5	Orkhon	Jargalant	Ulaantolgoi	137
6		Jargalant	Khangal gol	70
7		Jargalant	Jargalantiin khundii	136
8	Uvurkhangai	Kharkhorin	Kharkhorin	540
9	Selenge	Zuunburen	Zurkhangai	45
10		Zuunburen	Erkhetiin nuga	100
11		Khushaat	Orkhon khushaat	249
12		Khushaat	Mandaliin bulan	83
13		Khushaat	Rashaant	162
14		Khushaat	Zeenegeriin khotgor	388
15		Khushaat	Khuduu kharaat	40
16		Orkhon	Gurvan sertengiin khundii	100
17		Orkhontuul	Shar usnii khooloi	129
18		Orkhontuul	Salkhit	80
19		Baruunburen	Iveelt	213
20		Baruunburen	Khundiin amnii adag	190
21		Baruunburen	Zuun mod	210
22		Sant	Tsagaan Tolgoi	1265.8
23		Sant	Mukhar buduun	158.7
	Total			**4682.5**

Potato and vegetables are mostly planted on irrigation fields. The harvest of the irrigation fields is 20-40% higher than the average harvest of non-irrigation fields. This indicator is still lower than international standards. This is due to non-compliance with relevant irrigation procedures and lack of sufficient use of other technologies such as fertilizers and pesticides used for plantation.

5.2.3. Demand of food production.

The basin is advantageous as it is co-located across Central and Khangai regions with a high market capacity. Also, it is closely located to Ulaanbaatar which gives the basin the opportunity to supply and deliver agricultural products to fulfill the demand of the population in the capital city.

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.

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 4.5 of order No.257 by the Health minister. Please see Table 31 for details.

Table 31. Food demand of aimags in the basin in ton, 2010

Food products	Food demand, *kg/ per person per year*	Arkhangai	Bulgan	Orkhon	Uvurkhangai	Selenge	Total
Meat and meat products	68.50	6274.6	5829.4	5877.3	8041.9	7302.1	33325.3
Milk	59.25	5427.3	5042.2	5083.7	6955.95	6316.05	28825.1
Dairy product	81.55	7470.0	6939.9	6997.0	9573.97	8693.23	39674.2
Flour	36.50	3343.4	3106.2	3131.7	4285.1	3890.9	17757.3
Pastry	80.30	7355.5	6833.5	6889.7	9427.22	8559.98	39065.9
Rice	28.47	2607.9	2422.8	2442.7	3342.38	3034.9	13850.7
Sugar and sweet	8.40	769.4	714.8	720.7	986.16	895.44	4086.5
Potato	51.10	4680.8	4348.6	4384.4	5999.14	5447.26	24860.2
Vegetables	73.00	6686.8	6212.3	6263.4	8570.2	7781.8	35514.5
Fruit	65.70	6018.1	5591.1	5637.1	7713.18	7003.62	31963.1
Vegetable oil	9.13	836.3	777.0	783.4	1071.86	973.26	4441.8

5.3. Industry

In the basin, the industrial sector contributes 66.9% of the GDP which is higher than the country's average. Orkhon aimag solely produces 70% of the GDP of which 92.6% is contributed by the industrial sector. The status of manufacturing was calculated approximately by aimag centre located in the basin.

Orkhon aimag is definitely rich with copper and molybdenum resources. Based on this, the Erdenet mining and processing plant is being successfully operated so far. The aimag contributes 37.7% of the total export of the country and this amount is mostly supplied by the plant. There are also some of the largest processing plants in Orkhon aimag including Erdmin LLC, Erdenet Carpet shareholding company, Kukhgan LLC, Shimtechnology LLC, Ora metal LLC, Metal Industrial LLC, Orkhon Khiits LLC, Mongema LLC and Erdenet progress LLC, etc. Recently, small and medium enterprises have been extensively developed while production of construction material is being successfully developed. Also some manufacturing sectors have effectively appeared in the region such as cement, iron, iron design and chemical manufacturing, waste processing plant, bio/patent fuel, wooden design of construction, construction, brick, wooden items, garment, knitting, press factory, leather, products made from felt, fine-wool products, beverages, vodka, beer, fruit, vegetable processing plant, meat products, milk and dairy products, bread and bakery, minced dough, food and reserved products, intensive livestock husbandry, seed/grain, potato and vegetables, etc.

The production output of the industry reached to MNT1.2 trillion that increased by 10.7% compared to 2008 (which was MNT1.08 trillion). The mining sector produced 96.9% of the total production, the processing sector 2.1%, and the power and heating sector 0.9%, respectively. Of the processing sector, iron industry contributes 41.1%, wool and cashmere 33.6%, food product 8.7%, ironwork factory except machinery and equipment 5.2%, garment 3.9%, items/construction material made from non-metal substance 6.3%.[9] The production output of the mining sector increased by 45.2% in 2010, which is due to the increased price of copper and molybdenum in the world's commodity market.

In Selenge aimag, the manufacturing sector contributes 48.1% of the GDP. As of the end of 2010, the production output of manufacturing sector was measured at MNT342.2 trillion and its total sold products amounted to MNT376.3 trillion. The mining sector contributes 84.9% of the total manufacturing products, the food sector 6.9% and the construction material sector 6.8%.

For Bulgan aimag, the manufacturing sector contributes 2.5% of the GDP reaching MNT3356.6 million. In 2008, it was MNT2108 million.

Arkhangai aimag: According to current prices, the manufactured products amounted to MNT4255.1 million in 2010 and to MNT2476.3 million at constant prices in 2005. It has increased by 3.2% or MNT75.6 million compared to the previous year.

5.3.1. Light and Food Industries

In 2010, aimags of the ORB produced MNT48.4 billion products of light and food industry at current prices, from which MNT31.7 billion was produced in the food sector, MNT10.1 billion in the garment sector and MNT6.3 billion in the wood processing sector.

Table 32. Production of the light and food industry in million MNT, at current prices

Sector	Orkhon		Arkhangai		Bulgan		Selenge		Uvurkhangai	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Food, beverage, and alcohol drinks	3798.0	2278.2	2257.2	2126.6	1120.9	1267.4	26654.8	23698.2	1564.0	2392.6
Garment	11992.9	8831.4	-	-	118.7	76.6	-	-	-	-
Fur and leather	779.8	1013.8	56.4	61.7	-	-	-	-	97.4	116.8
Wood, wooden products	50.8	52.0	115.5	119.0	88.3	290.7	8797.0	4794.7	913.0	1009.7
Book and printing	118.7	68.3	15.1	17.6	4.0	3.6	-	-	16.7	21.2
Other products	138.0	83.3	-	-	-	-	-	-	29.8	63.0

Orkhon aimag: Orkhon aimag's industries are located in Erdenet city. The processing industry sector of Orkhon aimag produced MNT26.3 billion of products in 2010. The breakdown is: MNT2.3 billion of products were produced by the food sector; the garment sector produced MNT8.8 billion of products and the knitting sector produced MNT1.0 billion of products. 8.7% of aimag's processing industry is food industry; 33.6% is

[9] Statistical report of Orkhon aimag-2010

wool and garment industry; 3.9% is sewing industry. Alcohol and beverage production occupies 4.7% of food production; 18.4% is dairy production; 11.3% is meat production; 27.5% is flour and fodder production and 38.1% is other production (Table 32).

The meat production of Erdenet city is decreased by 90% compared to that of 2008. The alcoholic beverage production is dropped by 59% compared to that of 2008. The production of cosmetics, oxygen and toilet paper is completely stopped. It is possible to renew the dairy and meat production. Erdenet city exports carpets and meat.

As of 2010, there were some 86 entities which operate in the food production sector. They include: 3 meat processing industries; 3 dairy processing industries; 3 grain processing industries; 3 beverage industries and 29 entities in food production. The other industries are: 6 garment industries; 26 sewing industries; 2 wooden material industries; 1 chemical industry and 3 plastic material industries. Other big industries are: Erdenet carpet company, "Erdenet progress" LLC and Shimtechnology LLC.

The following industries are developing in Erdenet city: waste processing; wooden materials of construction; construction; wooden materials; sewing; garments; tannery; fruits; beverage; meat products; dairy products and bakery. As for Jargalant soum, developing industries are: grain, vegetables, bricks, bakery and animal husbandry.

Arkhangai aimag: In the aimag MNT4255.1 million of products at current prices were manufactured in 2010. Some MNT2476.3 million of products at constant prices of 2005 manufactured, which increased by 3.2% or MNT75.6 million from previous year. There were 50% of the total production is food and beverage production; 2.8% is wooden material production; 0.4% is publishing production and 1.5% is clothes production and light industries. It is possible to develop dairy and felt material productions.

Bulgan aimag: Total industrial production of Bulgan aimag reached MNT3356.6 million at the end of 2010. It increased by 104.1% or MNT131.4 million compared to that of 2009. Flour-product production increased by 120.0%; food production by 108.5% and wooden material production increased 3.2 times. Garment and clothes production decreased by 35.5%; publishing production by 11.2% and alcoholic beverage production decreased by 73.2%.

Selenge aimag: In the aimag MNT342.2 billion of products were produced in the industrial sector as of 2010. MNT376.3 billion of sales were made. Total production increased by 8.2% and sales increased by 37.9%. The basic products increased when comparing to the previous year: milk production by 53.8%; ice cream production 5 times; beverage production 2 times; flour production by 6.7%; bakery by 12%; mill offal production by 11.5% and ready-made flour (noodle) by 38%.

Uvurkhangai aimag: Arvaikheer city of Uvurkhangai aimag does not belong to Orkhon river basin. But Kharkhorin does and it is a center of the Khangai region. There are 923 entities in the aimag and 231 of them are located in soums that belong to the basin. As of 2010, MNT5973.5 million of products were manufactured in Uvurkhangai aimag industrial sector. MNT5619.2 million of sales were made as of current prices. Comparing to previous year, production was increased by 28.5% and sales were increased by 29%. The food sector produced 40.1% of total production; 23.1% wooden material production; 5.8% other small and medium industries. As for food production, 13.4% is alcohol, 5.4% is flour, 5.3% is dairy product and 3.2% is beverage, water and ice cream production. Also 1592.8 tons of flour and flour products were produced and it was 15.0% of aimag's food demand. Uvurkhangai aimag has a possibility to increase flour, potatoes and vegetables productions.

Development Perspective

The Ministry of Food, Agriculture and Light Industry announced that the following measures should be taken in local areas: construction of raw material processing industry, flour and fodder industry, cement industry, iron and glass processing industry, nanotechnology, fuel (smokeless) industry, planting seabuckthorn and producing vegetable oil.

The Government of Mongolia approved the “Industry Development Trend in Local Areas” by the resolution number 178 in June, 2009. In the framework of the program, the following small and medium industries will be developed in aimags which belong to the ORB (Table 33).

Table 33. Planned small and medium industries

Industries	Arkhangai	Bulgan	Orkhon	Uvurkhangai	Selenge
Livestock feeding farm		+			+
High breeding livestock farm	+	+			
Milk processing	+				
Milk processing plant (one of soums)	+	+	+	+	+
Milk cooling center and units	+	+	+	+	++
Farm with 50 cow	+	+	+	+	+
Fodder factory				+	
Greenhouses (for every soums)	+	+	+	+	+
Vegetable processing plant			+		+
Fruits and berries processing plant	+		+		+
Starch plant					+
Fish farming	+				
Poultry farm (construct and expand)	+	+	+	+	+
Service center (aimag, soum center)	+	+	+	+	+
Wool washing and felt plant	+	+	+	+	+
Garment factory	+	+	+	+	+
Wood work plant (construct and expand)	+	+			+
Stone work plant			+		
Patent fuel plant			+		
Small, metal work plant(construct and expand)			+		
Small and medium enterprises for export products			+		

Erdenet city has possibilities to develop the following industries: milk powder industry; greenhouse husbandry; fodder industry; animal husbandry of milk and meat and waste processing industry.

Orkhon aimag included following things in its development strategy policy till 2021: Increasing processing industries on the basis of raw material resources; establish cooperation with big industries like “Erdenet”; develop small spare-part producing industries; support export-available production; and sector’s GDP will be reached at 18% of industrial sector GDP by 2021.

As for Arkhangai aimag, the following things are included in the development program: develop light and food industries; planting trees; constructing woodworking industry; constructing garment and knitting industries in soums; constructing brick industry; greenhouses; establishing vegetables-packing workshops; building waste recycling workshops; building modern industry for processing butter and dairy products and building waste recycling plant in Erdenebulgan soum.

Bulgan aimag will increase its processing production growth by 11.9% a year on average and building or strengthening following industries.

Table 34. Development of small and medium industries in Bulgan aimag's soums

Soum	New small and medium industries
Khishig-Undur	Milk and dairy production plant, patent fuel, water bottling plant
Saikhan	Airag processing plant
Mogod	Airag processing plant, patent fuel, carpet plant
Orkhon	Flour plant, wood work, water bottling plant
Bulgan	Flour plant, meat processing plant, Milk and dairy production plant, fruits and berries processing plant, waste processing plant, vvegetable processing and chips plant, sea-buckthorn processing plant

As for Selenge aimag, the following is included in its development program: developing sub program to develop small and medium industries; constructing meat, milk and vegetables processing small industries in soums; increase competing capacity of knitted and woven products.

Uvurkhangai aimag has included following measures in its development program: develop small and medium industries on the basis of agricultural raw material and natural resources. The Table 35 shows planned small and medium industries in Uvurkhangai aimag's soums which are belong to the Orkhon RB.

Table 35. Development of small and medium industries in Uvurkhangai aimag's soums

Soum	New small and medium industries
Kharkhorin	Sausage and can industry, Milk and dairy production plant, pastry plant, fish and vegetable processing plant
Bat-Ulzii	Milk and dairy production plant, pastry plant, fish and vegetable processing plant
Khujirt	Milk and dairy production plant, pastry plant, fish and vegetable processing plant, yak wool processing plant

In the future, it is possible to establish plants in Orkhon aimag including the centralized fresh water and sewage system for Erdenet city, manufacturing based on industrial and technological park Erdenet, production output to replace import products of Erdenet LLC, iron design production, milk-powder plant, green-house farm, nutritional plant, intensive livestock husbandry for milk and meat products and waste processing plant. In Jargalant soum in the future, it is possible to establish a vegetable processing plant, green-house, vegetable, seed/grain, warehousing farm, agrotechnical vegetable park, tare/bag plant and flour plant. Water supply will increase due to development of light and food industry sectors.

5.3.2. Metal Processing Industry

In Mongolia, mining is rapidly developing. There are very few heavy industries except processing industries. The metal processing industry of the basin is located in Erdenet city. Iron industry started functioning in Sukhbaatar city since 2008.

The first part of Erdenet industry started working in 1978 and its capacity was as follows: ore-dressing of 25-25.6 million tons a year on average; 530.0 thousand tons of copper concentrate with 23.5% copper; 3.0 thousand tons of molybdenum concentrate (49-51% Molybdenum). Also other companies operate there. They are: Erdmin company (Mongolian-American joint), Copper cable industry, Khokhgan LLC, Ora metal LLC, "Metal Industrial" LLC, "Orkhon Khiits" LLC and "Mongema" LLC.

The Beren group LLC has constructed an iron industry in Erdenet city. As of 2010, followings have been produced in Erdenet city: 5522.0 thousand tons of copper concentrate and 4.3 thousand tons of molybdenum concentrate (Table 36).

Table 36. Main products of metal processing industry of Erdenet and Sukhbaatar

Commodity	Unit	2006	2007	2008	2009	2010	2010 / 2008, %
Copper concentrate	*Thous. ton*	537.7	543.2	525.3	531.3	522.0	99.4
Molybdenum concentrate	*ton*	3022.0	3978.0	3795.0	4769.1	4348.0	114.6
Metal cast product	*ton*	107.8	49.4	133.3	149.2	83.1	55.7
Metal products	*ton*	661.2	724.8	550.9	490.8	295.3	60.2
Steel construction	*ton*	13934.6	24705.6	3245.4	3482.8	3162.8	90.8
Cathode copper, 99%	*ton*	2618.4	3006.5	2594.7	2470.1	2746.2	111.2
Armature	*ton*	0	0	745	450.0	602.0	133.8

Erdenet industry plays a key role in our country's economy. For example: the industry produces 30% of Mongolia's export alone. As of 2010, Orkhon aimag exported MNT1135.7 billion of products (Table 37). Orkhon aimag imported MNT183.3 million of products.

Table 37. Exported products of Erdenet city by volume, at current prices

Indicator	Unit	2008	2009	2010
Total export	*Mil MNT*	1121.6	811.0	1135.7
	Mil USD,	-	-	844.6
Copper concentrate	*Thous. ton*	582.9	580.3	563.2
Molybdenum concentrate	*Thous. ton*	3.0	5.8	4.5
Cathode copper	*Thous. ton*	2.4	2.3	2.8
Carpet	*Thous. m2*	122.5	54.2	61.5
Meat	*ton*	2482.5	3674.4	2541.7
Bio fuel	*ton*	120.0	-	40.0
Other	*ton*	1.76	18.3	-
Calcium molibdate	*Thous. ton*	1.06	-	-
Molybdenum oxide	*Thous. ton*	0.6	-	-
Molybdenum concentrate not processed in torrefaction method	*Thous. ton*	0.1	-	-

Source: Statistical report of Orkhon aimag-2010

The technical and technological reforms of Erdenet industry need to be made step by step; producing pure copper and separating other elements; increasing capacity to process ore with small amount of copper; increasing cathode copper production; establishing metallurgic complex on the basis of iron-ore mines of Darkhan and Selenge regions where infrastructure is well-developed.

5.3.3. Mining and Quarrying

The mining production sector manufactured 22.7% of GDP, 66.7% of total industrial products and 81% of export products. It constitutes 40% of the local budget income and 34.1 thousand people work here. The mining sector benefits to the Mongolian economy are constantly increasing. This is presented in Table 38.

Table 38. Mining sector percentage in Mongolia's economy, %

Production	2006	2007	2008	2009	2010
GDP	30.0	27.4	20.6	19.8	22.7
Industrial output	69.9	63.4	56.4	62.7	66.7
Export	67.9	66.8	60.3	66.4	81.0

This basin has a lot of gold, iron-ore, copper and molybdenum resources. At the moment, there is 6198.9 square km area with mining exploration and exploitation licenses. This is 11.9% of the total area of the basin. Erdenet industry operates in the basin and it is strategically important. There are some 20 entities operating in areas near Orkhon River and they are mining gold. For example: “Altandornod Mongol” LLC, “Altan yondoi” LLC, “Mongol Gazar” LLC and “Gatsuurt” LLC etc. Also there is a mine in Saikhan soum of Bulgan aimag.

Gold is being extracted in places of Tsenkher soum of Arkhangai aimag, they are: Bavgariin am, Kharguitiin baruun salaa, Olt and Ulaan chuluut as well as Zuun sodot of Bat-Ulzii soum of Uvurkhangai aimag. The mining sector is very vital for our country’s economy, but we should regularly monitor impact on the environment. Orkhon River is being polluted heavily every year during the active gold-mining season. Also the surrounding ecosystem is damaged a lot. It is very vital to implement the “Law on Prohibition of Mineral Prospecting Exploration in Water Basin Areas and Forest Areas” in order to secure the stability of the ecosystem.

The government of Mongolia is focusing on developing mining and copper production on the basis of the Erdenet ore-processing facilities. The aimags in the basin will develop mining and processing industries within the framework of the development program. Most mining industries of the basin use water from the Orkhon River and its branch rivers. As for Erdenet industry, it is supplied from Selenge river basin. The mining water use of the basin was 3284.4 thousand cubic meter a year in 2008. In 2010, it was decreased to 927.1 thousand cubic meters a year.

5.3.4. Energy

Orkhon river basin belongs to the Central energy region. Erdenet’s thermal power station is located in the basin. The capacity is 36 MW of electricity. At the moment, it is producing 28.8 MW of electro energy and 193.5 Gcal/h of thermal energy annually on average. In 2010, the thermal power station produced 103.2 million KWh of electricity and 541.1 thousand Gcal of thermal energy. According to the water use norm calculation, it used some 1 million cubic meter water (Table 39).

Table 39. Erdenet’s thermal power station production and water use

Energy	Unit	2006	2007	2008	2009	2010
Electricity	*Mln.KWh*	108.4	110.0	113.6	113.2	103.2
Thermal energy	*Thous.Gcal*	581.4	648.3	618.6	640.5	541.4

At the moment, basin energy demand is fully supplied. Due to the increasing number of population and production, energy and thermal demand will increase in the future.

Orkhon river basin has many renewable energy and water energy resources. Kharkhorin hydro power station was constructed in 1959 but it is not working at the moment due to breakdown. A 100 MW capacity hydro power station will be built on Orkhon River as described in “National Program on Renewable Energy”, approved in 2005.

5.3.5. Construction and Construction Material

Mongolia’s construction sector was established in 1921 and it has played an important role in the country’s economy. Erdenet and Kharkhorin cities are located in the basin and this is one of the factors why the construction sector is developing rapidly.

There are 45 construction entities in Orkhon aimag and their construction works and maintenance were worth MNT22.5 billion. 33.9% or MNT7.6 billion was from the maintenance works. The investment was increased by 50.4% compared to the previous year and maintenance work was increased by 52.4%. Some 50% of Erdenet’s population lives in apartments and this figure will be increased in the future. There are 7 companies in Erdenet city which operate in the field of construction material. As of 2010, 2.5 million bricks and 3.9 thousand cubic meter concrete mixture were produced.

Table 40. Orkhon aimag's construction material production, by volume

Production	unit	2008	2009	2010	2010/2009, %
Door and window	m^2	729.5	338.1	480.7	142.2
Vacuum door and window	m^2	4461.5	2347.9	1337.7	57.0
Concrete mixture	m^3	4712.0	2198.0	3879.0	176.5
Plaster mixture	m^3	480.0	269.0	217.0	80.7
Red brick	Thous.pc	5641.9	0.0	2485.0	-
Concrete	m^3	2557.7	770.5	1179.0	153.0
Metal concrete construction	Thous. m^3	7.3	2.5	4.8	192.0
Cast construction	t	133.3	149.2	83.1	55.7

As of 2010, MNT4691.4 million of construction and maintenance works were done in Arkhangai aimag; MNT12901.3 million in Uvurkhangai aimag and 4127.7 million tugrugs in Kharkhorin city.

5.4. Services

5.4.1. Public urban services

The following organizations are operating in the field of water supply and sewerage in the basin cities. They are: "Erdenet UDTS" LLC (Erdenet city); "Undarga" LLC (Tsetserleg); "Bulgan Meej" LLC (Bulgan city); "Ursgal-Us" LLC (Sukhbaatar).

As for Erdenet city, "Erdenet UBU", "Erdenet UDTS" LLC and "Erdenet-Amidral" LLC companies are supplying the city population and organizations with drinking water and sewerage services. Some 39.5 thousand people are living in 212 apartment buildings with 1010.4 thousand square meter area. As of 2010, "Erdenet UDTS" LLC made a profit and "Erdenet-Amidral" LLC was at a loss of 758.9 million tugrugs. "Erdenet UDTS" LLC and 22 Apartment owners' associations are in the service of apartments and public utilities service. There are 47 kiosks and 8 water trucks operating in ger districts of Orkhon aimag.

Erdenet city supplies its water use from a distance of 64 km and the water price is high due to this. Some organizations are not interested in the centralized water supply due to the high water price. For example: the following companies drilled boreholes. They are: "Ochir tuv" LLC, "Selenge-Erdenet" LLC, "Otgontenger-Orgil" LLC, "Uils construction" LLC and "Orkhon khiits" LLC.

Attention needs to be paid to reduce the water supply system loss and water cost. The project "Urban development sector MON-2301" is being implemented with an Asian Development Bank loan. The following measures are planned to be taken: Construction of 4 boreholes, pumping stations, 2x1000 m3 and 1x100m3 reservoirs, 34 km drinking water pipelines and 26 kiosks. Some 24 kiosks will be maintained and connected to the centralized system.

The "Improving public utilities of local cities-II project" was implemented in Arkhangai aimag in 2008. This project was financed with an Asian Development Bank grant. The following things were done within the framework of the project: 3 borehole pumps were renovated; 1 borehole was drilled; 2.5 km pipelines with 250 mm diameter and 11.8 km pipelines in ger districts. Some 2.9 thousand people are living in 45 apartment buildings. Some 19 apartment buildings are connected to the centralized water supply, heating and sewerage services. The ger district households are supplied from 22 kiosks and 4 water trucks.

The "Improving public utilities of local cities-II project" was implemented in Bulgan city in 2007. This project was financed with an Asian Development Bank grant. The following things were done within the framework of the project: 2 boreholes were drilled; 10.4 km drinking water pipelines; 2x150m3 reservoirs and one of water disinfection equipment were installed.

Some 2 thousand people are living in 692 apartment buildings as of 2010 and public utility services and "Khantulga" AOA are operating. 18 apartment buildings are connected to the centralized water supply, heating and sewerage services. The ger district households are supplied from 15 kiosks and 2 water trucks.

In Sukhbaatar, "Ursgal-Us" LLC and 9 apartment owners' associations are responsible for public utility services in 55 apartment buildings with 55.2 thousand square meter area. Some 5 thousand people are living in those apartment buildings. The following measure will be implemented between 2013 and 2014 by state investment. The measure is called "Equipment renovation of water source constructions". The ger district population is supplied from 23 kiosks and 9 water trucks.

Kharkhorin city does not have a centralized water supply and sewerage facility. Some tourist camps are supplied from small size water supply and sewerage facility. 96 households live in 14 apartment buildings.

The water supply sector development plays a key role for the achievement of Mongolia's Millennium development objectives. Therefore, following things 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.

Public bathhouses. As of 2010, there were 56 bathhouses with a capacity of 230 people in one session in aimags and soums of the basin. If they use their current capacity, they will serve 1284.5 thousand people per year.

Table 41. Bathhouse survey of aimags in the basin

Aimag	year	Bathhouses		In the basin	
		number, pc	capacity, *person/per time*	number, pc	capacity, *person/per time*
Arkhangai	2009	16	64	9	36
	2010	19	64	9	36
Bulgan	2009	11	107	5	45
	2010	11	84	6	54
Orkhon	2009	6	40	6	40
	2010	13	38	13	38
Uvurkhangai	2009	27	115	9	36
	2010	33	135	10	40
Selenge	2009	49	131	19	57
	2010	42	119	17	51
Tuv	2009	43	198	1	4
	2010	41	184	1	4

According to the Ulaanbaatar health agency survey, 20% of the participants in the questionnairs take a shower every week; 12% take a shower every 2 weeks and 81% of the total households participating in the survey take a shower in more than 7 days. On the basis of the survey, a ger district resident takes a shower in 2 weeks on average. The bathhouse capacity of aimags and soums of the basin supplies only 40% of the demand.

According to the some surveys, per person uses 27-99 liter water at one time when taking a shower. This is 60-180 liter water according to other surveys. The current water use norm needs to be renewed due to the introduction of new technologies which decrease water loss.

5.4.2. Other Services

Some 200 entities are operating in the field of utilities and 1.2 thousand people are employed.

According to a 2007 survey, the number of people working in the field of utilities is estimated at 60 thousand. 98% of the sector's activities belong to the unofficial sector.

Laundry and dry cleaning: As for our country, there are not many laundry places. People do the laundry at home. In the warm season, people wash their clothes and cars in the river water. There is a laundry service called "Metro Express" in Ulaanbaatar where people can do their laundry. It has not become that popular due to location and tariff.

Dry cleaning is more popular. There were 2 dry cleaning services in Orkhon aimag which have been registered officially. The laundry services and dry cleaning places are connected to the centralized water supply and sewerage networks. The water use calculation is done together with organization and service water use.

Beauty and hairdressing services: Beauty services occupy most of the service sector. There are some 361 public utility services in Orkhon aimag and 42 of them are in the hair-dressing services. The hair-dressing service water use calculation in aimag and soum center of the basin is done together with organization and service water use. As described in the development program of the basin aimags, utility centers will be constructed in aimag centers and some soum centers.

Car wash: Car wash uses much water and pollutes water heavily. The number of cars is increasing along with the increasing living standard. There were 254.5 thousand cars in Mongolia in 2010. Some 6.9 thousand cars are in Orkhon aimag. There are 39 car maintenance and service centers in Orkhon aimag. At the moment, there is not any registered car washing center. But car maintenance centers do car washing as well. The registered car washing centers are generally connected to the centralized systems and have water meters.

It is difficult to define the water volume for car washing. There is no water use norm. It was defined as follows based on surveys. 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 a small size car. Some 80-100 liter water is used for a big car. According to a survey conducted in Texas, United States in 2002, 28-38 liter water is used for a small size car; 57-76 liter for medium size cars and 95-114 liter water for big cars. In the warm season, cars are washed 2-4 times a month on average and in winter 1-2 times. Some 7.5 thousand cubic meter water was used in the basin in 2010 if the calculation is as follows: 40 liter water is used for 1 car on average and it is washed 2 times a month. Although the water use is low, water pollution level is high.

Shop, hotel and restaurant services: Some 370 thousand people are employed. It is one of the important economic sectors. As of 2010, there were 746 shops and 163 hotels and restaurants in Orkhon aimag. Total sales were MNT 27.4 billion. As for other aimags of the basin, there were 350 shops, 50 hotels and restaurants. The hotels and restaurants in aimag centers are connected to the centralized networks. The hotels and restaurants in soum centers are supplied from boreholes.

Green areas. There is no separate water source to water parks and lawn areas. There is 68.7 hectares green areas according to data received from the aimag centers' Environmental and tourism agencies and soum governments. Some organizations water surrounding lawn and green areas from their own water source.

Table 42. Area of irrigated aimag center parks and green areas

№	Aimag	City	Green area, ha
1	Arkhangai	Tsetserleg	4.3
2	Bulgan	Bulgan	6.7
3	Orkhon	Erdenet	56.8
4	Selenge	Sukhbaatar	0.9
-	TOTAL	-	68.7

5.5. Tourism

The Orkhon river basin is a specific region which is rich with historic and cultural heritage and in which its tourist industry is being intensively developed. Besides monuments of ancient Turkic tribes, there is Kharkhorum, the ancient capital city of Great Mongol in the basin.

The Orkhon river basin includes Khangai mountain, Orkhon valley, Bulgan mountain and Ugiinuur lake which are national parks registered in the Ramsar convention, as well as Kharkhorum and Erdenezuu, historically important places. And it creates a convenient condition to develop tourism industry.

Figure 19. Erdenezuu temple, Ulaan tsutgalan, Kharkhorum museum and Ugii Lake

Kharkhorum was the capital city of Great Mongol in times of Uguudei and Guyeg kings, the next generation of Chingis Khaan and it was firstly included as protected area in 1961. Erdenezuu, the first Buddhist temple was established in 1486 in Kharkhorum city according to the order by then-Avtaisan king. Also the Kharkhorum museum was established in 2010 in order to store, protect, research and advertise valuable findings from historic memorial places in Orkhon valley which are registered as World Heritage.

Tourism: There are some registered 40 tourist camps which run tourism activities of which 34.1% in Arkhangai aimag, 31.7% in Selenge aimag and 26.8% in Uvurkhangai aimag.

According to a study carried out by the Ministry of Nature, Environment and Tourism in 2009, some 10% of overall tourists visit Arkhangai aimag in which the highest number of tourist camps is located. The main visiting period is from June 15 until Sep 15 with a length of 90 days. The majority of the tourists come from China, Russia, South Korea, Japan, USA, German Democratic Republic, France, Kazakhstan and Australia, etc.

Selenge aimag is famous for its Hunnu-era statues and tombs, Buur heeriin tal and Amarbayasgalant monastery. In Bulgan aimag there are some 10 tourist camps, 2 hunting camps and 10 resorts. There are mostly 2-star hotels in the basin. It is important to introduce small size water supply and sewerage facilities to these small hotels in order to develop the tourism sector in the basin.

Spa resort: There are many springs in the basin and some 10 spa resorts are operating. In our country, there are many springs which are good for human health. There are 100 spa resorts in Mongolia. As of 2010, only 27 of them were authorized. They include in the basin: “Elima Hujirt” in Uvurkhangai; “Erdenet” spa resort in Orkhon aimag; “Bujinkhen” children’s spa resort in Selenge; Suvd and Khasu Mandal spa resorts in Arkhangai aimag.

