

# Kherlen River the Lifeline of the Eastern Steppe



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and

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*Satellite image of Kherlen River basin in June 2014. (NASA MODIS Imagery 25 August 2013)*



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*Barbers' shop on Kherlen River floodplain at Togos-Ovoo. Photo-by E.Simonov*

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## FOREWORD

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Headwaters of the transboundary Amur-Heilong River basin – the Argun, Kherlen and Shilka rivers – and several inner, closed basins lie in the eastern part of Dauria ecoregion shared by Russia, China and Mongolia. Indigenous 30-year climate cycle determines dynamics of Dauria ecosystems, but impact of global climate change is also evident in the region. Droughts and floods are becoming more extreme through climate change, and recent rapid socio-economic changes in the region make local communities and ecosystems less resilient. Economic development and water use in three countries make it difficult to build an applicable transboundary- mechanism to protect and sustainably use common water resources.

During the first phase of the UNECE Programme of pilot projects on adaptation to climate change in transboundary basins Rivers without Boundaries International Coalition, Daurian Biosphere Reserve (representing DIPA) and WWF-Russia started “Dauria Going Dry” Project aiming to assist management of transboundary water use in Dauria by: Strategic assessment of river management with consideration of climate adaptation; establishment of wetland monitoring system in Dauria; establishment and expansion of protected areas as one of key measures for climate adaptation and ecosystem conservation; development of awareness raising programme on climate adaptation and water management in the Dauria region.

All activities have been integrated into the research and nature conservation programme “Impact of climate change on ecosystems of Daurian ecoregion and ecosystem-based adaptations” of Dauria International Protected Area. The Project information was used in regional development and water management processes such as official inspection of the Hailaer River – Dalai Lake Water Transfer Canal in 2011 and 2013, assessment of gold mining impacts on transboundary watercourses in 2011, planning of low-carbon development under UN-Habitat Program in Erguna City in 2012, development and implementation of Sino-Russian Strategy for Transboundary Protected Areas Network 2010 – 2014, The Second Assessment of Transboundary Rivers, Lakes and Groundwaters in the UNECE region in 2011, Sino-Russian assessment of 2013 flood in Amur river basin in 2014, preparation of the "Dauria Steppe" World Heritage site nomination in 2011-2014, etc.

In 2013 UNECE supported a report-production on strategic assessment of river and wetland conservation and management in the light of climate adaptation in Dauria: “Adaptation to climate change in the river basins of Dauria: Ecology and Water Resources Management” was published in Russian, English and Chinese. That first publication described general features of Dauria rivers and presented a case-study on the Argun River transboundary water resources management dispute.

Rivers without Boundaries Coalition continues documenting and analyzing transboundary basins of Dauria not well known by the international community. New report is focusing on water resources management in Kherlen\Kelulun River transboundary basin to promote climate adaptation, ecosystem-based river basin management approach, strategic environmental assessment of development options related in water management in transboundary river basins of Dauria. Kherlen was selected as extreme example of discrepancy between development plans, ecosystem health requirements and cyclical availability of water resources. Report shows that even in comparison with adjacent Ulz and Khalkh transboundary basin, the Kherlen has more acute and immediate water management and ecosystem conservation problems. Recommendations presented in the report are relevant to integrated river basin management in other river basins of Dauria. We hope that our

recommendations will be taken into consideration by water managers, policy-makers and research community in all transboundary basins of Dauria.

There are other activities also included into the second phase of “Dauria Going Dry” Project supported by UNECE, that reflect multifaceted research on ecosystem-based river management and climate adaptation undertaken by the project team :

- Research on ecosystem-based transboundary flood management and wetland conservation, possible alternatives and framework to evaluate them in the Amur River basin;
- Research on environmental flow norms as a basis for transboundary agreements ;
- Analyzing and preparing publication of data collected through Dauria Transboundary Ecological Monitoring Network and preparation of a report “Transboundary Lakes of the Torey Depression”;

Our research and fieldwork on Kherlen River and assessment of water transfers in 2012-2014 was supported by **Whitley Fund for Nature** , Conservation Leadership Programme, DIPA , WWF Amur Programme and others. Report preparation was made possible by Stockholm Environment Institute and the **UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes**. Sincere thanks to all institutions who contributed to this long process.

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## EXECUTIVE SUMMARY

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Dry salt lake in Dornod Province of Mongolia ( by V.Kiriliuk)

### Part I. Scarce waters – high ecological values

#### 1. Management of Mongolia's scarce waters.

Mongolia has much less water resources than any other country of continental East Asia and those resources require careful protection and management. Rapid and uncontrolled expansion of water-intensive activities such as mining, export oriented thermal power plants, coal-to-gas converters plants may severely threaten precious sources, unless water resources allocation is deliberately limited by implementing rigorously defined environmental norms and by fully protecting community rights and access to clean and safe water. Other nations with water stressed regions, most notably Mexico, South Africa, Australia, China and the USA, have recently made drastic adjustments in water allocation to safeguard environmental flows. Mongolia still can avoid crisis securing environmental flows before too much water is allocated to human use.

#### 2. Transboundary rivers of Dauria –water wasted abroad?

Dauria is a highland region and many rivers flow out across the border. These rivers are of high ecological value and support globally important natural heritage sites: the Selenge River - the main source of Lake Baikal, the Onon– the largest tributary of the Amur River, the Ulz draining into Torey Lakes and the Kherlen flowing into the Dalai Lake Ramsar Wetland. Together these unique transboundary rivers, however small, are supporting tremendous globally-important biodiversity values and the ecological balance of Mongolia and adjacent countries.

#### 3. Biodiversity in River basins of Eastern Dauria

The Kherlen River is the longest river of Dauria Steppe and the most remote source of Amur River which drains into Pacific Ocean. The river starts in the alpine zone of Henti Mountain range and runs over a distance of 1,250 kilometers through cedar-pine forests, forest steppes and vast Eastern steppes to empty into Dalai (Hulun) Lake in Inner Mongolia, China. The area possesses very high level of biodiversity for a steppe zone, and it is included in the list of Global 200 priority ecoregions for conservation as the “Dauria Steppe”.

More than 40 endangered bird species breed in, or migrating through the Lower Kherlen Basin and are listed on the IUCN Red List and in national Red Data Books of Russia, Mongolia, and China. Upstream just near the city of



Baganuur, the Kherlen valley is a breeding site for the threatened cranes and bustards and Argali sheep. Thirty eight species of fish are observed in the Kherlen River at the Gun-Galuut Nature Reserve near Baganuur, including the endangered Siberian Taimen.

#### 4. Ecosystem dynamics: Influence of climate cycles on habitats in Dauria Steppe

The Dauria Steppe's natural climate cycle, which typically spans 25 to 40 years, is a major force shaping regional ecosystems and peoples' lifestyles. During the dry phase, which is the most critical for many species, a few habitat refugia remain. River floodplains have more frequent flooding events and thus preserve more stable habitat in times of drought. The highly dynamic habitats of the Daurian eco-region are characterized by strong leaps and drops in biological productivity, and support high biodiversity of the Daurian steppes, including the before mentioned abundance of many mammal and bird species.

One of drivers of the rich biodiversity of the Kherlen river, is the low degree of human alteration of river processes, and its intact natural connectivity without interruption by dams from Henti Mountains all the way to the Dalai Lake in China

#### 5. Conservation efforts and water management

Several parts of Kherlen River valley are protected in nature reserves. The Kherlen source is located in the Khan Henti Strictly Protected Area. The river flows through the Gun Galuut, Khar Yamaat, Toson Khulstai nature reserves in Mongolia. The Dalai (Hulun) Lake Biosphere Reserve receives waters of Kherlen and Halkh rivers coming from Mongolia and is connected to Argun/Erguna River on the border with Russia and China. The Dalai lake is an important breeding, molting, and stopover site of water birds including endangered Swan geese. Dalai Lake Nature reserve forms part of the tri-national Dauria International Protected Area (DIPA) declared by all countries in 1994. Practically all existing conservation efforts are good examples of ecosystem-based-adaptation- they preserve resilience of biota and protect habitats to be used in all phases of climate cycle and during linear climate change.

In Mongolia Water Basin organizations have been formally established in 20 of the 29 Water Basins, including Onon (2012), Tuul (2012), Kherlen (2013) and Ulz(2014) basins. The Kherlen River Basin Authority is a state administrative organization that prevents water resource from water scarcity and environmental pollution, uses the inferred water reserves properly, restores water reserves, regulates interrelation between local and administrative departments and implements the integrated management plan for water reserve. In early 2014 through Hungary-Mongolia cooperation agreement development of the Kherlen River Basin Integrated Water Management Plan was initiated.

Song-Liao Water Resource Commission (SWRC) headquartered in Chanchun, Jilin Province is responsible for river basin management planning and technical supervision in all rivers in China part of Amur river Basin shared with Russia and Mongolia. The SWRC serves to manage the water resources and river courses of the basin in a "unified" manner and is responsible for "comprehensive harnessing, developing and managing major water control structures, doing the planning, management, coordination, supervision, and service to promote river harnessing and the comprehensive development, utilization and protection of water resources". SWRC works with Hulunbuir Prefecture of Inner Mongolia and Dalai Lake National Nature Reserve(subordinate to Forest Administration )) to manage Kherlen River and Dalai Lake. Given that there is very little water infrastructure associated with lower 200 kilometers of Kherlen River flow, the most persistent management question is adaptation to cyclical drought, that regularly leaves river stretch in China dry.

## 6. Kherlen river –stronghold of nomadic culture and economy

The large human population and huge livestock economy of the region depends on Kherlen River. The total population in the Kherlen river basin in Mongolia is 110,000 people, and settlements, camps and roads tend to line along Kherlen River, where best living environment is to be found. In China the Kherlen river flows through the “New Right Barga Banner” of Hulunbuir prefecture, with population of 35,000 - mostly ethnic Mongols, engaged in livestock business. Dalai Lake also has important fisheries enterprises and tourist resorts.

## 7. Hydrology in fluctuating climate – river management issues

As it flows from forest into dry steppe Kherlen river loses water. The Kherlen annual average flow rate decreases from 648 million cubic meters at Baganuur to 530 million cubic meters at Mongolia-China border. No surprise that in dry years, like in 2007, Kherlen River total annual inflow into Lake Dalai decreased to only 38 million cubic meters and for 200 days in a single year it completely dried up in China.

Floods are most important hydrological processes that shape the vitality of Kherlen River valley. Flood water is mostly utilized for groundwater recharge, filling of oxbows and lakes and growth of pasture vegetation in vast 2,900 sq.km. floodplain of the Kherlen river. Flood wave attenuation by the vast natural floodplain makes that the Kherlen floods do not pose any danger to human settlements along the river.

## 8. Climate change and the path to adaptation

The Mongolian nomadic tribes have adapted to temporal and spatial change in availability of water and other resources due to natural climate cycles for centuries. Recent rapid socio-economic changes and loss of nomadic heritage, however, make ecosystems and local communities less resilient to this natural fluctuation in resources and more vulnerable to droughts and floods which are exacerbated anthropogenic climate change.

It is important to understand that thus far changes in water availability in Dauria due to anthropogenic climate change, if any, have been an order of magnitude smaller than changes due to natural climate cycle. It is however likely that the impacts or timing of the climate cycles will change and that therefore the sustainability of adaptive measures for ecosystems and people increasingly less predictable. Drastically different cultures, differences in population density and the often highly unsustainable modes of economic development and water use in Russia, China and Mongolia, make it very difficult to build transboundary mechanisms for the protection of common water resources.

# **Part II.Existing and Planned Development and its Possible Impacts**

## 9. Human impacts on Kherlen and adjacent rivers

Total water withdrawal in the Mongolian part of the basin is currently around 24 million cubic meters annually, or 5% of Kherlen river flow across the border. It is reasonable to assume that another 3-5% is used in Chinese part of the basin. Large coal mining operations are presently located near the Kherlen River in Baganuur and Choibalsan and are the main sources of industrial pollution. Livestock overgrazing coupled with warming changing climate also contributes to decrease in water quality and quantity. Water mineralization and turbidity increases manifold as Kherlen flows through the dry steppe.

Kherlen, Khalkh and Ulz rivers share similar natural features: they flow through Dauria Steppe and have large freshwater\brackish lakes at the rivermouths,actingas evaporation basins. However, degree of human development is very uneven in three basins. The Ulz River has no large population centers, but only mining industry, while the Khalkh river, also has no sizable towns and so far is practically pristine in Mongolia, but has considerable degree of tourist resort development in China. The Kherlen River basin is the only transboundary basin of the steppe that has sizable and diverse industries and several provincial centers , that actively use and pollute its waters.

Nevertheless the vast majority of water samples taken in Kherlen River basin appears “clean” or “very clean”. Despite presence of three industrial towns and a sizable livestock industry, the Kherlen River is still clean and resilient, largely because it retains natural flow character.

## 10. Planned industrial water supply projects

Early in the 21<sup>st</sup> century, when the Mongolian economy started to be driven primarily by Chinese market, mineral licenses were given to various foreign and domestic companies to develop large ore and coal deposits: Oyu Tolgoi, Tsaagan Suvarga, Tavan Tolgoi, Shivee-Ovoo, etc. Development, however, was slowed down by absence of readily available water sources in Gobi regions, due to both natural water scarcity and groundwater exploration lagging far behind industrial demand. Mining and processing of copper ore and coal washing require considerable amounts of water, but even more water is required by coal-energy and coal-gasification complexes that convert coal that is otherwise difficult to transport into easily exportable electricity and gas. In more recent plans, the Mongolian government also seeks to process mining products before exporting them. Several water supply projects emerged:

### 1) Prestige Group Schemes

From 2006 to 2014 the Prestige Group, a Mongolian engineering firm, has developed various water transfer schemes for delivering water from the Kherlen and Orkhon rivers to Gobi. All designs envision network of water transmission pipelines with water pumped as far as 530-540 kilometers to Tsaagan Suvarga and Zamiin Uud, and serve various users in between. All designs count with a water intake from a reservoir that block the river with a 25 meter high dam. In addition infiltration water intakes were envisioned on wide Kherlen floodplain downstream to pump subsurface water from alluvial deposits. Proposed water transmission volumes vary from 1 to 2 m<sup>3</sup>/sec. (30-60 million m<sup>3</sup>/year).

### 2) “Monhydroconstruction” Sainshand Water Supply

This supply scheme would deliver water from the Kherlen over a distance of 225 to 260 kilometers directly to Sainshand and then fork to serve other users: Tsaagan Suvarga, Tavan Tolgoi, Oyu Tolgoi and Zamiin Uud (Ereenhot). The reservoir with a 20 meter high dam would be located 100 kilometers downstream from Baganuur and count with twice the volume and a surface area of 125 sq.km. The company claims that it has special eco-hydrological software to justify “environmentally safe” withdrawals up to 20% of annual average flow or 60% of flow in dry years.

### 3) JETRO Study Design

This study on the Kherlen-Gobi Project released in2007, sponsored by the Japanese agency JETRO, contains systematic analysis of the available alternatives for water intake and water transport/distribution system as well as other finance and engineering aspects. The study compared 5 different water intake methods: a large

dam on the river, a weir on the river, flood impoundment on the floodplain, a collection conduit and shallow wells to draw subsurface water from floodplain alluvium. Shallow wells were recognized as the least costly, and most easily built water intake option with lowest environmental impact. The financial cost of the full project without large dam was estimated in 2006 at 800 million dollars. Japanese agencies and companies did not follow up on the study and did not consider providing funds for project implementation.

The massive water supply schemes designed for Kherlen-Gobi water transfer systematically lack solid environmental impact assessments and plan to withdraw up to 60% of river flow in moderately dry years.

## 11. Water Supply to Gobi – potential impacts and risks

Long-distance water transfers are marketed to local communities as an “alternative” to using local groundwater. However, most water management schemes and real life situations suggest that local aquifers (if available) will be used first, and if water is still lacking, subsurface water from the floodplain will be pumped into long pipelines. Only if the previous two options would fail to deliver enough water, a reservoir may be built on the river, because it is the most expensive solution. Each of these steps may have different environmental and social consequences.

### **a) Supply from local groundwater**

Once large-scale development occurs in certain Gobi area, inevitably local aquifers become the first target for large-scale exploitation. This has purely economic reasons: local groundwater supply systems costs much less than any long-distance water conveyance whether it is sourced from deep aquifers, subsurface alluvial deposits or a reservoir. Therefore local groundwater is threatened in any case with or without additional long-distance sources. The implications of local groundwater exploitation is beyond the scope of this report though as it is about the Kherlen river basin.

### **b) Supply from infiltration water intake in floodplain**

Withdrawal of subsurface water from the Kherlen floodplain has potential for high impacts on the river ecosystem downstream. This impact may be serious, mainly during dry year sequences and during the low-flow season without ice (April-June). As the distribution of flow between months is very uneven, in drier years there will be many months when a 2 m<sup>3</sup>/s withdrawal would render the river dry downstream from the water intake point. Water withdrawals would make the waterless period, typical for the Kherlen River, much longer and extend much further upstream into Mongolia. Nevertheless, if subsurface water is taken from alluvial deposits, the resulting flow reduction in the Kherlen River would be delayed and to a certain extent decreased by the alluvial aquifer, which receives its main recharge during floods. Most changes that may occur due to subsurface water intake are very similar in their mechanism and timing to regular natural changes that occur in dry phases of 30-year climate cycle.

There is no doubt that some amount of water could be taken from Kherlen in a manner similar to the way Ulaanbaatar uses alluvial infiltration water intakes, but the environmental limits are likely many times less than the 100 million cubic meters targeted in plans such as the ones proposed by “Monhydroconstruction”. The limits are also thought to be much more variable and fluctuate from year to year with variations of natural river flow.

Rigorous research is needed to establish thresholds for withdrawal above which some ecosystem functions or social values may be seriously affected, and limits need to be set for both the volume and timing of water withdrawals based on these thresholds. By setting environmental flow norms before large scale exploitation of

water resources takes place excessive environmental, social and economic damage can be prevented and water can be managed in a climate resilient manner. Various examples of methods for environmental flow assessments and incorporation in national water laws and regulations are emerging from other often water stressed countries such as Mexico, South Africa, Australia, the USA and the European Union.

### **C) Supply from reservoir**

Building a large dam may evoke many unwanted consequences and many of those cannot be mitigated. Many previous studies clearly stressed that this is a very dangerous option not to be pursued if viable alternatives are available.

#### ***A reservoir exacerbates water losses***

Proponents of reservoirs say that “regulating the river would minimize negative effects on river flow. It is more likely however that a reservoir will drastically increase losses of water, due to evaporation from the reservoir surface, which according to some estimates could equal to intended supply volume.

, Following these calculations, the design suggested by “Monhydroconstruction” would fail during the dry phase of climate cycle and unable to observe their own proposed “20% environmental flow norms”. Due to evaporative losses the Chinese Water Ministry nowadays refuses to build reservoirs on water courses in dryland areas.

#### ***A reservoir would eliminate floods***

A dam would significantly reduce hydrologic variability and change the morphology of the river downstream. Especially episodic flooding is important for pasture areas in the floodplain, bringing precious nutrients and moisture to the soil, and episodic recharge of shallow aquifers lower in the basin.

#### ***A dam would block migration of fish***

The dam is planned between forested headwaters with many cold-water tributaries and the middle and lower reaches where wintering refuges are available in lakes and deep pools. Since the Kherlen River system is frozen to bottom in winter and too warm in hot summers many fish likely migrate from lower basin where they winter to spawning sites upstream. A dam built in between will abruptly decrease fish survival and likely eliminate most valuable fish over the 800 kilometer stretch downstream.

#### ***A reservoir would harm high biodiversity value areas.***

The planned reservoir, depending on its location, would harm either Gun Galuut Nature Reserve or the Kherlen Toono Uul area which was identified by The Nature Conservancy as high priority for future expansion of protected areas. A shallow reservoir would likely become a source of pollution, erosion and favorable habitat for many dangerous invasive species.

#### ***Negative socio-economic consequences***

A dam would displace people from reservoir area, significantly contribute to desiccation of downstream areas all the way to Dalai Lake. The population estimate for the affected area is about 130-150 thousand people, many of them-traditional Mongolian herders. Sectors of economy that would suffer most would be livestock breeding, fisheries of Dalai Lake, nature tourism in both Mongolia and China and especially fishing tourism. On the

economic side, the two greatest risks are likely rising corruption and seriously increasing national debt for this project cannot happen without state investment.

## 12. Impacts from Coal Industry and other sectors

In Kherlen river basin Baganuur (Tov), Chandgana (Henti) and Aduunchuluun (Dornod) are the three main coal mining operations. In the adjacent Gobi region, Shivee Ovoo and Tavan Tolgoi are two biggest coal deposits which would potentially be supplied by the planned water pipeline.

Coal is the world's most abundant but arguably, also most environmentally damaging fuel. At a global level it provides 40% of the world's electricity needs and is responsible for an estimated 44% of CO<sub>2</sub> emissions and 8 to 10 % of anthropogenic methane emissions. Between 2000 and 2012 global coal consumption has grown with 60% (or 4% annually), largely due to rapidly increasing consumption in China and other non-OECD countries.

Most of Mongolian coal enterprises are developed for the Chinese market. To predict impact from this sector we use data from coal industry in China, where large scale impacts from coal enterprises have already become a major security issue and are subject to strict regulation.

Nowadays Chinese and international investors seriously examine the environmental sustainability of any proposed coal industry projects. Chinese investors require proof that sustainable water sources are available for development of Sainshand Industrial Complex.

The entire life cycle of coal, mining, thermal power plants, coal-to-gas and coal-to-liquid processing, all characterized by high water demands. When all proposed projects in Eastern Mongolia are added together their consumption far exceeds the volume that the proposed water transfer could deliver.

## 13. Future Water Balance and Climate Risks

We developed preliminary water balance estimates for Kherlen River basin in Mongolia by 2030, which takes into account municipal use, agriculture, evaporative from a potential reservoir and future water loss due to climate change.