As for the basin, it is possible to establish spa resorts on the basis of the following spas and springs. They include: in Arkhangai aimag: Bor tal, Gyalgar and Tsenkher of Tsenkher soum, Tsagaan sum of Khotont soum, Shivert of Erdenebulgan soum; in Bulgan aimag: Saikhan hulij of Mogod soum; in Uvurkhangai aimag: Gyatruun, Mogoit and Hujirt Uurt of Bat-Ulzii soum.

Tourism development perspective: The Ministry of Environment and Tourism developed the program “Tourism” in 2011 in order to develop tourism and make it a leading economic sector. According to the program, tourism will develop in 6 different tourism regions depending on traditional methods and features. One of them is “Kharkhorin region to develop history; culture; spa cure and archeological research trips”.

A specific program for tourism development in the aimags of the Orkhon river basin has been proposed and is being implemented. Arkhangai aimag included in its development program: develop tourism and agricultural sectors as leading economic sectors of the aimag. In order to achieve it, the following measures will be taken: develop tourism infrastructure; construct tourism complex in Tsetserleg soum; construct international-standard hotels, tourist camps and motels to receive hunters and implement sub-program of winter tourism.

Bulgan aimag will develop tourism as leading economic sector of the aimag and following measures will be taken: implement sub-program to develop tourism; build tourism complex in Bulgan city; establish chain of hotels, tourist camps and motels; establish chain hotels to receive tourists in Khutag-Undur soum.

Uvurkhangai aimag is paying much attention to the development of tourism and spa resorts. The aimag developed a master plan to develop the aimag tourism sector and the following measures will be taken: develop micro regions of Kharkhorin, Khujirt, Bat-

Ulzii and Yusunzuil; renovate Erdenezuu monastery and build centers to serve tourists; connect the "Murguliin zam" route to regional and international routes; construct new tourist camps; improve tourist camp services and material base; develop spa resort on the basis of Khujirt spa and springs; build spa-bottling factories; rehabilitate hot spa areas which attract Japanese and Korean tourists.

Selenge aimag developed an "Aimag's candor program" in order to develop tourism in the aimag. It is being implemented in 2 stages. The 1st stage is to improve the capacity to transport and receive tourists; to register historical areas and beautiful landscapes in state and local area tourism networks; to establish tourism centers in regional centers and to develop different kinds of tourism types. .

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.[10]

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.[11] 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.[12] Furthermore, the tightening of China's monetary policy has also lead to a slowdown of the growth of Mongolian the economy.[13]

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

[10] WorldBank, Millennium Development Goals based comprehensive national development strategy of Mongolia, 2007
[11] WorldBank, Millennium Development Goals based comprehensive national development strategy of Mongolia, 2007
[12] ADB, Mongolia Development Outlook, 2011
[13] WorldBank, Mongolia Quarterly Update, 2011

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.[14]
- 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 43 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 considerably decrease and the national consumer index is expected to range at about 8-9%.

Table 43. 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*

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 44 presents the main indicators of the macro economy of Tuv and Khangai regions of ORB.

[14] WorldBank, Millennium Development Goals based comprehensive national development strategy of Mongolia, 2007

Table 44. Main macroeconomic targets of the ORB, in 2015

Target	Economic region	
	Tuv	Khangai
Social development		
Average annual growth rate of population, %	0.8	1.8
Enrolment ratio in pre-school, %	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	66	69
Unemployment ratio, %	1.0	2
Share of the poorest households, %	-	under 10
Reduce poverty (from 1998)	2 times	
Macro economy		
GDP growth, %	19.5	6.9
GDP growth of industrial sector, %	22.5	6.8
GDP growth of manufacturing, %	7.3	6.7
GDP growth of mining and quarrying, %	25.2	7.9
GDP growth of energy sector, %	10.6	-
GDP growth of agriculture, %	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, %	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

The drinking water supply of Orkhon aimag: In 1971, a Russian expedition made a groundwater survey in river basins in Khangal, Chingel and Erdenet in order to solve the water supply of Erdenet city and Erdenet mining company, but the expedition was not able to find sufficient water to fully supply the water use. So, it implemented a technical solution to supply water from 14 wells at 65 kilometers from a groundwater source using pump booster stations. Bayan-Undur soum is the capital city of Orkhon aimag and it has a large population. Schools, kindergartens and public utilities facilities have been built there due to increasing ger-districts. Thus ger-district water supply was increased.

Each day, 120-140 cubic meter water is transported to 24 water kiosks from boreholes to the 6th mini district by water trucks. In the last few years, people have drilled wells for themselves in their ger areas to supply their drinking water demand. They also sell water to other people.

''Energo'' plant of ''Erdenet'' Co., Ltd supplies Bayan-Undur with drinking water by using suction pump and 4 pressure pumps from 14 boreholes in the Selenge river areas of Khangal soum of Bulgan aimag. The water distribution passes through three central pipelines. ''Energo'' plant supplied the following companies with 22278.0 thousand cubic meter drinking water in 2008. They include: ''Erdenet industry'' Co., Ltd, ''Erdenet Us'' holding company, ''Erdenet Amidral'' Co., Ltd. In 2008, ''Energo'' plant supplied industries, entities and organizations with 13499.3 thousand cubic meter drinking water according to contract. ''Erdenet Us'' holding company was supplied with 4250.1 thousand cubic meter drinking water and ''Erdenet Amidral'' Co., Ltd with 3452.4 thousand cubic meter drinking water. The Orkhon aimag water demand was supplied by ''Energo'' plant.

Table 45. Water supply for companies and organizations of Orkhon aimag in thousand m^3

№	Division of consumption	"Erdenet amidral" Co.,Ltd		"Erdenet Us" holding company	
		2007	2008	2007	2008
1	For apartment	793.7	634.4	1026.9	599.9
2	For government organization	63.8	55.7	327.8	305.9
3	For companies and organizations	526.3	383.6	471.7	575.3
4	Water loss	1387.6	1585.0	3237.1	2769.0
5	For ger area of Bayan-Undur soum	-	-	56.7	64.9
6	For ger area of Jargalant soum	-	-	4.95	5.01
Total water supply		2771.4	2658.7	5125.1	4320.0

There are 25 soum centers of 4 aimags located in the Orkhon river basin. Most of the soum centers are located along the Orkhon River, so they use surface and groundwater for water supply. Some soums do not have surface water, so they only use groundwater. There are some 2-3 boreholes in each soum center. Some information on water supply has been included and more information is available from the report on water supply, water use and hydro construction.

The following companies are responsible for distributing drinking water and draining waste water through aimags' central system in aimag capitals located in the basin. They are: ''Undarga'' Co., Ltd in Arkhangai, ''Ursgal Us'' holding company in Selenge, ''Bulgan-Meej'' Co., Ltd in Bulgan, ''Erdenet Us'' holding company and ''Erdenet Amidral'' Co., Ltd in Orkhon aimag. Some organizations began to avoid the expensive water supply.

Revenues from water resource use fees are collected into the local budget. ''Erdenet Us'' holding company is responsible for Bayan-Undur soum water supply. It provides 11 bags and total 13200 households by distributing 42 kiosks from 3 well water resources. In 2008, 4000 cubic meter drinking water for apartments and 1010 cubic meter drinking water for ger districts were distributed from 4 central wells.

Table 46. Drinking water tariff in the ORB

City	Water supply company	Unit	Type of service and tariff, by MNT		
			For apartment	Company and organizations	Government organization
Arkhangai	"Undarga" Co.,Ltd	*m^3* *per person*	1200 1200	1574 -	1574 -
Bulgan	"Bulgan-Meej" Co.,Ltd	*m^3* *per person*	- 800	2175 -	2175 -
Orkhon	"Erdenet-Us" holding company	*m^3* *per person*	397 2739.3	700 -	700
	"Erdenet-Amidral" Co.,Ltd	*m^3* *per person*	436.7 3013.23	770 -	770 -
Selenge	"Ursgal-Us" Co.,Ltd	*per person*	1010	1400	1400

Table 47. Wastewater tariff

City	Water supply company	Unit	Type of service and tariff, by MNT		
			For apartment	Company and organizations	Government organization
Arkhangai	"Undarga" Co.,Ltd	*m^3* *per person*	900 900	1200 -	1200 -
Bulgan	"Bulgan-Meej" Co.,Ltd	*m^3* *per person*	- 300	2080 -	2080 -
Orkhon	"Erdenet-Us" holding company	*m^3* *per person*	240 1656	290 -	290 -
	"Erdenet-Amidral" Co.,Ltd	*m^3* *per person*	264 1821.6	319 -	319 -
Selenge	"Ursgal-Us" Co.,Ltd	*per person*	1110	1690	1690

The water service fee is estimated based on the ''Law on Water'' and the 'Law on Urban Water Supply, Sanitation Sewerage Use'', annex 1 of the 17th order of Infrastructure Minister, 2003 and mandates of aimag, soum and city governors. When they determine the fee, they use the ''drinking water fee and draining waste water service fee calculation'' method. In other words, municipal administration is in charge of water fee policy. The water service fees increased in the last few years due to labor expenses, maintenance expenses, increased electricity fees, gasoline fees and heating fees. The water service fee can be increased again due to the above-mentioned issues. As for Orkhon aimag, Erdenet Company is responsible for water source, artesian wells, transmitting lines and pump booster stations. The waste water treatment plant of Orkhon aimag is located near the mining industry.

The waste water treatment plant was built with mechanical and biological cleaning of sewage in 1978. And the wastewater treatment plant was improved in 1991. The WWTP functions in relation to the Erdenet Company. The WWTP has a capacity of 24000 cubic meter water a day.

Income of the water supply organizations of Erdenet presented in Table 48. In 2010, total income was MNT6.8 billion that increased by 15.4% compared to 2009.

Table 48. Income of water supply organizations of Orkhon aimag, in million MNT

Name of company	2008	2009	2010			
			Total	From		
				From apartments	From organizations	Others
"Erdenet-us" holding company	1252.3	2986.2	3553.4	1460.6	1877.2	215.6
"Erdenet-amidral" Co.,Ltd	2505	2918.3	3262.9	1730.3	1403.3	129.3
Total	3757.3	5904.5	6816.3	3190.9	3280.5	344.9

The households of ger districts have latrines and sewage pits inside the fence. It causes soil pollution. The reason is that these latrines and sewage pits are not well built. The latrines should be built far from gers. But, in winter time this is not suitable for ger district residents.

The total population of 8 bags is 35.8 thousand persons. These households are supplied from water kiosks. The households are served within the kiosk timetable. The kiosks distribute water 8 hours a day from 10am-14pm and 14pm-20pm. On Monday, the kiosks are closed.

The households carry water from kiosks everyday or once in 2 days depending on the household number, the payment capacity and the size of water container. The households should not keep water for many days. In the current circumstances, the ger areas do not have a waste water sanitation network, and the hygienic condition of ger areas is very bad. The kindergartens, baths and family hospitals in the ger areas have their own water supply and sewage-collecting tanks. The waste water is collected into sewage tanks and it is transported by sewage vacuum truck. The usage fee is increased due to transportation.

Therefore, it is necessary to rationally solve issues to determine the appropriate price for water supply in compliance with the human basic right to have a water supply and hygiene. As a result of effective water use, it is possible to increase water supply for citizens with low income.

The number of bathhouses in ger areas is limited. The customers consider that the bathhouse fee is high. They pay 1000-1500 tugrugs for half an hour. Few people pay service fees and are served. The public utility services operate bathhouses in aimags within the framework of increasing sanitation. Most of the public utility services are privatized. These public utility services use a service tariff based on their expenditures.

In rural areas as projected in the Millennium Development Goals, the percentage of people without safe water supply will be reduced to 40% and the percentage of people without improved sanitation facilities will be reduced to 60% by the year 2015.

The water supply resource is distributed unequally with respect to rural area location and regional surface and groundwater resources. Kiosks, rivers and ponds are used as rural people water supply. As for aimag capitals, public utility services are responsible for the drinking water and waste water services. The Local Representatives Khural establishes water service tariff based on representative steering committee resolution of public utility services.

The water tariff is unequally distributed to apartment and ger area residents. The Government of Mongolia need to implement the following measures: to eliminate unequal water tariff distributed to entities and residents; to improve cost recovery level; to have regular water tariff renovation and to reduce ger area tariff gradually-approximating it to the apartment tariff.

People have routine understanding that water supply is unlimited, eternal, and free and a natural gift. It is necessary to change this understanding nowadays with payment of water use. The water fees and tariffs are efficiency economic and management tool for wise use of water. The soum centers have one to three wells. Some households and organizations have their own wells. The water supply tariff for residents as of 2008 is presented in Table 49.

Table 49. Drinking water tariff for rural population

№	Province	Name of soum	Drinking water source	Water price, MNT/l
1	Arkhangai	Erdenebulgan	wells and rivers	2
		Battsengel	wells and rivers	1
		Bulgan	wells and rivers	1000 MNT/month/family
		Ikhtamir	wells and rivers	1
		Ugiinuur	wells and rivers	1
		Ulziit	wells and rivers	1
		Tuvshruulekh	wells and rivers	1
		Khotont	wells and rivers	1
		Tsenkher	wells and rivers	0.5
2	Bulgan	Bulgan	wells and rivers	2
		Mogod	wells and rivers	1
		Orkhon	wells and rivers	1
		Saikhan	wells and rivers	1
		Khishig-Undur	wells and rivers	1
3	Orkhon	Bayan-Undur	wells and rivers	1.50-2
		Jargalant	wells and rivers	1-2
4	Selenge	Sukhbaatar	wells and rivers	2
		Altanbulag	wells and rivers	2
		Baruunburen	wells and rivers	1
		Shaamar	wells and rivers	1
		Orkhon	wells and rivers	1
		Khushaat	wells and rivers	1
		Sant	wells and rivers	1
5	Tuv	Tseel	wells and rivers	1-3
6	Uvurkhangai	Bat-Ulzii	wells and rivers	1
		Yusunzuil	wells and rivers	2
		Ulziit	wells and rivers	1000 tug/month/family
		Kharkhorin	wells and rivers	1-2
		Khujirt	wells and rivers	1.50

The drinking water tariff is estimated on the basis of the Local Representatives Khural's resolution. The water service tariff varies with regard to the utilization fee. In summertime, drinking water is taken from surface water which has no charge.

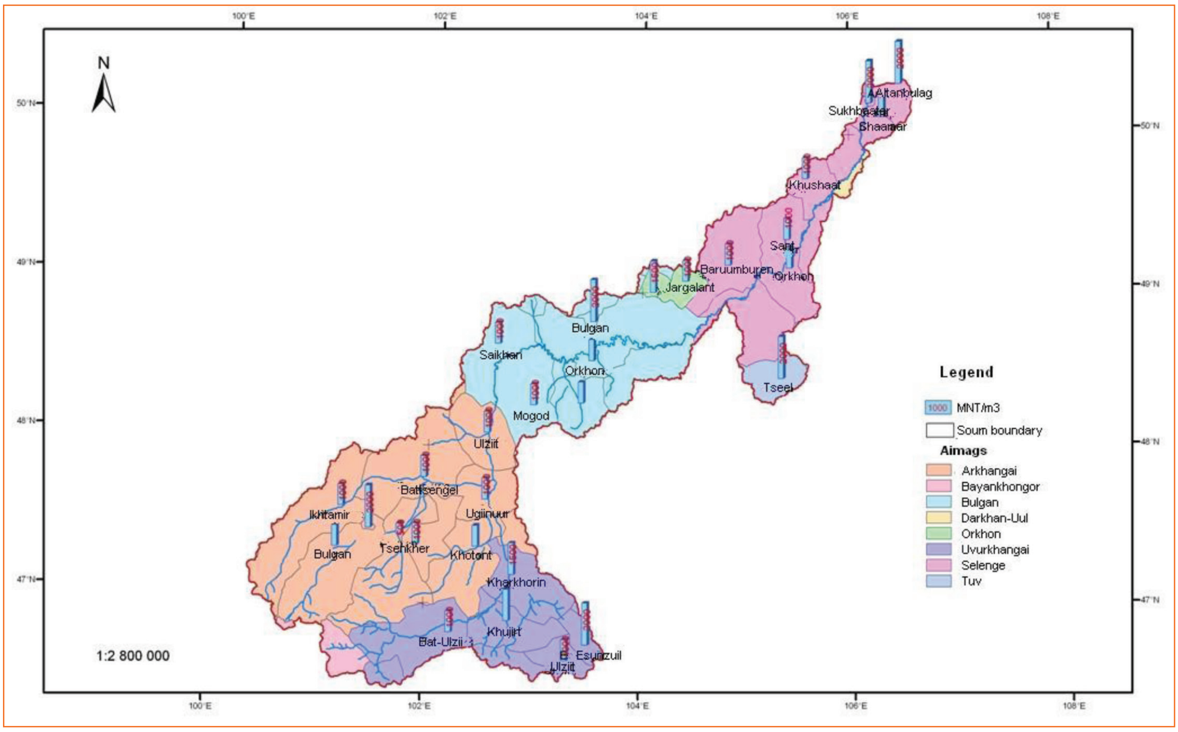

Figure 20. Water tariff of aimags and soums in the Orkhon river basin

Water supply of livestock: The water source of livestock includes wells, rivers and ponds. There are not enough pasture wells in soums with little surface water resources.

The issues for livestock water supply tariffs include insufficient pasture wells and pasture well-rent for herders. In some soums of the basin, the livestock drinking water tariff is estimated on the basis of the livestock water demand temporary norm of the Environmental Minister's 153rd order ''Approval of temporary norm'', 18th November, 1995. The livestock water tariff is estimated on the basis of a Local Representatives Khural's resolution.

Table 50. Water tariff on livestock water supply in soum center

No	Province	Soum	Water supply source of livestock	Tariff, MNT/month	
				Large cattle	Small cattle
1	Bulgan	Mogod	wells and rivers	Herders' discussion	
2	Orkhon	Bayan-Undur	wells	100	50
3	Tuv	Tseel	wells	400	80
4	Uvurkhangai	Yusunzuil	wells and rivers	2	2

In the rural area in most cases, the water tariff is determined by the herders themselves after discussion. Thus it is impossible to estimate revenue individually. The water tariff is low in soums with many surface water resources.

6.2. Revenues of Water Use Fees

The natural resource use fee is regulated by 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 and article 12.2.2, part 12 of the Government Specific Fund Law.

An equivalent of at least 70% of the timber and firewood harvesting fee revenues, of at least 20% of the land fee revenues and of at least 35% of the water and springs use fee revenues as described in article 4.1 of the Government Specific Fund Law must be spent from the state budget for the purposes of land, water and forest protection and restoration as described in the general policies on economic and social development. Some 20% of the water and springs use fee is collected into the soum budget and 80% into the aimag budget.

Table 51. Natural resource use fee revenue in the ORB in thousand MNT, 2008

Name of aimag and soum	Game resource use fee	Water and springs use fee revenues	Timber and firewood harvesting fee revenues	Common natural resource use fee revenues	Land use fee revenues
Arkhangai aimag					
Erdenebulgan	-	2.7	-	2.27	-
Battsengel	-	0.08	6.35	0.22	-
Bulgan	-	0.08	15.89	0.91	-
Ikhtamir	-	0.14	19.34	0.27	-
Ugiinuur	0.26	0.50	-	0.87	-
Ulziit	-	0.12	3.54	0.27	-
Tuvshruulekh	-	0.53	6.32	0.32	-
Khotont	-	0.81	6.09	4.00	-
Tsenkher	-	6.87	14.85	0.20	-
Bulgan aimag					
Bulgan	-	1309.35	-	-	14.89
Mogod	-	0.11	2.91	-	0.80
Orkhon	0.02	-	29.23	0.22	24.47
Saikhan	-	1.00	1.55	-	1.39
Khishig-Undur	-	-	8.97	-	5.65
Uvurkhangai aimag					
Bat-Ulzii	-	30.47	17.16	-	-
Yusunzuil	8.25	-	-	-	-
Ulziit	16.49	-	-	-	-
Kharkhorin	-	1.14	3.87	-	-
Khujirt	-	8.45	5.69	-	-
Selenge aimag					
Altanbulag	0.10	-	11.08	0.39	-
Baruunburen	-	-	5.99	-	-
Sukhbaatar	-	1.11	-	-	-
Orkhon	-	-	0.60	0.50	-
Shaamar	-	-	2.00	2.47	-
Khushaat	0.29	-	1.79	1.31	-
Sant	0.05	-	4.93	0.11	-
Tuv aimag					
Tseel	-	-	0.81	-	10.55
Orkhon aimag					
Bayan-Undur	-	1.88	-	-	6.76
Total	25.46	1365.34	168.96	14.33	64.51

The minimum percentage of fee revenues to be spent on an annual basis on environmental protection and natural resource restoration measures as designated in article 3.2 of this Law are as follows:

Table 52. Extent of fee revenues

Type of natural resource use fee revenue	Minimum mean percentage of fees to be dedicated to environmental protection and natural resource restoration /by percentage/
1. Natural resource use fee revenues	30
2. Game resource use fee	50
3. Land fee revenues	30
4. Timber and firewood harvesting fee revenues	85
5. Water and springs use fee revenues	35

The revenue of gold and coal use fee is collected into the state budget. The water use fee amount of Orkhon and Tuul rivers is based on the following laws and resolution: "Law on Water'', law on ''Water and springs resource use fee'' and Mongolian Government resolution №7 of 2005 ''Estimate of water use fee amount''. The Orkhon and Tuul rivers water use fee amount is presented in Figure 21.

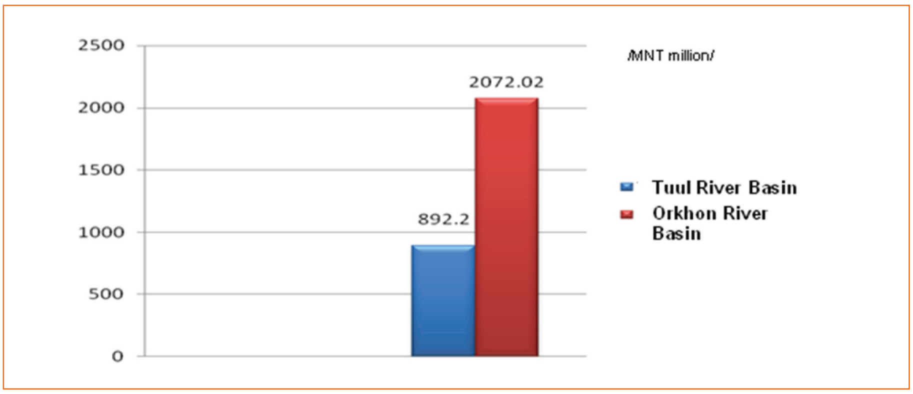

Figure 21. Water use fee revenue in 2010

As of 2008, the water resource use fee amount in the Tuul river basin was estimated at 466.35 million tugrugs and it is estimated at 1365.34 million tugrugs for the Orkhon river basin. Some 35% of the water and springs use fee revenue should be used for protecting and restoring water resources.

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 upper part of the Orkhon River is the major part that has the most negative impact.

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 on 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 of Mongolia consists of water resource use fee, 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 Water law, water use is classified like water consumption and use. The water consumers are paying water service charge and water users' are water resource use fee.

About water pricing system of Mongolia presented in Table 53.

Table 53. 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 "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 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 Table 54.

Table 54. Legal status of water tariff

Legal acts	Participants in the establishment of water tariff (former)
– 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 – Local Representatives' Khural – Agency for Fair Competition and Consumer Protection – Water supply and sewerage organizations

* *After establishing 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 compensates 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% and more must spend in order to protect water resources and rehabilitate. The local area administration should give some amount of money for the activities to protect water resources and rehabilitate. But, that amount of money is not spent in a useful way. The legal status of water use fee presented in Table 55.

Table 55. Legal status of water use fee

Legal acts	Respondents (former)
– 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 – Water Authority – Local Governors – Ministry of Finance, General Department of Taxation

For example: water resource use fee income reached MNT4.72 billion in 2010 and MNT1.1 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 Table 56.

Table 56. Legal status of water pollution compensation

Legal acts	Respondents (former)
▪ 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 ▪ Water Authority ▪ 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, direct subsidy principles are mainly used.

6.4.2. Possibility to Change Water Pricing System

The Mongolian water sector structures are being changed and renewed due to 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 57*.

Table 57. 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 are required to 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 need to be locally and differential. The water tax has to cover following 2 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 amount of compensation will at least be equivalent to expenses which 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 under RBC are planned to be established. On average, four people will work. The required expense estimation for RBA is presented in Table 58. If one RBA consists of 1 executive officer and 14 personnel, some MNT 224.7 million is required for annually on average. This cost can be financed from revenue of water use fee.

Table 58. Administrative expenses of the Orkhon River Basin Administration

Type of expenses	Annual, thous. MNT
Number of staff, persons	15
TOTAL EXPENSES	224723.9
Salaries with Social insurance premium	80197.2
Salaries	72249.8
Social insurance premium from employer	7947.5
Chancery, telecommunication, postage and freight	3600
Transport (fuel)	9600
Domestic travel	10500
Utilities	5000
Labor safety facilities	2500
Law value and fact depreciable items	600
Research and	6000
Payment for the others organizations work and service, fee and levies	3600
Information and advertising	2500
Other costs	20429.4

Also the financial sources of RBAs can be stakeholders' donations and aid. In the future need 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 are will spend only for administrative expenses of RBAs. Also need to make clear to determine financial sources for main activities of 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 ORB is one of the basins that accumulates many problems, which must be solved. Within this framework first water tax and water pollution fee should be used to finance the Orkhon RBA. To Orkhon RBA should work in close co-operation with local governments and Erdenet Company and should monitor the use of the revenue of water use fee and compensation for proper purpose.

7. Water Sector Investment in the Basin

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. Especially, agricultural water supply works lacked a specific policy and regulation until 2000.

As a result of the recovery of the country's economy and the implementation of government policies, investment has been increasingly growing and the sector's activities have been improved. On the other hand, climate change, global warming and desertification altogether create a certain requirement to address water sector issues in the scope of the state policy.

7.1. Investment in Agricultural Sector and Its Efficiency

As the Orkhon river basin is one of the densely populated, industrialized and agricultural regions, investment in the water sector in the field of agriculture has been increasing year by year.

As a result of the special focus on issues of grazing and irrigation by the government of Mongolia, the investment in this sector has increased. There wasn't any budget planned by the government for exploration and research of water supplies until 2008. In some cases, difficulties were faced with digging wells. In 2009, the MFALI approved a budget for water supply of pastures and this amount is now spent for exploration. Somehow, it became an approachable way to tackle the issue positively.

Table 59 shows the detailed investment in pasture water supply in aimags of the basin. For 5 aimags included in the basin, the investment in pasture water supply was MNT108.2 million in 2006 and MNT2611.5 million in 2010. Pasture water supply is a sector receiving a significant amount of investment based on loans and grant aid from foreign countries. For instance, it consisted 53% of the total assets which were spent for these 5 aimags in 2010. Also private investment varies between 10% and 30% of the total.

In the "Mongolian livestock program" approved in 2010, it was described that wells need to be built based on grazing needs and its necessary these to be owned by local people.

Table 59. Investment for wells of aimags in the Orkhon river basin in million MNT

Aimag	Number of well					Total					State budget					Financed by project/program by foreign and international organization					Private				
	2006	2007	2008	2009	2010	2006	2007	2008	2009	2010	2006	2007	2008	2009	2010	2006	2007	2008	2009	2010	2006	2007	2008	2009	2010
Newly built																									
Arkhangai	48	52	92	39	49	101.7	314.7	1003.2	296.1	571.9	68.5	134.7	704.6	145.0	472.9	26.3	176.4	296.6	135.5	75.6	6.9	3.6	2.0	15.6	23.4
Bulgan	120	107	56	61	60	260.6	589.8	533.6	352.4	605.0	53.2	372.5	281.0	86.5	211.5	188.8	195.3	238.8	253.0	365.1	18.6	22.0	13.8	12.9	28.4
Orkhon	11	25	9	2	3	32.7	159.5	79.9	21.0	32.0	32.5	114.5	79.9			0.0	45.0			32.0	0.2			21.0	
Uvurkhangai	91	102	72	47	59	96.2	322.7	312.2	201.1	698.6	49.9	238.8	215.5	26.3	58.3	28.7	40.0	47.8	76.8	549.9	17.6	43.9	48.9	98.0	90.4
Selenge	75	66	65	39	65	176.5	112.7	309.5	8.3	370.1	38.0	50.2	192.5	8.3	81.0	83.6	24.6	10.0		148.3	54.9	37.9	107.0		140.8
Rehabilitated/ Restored																									
Arkhangai	77	51	20	25	26	154.6	155.3	80.6	43.9	50.3	75.3	54.2	60.0		11.4	75.7	93.3	15.5	7.4	36.8	3.6	7.8	5.1	36.5	2.1
Bulgan	68	52	37	34	19	93.4	69.1	83.5	18.3	26.9	21.0	23.2	30.1	13.0	11.0	58.8	43.4	51.8	0.3	11.7	13.6	2.5	1.6	5.0	4.2
Orkhon	4			5	5	0.7	0.0	0.0	3.7	3.7	0.2								3.7	3.7	0.5				
Uvurkhangai	99	78	59	39	60	131.7	58.3	71.6	17.7	157.0	50.1	44.6	42.8	0.5	3.4	66.9	2.6	10.4	7.0	123.7	14.7	11.1	18.4	10.2	29.9
Selenge	78	36	37	38	68	34.1	57.7	124.5	118.8	96.0	25.3	2.4	64.0	1.2	32.0	2.7	41.8		4.7	25.0	6.1	13.5	60.5	112.9	39.0
Total																									
Arkhangai	125	103	112	64	75	256.3	470.0	1083.8	340.0	622.2	143.8	188.9	764.6	145.0	484.3	102.0	269.7	312.1	142.9	112.4	10.5	11.4	7.1	52.1	25.5
Bulgan	188	159	93	95	79	354.0	658.9	617.1	370.7	631.9	74.2	395.7	311.1	99.5	222.5	247.6	238.7	290.6	253.3	376.8	32.2	24.5	15.4	17.9	32.6
Orkhon	15	25	9	7	8	33.4	159.5	79.9	24.7	35.7	32.7	114.5	79.9	0.0	0.0	0.0	45.0	0.0	3.7	35.7	0.7	0.0	0.0	21.0	0.0
Uvurkhangai	190	180	131	86	119	227.9	381.0	383.8	218.8	855.6	100.0	283.4	258.3	26.8	61.7	95.6	42.6	58.2	83.8	673.6	32.3	55.0	67.3	108.2	120.3
Selenge	153	102	102	77	133	210.6	170.4	434.0	127.1	466.1	63.3	52.6	256.5	9.5	113.0	86.3	66.4	10.0	4.7	173.3	57.6	79.7	167.5	112.9	179.8
Total	671	569	447	329	414	1082	1839.8	2598.6	1081.3	2611.5	414	1035.1	1670.4	280.8	881.5	531.5	662.4	670.9	488.4	1372	133.3	170.6	257.3	312.1	358.2

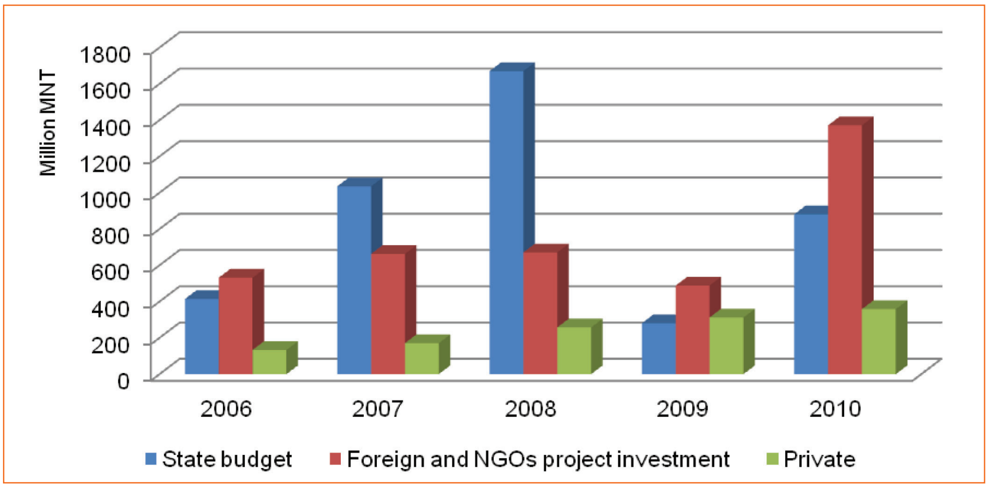

Figure 22. Investment for pasture water supply in the ORB

Investments in irrigation have been realized in the scope of "The 3rd agricultural campaign" implemented between 2008 and 2010 and also, the government has put emphasis to provide the domestic food demand from domestic agricultural products. Consequently, good conditions have been created to provide 100% of the domestic demand of seed/grain and potato, and to provide 50% of domestic demand of other vegetables. The investment by state budget in irrigation systems is being provided as grant aid; it encourages interest to carry on crop farming in the sector and increases the size of irrigated fields. Irrigation is one measure to realize the guaranteed crop/harvest as the country has unstable weather and increasing desertification. Please see the table below showing the detailed investments in irrigation in the basin. Last 2 years investment for the irrigation was in the other basins.