This calculation shows that by 2030 water consumption and losses could well equal or even exceed average river flow of the Kherlen at across the Chinese border. This illustrates that it is unrealistic to sustain environmental health of river valley and satisfy the currently projected demands. Cyclical change in flow volume typical for Kherlen River and uncertainty about anthropogenic climate change impacts make it impossible to meet such demands during dry phases of climate cycle.

Half of future consumption comes from economic activities within the Kherlen basin and the other half from projected demand based on the potential development of the long-distance water transfer and associated water losses from reservoir.

Downstream reaches of the river in China and the Dalai Lake Ramsar Wetland are severely threatened by planned developments. Even minimal consumption estimates would result in the water supply to Dalai Lake being reduced by 60 to 75%.

Even if all environmental norms are neglected and water resources at the border are equally divided between countries (following to international customary law) China would not be able to get its half at least every 4 years.

## Part III. Environmental Safeguards for Kherlen River

### 14. Cumulative and Strategic impact assessments

A basin-wide Cumulative impact assessment (CIA) of all planned water supply projects and natural changes in Kherlen River basin is currently missing. Decisions about on the Sainshand and Gobi water supply may profoundly affect development prospects of the whole Kherlen River basin. An assessment of cumulative impacts of all water infrastructure should incorporate provision for environmental flows in Kherlen River-Dalai Lake ecosystem as related to flow of water, sediments and nutrients and include a full evaluation of climate variability and change

A strategic environmental assessment (SEA) of the Kherlen Gobi Project and all associated development plans should be conducted to arrive at better roadmap for development options available in Kherlen River Basin and adjacent Gobi areas. This SEA should create a framework for evaluating possible development scenarios in water sector against wide array of interrelated costs, benefits and limitations in economic, environmental, social and political spheres. Analysis of a wide array of available alternatives lies at the heart of strategic assessment.

### 15. Water supply alternatives in the light of climate adaptation.

There are some alternatives for water supply of the Gobi region that should be further explored before considering tapping into the Kherlen River water resources:

#### **A. Thorough assessment of Gobi groundwater and setting environmental limits to its use.**

Groundwater supply potential of Southern Mongolia was conservatively estimated in 2010 by the World Bank at 180 million cubic meters per annum and does not include results of explorations conducted in last 5 years. Exploitation and efficient management of groundwater in Gobi could prove to provide an effective means for securing a medium term water supply. According to some experts the Choir and Sainshand areas count with sufficient recharge to support a sizeable industry with groundwater.

#### **B. Limiting development in Gobi, moving industries to water.**

The Government of Mongolia needs to assess objectively the sustainability of, and limits to development in arid regions. Recurring attempts to plan development of water-thirsty industries (besides mining) in Gobi are likely to be unsustainable in a long term. If placing processing industries in Mongolia is economically justifiable, then it is likely to be most feasible in regions with sufficient water supply and well developed infrastructure.

#### **C. Water Supply in fluctuating climate: appropriate adaptation measures.**

With approximately 70 to 75% of Mongolia's water coming from subsurface alluvial deposits, current supplies are thought to be relatively sustainable and more adaptive to a changing climate than development of reservoirs, which would spur massive evaporative losses. Additional solutions to enhance water management should be assessed and utilized such as artificial recharge of aquifers, targeted construction of building in floodplains alternating use of surface and ground water sources, and water demand management in concert with different phases of climate cycle, etc.

#### **D. Basin-wide Climate Adaptation Planning**

Environmental Flow norms should become of the foundation of river basin management plans, ensuring that human activities minimally disrupt flow patterns that sustain river health. Environmental Flow norms should

explicitly link hydrological characteristics and requirements of aquatic ecosystems, flora and fauna in all stages of the climate cycle and should be based on ecological requirements both of Kherlen river valley and Dalai Lake ecosystems. Similar norms safeguarding fragile Gobi ecosystems should be developed for various local aquifers.

#### 16. Transboundary river issues in Dauria

In 1994, Mongolia and China signed a water treaty which forms the foundation for transboundary cooperation around water management. The Chinese side has consistently requested a comprehensive bilateral evaluation of the Kherlen-Gobi Project and was finally assured by Mongolian side in 2013 that this water transfer is no longer planned. At the same time, China has been seeking to "improve" water flow from Khalkh to Orshun River, a scheme that would create a shortcut on this tributary that feeds in Dalai Lake, and which would effectively dry out Buir Lake, another Ramsar wetland site of international importance. In the worst case scenario China would seek "compensation" and demand Mongolia's consent for diversion of the transboundary Halkh River. In this case the natural character of two Ramsar sites (Dalai and Buir lakes) will be lost in one shot.

Dauria already has a major negative example of a water transfer affecting a transboundary river. Despite protests from Russia a canal was built from the Hailaer/Argun River to "restore" Dalai Lake that over the past decade has been experiencing dropping lake levels due to the natural dry phase of climate cycle. This canal redistributes river waters into Dalai Lake, potentially stabilizing its dynamic wetlands, but also likely inflicting harm on the floodplain wetlands of transboundary Argun River in Russia.

#### 17. Conclusion. **Towards Kherlen River Basin Management Plan**

The Kherlen River unites Mongolia and China and sustains the Dalai Lake Wetland of international importance. This great river with tiny flow volume is importance life line for biodiversity and socio-economic stability of Dauria Steppe. This report aims to provide a timely warning. Although plans are drafted for deep transformation of the whole Kherlen river system, there still is enough time to consider more sustainable development options that would secure the resilience and adaptive capacity of its people and its ecosystems and support diverse conomic activities in this river basin.



*Dauria lake bottom in dry phase of climate cycle. (by V.Kiriliuk)*



*Flood in Hulunbuir wetlands in Inner Mongolia. (by E.Simonov)*



## KHERLEN (KELULUN) RIVER AND ADJACENT RIVER BASINS IN DAURIA



Kherlen River valley is a green buffer between greener steppe and forest-steppe grasslands to the north and waterless expanses of Gobi to the south.

Source: Google Earth

## PART I. PRESENT VALUES AND STATUS OF KHERLEN RIVER

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*Sacred ovoo on roadside marks a place for spiritual ceremony. (-by E.Simonov)*

### 1 MANAGEMENT CHALLENGES OF MONGOLIA'S SCARCE WATERS.

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Mongolia is located at the Great Watershed Divide between the Pacific and Arctic Oceans and closed basins of Inner Asia, but it has very little water resources and is affected by great variations in regional climate conditions. The fact that water is one of the nation's most precious resources was understood as early as the 13th century when Genghis Khan's Great Law "Ikh Zasag" prescribed to protect it as national treasure.

The combined annual flow of all 5,565 Mongolian rivers amounts to an estimated 34.6 cubic kilometers (MARCC 2009), while in comparison, the neighboring Yellow River to the south in China with a drainage basin roughly half the area of Mongolia carries approximately 80 km<sup>3</sup>/year. The sparse precipitation that the country receives falls mainly in the Henti Mountains in the Northern fringe of the country and drains towards North (Baikal Lake – Yenisei river, Arctic drainage) and Northeast (Amur river, Pacific drainage), clearly illustrated by the contrast in vegetation observed in the satellite image below (Figure 1). In biogeographic sense two main transboundary drainages coincide with eastern and western parts of Dauria - largest relatively pristine plain grassland remaining in Eurasia. (Olson et al,2002). Since the bulk of Dauria Steppe lies within Mongolia national boundaries, the management of rivers in this region largely depend on water management policies in Mongolia.

Mongolia clearly does not have enough water to let it go to waste by developing huge reservoirs or large polluting industries. Since Mongolia is blessed with a relatively sparse population, water demands from communities for water, energy and food production as well as natural ecosystems are generally easily met, although periods of water scarcity due to climatic variations have been observed in recent decades. An exception is the rapidly growing nation's capital Ulaan Baatar where approximately 50% of the country's population resides and during sequences of dry years water shortage develops by spring. <sup>1</sup>



Figure 1 MODIS satellite composite of Mongolia,

Image showing the clear contrast between the green vegetated areas which receive precipitation in the North and the Desert region with tan colors in the Central and Southern parts of the country (by Bart Wickel. SEI)

At a crossroads of rapid economic development and increasing demands from a growing population the country has a great opportunity to learn from mistakes of others and focus on a development pathway that sustains a healthy rivers and a natural environment in which the traditional culture of the people can thrive while focusing on economic development that is in balance with the available water resources.

<sup>1</sup> See description of UB water supply management options in chapter 15. Water Management alternatives

That is why in 2009 the Mongolian people wholeheartedly supported the “Law on protection of forest areas, headwaters and water basins from mineral extraction and exploration”. This famous “Law with the Long Name” is a wise measure to protect natural foundation of Mongolian land in the time of accelerated development of mining industry.(Kiriliuk et al, 2012)

The future of water in Mongolia is rife with challenges. Global warming is likely to cause water resources to decrease, due to changes in rain and snowfall patterns. While some projections indicate that precipitation in the Henti Mountains may increase by 10% in the future, the rise in summer temperatures will also make cause a greater proportion of water to evaporate and transpire, and could actually result in lower river flows (MARCC 2009 ). Changes in the extent and depth of permafrost and freeze cycles of rivers due to increasing air temperatures and shortening winters are changing the hydrological responses of rivers and resulting in increasing water temperatures, often worsening conditions for fish and other aquatic wildlife. (WWF 2009).

Other nations with water stressed regions, most notably Mexico, South Africa, Australia, China and the USA, have recently made drastic adjustments in water allocation to safeguard environmental flows. Mongolia still can avoid water crisis securing environmental flows before too much water is allocated to human use.

Rapid and uncontrolled expansion of water resource intensive activities such as mining, export oriented thermal power plants, coal-to-gas conversion is putting the country on a crash course unless water resources use is deliberately limited in each river basin and aquifer by rigorously defined environmental norms.



*Kherlen River flows both ways as it meanders near Choibalsan, Dornod (by E.Simonov)*



part of DIPA). Kherlen also belongs to Argun River watershed. So Onon, Khalkh and Kherlen all belong to the watershed of the Pacific Ocean.

Together these unique transboundary rivers, however small in comparison with main rivers of Russia and China, are supporting tremendous biodiversity values and ecological balance of Mongolia and adjacent countries.

To protect and these river ecosystems use in a sustainable way, Mongolia signed treaties on the protection and use of transboundary waters with its adjacent countries. Holistic joint management of transboundary river basins that allows to sustain natural resilience of their ecosystems is believed to be the key to adaptation to rapidly changing climate (MARCC 2009, Dauria 2013).

Because of the outstanding achievements of Mongolia in sustaining healthy rivers and for his commitment to environmental protection, the United Nations Environmental Programme (UNEP) on 4 June 2012, recognized President Elbegdorj as a Champion of the Earth.

In recent years some Mongolian decision-makers have expressed regret, that "water is wasted abroad" in largest rivers of the country. Saying so, they forget that in Mongolia the rivers play most crucial function of sustaining livable environmental conditions for people, who mostly populate river valleys. This fairly irresponsible phrase was coined by some engineer and now is regularly used by many high officials.



*Cattle in Hulunbuir wetlands in Inner Mongolia. (by E.Simonov)*

### 3 BIODIVERSITY IN RIVER BASINS OF DAURIA

The Dauria steppe ecoregion (Dauria, Zuun Bus) is strongly ecologically dependent on climate variability. Most of the Dauria steppe area is situated in North-East China and Eastern Mongolia; the Russian part is confined to Zabaikalsky Province and Buryat Republic. The area possess very high level of biodiversity for a steppe zone, and it is included in the list of most important Global 200 Ecoregions of the World as “Dauria Steppe”. These grassland areas are united by geographic location, annual and multi-year rhythms in ecological factors, and structure and composition of communities (Kiriliuk et al.2012). In terms of freshwater ecosystems, Dauria is divided into 3 principal freshwater ecoregions: Argun River with Kherlen as longest tributary, Shilka River which origin is Onon, and endorheic or “closed” basins of which Torey Lakes/Ulz River Basin is the most prominent. (Abel et al. 2008).

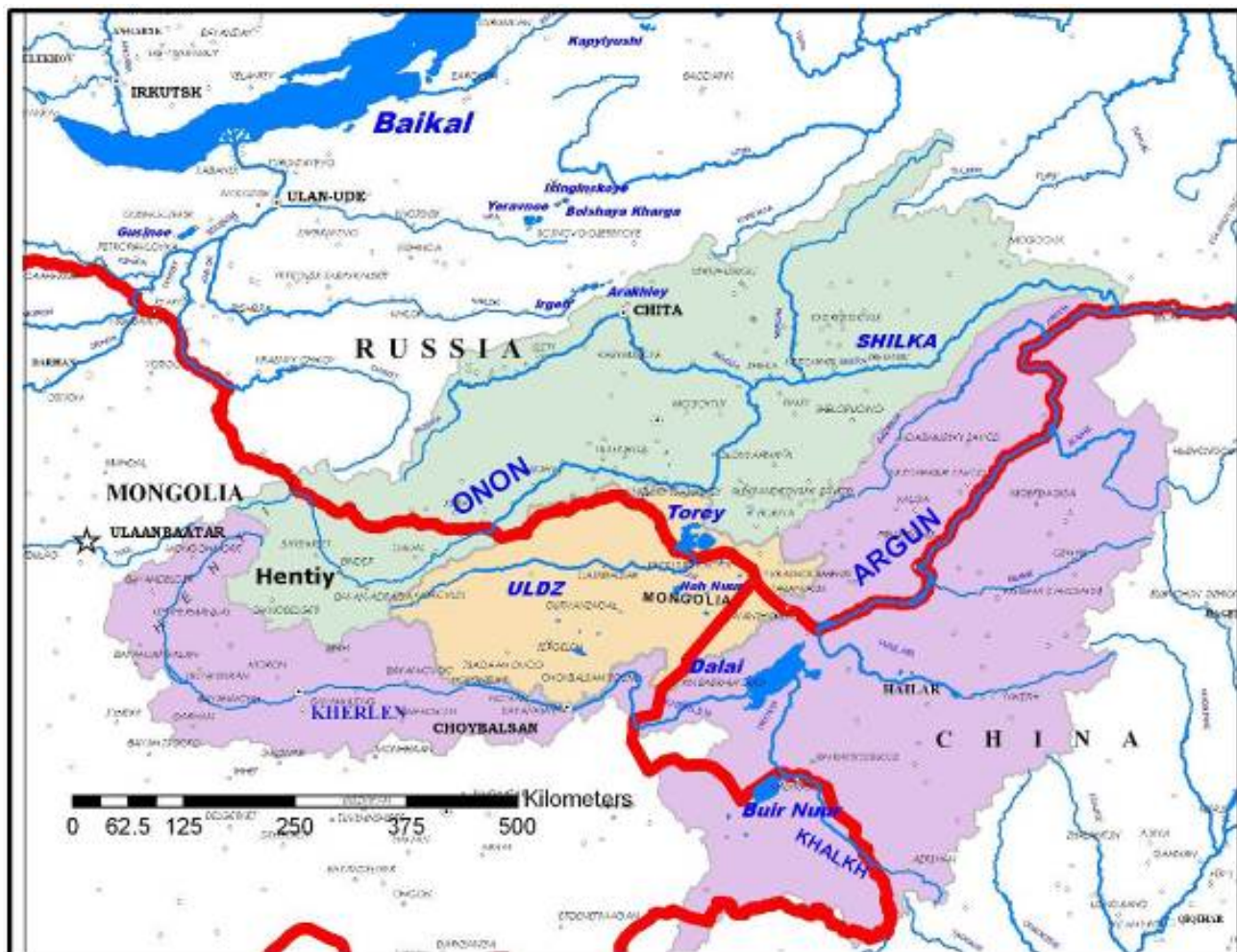


Figure 3: Kherlen river basin and adjacent transboundary river basins of Mongolia

The Kherlen River is the principal and longest river of Dauria Steppe and the most remote source of Amur River draining into Pacific Ocean. The river starts in the alpine zone of Henti Mountain range and runs for 1,250 kilometers through Cedar-pine forests, forest steppes and vast Eastern steppes to empty into Dalai (Hulunhu) Lake in Inner Mongolia. The Kherlen valley has more than 2,500 square kilometers of floodplain meadows, lakes and wetlands, serving as an important ecological divide between deserts of Gobi to the south and fertile steppe to the north. This river basin possesses rich diversity of ecosystems and species.



**White-naped crane (by O.Goroshko)**



**Loach (by Oleg Korsun)**



**Pallas cat (by V.Kiriliuk)**



**Swan goose (by O.Goroshko)**



**Gazelle migration (by A.Barashkova)**



**Mongolian toad (by Oleg Korsun)**

A peculiar feature of the Dauria Steppe is diversity of bird species determined by the narrowing of the global migration routes of birds in the Dalainor-Torey depression (Goroshko 2009, Dauria, 2013). More than 40 bird species breeding in or migrating through the Lower Kherlen Basin are on the IUCN Red List of endangered bird species and the national Red Data Books of Russia, Mongolia, and China. 700 kilometers upstream just near Baganuur, the Kherlen valley is a breeding site for White-naped Crane, Great Bustard, Relict Gull, Swan Goose, and important stop-over site for Hooded Crane, Black Vulture, Siberian White Crane, all marked as globally threatened and listed in the IUCN Red List. Also, there are nationally threatened species such as Whooper Swan, Black Stork, Great White Egret, Bar-Headed Goose, Bearded Vulture and Eurasian Penduline ([www.argalipark.com](http://www.argalipark.com)). Among mammals - the endemics of Dauria are Mongolian gazelle (*Procapra gutturosa*) (up to 90 % of the world population of the species live here), Dauria hedgehog (*Mesechinus dauuricus*), Daurian souslik (*Spermophilus dauricus*), and others. (Dauria 2013).

There are 75 species of fish living in Mongolian rivers and lakes, of which 43 species are found in the Pacific Ocean basins. Currently 38 species of fish are observed in the Kherlen River at Gun-Galuut Nature Reserve more known from its river mouth. Fish includes, Siberian Taimen (*Hucho Taimen*), Lenok (*Brachymystax lenok*), Amur



pike (*Esox reicherti*), Burbot (*Lota lota*), Amur dase (*Leuciscus waleski*) and Flathead asp (*Pseudaspius parva*) and many more. See List of fish species in the River Kherlen. ([www.argalipark.com](http://www.argalipark.com)). The Siberian Taimen inhabits in the crystal clear waters of Mongolia and it is the largest fish among salmonids as well as among fish of Mongolia. The recorded biggest one was up to 2 m and weighed over 70 kg. They dwell at the deepest and coolest pools of fast flowing clear rivers that is rich in oxygen. In spring, Taimen migrate up the river to spawn and may enter smaller tributaries, while in fall it returns downstream for the winter in search of river stretches that do not freeze to the bottom. It is also known to take winter asylum in Dalai Lake. Taimen is threatened by overfishing, gold mining and dams and in 2012 this species was listed as vulnerable in the Red List by IUCN (Hogan and Jensen, 2012).

One of reasons behind the rich biodiversity of the Kherlen river, is the low degree of human alteration of river processes, and its intact natural connectivity without interruption by dams from Henti Mountains to Dalai Lake. In the adjacent Inner Mongolia region in China many other rivers like Yiminhe or Huihe are blocked by dams and diverted by canals. The Kherlen is a truly free flowing river and has no significant water infrastructure even in its lower parts flowing through China. See satellite image on Figure 4.



*Figure 4 Kherlen from Mongolian Border to Dalai lake has no dams and reservoirs-exceptional situation for China (MODIS Imagery 2013)*

## 4 ECOSYSTEM DYNAMICS: INFLUENCE OF CLIMATE CYCLES ON HABITATS IN DAURIAN STEPPE<sup>2</sup>

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The Daurian Steppe's natural climate cycle, which typically spans 25-40 years, is a major force in shaping regional ecosystems and peoples' lifestyles. Climate changes in the Daurian eco-region, especially humidification cycles and continuing warming, cause habitat alteration and even habitat disappearance. The most intensive changes occur in wetlands and rivers of the steppe zone. In the dry phase of the cycle all small rivers and most of the springs and up to 90 to 98 % of lakes dry up. Large rivers such as the Kherlen, the Onon, and the Hailaer/Argun lose most of their tributaries and also become shallow and intermittent. At the same time the levels of lakes Dalai, Buir, and Khukhnor also fall considerably. Each water body has its own drying and filling dynamic depending on its depth, volume, hydrogeology and topographic location. The giant Dalai Lake (4<sup>th</sup> largest natural lake in China) at its maximum stage covers 2300 sq. km. while during the dry stage becoming a chain of shallow pools. "Pulsating" water bodies provide higher but much less stable biological productivity than stable ones. The alternation of the wet and dry phases as well as the diversity in water bodies creates dynamic mosaic of habitats and triggers migration and changes in species populations. In 1999 the Torey Lakes system yielded a thousand tons of fish, and in 2011 meadow at Barun-Torey Lake bottom serves as pasture for Mongolian Gazelle.

River floodplains experience frequent flooding events and typically have shallow groundwater, thus preserving more stable habitat in times of drought. The large lakes and most stable wetlands serve as life-support systems for wildlife and humans through all phases of climate cycles and provide refugia for aquatic life in the driest periods.

At the beginning of a wet phase rivers and lakes fill with water, a process that goes much faster than drying. In the steppe zone many aquatic and fringe habitats with rich foraging bases re-appear. Once every 30 years during the wettest phase of the cycle thousands of ephemeral lakes scattered throughout the steppe provide incredibly productive habitat for birds and semi-aquatic species. Subsequently, ground vegetation, growing densely in river beds and on lake shores, is flooded and rots. The processes of die-off of large amounts of organic matter with simultaneous filling and warming up of the water give a sharp rise in the productivity of plants and animals. The foraging capacity of the steppe biotopes sharply increases, and shelter conditions increase.