Table 60. Investments in irrigation in the Orkhon river basin in million MNT

Year	Total investment	Of this: state budget	Private
2005	90.4	40.4	50.0
2007	64.4	15.4	49.0
2008	8031.2	6401.6	1470.0

The investments in irrigation have increasingly grown and reached MNT8 billion in 2008 in connection with a successful implementation of "3rd Crop Rehabilitation" program. Of this, investment by state budget reached to MNT6.4 billion that increased by MNT6.3 billion compared to 2005. Also private investment contributes a significant amount in irrigation systems by reaching sometimes to 50%. It shows that it is possible to get some benefits by getting the guaranteed crop/harvest from the irrigated field.

7.2. Investment in Other Water Constructions

An investment of MNT968 million in the construction of flood protection dams and canals etc. in Bulgan and Erdenebulgan cities in the Orkhon basin has been realized between 2007 and 2008. This kind of construction work hasn't been done in other aimag centres and soums. So, more flood control constructions may be built by carrying out detailed studies as the basin is located in mountainous region with plenty of surface water.

Table 61. Investment in other water constructions in aimags in the Orkhon basin, in million MNT

Type	2007	2008	2009	2010
Flood protection and drainage	150.0	818.0	-	-
Water supply and sewerage	150.0	80.0	2355.6	260.0
Total	300	798.0	2355.6	260.0

According to the above table, MNT2355.6 million was spent for water supply and sanitation facilities in 2009 and it was the highest amount in the last 5 years. In 2007, MNT150 million was spent for solving water supply issues for hospitals in some soums of Arkhangai aimag while MNT80 million was spent for water supply of Altanbulag free zone in 2008. Not a large amount of money was spent for water supply and sewerage issues in the basin and somehow, it depends on population density. But it needs to take action in the future. The basin stands at 2nd place by number of population among 29 basins in the country and it needs to focus on water supply and sanitation issues of the population in soum centres and rural areas. And also it is an important step to achieve the Millennium Development Goals of Mongolia.

7.3. Future Trend of Investment

Relation of the economic development of Mongolia, especially intensive growth of mining and quarrying the investment in the water infrastructure will be rapidly increased.

According to resolution No.320 by the government of Mongolia, the “Orkhon-Gobi” project to provide the increasing demand of the Gobi region with water transferred from the Orkhon River is included in the list of large-scale projects to be implemented and it is also included in a concession list. In order to implement this project, so far it may require USD540 million in advance to complete construction by soft loan.

In the 2nd part of main priority of large-scale projects planned to implement “Support Development of Irrigated Crops” project, in result of which in 25.0 thousand ha irrigated area will sown wheat and 10 thousand ha-vegetables and another 5 thousand ha green forage. In the project planned to invest 50 mln USD. The MFALI estimated primarily need for irrigation development 18.1 bln MNT (about 13.4[15] mln USD).[16]

The “National Water Programme” approved in 2010, planned to restore/rehabilitate the water supply and sanitation facilities in Arkhangai and Selenge aimag centres until 2015.

Due to the development of the Mongolian economy foreign aid and soft loans will decrease and it is necessary to identify other sources for water sector investments.

[15] USD 1= MNT 1350

[16] Sh.Baranchuluun, MFALI, Department of implementation of crop policy

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", 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 on water in Mongolia and scientific background for use, protection and restoration of water resource" (G.Dolgorsuren) in 2000 and "Methodology to calculate loss assessment 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 payment' has been used in making economic assessment on water resource in the Orkhon 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 the willingness to pay 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 Orkhon river basin which was carried out based on the willingness to pay from Figure 23.

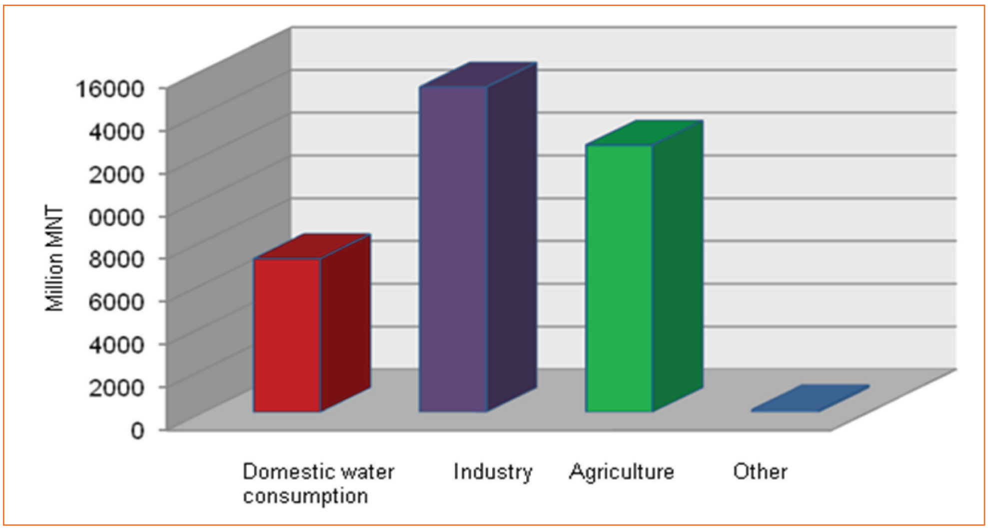

Figure 23. Value of water in the Orkhon river basin

The industrial 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 water supply for the industrial and agricultural sectors as a priority in tackling issues of the water sector. But drinking water supply for the population is a top priority in any community as it is included in the Millennium Development Goals of Mongolia.

9. Conclusions

1. Some 9 percent of our country's population lives in Orkhon river basin. The industries are well developed and 30 percent of our country's export is constituted here. This region has high economic importance. According to the economic assessment of water, it is required to pay attention mostly to mining and industrial water supply issues in the basin.
2. In the basin, the following cities are located. They include: Kharkhorin, Khangai region main center; Erdenet city; Bulgan; Sukhbaatar and Tsetserleg. The attention needs to be paid for the improvement of these cities' water supply and sewerage facilities.
3. According to MDG-based Comprehensive National Development Policy, tourism will be developed intensively. The Orkhon river basin has many historical and cultural places as well as beautiful landscapes including Orkhon valley which was registered in world cultural heritage. The environment is right to develop tourism. It is required to pay attention to develop tourism infrastructures and introduce new technologies of small size water supply and wastewater treatment and discharge facilities in tourist camps.
4. There is much water energy resource. The construction and use of hydropower plants has a high importance to economy and ecology.
5. In terms of nature and weather, the environment is suitable to develop irrigation. It is required to construct new irrigation systems and conduct maintenance. The ownership and use needs to be improved.
6. In the basin, especially in Orkhon and Selenge aimags, livestock numbers per 100 ha pasture is too high. It shows that livestock quality needs to be improved, not livestock numbers.

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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, PUSOs	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, PUSOs	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			
1	Population growth	NSO, WB, ADB and others	2000-2010	good
2	livestock growth		2000-2010	good
3	Economic growth		2000-2010	good

№	Data type	Source	Period	Data quality
4	Water tariff, its change	NSO, PUSOs	2004-2010	good
5	Technology	MFALI, NDIC and other ministries	2010	good
6	Drinking water consumption	NSO, PUSOs	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	PUSOs	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	PUSOs	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 number and its density, 2010

No	Aimag and soum	Pasture, %	Total	Aimag center	Soum center	Rural	Density, per person/м²
	Arkhangai		**49405**	**20054**	**7346**	**22005**	**2.4**
1	Battsengel	100	3745		1051	2694	1.1
2	Bulgan	100	2436		972	1464	0.8
3	Ikhtamir	74.4	4162		1057	3105	1.2
4	Ugiinuur	82.1	2593		629	1964	1.8
5	Ulziit	100	3040		801	2239	1.8
6	Tuvshruulekh	100	3280		1088	2192	2.8
7	Khashaat	100	5407		966	4441	1.7
8	Khotont	16.7	365			365	0.8
9	Tsenkher	100	4324		782	3542	1.8
10	Erdenebulgan	100	20054	20054		0	319.4
	Bayankhongor		**670**	**0**	**0**	**670**	**0.9**
11	Erdenetsogt	20.9	670			670	0.9
	Bulgan		**23627**	**11638**	**4004**	**7985**	**3.1**
13	Bugat	23.2	266			266	0.6
19	Bulgan	100	12408	11638		770	139.6
14	Buregkhangai	37.7	623			623	0.4
17	Mogod	74	2136		579	1557	1
18	Orkhon	100	2924		959	1965	0.7
16	Saikhan	67	2896		1211	1685	1.6
12	Khangal	9.8	86			86	1.4
15	Khishig-Undur	54.9	2288		1255	1033	1.6
	Darkhan-Uul		**326**	**0**	**0**	**326**	**1.6**
20	Orkhon	46.4	326			326	1.6
	Orkhon		**87869**	**84950**	**1110**	**1809**	**106.3**
21	Bayan-Undur	100	84950	84950			153.5
22	Jargalant	100	2919		1110	1809	10.7
	Uvurkhangai		**29768**	**0**	**17431**	**12337**	**3.4**
28	Bat-Ulzii	100	6381		4091	2290	2.5
25	Yusunzuil	24.4	1440		858	582	2.8
24	Zuunbayan-Ulaan	20.2	687			687	1.1
26	Ulziit	35.6	1355		560	795	1.7
23	Uyanga	10.1	683			683	1.6
27	Kharkhorin	86.6	12411		9040	3371	6.2
29	Khujirt	100	6811		2882	3929	4.1
	Selenge		**42101**	**21942**	**12756**	**7403**	**4.4**
30	Altanbulag	36.5	4426		4067	359	7.2
35	Baruunburen	100.0	2850		1283	1567	1.2
32	Zuunburen	57.5	476			476	1.0
36	Orkhon	83.0	2080		1013	1067	2.0
34	Orkhontuul	71.9	1658			1658	0.9
38	Sant	100	2225		1575	650	1.7
31	Saikhan	47.6	982			982	1.9
39	Sukhbaatar	100	22065	21942		123	484.3
33	Khushaat	54.4	1406		991	415	1.7
37	Shaamar	75.4	3933		3827	106	7.6
	Tuv		**1832**	**0**	**630**	**1202**	**2**
40	Tseel	65	1832	0	630	1202	2
	TOTAL		**235599**	**138584**	**43277**	**53737**	**4.4**

Source: NSO, and estimation of expert

Annex 3. Population of the ORB by age, 2010

Aimag and soum	Population, person			0-15	16-60	Over 60
	Soum	River basin	%			
Arkhangai		**49405**		**14324**	**32229**	**2853**
Battsengel	3745	3745	100	1037	2423	285
Bulgan	2436	2436	100	722	1578	136
Ikhtamir	5230	4162	79.6	1286	2621	255
Ugiinuur	3021	2593	85.8	796	1681	116
Ulziit	3040	3040	100	920	1970	150
Tuvshruulekh	3280	3280	100	875	2196	209
Khashaat	3325	365	11.0	111	232	22
Khotont	4324	4324	100	1432	2543	349
Tsenkher	5407	5407	100	1757	3393	257
Erdenebulgan	20054	20054	100	5388	13592	1074
Bayankhongor		**670**		**242**	**395**	**33**
Erdenetsogt	4206	670	15.9	242	395	33
Bulgan		**23627**		**6046**	**15905**	**1676**
Bugat	2486	266	10.7	77	175	14
Bulgan	12408	12408	100	2949	8510	949
Buregkhangai	2486	623	25.1	198	376	49
Mogod	2683	2136	79.6	646	1347	143
Orkhon	2924	2924	100	750	1989	185
Saikhan	3726	2896	77.7	829	1885	182
Khangal	4522	86	1.9	22	58	6
Khishig-Undur	3137	2288	72.9	574	1565	149
Darkhan-Uul		**326**		**82**	**225**	**19**
Orkhon	95043	326	0.3	82	225	19
Orkhon	**0**	**87869**		**28219**	**54703**	**4947**
Bayan-Undur	84950	84950	100	27185	53051	4714
Jargalant	2919	2919	100	1034	1652	233
Uvurkhangai		**29768**		**9394**	**18384**	**1990**
Bat-Ulzii	6381	6381	100	2253	3826	302
Yusunzuil	3242	1440	44.4	508	830	102
Zuunbayan-Ulaan	4166	687	16.5	204	449	34
Ulziit	2739	1355	49.5	441	813	101
Uyanga	9659	683	7.1	218	438	27
Kharkhorin	12933	12411	96.0	3631	7876	904
Khujirt	6811	6811	100	2140	4152	519
Selenge		**42101**		**11188**	**28575**	**2337**
Altanbulag	5051	4426	87.6	1213	3013	201
Baruunburen	2850	2850	100	933	1772	145
Zuunburen	2665	476	17.8	132	316	27
Orkhontuul	3617	1658	45.8	495	1067	96
Orkhon	2298	2080	90.5	601	1348	130
Saikhan	8809	982	11.2	251	692	39
Sant	2225	2225	100	628	1495	102
Sukhbaatar	22065	22065	100	5513	15287	1265
Khushaat	1754	1406	80.2	444	887	75
Shaamar	3968	3933	99.1	978	2698	257
Tuv		**1832**		**523**	**1210**	**98**
Tseel	2387	1832	76.7	523	1210	98
TOTAL		**235599**		**70019**	**151627**	**13953**

Annex 4. Livestock number of the basin in head, 2010

Aimag and soum	Camel	Horse	Cattle	Sheep	Goat	Total
Arkhangai	**529**	**84763**	**98563**	**487843**	**369287**	**1508446**
Battsengel	45	16652	14768	95941	67420	194826
Bulgan		6 238	13775	15450	21695	57158
Ikhtamir	1	13186	19882	61733	43927	138728
Ugiinuur	380	7290	6647	66 775	44281	125374
Ulziit	32	10773	8167	78759	51833	149564
Tuvshruulekh		2940	3 545	22 989	19 096	48570
Khashaat	49	2118	1 303	22196	11925	37593
Khotont		7728	6675	48716	44322	107441
Tsenkher	20	11271	15 679	42163	38543	107676
Erdenebulgan	2	6566	8122	33121	26244	74055
Bayankhongor	**2**	**1120**	**5063**	**7732**	**7461**	**21379**
Erdenetsogt	2	1120	5063	7732	7461	21379
Bulgan	**220**	**68977**	**51981**	**366831**	**218780**	**706789**
Bugat	0	1450	2100	7436	5362	16348
Bulgan	1	2881	5168	22733	16554	47337
Buregkhangai	153	4076	4734	39099	29005	77066
Mogod	9	14912	8770	82364	36295	142351
Orkhon	14	18861	14984	83890	65765	183514
Saikhan	42	18944	9546	87694	34731	150958
Khangal	0	454	1119	2949	2914	7436
Khishig-Undur	1	7399	5559	40665	28154	81778
Darkhan-Uul	**130**	**584**	**3113**	**7819**	**4384**	**16029**
Orkhon	130	584	3113	7819	4384	16029
Orkhon	**182**	**10713**	**17767**	**73090**	**67447**	**169199**
Bayan-Undur	176	6899	11442	55789	48146	122452
Jargalant	6	3814	6325	17301	19301	46747
Uvurkhangai	**294**	**33539**	**26456**	**190494**	**150404**	**401186**
Bat-Ulzii	0	7958	11053	33033	35310	87354
Yusunzuil	31	1537	591	12020	8496	22675
Zuunbayan-Ulaan	1	1021	668	5299	5425	12415
Ulziit	54	2320	1036	18209	10415	32035
Uyanga	0	866	1787	4299	5642	12594
Kharkhorin	165	9946	6326	67259	49540	133236
Khujirt	43	9891	4994	50374	35576	100878
Selenge	**429**	**25259**	**50332**	**237039**	**182418**	**495476**
Altanbulag	1	489	2111	6297	3630	12527
Baruunburen	75	6954	10169	65573	44330	127101
Zuunburen	5	1210	3913	16649	11419	33196
Orkhon	0	2825	6979	31128	29397	70330
Orkhontuul	292	6861	7542	52670	42737	110103
Saikhan	1	1635	3405	17833	13630	36503
Sant	55	2781	6235	30368	23125	62564
Sukhbaatar	0	815	3935	4145	4619	13514
Khushaat		1084	2651	5942	3936	13613
Shaamar	0	605	3391	6434	5595	16025
Tuv	**46**	**4623**	**4293**	**31105**	**24801**	**64867**
Tseel	46	4623	4293	31105	24801	64867
TOTAL	1 831	229579	257568	1 401952	1 024981	2 915911

Annex 5. Livestock used for food in head, 2010

Aimag and soum	Camel	Horse	Cattle	Sheep	Goat	Total
Arkhangai	**26**	**4070**	**6477**	**100241**	**43593**	**154407**
Battsengel	2	687	899	18285	7223	27096
Bulgan	0	207	752	3281	2228	6467
Ikhtamir	0	455	1227	11585	4742	18008
Ugiinuur	17	304	385	9010	3428	13144
Ulziit	2	398	440	13801	5248	19889
Tuvshruulekh	0	325	299	7979	3711	12313
Khashaat	2	86	71	3337	1039	4536
Khotont	0	772	674	14567	7415	23428
Tsenkher	2	521	1029	10516	4807	16875
Erdenebulgan	0	316	702	7880	3753	12651
Bayankhongor	**0**	**55**	**459**	**1306**	**818**	**2639**
Erdenetsogt	0	55	459	1306	818	2639
Bulgan	**18**	**11738**	**11236**	**122931**	**85147**	**231069**
Bugat	0	208	616	3272	2387	6484
Bulgan	6	1157	2445	14418	10897	28922
Buregkhangai	1	99	317	4939	5424	10779
Mogod	3	2319	1648	25695	11774	41439
Orkhon	5	2902	2624	23103	26034	54667
Saikhan	2	4196	2214	35966	14368	56746
Khangal	0	78	297	1347	1621	3342
Khishig-Undur	1	779	1076	14191	12642	28690
Darkhan-Uul	**30**	**171**	**1887**	**9462**	**8206**	**19755**
Orkhon	30	171	1887	9462	8206	19755
Orkhon	**3**	**2313**	**6837**	**57047**	**45944**	**112144**
Bayan-Undur	30	0	0	39157	9561	48748
Jargalant	0	0	0	6661	1995	8656
Uvurkhangai	**4**	**0**	**0**	**2068**	**468**	**2540**
Bat-Ulzii	0	0	0	1731	376	2108
Yusunzuil	5	0	0	3951	631	4588
Zuunbayan-Ulaan	0	0	0	993	340	1332
Ulziit	16	0	0	11232	3009	14257
Uyanga	5	0	0	12520	2742	15267
Kharkhorin	60	1252	5110	33473	49541	89436
Khujirt	4	12	113	1291	616	2036
Selenge	**24**	**279**	**412**	**2527**	**12337**	**15580**
Altanbulag	0	69	421	1202	2822	4515
Baruunburen	4	206	880	3793	4658	9541
Zuunburen	0	88	118	2008	1567	3781
Orkhon	1	108	354	3306	2936	6704
Orkhontuul	0	213	885	4717	4889	10705
Saikhan	11	132	499	2039	2874	5556
Sant	16	21	494	11299	12355	24185
Sukhbaatar	0	124	933	1289	4486	6833
Khushaat	0	491	373	3471	2579	6914
Shaamar	0	491	373	3471	2579	6914
Tuv	**166**	**20089**	**32379**	**367088**	**245390**	**665113**
Tseel						
TOTAL						

Annex 6. Meat production in ton by slaughter weight, 2010

Aimag and soum	Camel	Horse	Cattle	Sheep	Goat	Total
Arkhangai	**7.8**	**1172.0**	**1768.3**	**4009.6**	**1569.4**	**8527.1**
Battsengel	0.7	197.7	245.5	731.4	260.0	1435.4
Bulgan	0.0	59.6	205.3	131.2	80.2	476.3
Ikhtamir	0.0	130.9	335.0	463.4	170.7	1100.0
Ugiinuur	5.1	87.4	105.2	360.4	123.4	681.6
Ulziit	0.5	114.5	120.2	552.0	188.9	976.2
Tuvshruulekh	0.0	93.5	81.5	319.2	133.6	627.7
Khashaat	0.7	24.9	19.3	133.5	37.4	215.8
Khotont	0.1	222.5	183.9	582.7	266.9	1256.1
Tsenkher	0.5	150.0	280.9	420.7	173.0	1025.1
Erdenebulgan	0.0	90.9	191.5	315.2	135.1	732.8
Bayankhongor	**0.0**	**16.0**	**125.4**	**52.2**	**29.5**	**223.1**
Erdenetsogt	0.0	16.0	125.4	52.2	29.5	223.1
Bulgan	**5.3**	**3380.5**	**3067.3**	**4917.2**	**3065.3**	**14435.6**
Bugat	0.1	60.0	168.1	130.9	85.9	445.0
Bulgan	1.7	333.2	667.4	576.7	392.3	1971.3
Buregkhangai	0.2	28.5	86.5	197.5	195.3	508.0
Mogod	0.9	668.0	449.8	1027.8	423.9	2570.3
Orkhon	1.4	835.7	716.4	924.1	937.2	3414.8
Saikhan	0.6	1208.5	604.3	1438.6	517.2	3769.4
Khangal	0.0	22.3	80.9	53.9	58.4	215.5
Khishig-Undur	0.4	224.3	293.9	567.7	455.1	1541.3
Darkhan-Uul	**8.9**	**49.1**	**515.2**	**378.5**	**295.4**	**1247.1**
Orkhon	8.9	49.1	515.2	378.5	295.4	1247.1
Orkhon	**0.9**	**666.1**	**1866.5**	**2281.9**	**1654.0**	**6469.4**
Bayan-Undur	9.0	0.0	0.0	1566.3	344.2	1919.5
Jargalant	0.0	0.0	0.0	266.4	71.8	338.3
Uvurkhangai	**1.1**	**0.0**	**0.0**	**82.7**	**16.9**	**100.7**
Bat-Ulzii	0.1	0.0	0.0	69.2	13.6	82.9
Yusunzuil	1.6	0.0	0.0	158.1	22.7	182.4
Zuunbayan-Ulaan	0.0	0.0	0.0	39.7	12.2	52.0
Ulziit	4.8	0.0	0.0	449.3	108.3	562.4
Uyanga	1.4	0.0	0.0	500.8	98.7	601.0
Kharkhorin	18.0	360.5	1395.0	1338.9	1783.5	4895.9
Khujirt	1.2	3.4	30.9	51.6	22.2	109.3
Selenge	**7.1**	**80.3**	**112.5**	**101.1**	**444.1**	**745.2**
Altanbulag	0.0	20.0	114.9	48.1	101.6	284.6
Baruunburen	1.2	59.4	240.3	151.7	167.7	620.2
Zuunburen	0.0	25.3	32.3	80.3	56.4	194.4
Orkhon	0.3	31.0	96.5	132.3	105.7	365.8
Orkhontuul	0.0	61.3	241.6	188.7	176.0	667.7
Saikhan	0.3	31.0	96.5	132.3	105.7	365.8
Sant	0.0	61.3	241.6	188.7	176.0	667.7
Sukhbaatar	3.4	38.0	136.3	81.6	103.5	362.7
Khushaat	4.8	5.9	134.9	452.0	444.8	1042.4
Shaamar	0.0	35.8	254.8	51.6	161.5	503.7
Tuv	**0.1**	**141.4**	**101.8**	**138.8**	**92.9**	**475.0**
Tseel	0.1	141.4	101.8	138.8	92.9	475.0
TOTAL	**49.9**	**5785.7**	**8839.5**	**14683.5**	**8834.0**	**38192.7**

Annex 7. Milk, dairy production in thousand liters, 2010

Aimag and soum	Horse	Cattle	Sheep	Goat	Total
Arkhangai	**2142.3**	**11318.8**	**642.3**	**376.9**	**14480.4**
Battsengel	256.8	1180.8	82.3	29.3	1549.2
Bulgan	101.9	1268.8	18.4	18.9	1408.0
Ikhtamir	266.9	2218.9	65.6	28.6	2579.9
Ugiinuur	228.4	853.9	104.7	62.7	1249.7
Ulziit	269.8	987.8	116.4	53.7	1427.6
Tuvshruulekh	409.3	922.3	83.6	72.6	1487.7
Khashaat	28.7	149.9	28.8	9.4	216.8
Khotont	53.8	474.6	37.5	16.2	582.1
Tsenkher	161.8	1274.7	23.1	12.0	1471.6
Erdenebulgan	364.9	1987.3	82.1	73.6	2507.9
Bayankhongor	**30.7**	**609.0**	**9.3**	**8.0**	**657.0**
Erdenetsogt	30.7	609.0	9.3	8.0	657.0
Bulgan	2721.1	7135.5	659.6	410.3	10926.5
Bugat	45.2	301.4	14.4	9.6	370.6
Bulgan	170.1	1078.7	61.1	47.3	1357.1
Buregkhangai	112.1	502.1	39.1	27.4	680.8
Mogod	554.5	1235.5	157.7	70.3	2017.9
Orkhon	661.9	1874.8	133.6	122.2	2792.6
Saikhan	925.7	1272.8	176.6	72.9	2448.1
Khangal	15.2	162.3	5.4	5.7	188.6
Khishig-Undur	236.4	707.8	71.7	54.9	1070.8
Darkhan-Uul	**20.8**	**431.5**	**21.4**	**16.2**	**489.9**
Orkhon	20.8	431.5	21.4	16.2	489.9
Orkhon	**384.5**	**2820.6**	**144.1**	**81.9**	**3431.1**
Bayan-Undur	381.3	2202.1	157.8	79.4	2820.5
Jargalant	170.1	1161.3	38.9	34.1	1404.3
Uvurkhangai	**31.8**	**77.4**	**16.6**	**6.9**	**132.7**
Bat-Ulzii	7.9	42.6	1.3	1.1	52.9
Yusunzuil	17.8	87.4	9.5	4.2	118.9
Zuunbayan-Ulaan	9.9	126.2	2.8	2.9	141.8
Ulziit	87.1	458.0	66.8	26.6	638.5
Uyanga	56.7	249.3	21.9	3.7	331.5
Kharkhorin	1316.9	8000.3	355.0	277.2	9949.5
Khujirt	31.5	393.2	11.5	6.6	442.8
Selenge	**279.1**	**1182.4**	**74.9**	**50.6**	**1587.0**
Altanbulag	58.4	547.5	22.9	15.7	644.5
Baruunburen	179.9	1287.6	56.4	53.3	1577.2
Zuunburen	340.9	1085.6	74.5	60.4	1561.4
Orkhon	111.4	672.4	34.6	26.4	844.8
Orkhontuul	169.2	1099.1	52.6	40.0	1360.9
Saikhan	50.9	712.6	7.4	8.2	779.1
Sant	57.9	410.2	9.0	6.0	483.1
Sukhbaatar	37.5	609.8	11.4	9.9	668.5
Khushaat	119.5	594.3	45.3	26.5	785.7
Shaamar	119.5	594.3	45.3	26.5	785.7
Tuv	**7117.3**	**33112.0**	**2034.9**	**1276.3**	**43540.5**
Tseel					
TOTAL					

Annex 8. Wool and cashmere production in ton, 2010

Aimag and soum	Camel wool	Cattle wool	Cattle hair	Sheep wool	Cashmere
Arkhangai	**1.7**	**15.0**	**20.4**	**804.4**	**165.2**
Battsengel	0.1	2.3	3.1	146.7	27.4
Bulgan	0.0	1.3	1.7	26.3	8.4
Ikhtamir	0.0	2.3	3.1	93.0	18.0
Ugiinuur	1.1	1.0	1.4	72.3	13.0
Ulziit	0.1	1.2	1.7	110.7	19.9
Tuvshruulekh	0.0	0.9	1.3	64.0	14.1
Khashaat	0.2	0.2	0.3	26.8	3.9
Khotont	0.0	2.2	3.0	116.9	28.1
Tsenkher	0.1	2.2	2.9	84.4	18.2
Erdenebulgan	0.0	1.4	1.9	63.2	14.2
Bayankhongor	**0.0**	**0.3**	**0.4**	**9.0**	**1.9**
Erdenetsogt	0.0	0.3	0.4	9.0	1.9
Bulgan	**0.7**	**6.9**	**9.4**	**465.2**	**72.2**
Bugat	0.0	0.2	0.3	9.8	1.7
Bulgan	0.0	0.5	0.7	33.4	5.8
Buregkhangai	0.5	0.4	0.6	40.9	8.4
Mogod	0.0	1.4	1.9	108.5	12.3
Orkhon	0.1	1.9	2.6	104.0	22.1
Saikhan	0.1	1.6	2.2	117.2	11.8
Khangal	0.0	0.1	0.1	3.8	1.0
Khishig-Undur	0.0	0.7	0.9	47.6	9.0
Darkhan-Uul	**0.4**	**0.3**	**0.4**	**14.4**	**2.6**
Orkhon	0.4	0.3	0.4	14.4	2.6
Orkhon	**0.6**	**1.8**	**2.5**	**124.7**	**31.2**
Uvurkhangai	**1.1**	**5.8**	**8.0**	**393.7**	**74.6**
Bat-Ulzii	0.0	2.1	2.9	67.0	15.6
Yusunzuil	0.1	0.2	0.2	20.8	3.7
Zuunbayan-Ulaan	0.0	0.2	0.3	17.4	2.9
Ulziit	0.2	0.3	0.4	39.7	4.9
Uyanga	0.0	0.2	0.3	10.0	2.7
Kharkhorin	0.6	1.2	1.6	112.9	23.5
Khujirt	0.2	1.6	2.2	125.9	21.4
Selenge	**0.8**	**2.8**	**3.8**	**180.5**	**44.8**
Altanbulag	0.0	0.1	0.2	8.0	1.2
Baruunburen	0.3	0.8	1.0	60.6	13.5
Zuunburen	0.0	0.2	0.3	11.1	2.6
Orkhon	0.0	0.3	0.3	18.0	5.0
Orkhontuul	0.3	0.4	0.6	21.1	6.2
Saikhan	0.0	0.2	0.3	16.4	4.0
Sant	0.0	0.2	0.2	14.5	3.5
Sukhbaatar	0.1	0.3	0.3	7.4	2.4
Khushaat	0.1	0.2	0.2	17.3	4.2
Shaamar	0.0	0.2	0.3	6.2	2.2
Tuv	**0.1**	**0.3**	**0.5**	**21.5**	**5.0**
Tseel	0.1	0.3	0.5	21.5	5.0
TOTAL	**5.3**	**33.3**	**45.4**	**2013.3**	**397.6**