On the whole, the habitats of the Daurian eco-region are subject to cyclic changes with strong amplitudes. Accordingly, the amount of biomass of living organisms differs many-fold between dry and wet phases. Thus, food supply and other conditions for life and reproduction also vary significantly. During the dry phase, which is the most critical for many vertebrate species, a few habitat refuges remain, such as large rivers and river floodplains, lakes that don not dry up, etc.

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<sup>2</sup> This section summarizes findings from a recent publication by DIPA: O.Kiriliuk and E.Simonov editors. ADAPTATION TO CLIMATE CHANGE IN RIVER BASINS OF DAURIA: ECOLOGY AND WATER MANAGEMENT, Simonov Evgeny, Goroshko Oleg, Kiriluk Olga, Kochneva Natalia, Obyazov Victor, Tkachuk Tatiana, Egidarev Eugene, Kiriliuk Vadim. 2013. Peoples Daily Press. Beijing (in Russian, English and Chinese)

The high dynamics in habitats in the Daurian eco-region are accompanied by strong leaps in biological productivity, and these support the high biodiversity of the Daurian steppes, including the abundance of many mammal and bird species.

Climate variations influences vertebrate animals both through transformation of habitats and directly. A convincing example of indirect impact is the drying up and shallowing of water basins and courses, which are the natural habitat for aquatic animals and the main habitat for animals that live near water. In such cases aquatic organisms, including fish, die off completely or survive in near-dormant regenerative stages, including larvae and roe at remaining survival stations. Also the Golden Carp (*Carassius auratus gibelio*) can preserve its vitality for some time after the water basin has dried up by burying itself in the silt.

Reduction of depth and mineralization of the water of the lakes and rivers also lead to the loss of suitable nesting sites, including islands, and changes in the availability of foraging items. This actually causes considerable cyclical changes in the composition and numbers of waterfowl and near-water birds nesting at steppe lakes.



*Dead fish on the Torey lakes shore during a dry period of climate cycle (by DIPA)*

During the wet phase millions of waterfowl pass through the Daurian steppe using thousands of forage-rich lakes for resting and feeding before rushing across the taiga to the tundra. But as the lakes dry up the broad steppe zone becomes almost insurmountable for waterfowl, and their migration routes adjust to the emerging pattern of remaining humid patches in the landscape.

With the rivers and lakes drying up almost all White-naped Cranes (*Grus vipio*) have moved from the steppe to the forest-steppe for nesting. Total numbers of nesting White-naped Cranes during the last dry cycle fell sharply, which led to a general reduction of the western population of the species from 4000 to 3000 birds.

- An important biological characteristic of the region is that the high amount of endemic natural communities in Dauria, which have been formed with participation of different floras and faunas under conditions of permanent climate change. Under conditions of global warming and cyclic changes in moisture availability characteristic for the region, appreciable changes in species composition, abundance and spatial distribution of wildlife are expected to take place.

- Due to the cyclic changes in humidity, habitats in Daurian eco-region change. During dry phases habitats with tall plants, which provide much foraging capacity and good protection, reduce in area, and most of the wetlands vanish completely, while in wet phases they appear again and provide a sharp rise in biological productivity.
- The vegetation of Dauria is adapted to cyclical climate changes and resiliently reacts with fluctuations and cyclical succession.
- Most of the species, both aquatic and terrestrial, survive drought using different adaptation strategies. The most important are: surviving in few refuge habitats; persisting in the dormant phase of the life cycle; survival of non-reproductive adult individuals. The distribution areas of many vertebrates pulsate in concord with the cyclic changes in humidity. But the continuing warming gradually destroys the complete reversibility of these processes and leads to desertification.
- On the whole, in Dauria the dry phase of the 30-year humidity climate cycle, which occurs against the background of global warming, causes remarkably strong changes in nature with mostly negative consequences: the level of biological diversity falls, as well as the sustainability and productivity of natural ecosystem complexes, the biomass of living organisms decreases, the borders of the ranges and migration routes of mammals and birds shift. Many vertebrate species find themselves on the brink of survival.



*Erguna-Argun transboundary river at Huliyetu (by E.Simonov).*

## 5 CONSERVATION EFFORTS IN DAURIA AND RIVER BASIN MANAGEMENT.

Several parts of Kherlen River valley are protected by nature reserves. From its source in the Khan Henti Strictly Protected Area in Mongolia, the river flows by the Gun Galuut, Khar Yamaat, Toson Khulstai nature reserves in Mongolia and Baerhu Gazelle Provincial Nature Reserve in China. The Dalai Lake Biosphere Reserve, just across the border with China receives water from the Kherlen river and the Khalkh river which and is connected to the Argun River on the border with Russia. The 750,000 ha Dalai Lake Ramsar wetland is a complex of lakes, rivers, marshes, shrublands, grasslands and reed beds typical of arid steppe wetlands, stretching north-south from Russian to Mongolian border. The lake is an important breeding, molting, and stopover site for many waterbirds including endangered Swan geese (*Anser cygnoides*). In China the Dalai Lake National Nature Reserve also includes China part of Buir Lake - another most important lake of Dauria Steppe.

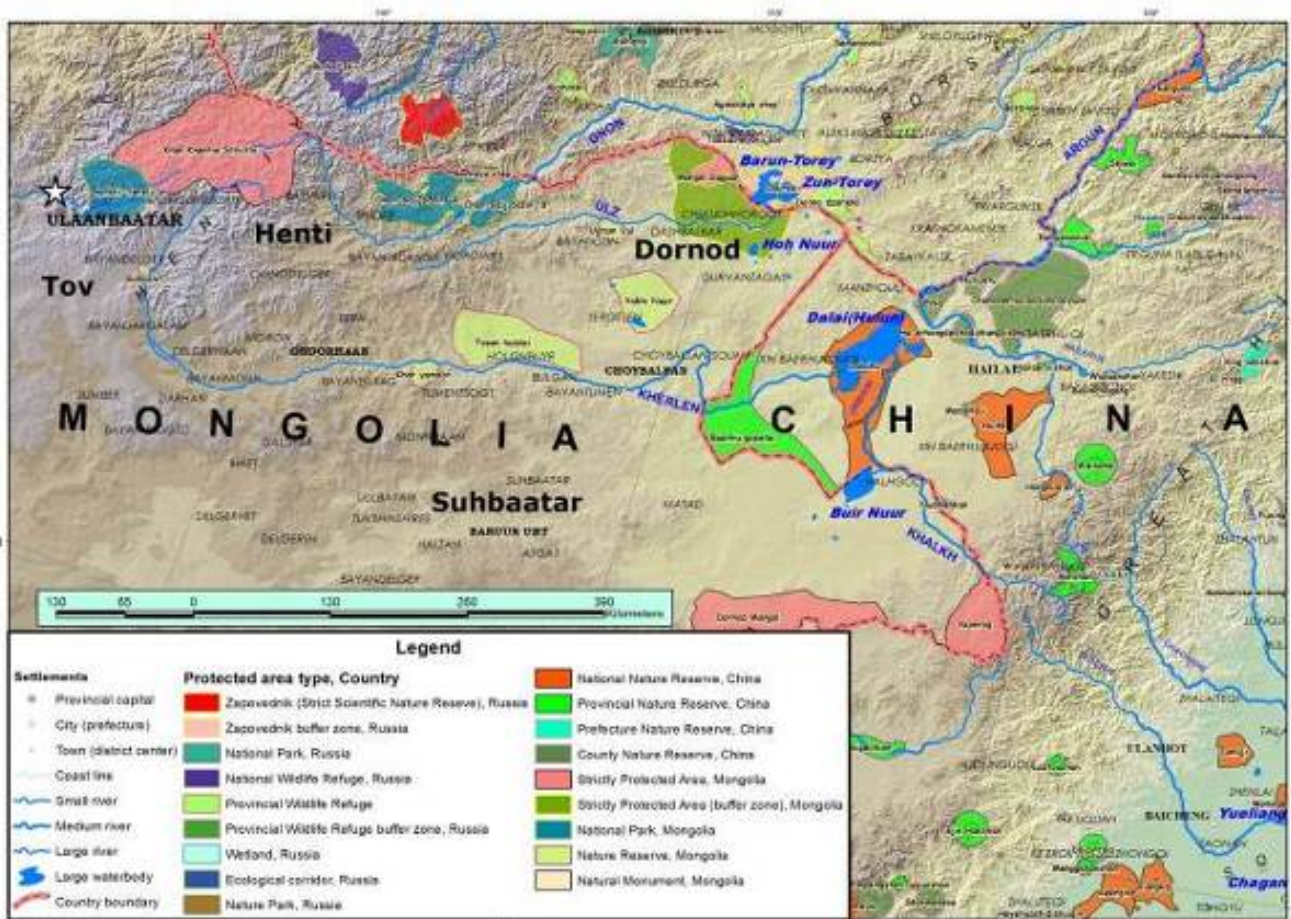


Figure 5: Protected areas of Dauria

## 5.1 DAURIA INTERNATIONAL PROTECTED AREA (DIPA)

The trilateral Dauria International Protected Area (DIPA) was founded at the junction of the borders between Russia, Mongolia and China on 29 March 1994 through the combination of four separate protected nature areas: Dalai Lake National Nature Reserve in the Inner Mongolia Autonomous Region in China, Daursky Zapovednik (national strict nature reserve) and Tsasucheisky Bor National Wildlife Refuge in Zabaikalsky Krai in Russia; and the Mongol Daguur strictly protected nature area in Dornod aimag of Mongolia.

The creation of this trilateral protected area, consisting of functionally connected wetland and steppe habitats, is of high importance for biodiversity conservation in Dauria, in particular for the protection of migratory birds and mammals. Besides biodiversity and ecosystem conservation, an important function of the international protected area is monitoring and scientific study of natural processes and phenomena in the Dauria steppe ecosystem.

Despite differences in management and level of protection between of the four areas, DIPA as a combined international reserve has been a conservation success. Since the first years of DIPA's existence, the area was managed to promote cooperation, first in science and later in environmental education. Cooperative activities have focused on joint inventories of flora and fauna within the reserves. Since its establishment, more than 300,000 km<sup>2</sup> of the region have been investigated by joint scientific expeditions spanning the region from the Henti to the Great Hingan Mountains and from the Gobi Desert to Siberian taiga forests. This enormous tri-national survey has been a great opportunity to acquire data on biodiversity and distribution of rare species, define conditions of regional ecosystems, and also to select key areas for conservation of a number of species. Careful analyses of ecosystems and populations of rare species in relation to natural and anthropogenic factors enabled DIPA workers to propose a number of conservation measures. These included: (i) an interconnected multi-level regional network of protected areas; (ii) programs for conservation of critically threatened species, and (iii) integration of economic development planning with conservation planning to achieve sustainability. DIPA personnel played key role in establishment of several protected areas: the Valley of Gazelles National Wildlife Refuge, Aginskaya Steppe Regional Wildlife Refuge in Russia and Onon Balj National Park in Mongolia. Mongolian part of DIPA is managed by Dornod Administration of Protected Areas located in Choibalsan.

In Mongolia Khar Yamaat and Toson Khulstai nature reserves are managed by the same Dornod Administration of Protected Areas and covered by research programs of DIPA and receive management assistance from Mongolia chapters of WWF and The Nature Conservancy. Khan Henti Strict Reserve has its own Directorate located in Ulaanbaatar City. The Gun Galuut Nature Reserve in Tov Province has been established by decision of soum government following initiative of local herder community to protect Kherlen River valley and develop ecotourism business that is beneficial for local people. Presently Selena Travel Co. owns the "Steppe Nomads" Ecotourist Camp and provides funds to support local employment and conservation initiatives.

While in China roughly half of the Kherlen (Kelulun) River valley is under formal protection, a very small percentage of vast and biologically rich floodplain of Kherlen River has been preserved through protected areas in Mongolia. Additional protection, from mineral extraction activities has been granted by the 2009 "Law to prohibit mineral extraction and exploration activities in forest lands, headwaters and river-protection zones". This important piece of legislation, known by the population as "The Law with the Long Name" grants protection to the most valuable landscape features throughout Mongolia: river valleys, lakeshores, forests, springs, areas important for flow accumulation, etc. Boundaries of protection zones were delineated in 2010-2012 with participation of conservation NGOs and local communities. Practically the whole Kherlen River valley is covered by such protection zones. When in 2012 the skyrocketing growth of GDP in Mongolia slowed down the Ministry

of Mining claimed that the Law hampers economic development by preventing miners from going to areas adjacent to waterbodies and forests. In 2013-2014 the Mongolian Government made an attempt to "improve implementation of the Law with the Long Name", which included revision of protection zones that led to a drastic reduction in their acreage\extent.

Practically all existing conservation efforts are good examples of ecosystem-based-adaptation- they preserve resilience of biota and protect habitats to be used in all phases of climate cycle and during linear climate change.

## 5.2 KHERLEN RIVER BASIN MANAGERS

Basin management arrangement have recently undergone drastic changes in Mongolia. Prior to late 2012 there was Mongolia Water Agency as a stand-alone relatively non-influential institution with high technical expertise in water management. A government restructuring in 2012 has considerably changed the organizational structure of water sector management in Mongolia. The new organizational structure is shown in *Figure 5*. It illustrates that the primary responsibility for water resources management lies with the Ministry of Environment and Green Development. Other ministries, state departments and nongovernmental organizations are also involved in usage planning of water resources. The concept of integrated water management (IWM) has been introduced in Mongolia in order to improve planning and ensure a coordinated usage of water resources. The IWM approach should eventually change the focus from a primarily supply-oriented and engineering-based approach to a demand-oriented, multi-sectorial approach. Key principles of the IWM include a participatory approach, recognition of the economic value of water, and emphasizing sustainability, and the principle of subsidiarity, that is, delegating decisions to the lowest practical level. (2030 WRG, 2014)

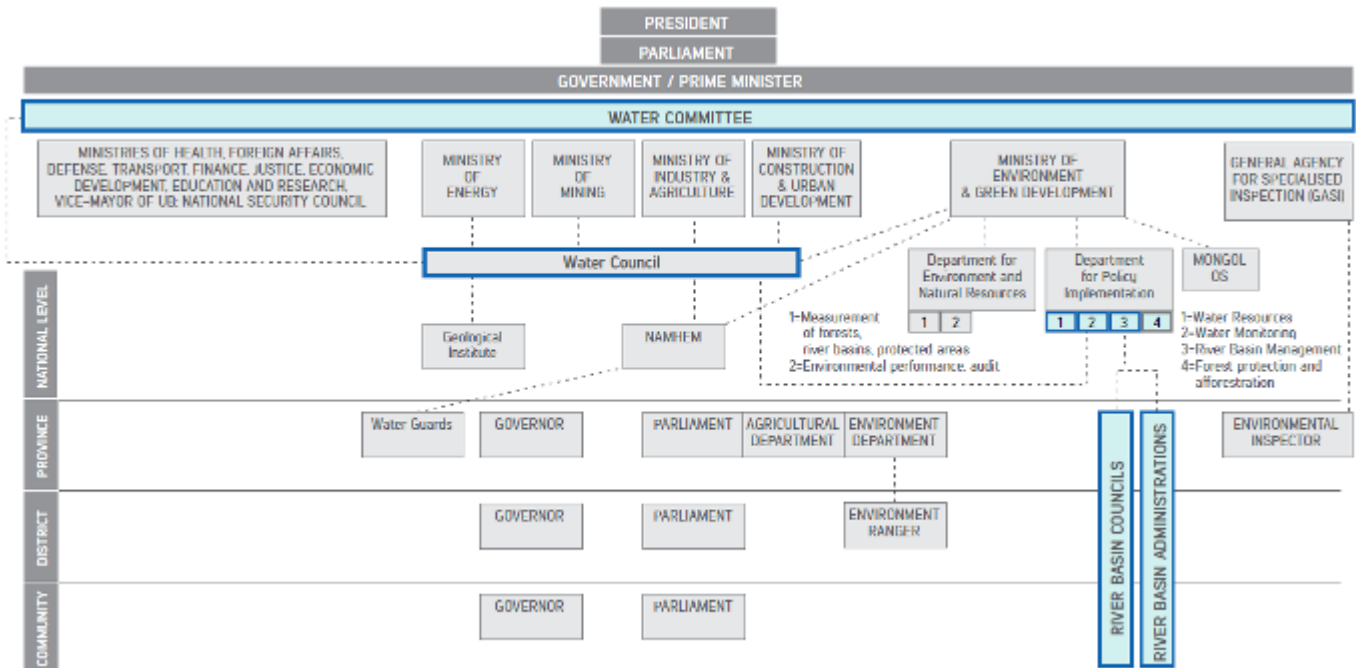


Figure 6: Organizational Structure of Mongolia's Water Management

(Source: Dombrowsky, I., A. Houdret and L. Horlemann (2014): *Evolving Water Basin management in Mongolia?* In: Huitema, D., Meijerink, S. (Eds.): *The Politics of Water Basin Organisations*. Edward Elgar, Cheltenham.)

As part of this process, Water Basin organizations have been formally established in 20 of the 29 Water Basins, including Onon (2012), Tuul (2012), Kherlen (2013) and Ulz (2014) basins. (see Figure ). If previously Selenge

River Basin was treated as a holistic basin and even development of a joint transboundary basin management scheme was envisioned with Russia, now it is divided into a dozen relatively independent planning and management basin units. Fortunately all rivers of the eastern Dauria have not been fragmented and each is managed by its own river basin organization. However, there is a lack of skilled workers to staff 28 river management units, therefore many management positions are still vacant, or staffed by people requiring to be retrained into river management specialists.

Each Water Basin administration is a Government organization under Ministry of Environment and Green Development's Department for Policy Implementation with the following responsibilities:

- Develop draft Water Basin management plans and monitor their implementation
- Provide local governors and local parliaments at various levels with professional guidance and support
- Operate and maintain a Water Basin database and disseminate required information to the public
- Process requests from individual citizens and economic entities to drill groundwater wells and construct drainage systems and forward technical assessment report to competent authorities
- Prepare charges for water use fee and pollution fee, based on the law
- Determine locations for water supply abstraction and disposal of waste water within the Water Basin
- Prepare technical recommendations for the cancellation of licenses for water use and/or disposal of waste water from citizens and economic entities, who violate the legal requirements for water use and disposal of waste water
- Propose the establishment of a Water Basin council along with local authorities.

Water Basin councils are government-initiated non-governmental organization with 31 to 45 members with one third representing public administration and legislature; one third representing NGOs and civil societies; and one third representing water users industrial and agricultural sector. They are supposed to:

- Enable public participation in water resources planning, implementation and monitoring water use and pollution
- Submit proposals for the suspension of water use licenses
- Advise Water Basin Administration (RBA) on development and implementation of a Water Basin management plan

Communicate citizens' proposals and opinions to RBAs and incidents of violation of the Water Law to competent authorities.

Kherlen River Basin Authority (KhRBA) was established on September 30, 2013 by Resolution A/278 of the Minister of Environment and Green Development on "Approving the structure, vacancy and rules of the Kherlen River Basin Authority". The office is located in Baganuur 140 kilometers east of the Ulaan Baatar at one of the most impacted and at the same time most scenic stretches of Kherlen river. KhRBA has a bi-lingual web-site <http://khrb.mn/en/>, which states that " The Kherlen River Basin Authority is a state administrative organization that prevents water resource from water scarcity and environmental pollution, uses the inferred water reserves properly, restores water reserves, regulates interrelation between local and administrative departments and implements the integrated management plan for water reserve."

In 2013-2014 KhRBA has been recruiting the Head and some key staff, so it limited its efforts in collaboration with other organizations and river basin management planning.

So far, the majority of most important Basin management plans in Mongolia have been prepared in collaboration with international organizations and projects. Onon and Khovd river basin plans were supported by WWF, Tuul and Orkhon -by Dutch consultants, Eg and Selenge plans were done through UNDP-GEF Baikal Project.



Work done in the 1970-80-s by hydro-engineers from Hungary on river basin water resources development schemes on Kherlen and western rivers was highly praised by the Great Khural of Mongolia and more technical assistance was requested. In early 2014 through Hungary-Mongolia cooperation agreement development of the Kherlen River Basin Integrated Water Management Plan was initiated with help from the "National Institute for Environment" and "General Directorate of Water Management" of Hungary. Also a private Hungarian firm VIZITERV Environ KFT was contracted to develop proposals for new water management schemes. Hungarian experts worked with Mongolian team led by Dr.Janchivdorj from Hydroecology Institute throughout summer 2014 and developed for international finance institutions a proposal for planning "Eastern Mongolia Water Management Scheme" that should include a) Kherlen River Basin Integrated Water Management Plan; b) Kherlen-Gobi Water Transfer Scheme; c) Comprehensive Plan for Water Monitoring in Kherlen Basin. Since November 2014 relevant Mongolian authorities are approaching WB, ADB, EU in search of funds to support this 2-year long planning exercise.

We already drafted this report when all of a sudden, in February 2015 on the pretext of national economic crisis the new Mongolian government dissolved 17 basin management authorities with the aim of restructuring them to cover larger basins in more efficient way. As of end of March 2015 we do not know in which form Kherlen River Basin Authority will exist in future. Since Kherlen River Authority covered the whole large transboundary basin it may survive the reform and be strengthened to face future challenges.