Annex 9. Hide and skin provision, 2010

Aimag and soum	Camel hide	Horse hide	Cattle hide	Sheep skin	Goat skin	Total
Arkhangai	**26**	**14726**	**24802**	**140218**	**81626**	**261398**
Battsengel	2	1890	2879	23444	11553	39769
Bulgan	0	356	2151	4585	3735	10828
Ikhtamir	0	934	4382	15131	7928	28376
Ugiinuur	17	986	1351	10631	5164	18150
Ulziit	2	1013	1379	18440	8979	29813
Tuvshruulekh	0	2221	1688	14553	10064	28526
Khashaat	2	229	218	4004	1491	5945
Khotont	0	4049	3221	21957	15161	44388
Tsenkher	2	1667	3612	14677	8405	28363
Erdenebulgan	0	1380	3919	12796	9145	27240
Bayankhongor	**0**	**58**	**583**	**1451**	**858**	**2949**
Erdenetsogt	0	58	583	1451	858	2949
Bulgan	**18**	**12854**	**14623**	**135503**	**92634**	**255631**
Bugat	0	231	661	3435	2456	6783
Bulgan	6	1228	2797	15246	11374	30650
Buregkhangai	1	107	334	5046	5591	11079
Mogod	3	2629	2276	28998	13336	47242
Orkhon	5	3151	3327	25206	27904	59592
Saikhan	2	4495	2587	38690	15566	61340
Khangal	0	79	311	1378	1652	3420
Khishig-Undur	1	818	1165	14603	13041	29628
Darkhan-Uul	**30**	**171**	**1905**	**9472**	**8222**	**19799**
Orkhon	30	171	1905	9472	8222	19799
Orkhon	**0**	**136**	**906**	**1749**	**2193**	**4984**
Uvurkhangai	**30**	**4987**	**10612**	**66053**	**32271**	**113953**
Bat-Ulzii	0	1412	4769	10923	5777	22880
Yusunzuil	4	154	117	3267	1290	4832
Zuunbayan-Ulaan	0	221	433	3057	1109	4819
Ulziit	5	286	229	6264	1734	8519
Uyanga	0	71	524	1628	948	3170
Kharkhorin	16	756	812	16726	8495	26804
Khujirt	5	1815	1917	20689	8533	32959
Selenge	**60**	**1503**	**5830**	**27282**	**31188**	**65863**
Altanbulag	4	39	268	1583	847	2741
Baruunburen	24	306	567	2820	4032	7749
Zuunburen	0	97	576	1495	3053	5220
Orkhon	4	233	1035	4085	4889	10246
Orkhontuul	0	115	273	2301	1798	4487
Saikhan	1	135	508	3599	3166	7410
Sant	0	240	1040	5010	5120	11410
Sukhbaatar	11	159	654	2332	3105	6261
Khushaat	16	82	381	2285	3264	6027
Shaamar	0	98	528	1772	1915	4313
Tuv	**0**	**497**	**380**	**3495**	**2608**	**6980**
Tseel	0	497	380	3495	2608	6980
TOTAL	146	22079	45016	249719	158967	475926

Annex 10. Livestock growth forecasting in thousand heads

Aimag	Type	2008	2010	2015	2021
Arkhangai	**Total**	**1508.4**	**1041.0**	**1226.3**	**1202.7**
	Camel	0.4	0.5	0.6	0.7
	Horse	122.6	84.8	107.1	96.8
	Cattle	130.7	98.6	176.0	237.7
	Sheep	668.3	487.8	581.0	569.0
	Goat	586.5	369.3	361.6	298.4
Bayankhongor	**Total**	**18.6**	**21.4**	**25.5**	**24.2**
	Camel	0.0	0.0	0.0	0.0
	Horse	0.9	1.1	1.4	1.3
	Cattle	4.3	5.1	7.2	8.0
	Sheep	7.3	7.7	9.6	9.3
	Goat	6.1	7.5	7.2	5.6
Bulgan	**Total**	**801.2**	**706.8**	**884.9**	**917.8**
	Camel	0.1	0.2	0.3	0.5
	Horse	70.7	69.0	109.1	111.9
	Cattle	51.3	52.0	123.4	206.4
	Sheep	405.0	366.8	439.0	429.6
	Goat	274.0	218.8	213.0	169.4
Uvurkhangai	**Total**	**632.4**	**401.2**	**447.9**	**420.0**
	Camel	0.3	0.3	0.4	0.7
	Horse	48.0	33.5	43.7	40.0
	Cattle	45.7	26.5	37.1	41.0
	Sheep	302.4	190.5	219.3	216.1
	Goat	236.1	150.4	147.4	122.2
Selenge	**Total**	**575.7**	**495.5**	**719.5**	**855.4**
	Camel	0.4	0.4	0.7	1.1
	Horse	22.6	25.3	70.1	133.7
	Cattle	46.0	50.3	144.9	297.0
	Sheep	254.3	237.0	332.6	315.9
	Goat	252.3	182.4	171.2	107.7
Tuv	**Total**	**62.6**	**64.9**	**107.7**	**156.0**
	Camel	0.0	0.0	0.1	0.1
	Horse	4.2	4.6	23.1	56.7
	Cattle	3.2	4.3	17.5	44.1
	Sheep	29.8	31.1	44.0	41.8
	Goat	25.5	24.8	23.0	13.2
Darkhan-Uul	**Total**	**29.5**	**16.0**	**23.8**	**28.4**
	Camel	0.2	0.1	0.2	0.4
	Horse	0.6	0.6	0.6	0.5
	Cattle	3.8	3.1	8.3	14.7
	Sheep	13.4	7.8	10.6	10.2
	Goat	11.5	4.4	4.1	2.6

Aimag	Type	2008	2010	2015	2021
Orkhon	**Total**	**268.9**	**169.2**	**213.5**	**224.7**
	Camel	0.2	0.2	0.3	0.6
	Horse	11.3	10.7	16.7	24.0
	Cattle	21.1	17.8	38.7	63.4
	Sheep	111.0	73.1	93.2	90.2
	Goat	125.3	67.4	64.7	46.6
Total of the basin	**Total**	**3897.3**	**2915.9**	**3649.2**	**3829.1**
	Camel	1.6	1.8	2.6	4.2
	Horse	280.9	229.6	371.8	464.8
	Cattle	306.1	257.6	553.2	912.3
	Sheep	1791.4	1402.0	1729.4	1682.0
	Goat	1517.3	1025.0	992.3	765.7

Explanation: Based on National Livestock Program of Mongolia.

Annex 11. Sown area in the ORB, 2007–2010

Aimag and soum	Wheat, ha				Potato, ha				Vegetable, ha				Fodder, ha		Oil plants, ha		
	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010	2009	2010	2007	2008	2010
Arkhangai	**548**	**670**	**4000**	**3515**	**401.8**	**568.5**	**551.7**	**316.3**	**171.6**	**159.4**	**162.9**	**118.9**	**39**	**1231.9**	-	-	-
Battsengel					11	15	20	20	3	8.7	8	8	5	5	-	-	-
Bulgan			90	20	6	10	20	19	2	3	5	3.4	4	10	-	-	-
Ikhtamir					5	8	11.4	11.5	4	3	5.8	8.5	25	30	-	-	-
Ugiinuur					3.5	2.5	5	3	0.5	0.5	0.8	0.6	5	60	-	-	-
Ulziit					4	4.5	2.3	2.3	2	2	5.4	0.2	0	0	-	-	-
Tuvshruulekh			1820	1070	98.5	122.3	105	16.5	15.8	9.7	2.9	6	0	400	-	-	-
Khashaat					0	0	0	0	0	0	0	0	0	0	-	-	-
Khotont	548	670	2090	2425	10	10	8	8	2	4	3.5	5	0	50	-	-	-
Tsenkher					1	10	5	10	0	0.5	0.5	0.5	0	50	-	-	-
Erdenebulgan					262.8	386.2	375	226	142.3	128	131	86.7	0	626.9	-	-	-
Bulgan	**1271**	**1781**	**1121**	**3166**	**158.2**	**144**	**154**	**154**	**62.6**	**80**	**79**	**88**	**0**	**0**	**0**	**0**	**0**
Bugat	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-
Bulgan	0	0	0	0	80.2	83	88	88	30	30	35	37	-	-	-	-	-
Buregkhangai	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-
Mogod	0	0	0	0	9	10	11	11	4	4	4	4	-	-	-	-	-
Orkhon	1271	1781	1081	3136	60	40	42	42	20.6	38	30	35	-	-	-	-	-
Saikhan	0	0	0	0	3	4	5	5	4	4	5	6	-	-	-	-	-
Khangal	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-
Khishig-Undur	0	0	40	30	6	7	8	8	4	4	5	6	-	-	-	-	-
Orkhon	**2009.2**	**2326**	**4529**	**4102**	**487.5**	**561**	**672.8**	**479.1**	**323.6**	**448.3**	**436.7**	**367.6**	**0**	**0**	**29**	**8**	**60**
Bayan-Undur	500	420	1461	1156	240.5	340.9	366.8	254.6	139.1	187.5	182.8	121.9	-	-	-	-	-
Jargalant	1509.2	1906	3068	2946	247	220.1	306	224.5	184.5	260.8	253.9	245.7	-	-	29.0	8.0	60
Uvurkhangai	**1145.0**	**570.0**	**980.0**	**1395.0**	**80.5**	**87.2**	**97.0**	**104.3**	**72.0**	**45.8**	**60.3**	**55.3**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Bat-Ulzii	0	0	0	0	5.3	3.8	8.0	10.0	2.0	1.2	3.0	2.0	-	-	-	-	-
Yusunzuil	0	0	0	0	5.2	7.5	8.0	9.5	2.0	2.1	3.0	2.9	-	-	-	-	-

Aimag and soum	Wheat, ha				Potato, ha				Vegetable, ha				Fodder, ha		Oil plants, ha		
	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010	2009	2010	2007	2008	2010
Zuunbayan-Ulaan	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Ulziit	0	0	0	0	5.0	2.5	3.0	6.8	2.0	0.5	1.3	0.9	-	-	-	-	-
Uyanga	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Kharkhorin	1145	570	980	1395	60.0	65.0	70.0	70.0	38.0	40.0	50.0	48.0	-	-	-	-	-
Khujirt	-	-	-	-	5.0	8.4	8.0	8.0	28.0	2.0	3.0	1.5	-	-	-	-	-
Selenge	**14840**	**26366**	**44715**	**49162**	**889.4**	**1095**	**1166**	**1126**	**531**	**596**	**646**	**724**	-	-	-	-	-
Altanbulag	-	-	-	-	173.5	173.0	173.0	173.0	52.2	53.0	53.0	53.0	-	-	-	-	-
Baruunburen	2649	4710	7977	10346	97.0	145.0	155.0	160.0	34.6	70.0	60.0	85.0	-	-	-	-	-
Zuunburen	1003	2067.5	4063.5	3144	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Orkhon	2013	4181	9476	10029	140.0	175.0	175.0	186.0	49.2	50.0	42.0	64.0	-	-	-	-	-
Orkhontuul	3548	6151	8782	11330	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Saikhan	2398.5	3909.5	5638.5	5958.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Sant	115	161	2379	3199	170.0	210.0	221.0	190.0	60.0	60.0	72.0	84.0	-	-	-	-	-
Sukhbaatar	-	-	-	-	140.0	130.0	74.0	92.0	74.2	52.0	74.0	87.0	-	-	-	-	-
Khushaat	2213.5	4226	4810	4651.5	78.9	147.0	189.0	190.0	64.8	74.0	85.0	90.0	-	-	-	-	-
Shaamar	900	960	1589	504	90.0	115.0	179.0	135.0	196.0	237.0	260.0	261.0	-	-	-	-	-
Tuv	**2183**	**2861**	**9907**	**12885**	**110**	**115**	**110.3**	**113.5**	**13.6**	**10.0**	**14.0**	**15.8**	**0.0**	**150.0**	**0.0**	**0.0**	**276.0**
Tseel	2183	2861	9907	12885	110	115	110.3	113.5	13.6	10.0	14.0	15.8	-	150.0	-	-	276
TOTAL	**21996.2**	**34574.0**	**65252.0**	**74225.0**	**2127.4**	**2570.7**	**2751.8**	**2293.2**	**1174.4**	**1339.5**	**1398.9**	**1369.6**	**39.0**	**1381.9**	**29.0**	**8.0**	**336.0**

Annex 12. Crop of soums of the ORB, 2007–2010

Aimag and soum	Crop, *ton*				Yield from per hectare, *c/ha*			
	2007	2008	2009	2010	2007	2008	2009	2010
				Wheat				
Arkhangai	**142.5**	**880.0**	**2395.0**	**2753.0**	**2.6**	**13.1**	**6.0**	**7.8**
Tuvshruulekh	142.5	880.0	1855.0	1435.0	2.6	13.1	8.9	5.9
Khotont	-	-	50.0	20.0	-	-	5.6	10.0
Erdenebulgan	-	-	490.0	1298.0	-	-	2.7	12.1
Bulgan	**1052.0**	**3380.0**	**1642.0**	**3216.0**	**8.3**	**19.0**	**14.6**	**10.2**
Orkhon	1052.0	3380.0	1582.0	3136.0	8.3	19.0	14.6	10.0
Khishig-Undur	-	-	60.0	80.0	-	-	15.0	26.7
Orkhon	**1349.8**	**5134.9**	**11322.0**	**8491.2**	**6.7**	**22.1**	**25.0**	**20.7**
Bayan-Undur	576.8	446.0	3652.0	2392.9	11.5	10.6	25.0	20.7
Jargalant	773.0	4688.9	7670.0	6098.3	5.1	24.6	25.0	20.7
Uvurkhangai	**0.0**	**150.3**	**702.0**	**1088.0**	**0.0**	**2.6**	**7.2**	**7.8**
Kharkhorin	0.0	150.3	702.0	1088.0	0.0	2.6	7.2	7.8
Selenge	**12284.9**	**36020.5**	**57743.0**	**64526.0**	**8.3**	**13.7**	**12.9**	**13.1**
Baruunburen	1470.0	4967.0	11633.0	9202.0	5.5	10.5	14.6	8.9
Zuunburen	1656.1	3478.0	5432.0	4607.0	16.5	16.8	13.4	14.7
Orkhon	1674.3	6403.0	10022.0	13590.0	8.3	15.3	10.6	13.6
Orkhontuul	2880.0	8884.0	12279.0	16308.0	8.1	14.4	14.0	14.4
Saikhan	2186.7	4586.0	7862.5	9449.0	9.1	11.7	13.9	15.9
Sant	60.0	530.0	3210.0	4159.0	5.2	32.9	13.5	13.0
Khushaat	1937.8	6744.5	5371.5	6757.0	8.8	16.0	11.2	14.5
Shaamar	420.0	428.0	1933.0	454.0	4.7	4.5	12.2	9.0
Tuv	**2401.0**	**2993.8**	**20407.6**	**26413.9**	**11.0**	**10.5**	**20.6**	**20.5**
Tseel	2401.0	2993.8	20407.6	26413.9	11.0	10.5	20.6	20.5
Total	**17230.1**	**48559.5**	**94211.6**	**106488.1**	**7.8**	**14.0**	**14.4**	**14.3**
				Potato				
Arkhangai	**2704.1**	4234.8	**1515.8**	**3861.6**	**68.3**	**74.5**	**27.5**	**122.1**
Battsengel	74.0	95.0	160.0	160.0	67.3	63.3	80.0	80.0
Bulgan	**40.4**	70.0	**30.0**	**25.0**	**67.3**	**70.0**	**15.0**	**13.2**
Ikhtamir	33.7	56.0	103.0	107.0	67.3	70.0	90.4	93.0
Ugiinuur	23.6	17.0	5.4	4.0	67.3	68.0	10.8	13.3
Ulziit	26.9	30.0	25.0	16.0	67.3	66.7	108.7	69.6
Tuvshruulekh	662.9	900.0	73.4	132.0	67.3	73.6	7.0	80.0
Khotont	67.3	70.0	55.0	50.0	67.3	70.0	68.8	62.5
Tsenkher	6.7	70.0	42.0	45.0	67.3	70.0	84.0	45.0
Erdenebulgan	1768.6	2926.8	1022.0	3322.6	67.3	75.8	27.3	147.0
Bulgan	**1385.0**	1494.0	**1476.7**	**1635.5**	**87.5**	**103.8**	**95.9**	**106.2**
Bulgan	540.0	830.0	871.2	968.0	67.3	100.0	99.0	110.0
Mogod	72.0	80.0	105.0	110.0	80.0	80.0	95.5	100.0
Orkhon	**690.0**	480.0	**378.0**	**420.0**	**115.0**	**120.0**	**90.0**	**100.0**
Saikhan	32.0	34.0	46.5	47.5	106.7	85.0	93.0	95.0
Khishig-Undur	51.0	70.0	76.0	90.0	85.0	100.0	95.0	112.5

Aimag and soum	Crop, *ton*				Yield from per hectare, *c/ha*			
	2007	2008	2009	2010	2007	2008	2009	2010
Orkhon	4465.2	5670.1	6519.4	5418.6	91.6	101.1	96.9	113.1
Bayan-Undur	2092.7	3555.7	3554.3	2879.5	87.0	104.3	96.9	113.1
Jargalant	2372.5	2114.4	2965.1	2539.1	96.1	96.1	96.9	113.1
Uvurkhangai	**695.0**	**824.8**	**887.1**	**931.7**	**86.3**	**94.6**	**91.5**	**89.3**
Bat-Ulzii	42.4	18.0	50.4	90.0	80.0	47.4	63.0	90.0
Yusunzuil	41.6	60.0	64.0	69.0	80.0	80.0	80.0	72.6
Ulziit	25.0	10.5	25.3	30.2	50.0	42.0	84.3	44.4
Kharkhorin	540.0	715.0	700.0	697.5	90.0	110.0	100.0	99.6
Khujirt	46.0	21.3	47.4	45.0	92.0	25.4	59.3	56.3
Selenge	**13498.5**	**19071.0**	**17814.0**	**15771.0**	**151.8**	**174.2**	**152.8**	**140.1**
Altanbulag	2602.5	3790.0	2846.0	1730.0	150.0	219.1	164.5	100.0
Baruunburen	1400.0	2088.0	2325.0	2300.0	144.3	144.0	150.0	143.8
Orkhon	1946.0	2590.0	2341.0	2735.0	139.0	148.0	133.8	147.0
Shaamar	1530.0	2012.0	2886.0	2350.0	170.0	175.0	161.2	174.1
Sant	3060.0	4808.0	3884.0	3040.0	180.0	229.0	175.7	160.0
Sukhbaatar	1820.0	1835.0	962.0	1336.0	130.0	141.2	130.0	145.2
Khushaat	1140.0	1948.0	2570.0	2280.0	144.5	132.5	136.0	120.0
Tuv	**550.0**	**575.0**	**880.0**	**1305.2**	**50.0**	**50.0**	**79.8**	**115.0**
Tseel	550.0	575.0	880.0	1305.2	50.0	50.0	79.8	115.0
Total	**23297.8**	**31869.7**	**29093.0**	**28923.6**	**109.5**	**124.0**	**105.7**	**126.1**
Vegetable								
Arkhangai	**495.9**	**1037.6**	**1076.0**	**1218.8**	**28.9**	**65.1**	**66.1**	**102.5**
Battsengel	8.7	15.0	64.0	64.0	28.9	17.2	80.0	80.0
Ikhtamir	11.6	28.5	29.0	72.0	28.9	95.0	50.0	84.7
Ugiinuur	1.4	9.0	1.0	0.5	28.9	180.0	12.5	8.3
Ulziit	5.8	4.0	15.0	2.0	28.9	20.0	27.8	100.0
Tuvshruulekh	45.7	12.0	12.0	40.0	28.9	12.4	41.4	66.7
Khotont	5.8	11.0	6.5	57.9	28.9	27.5	18.6	115.8
Tsenkher	0.0	0.9	3.5	2.4	28.9	18.0	70.0	48.0
Erdenebulgan	411.2	954.2	942.0	950.0	28.9	74.5	71.9	109.6
Bulgan	**582.0**	**834.0**	**742.5**	**832.0**	**93.0**	**104.3**	**94.0**	**94.5**
Bulgan	300.0	300.0	329.0	389.0	100.0	100.0	94.0	105.1
Mogod	32.0	40.0	36.0	50.0	80.0	100.0	90.0	125.0
Orkhon	198.0	418.0	285.0	279.0	96.1	110.0	95.0	79.7
Saikhan	20.0	36.0	46.0	51.0	50.0	90.0	92.0	85.0
Khishig-Undur	32.0	40.0	46.5	63.0	80.0	100.0	93.0	105.0
Orkhon	**3375.9**	**4220.8**	**4487.3**	**4517.9**	**104.3**	**94.2**	**102.8**	**122.9**
Bayan-Undur	1184.1	1788.6	1878.2	1498.2	85.1	95.4	102.8	122.9
Jargalant	2191.8	2432.2	2609.1	3019.7	118.8	93.3	102.8	122.9
Uvurkhangai	**435.4**	**511.7**	**457.0**	**406.8**	**60.5**	**111.7**	**75.8**	**73.6**
Bat-Ulzii	16.0	8.4	18.0	8.0	80.0	70.0	60.0	40.0
Yusunzuil	14.8	15.0	21.0	20.4	74.0	71.4	70.0	70.3
Ulziit	0.6	3.8	5.0	2.8	3.0	76.0	38.5	31.1
Kharkhorin	380.0	480.0	395.0	368.6	100.0	120.0	79.0	76.8
Khujirt	24.0	4.5	18.0	7.0	8.6	22.5	60.0	46.7

Aimag and soum	Crop, *ton*				Yield from per hectare, *c/ha*			
	2007	2008	2009	2010	2007	2008	2009	2010
Selenge	**10685.3**	**10815.0**	**9789.0**	**10287.0**	**201.2**	**181.5**	**151.5**	**142.1**
Altanbulag	946.8	1113.0	1266.0	795.0	181.4	210.0	238.9	150.0
Baruunburen	584.7	1095.0	660.0	1190.0	169.0	156.4	110.0	140.0
Orkhon	1176.0	716.0	604.0	1319.0	239.0	143.2	143.8	206.1
Sant	1176.0	1164.0	1325.0	1445.0	196.0	194.0	184.0	172.0
Sukhbaatar	1094.5	886.0	283.0	337.0	147.5	170.4	38.2	38.7
Khushaat	905.3	1121.0	1021.0	1091.0	139.7	151.5	120.1	121.2
Shaamar	4802.0	4720.0	4630.0	4110.0	245.0	199.2	178.1	157.5
Tuv	**54.4**	**45.0**	**92.1**	**208.5**	**40.0**	**45.0**	**66.0**	**132.0**
Tseel	54.4	45.0	92.1	208.5	40.0	45.0	66.0	132.0
Total	**15628.9**	**17464.1**	**16643.9**	**17471.0**	**133.1**	**130.4**	**119.0**	**127.6**

PART 6.
WATER SUPPLY, WASTEWATER TREATMENT AND SANITATION, WATER CONSUMPTION, WATER USE AND WATER DEMAND

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Foreword

The Orkhon River is the longest river in Mongolia which originates from the north-east side of the Khangai Mountains and flows into the Selenge River. Its watershed area amounts to 132855 km^2 and it is the largest tributary of the Selenge River. Tributaries of the Orkhon River which flow from its left side are Jarantai, Tamir, Khavchuu, Urum and Achit rivers, and the tributaries which flow from its right side are Tsagaan, Khujirt, Nariin, Tuul, Kharaa and Eruu rivers, etc which are large rivers in Mongolia. Also Ulaan Tsutgalan, the largest waterfall which is one of Mongolia's beautiful landscapes is located in the Orkhon River Basin.

Cities of Erdenet and Kharkhorin as well as aimag centres of Tsetserleg, Bulgan and Sukhbaatar of Arkhangai, Bulgan and Selenge aimags are located in the Orkhon River Basin. Also 53 soum territories of Arkhangai, Bayankhongor, Bulgan, Darkhan-Uul, Orkhon, Uvurkhangai, Selenge and Tuv aimags are fully or partially included in this basin. Of these soums, some 26 soum centres are included in the basin and some 15 soums have an area less than 5.6% in the basin. In view of geographical location study, these 15 soums are limited by the basin watershed boundary and administrative unit boundary, and outer part of soums' administrative unit boundaries is barely included in the basin boundary. There are high mountains and some wild areas where herdsmen don't often reach and water consumption here is very low. Therefore, these soums are not included in the water consumption calculation.

The Orkhon River Basin is important region of Mongolia's economic development and agricultural industries dominate in most parts of the basin. Erdenet large copper mining factory is located in the basin and it enables manufacturing industries to take advantage. It is also good that many gold mining activities are located in this basin. However, most gold mines are located in the upstream part of the Orkhon River and pollute the river water.

In this report, the current situation of water supply and sewerage, and the water consumption-water use (as of 2008 and 2010) and the water demand (for 2015 and 2021) have been calculated by aimag, soum and sector (population, manufacturing industries: light, food, mining and energy, agriculture, services, tourism, construction and building material industries) on an annual basis.

Water consumption for people and livestock has been calculated by 38 soums which have more than 5.6% of their territories included in the basin.

The 'Water National Programme' and the 'One Hundred Thousand Apartments Programme' have been approved by the State Great Khural /Parliament/ as these programmes are highly important in water supply and sewerage activities and social changes. And the government of Mongolia is significantly focusing on implementation of these programmes.

In preparing this report, it is based on the objectives and measures of above programmes and projects, and used the related legal documents, information of public administrative authorities and work reports by G.Davaadorj (Food, Agriculture and Light Industry), U.Tsedendamba (Road, Transportation, Construction and Urban Development), D.Dagvadorj (Nature, Environment and Tourism) and U.Borchuluun (Natural Resources and Energy), sectors' policy experts of the National Consulting Team of the 'Strengthening Integrated Water Resource Management in Mongolia' project.

1. Used data and information and calculation method

1.1. Basin and soum areas

Water consumption-water use and water demand for the Orkhon River Basin has been calculated by 5 cities (4 aimag centers and 1 soum centre-Kharkhorin), 25 soum centers (including Khutul village or Saikhan soum centre of Selenge aimag) and 38 soums which have more than 5.6% of their territories included in the basin (Figure 1 and Table 1).

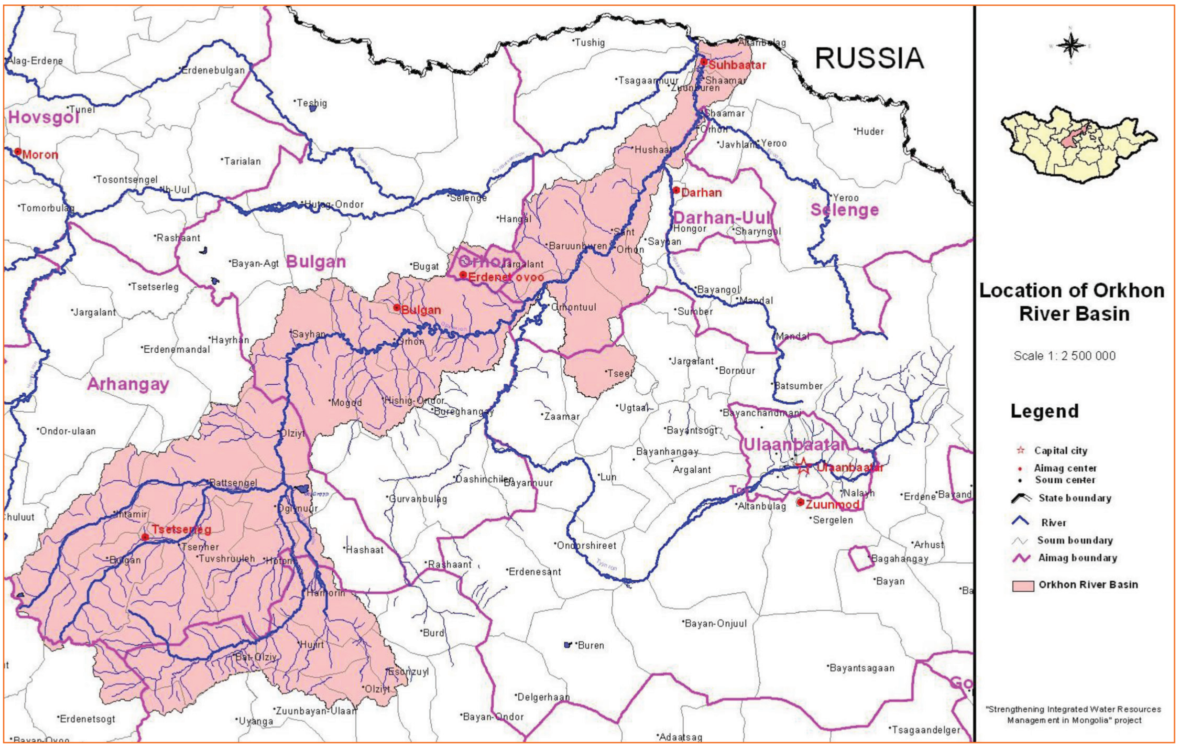

Figure 1. Location of the Orkhon River Basin

Table 1. Aimags and soums included in the basin and size/percentage of their territories in the basin

№	Aimag	№	Soum/city	Total soum area, km²	Within the basin, soum area		Percent of total basin territory, %
					area, km²	percent, %	
1	Arkhangai	1	Battsengel**	3519.29	3378.52	96.0	6.3
		2	Bulgan**	3218.81	3218.81	100.0	6.0
		3	Ikhtamir**	4873.57	3591.82	73.7	6.7
		4	Ugiinuur**	1681.94	1385.92	82.4	2.6
		5	Ulziit**	1717.54	1717.54	100.0	3.2
		6	Undur-Ulaan***	4394.00	0.05	0.0	0.0
		7	Tuvshruulekh**	1185.41	1185.41	100.0	2.2
		8	Khairkhan***	2512.07	72.85	2.9	0.1
		9	Khashaat***	2591.04	424.93	16.4	0.8
		10	Khotont**	2343.07	2343.07	100.0	4.4
		11	Chuluut***	3435.00	6.87	0.2	0.0
		12	Tsenkher**	3147.09	3147.09	100.0	5.9
		13	Erdenebulgan (Tsetserleg)*	62.68	62.68	100.0	0.1
		14	Erdenemandal***	3363.30	0.45	0.0	0.0
2	Bayankhongor	15	Galuut***	6330.00	6.33	0.1	0.0
		16	Erdenetsogt	4061.89	836.75	20.6	1.6
3	Bulgan	17	Bugat***	3200.13	476.82	14.9	0.9
		18	Bulgan (Bulgan)*	88.76	88.76	100.0	0.2
		19	Burenkhangai	3487.77	1468.35	42.1	2.7
		20	Gurvanbulag***	2686.10	0.06	0.0	0.0
		21	Mogod**	2819.56	2199.26	78.0	4.1
		22	Orkhon**	4092.36	4080.08	99.7	7.6
		23	Saikhan**	2759.99	1849.19	67.0	3.4
		24	Selenge***	4650.00	18.60	0.4	0.0
		25	Khangal***	1640.54	91.87	5.6	0.2
		26	Khishig-Undur**	2436.82	1476.71	60.6	2.8
		27	Khutag-Undur***	5669.50	113.39	2.0	0.2
4	Darkhan-Uul	28	Orkhon	461.92	214.33	46.4	0.4
5	Orkhon	29	Bayan-Undur (Erdenet)*	567.48	562.94	99.2	1.1
		30	Jargalant**	273.00	273.00	100.0	0.5
6	Uvurkhangai	31	Bat-Ulzii**	2586.90	2579.14	99.7	4.8
		32	Burd***	2707.78	24.37	0.9	0.1
		33	Yesunzuil**	1961.04	566.74	28.9	1.1
		34	Zuunbayan-Ulaan	2512.42	540.17	21.5	1.0
		35	Ulziit**	1967.05	733.71	37.3	1.4
		36	Uyanga	3047.14	405.27	13.3	0.8
		37	Kharkhorin (Kharkhorin)*	2301.26	2043.52	88.8	3.8
		38	Khujjrt**	1661.41	1661.41	100.0	3.1

№	Aimag	№	Soum/city	Total soum area, km²	Within the basin, soum area		Percent of total basin territory, %
					area, km²	percent, %	
7	Selenge	39	Altanbulag**	2435.34	674.59	27.7	1.3
		40	Baruunburen**	2805.70	2334.34	83.2	4.3
		41	Zuunburen	1191.88	609.05	51.1	1.1
		42	Orkhon**	1264.73	1040.87	82.3	1.9
		43	Orkhontuul	2935.07	2001.72	68.2	3.7
		44	Saikhan (Khutul)****	1306.87	546.27	41.8	1.0
		45	Sant**	1350.99	1337.48	99.0	2.5
		46	Sukhbaatar (Sukhbaatar)*	46.89	46.47	99.1	0.1
		47	Khushaat**	2002.06	856.88	42.8	1.6
		48	Shaamar**	617.88	474.53	76.8	0.9
8	Tuv	49	Jargalant***	1840.00	7.36	0.4	0.0
		50	Zaamar***	1900.00	1.90	0.1	0.0
		51	Sumber***	527.50	4.22	0.8	0.0
		52	Ugtaal***	1680.00	1.68	0.1	0.0
		53	Tseel**	1641.16	1002.75	61.1	1.9
			Total		53786.89		100.00

Remarks: *1. * Cities or aimag and soum centers included in the basin*
*2. ** Soum centers included in the basin*
*3.*** Not included in water consumption-use calculation because soum territory included in the basin is less than 5.6%*
*4.**** Khutul or Saikhan soum centre of Selenge aimag is a large village. The town abstracts water from the Orkhon River floodplain, however included in the Kharaa River Basin. Therefore, it is subject to soum centre according to the calculation.*

1.2. Water consumption and water demand by people

In calculating water consumption and water demand by people, it has been divided into aimag centre or city (including Kharkhorin city, regional main centre) and rural people.