In China there is no special management unit for Kelulun River basin. Song-Liao Water Resource Commission (SWRC) headquartered in Chanchun, Jilin Province is responsible for river basin management planning and technical supervision in all rivers in China part of Amur river Basin shared with Russia and Mongolia. The SWRC is an agency of the Ministry of Water Resources with responsibilities in the Amur-Heilong, the Liao, and the basins of international rivers draining directly to the sea in northeast China (i.e. Tumen and Yalu Rivers). It is one of seven such water resource commissions in China. The state government empowers the commissions to exercise their administrative functions and powers within drainage basins. The SWRC serves to manage the water resources and river courses of the basin in a "unified" manner and is responsible for "comprehensive harnessing, developing and managing major water control structures, doing the planning, management, coordination, supervision, and service to promote river harnessing and the comprehensive development, utilization and protection of water resources". The SWRC has the following functions:

- Implementation, supervision, and inspection of the "Water Law," "Soil and Water Conservation Law," and other laws and regulations; draw up policies, laws and regulations for the basin.
- Formulate a strategic water resource development plan and mid- and long-term master plans for Song-Liao basin jointly with the related agencies and provincial and regional governments; supervise and implement the master plans upon their approval.
- Manage water resources of the Song-Liao basin in a unified manner; monitor, survey, and assess water resources in the basin; draw up a long-term inter-provincial and inter-regional water demand and supply plan and water allocation plan for the basin, supervise and manage the plan; administer the implementation of the water withdrawal permit system; supervise and manage protection of water resources within the basin.
- Manage the rivers, lakes, river mouths, and beach lands in a unified manner; manage river courses.
- Formulate and review plan(s) for flood control for the basin and the international river basins; coordinate flood and draught control; advise on safety and construction in the flood storage and detention areas.
- Manage water disputes between agencies, provinces, or provinces and regions.
- Manage soil erosion and advise communities on soil and water conservation.
- Review proposals, feasibility study reports, and preliminary designs of projects; draw up annual proposed plans for investments for the basin by the MWR and implement plans upon their approval.
- "Comprehensively harness and develop" the basin including river mouths; construct and manage key water structures and major inter-province/region water works; work with related agencies on water cooperation

and foreign affairs concerning international river basins.

- Advise with regard to local rural water conservancy, urban water conservancy, water works management, hydropower, and rural electrification.

The Song-Liao Water Resource Commission coordinates the provincial governments in the Northeast region (Liaoning, Heilongjiang, Jilin, and Inner Mongolia) to implement the Water Law and regulations and protect the water resource in the Northeast region. SWRC cooperates with many agencies but lacks the authority to command any of them. The structure of the water management sector suggests that all water departments of provincial and local governments are subordinate to SWRC to some extent. However, to a much greater extent they are linked to their own provincial or local governments. This means that SWRC must work through many links between agencies and committees to manage water in the basin

Although there is a network of specialized wetland management bureaus in forestry offices, these are not directly related to SWRC, the basin water resource commission. For example the State Forestry Administration rather than SWRC takes charge of wetland management.

Therefore SWRC works with Hulunbuir Prefecture of Inner Mongolia and Dalai Lake National Nature Reserve (subordinate to Forest Administration) to manage Kherlen River and Dalai Lake. Given that there is very little water infrastructure associated with lower 200 kilometers of Kherlen River flow, the most persistent management question is adaptation to cyclical drought, that regularly leaves river stretch in China dry.



*Kherlen River valley at Gun Galuut Nature reserve 150 km east of UB (by E.Simonov)*

## 6 KHERLEN RIVER — STRONGHOLD OF NOMADIC CULTURE AND ECONOMY

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*Herder camp in Dornod (by V.Kiriliuk)*

The Kherlen River Basin is the heart of the Daurian Steppe and the original homeland of the Mongol tribe. Avarga, at the confluence of the Kherlen and Tsenker River is the site where the first nomadic capital of the Mongol Empire was established. It is believed to have been the "Great Ordu (royal camp) of Genghis Khan" the most important of Genghis Khan's three seasonal Ordus. After Genghis Khan's death, his palace tent was transformed into a shrine where offerings were made, new Khans were throned, and important meetings were held. It was a center for collection and distribution of goods from around the empire; but soon proved too small and the Mongol court established the new base of Harkhorin (Karakorum) on the Orkhon River. Many other important historic events took place in the basin, including the Kherlen battle against Chinese invaders in 1409.

The Kherlen river flows through 4 provinces (aimags) of Mongolia: Tov, Henti, Sukhbaatar and Dornod. 23 districts-soums and aimag capitals of Dornod ( Choibalsan) and Henti (Underkhaan) are located in the Kherlen River Valley. Total population in the Kherlen river basin in Mongolia is 110,000 people, and most settlements, camps and roads line the Kherlen River, where the best living environment is found. Total livestock in the Kherlen river basin in Mongolia is 1.4 million or 3.4 percent of all livestock in the country (Oynbaatar et al 2012). More than half of population of the Eastern Steppe are herder families. Since Kherlen has only small number of tributaries in the middle and lower reaches, in dry years livestock tends to concentrate in Kherlen river floodplain, which provides both more reliable forage and water in all seasons. Eastern Mongolia, primarily Dornod aimag, is also responsible for 65% of nation-wide hay production for supplemental feeding of livestock. (Integrated Water Management in Mongolia, IWRM 2012). The total cultivated area for wheat and potato and vegetables in the Kherlen river basin is less than 0,5% of the basin area due to relatively poor soils and harsh dry climate unsuitable for land cultivation. However, future expansion of irrigation will likely occur in the Kherlen River valley due to abundance of suitable flat areas and availability of water (Prestige 2011, IWRM 2012).

In China the Kherlen river flows through 2 soums and one town Altan-Emel – the center of New Right Barga Banner belonging to Hulunbuir Prefecture of Inner Mongolia, with population of 35,000 - mostly ethnic Mongols. In 2013 there were 1.3 million heads of livestock in New Right Barga Banner and they are similarly dependent on Kherlen river for water supply. Overgrazing is a problem in Mongolia, but even much bigger in China part of the basin due to the greater density of herder population in the river valley and better market conditions for sale of livestock products.

Tourism focused on nomadic culture, Mongolian history, sport-fishing and bird watching is a growing segment of the local economy in both countries. The “Steppe Nomads Eco Camp” near Baganuur is an outstanding example how business, nature conservation and cooperation with local community can be united in one sustainable development effort in Mongolia. In China grassland-based tourist operations reach much greater scale, with Hulunbuir being the most important destination for "steppe tourism". Majority of tourist camps are set near rivers or Dalai(Hulun) Lake and very dependent on healthy water bodies. In 2005 dropping levels of Dalai Lake caused significant economic losses among many tourist operators occupying its shores and they petitioned the government asking for help. (see O.Kiriliuk and E.Simonov 2013).



*Many facilities built in Soviet times are now in disrepair (by D.Pliukhin)*

## 7 HYDROLOGY IN A VARIABLE CLIMATE

Low winter temperatures in the Kherlen basin result in deep freezing of the soils and even to formation of permafrost pockets. Most river courses, including the Kherlen downstream from Baganuur, freeze down to the bottom, making fish seek refuge near areas of groundwater release at river bottom and in lakes. The spring is cold, windy and dry, while most of the rainfall coincides with the highest annual temperatures during the second half of summer. This leads to a highly intensive cycling of nutrients in the short summer period and, as a result, to the formation of primarily poor, shallow soils.

According to recent research 82.1- 90.7% of annual runoff along the Kherlen river is generated between April and September.



Figure 7 Annual distribution of the Kherlen river flow at Baganuur, Underkhaan and Kherlen-Toono (million cubic meters) (Monhydroconstruction 2014)

In a typical wet year for the Kherlen river basin, the annual sum of precipitation may reach up to 400 mm while being as low as 150 mm in dry years. Long term mean evaporation from water surface in the middle and lower parts of the basin is estimated to be between 970 and 1100 mm which is typical for arid regions (Oyunbaatar et al 2011, Kamimera et al, 2004).

Precipitation in the region, due to its strong correlation with the Pacific Decadal Oscillation (PDO), a variation in the seas surface temperature of the Pacific ocean with an intra-decadal time scale of 20 to 30 years. In Dauria these cycles are most vividly apparent within the time span of a century (Obiazov 1994). As illustrated by Figure 8, the Kherlen experienced large variation in flows that follow these precipitation cycles. , From 1947 to 1958 (12 years), the Kherlen river experienced a low flow period, between 1959-1974 (16 years) high flow ,from 1975 to 1982 (8 years) another low flow period, and from 1983 to 1995 (13 years) another high flow period etc. Since

the mid 1990's up to 2010 Kherlen had a low flow period. Thus, up to two full cycles in precipitation occurred in the area over the past 60 years.

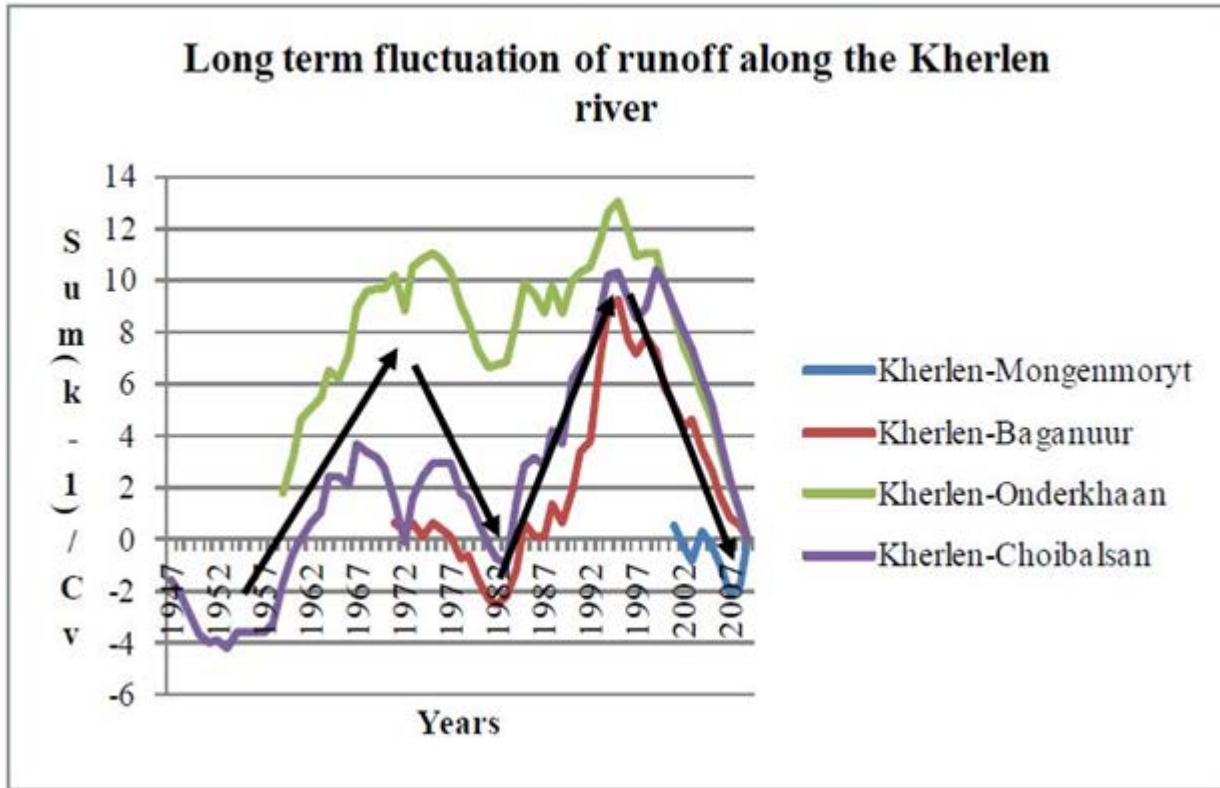


Figure 8 Cyclical change in Kherlen river discharge (Oyunbaatar et al 2011)

The Kherlen River Basin is the second largest in Mongolia (116,455 sq.km) but has the lowest stream network density among all basins outside Gobi - 0.1 km per 1 sq.km.- and practically all permanent tributaries are located in upper reaches (Figure 8).

Only 0.5 cubic kilometers of Kherlen water annually is leaving Mongolian territory and that amounts just to 1,5% of total surface runoff in Mongolia. The main fraction of runoff forms in upper forested area upstream from Baganuur and then significant runoff loss through evaporation and bank infiltration is observed for 800 km downstream along the river running through steppe with predominantly sandy soils. From the forest-steppe region into the dry steppe, the Kherlen river run-off loss reaches 40 to 50%. The Kherlen annual average flow rate decreases from 648 million cubic meters at Baganuur to 530 million cubic meters at Mongolia-China border (Figure 10). (Oyunbaatar et al 2011). The annual average river discharge into Dalai Lake is on average 483 million cubic meters. In dry years such as 2007, the total inflow into Dalai Lake reached only 38 million cubic meters and for 200 days that year the Chinese stretch of the Kherlen dried up completely. (after 克鲁伦河流域水文特性分析 2012).

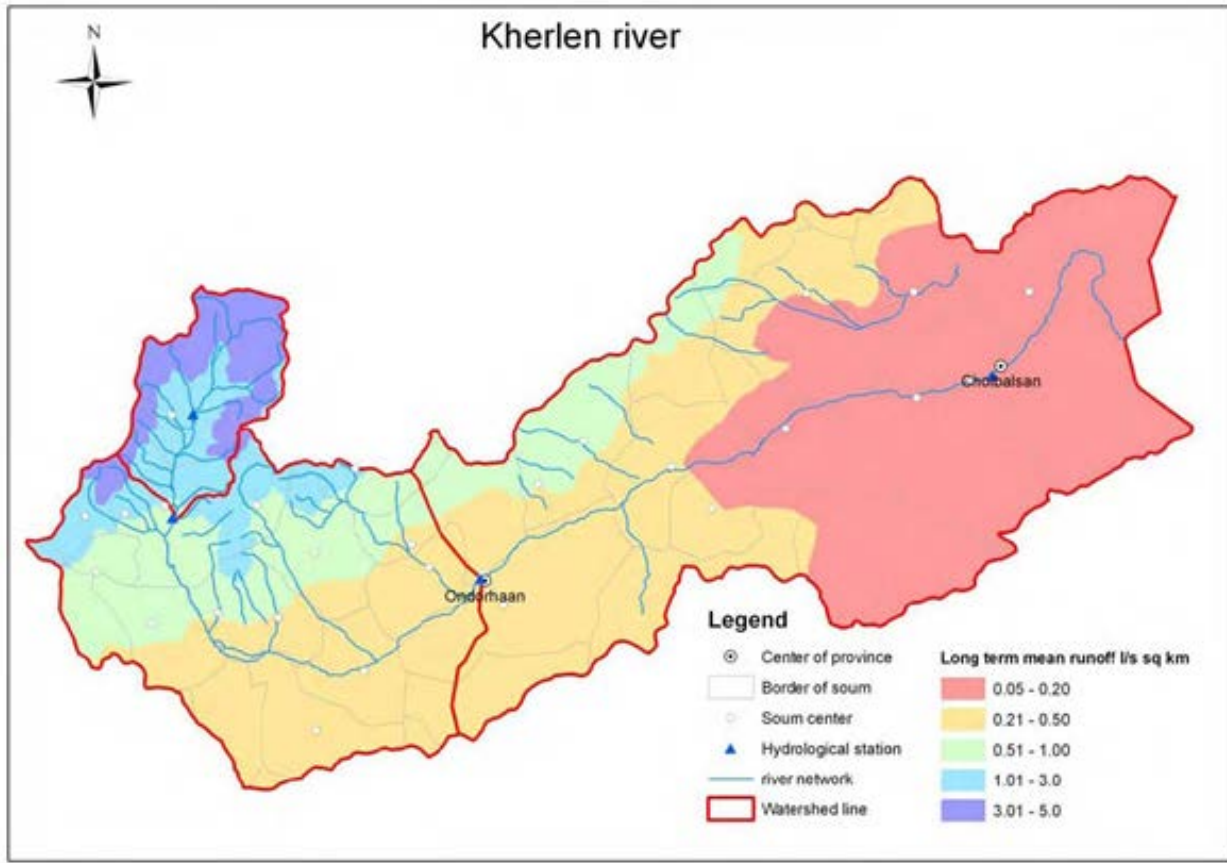


Figure 9 Annual mean runoff distribution in the Kherlen river basin in Mongolia (D. Oyunbaatar et al 2011)

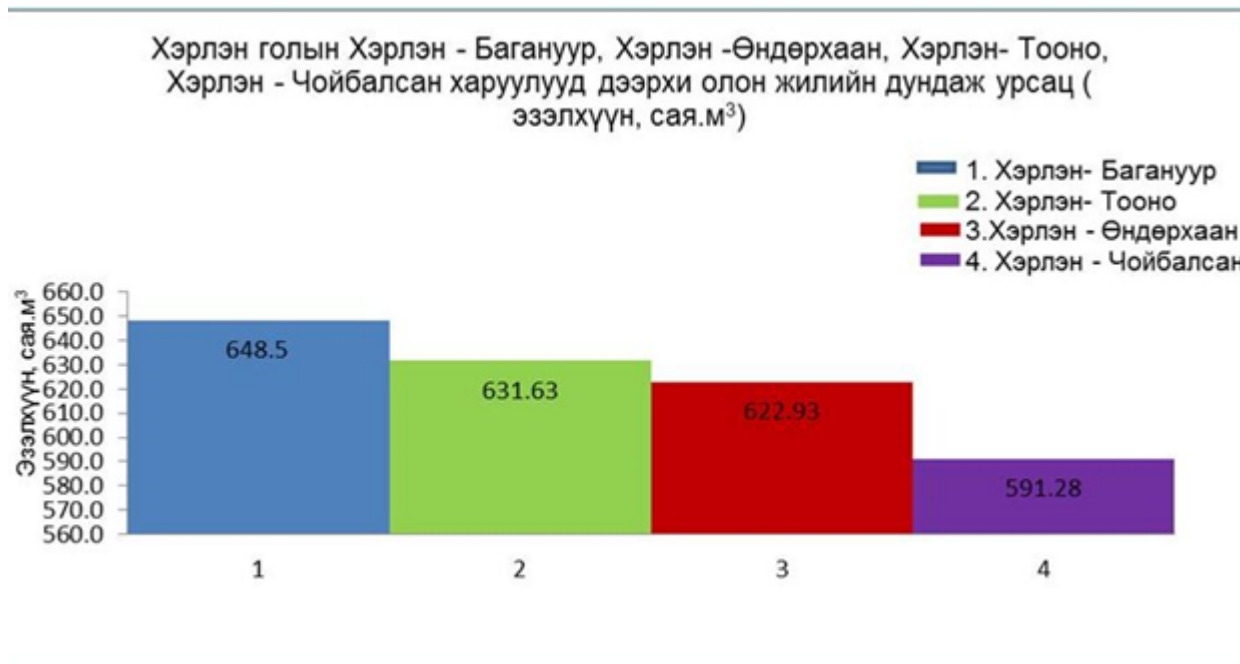


Figure 10 Decrease in average annual flow volume along Kherlen river from Baganuur(1) ,via Kherlen-Toono(2) and Underkhaan(3) , to Choibalsan(4) (in million cubic meters) (Monhydroconstruction 2014)

During a year of highest flows, annual runoff in the upper river basin can reach up to 58.9 m<sup>3</sup>/sec with this value dropping by 29.7% at Underkhaan and 50.6% at Choibalsan. During low flow years, the percentage of lost runoff at Underkhaan is 7.7 % of upper basin value of annual mean runoff and at Choibalsan site 53.6 %. Flow measurements in 2003 showed that the Kherlen river runoff increases until Underkhaan site due to groundwater contributions and after Underkhaan to the downstream site, low flow remains relatively constant and reduces in lower reaches (“Mongol Guan-Yuan” Ltd , 2006).

Floods are the most important hydrological process that maintains the vitality of Kherlen River valley. The highest observed historic discharge at Baganuur was 1,320 m<sup>3</sup>/sec. Due to its large floodplain with thick alluvium flood peak discharge drops by 40% at Underkhaan and by 60% at Choibalsan (D. Oyunbaatar 2004). Due to the strong attenuation of the flood wave attenuation by the vast natural floodplain, the Kherlen floods do not pose any danger to human settlements along the river downstream from Baganuur. Flood water drive groundwater recharge, fills oxbows and lakes and triggers the growth of pasture vegetation in the vast 2,000 sq.km. floodplain of the Kherlen river.

Floods also carry sand and silt, essential sediments for building floodplains and river habitats. The Kherlen River is estimated to deposit several millions of tons of sediments annually over its wide floodplain with an annual average of 247,000 tons reaching the river mouth in China. (克鲁伦河流域水文特性分析 2012)



*Transboundary Argun River during flood (top) and in low water (bottom). ( by Daniel Hanisch)*



## 8 CLIMATE CHANGE AND THE PATH TO ADAPTATION

In the Kherlen River-Dalai lake basin cyclical climate fluctuations of high magnitude and long periodicity may also mask linear changes in regional climate. (Kiriliuk, 2012). This is quite vividly demonstrated integral curve of regular lake level fluctuation in Dauria (Figure 11). Nevertheless region shows discernible climate change pattern.

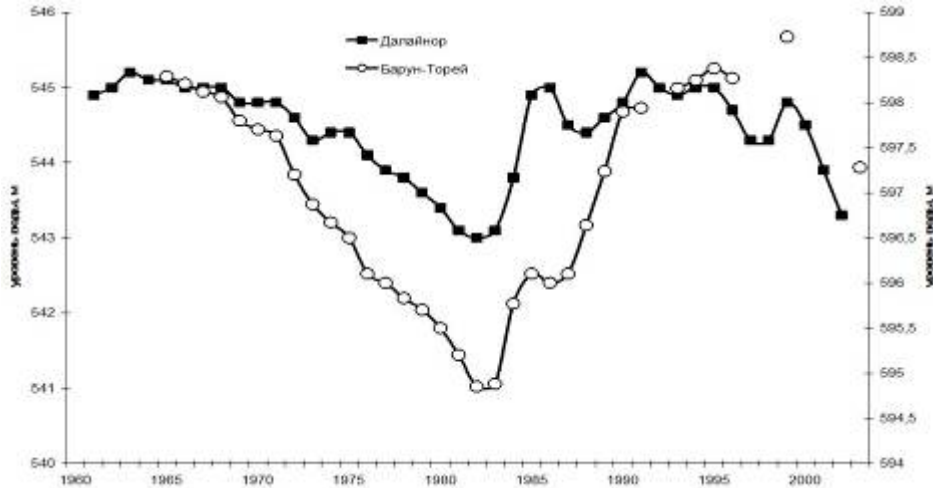


Figure 11 Fluctuation in level of terminal lakes in transboundary basins: Dalai lake (left scale-black squares) and Barun-Torey lake (right scale white circles) (by V.Obiazov 2011)

Between 1950 to 2009 (60 years) the average annual temperature in Dauria increased by approximately 1.9 °C. In past decade this trend has somewhat slowed down (Figure 12). (Dauria 2013). This is much more than "global warming" trend which is under 1 °C increase during last 100 years.

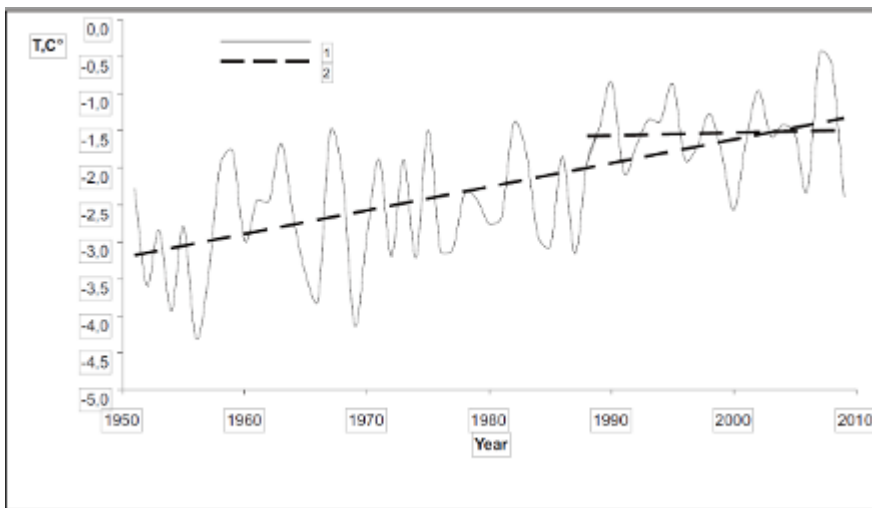


Figure 12 Long-term changes in average annual air temperature for the Onon-Argun inter-river area in the period 1951 – 2009. 1 original series, 2 linear trend (from Dauria 2013 graph by V.Obiazov)

Precipitation in the region is subject to regular cycles that seem to be driven by the variations in Pacific ocean water temperatures (PDO). Around 2011 the most recent dry phase of a cycle ended and a new wet phase began. This has resulted in a marked increase in river discharge of the Kherlen river.

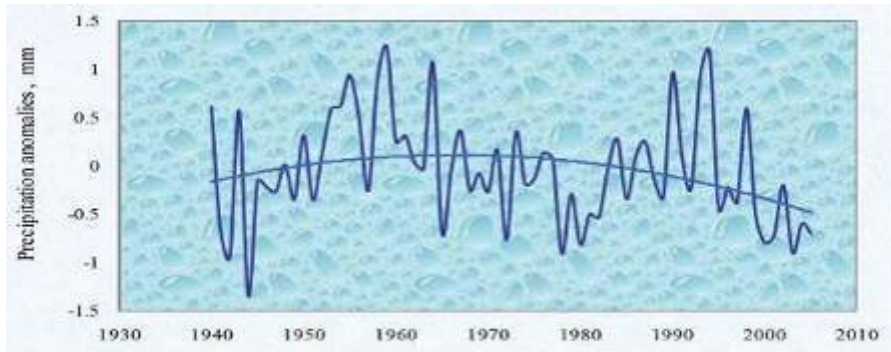


Figure 13. Trends in annual mean precipitation in Mongolia (anomalies to the long-term average, 1940-2007) (Source: Natsagdorj, 2008)

Water balance studies with river discharge and precipitation data have revealed that on average, 70-90% of the precipitation evaporates from the land surfaces into the atmosphere, while remaining parts recharge groundwater and rivers. Since 1961 precipitation increased by 30-70 mm in the southern part of the Eastern steppe region (Gomboluudev et al., 2005). In the same period the potential evapotranspiration has increased by 12, 10, 9, and 7% in the forest-steppe, steppe, Mongolia Altai mountains and Gobi respectively (Gantsetseg and Bolortsetseg, 2003). This is equivalent to increases of 74, 70, 50 and 63 mm of potential evapotranspiration in these respective areas. The increased evapotranspiration causing soil moisture decline and greater aridity leads to water balance changes in not only water limited regions, such as Gobi and Gobi-desert, but also steppe and forest steppe areas of Mongolia and adjacent China. Trends described above suggest that runoff in the steppe region partly determined by difference between precipitation and evapotranspiration could either stay the same or decrease. (P.Batimaa et al 2011).

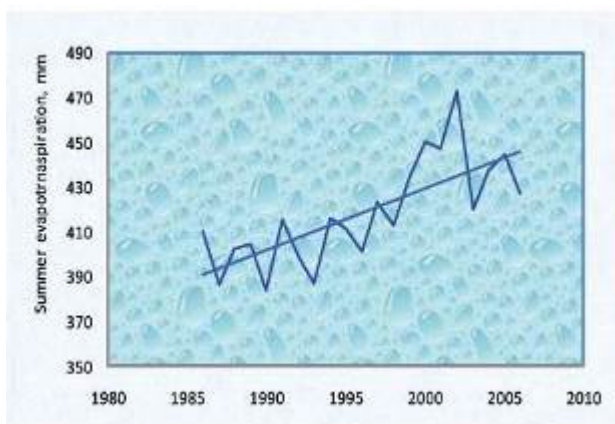


Figure 14 Increase in evapotranspiration near Ulaanbaatar City. (Adopted from Batimaa et al 2011)

There is a debate over whether there is a noticeable decreasing trend in long term average runoff of the Kherlen river, or not. Obiazov and Batimaa in two separate studies conclude that there is no discernible trend in river runoff over the past 60 years, while a study by WWF Mongolia (Figure 15) concluded that flows have been following a negative trend due to increasing evapotranspiration and rising temperatures (WWF, 2009).

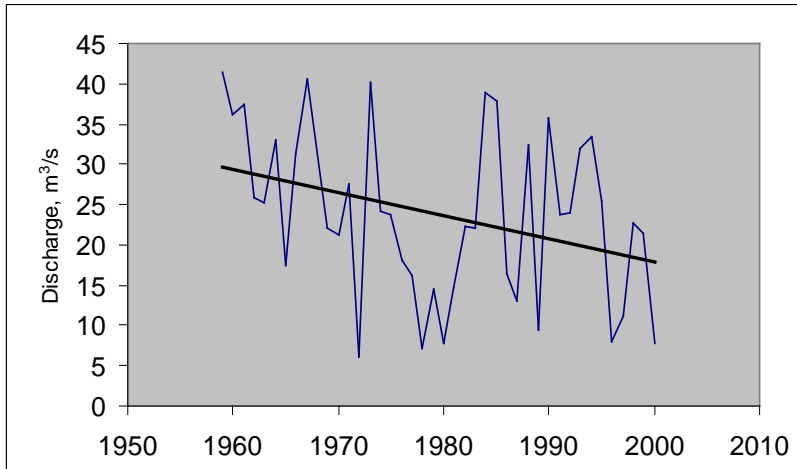


Figure 15. Trend of water resources at the Kherlen river according to a climate study by WWF (WWF/Climate Change... 2009).

It is important to understand that thus far changes in water availability due to global warming in Dauria, if any, have been an order of magnitude smaller than changes due to natural climate cycle. It is however likely that the impacts or timing of the climate cycles will change and that therefore the sustainability of adaptive measures for ecosystems and people is expected to be less predictable.

Permafrost occurs in the subsurface of about 63% of the total territory of Mongolia. The Mongolian permafrost is thinner and distributed more sparsely when compared to permafrost in northern Russia. Therefore it is relatively sensitive to air temperature. The thickness of seasonally frozen ground has decreased by 10-20 cm in the Dornod for the last 30 years. Changes in timing of the seasonal frozen ground and ground temperature of permafrost indicate that as warming trends continue; the active layer of permafrost will thaw more readily, affecting ecosystems, carbon reservoirs in the upper part of permafrost and hydrology. Permafrost is found in peatlands throughout the discontinuous permafrost zone of Mongolia and serve as reservoir of organic carbon, which may be released in the form of greenhouse gases if the permafrost thaws. (P.Batimaa et al 2011)

All surface water in Mongolia is covered by ice for about six months a year. Thus groundwater is the primary source of water supply for major urban and industrial centres and the extensive animal husbandry sector. It is easy to access and often of high quality. Alluvial aquifers contain groundwater at the shallowest depths. The shallow alluvial deposits along the river basins are the main source of water for the major cities such as Ulaanbaatar, Erdenet and Darkhan. Many factors affect the recharge: alterations in precipitation, evaporation and temperature regimes, soil properties and their changes, urbanization and changes in forest management and agricultural practices. Climate change will affect groundwater resources throughout the country. It is expected that aquifer recharge is reduced, just as ground water levels are reduced, especially in the shallow aquifers. Higher temperatures and droughts will result in increased evapotranspiration. Recharge will also suffer from more extreme precipitation events, because more water will runoff before it can percolate into the aquifers. (P.Batimaa et al 2011)

The most recent climate change study results show an increase in monthly mean temperature and a small increase in precipitation (P.Batimaa et al 2011). A study by Gomboluudev (2009) concluded that summer air temperatures will potentially increase by 3.6- 6.1 by 2065. Summer precipitation is projected to increase by 24.5

mm by 2065. As a result river runoff could correspondingly increase by 5-9 mm in 2020-2080. In Mongolia, the projected increase in evapotranspiration is going to outrun the projected increase in precipitation, increasing in steppe zone by 18 mm/year by 2020, 34 mm/year by 2050 and by 69 mm/year by 2080 under HadCM3 A2 (Bolortsetseg, 2005). Moreover, annual evaporation from water surfaces in Pacific basin watersheds of Mongolia is projected to increase by 66.1 mm in 2020, 72.7 mm by 2050 and 193.4 mm by 2080 by HadCM3 A2 (G.Davaa 2008). As a result, evaporation increases will be by an order of magnitude bigger than increases in runoff, and result in much dryer conditions in the Kherlen river basin and most other basins (Oyunbaatar et al, 2011). Projected river runoff changes in drainage basins of Mongolia are presented in table below. Climate change can be approached as a new sector of water consumption as it is projected to decrease the water resources of a country. Different GCMs suggest that changes in temperature and precipitation will result in a runoff decrease of 29.3% to 15.3% increase (Table 7) (Batimaa et al., 2005, 2009).

Table1. Projected river runoff changes in drainage basins of Mongolia. Source: Batimaa, 2005, 2009,2011

Change Scenario GCM	A2-medium-high emissions			B2-medium-low emissions		
	2020	2050	2080	2020	2050	2080
<i>Internal Drainage Basin</i>						
<i>HadCM3</i>	-1.4	9.1	-8.6	7.2	9.6	-0.3
<i>ECHAM4</i>	15.3	10.9	-10.1	16.2	6.2	-2.8
<i>CSIRO-Mk2b</i>	-1.3	-0.6	-5.1	0.8	-1.7	-7.1
<i>Arctic Ocean Basin</i>						
<i>HadCM3</i>	-13.9	-5.4	-12.6	-0.5	-2.6	-19.2
<i>ECHAM4</i>	1.4	-7.3	-26.9	1.4	-3.2	-17.5
<i>CSIRO-Mk2b</i>	-6.4	-13.2	-24.7	-9.1	-14.6	-17.9
<i>Pacific Ocean Basin</i>						
<i>HadCM3</i>	-23.5	-20.9	-27.5	-19.1	-23.6	-29.1
<i>ECHAM4</i>	-9.8	-18.3	-24.7	-4.2	-18.8	-26.1
<i>CSIRO-Mk2b</i>	-17.5	-22.9	-35.6	-20.5	-24.2	-29.3

The WWF study also concludes that the runoff of the Kherlen river could be reduced by 16 to 25% in between 2020 and 2080. This decrease may be explained by increase in temperature. Because changes in temperature affect potential evaporation this offsets small increases in precipitation. Based on these large scale models there is a likelihood that the flows of the Kherlen River may be reduced by one quarter due to climate change by the end of this century and that it is likely that the dry phases of climate cycle will be longer and dryer than experienced before.

The fish and invertebrates of the Daurian rivers are adapted to cold temperatures with their life cycles completely synchronized to the ice-free period. With increasing warming the extension of the ice-free period and increased water temperatures will lead to enhanced primary production and eutrophication, desynchronize life cycles and cause physiological problems for cold-adapted aquatic species. Shorter ice cover periods and earlier ice-breakup results in thermal instability and also in changes of food-web dynamics. (WWF, 2009). It is thought that Salmonid fish such as the Siberian Taimen, Lenok and Grayling will be the first to suffer from these changes. To survive they will likely have to migrate further upstream in spring to spawn and reach the cold, oxygen-rich waters and cover greater distances in fall to reach for wintering habitat with deep non-freezing water. (WWF 2009).

Authors of the WWF report also warn that there is a potential political for conflict over water under climate change due to periodic water shortages. The demand for water by different sectors such as agriculture, tourism,

and households usually increases precisely during the times of greater water stress. (WWF Climate change 2009).

Adaptation to changes in climate is not new to the people of Dauria. One could even say that adapting to the ever changes availability of water in time and spaces is at the core of the existence of the Mongolian nomadic tribes. The cyclical behavior of climate has been the main driver and inhibited the possibilities for setting up permanent settlements. However, the current mode of development, associated with increasingly stationary settlements/production facilities and rapid growth in economic output are inevitably leading to severe competition for water and other resources during periods of drought. Man made “global warming” is likely to make the climate cycles even more pronounced and is bound to alter the duration of phases.

Recent rapid socio-economic changes and loss of nomadic heritage in the Dauria Steppe make local communities less resilient but also adversely affect natural ecosystems and their ability to adapt. Drastically different cultures, differences in population density and the often highly unsustainable mode of economic development and water use in Russia, China and Mongolia, make it very difficult to build transboundary mechanisms for the protection of common water resources. While largely a naturally occurring event in this arid region, drought is nowadays perceived as a “disaster” and questionable water engineering “solutions” are proposed to protect environment and society from climate change. Poorly planned human development activities initiated in anticipation of climate change (including some “adaptation” measures) may profoundly damage ecosystems much earlier and more severely than the consequences of actual global warming, and could be labeled as mal-adaptive (UNECE, 2009). This Threats to river and wetland ecosystems and dependent human population are further exacerbated by proposals for several inter-basin water transfer projects and other infrastructure in the Argun River Basin. The water management crisis is actively developing in all three countries – China, Mongolia and Russia. The Argun-Hailaer, Halkh, Kherlen, Ulz, Onon, Imalka rivers – virtually all notable watercourses of Dauria - are transboundary. The greatest threats unfold when competition for water among countries is made the implicit goal of national policies and when short-sighted politicians pledge to store waters on national territories, leading to severe damage of the naturally resilient ecosystems of transboundary rivers and wetlands. Therefore, adaptation efforts to climate change in Dauria must first of all occur through the prevention and removal of maladaptive water management practices that increase to vulnerability rather than decreasing it.



*Changing of time and duration of ice formation - one of early signs of climate change in Dauria. Onon river (by E.Simonov)*

## PART II. EXISTING AND PLANNED DEVELOPMENT AND ITS POSSIBLE IMPACTS

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*Pipeline construction at Dalai Lake in 2008. Hulunbuir, Inner Mongolia (RwB archives)*

## 9 HUMAN IMPACTS ON THE KHERLEN AND ADJACENT RIVER BASINS TODAY

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### 9.1 IMPACTS IN KHERLEN RIVER VALLEY

There are currently three major factors that affect water quality of the Kherlen river: mining, oil and gas development and intensification of grazing. The latter is thought to be exacerbated by climate change.

According to Monhydroconstruction (2014) the total water withdrawal in the Mongolian part of the basin now is 24 million cubic meters annually, or 5% of Kherlen river annual average flow across the border into China, and this figure is consistent with official estimates (IWRM 2012.-See Table 2)). This current rate of withdrawal likely has little adverse impact on Kherlen River because it occurs in many locations and significant part of this water comes back into the river network in the form of return flows. It is reasonable to assume that another 3-4% of Kherlen river annual average flow is used in Chinese part of the basin. (克鲁伦河流域水文特性分析 2012)

The large coal mining operations in the Kherlen Basin are presently located near Baganuur and Choibalsan. The Baganuur mine, located in 120 kilometers from UB, currently produces approximately 3 million tons of coal and

supports 40% of domestic coal consumption and majority of Mongolia's thermal power plants. Measurements of pollution impacts based on biological indicators have shown signs of river ecosystem degradation at Baganuur, but concentrations of pollutants in chemical analyses did not exceed national norms. Nevertheless, mining is known to contribute to river pollution/water turbidity at other mining sites in Kherlen basin, especially on smaller tributaries and that was studied and documented (IWRM 2012).



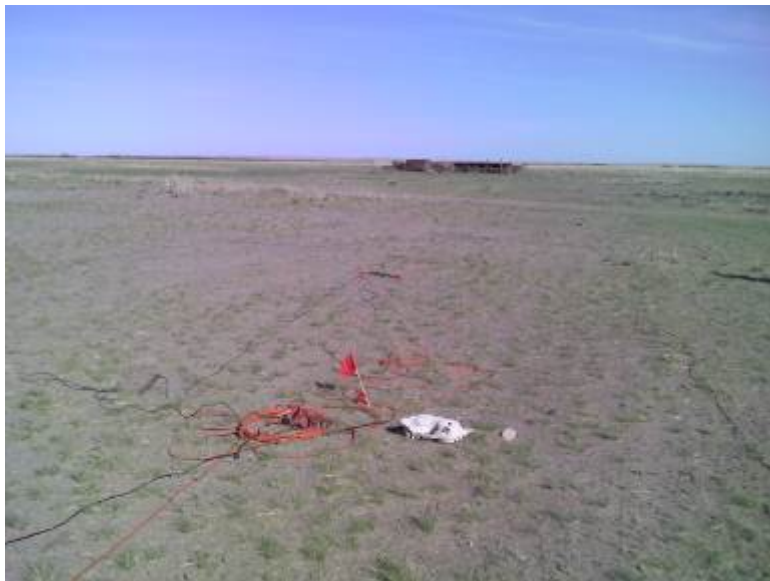
*Baganuur Coal Mine and Steppe Nomads Eco-camp in Kherlen River Valley*

Although there is some local pollution from other industrial and municipal sources it is mostly of local concern and has not reached a degree dangerous for ecosystem at basin-wide scale. For example at Choibalsan, a leaking wastewater treatment plant is known to pollute the Kherlen river (IWRM 2012).



*China Daqin Oil company exploration vehicle in Kherlen floodplain. (by Simonov)*

Recently an increase of exploration and exploitation of oil by both Chinese and domestic companies in the lower Kherlen valley and may cause considerable pollution and water loss. While reliable data on current impacts of oil exploration in Kherlen River Basin is missing, it is clear from the cases in the adjacent dry areas of Inner Mongolia, Jilin and Heilongjiang provinces of China, that the oil industry may cause acute competition for water and considerable pollution. Technologies and even operating companies in two adjacent countries are the same.



*Prospecting for oil in Kherlen river valley (by Simonov)*

Livestock overgrazing also adversely affects water quality and quantity (IWRM 2012). Water mineralization and turbidity increase as Kherlen flows through the dry steppe. After privatization of livestock herding in 1990,



grazing pressure has increased at each site and may have strongly contributed to overgrazing of the grasslands. The mean grazing pressure of the Kherlen river basin was increased by 43.8% between 1984 and 2003. In the Kherlen river basin, the maximum sustainable grazing pressure (carrying capacity) is estimated 0.8 animal unit per hectare. This capacity however, is reduced to 0.6 if overgrazing and other dry climate change impacts are factored in (Ishgaldan Byambakhuu 2011). This decrease in carrying capacity of steppe grasslands also results in even greater proportion of livestock being grazed in floodplains, where some forage is still available in dry years. According to UNDP supported study of ecosystem -based adaptation in selected steppe watersheds of Mongolia degradation of floodplain and river banks is one of major problems in adjacent Ulz River basin in dry years.(EBA 2013).

## 9.2 KHERLEN RIVER BASIN IN COMPARISON WITH OTHER RIVERS OF DAURIA STEPPE

Kherlen River basin is adjacent to the transboundary Khalkh River basin in the east and to the Ulz River basin in the north. South of Kherlen lies Eastern Gobi region dominated by desert-steppe landscapes, which has only aquifers, but no permanent rivers. Table 2 presents documented and projected water consumption in three adjacent transboundary basins, showing that Kherlen is the most important water source for the economy.

Table2. Water use in Kherlen, Khalkh, and Ulz transboundary basins in 2010 and (demand projection for 2015) .

River Basin	Population	Industrial	Livestock	Irrigation	TOTAL 2010	Demand projection (2015)
Ulz	0,04 (0,06)	3,4(12)	1,3(1,4)	0	4,74	(13,46)
Kherlen	1,46 (2,36)	8,9(13)	6,5 (6,4)	5,4(8,7)	22,36	(31,3)
Khalkh-Buir	0,01(0,02)	0	0,2 (0,3)	0,56 (0,9)	0,78	(1,22)

Units -million cubic meters per year. Source (IWRM 2012)

### KHALKH RIVER BASIN

The Khalkh river originates from the northern slope of the Ikh-Khyangan (Da Xing' an) mountains. The Khalkh River Basin is located in the most eastern part of Mongolia and covers an area of 11755 km<sup>2</sup> and 43% or 7440 km<sup>2</sup> out of the total area are within boundaries of Mongolia, and the rest in China. The total length is 399 km from which 264 are in Mongolian territory. Annually the basin receives 400-500 mm of precipitation, which is almost twice the amount in Kherlen river basin. The river flows into transboundary Buir and Dalai lakes. Development of any economic activity in this remote region is constrained by relative isolation from markets. This may be changed by construction of "Millennium Road" that transverses Mongolia from Russian Altay in the west to China's Xing'anmeng in the East and passes the border in the Khalkh river basin.