1.2.1. Water consumption for aimag centre/or city people

In making calculation, aimag centre (city) people have been divided into apartment resident connected to the centralized water supply and ger area resident not connected to the centralized water supply. And ger area people in aimag centre have been divided into people supplied from water kiosk connected to the water supply pipeline and supplied from water kiosk not connected to the pipeline.

Calculation of water consumption and water demand by people based on 'Temporary Drinking and Domestic Water Norm for People' approved by Appendix 3 of the Resolution No.153 of the Ministry of Nature and Environment in 1995 (Table 3).

1.2.2. Water consumption for rural people

The National Statistics Committee releases data and information related to rural water consumers including rural population and number of livestock, etc in terms of administrative unit.

In the event of the basin boundary crosses the administrative boundary and soum territory is not completely included in the basin, the population and number of livestock in the basin have been calculated by comparing the density of the soum's rural people (herdsmen and farmers) and livestock to its pasture area. After the detailed calculation of water consumers, water demand for 2015 and 2021 has been determined by using Matlab calculation programme (discussed and approved by the team consultation) developed by the project team consultant Mr.Olaf Scholz based on the water consumption norm.

1.3. Water use for manufacturing industry

Manufacturing industries are divided into light, food, energy, construction and mining industries. Water use and water demand has been calculated for each industry. The water use is calculated for the industries based on annual output produced by economic entities that run industrial activities in the basin as well as the water use norm per product. The output figures have been obtained from the statistic books released by the National Statistics Committee and annual reports by some enterprises. Some products with undetermined water use norm have been calculated by comparing these to similar products and service norms.

The water use of the mining industry has been calculated based on the annual mining plan by mining companies that run mining activities in the basin and the Conclusion on Water Use by the Water Authority, Government Implementing Agency.

1.4. Water consumption-use for agriculture

The main water consumer and user in agricultural sector is livestock water consumption and irrigated area (greenhouse).

Livestock water consumption in the basin has been calculated by the 'Temporary Livestock Water Consumption Norm' approved by Appendix 4 of the Resolution No.153 on Approval of Temporary Norm of the Ministry of Nature and Environment in 1995. And water use for irrigated area has been calculated based on the Irrigation Norm for Irrigated Area approved by Appendix 5 of the resolution considering natural zone and melioration zone. Water consumption for pig and poultry farms is based on a norm that is used in Russia.

1.5. Water consumption for tourism, sanatorium/spa resorts and green areas

Water consumption for tourism has been calculated by the Water Consumption Norm for Public Utility Service Establishments approved by Appendix 2 of the Resolution No.153 on Approval of Temporary Norm by the Ministry of Nature and Environment in 1995 considering number, class, capacity and operating period of tourist camps/sanatoriums as well as number of tourists arrived in the basin.

Water consumption has been calculated by considering irrigated lawns, parks, gardens and green areas, irrigated forest areas as well as type, age and quantity of seedlings and trees in aimag centers located in the Orkhon River Basin. In calculating water consumption for green areas, lawns and trees, it is based on the Lawn Irrigation Norm and the Water Consumption Norm for Planting Trees approved by Appendix 6 and 7 of the Resolution No.153 on Approval of Temporary Norm by the Ministry of Nature and Environment in 1995.

2. Water supply, sewerage, sanitation, water consumption and water demand by people

The Joint Programme for Improving Water Supply and Sanitation Service is being implemented by UNDP, UNICEF, WHO and UNFPA in Mongolia in collaboration with the Government of Mongolia.

Within the framework of this programme, drinking water supply sources have been divided into improved and unimproved sources. And the improved source is accessed by three main indicators: water quality, access to water and water availability.

In a joint water supply and sanitation monitoring programme by UNICEF and WHO, water sources have been described as follows (Table 2).

Table 2. Difference between improved and unimproved drinking water sources

Improved water supply source	Unimproved water supply source
▪ Centralized water supply	▪ Unprotected well and spring
▪ Water kiosk	▪ River and spring
▪ Borehole	▪ Bottled water*
▪ Protected hand well and spring	▪ Water distribution by water truck**
▪ Rain water harvesting construction	

Remarks: *1. * Due to amount of bottled water is small (insufficient) it is not included in the improved source.*
*2. ** Water truck tank is considered that sometimes it doesn't meet the hygienic requirements.*

In determining the water demand of aimag and soum centers' people in the Orkhon River Basin, their water consumption norm is differentiated depending on what source is used for their water supply. In each phase of the IWRM plan, it has been adhered to a policy which aims to reduce water consumption by water consumers that are connected to the centralized water supply system in urban areas to the level of water consumption in the world's biggest cities, to reduce the number of water consumers that are supplied from unimproved sources and to increase the water availability. Water consumption for urban and rural people in the basin has been calculated within the framework of the IWRM plan according to the following norm.

Table 3. Water consumption norm for people in aimag, soum centres and cities

Type of water supply source	Coverage	Water consumption norm, *l/day person*			
		2008	2010	2015	2021
Improved source	Resident of apartment connected to centralized water supply (with hot and cold water)	230	230	200	160
	Resident of apartment connected to centralized water supply (with cold water)	175*	175*	170	160
	Resident of ger area supplied from water kiosk connected to the centralized water supply	8*	10*	25	30
	Resident of ger area supplied from water kiosk not connected to the centralized water supply	6*	8*	15	20
Unimproved source	Resident who fetches water from open water such as springs and rivers	6*	8*	10	15

* The water consumption in 2008 and 2010 was calculated using the actual water use in l/day per person

There are in total 16 wastewater treatment plants /WWTP/ in the Orkhon River Basin. Of these, there is 1 WWTP in Arkhangai aimag, 1 in Bulgan aimag, 1 in Darkhan-Uul aimag, 3 in Orkhon aimag, 5 in Selenge aimag and 5 in Uvurkhangai aimag (Table 4 and Figure 2).

Table 4. Number of WWTPs in the Orkhon River Basin

Aimag	Soum	Number of WWTP
Arkhangai	Erdenebulgan	1
Bulgan	Bulgan	1
Darkhan-Uul	Orkhon	1
Orkhon	Bayan-Undur, Jargalant	3
Selenge	Altanbulag, Baruunburen, Shaamar, Sant, Sukhbaatar	5
Uvurkhangai	Ulziit, Khujirt, Bat-Ulzii, Kharkhorin	5
Total		16

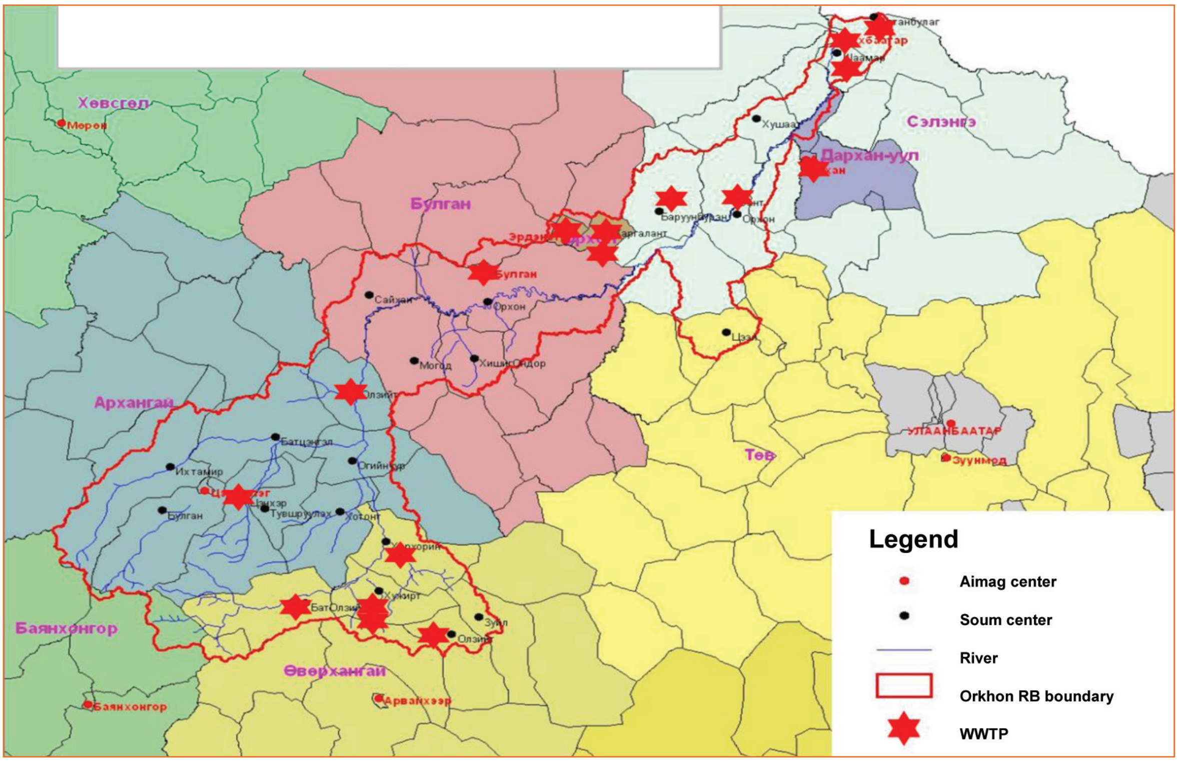

Figure 2. Location of WWTPs in the Orkhon River Basin

2.1. Water supply, sewerage, water consumption and water demand by urban people

Tsetserleg city (Erdenebulgan soum) of Arkhangai aimag, Bulgan city (Bulgan soum) of Bulgan aimag, Erdenet city (Bayan-Undur soum) of Orkhon aimag, Sukhbaatar city (Sukhbaatar soum) of Selenge aimag and Kharkhorin city (Kharkhorin soum centre) of Uvurkhangai aimag are included in the Orkhon River Basin. Water supply, sewerage and water consumption have been considered for each city as follows.

2.1.1. Tsetserleg city, centre of Arkhangai aimag

Water supply system, water consumption and water demand: Tsetserleg city is elevated at 1695 m and located in front side of Bulgan Mountain beautiful protected area of Khangai Mountain Range, between the north and south Tamir Rivers, 480 km to the west of Ulaanbaatar city. The city, during its development, was called Tsetserleg in 1961 according to administrative restructuring. Undarga Public Utility Service Shareholding Company is responsible for water supply in Tsetserleg city.

Tsetserleg city's main water supply sources are 6 boreholes: 3 in floodplain of Tarvuu River located 4 km in the south-west of the city, 2 at the general education school and 1 in the west district's ger area. There is a ferro-concrete water tank with a capacity of 10,000 m^3 (Figure 3).

Figure 3. Location of Tsetserleg city water supply source

As of 2010, some 6.0% of Tsetserleg population live in apartments that are connected to engineering pipeline and 94.0% live in ger areas.

Groundwater use for water supply is 3102.5 thousand m^3/year. Chlorination is not used at this moment. However it was built in 2000 for the purpose of disinfection and purification of wastewater used in the city's water supply.

The city's centralized water supply source was established and put into operation between 1988 and 1990. The total length of fresh water distribution and transmission pipeline is 39 km.

The drinking and domestic water for ger area people is supplied from 13 water kiosks. Also many households in the 1st and 2nd bagh (sub-soum) of Erdenebulgan soum fetch water from protected and improved Gants Modnii Bulag spring located in front side of Tsagaan mountain pass. Citizens and economic entities have established and are using 23 drilled wells in ger areas of the aimag centre for their own demand. Public administration and service organizations, and communal apartments in aimag centre are supplied by cold water only.

Table 5. Water consumption and water demand by Tsetserleg city population

№	Water supply source and its coverage		Population, *thous. person*				Water consumption, *thous. m^3/year*			
			2008	2010	2015	2021	2008	2010	2015	2021
1	Centralized water supply	Apartment with hot and cold water	-	-	-	-	-	-	-	-
		Apartment with only cold water	1.2	1.2	2.1	2.6	74.2	78.2	128.5	152.4
		Water kiosk	5.5	8.4	11.1	10.1	16.0	30.6	101.5	155.1
2	Non-centralized water supply	Water kiosk	11.4	10.5	6.6	7.6	25.0	30.6	36.0	25.7
3	Protected source									
4	Unprotected source		-	-	-	-	-	-	-	-
5	Other sources		-	-	-	-	-	-	-	-
	Total		18.1	20.1	19.8	20.3	115.2	139.4	266.0	333.2

In order to increase Tsetserleg city's water supply source resources, Ar Chandmani LLC carried out an investigation and hydrogeological study on the groundwater deposit in the valleys of South Tamir and Taruu Rivers in 2012 and newly determined its exploitable resource as 5702.4 m^3 per day.

Arkhangai aimag's Governor's Decree No.256 was released in 2010 and is being implemented on processing water consumption payment according to indication of water meter for the purpose of water loss reduction and efficient consumption by water consuming economic entities and apartment residents.

In total 60% of fresh water pipelines or 11.3 km new pipelines have been installed by 'MON-1907 to Support Utility Service Development' project implemented by finance from the Asian Development Bank /ADB/ from 2003 to 2009.

WWTP: with a capacity to treat 1200 m^3 wastewater by mechanical method was established in Tsetserleg city in 1987. The plant used to treat and disinfect 900 m^3 wastewater by method of percolating down to soil per day. In 2003 WWTP's old technology was renovated within the framework of the project (MON-1907), new bio-ponds with totally 8 areas were established and 75% of the total wastewater started to be treated through the WWTP.

Arkhangai Aimag's Strategic Development Plan for 2016-2021 includes some measures including improvement of Tsetserleg WWTP technology, increase its capacity, reuse of wastewater, connection of some part of ger area to the centralized water supply system and creation of a model apartment block, etc.

Figure 4. Wastewater treatment bio-pond in Tsetserleg city

2.1.2. Bulgan city, centre of Bulgan aimag

Water supply, water supply system, water consumption and water demand: as of 2010, some 13.8% of Bulgan population live in apartment buildings connected to the centralized water supply and 86.2% of the population live in ger areas not connected to the centralized system. Bulgan-Meej LLC holds a special license to provide public utility service and is responsible for water supply of Bulgan city.

Bulgan city water supply source comes from totally 9 drilled wells: 2 along the Achuut River floodplain located 4 km in the north-west of the city and 7 which previously used in the city. Water is distributed to offices and apartment consumers from a pressure tower with a capacity of 50 m^3 through fresh water pipelines.

Offices and apartments in Bulgan city are connected to the centralized water supply pipelines with only cold water.

In order to increase the Bulgan city water supply source resource, Orkhon Hydrogeo Shareholding Company carried out an investigation and hydrogeological study on a groundwater deposit in 1983 and 1984 and determined that its potential exploitable resource is 4907.6 m^3 per day.

Figure 5. Location of Bulgan city water supply source

Table 6. Water consumption and water demand by Bulgan city population

№	Water supply source and its coverage		Population, *thous. person*				Water consumption, *thous. m^3/year*			
			2008	2010	2015	2021	2008	2010	2015	2021
1	Centralized water supply	Apartment with hot and cold water	-	-	-	-	-	-	-	-
		Apartment with only cold water	1.5	1.6	2.7	3.4	97.1	102.4	168.2	199.6
		Water kiosk	3.5	5.4	7.2	8.3	10.3	19.8	65.8	90.8
2	Non-centralized water supply	Water kiosk	6.1	4.6	1.5	0.0	13.4	13.5	8.2	0.0
3	Protected source		-	-	-	-	-	-	-	-
4	Unprotected source		-	-	-	-	-	-	-	-
5	Other sources		-	-	-	-	-	-	-	-
Total			11.1	11.6	11.4	11.7	120.9	135.7	242.2	290.4

WWTP: with a capacity of 1400 m^3 wastewater per day to carry out mechanical treatment and disinfection started its operation in 1989.

Figure 6. Bulgan city central WWTP or bio-pond

At present time, the plant carries out mechanical treatment of 200 m^3 wastewater at 45% treatment level per day and the treated wastewater is directly infriltated to the soil from the bio-pond. Due to damage in the bio-pond dam, it creates a bad condition which doesn't meet the sanitation requirements and the wastewater pollutes the surrounding environment. Therefore, it is necessary to precisely determine sanitation and protection zones.

A goal to develop Bulgan as a city with industries, service and intensified agriculture based on its infrastructure and a city which is influential on regional economy has been set in the Aimag's Strategic Development Plan. Within this framework, the centralized water supply system has been planned to be expanded.

Therefore, it would be appropriate to improve water supply for people and water supply for aimag centre industries and service, to determine content and pollution levels of wastewater from the industries and service, and to establish biological WWTP with nature-friendly equipment and technology.

2.1.3. Erdenet city, centre of Orkhon aimag

Water supply system, water consumption and water demand: Erdenet city is different from other aimags and cities by its water supply management and water source.

The energy workshop of Erdenet copper mining factory is responsible for the city's water supply and sewerage activities. It provides hot and cold water supply and wastewater drainage and treatment service to people, factories and economic entities through Erdenet-Us heat transmission network shareholding company and Erdenet-Amidral locally owned company. Also it supplies water for technological demand of the mining factory.

Erdenet-Us heat transmission network company abstracts water from 3 boreholes located in the 6^{th} sub-district and delivers it to 45 water kiosks by water trucks for water supply of ger area households.

Around 100 drilled wells have been established and are being used by individuals, industry and service providers in suburban sub-districts for water supply purposes.

The main water supply source is a groundwater resource in the Selenge River floodplain located 63 km from the factory. Water is abstracted from 14 drilled wells in 'Akhai Gun' fresh water deposit of Selenge River in the territory of Khangal soum, Bulgan aimag with the support of 4 pumping stations and the water is delivered to the city through pipelines. Groundwater hydrogeological investigation, drilling, pumptests have been carried out between 1973 and 1976, and the usable resource was determined to be 135.5 thousand m^3/day with C_2 classification. The groundwater mineralisation is 0.19-0.23 mg/l, very soft and it completely meets drinking water standard requirements for chemical composition. On average 60-70 thousand m^3 water is abstracted from the Akhai Gun groundwater deposit per day.

In order to create a new water supply source for Erdenet city, Orkhon Hydrogeo Sshareholding Company carried out groundwater investigations in 2003 and determined a 7197.1 m^3/day resource in Chingel River floodplain, 2109.5 m^3/day in Erdenet River floodplain and 1693.4 m^3/day in Govil River floodplain, respectively. Steel pipelines with a length of 180 km are used in the Erdenet mining factory and the centralized water supply system of Erdenet city.

For the purpose of efficient use of fresh water, the Erdenet mining factory has launched a SCADA system in its industry for monitoring water consumption and installed water meters in pipelines of the water supply system. By doing so, water loss has been reduced by 10%.

Table 7. Water consumption and water demand by Erdenet city

№	Water supply source and its coverage		Population, *thous. person*				Water consumption, *thous. m^3/year*			
			2008	2010	2015	2021	2008	2010	2015	2021
1	Centralized water supply	Apartment with hot and cold water	38.4	40.0	67.7	85.3	3223.7	3359.1	4938.7	4980.5
		Apartment with only cold water	-	-	-	-	-	-	-	-
		Water kiosk	5.5	8.4	11.2	14.3	16.1	30.7	102.2	156.1
2	Non-centralized water supply	Water kiosk	39.4	36.5	16.3	8.4	86.4	106.6	89.5	61.2
3	Protected source		-	-	-	-	-	-	-	-
4	Unprotected source		-	-	-	-	-	-	-	-
5	Other sources		-	-	-	-	-	-	-	-
Total			83.3	84.9	95.2	108.0	3326.2	3496.4	5130.4	5197.8

WWTP: established in 1978 with a treatment capacity of 24000 m^3 wastewater per day and still in use so far. Erdenet city WWTP underwent expansion: deep treatment plant established in 1991 and sludge bed in 2003, respectively. Recently, the plant treats 31.4 thousand m^3 wastewater per day on average, but this amount exceeds its normal capacity by 7.4 thousand m^3 wastewater. The treated wastewater from the WWTP is disinfected through chlorination.

A design for expanding the Erdenet city WWTP was made in 2009 with contribution of France and the related equipment supply has just started. The expected result is to increase WWTP capacity by as much as twice the existing capacity, to treat wastewater up to 48,000 m^3 per day, to save some material cost by 40% by launching a new disinfection and treatment technology and to bring the wastewater treatment level up to 98%.

According to analyses carried out by the Geoecological Institute of the Academy of Science of Mongolia on treated wastewater from the Erdenet city WWTP and Khangal River water, pollution level of the Khangal River water was higher than the treated water from the WWTP and bacteriological pollution was found in the river water. In other words, the treated wastewater was cleaner than the Khangal River water or its treatment level was more than 90%. This indicator reveals that the Erdenet WWTP treats wastewater well according to technology.

a. Clarifier

b. Deep treatment section

Figure 7. Erdenet city WWTP

As the Erdenet city WWTP has an advanced wastewater treatment technology, its treatment level is high. Previously, the plant used to discharge its treated wastewater into the Khangal River. But later it came up with a solution to reuse the wastewater.

Since 2004 the treated wastewater is collected in a pond and water leaking through the pond dam was started to be used for some technological demand of the factory.

In the Aimag Strategic Development Plan for 2009-2021, it was planned to provide ger area households with houses and connect them to the engineering pipeline network, to reduce air pollution and to connect domestic and industrial wastewater from people, economic entities and organizations to the sewerage pipelines.

2.1.4. Sukhbaatar city, centre of Selenge aimag

Water supply system, water consumption and water demand: as of 2010, some 21.9% of Sukhbaatar city population live in apartments connected to the centralized water supply system and 78.1% of the population live in ger areas.

The water supply source is groundwater in the Orkhon River floodplain. Fresh water is supplied to consumers from 4 boreholes established in 1991 located 2km to the south of Sukhbaatar city through pipelines with a length of 45 km.

Table 8. Water consumption and water demand by Sukhbaatar city population

№	Water supply source and its coverage		Population, *thous. person*				Water consumption, *thous. m³/year*			
			2008	2010	2015	2021	2008	2010	2015	2021
1	Centralized water supply	Apartment with hot and cold water	4.5	4.8	8.2	10.3	286.0	309.2	507.8	602.5
		Apartment with only cold water	-	-	-	-	-	-	-	-
		Water kiosk	5.8	8.9	11.9	12.5	17.0	32.6	108.3	136.7
2	Non-centralized water supply	Water kiosk	9.1	8.2	1.9	0.0	19.9	23.9	10.4	0.0
3	Protected source		-	-	-	-	-	-	-	-
4	Unprotected source		-	-	-	-	-	-	-	-
5	Other sources		-	-	-	-	-	-	-	-
Total			19.4	21.9	22.0	22.8	322.9	365.7	626.5	739.2

The 1st and 2nd pumping stations, double reservoirs with a capacity of 500 m^3 located in front of the 2nd station, double reservoirs with a capacity of 1400 m^3 located in the end of pipeline network and 4 main ring pipes with a length of 32 km are used in hot and cold water supply for apartments, economic entities and organizations in Sukhbaatar city. Ger area residents are supplied from 7 water kiosks connected to the pipelines and 13 not connected water kiosks.

There are many hand wells on private grounds of ger area residents located on the south embankment of Buur River 7 km from Sukhbaatar city and the well water is consumed for their drinking and domestic purpose as well as for other uses.

In 2008, Tuv Us Shareholding Company carried out groundwater resource investigations to increase the city's water supply along the Orkhon River floodplain in the upstream part of Buur River and determined its resource as 17280 m^3 per day.

WWTP: established with a treatment capacity of 12,000 m^3 wastewater by biological method in Sukhbaatar city in 1990. During its operation, 9000 m^3 wastewater was treated and disinfected at 90% treatment level per day on average. A minor part of the wastewater percolated down to the soil and the majority was discharged into the Orkhon River.

In recent years the water supply and sewerage organisation receives wastewater through the central sewerage, carries out only mechanical treatment and discharges its treated wastewater into the Orkhon River directly. This WWTP is planned to undergo maintenance and renovation.

Figure 8. Sukhbaatar city WWTP

2.1.5. Kharkhorin city, centre of Kharkhorin soum of Uvurkhangai aimag

Kharkhorin is the ancient capital city of Mongolia and is now considered as one of the largest tourism centres combined with irrigated area, flour and animal feed factories.

In the Regional Development Concept approved by the State Great Khural (Parliament) in 2011, the main guideline has been set to develop Kharkhorin city as main Khangai regional centre and to develop pastoral farming, crop farming, tourism, sanatorium/spa resorts, small and medium sized enterprise, mining and processing, and wood processing industry.

Water supply system, water consumption and water demand: the Kharkhorin city water supply source are 6 drilled wells established in the Orkhon River floodplain. Water is abstracted from these sources and delivered to the city's public administrative organisations, factories, economic entities, apartment buildings and people. The city has a centralized water supply and 5.1 km fresh water pipelines were renovated in 2011. Over 40 wells have been established and are used by factories, economic entities and citizens on their own cost for the purpose of increasing the water supply availability.

Figure 9. Renovation of Kharkhorin city water supply source

A locally owned shareholding company in charge of water supply and sewerage is planned to be established in Kharkhorin soum.

Table 9. Water consumption and water demand by Kharkhorin city population

№	Water supply source and its coverage		Population, *thous. person*				Water consumption, *thous. m³/year*			
			2008	2010	2015	2021	2008	2010	2015	2021
1	Centralized water supply	Apartment with hot and cold water	-	-	-	-	-	-	-	-
		Apartment with only cold water	-	-	-	-	-	-	-	-
		Water kiosk	-	-	-	-	-	-	-	-
2	Non-centralized water supply	Water kiosk	0.7	0.8	0.9	1.1	1.5	2.2	4.8	8.0
3	Protected source		2.3	2.8	3.4	4.2	5.1	8.3	12.5	23.1
4	Unprotected source		4.7	5.4	4.7	3.9	10.3	15.9	17.0	21.4
5	Other sources		1.5	-	-	-	3.3	-	-	-
Total			9.2	9.0	9.0	9.2	20.2	26.4	34.3	52.5

Kharkhorin WWTP: established in 1979 with a capacity to treat 1000 m³ wastewater by mechanical method. Currently, few organisations deliver their wastewater to this plant and 20 m³ wastewater is being treated per day on average. Expansion and renovation framework for engineering pipelines, water supply system and WWTP has been started since 2011.

Figure 10. Under-construction new WWTP in Kharkhorin city

For Kharkhorin city, it is necessary to establish independent organisation for water supply and sewerage use, to provide normal operation of pipeline network and improve its use, and to determine water source resource.

2.1.6. Total water consumption and water demand by the cities' population

At the basin level, Sukhbaatar and Erdenet cities have thermo-power plants. The plants heat water for domestic demand all year around and distribute it to factories, economic entities, service centres and apartments on a regular basis. In the future, it is necessary to take measures such as increasing the number of water consumers connected to the centralized water supply system, and to supply safe hot and cold water in other aimag centres on a regular basis.

Table 10. Water consumption and water demand by the cities located in the Orkhon River Basin

№	City	Population, *thous. person*				Water consumption, *thous. m³/year*			
		2008	2010	2015	2021	2008	2010	2015	2021
1	Tsetserleg	18.0	20.1	19.8	20.3	115.1	139.3	266.0	333.2
2	Bulgan	11.2	11.6	11.4	11.7	120.9	135.7	242.2	290.4
3	Sukhbaatar	19.4	21.9	21.9	22.8	322.9	365.6	626.5	739.1
4	Erdenet	83.3	85.0	95.2	107.9	3326.1	3496.4	5130.4	5197.8
5	Kharkhorin	9.2	9.0	9.0	9.2	20.2	26.4	34.3	52.6
Total		141.1	147.6	157.3	171.9	3905.2	4163.4	6299.4	6613.1

2.2. Water supply, sanitation, water consumption and water demand by soum centre and rural population

2.2.1. Soum centre population

In total 26 soum centers, 8 soum centres of Arkhangai aimag, 5 of Uvurkhangai aimag, 4 of Bulgan aimag, 1 of Tuv aimag, 1 of Orkhon aimag and 7 of Selenge aimag are included in the Orkhon River Basin and 10 of them are located along the river floodplain.

Water supply system, water consumption and water demand: the main water supply source for soum centre people is groundwater. In some soums located along the river floodplain, open water such as rivers and springs, etc is used during warm seasons.

Figure 11. Boreholes used in soum centre water supply

Khutul city or Saikhan soum centre of Selenge aimag is included in the Kharaa River Basin. But its water consumption is from 4 boreholes established in the Orkhon River floodplain through 2 pumping stations and pipelines with a length of 23 km. Therefore, this water consumption is included in the soum centre calculation.

Soum centre people are supplied from boreholes established for water supply. Some soums have only two boreholes while others have 16 boreholes. Water is collected in a reservoir with a capacity of 2-4 m³ which is located inside the water kiosk building and distributed to consumers. When consumers fetch water, they use a variety of buckets carryied on a cart, but mostly by hand.

Water truck and horse carts deliver water to some service centres in soum centres, but not on a regular basis throughout the year. Some soum centre people fetch water from the river by using their own transport and small carts. Also water consumers who live along the large river floodplain carry ice by breaking it and use it for drinking and domestic water purpose during winter time.

Figure 12. Water softening equipment installed at water kiosk in Mogod soum centre of Bulgan aimag

So far, there hasn't been any treatment measure such as chlorination and filtration in drinking water of soum centres and constant analysis hasn't been carried out in water quality and composition ever since chemical analysis was firstly carried out when wells were drilled.

Water softener equipment has been installed in a drilled well with high minerilsation in Ugiinuur and Khotont soum centres of Arkhangai aimag and Ulziit soum centre of Uvurkhangai aimag between 2008 and 2010. But the equipments have been damaged and the wells are no longer available for use.

According to definition by the National Statistics Committee, soum centre and rural people are included in Rural Population. But depending on their different water consumption norm, these people have been divided into soum centre consumer and rural consumer, and their water consumption and water demand have been calculated as follows (Table 11).

Table 11. Water consumption and water demand by soum centre people

№	Aimag	Soum	Population, *thous. person*				Water consumption, *thous. m^3/year*			
			2008	2010	2015	2021	2008	2010	2015	2021
1	Arkhangai	Battsengel	1.1	1.1	1.0	1.1	2.4	3.1	4.5	6.8
2		Bulgan	0.9	1.0	1.0	1.0	2.0	2.8	0.0	0.0
3		Ikhtamir	1.2	1.1	1.0	1.1	2.6	3.1	4.5	6.9
4		Ugiinuur	0.6	0.6	0.6	0.6	1.2	1.8	2.7	4.1
5		Ulziit	0.8	0.8	0.8	0.8	1.8	2.3	3.4	5.2
6		Tuvshruulekh	1.9	1.1	1.1	1.1	4.1	3.2	4.7	7.1
7		Khotont	1.3	0.8	0.8	0.8	2.8	2.3	3.4	5.1
8		Tsenkher	1.0	1.0	1.0	1.0	2.1	2.8	4.1	6.3
Total of Arkhangai			8.7	7.3	7.2	7.4	19.0	21.5	27.3	41.5
1	Bulgan	Mogod	0.6	0.6	0.6	0.6	1.4	1.7	2.5	3.7
2		Orkhon	1.0	1.0	0.9	1.0	2.1	2.8	4.1	6.2
3		Saikhan	0.9	1.2	1.2	1.2	1.9	3.5	5.2	7.8
4		Khishig-Undur	1.3	1.3	1.2	1.3	2.9	3.7	5.4	8.1
Total of Bulgan			3.8	4.0	3.9	4.0	8.3	11.7	17.1	25.9
1	Orkhon	Jargalant	2.3	1.1	1.2	1.4	4.9	3.2	5.4	9.1
Total of Orkhon			2.3	1.1	1.2	1.4	4.9	3.2	5.4	9.1
1	Uvurkhangai	Bat-Ulzii	2.2	4.1	4.1	4.2	4.9	11.9	17.6	26.9
2		Yesunzuil	0.9	0.9	0.8	0.9	1.9	2.5	3.7	5.6
3		Ulziit	0.9	0.6	0.6	0.6	1.9	1.6	2.4	3.7
4		Uyanga	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5		Khujirt	3.1	2.9	2.9	2.9	6.8	8.4	12.4	18.9

№	Aimag	Soum	Population, *thous. person*				Water consumption, *thous. m³/year*			
			2008	2010	2015	2021	2008	2010	2015	2021
Total of Uvurkhangai			7.1	8.4	8.3	8.6	15.5	24.5	36.1	55.1
1	Selenge	Altanbulag	3.6	4.1	4.1	4.2	7.9	11.9	17.7	27.2
2		Baruunburen	1.3	1.3	1.3	1.3	2.9	3.7	5.6	8.6
3		Orkhon	1.1	1.0	1.0	1.1	2.3	3.0	4.4	6.8
5		Saikhan*	7.4	6.7	6.7	7.0	16.3	19.7	29.3	45.1
6		Sant	1.4	1.6	1.6	1.6	3.0	4.6	6.9	10.5
7		Khushaat	0.9	1.0	1.0	1.0	2.0	2.9	4.3	6.6
8		Shaamar	3.9	3.8	3.8	4.0	8.5	11.2	16.7	25.6
Total of Selenge			19.6	19.5	19.5	20.3	42.9	56.9	84.8	130.4
1	Tuv	Tseel	1.5	0.6	0.6	0.6	3.4	1.8	2.7	4.1
Total of Tuv			1.5	0.6	0.6	0.6	3.4	1.8	2.7	4.1
Grand total			42.9	41.0	40.8	42.3	94.0	119.7	173.5	266.1

Remark: ** Saikhan soum of Selenge aimag or Khutul city is included in the Kharaa River Basin, but water is abstracted from the Orkhon River floodplain. Therefore, its water consumption is included in soum centre calculation.*

Some boreholes used in the soum centre water supply are being used for other domestic activities such as industry, vegetable irrigation, etc, and not for drinking or domestic purpose.

Local administrative organisations have released and are enforcing the resolution which sets the sanitation zone and build fences 25 m around the wells/boreholes used in water supply and to prohibit building apartment blocks and buildings for industrial and service purposes.

Soum centre inhabitants are consuming 25-30 m³ water per day on an average.

The distance to fetch water from the soum centre water kiosk to the consumer's destination is different and 400 m on average. Water source resource investigations have not been carried out in most soum centres which are supplied from groundwater.

WWTP: there are WWTPs in the basin with a treatment capacity of 100-1400 m³ wastewater per day in Khairkhan soum centre out of 8 soums of Arkhangai aimag and in Orkhon and Mogod soum centres out of 4 soums of Bulgan aimag. These WWTPs are non-operated at this moment due to damage and vandalization.

There is a sewerage network in Jargalant soum of Orkhon aimag and a WWTP was established in 1989 with a capacity to carry out mechanical treatment at 400 m³ wastewater per day. Due to absence of service during the operation of the soum centre WWTP, its technological mode has been lost and wastewater passes through the plant with no treatment. Currently, the wastewater is only disinfected and drained by percolating it down to soil.

A WWTP with a capacity to carry out biological treatment at 450 m³ wastewater per day was established in Altanbulag soum of Selenge aimag in 1970 and a WWTP with a capacity to carry out biological treatment of 200 m³ wastewater in Baruun soum in 1990, respectively. But these WWTPs are not operating and only function to receive and drain wastewater without any treatment.

A WWTP with a capacity to carry out mechanical treatment at 200 m³ wastewater per day was established in Sant soum of Selenge aimag in 1980 and the plant discharges its treated wastewater into Yeven River. At the time the plant used to receive and treat 190 m³ wastewater per day. But currently, this plant is out of service and vandalized. In recent years wastewater is discharged into the Yeven River without any treatment. However, there is a water supply and sewerage network in the soum.

A WWTP was established in in Shaamar soum of Selenge aimag in 1973 with a capacity to carry out mechanical treatment of 200 m^3 wastewater per day and to percolate down to soil. The plant has been vandalized as it hasn't been used for a while.

Figure 13. Soum centre WWTP and bio pond

Saikhan soum of Selenge aimag (Khutul city) is a large settled area with sewerage network and WWTP. The plant was established in 1985 with a capacity to carry out biological treatment of 3000 m^3 wastewater per day and to percolate down to soil. Now the plant receives and treats 2600 m^3 wastewater from economic entities, organisations and apartment buildings a day. Since it was established, routine maintenance has been carried out on a regular basis. Consequently, the plant now operates normally, treats and disinfects wastewater with more than 85% treatment level, and drains treated wastewater by percolating down to soil and evaporation.

A WWTP with a capacity to carry out mechanical treatment of 100 m^3 wastewater was built in Ulziit soum of Uvurkhangai aimag in 1976, but the plant is not operating at this moment. A wastewater borehole with internal layer and a capacity of 30 m^3 is being used in a kindergarten in Bat-Ulzii soum and a hospital in Khujirt soum, respectively.

Khujirt sanatorium WWTP nearby Khujirt soum of Uvurkhangai aimag treats 90 m^3 wastewater up to 60% treatment level per day and percolates its treated wastewater down to soil. Elma Khujirt sanatorium WWTP has a capacity to carry out biological treatment of 20 m^3 wastewater per day. At this moment, the plant treats 12 m^3 wastewater per day. The WWTPs of Khujirt, Elma Khujirt, Bu-Ba-Se sanatoriums and Gem Khujirt spa bottling factory are no longer able to meet the sanitation and technical requirements. Therefore, new WWTPs with modern technology, high productivity and high treatment indicator are urgently needed to be established in the near future.

A sewerage network and WWTP operated normally in Orkhon soum of Darkhan-Uul aimag prior to 1990 or during operation period of vegetable processing factory that was established with support of People's Republic of Bulgaria (former). This WWTP was established in 1981 with a capacity to carry biological treatment of 200 m^3 wastewater per day and used to treat 140 m^3 wastewater per day and discharge its treated wastewater into the Orkhon River. The water supply and sewerage network is completely available to be restored and used.

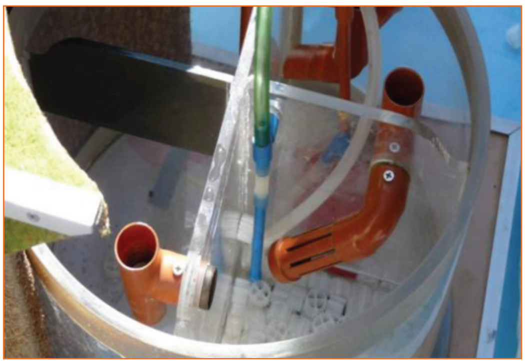

Figure 14. Secondary school WWTP in Orkhon soum of Darkhan-Uul aimag

Within the framework of the MoMo project which is being implemented in Mongolia by Germany, a mini-biological WWTP with treatment capacity of 10 m^3 wastewater per day has been established near the school in Orkhon soum and it is achieving a good result.

2.2.2. Rural people (herdsmen and farmers)

Rural people include herdsmen and farmers who run agricultural businesses in the basin. Water demand by herdsmen who run pastoral farming depending on natural difficulties are supplied from the wells that are established for livestock watering as well as open water such as rivers, springs and streams. In other words, water supply for both herdsmen families and livestock is from the same water source.

In recent years herdsmen have been turned into settled form from traditional pastoral farming in a way of running farm and intensified farm. Farmers who run intensified livestock farm and crop industry established drilled wells in their dwellings.

Rivers and springs in the Orkhon River Basin have plenty of runoff and fresh water on a regular basis, and mineralisation in surface and ground water is a low.

Figure 15. Water source for rural people and livestock

Monitoring is not carried out on drinking water quality for rural people on a regular basis. Also there isn't any particular policy on water supply for herdsmen. However, a number of projects and programmes are being implemented by the government.

The Orkhon River Basin boundary is determined by the watershed of the Orkhon River and its tributaries. Data and information related to water consumers and water users is released by soum which is a territorial administrative unit. In the event of the basin boundary partially dividing the soum territory, the rural population in the basin has been determined by the pastoral area included in the basin (Table 12).

Compared to 2008, the rural population in 2010 was not increased, but decreased by 3.5%.

Table 12. Water consumption and water demand by soums' rural people included in the Orkhon River Basin

№	Aimag	Soum	Population, *thous. person*				Water consumption, *thous. m³/year*			
			2008	2010	2015	2021	2008	2010	2015	2021
1	Arkhangai	Battsengel	2.8	2.7	2.7	2.7	6.0	7.9	9.7	14.9
2		Bulgan	1.5	1.5	1.4	1.5	3.2	4.3	5.3	8.1
3		Ikhtamir	2.9	3.1	3.1	3.1	6.4	9.1	11.2	17.2
4		Ugiinuur	2.0	2.0	1.9	2.0	4.5	5.7	7.1	10.9
5		Ulziit	2.2	2.2	2.2	2.3	4.9	6.5	8.1	12.4
6		Tuvshruulekh	1.5	2.2	2.2	2.2	3.4	6.4	7.9	12.1
7		Khashaat	0.4	0.4	0.4	0.4	0.9	1.1	1.3	2.0
8		Khotont	3.5	3.5	3.5	3.6	7.7	10.3	12.7	19.6
9		Tsenkher	4.4	4.4	4.4	4.5	9.7	13.0	16.0	24.6
Total of Arkhangai			21.3	22.0	21.7	22.3	46.7	64.3	79.1	121.9
10	Bayankhongor	Erdenetsogt	0.7	0.7	0.7	0.7	1.5	2.0	2.4	3.7
Total of Bayankhongor			0.7	0.7	0.7	0.7	1.5	2.0	2.4	3.7
11	Bulgan	Bugat	0.3	0.3	0.3	0.3	0.6	0.8	1.0	1.5
		Bulgan	1.1	0.8	0.8	0.8	2.5	2.2	2.8	4.2
12		Buregkhangai	0.6	0.6	0.6	0.6	1.2	1.8	2.2	3.4
13		Mogod	1.5	1.6	1.5	1.6	3.3	4.5	5.6	8.6
14		Orkhon	2.0	2.0	1.9	2.0	4.3	5.7	7.0	10.8
15		Saikhan	1.9	1.7	1.7	1.7	4.2	4.9	6.0	9.3
16		Khangal	0.1	0.1	0.1	0.1	0.2	0.3	0.3	0.5
17		Khishig-Undur	1.0	1.0	1.0	1.0	2.3	3.0	3.7	5.7
Total of Bulgan			8.5	8.0	7.8	8.0	18.6	23.3	28.6	44.0
18	Darkhan-Uul	Orkhon	0.3	0.3	0.3	0.4	0.6	1.0	1.3	2.0
Total of Darkhan-Uul			0.3	0.3	0.3	0.4	0.6	1.0	1.3	2.0
19	Orkhon	Orkhon	3.5	0.0	0.0	0.0	7.7	0.0	0.0	0.0
		Jargalant	0.8	1.8	2.0	2.3	1.7	5.3	7.4	12.6
Total of Orkhon			4.3	1.8	2.0	2.3	9.4	5.3	7.4	12.6
20	Uvurkhangai	Bat-Ulzii	4.0	2.3	2.3	2.3	8.7	6.7	8.3	12.8
21		Yesunzuil	0.6	0.6	0.6	0.6	1.4	1.7	2.1	3.3
22		Zuunbayan-Ulaan	0.6	0.7	0.7	0.7	1.2	2.0	2.5	3.8
23		Ulziit	0.7	0.8	0.8	0.8	1.5	2.3	2.9	4.4
24		Uyanga	0.6	0.7	0.7	0.7	1.3	2.0	2.5	3.8
25		Kharkhorin	3.2	3.4	3.3	3.4	7.0	9.8	12.2	18.9
26		Khujirt	3.5	3.9	3.9	4.0	7.8	11.5	14.2	22.0
Total of Uvurkhangai			13.2	12.3	12.2	12.6	28.9	36.0	44.6	69.0
27	Selenge	Altanbulag	0.3	0.4	0.4	0.4	0.8	1.0	1.3	2.0
28		Baruunburen	1.4	1.6	1.6	1.6	3.0	4.6	5.7	8.9
29		Zuunburen	0.4	0.5	0.5	0.5	0.9	1.4	1.7	2.7
30		Orkhon	0.9	1.1	1.1	1.1	2.0	3.1	3.9	6.1
31		Orkhontuul	1.4	1.7	1.7	1.7	3.2	4.8	6.1	9.4
32		Saikhan	0.4	1.0	1.0	1.0	0.9	2.9	3.6	5.6
33		Sant	0.7	0.7	0.7	0.7	1.5	1.9	2.4	3.7
		Sukhbaatar	0.2	0.1	0.1	0.1	0.5	0.4	0.4	0.7
34		Khushaat	0.4	0.4	0.4	0.4	0.8	1.2	1.5	2.4
35		Shaamar	0.2	0.1	0.1	0.1	0.5	0.3	0.4	0.6
Total of Selenge			6.4	7.4	7.4	7.7	14.0	21.6	27.0	42.1
36	Tuv	Tseel	0.6	1.2	1.2	1.2	1.2	3.5	4.3	6.6
Total of Tuv			0.6	1.2	1.2	1.2	1.2	3.5	4.3	6.6
Grand total			55.2	53.7	53.4	55.2	120.9	156.9	194.7	302.0

2.3. Conclusion on water supply, sewerage and water consumption for people

The following conclusions have been made based on the current status of water supply and sewerage, sanitation and water consumption for people in the Orkhon River Basin:

- Orkhon River and its tributaries originate from branches of the Khangai Mountain and they have plenty streams and springs which contain a variety of minerals and chemical elements that are used in water and mud therapies. Therefore, it is necessary to carry out study on their resources, quality and composition, to set their protection zones and to improve their use;
- most people in aimag and soum centres are supplied from non-centralized water supplies and systems need to be expanded to connect them to a centralized water supply in the future;
- measures should be taken to improve efficient water consumption by installing tap devices, shower sprinklers and tanks in toilets of public utility service establishments connected to the centralized water supply e.g. apartment blocks, hotels, schools and hospitals, i.e.;
- There is experience e.g. in China and Germany, to treat wastewater from domestic consumption (water consumed for washing body and clothes) by collecting it in the basement or the 1st floor of a building and reuse it in toilets. This is called 'grey water'. Measures need to be taken to include this good experience in the design of new buildings;
- Rural people who run pastoral farming and their livestock use the same water source. It is necessary to provide mini-portable water treatment equipment to nomadic herdsmen in areas where the mineral content and hardness of water is high and surface water is scarce, and to help them to become accustomed to filtration of drinking water before use;
- It is important to make planning for urban area and mining processing factory which will be newly established and to implement the plan within the framework of the Water National Programme approved by the State Great Khural (Parliament) in 2010 on the ground of e.g. carrying out monitoring on the current status of water supply sources for cities and urban areas, newly setting their sanitation zone and recharge area, bringing them under local protection and determining regime to be enforced i.e.

3. Water use and water demand by manufacturing industry

The manufacturing industry consists of light industry, food industry, mining industry, energy industry and construction and building material industry.

3.1. Food industry

Every year the number of large and small food factories is increasing in all the aimag centres and soums located in the Orkhon River Basin. Most of these factories have been established for the purpose of supplying the local demand of the main food products. E.g. small bread and bakery factories are in operation based at each aimag and soum centre, and supply not only local demand, but also supply lunch demand of school children and food demand of kindergarten children.

Figure 16. Food industry products

Everyday bread and pastry production is different in each factory. However the water use is calculated depending on type and quantity of above products. But it's not possible to calculate the actual water consumption as the output is different according to factory capacity, consumers' purchase power, demand and supply.

Bulgan aimag flour factory has a capacity to produce 11500 ton flour and 18000 ton mixed fodder and fodder in granules on an annual basis. Its water demand is supplied from a borehole.

There have been factories of food, flour, spirit, asphalt and concrete, and elevator for granule storage, and thermo-power plant in Kharkhorin soum of Uvurkhangai aimag. But these factories are currently not operating.

There are some factories of food, flour, bread and pastry operating in Sukhbaatar city of Selenge aimag.

Water use and water demand have been calculated according to the average annual output growth 6.9% in the Regional Development Programme (Table 13).

Table 13. Water use and water demand by food industry

Year	2008	2010	2015	2021
Water use, thous. m^3/year	242.3	127.0	177.3	264.6

Factories based at aimag centres and large settled areas are mostly connected to water supply and sewerage network. But soum centre factories are subject to transported water supply as there is no water supply and the wastewater is discharged without treatment.

Some equipment designed to screen and clarify solid wastes have been installed in large food factories prior to delivering their wastewater to the WWTP.

3.2. Light industry

There are some factories of carpet, knitting, felt and felt footwear in Erdenet city and these factories use water from the centralized water supply for their technological demand. In other cities and soum centres, some knitting and felt craft products are manufactured with support from the Small and Medium Enterprise Development Fund. But there is no data and information on their output at the basin level. Therefore, it's not possible to calculate its water consumption.

Figure 17. Erdenet carpet factory

Water use and water demand by light industry has been calculated according to the average annual output growth 6.9% in the Aimags' Regional Development Programme of Khangai Region (Table 14).

Table 14. Water use and water demand by light industry

Year	2008	2010	2015	2021
Water use, thous. m^3/year	176.4	136.4	190.4	284.2

Aimag and soum centre small factories mostly don't have water supply and sewerage network and have transported water or a borehole water supply. Therefore, wastewater is discharged without treatment.

3.3. Mining industry

Strategically important large deposits are located in the Orkhon River Basin. These are the Erdenet copper mining factory and over 20 gold mining companies e.g. Altandornod Mongolia LLC, Altan Yondoi LLC, Mongol Gazar LLC, Gatsuurt LLC i.e. that run gold mining activities in the basin. Also coal mining is being carried out in Ereen coal deposit in Saikhan soum of Bulgan aimag.

Mongol Gazar LLC holds some licenses to run gold exploration and mining activities in river valleys of Ul, Shiirt, Ulaan Chuluut, Ulziit Teel Rivers in Tsenkher soum of Arkhangai aimag where the Orkhon River runoff is originated as well as in Zuun Sudut area in Bat-Ulzii soum of Uvurkhangai aimag. Also ethyl mining activity is being run in

Shiirtiin Salaa and Kharguit areas, etc in the territory of Tsenkher soum of Arkhangai aimag. All above areas are included in the Orkhon River Basin.

Water use for 11 large mining companies that run mining activities in the basin has been calculated as of 2008 and 2010 (Table 15 and Table 16). The water source of the Erdenet ine is along the Selenge river in the Selenge River Basin and therefore the water use of this mine is to be included in the Selenge River Basin.

Figure 18. Gold mining in the territory of Tsenkher soum, Arkhangai aimag

Figure 19. Former mining site undergone technical and biological rehabilitation by Mongol Gazar LLC

Table 15. Water use by mining industry in 2008

№	Aimag	Soum	№	Deposit	Water use, thous. m³/year
1	Arkhangai	Tsenkher	1	Ulziit Teel	7.0
			2	Kharguitiin Baruun Salaa	538.0
		Tuvshruulekh	3	Beren	543.9
2	Selenge	Orkhontuul	4	Tsagaan Gozgor	86.7
	Uvurkhangai	Uyanga	5	Asgatiin Darkhad	46.6
		Bat-Ulzii	6	Khongilt	23.3
			7	Zuunsudut	336.3
3	Orkhon	Bayan-Undur	8	Erdenetiin Ovoo	14300.0
Total					15881.8
Total water use in Orkhon River Basin					1581.8

Table 16. Water use by mining industry in 2010

№	Aimag	Soum	№	Deposit	Water use, *thous. m³/year*
1	Arkhangai	Tsenkher	1	Bavgariin Am	142.8
			2	Kharguitiin Baruun Salaa	300.1
			3	Ult and Ulaan Chuluut	21.9
			4	Ulaan Chuluut	14.7
			5	Shiirtiin Salaa. Yastiin Am	22.2
			6	Uliin	22.2
			7	Khar Chuluut	8.7
			8	Shiirtiin Salaa	21.2
		Tuvshruulekh	9	Beren	576.7
2	Orkhon	Bayan-Undur	10	Erdenet	15118.0
3	Uvurkhangai	Bat Ulzii	11	Zuun sudut	212.8
4	Selenge	Orkhontuul	12	Tsagaan Gozgor	79.1
Total					16540.4
Total water use in Orkhon River Basin					1422.4

The water use of these mining companies is based on data and information on water use obtained from the mining companies' experts in charge of water supply.

Compared to 2008, water use by mining industry increased by 3% in 2010. Water demand by mining industries has been calculated to be increased by 10.5% considering the industrial growth and water demand by factories which will be newly established or expanded every year (Table 17).

Table 17. Water use and water demand by mining industry

Year	2008	2010	2015	2021
Water use excluding Erdenet mine, *thous. m³/year*	1581.8	1422.4	2,368.3	4,311.4
Total water use, *thous. m³/year*	15881.8	16540.4	17368.3	19311.8

The government of Mongolia is adhering to a policy on developing a copper industry based on the Erdenet copper mining factory. It's been also included in Aimags' Development Programmes to develop mining and processing factories.

Figure 20. Erdenet copper mining factory

In recent years, it has been planned to improve the capacity of the Erdenet mining factory, to establish copper mill, to renovate thermo-power plant and to establish a new hydro-power plant with a capacity of 10MBt on the Orkhon River. Water use by Erdenet mining factory is expected to increase by 1% every year. But water use by Erdenet carpet factory, steel mill in Beren, spirit and flour factories in Bulgan, thermo-power plant in Erdenet, cement and lime factory in Khutul and thermo-power plant in Sukhbaatar city are likely to increase by 3% every year as a goal has been set to improve the capacity of these factories.

There are common deficiencies among the mining companies running activities in the Orkhon River Basin (except Erdenet mining factory) e.g. percolation of their domestic wastewater down to soil without pre-treatment and disinfection, and discharge of industrial wastewater into the river without treatment. It's been many years since both direct and indirect pollutions of surface and groundwater started to have a negative impact on human health, nature and ecology.

Figure 21. Erdenet factory wastewater collecting dyke and reservoir

In the future, mining companies have to comply with some clauses on maintaining ecological balance that are specified in Mongolian Law on Nature Conservation.

Due to the fast development of the mining industry, water demand by this industry is significantly increasing. Therefore, it's important to launch a technology which reuses wastewater in mining industry.

Recently there is a lot of discussion on transfer and use of the Orkhon River water, and the related feasibility study has been started on the detailed investigation and calculation of the dam and reservoir. In order to supply water demand of other basins especially south Gobi, water is collected from the Orkhon River, regulating its runoff and transferring water from the river.

3.4. Energy and heating industry

Aimag centres, soum centres and large settled areas in the Orkhon River Basin are connected to the mains of the Central Region. There is a thermo-power plant in Erdenet city of Orkhon aimag, thermo plant in Sukhbaatar city of Selenge aimag and solid-fuel-burning heating stove in Arkhangai and Bulgan aimags for energy and heating supply for apartment buildings, offices and factories in the cities.

In 1960 Chinese experts established a hydropower plant with a capacity of 528 kBt on the main channel of the irrigation system in Kharkhorin of Uvurkhangai aimag. The plant used to supply energy to Kharkhorin soum centre until it was connected to the / high voltage/ power line and supplied energy to sprinkling machines of the irrigation system. As these generators have been damaged, they are now unused.


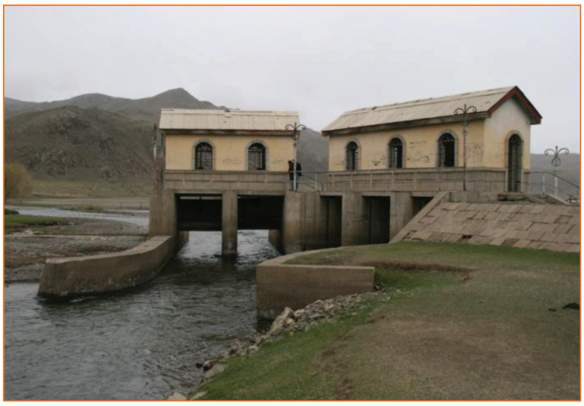

Figure 22. Hydropower plant established on main channel of Kharkhorin irrigation system

The water use and water demand has been calculated by water use norm by obtaining data and information on annual water use from Erdenet thermo-power plant and Sukhbaatar thermo plant producers, and by obtaining data and information on heat produced by Tsetserleg and Bulgan cities from the statistics information, respectively.

Table 18. Water use and water demand by energy and heating industry

Aimag	Product name, quantity, water use and water demand											
	2008			2010			2015			2021		
	Energy, mil.kbt.hour	Heat, Thous.gkal	Water use, Thous. M³/year	Energy, mil.kbt.hour	Heat, Thous.gkal	Water use, Thous. M³/year	Energy, mil.kbt.hour	Heat, Thous.gkal	Water use, Thous. M³/year	Energy, mil.kbt.hour	Heat, Thous.gkal	Water use, Thous. M³/year
Arkhangai	-	12.6	12.6	-	20.0	20.0	-	26.8	26.7	-	38.0	37.9
Bulgan	-	16.4	16.4	-	24.3	24.3	-	32.5	32.5	-	46.1	46.1
Orkhon	114.0	619.0	1200.0	103.0	541.0	1500.0	138.1	724.5	2007.3	195.9	1027.7	2847.4
Selenge	-	143.0	226.0	-	160.0	160.0	-	214.2	214.1	-	303.9	303.7
Total	114.0	790.7	1454.6	103.0	745.8	1704.3	138.1	998.0	2280.6	195.9	1415.8	3235.1

The annual growth of energy consumption is 5.0% at national level in recent years and it has been calculated to be 6.0% according to the IWRM plan.

Energy supply tends to become insufficient due to the rapid increase of energy and heat consumption by energy system from year to year.

Therefore, it is necessary to supply the increasing energy demand in Mongolia, to tackle infrastructure issues followed by mining, and the government needs to solve issues related to the safe operation of the energy industry in complex manner. In achieving this goal, it is necessary to come up with some necessities e.g. lengthen power transmission network line, renovate and expand thermo-power plants in Darkhan and Erdenet cities which need a fuel and water resource, and establish a new thermo-power plant in some areas i.e. At the same time, it is necessary to tackle issues on their water use in a rational way.

4. Water consumption–use and water demand in agricultural sector

4.1. Pastoral farming

Pasture use is directly associated with water supply for livestock. The way of running pastoral farming is changing it appears in recent years depending on the necessity of socio-economic development and climate change.

As of 2010, over 500 rivers, 600 springs and 3200 engineering designed and hand wells have been used in the Orkhon River Basin.

Figure 23. Water sources used for watering livestock in pasture area

Depending on livestock water supply conditions, pasture use has been limited and herdsmen settled near open water area for long periods of time during warm seasons. It leads to loss of restoration opportunity of pasture vegetation and to loss of pasture grazing. Cattle which is a marketable product comprises merely 5.2%-5.9% of all livestock at the basin level.

Livestock number and average annual water consumption in the basin's soums have been calculated based on the result of the state census on livestock in 2008 and 2010 by the National Statistics Committee of Mongolia; the livestock growth projection for 2015 and 2021; and the researchers' conclusions which determined the water consumption norms for livestock per day on seasonal basis.

Table 19. Water consumption and water demand of livestock in the basin (by aimags)

№	Aimag	Livestock number, *thous. head*				Water consumption, *thous. m3/year*			
		2008	2010	2015	2021	2008	2010	2015	2021
1	Arkhangai	1508.4	1041	1226.3	1202.7	3782.6	2676.0	3876.6	4734.4
2	Bayankhongor	18.6	21.4	25.5	24.2	61.2	71.8	111.6	146.9
3	Bulgan	801.2	706.8	884.9	917.8	1919.8	1793.3	2586.1	3119.8
4	Darkhan-Uul	29.5	16	23.8	28.4	72.9	49.5	74.8	96.9
5	Orkhon	268.9	169.2	213.5	224.7	581.9	426.3	545.3	642.9
6	Uvurkhangai	632.4	401.2	447.9	420	1498.0	957.5	1337.0	1584.4
7	Selenge	575.7	495.5	719.5	855.4	1239.6	1188.6	1682.9	2048.2
8	Tuv	62.6	64.9	107.7	156	134.6	148.9	208.5	247.0
Total		3897.3	2916.0	3649.1	3829.2	9290.6	7311.9	10422.8	12620.6

Some initiatives are being carried out aimed at improving pasture use e.g. establishing herdsmen's groups, having winter and spring camps area owned by herdsmen, joint pasture use by them, establishing new boreholes based on their demand and ownership of such wells.

It is stated in the state policy on food and agriculture that it is necessary to increase engineering and ordinary wells and water points, to improve their ownership and use, and to improve water supply for pasture to use water resources efficiently. Accordingly, the related framework for livestock water supply has been organised in two phases. At first phase, some 2.9 thousand wells have been restored financed from the state budget at MNT7.1 billion in 1998-2008. At second phase, 2.5 thousand new wells were established by financing from the state budget at MNT26.8 billion in 2004-2010.

At this moment, there is no artificial lake or pond which is established for the purpose of water supply for people and agriculture in the basin. But study and design to establish ponds for livestock watering and crop irrigation have been started in some soums from 2010. Also the required investment has just been provided by the Ministry of Nature, Environment and Tourism.

Figure 24. Pond in pasture area

It is considered to establish runoff-regulating reservoir for livestock watering and crop irrigation on several potential dam sites on the Orkhon River.

Also water investigation has been carried out in some 5 aimags financed from the state budget at MNT300 million in 2008 in order to identify water points to establish new wells in pasture area of soums included in the basin. As a result, some 438 water points have been identified. 9 aimags have undergone water investigation with state budget of MNT 500 million in 2010.

Within the framework of projects and programmes implemented by foreign countries and international financial organisations (ADB, IFAD, WB, UNDP, JICA and KOICA), they have supported and contributed herdsmen by spending MNT4.9 billion for restoration of 1.6 thousand old wells and MNT860 million for establishing 96 new wells.

4.2. Irrigation

The Orkhon River Basin belongs to the Khangai and Central Regions of economic development and is located close to marketplaces. It is an area with favorable natural and climate conditions for agricultural development. Most parts of the basin are suitable for crop farming according to assessment on soil quality. Traditionally, locals used to do crop farming. Irrigation systems currently used in the basin are shown in Table 20.

Figure 25. Sprinkler machine and reservoir used in irrigated area

Table 20. Irrigation systems used in the Orkhon River Basin (as of 2010)

	Aimag	Soum	№	Irrigation system name	Capacity, ha
1	Arkhangai	Battsengel	1	Suultolgoi	136.0
		Khotont	2	Tsagaan Sumiin Gol	122.0
2	Bulgan	Orkhon	3	Kheltgii Nuga	52.0
			4	Shuvuut River	76.0
3	Orkhon	Jargalant	5	Ulaan Tolgoi	137.0
			6	Khangal River	70.0
			7	Jargalantiin Khundii /valley	136.0
4	Uvurkhangai	Kharkhorin	8	Kharkhorin	540.0
5	Selenge	Zuunburen	9	Zurkhangai	45.0
			10	Erkhetiin Nuga	100.0
		Khushaat	11	Orkhon Khushaat	249.0
			12	Mandaliin Bulan	83.0
			13	Rashaant	162.0
			14	Zeenegeriin Khotgor	388.0
			15	Khuduu Kharaat	40.0
		Orkhon	16	Gurvan Sertengiin Khundii	100.0
		Orkhontuul	17	Shar Usnii Khooloi	129.0
			18	Salkhit	80.0
		Baruunburen	19	Iveelt	213.0
			20	Khundiin Amnii Adag	190.0
			21	Zuunmod	210.0
		Sant	22	Tsagaan Tolgoi	1265.8
			23	Mukhar Buduun	158.7
Total					4682.5

Most economic entities which are using irrigation systems don't completely use their area and don't comply with replacement, fertilizer and irrigation norms but depend on their own initiative, knowledge and experience. Over 60% of currently used irrigation systems are located in the Selenge aimag.