Khalkh Basin is more than Kherlen suitable for irrigated agriculture, and a large 250 000 ha agricultural reclamation project to develop Mongolian-Korean food exports enterprise was once envisioned there, however it has not been implemented and relatively little water is used for irrigation up to date.

Except for China Daqin-Oil Company conducting exploration, presently there is no industry and only 0,5% is covered by cropland. Buir lake is the only place in Mongolia with export-oriented fisheries enterprise, which is practically under Chinese management. Nevertheless oil producers, fishing enterprise and some other economic interest groups have been for many years effectively blocking establishment of very much needed protected area at Buir Lake Ramsar Site which according to international law requires special protection.



*Khalkh river basin with Buir (Beier) lake divided by Mongolian-Chinese border.(Google Earth)*

In China Khalkh(Halaha) basin belong to very undeveloped Xing'anmeng prefecture, which is famous for Arshan Resort and Nature reserve located in upper part of the basin. Nevertheless intensity of development in Xing'anmeng is greater than in Eastern Mongolia (see Table 3). Significant impacts arise from development of croplands, mining, overgrazing and tourism sector in China.

**Table 3. Population, economy, and land-use in neighboring aimags of Mongolia and Xing'anmeng Prefecture of Inner Mongolia Autonomous region.**

Parameter	IMAR Xing'anmeng prefecture	Aimags of Eastern Mongolia
Area (km <sup>2</sup> )	60,000	287,500
Population count	162,000	210,000
Population per km <sup>2</sup>	27.0	0.7
GDP mln. USD	767.5	28.9
GDP/person USD	476.6	300.0
Percent arable	11.1	0.8
Livestock (mln).	4.2	3.35
Livestock/100 ha	70	11.9

Source: Strategic development outline for economic cooperation between the PRC and Mongolia (area: Xing'anmeng Prefecture in the Inner Mongolia Autonomous Region of the PRC and aimags of Dornod, Henti, Sukhbaatar of Mongolia). ADB, Manila, Philippines, 2002

Interrelation between Khalkh and Kherlen River water management will be discussed in Chapter 16.

## ULZ RIVER BASIN

The Ulz river basin occupies in Mongolia less than 9 000 square kilometers and is a part of endorheic basin of Torey (Toreyskiye) Lakes, which receive transboundary Ulz (Uldza) and Yamalkhyn(Yamalka) rivers. The Ulz is the transboundary river basin adjacent to Kherlen River basin and taking its origin from Ikh and Baga Burd springs on territory of Norovlin soum of Henti province that flows through Henti and Dornod provinces to the northeast, crossing the state border it flows into Baruun Torey located in Torey Lake depression in Russia. Before crossing the border Ulz river forks and delivers part of its flow to Khukh lake in the same depression in Mongolia.



*Ulz-Torey transboundary basin (Google-Earth) .*

Although on average Ulz River basin gets slightly more precipitation per unit area than Kherlen River basin, it has extremely uneven flow (see Chapter 4) and in dry phases of climate cycle the river does not reach Torey lake depression for several years in a row. However it has much better agricultural conditions and croplands occupy 2,5% of the basin. (IWRM2012)

Similarly to Khalkh river the Ulz basin is also located off the main transportation routes, which helps to limit development of settlements and industries. Cattle breeding, crop farming and mining are the main activities.

During recent integrative baseline study on the “The Ulz River Basin Environmental and Socioeconomic condition” by UNDP “Water demand Calculator 3” (WDC) software was used to estimate water use balance in 2015, 2021. The result of the water balance estimation shows that water consumption of water will be increased 3 times in the river basin by 2021. Out of all consumption surface water makes 6.4 % and groundwater is 93.6 percent. The current consumption of the mining is 71 % of the total water use; and it would be 82 percent in

2021. However, the livestock water consumption-makes 27 percent of the current demand; and it would decrease to 16 percent in 2021. (EBA Project 2013 ) Remaining 2% are divided among irrigation and household use. Figure 16 shows the central part of Ulz river basin with many mining and exploratory licenses, some of them conflicting with new water protection zones delineated in 2010-11 under the "Law with long name".

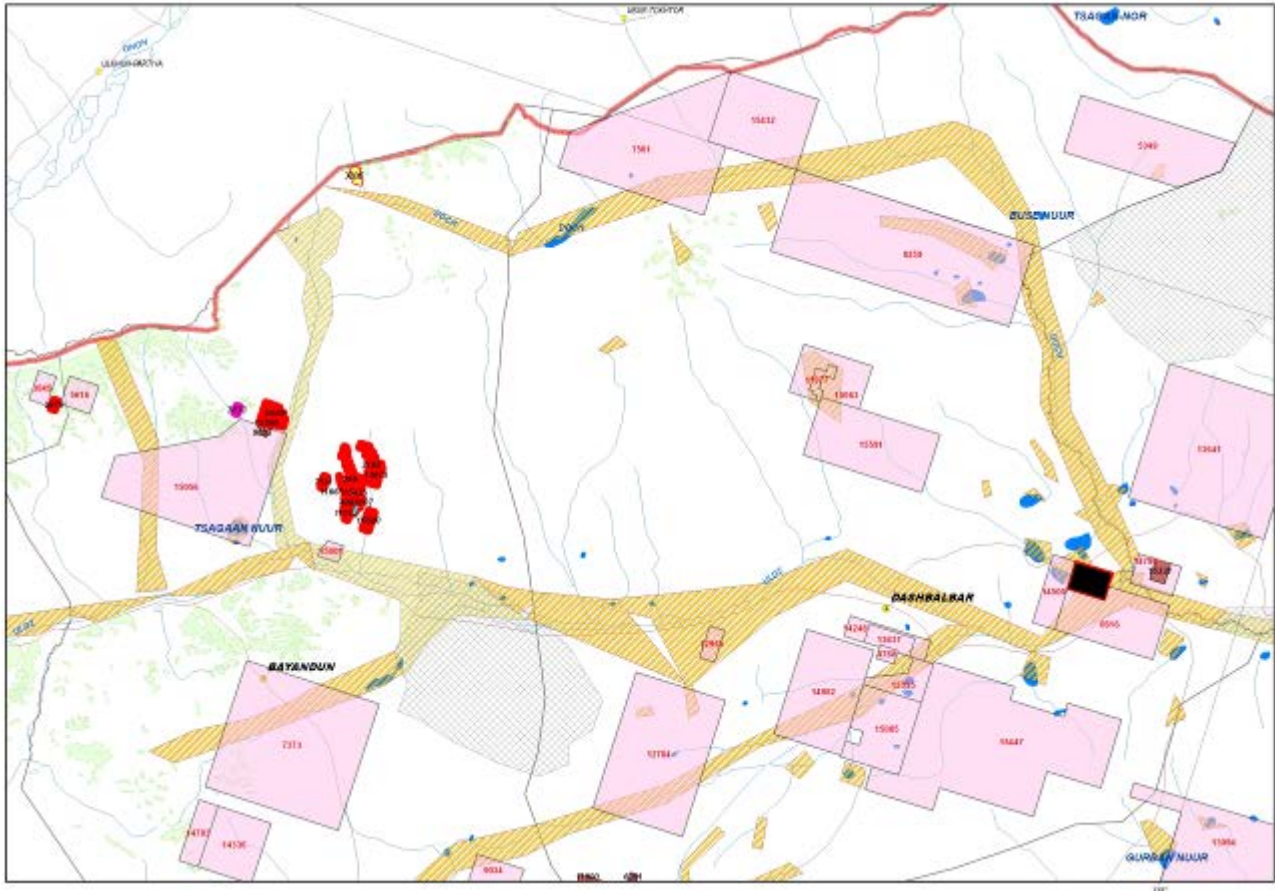


Figure 16 Mining licenses in Dashbalbar and Bayandun soum in middle reaches of Ulz river .

Gold(red), polymetals (black) and exploration (pink) licenses superimposed with water protection zones (orange dashed) prescribed by the 2009 "Law to prohibit mineral extraction and exploration activities in forest lands, headwaters and river-protection zones". (MRAM Database 2010)

Therefore mining presently is and is expected to be in future the most important water-consuming sector in Mongolia part of Ulz river basin. Most important local mine -Mardai uranium deposit was developed by Soviet Union and now is under dispute between Russian and Canadian mining enterprises. According to national mining database (<http://cmcs.mram.gov.mn>) in Ulz river basin by 2010 60 mining firms and individuals owned 45 mining licenses (35 of them for placer gold mining), and 60 exploration licenses. Total area of mining licenses was 13 656 ha, while exploration rights covered 600 000 hectares.

Placer gold mining is known as the most wide-spread and important source of river pollution in Mongolia, which resulted in serious tensions between nomadic herders and miners all over the country. In 2011 in adjacent Onon River basin Russian and Mongolian NGOs joined forces to stop placer gold mining by Russian firm "Balja" on transboundary Ashinga tributary(Kiriliuk 2012). Besides raising turbidity and toxic pollution

mining is known to be the primary reason for local overexploitation and decrease in water resources. This is especially dangerous in Ulz river basin, where dramatic drought cycles regularly create extreme natural water deficit. Therefore mining in such river basin requires extreme caution and a preventive planning for time of drought should be exercised by authorities.



*Placer gold mining site in northeastern Mongolia. (by Simonov)*

Despite growing mining problems, the most immediate threat to Ulz river is still overgrazing. Unlike all other rivers of the east Dauria the headwaters of Ulz are not covered by forests. It is a rich meadow growing over relatively thick peat deposit, that acts as a giant sponge - the main regulator of water regime for this small river. Since peatlands at headwaters and wet floodplain meadows of the Ulz are used by ever increasing livestock during ever increasing drought periods, there is a serious loss in water-retention capacity of natural ecosystems expected by wetland scientists (T.Minaeva et al, 2013). Fencing was suggested as protective measure from overgrazing sensitive wetland areas, which is yet to be implemented at necessary scale to prove its effectiveness.

Russian part of Ulz-Toreskye Lakes basin is approximately 70% covered by Daursky Biosphere Reserve (see chapter 5) and the rest is divided by local farmers raising cattle. It is interesting that in XXI century due to extreme drought local agricultural cooperatives practically ceased to plant fodder in the basin, but lease croplands and hayfields 100 kilometers to the north in Onon river basin and supply supplementary feed to their cows from such external sources. However, when wet phase of climate cycle comes they still plan to plant fodder in the Torey Lake vicinity to avoid transportation costs. Locals tell that during dry phase of climate cycle the Russian-Mongolian border was once moved to ensure that livestock in Mongolia has access to Baruun Torey lake waters and that is how this lake became transboundary.

The only sizable infrastructure of the Russian basin is Solovyevsk railroad station at border crossing, which lost its significance due to post-Soviet decrease in border trade. Water use in Russia is so insignificant that water

balance in the Ulz basin is not accounted for in any Russian water management schemes despite having two hydrometeorological stations.

All three transboundary rivers in question share similar natural features: they flow through Dauria Steppe and have large freshwater\brackish lakes at the rivermouths, acting as evaporation basins. Degree of human development is very uneven in three basins. From the comparison above we can see that Ulz River has no large population centers, but only mining industry, while Khalkh river, also has no sizable towns and so far is practically pristine in Mongolia, but has considerable degree of tourist resort development in China. The Kherlen River basin is the only transboundary basin of the steppe that has sizable and diverse industries and several towns-provincial centers, that actively use and pollute its waters.

*Nevertheless the vast majority of water samples taken in Kherlen River basin appears “clean” or “very clean”. At present Kherlen is a river with natural ecosystem processes and moderate human impacts on water quality and quantity. River and local people seem to coexist in relative harmony. This harmony is threatened by enormous appetite for natural resources in neighboring China and common desire of politicians and Soviet-school engineers to “harness” natural rivers and benefit from large investment for export-oriented projects.*



***Overgrazing effects on floodplain in dry year. Hulunbuir, Inner Mongolia (by Simonov)***

## 10 PLANNED INDUSTRIAL WATER SUPPLY PROJECTS

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Soviet engineers and their colleagues from China and Warsaw Pact countries in 1970-80s assisted water management planning in Mongolia and developed extensive schemes for construction of dam cascades and water transfers on every sizeable river in the country. Under the socialist system, with little consideration for environment it was deemed logical not to leave rivers “idle” but make them produce electricity, irrigate crops, supply mines and support man-made oases in dry deserts. The capacity of natural systems to accommodate these human activities was largely disregarded. For example for the Kherlen River, which was already serving a large human population and supported the economy of four provinces, engineers planned a large reservoir and water supply system to Ulaan Baatar as well as pumped-storage hydropower station and several water supply systems for irrigation of 30,000 hectares. They also planned water transmission line to the Gobi desert. Some of those plans were better designed than others, but fortunately for the local people of the basin, no plans made it past the planning stages because the national economy did not need them.

Early in 21 century, when Mongolian economy started to be driven primarily by Chinese market, mineral licenses were given to various foreign and domestic companies to develop large ore and coal deposits: Oyu Tolgoi, Tsaagan Suvarga, Tavan Tolgoi, Shivee-Ovoo, etc. However, their development was slowed by the absence of readily available water sources in Gobi regions. Mining and processing of copper ore, coal washing require considerable amounts of water, but even more water is required for coal fired power plants and coal-gasification complexes. Converting coal to electricity or gas makes it easier to transport over larger distances. Lastly, the Mongolian government seeks to process mining products before exporting them. To this end the Sainshand Industrial Complex was planned in the Eastern Gobi with nine industrial plants and at least 10,000 workers which would require substantial additional amounts of water. In addition, the neighboring Inner Mongolia Region in China has already largely depleted its water resources and the administration of the border town of Erenhot expressed a serious desire to build a pipeline to draw water from Mongolia or even Russian Baikal Lake.

The Kherlen River is the closest large river to the East Gobi, and is eyed as the primary water source for all these development plans. Therefore the old Soviet engineering designs for long-distance water transmission were dusted off and updated by engineering companies and presented to the Government and public in recent years.

Four design proposals have been developed for water supply plans for the development activities in the Eastern Gobi, and mining in particular, which will be discussed in the following sections.

### 10.1 PRESTIGE GROUP DESIGNS

The Prestige Group was the first to come up with revived designs for long water transmission pipelines from Kherlen to Shivee-Ovoo, Sainshand, Tsaagan Suvarga and Zamiin Uud (Erenhot). There are two main parts to this plan: the Dam, Reservoir and Water Intake Structure for water collection and storage, and the Pipeline, Pump Station, and Water Treatment system for transmission and distribution of water to customers.

The reservoir at Togos Ovoo 50 km downstream from Baganuur would be created by constructing a 25-meter high dam, which would ensure volume of 500-800 million cubic meters and a reservoir surface area of 62 square kilometers. The drainage and water intake structure would include a 5MW hydroelectric plant that could

generate electricity for operation of the dam facilities and the first pump station. In addition two infiltration water intakes were envisioned on the wide Kherlen floodplain downstream to pump subsurface water from alluvial deposits – a design very similar to the system which is already used to supply Ulaan Bator with water from the Tuul River. In order to make the project “environmentally friendly” a fish passage for the dam and anti-seepage shields for the water intake points was planned, but there is no evidence that their construction is feasible or effective./



Figure 17 Kherlen-Gobi water conveyance project. (Water Center, 2010)



Kherlen River at Gun Galuut near Togos Ovoo dam site (by E.Simonov)

The Prestige Group plans envisioned pumping water as far as 530-540 kilometers South-East to Tsaagan Suvarga and Zamiin Uud, but the nearest large consumer, the Shivee-Ovoo coal-energy complex in Choir, would be just 140 kilometers away. The plans show two pump stations between the dam and Choir, five pump stations on the southern leg to Tsaagan Suvarga, and three pump stations on the southeastern leg to Zamiin-Uud. There are no significant hills or mountains on either leg and the total pump station requirements/consumption is estimated to be 24.2 MW. The pipelines (likely 0.5- 1 meter in diameter) are planned as coated steel, installed in a ditch below seasonal freezing depth (3-5 meters under the land surface).

The Prestige Group plan of 2007 suggested that the project would provide water not only to industry and settlements, but for agricultural users including livestock raising and farming, of which the cost of construction would be paid by mining enterprises. In reality it was implied that most costs for planning and initial development of this scheme would be paid by Mongolian national budget through "private-public partnership" arrangement.



Table 4. Water demand\supply for Kherlen-Gobi Project 2010

№	Water customer	Water settlement consumption, l/sec	From it, l/sec	
			Surface water	Underground water
<b>Energy and Mining industry</b>				
1	Shivee-Ovoo	616	467	149
2	Tsagaan Suvraga	604	300	304
<b>Subtotal</b>		<b>1220</b>	<b>767</b>	<b>453</b>
<b>Urban Water Supply</b>				
3	Choir	40	40	0
4	Sainshand	435	65	370
5	Zamiin-Uud, Economical Free Zone	350	300	50
6	Soum center & Rural population	23	23	0
<b>Subtotal</b>		<b>848</b>	<b>428</b>	<b>420</b>
<b>Agriculture and Environment</b>				
7	Pasture watering	45	45	0
8	Agriculture Irrigation	260	260	0
9	Environment	77	50	27
<b>Subtotal</b>		<b>382</b>	<b>355</b>	<b>27</b>
<b>Total</b>		<b>2450</b>	<b>1550</b>	<b>900</b>

Source: "Mongolia Water Center" web-site (<http://www.watercenter.mn/project/show/id/10>)

Since 2004 there have been at least 4-5 different designs of the Kherlen–Gobi Scheme developed by Prestige Group and most designs were financed by public money or foreign donor assistance to Mongolia. Thus the scheme ordered by the Ministry of industry and Agriculture in 2011 envisioned five additional reservoirs on the Kherlen river to support development of agricultural irrigation in the river valley similar to plans proposed in the past by Soviet engineers eons ago.



Figure 18 Scheme with five reservoirs for industry and agriculture marked as green and black triangles (Prestige Group. 2011)

In August 2013 the Prestige Group updated the Kherlen Gobi design and suggested two options "A" and "B": "A" "the old one with a reservoir described above and "B" an option without any reservoir, but only shallow wells on the floodplain. These wells would ensure a water intake of approximately 1500 liters per second. This scheme does not include a pipeline to Tsaagan Suvarga, probably because that mining site currently has sufficient groundwater resources to serve its needs. See Figure 19 and table 5.

In Prestige designs for Kherlen -Gobi proposed water transmission volume varies from 30 to 60 mln. м3/year. Over the years the planners have struggled to prove that water demand is actually large enough to justify such grand construction. Comparison of tables 2 and 3 developed for exactly the same service area and water consumers shows that just in 3 years expected water demand increased by 30%. On the other hand catering solely to "foreign" miners was not always politically acceptable and at least equal water supply should target needs of local population, even if it has no need in such quantities. That is why supply from the project in a "comprehensive" way divided Kherlen water to all imaginable needs of Gobi economy (see tables 4 and 5). The figures in supply\demand tables differ significantly from those estimated in Mongolian National IRWM study, for example while Prestige estimates irrigation needs in Gobi at 15 million cubic meters annually, the IRWM Study expects much smaller demand of 2,5 million cum/year.(IWRM 2012). However not Prestige Group only biased opinion, but haphazard poorly formulated development policies of many government agencies make impossible any realistic water consumption projections. Subject is too politicized and monetized with multi-billion investments from Chinese and western companies being promised for different development projects in Gobi. Many of those projects are disregarding the fact that waterless desert is not the best location for water-thirsty processing industries and there is no government policy to cap future consumption based on carrying capacity of local ecosystems.

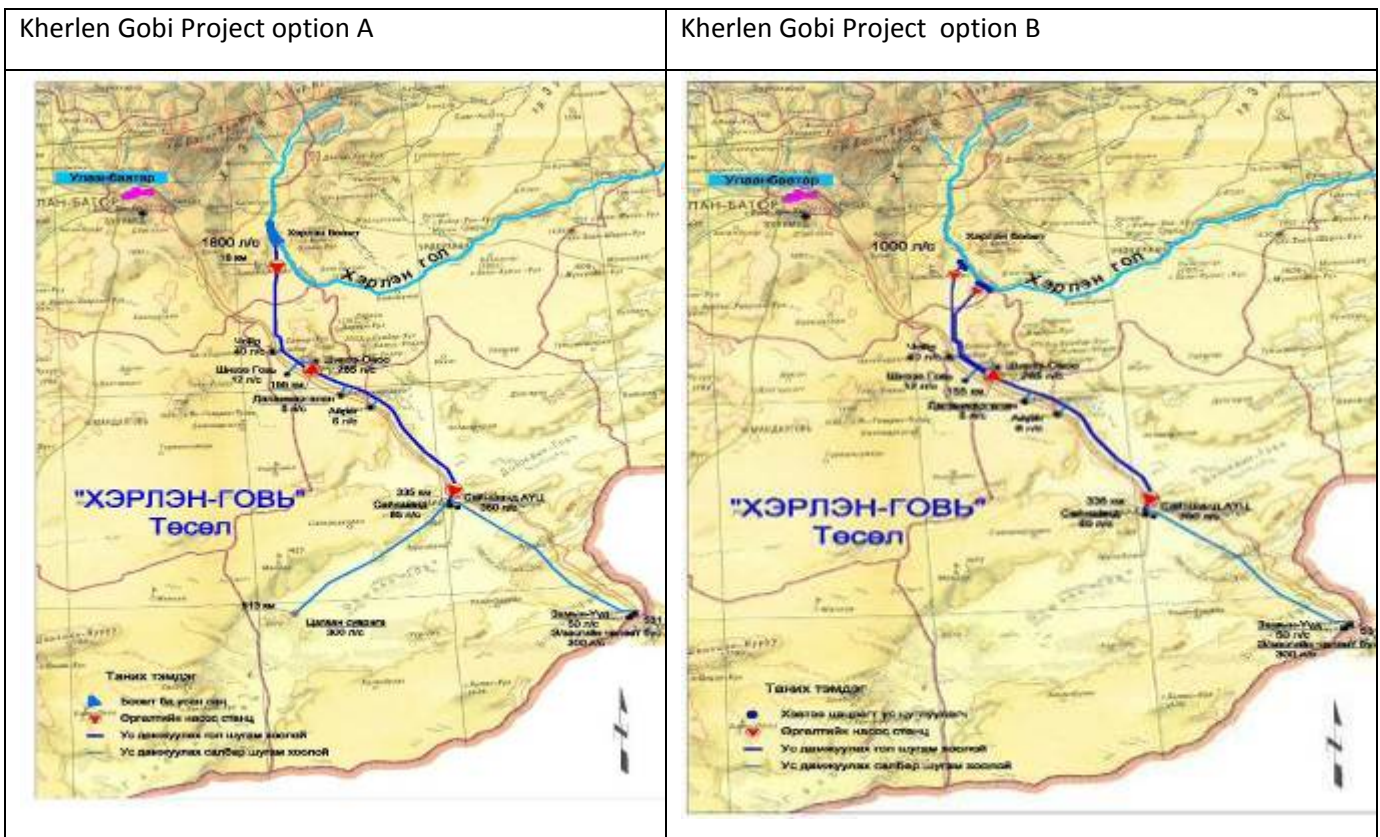


Figure 19. The Kherlen-Gobi water conveyance project option without reservoir presented by the Prestige Group in 2013

Table 5. Water Demand Projections presented with 2013 Scheme

<b>Table 3. Water Demand Projections Kherlen Gobi Project</b>					
№	Water User	Demand liter/sec	2013 Designs		Local Ground-water
			A-reservoir	B-infiltration	
<b>Energy and Mining Industry</b>					
1	Shivee-Ovoo	466	285	100-285	181
2	Tsagaan Suvarga	604	300	no	304
3	Sainshand IC	685	350	350	335
	<b>Subtotal</b>	<b>1755</b>	<b>935</b>	<b>435-635</b>	<b>820</b>
<b>Urban Water Supply</b>					
4	Choir	40	30	30	10
5	Sainshand	120	85	85	35
6	Zamiin-Uud	350	300	200-300	50
7	Soum Center and rural	55	55	55	
	<b>Subtotal</b>	<b>565</b>	<b>470</b>	<b>370-470</b>	<b>85</b>
<b>Agriculture and Environment</b>					
8	Livestock	150	55	55	95
9	Agriculture	490	240	100-240	
10	Environment	300	100	40-100	200
	<b>Subtotal</b>	<b>940</b>	<b>395</b>	<b>395</b>	<b>555</b>
	<b>TOTAL</b>	<b>3260</b>	<b>1800</b>	<b>1000-1500</b>	<b>1460</b>

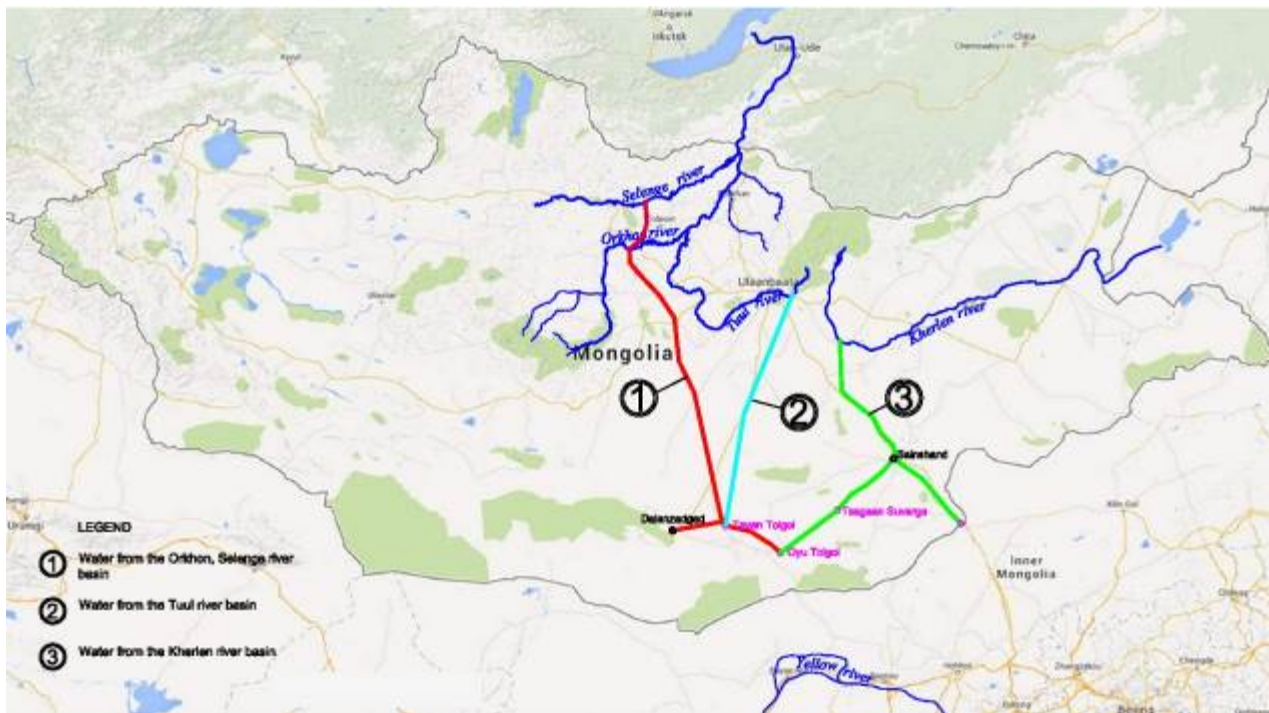


Figure 20. : Alternative of use of surface water by regulating the flow of Mongolian rivers (Source: Prestige 2014)

The Prestige Group has a portfolio of water-supply projects, from which Orkhon-Gobi Water Reservoir Complex with 1000 kilometer pipeline system to South Gobi Province is very similar to Kherlen-Gobi Project. Overall conceptual scheme of various long-distance water-transmission pipelines explored by Prestige Group is presented in the *Figure 20*.



*Pipeline construction. Hulunbuir, Inner Mongolia (RwB archives)*

## 10.2 “MONHYDROCONSTRUCTION” SAINSHAND WATER SUPPLY DESIGN

In 2013, the Prestige Group lost to another firm - “Monhydroconstruction” in a tender for a “Feasibility Study for Inter-basin Water Transmission for Sainshand Industrial Park”. In a presentation to the Ministry of Environment and Green Development (MEGD) Monhydroconstruction shows the giant Three Gorges dam on Yangtze River and the very controversial South-North Water Transfer Project developed by the Chinese government as inspiring examples for the Mongolian water sector. The general design for the water transfer by Monhydroconstruction is very similar to the design by the Prestige Group but the reservoir with a 20-meter high dam is located at Toono (100 kilometers downstream from Togos Ovoo) and has twice the surface area (95-125 sq.km) and volume (1,2 cubic kilometers). There are vague references to a possible hydropower setup, but no capacity is specified. See Figure 21 and Figure 22.

“Monhydroconstruction” also conducted a short exploration of alluvial subsurface water extraction in Bayanhutag soum along the Kherlen which amounting to at least 217 liters per second and the study claims it could be increased with further exploration.

The company claims that it used IHA software developed by TNC to justify “environmentally safe” annual withdrawals from the Kherlen of 4 m<sup>3</sup>/sec. That amounts to 20% of the annual average flow at the dam site and 60% of flow in dry year. It is unclear how the project accounts for evaporation losses from the reservoir surface which likely exceed 90 million m<sup>3</sup> annually due to evaporation rate exceeding 1,000 mm annually. The 2014 “Monhydroconstruction” presentation concludes that it would be “a shame to let blue money flow out of our country!”.

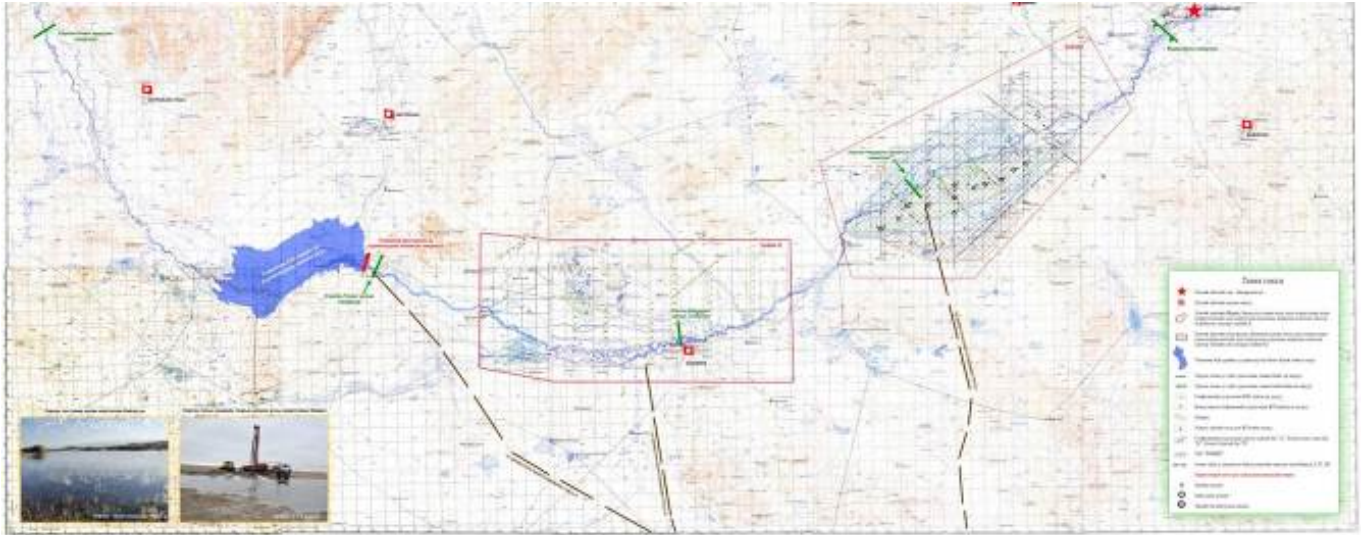


Figure 21. Map from Monhydroconstruction presentation, May 2014.

The map shows 4 gauging stations, Kherlen-Toono reservoir, two downstream areas of groundwater exploration and potential pipeline routes.

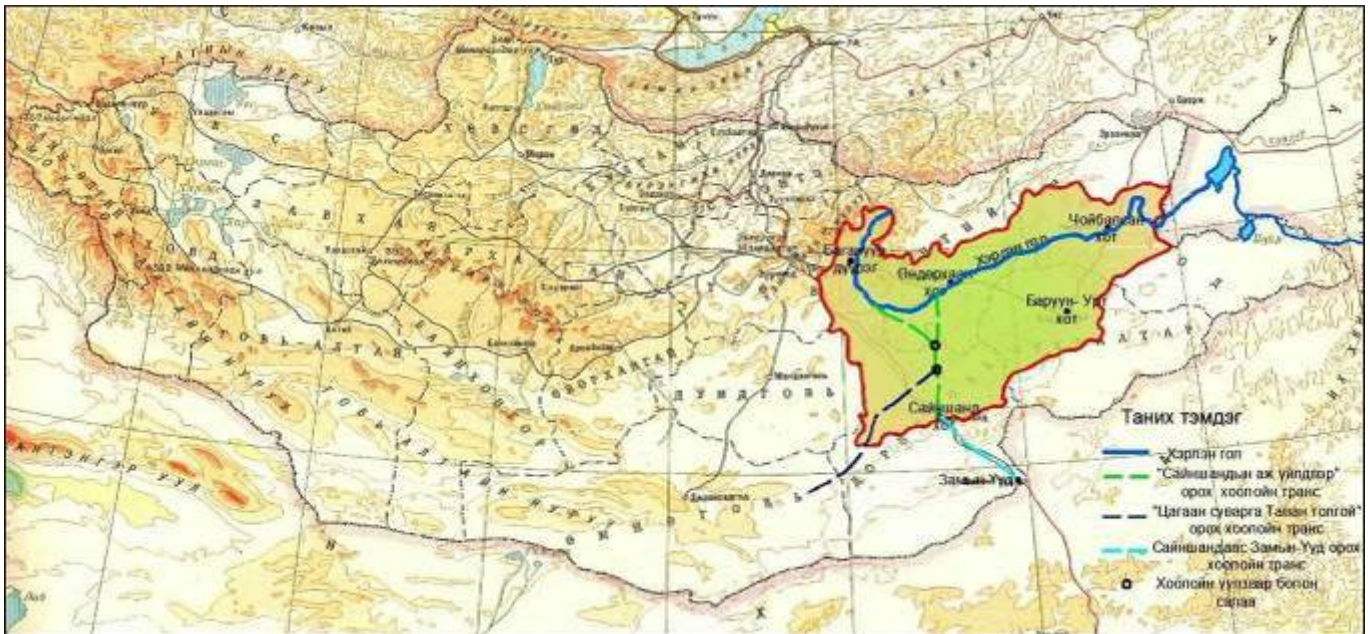


Figure 22. Full scheme from Monhydroconstruction presentation, May 2014.

Base pipeline to Sainshand -green-line, pipeline to Tsaagan-ovoo \Tavan Tolgoi -dark blue, pipeline to China border -light blue. -

The design of the project does not serve Choir and Shivee Owoo and the pipeline goes 225-260 kilometers directly to Sainshand and then forks to serve other users: Tsaagan Suvarga, Tavan Tolgoi, Oyu Tolgoi and Zamiin Uud (Ereenhot). Principle scheme of full development of this water-supply system is presented on figure 20. There is also mention of 30,000 ha of new irrigation in the downstream areas but no specific explanation how that would be developed. This water supply, most likely, is also intended to serve a new coal-energy complex planned north of Kherlen River at Chandgana Tal (Murun, Henti aimag) but would require separate water supply

pipeline. (Current description of Chandgana Coal Project on the web-site of Prophecy Coal co. states that local groundwater will be primary source with Kherlen river used as back-up source).

“Monhydroconstruction” conservative cost estimates show that the reservoir costs at least 200 million USD, while the 260 kilometer pipeline to Sainshand costs somewhere between 260 to 370 million USD. The total cost of the supply system for the Sainshand industrial Park alone is from 480 to 510 million USD. This means that bringing water to other potential consumers (Tsaagan Suvarga, Tavan Tolgoi, Zamiin Uud, etc.) scattered in Mongolian steppe will come at more than 1 million USD per 1 kilometer of pipeline.

Budget presented in documents we have obtained covers only supply to Sainshand and our estimates of the construction budget for such supply system that reaches at least Tsaagan Suvarga, Tavan Tolgoi, Zamiin Uud would go far beyond 1 billion USD. Such budget does not contain any social and environmental mitigation and compensation measures and costs are likely to be seriously underestimated.



*Kherlen River valley at Kherlen-Toono where reservoir is planned ( by "Monhydroconstruction")*

### 10.3 JETRO STUDY DESIGN

Our review of recent project proposals would not be complete without a much earlier study on Kherlen-Gobi Project sponsored by the Japan External Trade Organization "JETRO Study on Kherlen River Basin Water Supply Project in Mongolia" which was completed in 2007 and presented detailed systematic analysis of available alternatives for a water intake and distribution system as well as other finance and engineering aspects of the water-transfer projects to Gobi. The water supply system in this study was planned to serve Choir, Sainshand, Tsaagan Suvraga, Zamiin Uud (Figure 23)

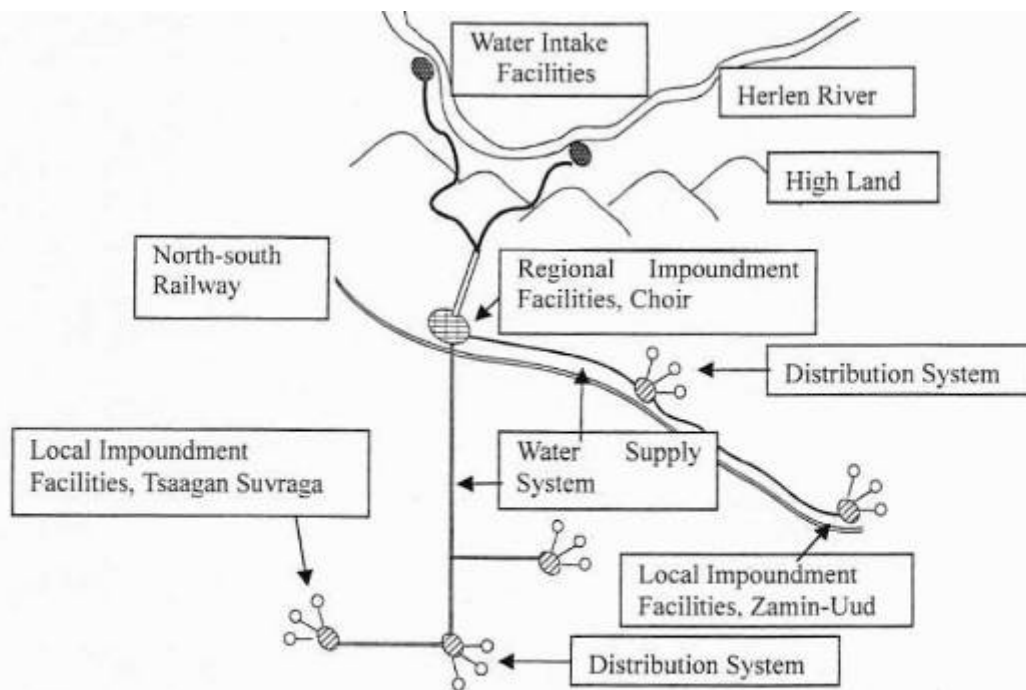


Fig. S3-1 Layout of Water Supply System and Facilities

“Water Supply System” comprises water tanks, pipelines and pump stations to supply water

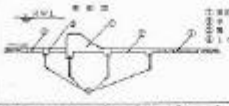

Figure 23. Water supply scheme assessed by JETRO Study.

In order to transfer 1-2 m<sup>3</sup>/s via pipelines to the Eastern Gobi the Study compared 5 different water intake/sourcing methods: a large dam on the river, a weir on the river, flood impoundment on the floodplain, collection conduits and shallow wells to draw subsurface water from floodplain alluvium.

The conclusion of the evaluation of these five options in the JETRO study was that “considering flow analysis results” it is desirable to use stable subsurface flow to get a constant water supply for all days of year even in years with low precipitation in the upstream mountain area. Shallow wells were identified as the least costly option, which could be built most easily as a water intake option with lowest environmental impact. This option also yields water of better quality since it would be filtered through alluvium. One of JETRO suggestions was that in any case it is more responsible to proceed sequentially, first tapping to infiltration water in floodplain

alluvium and then, if still needed, to build a flood impoundment while leaving the construction of a dam and reservoir, as an ultimate solution which would potential cause very severe environmental damage. The study concludes that besides the need for a more thorough and longer period for investigation of the design and construction, the cost of dam option is orders of magnitude higher than the option of subsurface water intake.