Irrigation water use depend on seedling growth, air temperature and humidity. In the event of irrigation comes from groundwater, water consumption for irrigated area has been calculated by irrigation norm minimum indicator considering that it can't reach norm amount depending on high energy cost.

Table 21. Water use and water demand of irrigated area

Irrigated area, ha				Water consumption, *thous. m^3/year*			
2008	2010	2015	2021.0	2008	2010	2015	2021
3728.2	4666.0	7452.3	11426.7	10374.5	12259.2	21,092.6	32,389.2

According to studies carried out by the related ministries and scientists, 124 new irrigation systems with a capacity of irrigating 43.7 thousand ha area in the Orkhon and Tuul River Basins can be established and old irrigation systems with a capacity of irrigating 16.9 thousand ha area can be restored and used. A total area of 60.6 thousand ha.

Irrigation will guarantee a regular harvest and supply the increasing demand of food/ fodder for people/intensified livestock in the basin.

Within the framework of programme to support the 'Third Campaign for Cultivation of Arid Land' by the government of Mongolia, crop industry has been rehabilitated, unused irrigation systems have been restored and significant amount of investment has been spent for this campaign. As a result, 3 old irrigation systems covering 193 ha area have been restored and 7 new irrigation systems covering 1145 ha area have been established in the Orkhon River Basin from 2008 to 2010.

As the crop industry is intensively developed in the basin, groundwater as water source of irrigated area is likely to increase. But it violates the clause of the National Security Concept that 'limits groundwater consumption in crop irrigation and limits drinking water consumption in non-food industry sector...'. Groundwater is used in irrigation systems at Ulaan Tolgoi area in Jargalant soum of Orkhon aimag and at Mandaliin Bulan and Khuduu Kharaat areas in Khushaat soum of Selenge aimag.

Main seedlings planted in irrigated areas are grains, vegetables, sea-buckthorn and fruit bushes.

The aim to harvest 25-30% of grains and fodders from irrigated area is stated in the State Policy on Food and Agriculture and the Water National Programme. Accordingly, it has been planned in the IWRM plan to increase the irrigated area size by 4% every year in this basin starting from the 2010 level which is the most potential area for crop irrigation.

4.3. Farming

Due to the necessity of a sustainable safe food supply for people in urban areas, intensive livestock farming development is now becoming an important goal in increasing food industry. In order to enforce the state policy on herdsmen approved by the State Great Khural (Parliament) and the related clauses of the Mongolian Law on Small and Medium sized Enterprise, some measures are being taken such as turning herdsmen families into small and medium enterprisers and supporting their businesses by granting a loan from the government, etc.

For herdsmen households in the Orkhon River Basin, they are enabled to develop farming or intensive farming by receiving financial assistance and by taking their advantages e.g. relatively good infrastructure and close location to large urban areas i.e.

Intensive farming is different from pastoral farming by breeding livestock with a high productivity and feeding them with water and fodder and keeping them in warm fences and shelters in manner of a fully-settled or semi-settled farming. In other words, more products can be produced by ensuring a good living condition, water and fodder for livestock.

Fodder is required to be plant on irrigated area for more harvesting. In recent years, the number of farmers is increasing in the vicinity of urban areas. But intensive farmers are limited to plant a their own fodder due to lack of sufficient area for plantation of such fodder and lack of technical supply. Therefore, they usually purchase fodder from the market which does not enable them to decrease their products' price.

Water consumption by both livestock and irrigated area which are owned by intensive farmers have been calculated and are shown in Table 19 of section 4.1 and Table 21 of section 4.2.

In recent years there is a trend that farmers and economic entities dominantly develop greenhouses in the Orkhon River Basin for the purpose of a sustainable harvest of some vegetables on a regular basis.

4.4. Recommendations on water supply for agriculture

- Recently many wells and water points have been established with financial support from the state budget, foreign and national projects and special funds aimed at improving water supply for livestock. It is necessary to make conclusion on unavailability of irrigated area for number of livestock which is intensively increasing recent years due to significant percentage of newly established wells and water points are established near damaged and vandalized old wells;
- To establish new wells for livestock water supply based on ownership by herdsmen group and organization of operation and maintenance;
- Drought and evaporation of soil water have increased and many rivers stopped flowing in recent years. Consequently, there is a lack of water sources of some irrigation systems which were established based on runoff of these rivers. It is necessary to study the benefits to establish hydro-technical construction with runoff regulation, dam and dyke on rivers with constant runoff;
- To increase percentage of fodder especially plant fodder in irrigated areas;
- If there is an urgent need of groundwater use in irrigated area, it is necessary to carry out a complete hydrogeological investigation and study and to determine the groundwater recharge regime and groundwater water resource;
- It is necessary to widely use methods for sustainable harvest in Mongolia: to establish greenhouse made from synthetic film and glass to create warm and humid environment, and to plant vegetables by covering soil by synthetic film and making hole on the film. These methods are to protect soil moisture from evaporation loss and weeds, and to maintain heat.

5. Water consumption and water demand by municipal service sector

5.1. Education, culture and health organisations

There are 6 universities, 7 vocational training centers, 70 schools and 80 kindergartens in the cities located in the Orkhon River Basin involving over 90,000 students and children. Also there are 4 polyclinics and 37 household medical centers in the cities. Every year the number of those who are using social services is increasing. At the same time, expansion and construction works for these service organisations are being performed by finance from the state budget.

For these organisations, water consumption is supplied from the centralized water supply in aimag centers and supplied from transported water in soum centers.

At the basin level, 14.7 thousand people are working at public administrative organisations and other 200 companies and offices. Water consumption for these organisations has been calculated by obtaining data and information from aimags' statistics departments on number of students of university, vocational training centre and general education schools, and inpatients and outpatients of the health centers and medical service centers for household.

Table 22. Water consumption by the cities' public service organisations and offices in the basin (as of 2010)

№	City	Education organisation, thous.students				Health organisation, thous. people			Organisations, *thous. person*	Water consumption, thous. m3/year			
		Kindergarten	General education school	University	Vocational training and industrial centre	Employees	Outpatients	Inpatients		Education organisations	Health organisations	Offices	Total
1	Tsetserleg	3.2	19.6	1.6	1.3	1.2	23.2	23.2	3.9	67.3	28.8	18.9	115.0
2	Bulgan	2.3	10.4	0.7	0.6	0.8	30.6	12.8	3.3	38.9	17.9	16.0	72.8
3	Sukhbaatar	4.9	18.9	1.2	1.4	1.4	27.1	23.3	4.2	76.5	53.8	20.3	150.6
4	Erdenet	4.8	18.1	1.6	1.5	1.2	42.6	17.1	3.3	141.3	42.9	16.0	200.1
Total		15.2	67.0	5.1	4.8	4.6	123.5	76.4	14.7	324.0	143.4	71.2	538.5

Water consumption has been calculated to be 75 l/day per kindergarten child in Erdenet city with the centralized water supply and sewerage network, 37.5 l/day per kindergarten child in other cities and 20 l/day per general education school child based on the water consumption norm approved by the resolution No.153 of the Ministry of Nature and Environment in 1995. Duration of academic year has been calculated to be 180 days for general education schools and kindergartens, duration of working day is 242 for office employees, and 365 days for inpatients, respectively.

5.2. Commercial services

Commercial service is one of Mongolia's oldest sectors that represent a valuable contribution to socio-economic development such as population employment, household revenue increase, poverty reduction and utility culture improvement, etc. The following services in which water is inevitably used in our daily work and service have been selected for water consumption. However, there are many types of utility services.

There are approximately 270 commercial service points such as hairdressers/barbers, bathes, laundry and dry cleanings to serve people in aimag and soum centers included in the basin.

Table 23. Commercial service points

№	Aimag	Number of utility service point (as of 2010)			
		Hairdresser	Beauty salon	Bathes	Dry cleaning
1	Arkhangai	44	4	7	2
2	Bulgan	23	3	5	1
3	Uvurkhangai	8	-	5	-
4	Orkhon	80	22	9	4
5	Tuv	2	-	1	-
6	Selenge	33	7	13	-
Total		190	36	40	7

For water supply, commercial service points in aimag centres are mostly connected to the centralized water supply. But some soum bathes have their own wells and some are supplied by transported water.

There are approximately 300 catering establishments such as restaurants and canteens in aimag, soum centres and other large settled areas.

Table 24. Catering establishments

№	Aimag	Catering establishment (as of 2010)		
		Restaurant	Canteen	Total
1	Arkhangai	33	15	48
2	Bulgan	25	36	61
3	Selenge	56	18	74
4	Orkhon	61	26	87
5	Uvurkhangai	8	12	20
6	Tuv	1	4	5
Total		184	111	295

Water consumption by commercial service and catering establishments has been calculated by method of comparison with approximate number of their clients and price of sold products.

Table 25. Total water consumption by commercial services and catering establishments

№	Aimag	Water consumption (2010), thous. m3/year
1	Arkhangai	15,600
2	Bulgan	4,000
3	Selenge	45,000
4	Orkhon	31,300*
Total		95,900

Remark: ** Water consumption has been calculated by amount of water withdrawn from the Khangal River source which is a tributary of the Orkhon River.*

It has been stated in a draft IWRM plan that the number of those who are involved in the social service sector in the basin is to be 1.4% and annual growth of water consumption in public utility sector is to be 7.6% based on the utility service sector's GDP that included in the Regional Economic Development Programmes, respectively.

Table 26. Water consumption and water demand of the cities' public utilities and social service organisations in the basin

№	City	Water consumption, thous. m³/year			
		2008	2010	2015	2021
1	Tsetserleg	124.0	130.6	145.7	168.9
2	Bulgan	72.9	76.8	83.8	93.8
3	Sukhbaatar	185.8	195.6	226.4	276.2
4	Erdenet	219.9	231.4	259.7	303.3
Total		602.6	634.4	715.6	842.2

5.3. Green area

There is in total 75.3 ha green area in the cities according to the Nature, Environment and Tourism Departments and Governor's Offices in aimags that are included in the basin. Water source for parks and lawn area irrigation is groundwater. Some organisations irrigate their surrounding lawn and green areas by the same water which is consumed for domestic purposes.

In some aimag centres, wells are established for the purpose of irrigating parks/gardens and the irrigation is made by mini-portable sprinkler machine or sometimes mechanically by hand. In recent years, two fountains were established in Erdenet city centre for the purpose of creating a convenient and humid environment for people to spend their leisure time and to feel comfortable.

There are 1-2 green parks in each aimag centre. And offices, factories and economic entities and service organisations provide gardening and ministrations service such as planting lawn, larch, spruce and bushes in their surrounding area. But the cities' landscaping companies are responsible for ministrations, maintenance, expansion and renovation of publicly owned green areas. Amount of green areas as of 2010 is shown in Table 27.

Table 27. The cities' irrigated lawn and green areas' size

№	City or aimag centre	Green area size, ha	Water source
1	Tsetserleg	4.3	Groundwater /borehole/
2	Bulgan	6.7	Groundwater /borehole/
3	Erdenet	56.8	Groundwater /borehole/
4	Sukhbaatar	7.5	Groundwater /borehole/
Total		75.3	-

Figure 26. Green area landscape

In recent years when landscaping the publicly owned parks, not only trees and lawn has been planted, but a complete landscaping and architectural solution including statue, sculpture, illumination and fountain, etc has been carried out and a significant amount of cost is being spent for landscaping works. Cost amount for landscaping and gardening work is approved by local Citizens' Representative's Meeting and the green areas' size has been calculated to increase by 2% every year than the current amount according to the plan.

Table 28. Water consumption and water demand by the cities' green area

Green area, *ha*				Water consumption, *thous. m³/year*			
2008	2010	2015	2021	2008	2010	2015	2021
72.3	75.3	82.8	91.8	144.6	150.6	165.6	182.8

5.4. Flood protection constructions

Dykes and channel constructions were built in some 4 aimag centres and Khangal soum centre of Bulgan aimag included in the basin for the purpose of protection from spring flood, heavy shower and flash floods (Table 29).

Table 29. Flood protection constructions in the basin

№	Aimag	Aimag and soun centre	Type of flood protection		Location	Length of dyke and channel, km
1	Selenge	Sukhbaatar	Dyke		In the north of the city along the Orkhon River	3.4
2	Bulgan	Bulgan		Channel	In the middle of ger area	3.0
3	Bulgan	Khangal	Dyke		In the east of soum	3.0
4	Arkhangai	Tsetserleg	Dyke		In the south-west of the centre	3.5
5	Orkhon	Erdenet		Channel	In the north-west of the centre	6.0
Total						18.9

Tsetserleg city flood protection channel was built in 2007 in the north of a hill beside of Khalzan mountain pass in the south-west of aimag centre. But the aimag governor considered that this is not a rational solution and didn't accept it. Because there is a high risk of a flood through Tsagaan Davaa mountain pass and Arslantai Tsokhio valley located in the north of the aimag centre.

Figure 27. Tsetserleg city flood protection channel

In 2010 a flood protection channel with a concrete and stone lining was built in Bulgan city for the purpose of protecting the city centre and ger area from flood disaster. At this moment, its expansion work is being carried out.

Figure 28. Bulgan city flood protection channel

Sukhbaatar city flood protection dyke and channel were established in the north and north-west of the city as well as along the railway. The dyke along the railway was renovated by foreign investment and additionally equipped with a concrete lining in 2000-2002. But the channel with a length of 3428 m in the north of city hasn't undergone maintenance last 15 years and became unable to pass flood water. Therefore, it is necessary to make a new design and provide maintenance and renovation.

6. Water consumption and water demand by tourism, sanatorium and spa resorts

6.1. Tourism

There are many historical and cultural places in the basin. Based on these areas, over 40 tourist camps have been registered at the basin level. Of these, 34.1% is located in the territory of Arkhangai aimag, 31.7% is in Selenge aimag and 26.8% is in Uvurkhangai aimag. Of these camps, some 21 camps are being normally operated.

Table 30. Tourist camps operating in the Orkhon River Basin

№	Aimag	Soum	Number of tourist camp	Capacity, person/day	Water source
1	Arkhangai	Ikhtamir	4	380	Groundwater (4 boreholes)
2	Arkhangai	Erdenebulgan	1	85	Transported water
3	Arkhangai	Tsenkher	3	190	Tsenkheriin Bulag
4	Uvurkhangai	Bat-Ulzii	1	60	Orkhon River
5	Uvurkhangai	Kharkhorin	6	400	Orkhon River (5 boreholes)
6	Bulgan	Bulgan	2	40	Groundwater (2 boreholes)
7	Selenge	Sukhbaatar	4	95	Orkhon River (2 boreholes)
Total			21	1250	

In 2009, 10% of foreign tourists visited Arkhangai aimag and their trip period was 90 days between June 15 and September 15 according to the study carried out by the Ministry of Nature, Environment and Tourism.

Now there are 10 tourist camps and 2 hunter's camps in Bulgan aimag.

Figure 29. Erdene-Zuu Monastery in Kharkhorin soum

Tourism has been well developed in Kharkhorin soum of Uvurkhangai aimag. And significant percentages of soum citizens solely runs tourism activity in summer time as their income sources are generated from tourism.

Currently 5 tourist camps are operating in Baruunburen soum of Selenge aimag.

Drinking and domestic water consumption by most tourist camps is supplied from groundwater while there is a minority in which water consumption is supplied by water truck and cart. According to study, one tourist camp with a capacity of 50-60 beds consumes 5 ton of water for 3 days when it the most overloaded. Tourist camps have their own open fresh water pipeline and underground wastewater pipeline network which connected to kitchen and sanitation which used during warm seasons.

Figure 30. Amarbayasgalant Monastery in Baruunburen soum

Figure 31. Tourist camps in the basin

Some camps established swimming pool and bathroom in order to provide a convenient condition to their clients and tourists. Most of tourist camps collect their wastewater in wastewater tank which installed underground. And the wastewater is transported by sewer sucking truck and dumped into a particular landfill which permitted by local competent authority.

According to specified in the norm and procedure for ‘Water Supply and Sewerage inside Construction’ (BNbD 40-05-98), when tourist camps are the most overloaded they produce 110 m^3 wastewater per day in terms of wastewater 85 l/day per person.

But some tourist camps cause pollutant source to pollute nature, soil and water environment by directly discharging their wastewater into river and percolating down to soil. Most camps have improved toilet, shower, sink and flush toilet while some camps have only pit latrine.

In developing tourism sector in the future, it’s important to launch mini water supply and sewerage facility for tourist camps, to protect nature and environment and to provide amenity to tourists.

The total water consumption has been calculated based on capacity and operating period of tourist camps, number of received tourists and the water consumption norm. As of 2010, water consumption by all the tourist camps in the Orkhon River Basin amounted to 10.9 thousand m^3. If the sector’s annual water consumption is calculated to be 6.9% according to regional development programmes, water consumption is expected to reach 15.1 thousand m^3/year in 2015 and 18.6 thousand m^3/year in 2021, respectively.

6.2. Sanatorium and spa resorts

There are many hot and cold springs in the Orkhon River Basin and a number of sanatorium and spa resorts have been established and are operating based on these springs.

Figure 32. Sanatorium and spa resorts

There are totally 100 sanatorium and spa resorts at national level based on spas, springs and mud as there are a plenty of them in Mongolia which used for spa, water and mud therapy. As of 2010, only 27 of them have been accredited.

Figure 33. Spa resort

Accredited large sanatorium and spa resorts located in the Orkhon River Basin include Khujirt and Elma Khujirt spa resorts in Khujirt soum of Uvurkhangai aimag, Erdenet spa resorts in Orkhon aimag, Bujinkhen children's spa resort in Selenge aimag, Khudulmur, Suvd and Khasu Mandal spa resorts in Battsengel soum of Arkhangai aimag and Shivert spa resort in Erdenebulgan soum of Arkhangai aimag.

There are 11 spa resorts with a capacity of receiving 1100 clients at the same time in Erdenet city, the centre of Orkhon aimag and some 3 spa resorts in Jargalant soum of Orkhon aimag. And there are few small camps which serve airag (fermented mare's milk) and saam (mare's fresh milk) on a temporary basis.

There are 10 sanatoriums and spa resorts that operate on a regular basis in Bulgan aimag.

Khujirt spa resort located near Khujirt soum of Uvurkhangai aimag established a WWTP with a capacity of treating 90 m^3 wastewater per day in 2002. And wastewater treatment is carried out up to 60% of treatment level at three stages by adding active bio-preparation in the wastewater once in a month. But treated wastewater overflows its spillway, pollutes environment and flows into spring. However, treated wastewater is drained by percolating down to soil. In 2009, Elma Khujirt spa resort established a new WWTP with a capacity of carrying out biological treatment in 20 m^3 wastewater per day and installed P-50, P-20, P-11, P-08 and P-02 equipments that manufactured in Korea. By now, the plant treats 12 m^3 wastewater up to 95% treatment level per day at three stages. Live bacteria added in the wastewater on quarterly basis to activate biological treatment. And its treated wastewater is disinfected and drained by percolating down to soil.

In the future, a new sanatorium and spa resort can be established based on the following springs and spas in the Orkhon River Basin: Bor Tal, Gyalgar and Tsenkher springs in Tsenkher soum of Arkhangai aimag, Tsagaan Sum spring in Khotont soum of Arkhangai aimag, Saikhan Khulij spring in Mogod soum of Bulgan aimag, Gyatruun, Mogoit, Khujirt and Uurtiin Tokhoi springs in Bat-Ulzii soum of Uvurkhangai aimag, etc.

It is considered unnecessary to calculate water consumption for clients of these sanatoriums and spa resorts as they are included in calculation of water consumption for people in the related basin in which their residential areas involved.

6.3. Conclusion on water supply and sanitation for tourism, sanatorium and spa resorts

- To put old WWTPs into operation which are able to be restored amongst unused WWTPs in aimag and soum centres that included in the basin;
- To install a new biological treatment plants with a modern technology in soum centre and tourist camps located in the basin,
- To launch a new technology to carry out biological treatment in wastewater and to create acclimatized/introduced type of microorganism which decompose organic and mineral substances;
- To carry out renovation of machanism and equipment park designed for water supply and sewerage in the required urban areas;
- To establish a new drinking and wastewater monitoring laboratory in aimag centres and to stabilise its operation;
- It's important to launch an advanced technology of nature-friendly sanitation, toilet (bio toilet and dry toilet), treatment and reuse of waste (grey) water for household buildings, offices and tourist camps not connected to the centralized water supply and sewerage system.

7. Construction and building material industry

This sector hasn't well developed in the Orkhon River Basin. There are small and medium enterprises such as cement and concrete factory, brick factory, wood and wooden product factory, straw-bale construction industry, etc in aimag centre and some soums.

Figure 34. Construction work

There are 14 construction and building material producing companies, one ministrations company and one road maintenance company in Arkhangai aimag. These companies not only build new apartment buildings and roads, but carry out the related maintenance and expansion work. Building material factories supplied by sand, commonly spread material from Elstei deposit in Ikh Tamir. Gunjiin Davaa red brick producing company is supplied by mud which is main raw material for producing bricks from Ulaan Baayu deposit in the vicinity of Tsetserleg city. It was planned to build 100 apartment blocks in Arkhangai aimag centre within the framework of the Programme for 100,000 Apartment Blocks.

Construction and building material industry hasn't developed well in Bulgan city of Bulgan aimag, its construction area is a small and its general construction plan has been delayed for the years due to financial difficulty. But new buildings and apartment blocks still built by private companies or individuals. And 40% of investment, construction work and overhaul is being carried out in the city of Bulgan.

There are 3 companies that provide road maintenance and care service and 4 companies that produce construction and building material in Erdenet city, the centre of Orkhon aimag.

Based on wood processing factory in Sukhbaatar city of Selenge aimag, it is planned to supply Sukhbaatar city thermo-plant demand by producing bio-fuel such as pellet and briquette using sawdust and excessive woods from own factory, dead and excessive woods collected from its region. Amount of supplying pellet and briquette is to reduce amount of coal-burning and greenhouse emission. There are Khutul cement and lime factory, steel mill and railway sleeper factory in Saikhan soum.

Industrial wastewater from construction and building material industry is discharged into surrounding environment and percolated down to soil.

Water use and water demand of construction and building material industry has been calculated based on performance by construction companies that run activities in the Orkhon River Basin and data and information of aimags' statistics departments (Table 31).

Table 31. Water use and water demand by construction and building material industry in the basin

Year	2008	2010	2015	2021
Water use, *thous. m^3/year*	430.9	498.4	695.7	1038.2

8. Total amount of water consumption–use and water demand in the Orkhon River Basin

Compared to 2010 or the initial year of the IWRM plan for the Orkhon River Basin, water consumption-use in 2021 or the final year of the IWRM plan is increased by 57%.

Recently, a feasibility study was started for implementing the Orkhon-Gobi project for the purpose of transferring Orkhon River water for people and mining to the South Gobi. The volume of water to be collected in a reservoir which will be newly established for this purpose has not been included in this calculation.

The total water consumption-use and water demand of the basin has been included in Table 32 and Figure 35.

Table 32. Total water consumption-use and water demand in the Orkhon River Basin

№	Water consumer and user	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	Domestic water for the cities' population	3905.2	13.7	4163.4	14.5	6299.4	14.1	6613.1	10.6
2	Domestic water for soum centre population	94	0.3	119.7	0.4	173.5	0.4	266.1	0.4
3	Domestic water for rural population	120.9	0.4	156.9	0.5	194.7	0.4	302	0.5
4	Food industry	242.3	0.9	127	0.4	177.3	0.4	264.6	0.4
5	Light industry	176.4	0.6	136.4	0.5	190.4	0.4	284.2	0.5
6	Mining*	1581.8	5.6	1422.4	5.0	2368.3	5.3	4311.4	6.9
7	Energy and Heating	1454.6	5.1	1704.3	5.9	2280.6	5.1	3235.1	5.2
8	Livestock	9290.6	32.7	7311.9	25.5	10422.8	23.3	12620.6	20.2
9	Irrigation	10374.5	36.5	12259.2	42.7	21092.6	47.1	32389.2	51.9
10	Services and public utilities	602.6	2.1	634.4	2.2	715.6	1.6	842.2	1.4
11	Tourism	0	0.0	10.9	0.0	15.1	0.0	18.6	0.0
12	Green area	144.6	0.5	150.6	0.5	165.6	0.4	182.8	0.3
13	Construction	430.9	1.5	498.4	1.7	695.7	1.6	1038.2	1.7
	Total	28418.4	100	28695.5	100	44791.6	100	62368.1	100

Remark: ** Erdenet mining factory is not included in calculation of water use and water demand because the mine uses water from the Selenge River Basin.*

A number of mining companies and individuals are mining gold in the upstream part of the Orkhon River and are polluting the river water. Therefore, it is necessary to take measures systematically and step by step such as stopping these mining activities and bringing the upstream part under national and local protection.

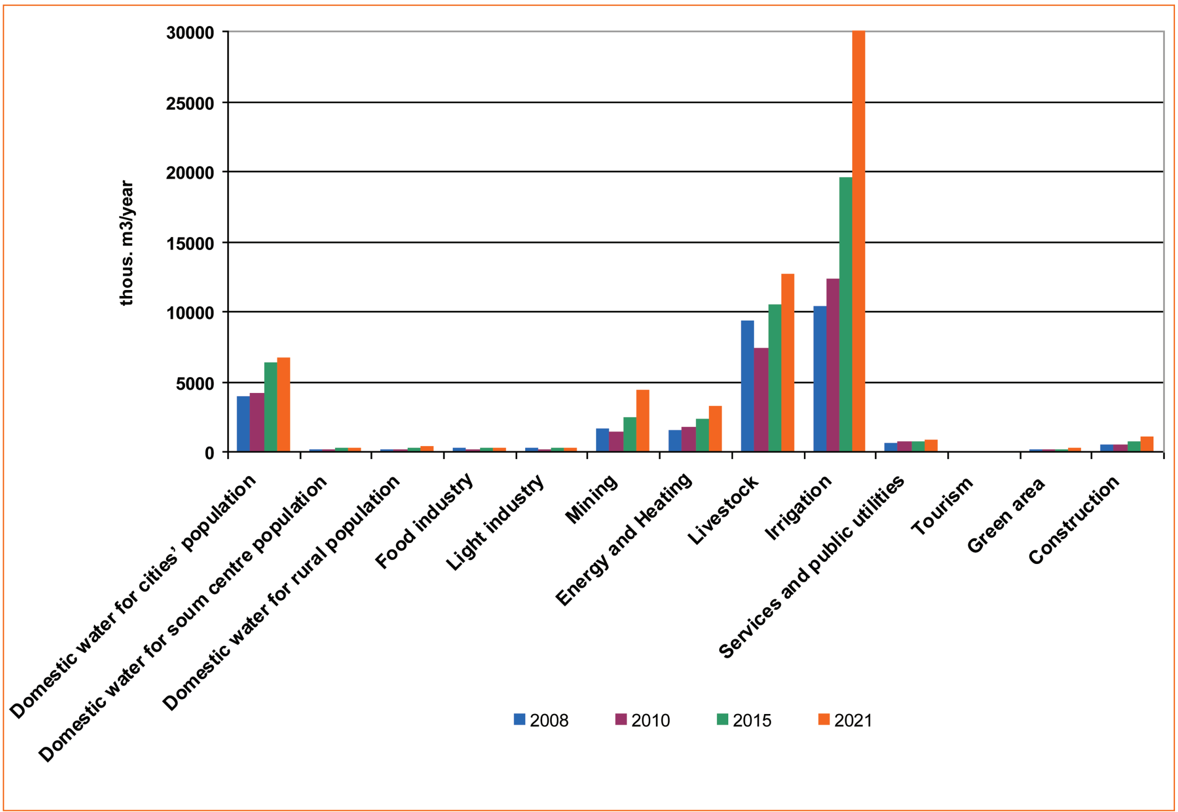

Figure 35. Total water consumption-use and water demand of the sectors in the Orkhon River Basin

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ANNEX 1. Irrigated area used and potential use in the Orkhon River Basin

№	Aimag	Soum	Used		Potential use	
			Area	Area size, ha	Area name	Area size, ha
1	Bayankhongor	Erdenetsogt			Khushuugiin Am	114
2	Arkhangai	Khotont			Taliin Balgas	6600
		Khashaat			Tarniin River	100
		Tuvshruulekh			Arnuur	1100
					Khukh Sumiin River	300
		Ugiinuur			Toglokhiin Tal	1000
		Ulziit			Khar Khyaraan River	1000
		Bulgan	Arbel	258	Drilled well	16
		Erdenemandal			Dun Tsur	200
					Baga Khalzan	50
					Tenuun Tal	100
					Khaanii Balgas	1500
					Tsorgiin Am	700
		Battsengel	Suul Tolgoi	70	Erdene Tolgoi	800
					Urd Tamiriin Adag / South Tamir River downstream/	50
		Ikhtamir			Ulunt	50
		Tsenkher	Shirguu	408		
3	Bulgan	Mogod			Orkhonii Khundii / valley/	400
		Orkhon	Seeriing Nuruu	48	Mogoin River	100
			Shuvuutiin River	85		
		Khishig Undur			Kharkhain River	150
					Bayangol	100
					Shivert	100
		Buregkhangai			Angirt	5.0
					Yamaat	80
		Gurvanbulag			Takhilt	160
					Tarnain River	200
		Dashinchilen			Shar Dov	450
					Milan River	60
		Rashaant			Tarniin River	21.0
		Bayannuur	Daliin Bulag	57.0	Zaan Khoshuu	2000
					Shar Tal	3000
		Saikhan			Buurliin River	100
		khutag			Buur Lake	200
		Bugat			Khujirt	100
		Khangal			Deed Evert	200
					Ar Khushuu	300
					Tsulkhar	150
4	Orkhon	Bayanundur				
		Jargalant	Ulaantolgoi	547		

№	Aimag	Soum	Used		Potential use	
			Area	Area size, ha	Area name	Area size, ha
5	Uvurkhangai	Bat-Ulzii			Khiuten Bulag	10
					Ongotsot	30
		Khujirt	Tsuurain River	219	Khaakhai Bulag	30
					Shavar Turuu	100
		Kharkhorin	Kharkhorin	3285	Bayangol	60
					Orkhonii Zuun Ereg / Orkhon east bank/	1200
		Zuunbayanulaan			Emt Bulag	2.0
					Khungui Mukhar	300
		Ulziit			Khuisiin River	65.0
		Uyanga			Baaraan River	100
		Burd			Tarian Tolgoi	100
					Baga Barigdai	20
					Khar Biluut	90
		Yesunzuil	Sarankhundii	74	Ulaan Ereg	150
		Bayanundur			Bor Khujir	20
					Kharztain River	70
6	Tuv	Bayanunjuul			Bayanbulag	3.0
		Undurshireet			Maikhan Denj	100
					Berkhiin Khundii /valley/	50
					Taliin Bayan	100
		Lun			Burkhantiin Khundii / valley/	10
					Yatuutiin Khundii / valley/	100
		Zaamar	Ar Urt	125	Khadan Khoshuu	200
		Altanbulag			Tuuliin River	50
					Bukhugiin River	70
					Soum centre	50
		Jargalant	Jargalant	850	Mendiin Uzuur	60
					Bor Khujir	120
		Mungunmorit			Yudegiin Denj	300
					Khongoriin Tal	2300
		Ugtaal			Tuutiin Adag	200
					Bor Khujir	5.0
		Bayankhangai			Buduun Dugar	3.0
		Bayanchandmani	Bayanchandmani	72	Zuun Mukhar	30
			Shariin Am	60		
		Tseel			Teeliin River	200
					Bor River	20
		Bayantsogt	Guna	70		
			Dund Urt	57		
		Bornuur	Bornuur	966		
			Arangat	280		
		Batsumber	Batsumber	802	Dugan Davaa	300
			Bayantolgoi	250	Jargalantiin Ar	150
			Bayangol	34	Sugnugur River	40
		Erdenesant			Urtiin River	5.0
		Bayanunjuul			Bayanbulag	3.0
		Sergelen			Bayanbulag	2.0
		Erdene	Uubulan	36		

№	Aimag	Soum	Used		Potential use	
			Area	Area size, ha	Area name	Area size, ha
7	Ulaanbaatar	Gachuurt	Khar Usan Tokhoi	95		
			Uvurbayan	74		
			Uliastain Am	240		
		Jargalant	Ayushiin Am	150	Poultry farm	200
			Arshand	83		
		Khan-Uul	Bukhug-1	150		
			Bukhug-2	189		
8	Selenge	Orkhontuul			Tsagaan Ereg	400
					Burgaltai	80
					Chuluut River	20
		Orkhon			Khudgiin Khundii	500
					Shiir	30
					Mangirt	180
					Chuluun Khoroot	210
		Sant	Tsagaantolgoi	3300	Mukhariin Am	200
		Saikhan			Nogoon Brigade	30
					Khushuu Chuluu	20
					Kharaa Orkhonii Belchir /confluence/	1000
		Javkhlant			Khuitnii River	60
					Shariin River	100
					Khongoriin Ovoo	200
		Shaamar	Shar Tokhoi	61	Japan Tokhoi	500
					Manjiin Dotor	300
		Khuder			Shorgoolj	500
					Khudriin Khundii	300
					Tumurtei	500
		Mandal	Zuunkharaa-1	400	Tsagaan Khutul	300
			Zuunkharaa-2	144	Tukhumiin Bulag	60
			Boroo River	30	Boroogiin Bulag	1400
					Bayanbulag	100
		Bayangol	Zagdliin River	76	Bayangol	80
			Bayanii Uvur	214	Tariatiin Am	50
			Dorgont	20	Erkhet	100
					Zagdal	30
					Tumurtei	70
		Baruunburen	Zuunmod	666	Zuunmod	333
		Khushaat			Artoilbo	400
					Khashaat	200
					Naadmiin Denj	500
					Tashir Erkhet	400
		Altanbulag	Khyaraan River	216	Baruun River	13
			Tukhum	50	Bor Bulan	800
					Nariin Mogoit	20
		Sukhbaatar city				
		Zuunburen	Bongiin Tokhoi	1000	Orkhon and Selenge belcher /confluence/	3000
		Yeruu			Enkh Tal	1500
					Karnakov	200
					Khar Ereg	100
					Tsagaan Tokhoi	200

№	Aimag	Soum	Used		Potential use	
			Area	Area size, ha	Area name	Area size, ha
9	Darkhan-Uul	Khongor	Khongoriin River	90	Serten	100
			Uujim Bulgan	20		
		Orkhon	Shariin River	436	Shariin River	186
			Burentolgoi	380	79-iin Tokhoi	42
			79-iin Tokhoi	58		
		Shariin River	Buurt	130		
Total of basin				16925		43774

Part 7. ORKHON RIVER BASIN COUNCIL

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1. Orkhon River Basin Council

1.1. General introduction

The objectives are to establish river basin councils in pilot basins including Orkhon and Tuul river basins, chosen within the framework of the "Strengthening Integrated Water Resources Management in Mongolia" project; to support their activities; to improve human resource capacity and to support the development of the basin water resources management plan.

Within the framework of the above-mentioned objectives, the project cooperated with the Water Authority and established the Tuul and Orkhon River Basin Councils. The project supported these two councils' actions and activities. This part covers the Orkhon River Basin Council, its formation, structures and activities, as well as recommendations of future issues.

1.2. River Basin Council and its formation

The "Strengthening Integrated Water Resources Management in Mongolia" project organized a first consultative meeting to establish the Orkhon River Basin Council in May 2011 in Kharkhorin soum of Uvurkhangai aimag. Some 130 people, representatives from all aimags and soums that belong to the Orkhon 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 agreed upon. The nomination issue for council members within the agreed numbers was referred to the respective aimags' and soums' Peoples' Representative Khural. It was the first step to establish the Orkhon River Basin Council.

Figure 1. Consultative meeting, Kharkhorin soum of Uvurkhangai aimag (2011.05.21)

Based on the article 19.2.1 of the Law on Water and Peoples' Representative Khural considerations of aimags and soums that belong to the basin, the Orkhon River Basin Council was established with 16 members according to order A-456 of December 20, 2011 of the Minister of Nature, Environment and Tourism. Representatives from Ulaanbaatar city, Orkhon, Selenge, Arkhangai, Bayankhongor, Bulgan and Uvurkhangai aimags are included in the Orkhon River Basin Council.

According to article 19.4 of the Law on Water, representatives from environmental agency, professional inspection agency, NGOs and the Water Authority are included as well. By doing so, conditions were created to provide law implementation and to provide equal participation of relevant parties in the basin water management.

When comparing the Orkhon River Basin Council representation to other RBCs, the advantages are that the number of representatives from state organization administrations is decreased and that the number of representatives from NGOs, citizens, environmental organizations and water experts are increased in the RBC.

Figure 2. Members of Orkhon River Basin Council

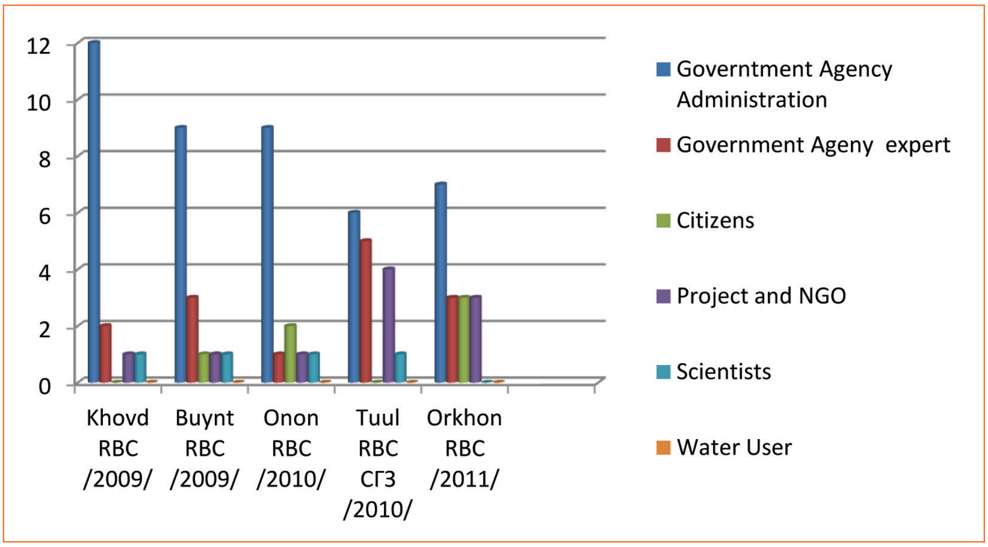

Figure 3. River basin councils' structures.

According to article 19.6.2 of the Law on Water, a stable operation of the basin council, financing and capacity of members are required when the Orkhon River Basin Council develops the water resources management plan of the basin and implements other rights given by law. The water and environmental experts dominate in the formation of the Orkhon River Basin Council. It is possible to accomplish the duties given by the Law on Water and basin council rules.

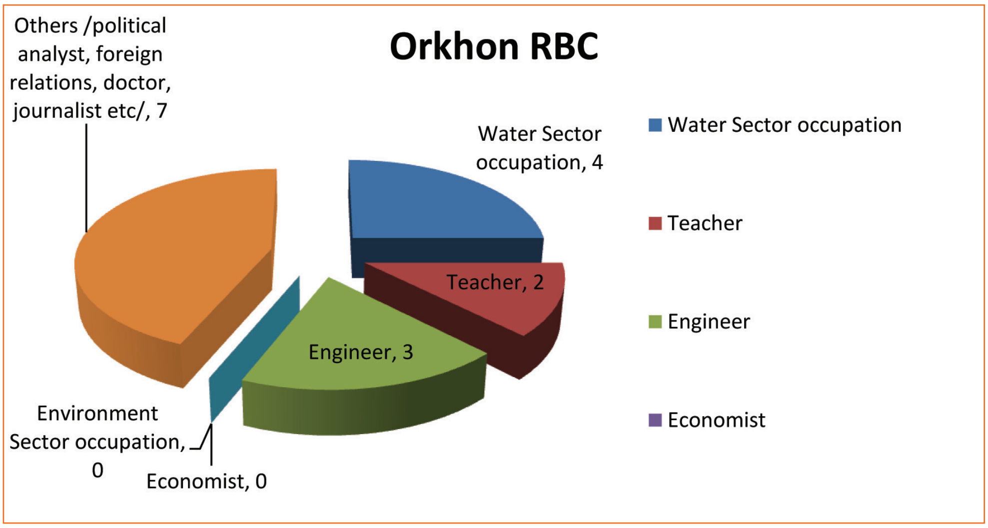

Figure 4. Occupation directions of River Basin Council members

1.3. Rules, full rights and duties of the River Basin Council

The Orkhon River Basin Council rules were approved on February 9, 2012 by the all-member meeting. The following points were included in the rules. They are: basic principle of the council activities, formation, common rights and duties of council chairman, secretary and members as well as financial sources. The Orkhon River Basin Council included the following principles in its rules for implementing its activities. They are:

- Reporting is honest, democratic, open and apparent;
- Public interests will lead while respecting private or group, sector and local residents' interests;
- Land use and land use demand will be related to water resources management;
- According to rights and duties of Mongolia in international agreements and conventions, the principle to prevent trans-boundary negative impacts will be followed.

According to article 3.10 of the Orkhon River Basin Council rules, RBC can have offices of operation, monitoring and training, as well as training-methodology and public participation. Implementation of full rights and duties given by the law will be executed through these offices.

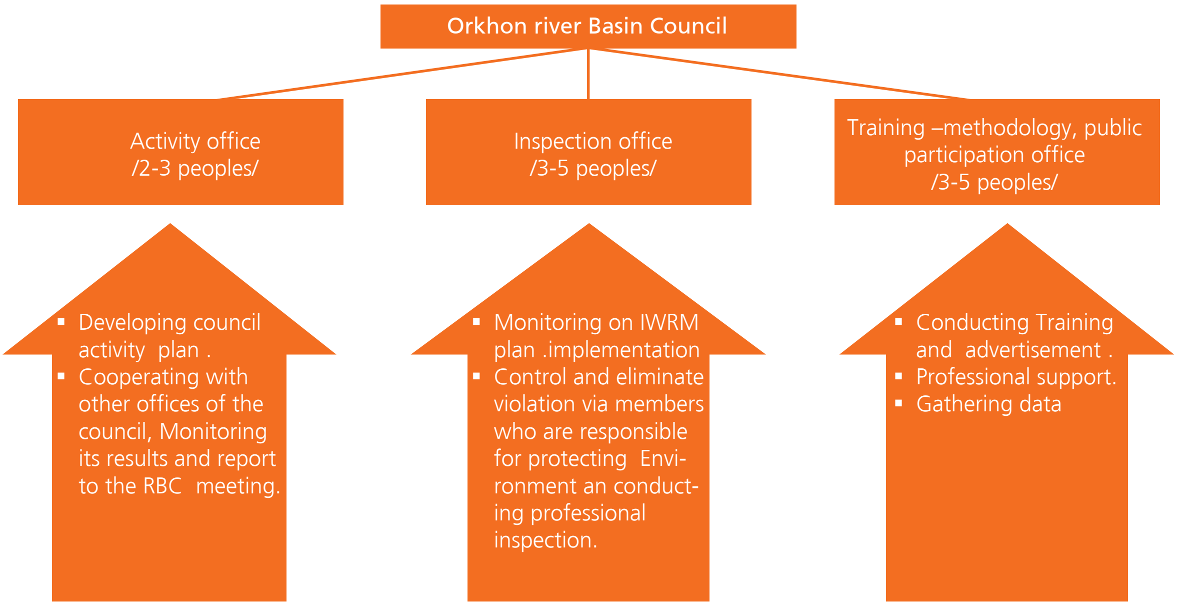

Figure 5. Structures and directions of the river basin council

According to article 20.4 of law on water, a river basin council shall exercise the following plenary powers:

- To include proposals of citizens in making a decision on protection and effective use of water;
- to make proposals on projects for collection and use of water resource, operating large mining industry and construction of a dam and canal;
- to monitor implementation of water management plans by the Basin administration, and to take decisions on eliminating violations;
- to monitor whether water users completely perform duties specified in an agreement and the article 27 of this law;
- to monitor whether water users completely perform duties such as reduction of adverse impacts, recovery of caused damage/loss and restoration according to the Environmental Impact Assessment;
- to monitor enforcement of a regime for special and ordinary protection and sanitary zones in basin area and water source;
- to organize activities for protection, reforestation, appearance improvement and

restoration of runoff and water sources with a support, initiative and effort of local citizens and professional organizations;

- to submit proposals to competent authorities on suspending construction work in the event of drawing of water facilities is confirmed that it has a adverse impact on the water resources as concluded by professional organizations;
- to submit proposals to competent authorities to invalidate decisions by the Basin Administration pertaining to water use.

There are in total 53 soums of 8 aimags in the basin. When developing the water resources management plan of the Orkhon river basin, these aimags and soums will be included and the Orkhon RBC included in article 3.8 of its rules about the plan approval. It refers as “River basin council needs to have approved and integrated Basin’s integrated water resources management plan by each People’s Representative Khural of the aimags that belong to the basin in the first three months”.

According to the river basin council rules, a “Monitoring Office” will be operated. The basic role of the office is to monitor Orkhon River Basin Council activities. This office will have 3 representatives from citizens and NGOs. It is detailed and projected in the rules that the RBC can establish branch councils in order to implement its own duties and functions along the rivers which flow into Orkhon River or flow from it.

2. River Basin Council activities

2.1. Beginning of the activities

The Orkhon River Basin Council started its operation from January 1, 2012. The council has an official stamp, state registration certificate and printed forms. It is registered in the relevant district's tax department and it is operating normal now.

2.2. Financial sources

Orkhon RBC is operating with financial aid from the "Strengthening Integrated Water Resources Management in Mongolia" project, which is being implemented using a Dutch Government grant. This aid becomes the main base to run the river basin council activities.

Figure 6. Equipment is handed over to RBC from IWRM project

2.3. First meeting of the River Basin Council

The first meeting of the River Basin Council was held at the Water Authority, Government Implementing Agency on February 9, 2012. The basin council administration and members participated in the meeting. During the meeting, the rules of the basin council and the 2012 activities plan were discussed and approved.

Figure 7. First meeting of the basin council

2.4. Training of integrated water resources management

The "Strengthening Integrated Water Resources Management in Mongolia" project organized a short training and seminar on 9-10 February 2012 for the purpose of giving general understanding to the Orkhon River Basin Council members on integrated water resources management.

Training and seminar program:

- "Strengthening Integrated Water Resources Management in Mongolia" project progress and results
- General concept of river basin management
- River basin organizations and their legal environment
- International experience of river basins
- Activities and future perspectives of river basin councils
- Development progress of Orkhon river basin water management plan

Figure 8. Integrated water resources management training

The basic results of the training and the seminar are: water-related issues facing the basin are discussed and measures to solve those issues were determined; it was agreed that official recommendations will be given from local administration and nature, environment and tourism offices and these recommendations will be included in the integrated water resources management plan of the Orkhon river basin.

2.5. River Basin Council and project team's function in local areas

River Basin Council in local areas

The second meeting and discussions of Orkhon River Basin Council were held on 6-10 June 2012 in Kharkhorin and Bat-Ulziit soums of Uvurkhangai aimag; Tsetserleg and Ugiinuur soums as well as Orkhon bag of Tsenkher soum of Arkhangai aimag.

During the basin council members' mission in local areas, they travelled from Kharkhorin soum of Uvurkhangai aimag to Orkhon bag of Tsenkher soum of Arkhangai aimag in the upstream part of the Orkhon River. They discussed with big water users and mines that operated in the Orkhon river basin and they inspected the negative impacts on site that were caused by them. They discussed about further measures.

Figure 9. River basin council in local areas (Kharkhorin soum of Uvurkhangai aimag, 2012.06.07)

In the discussions organized in local areas, the following organizations and experts participated. They are: Orkhon River Basin Council administration and members; "Strengthening Integrated Water Resources Management in Mongolia" project team; aimag and soum administrations; environmental experts.

They discussed the integrated water resources management plan project of the Orkhon River Basin and measures to be included in it. It was beneficial that certain recommendations were made and advices were given.

Figure 10. Tsenkher soum of Arkhangai aimag, Orkhon upstream (2012.06.08)

Figure 11. Tsenkher soum of Arkhangai aimag, council members at Orkhon upstream (2012.06.08)

Project team in local areas

The “Strengthening Integrated Water Resources Management in Mongolia” project conducted recommendations and introduced a first draft of the integrated water resources management plan of the Orkhon River Basin in the aimags and soums that belong to the basin with the participation of the Orkhon River Basin Council between June 6, 2012 and June 17, 2012 in Uvurkhangai, Arkhangai, Bulgan, Orkhon, Selenge and Darkhan-Uul aimags. It lasted for 11 days.

Ts.Baldandorj, Ph.D, senior consultant of the “Strengthening Integrated Water Resources Management in Mongolia” project; S.Tumurchudur and B.Batbayar, project experts and L.Narangerel the driver participated.

The team has been to following places in the framework of the mission. They are: Kharkhorin, Khujirt and Bat-Ulzii soums of Uvurkhangai aimag; Tsetserleg, Ugiinuur, Tsenkher and Tuvshruulekh soums of Arkhangai aimag; Bulgan, Mogod and Orkhon soums of Bulgan aimag; Erdenet of Orkhon aimag; Sukhbaatar, Shaamar, Altanbulag, Khushaat, Sant and Baruunburen soums of Selenge aimag and Orkhon and Darkhan soums of Darkhan-Uul aimag.

Extra information was given and introductions were made of the first draft of the IWRM plan of the Orkhon River Basin and previously sent materials to aimags. Recommendations for the plan project were collected from the aimags and some soums. These were received as protocol in the form of discussion and meeting notes. The decisions and the notes of the discussions and meetings in aimags and soums will be sent soon as discussed with the relevant officers due to work availability. The team inspected in Kharkhorin soum of Uvurkhangai aimag: newly built fresh water sources, WWTP-in-construction-process, channel and hydropower station. The Orkhon River Basin Council members pre-discussed about involvement in the river basin IWRM plan with soum authorities and protection administration of Orkhon valley national park.

The team also went to Khujirt and Bat-Ulzii soums of Uvurkhangai aimag and inspected: the water supply condition of soum centers and rural population; water supply, environmental condition, water resources of public utility services, camps, nursing homes and tourism as well as their usage and protection condition.

The following places' wastewater treatment facilities do not meet the sanitation and technical requirements in Khujirt soum center. They are wastewater treatment facilities of "Khujirt", "Elma Khujirt", "Bo-Ba-Se" camps and nursing homes and "Gem Khujirt" spa-bottling factory. Those water user organizations should establish integrated wastewater treatment facilities, which meet the current sanitation standard. This issue is included in the basin IWRM plan.

The population drinking water borehole of Bat-Ulzii soum center is owned by an individual and a garden was established with the aid of it. This rational solution is included in the plan as rational activity, which is possible to be introduced in other places.

Figure 12. IWRM plan introduction in local areas

The team inspected the fresh water sources and industrial wastewater filtration facility of "Beren Mining" LLC, which mines iron ore in Tuvshruulekh soum of Arkhangai aimag. They discussed about soum authority requirements to mine administration and issues both sides cannot settle. The team went to Ugiinuur soum of Arkhangai aimag and discussed with relevant people and experts about water resources of Ugii Lake, Orkhon and Khugshin Orkhon rivers; regime studies and future activities. It was advised that the information and public relation center of Ugii lake belongs to a professional organization (maybe the Water Authority) in the future and it needs to become a training and information center and its activities need to be activated.

Amendments were made in the plan about the water resources of Ugii Lake and Khugshin Orkhon River as well as regime studies. The team inspected the Khuljiin hot spa condition in Mogod soum center of Bulgan aimag. The following was added in the plan project. They include: to define protection zones of Khuljiin hot spa and Khar Lake; to make fences; to install water meter at water-in-use and expand wastewater facility.

The team went to Orkhon soum of Bulgan aimag and discussed with soum's Peoples' Representative Khural chairman about soum center water supply, irrigation field use and ownerships. He gave information as follows: there are no problems in water supply and flood protection. Old irrigation system of Seer River ran out of water and it is impossible to use.

It was arranged that some emphasis on extra measures of fresh water sources and required rehabilitation and expansion of wastewater treatment facilities in Bulgan city of Bulgan aimag will be made in the plan project with the participation of aimag authorities, representatives from environment and tourism agency and water supply organizations. It was discussed that the wastewater treatment facility of Bulgan city is suitable in terms of its location and treated wastewater can be used in a nearby vegetable garden.

We were grateful that the Orkhon river basin IWRM plan project was discussed by the leaders' meeting of the Bulgan aimag Peoples' Representative Khural and recommendations were defined. They gave high importance to the issues and they were active.

The team inspected the usage condition of the Erdenet ore concentrator factory water supply, industrial wastewater reservoir, leakage channel, extra filtration and circulation pump stations.

They also inspected the Lamiin Khiid spa and other springs conditions on sight that are located in the upper part of the Khangal river and Daliu Bulag as well as Khangal, Erdenet and Govil rivers. It is required that these springs (total of 7 springs) sources have protection zones as well as signs need to be put and fences should be built.

They are included in the plan. The team inspected the fresh water sources, wastewater facility and irrigation field of Baruunburen, Sant, Khushaat, Altanbulag and Shaamar soums of Selenge aimag. There were some issues and they are included in the plan. The issues are: to establish new water supply sources in some soums, to rehabilitate wastewater treatment facility, to change the location of solid waste dumps and to use small size wastewater treatment facility.

The local area authority requested to increase Ishgent lake water, which is located in Khushaat soum of Selenge aimag. It was included in the plan and study will be conducted professionally. The local area authority had an opinion to rehabilitate and use old dam on Iven River in order to increase Iven river flow, which flows nearby Sant soum and to divert water to an old irrigation channel which was laid behind the soum center and use it for household crop irrigation.

It was supported and discussed that it will be included in the plan. There are some 10 irrigation systems for crops constructed in Sant, Khushaat and Baruunburen soum territories. For example: “New Crop” LLC, “Shandas Uguuj” LLC. Most of these irrigation systems will be supplied from the Orkhon River. This was included in the project documents.

The layout to rehabilitate the wastewater treatment facility in Orkhon soum center of Darkhan Uul aimag was designed. The client is working to include it in the state budget investment plan amendment of 2013.

2.6. Orkhon River Basin and Ramsar agreement

Ugii Lake is registered in the Ramsar Convention on wetlands of international importance. It is situated in Arkhangai aimag territory that belongs to the Orkhon River Basin. The Ministry of Nature, Environment and Tourism of Mongolia implemented a model project in Orkhon River Basin between 2005 and 2006 with the cooperation of the Japanese International Cooperation Agency or JICA. The model project is “River Basin Management to Use Wisely and Protect Wetland Ecosystem”.

Mongolian and Japanese experts participated in the project and they conducted researches in the Ugii lake ecosystem. Two reports were developed and published as a result.

The countries that joined the Ramsar convention have possibilities to develop projects to protect their own wetlands, to obtain finances and if necessary, to define measures and difficulties that block them executing their duties with the aid of Ramsar Consulting Team. Even it is possible to have finances.

One important duty of the convention is to implement the program "Communication, Education, Participation and Public Awareness" by using traditional method with the participation of local area citizens.

Figure 13. Arkhangai aimag, Ugii lake (2012.06.09)

Figure 14. Council members and project team in local area (Khugshin Orkhon River 2012.06.09)

It is considered that it is possible to have some issues solved within the framework of trans-boundary water protection and usage agreement between Mongolian and Russian Governments.

3. Future directions of the activities

- To organize river basin council meeting regularly as referred in the rules;
- To implement IWRM plan of Orkhon River Basin, to provide local area and inter-sector management and to monitor the implementation;
- To organize water inventory in the basin each year with the participation of local authorities and report to state regulatory body responsible for water issues;
- To establish sub water database of the basin and provide public with information
- To rehabilitate and protect spring sources in Orkhon River Basin;
- To conduct monitoring in the water use and activities of big water users operating in Orkhon River Basin including mines and tourist camps;
- To increase education and knowledge on water and ecology in preschool educational institutions, elementary schools, middle schools and high schools;
- To participate in World Water Day and other water related activities organized in international and regional levels actively, to organize them according to own features and inform their results to the public;
- To make a documentary on Orkhon river involving "Ariun Suvraga" NGO;
- To implement recommendations from Orkhon River Basin Council members.

4. Recommendations

- The Orkhon River Basin Council was established just 6 months ago and it is registered in state registration and organized 2 meetings in this short period of time. It approved its own rules and action plan and it is operating in stable condition. The "Strengthening Integrated Water Resources Management in Mongolia" project plays a key role for strengthening the RBC and the project is about to finish in December, 2012. It is required to solve issues about how to finance RBC activities when the project comes to an end;
- The council members functioned in the basin in June, 2012 and they visually inspected water related issues facing the basin. It was fruitful to develop the IWRM plan and to have it approved;
- According to the revised "Law on Water" which is being implemented from June 12, 2012, the action structures and plan to establish Orkhon river basin administration are developed and approved by the Minister of Nature, Environment and Tourism and job position as well as action expenditures are to be budgeted in the state budget by the 2012 budget amendment.

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4. “Strengthening Integrated Water Resources Management in Mongolia” project, Integrated Water Resources management plan of Orkhon River Basin, Ulaanbaatar, 2012.
5. Orkhon River basin Council rules, Members of Orkhon river basin council, Ulaanbaatar, 2012.
6. Report of Orkhon river basin council, Ulaanbaatar, 2012.
7. Ministry of Nature, Environment and Tourism., River Basin Management Model Project for the Conservation of Wetland Ecosystem and its Sustainable Use in Mongolia., Japanese International Cooperation Agency or JICA., “River Basin Management to use wisely and protect Wetland Ecosystem” report, 2005-2006.

ANNEX 1. Minister Order of Nature, Environment and Tourism

МОНГОЛ УЛСЫН
БАЙГАЛЬ ОРЧИН, АЯЛАЛ ЖУУЛЧЛАЛЫН
САЙДЫН ТУШААЛ

2011 оны 12 сарын 20 өдөр Дугаар А-456 Улаанбаатар хот

"Орхон голын сав газрын зөвлөл"
байгуулах тухай

"Усны тухай" хуулийн 19 дүгээр зүйлийн 19.2.1, 19.4, 19.6 "Орхон голын сав газрын зөвлөл байгуулахыг дэмжиж, нэр дэвшүүлэх тухай" Архангай аймгийн ИТХТ-ийн 61 дүгээр, Сэлэнгэ аймгийн ИТХТ-ийн 155 дугаар, Орхон аймгийн ИТХ-ын 158 дугаар, Дархан-Уул аймгийн ИТХТ-ийн 195 дугаар, Баянхонгор аймгийн ИТХТ-ийн 16/32 дугаар, Булган аймгийн ИТХТ-ийн 63 дугаар, Өвөрхангай аймгийн ИТХТ-ийн 47 дугаар тогтоолыг тус тус үндэслэн ТУШААХ нь:

1. Орхон голын сав газрын зөвлөлийн бүрэлдэхүүнийг хавсралт ёсоор баталсугай.

2. Сав газрын зөвлөлийг мэргэжлийн удирдлагаар хангаж хуулийн хүрээнд ажиллуулах арга хэмжээг шуурхай зохион байгуулж ажиллахыг Усны газрын дарга Ц.Бадрахад үүрэг болгосугай.

САЙД Л.ГАНСҮХ

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ANNEX 2. Orkhon River Basin Council formation

Байгаль орчин, аялал жуулчлалын
сайдын 2011 оны 12 сарын 20 ны өдрийн
А-456 тоот тушаалын хавсралт

Орхон голын сав газрын зөвлөлийн
Бүрэлдэхүүн

Сав газрын зөвлөлийн дарга:	Ц.Бадрах	Усны газрын дарга
Сав газрын зөвлөлийн нарийн бичгийн дарга:	Ц.Оюунтөгс	Улаанбаатар хотын Баянзүрх дүүргийн 7 дугаар хорооны иргэн
Сав газрын зөвлөлийн гишүүд:	Д.Сүхбат	Орхон аймгийн Мэргэжлийн Хяналтын Газрын Байгаль орчин, геологи уул уурхайн хяналтын улсын байцаагч
	Т.Батсүх	Орхон аймгийн “Эрдэнэт үйлдвэр” ХХК-ний Энерги цехийн үйлдвэр техникийн товчооны дарга
	Г.Эрдэнэбилэг	Өвөрхангай аймгийн Орхоны хөндийн байгалийн цогцолборт газрын хамгаалалтын захиргааны дарга
	Д.Дашцэрэн	Өвөрхангай аймгийн “Түшээ гүн” нийгэмлэгийн тэргүүн
	Л.Найманжин	Өвөрхангай аймгийн Хархорин сумын иргэн
	Г.Батжаргал	Баянхонгор аймгийн Иргэдийн Төлөөлөгчдийн Хурлын дарга
	И.Гансувд	Булган аймгийн Ус, Цаг Уур Орчны Шинжилгээний Албаны усны инженер
	Ц.Дашзэвэг	Булган аймгийн Хишиг-Өндөр сумын Мааньт багийн иргэн
	Ш.Дорж	Сэлэнгэ аймгийн Байгаль орчин, аялал жуулчлалын газрын ахлах мэргэжилтэн
	Ё.Дандарваанчиг	Архангай аймгийн Ус, Цаг Уур Орчны Шинжилгээний Албаны дарга
	Р.Сүглэгмаа	Архангай аймгийн Байгаль орчин, аялал жуулчлалын газрын дарга
	Д.Батсүх	Дархан-Уул аймгийн Засаг даргын орлогч
	Д.Сүхгэрэл	“Оюутолгой хяналт” ТББ-ын тэргүүн
	Г.Чагнаадорж	“Ариун суврага хөдөлгөөн” ТББ-н тэргүүн

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ANNEX 3. River basin registration certificate

УБ-2

Монгол Улсын Засгийн газрын
2004 оны 20 дугаар тогтоолоор батлав.

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/ Хуулийн этгээдийн нэр, хариуцлагын хэлбэр /

Дүрэм
/ Үүсгэн байгуулах баримт бичиг /

Тушаал	А-456	2011.12.20
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/ Үндсэн эрхлэх үйл ажиллагааны чиглэл /

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/ Туслах эрхлэх үйл ажиллагааны чиглэл /

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/ хуулийн этгээдийн албан ёсны хаяг /

Улсын бүртгэлийн ерөнхий газрын Хуулийн этгээдийн бүртгэлийн газар
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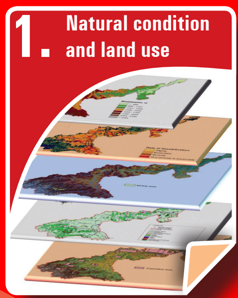

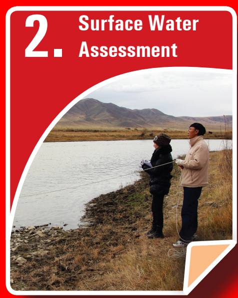

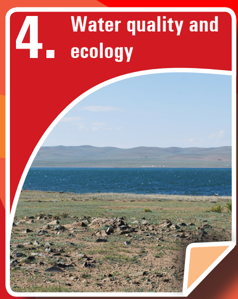

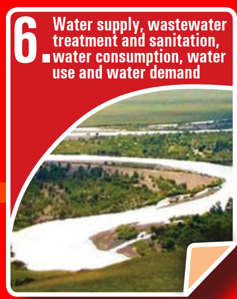

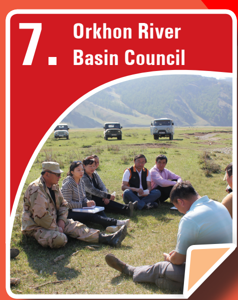

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ISBN 999624536-5
9 789996 245367