**Table 3-10(1) Primary selection of water intake methods**

	Option 1: Weir	Option 2: Dam
<b>Outline drawing</b>		
<b>Over view</b>	Weir crosses the river channel and elevates water level for water intake.	Fill dam may be suitable because no base rock of the river is exposed.
<b>Type of intake water</b>	Surface water	Surface water
<b>Intake location</b>	In river channel	In river channel
<b>Ancillary facilities</b>	Intake gate Settling basin	Intake tower
<b>Tolerance against drought</b>	Possible to have lower level intake than planned when droughts happen.	As potentially reserved volume of dam is larger than weir, its tolerance against drought is higher.
	<b>Medium</b>	<b>High</b>
<b>Influences of turbid water</b>	Turbid flood inflow increases water processing steps (e.g., coagulating sedimentation)	Turbid flood inflow increases water processing steps (e.g., coagulating sedimentation)
	<b>Large</b>	<b>Large</b>
<b>Tolerance against flood</b>	Structure is designed and constructed safely against floods.	Structure is designed and constructed safely against floods.
	<b>High</b>	<b>High</b>
<b>Applicability to frozen river</b>	As water depth is not large, the intake is near impossible when surface water frozen completely.	As water depth is large the intake is still possible though surface water frozen completely.
	<b>Very low</b>	<b>High</b>
<b>Operation &amp; Maintenance</b>	Facilities operations during flood duration and maintenance of gates of intake and sand sluiceway are required. Sand discharge of settling basin also needed.	Facilities operations during flood duration and maintenance of intake tower and flood spill gate are required.
	<b>Difficult and costly</b>	<b>Difficult and costly</b>
<b>Influences on river /catchment</b>	Size of the submerged area and sediment supply change are relatively smaller than those of dam.	Size of the submerged area is very large and remarkable reduction of sediment supply for down stream is expected.
	<b>Medium</b>	<b>Large</b>
<b>Effects on environment</b>	There is a possibility to degrade the fauna around the site by the influences of water impoundment and soil and sand sedimentation in its upstream.	Massive alteration of vegetations, fishes and aquatic life are expected because of lake created by dam.
	<b>Medium</b>	<b>Large</b>
<b>Construction feasibility</b>	There is no expected particular obstacle to construction. The weir may be constructed in parallel with water supply pipeline. Thus, the weir construction is not a critical path for the project.	As the foundation rock is not exposed, it needs a long term for settling construction. Thus, the dam construction is a critical path for the project.
	<b>Medium</b>	<b>Low</b>
<b>Comprehensive Evaluation</b>	It is unacceptable as the continuous intake is difficult in winter.	Effective utilization of flood water is a large advantage. However, the construction term is too long.
	<b>Not adopted</b>	<b>Future investigation subject</b>

**Table 3-10(2) Primary selection of water intake methods**

	Option 3:Collecting conduit	Option 4:Shallow well
<b>Outline drawing</b>		
<b>Over view</b>	Water intake by installing underground porous pipe.	Water intake by shallow wells. Especially, the radial arms (pipes) are installed to gain high collect water capacity.
<b>Type of intake water</b>	Subsurface water	Subsurface water
<b>Intake location</b>	Inside or outside of the river channel	In floodplain or outside of the river channel
<b>Ancillary facilities</b>	Function wells	-
<b>Tolerance against drought</b>	Because the intake flow is small compared with the existing subsurface water storage potential, the intake is sustained in droughts.	Because the intake flow is small compared with the existing subsurface water storage potential, the intake is sustained in droughts.
	<b>High</b>	<b>High</b>
<b>Influences of turbid water</b>	Not affected by the river's flood turbid water.	Not affected by the river's flood turbid water.
	<b>Not affected</b>	<b>Not affected</b>
<b>Tolerance against flood</b>	Not affected by floods as installed in underground with sufficient depth.	Not affected by floods as installed on sufficiently high land.
	<b>Not affected</b>	<b>Not affected</b>
<b>Applicability to frozen river</b>	As installed in underground with sufficient depth, it is not affected by the freezing.	As installed with sufficient depth, it is not affected by the freezing.
	<b>High</b>	<b>High</b>
<b>Operation &amp; Maintenance</b>	Substantially maintenance-free.	Substantially maintenance-free.
	<b>Easy and lower cost</b>	<b>Easy and lower cost</b>
<b>Influences on river /catchment</b>	No impact on the river / catchment is expected.	No impact on the river / catchment is expected.
	<b>No influence</b>	<b>No influence</b>
<b>Effects on environment</b>	Because the intake flow is small compared with the existing subsurface water storage potential, there is no influence on the environment.	Because the intake flow is small compared with the existing subsurface water storage potential, there is no influence on the environment.
	<b>No influence</b>	<b>No influence</b>
<b>Construction feasibility</b>	There is no expected particular obstacle to construction. The weir may be constructed in parallel with water supply pipeline. Thus, the weir construction is not a critical path for the project.	There is no expected particular obstacle to construction. The weir may be constructed in parallel with water supply pipeline. Thus, the weir construction is not a critical path for the project.
	<b>High</b>	<b>High</b>
<b>Comprehensive Evaluation</b>	High feasibility	High feasibility
	<b>Selected</b>	<b>Selected</b>

Figure 24. Comparison of dam on the river, a weir, , collection conduits and shallow wells(Source: JETRO 2007)



Figure 25. Shallow wells – a water intake option favored by the JETRO Study



Financial cost of the full project (even without large dam) was estimated in 2007 at 800 million dollars.

The JETRO study has also demonstrated that without generous international development assistance (IDA) the FIRR - return on investment of such project will be only about 2.8 % making it hardly attractive for private-public partnerships (PPP) and any other private investments. In other words this project is economically not viable unless someone provides 60-70% of costs through IDA. So far, Japanese agencies and companies did not follow up on the study and do not consider providing funds for project implementation in any form.

Lessons provided by JETRO Study are very important for any future planning of long-distance water transfers in Mongolia, for this Study has shown that:

- Comparison of alternatives is very fruitful essential part of the feasibility study process;
- Technologically simple infiltration wells have shown to be the most reliable design option;
- Dam is the most sophisticated and by far most expensive option, associated with greatest risks;
- Combination of various water intake methods and sequential development may reduce risks of overall project;
- Due to high costs of pipeline none of assessed options is likely to be financially viable;

*Presently as some officials, businessmen and even NGOs are seemingly trying to initiate a dispute about which of the two Kherlen-Gobi projects with reservoirs Prestige "A" or "Monhydroconstruction" is better from social and environmental standpoint the JETRO Study is a precious evidence. Rwb experts believe that using the two worst options as a starting point it is not advisable. There are many other development options which would result in much smaller negative impacts on environment and livelihoods of people in Kherlen valley.*



***Kherlen River near Mongolia-China border in Dornod (by Simonov)***

## 11 WATER SUPPLY TO GOBI – POTENTIAL IMPACTS AND RISKS

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There are three potential major sources of water and various variations in design to access them.

1. Local deep groundwater near mines and industrial facilities in the Gobi
2. Water extracted from shallow alluvial aquifers along the Kherlen River
3. Water diverted directly from the Kherlen river

Most of the proposed water management schemes suggest that the local water resources should be exploited first, after which one or both of the remote supply options and associated (long!) pipelines are considered.

In this section we discuss the potential environmental impacts of the various designs that have been proposed by engineering firms and discuss their economic and social implications and discuss additional areas of environmental impacts that have not made it into the assessment of these projects so far.

For example the environmental impacts of the construction of a 500 to 1000 km long pipeline across pristine steppe habitats, the impacts of associated infrastructure that will be developed based on the “new” availability of water, as well as the vulnerability of these projects to climate change remain unaddressed thus far.

Checklists in Appendix 1 summarize the environmental and socio-economic impacts that should be considered and provides a preliminary ranking of these impacts and could be for considered in future impact assessments and public consultations on water infrastructure projects.

### 11.1 DEEP GROUNDWATER

The use of deep groundwater near the points of use makes most economic sense since it would require the lowest initial investment and lowest cost of operation.

When local groundwater is used in the Gobi, there is a high likelihood that excessive pumping will result in rapid depletion of these resources (Prestige 2014). Wells and springs in valleys above the exploited aquifer could dry up and be subject to degradation if there is a direct connection between subsurface groundwater and deep aquifers. This may lead to shortages for local herders and other local communities relying on this groundwater.

When groundwater resources are exploited, it is very important to implement a reliable environmental monitoring system to discern early changes in vegetation and fluctuation of shallow groundwater. There should be clear limits prescribed for use of each aquifer, established through transparent participatory procedures. Some aquifers should be declared off-limits to industrial water supply due to a high likelihood of negative consequences for local nature and people.

Recent report by 2030 Water industry Group says: "*In many locations thick clay deposits separate the deep and shallow groundwater and hydrogeologists predict no effect. But the accuracy of these predictions will be confirmed only after deeper groundwater is used. The monitoring of groundwater levels and groundwater quality therefore is important. The availability of groundwater resources now and in the future should be determined using integrated modelling and other techniques to forecast the possible use of the water resources; models are to be updated once monitoring data becomes available, especially after groundwater abstraction has started*". (Mongolia 2030 WRG, 2014)

Considerable policy debate on consequences and limits of groundwater use is already well underway in Mongolia. However government-sponsored monitoring system is weak and monitoring performed by international mining companies is largely not trusted by local communities and NGOs. Data on impacts from exploitation of deep aquifers in Gobi is fairly limited, but it is already established that different deep aquifers have different degree of connection with near-surface groundwater. (Ecotrade 2005). An important consideration however is the long term alteration of aquifer levels and the lack of buffering capacity during periods of extreme shortage that could be provided by local aquifers.

Energy implications of groundwater extraction are also noteworthy due to increasing costs of “following the water” once aquifer levels start dropping. Necessity to tap into new aquifers more remote from consuming industries will also lead to greater expenses for pumping water over longer distances.

Recently there has been a lot of discussion about substituting and/or supplementing local groundwater supply with long-distance transfers of surface water from rivers. The ultimate truth however, is that once large-scale development occurs in the Gobi region, local aquifers inevitably become the first target for large-scale water-supply to mining enterprises. This has purely economic reasons: local groundwater supply system costs much less than long-distance water conveyance schemes. Therefore prevention and mitigation of negative social and environmental impacts from the use of local aquifers in Gobi is an important, but a separate discussion subject. The focus of this report is the impacts occurring in Kherlen River basin.

**11.2 ALLUVIAL WATER INTAKE FROM THE KHERLEN RIVER VALLEY.**

Withdrawal of subsurface water from the floodplain has potential for high impacts on the river ecosystem downstream which depend directly on the amount of withdrawal. This impact may be most significant in dry year sequences and during low-flow season without ice (e.g. early summer).

Table 6. Annual mean runoff with probability of occurrence

Gauging-station	Probability of occurrence, P,%								
	1	5	10	25	50	75	90	95	97
Kherlen-Baganuur	58.9	48.5	45.3	33.0	23.6	15.6	7.92	7.37	6.45
Kherlen-Underkhaan	41.4	40.1	37.4	26.0	21.2	14.7	7.88	7.16	6.00
Kherlen-Choibalsan	44.6	35.2	34.4	25.3	18.8	14.1	8.79	7.08	3.32

(Source “Mongol Guan-Yuan” Ltd- 2006)

Similar impacts are well studied and documented in Mongolia for the Ulaan Baatar water supply system which takes up to 0.1 cubic kilometers a year from Tuul River, which has an average flow rate of 25 cubic meters per second at the intake point. So far the impact of water withdrawal has been moderate and water has been effectively supplied, except for periods during most dry years. There are two notable differences between the Tuul and the Kherlen however a) UB water is used locally and at least 50% returns to the Tuul River, b) The Tuul river is situated in a more humid conditions, and unlike the Kherlen has many water-abundant tributaries, so river flow naturally increases and recovers downstream from UB. In contrast all water taken from Kherlen would

end up in the Gobi and because of the dry climate and lack of tributaries downstream, the Kherlen discharge naturally decreases as it flows to Choibalsan.

A water intake of 2 cubic meters per second from the Kherlen river at Baganuur will likely result in a decrease in river flow by 1.7. to 2 cubic meters per second anywhere downstream from point of withdrawal to Lake Dalai. Table 4 shows the annual average flow rates in the Kherlen under various probabilities of occurrence (P%). For example once in 10 years (P=90) average flow in Underkhaan is 7.88 cubic meters per second, but if you abstract 2 cubic meters per second it will likely decrease by 25% to 5.88 cubic meters per second. At the same point in a dry year with P=97% (that happens once every 33 years) annual average flow is 6 cubic meters per second and the same withdrawal would amount to 33% of all water flow.

As the distribution of flow between months is very uneven (Figure 26), in drier years there will be many months in spring and fall when 2 cubic meters withdrawal would dry out the river downstream from a water intake. Currently on average, lower reaches of the Kherlen river in China are dry 114 days a year (including frozen conditions in winter). Water withdrawal can make this last longer and, likely, occur not only in China but extend further upstream into Mongolia. It is also important to note that these dry conditions would likely occur during periods when scarcity is greatest downstream. If subsurface water is taken from alluvial deposits the flow reduction in Kherlen River would be delayed and to certain extent buffered by effects of alluvial aquifer, which has certain degree of autonomy and receives its main recharge during floods. Many experts in the last decade have warned about high potential environmental risks of this water withdrawal (“Mongol Guan-Yuan” Ltd-2006, IWRM 2012, Dauria 2013, etc.)



Figure 26. Monthly flow distribution in Kherlen at Underkhaan in water abundant 1967(red),average 1982(blue)and dry year 2007(green) (Monhydroconstruction 2014)

On the brighter side all changes that may occur due to subsurface water intake are very similar in their mechanism and timing to regular natural changes that occur in dry phases of 30-year climate cycle. The river ecosystem, most native species and nomadic communities are used to and to a certain extent adapted to dry years in which streams run dry, water sources less abundant, etc.

In general terms the flow regime needs to maintain natural variability. If withdrawal from a given river is proportional to its current daily flow and follows natural fluctuation patterns it is likely that we can withdraw more water without significant damage to ecosystems and people along the river. In 2006 Mongolian hydrologists came to the conclusion that withdrawal of water from the Kherlen river midflow should not exceed 8 percent of low flow in a year with 97 percent of probability of occurrence which is only 15 million cubic meters annually. In case of flow in year with 75 percent of probability of occurrence, 45 million m<sup>3</sup> year of water could be withdrawn from the Kherlen river. (Mongol Guan Yuan Ltd 2006). However those estimated limitations were based on general considerations without detailed research of significance of specific hydrological phases for different river ecosystems and species (G.Davaa. pers. comm. 2013). Rigorous research is needed to establish thresholds in withdrawal after which some ecosystem functions or social values may be seriously affected and guidelines need to be developed for limitations on the volume and timing of water withdrawals. This is essential a part of developing Environmental Flow Norms, that required to safeguard any river basin from excessive human impacts. To decrease impacts on the river one can also alternate use of subsurface water intakes (used most of the time) and deep local aquifers (exploited in dry months and dry years). If geology allows this, one could consider using water-abundant years to pump water from the river to replenish aquifers around industrial facilities and settlements in Gobi, thus saving it from evaporation.

In the case of the Kherlen River, the downstream Dalai lake Ramsar Site is likely to impose the most rigid environmental flow requirements, because it accumulates flows throughout the year and depends on annual runoff rather than on daily flow variation. The destination of Kherlen river waters, the Dalai Lake Ramsar Site, is already subject to heavy human impacts. Chinese scientists believe it is very sensitive to reductions in inflow, because it has high evaporation rate (more than 1000 mm annually). The Chinese Government has been deeply concerned with dropping levels of Dalai Lake and in 2009 commissioned construction of a very controversial water transfer canal to “restore” water supply from Hailaer (Argun) River (Dauria 2013). The JETRO Study emphasizes that a written agreement with Chinese Government is necessary due to the possibility of decreases in water flow. However the Secretariat of Ramsar Convention should be also involved in determining environmental flow requirements. Given that even after construction of a special canal from the Hailaer River in 2009, Dalai Lake has not been restored to levels prescribed in restoration plans, it is very unlikely that China and the Secretariat of Ramsar Convention would agree to a significant reduction to the inflow is very low.

Pumping facilities affect a relatively small area, where wells are located and the main expected impact is prohibition of grazing for sanitary reasons and vibration effects from pumps.

To summarize, we see only one really substantial potential impact from the alluvial water intake - reduction in flow in downstream stretches of Kherlen river and subsequent inflow into Dalai Lake. The degree of impact will depend on timing and intensity of water withdrawal and have greatest negative effects during dry years and dry seasons. From all consequences, the impacts on Dalai Lake water level are likely to be most difficult to mitigate, because they would be directly proportional to amount of water withdrawal.

### **11.3 WATER DIVERSION FROM THE KHERLEN RIVER**

If building a large dam is considered, it may evoke many undesirable consequences, and many of those cannot be mitigated (see table in Annex 1).

Many experts in last 10-20 years have warned that construction of a dam on Kherlen may ruin this fragile river ecosystem and the JETRO report clearly stressed that this is a very dangerous option which should not be pursued if alternatives are available (JETRO 2007). UN World Commission on Dams in 2000 released the most

authoritative report which simple central conclusion could be summarized as follows : “Do not build a large dam unless it is absolutely necessary and you have no another alternative option for problem solving”.

Proponents of the dam option on the Kherlen say that “regulating the river” will minimize negative effects on river flow. In reality the creation of a reservoir will at least double the loss of water, because evaporation from reservoir surface will likely exceed 1000 mm annually. The loss is estimated as the difference between precipitation and evaporation on reservoir surface. According to this estimation, 850,000 m<sup>3</sup> of water each year could be lost from each square kilometer of open water surface by evaporation (Mongol Guan Yuan 2006). If reservoir surface is 100 square kilometers it will lead to evaporation of 2.8 cubic meters per second on annual basis. In hot dry years evaporation will further increase. So in the case of the Prestige Group design, evaporation losses would exceed 1,75 cubic meters per second ( 50 million cubic meters annually) for a reservoir designed to deliver 47-58 million cubic meters to the Gobi. The design by “Monhydroconstruction” would significantly increase those figures. This argument cautioning against reservoir construction on Kherlen was also voiced by Mongolian Hydro-meteorology Institute on many occasions (G.Davaa- pers. communication 2014).

Given from the waste of water due to reservoir construction we doubt that “river regulation” may lead to sustaining the necessary environmental flows in dry years. The JETRO Study contains simple modeling that assumes environmental requirement for constant release of at least 10 cubic meters per second downstream from the dam and concludes that this requirement would fail at least “once in ten years”.

According to our calculations, the design by “Monhydroconstruction” will fail to observe their own “environmental flow norms” which by their “extremely generous” definition allow to withdraw 20% of flow in a given year. Even if they withdraw only 63 million cubic meters a year (2 cum/sec) and the evaporation loss from the reservoir will average 76 million cubic meters a year, they would still fail to deliver water as planned within the first 6-7 years of a dry phase of climate cycle. If, as proposed, they seek to supply 100-130 million - they would fail much earlier. So the promise to “adhere to 80% environmental flow” cannot be fulfilled. In a “business as usual” mode of reservoir management the likely consequence of such failure would be a drastic reduction in released flows by the dam in an attempt to keep reservoir at least half-full. As mentioned before, Mongolian hydrologists once suggested that to preserve environmental flow the overall withdrawal in Kherlen River middle reaches should not exceed 6-8% of river flow in a given year (Davaa et al, 1999).

However the even bigger environmental impact associated with “river flow regulation” is that dam will augment high flows. “This will significantly reduce habitats and change morphology of the river downstream. The water transfer may lead to the loss of floods which are beneficial for floodplain pastures, and bringing precious nutrients and moisture to the soil.” (IWRM 2012). Floods are responsible for shaping riverine and floodplain habitats, supporting life cycles of all aquatic life, replenishing subsurface shallow aquifers and sustaining pastoralist economy. For its size the Kherlen River has an unusually large floodplain, with at least 2,500 sq. km below the proposed dam. Attenuation of floods by the dam will kill the natural river ecosystem of Kherlen by disrupting flood and drought cycle.

The promise to eliminate extremely low flows downstream, although likely unfeasible, would have negative consequences as well. Low flows that most vividly occur in dry phase of climate cycle also have important ecological functions, one of which is preventing intrusion of invasive exotic species not adapted to local climate fluctuations. These species die off during low-water periods. Given that Dalai Lake already has at least 10 species of exotic fish, Chinese mitten crab and other introduced aquatic organisms this barrier function of temporarily drying Kherlen river has clear practical utility right now.

The dam will also block migration of fish and other aquatic species and it may affect Kherlen ecosystem to much greater extent than it would in many other rivers. The dam is planned between the forested headwaters with many cold-water tributaries and middle and lower reaches where wintering refuges are available in lakes and deep pools. Since the Kherlen river system is frozen to bottom in winter and too warm in hot summers many fish likely migrate from lower basin where they winters to spawning sites upstream. A dam would abruptly decrease fish survival and likely eliminate most valuable fish for least in the 800 kilometer stretch downstream.

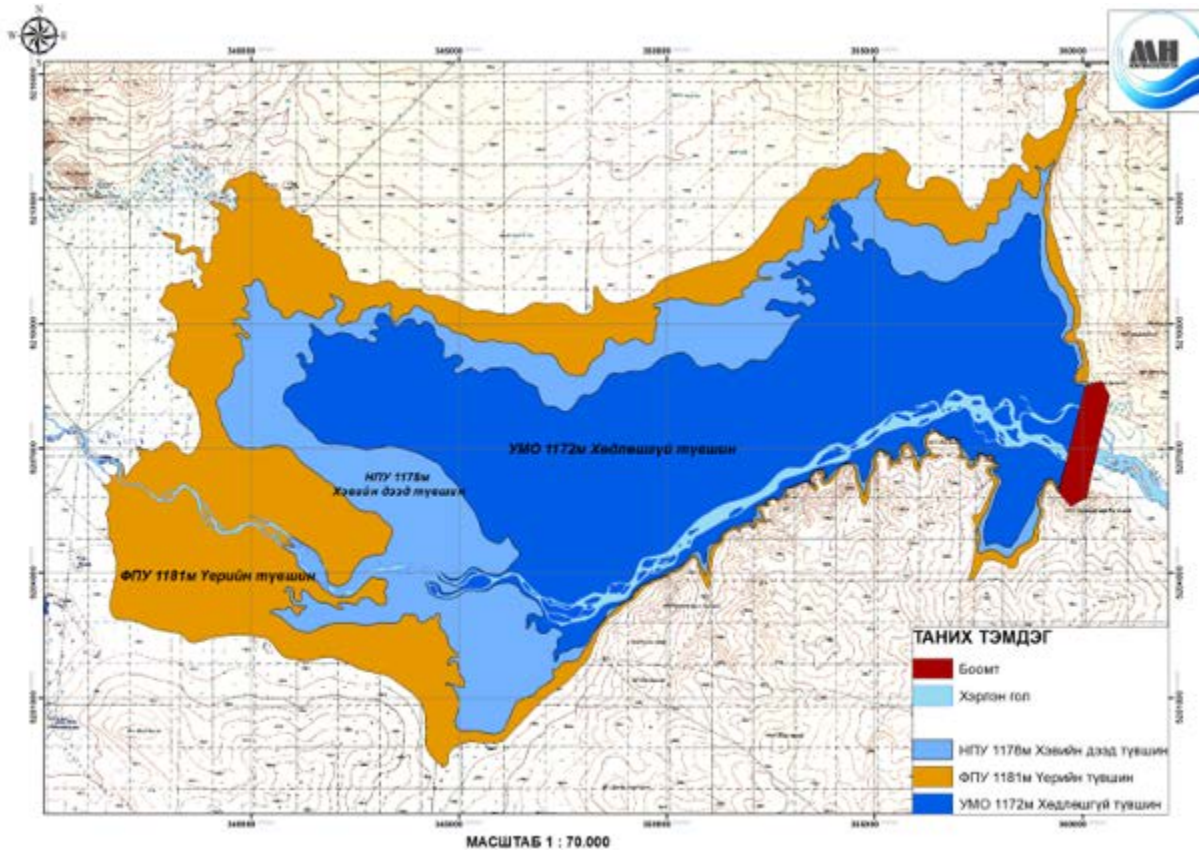


Figure 27. Reservoir planned by “Monhydroconstruction” with indication of dead volume level (dark blue), normal level (light blue), forced level (orange)- showing large area to be affected by water level fluctuation.

The reservoir on the Kherlen river is unlikely to be a “beautiful lake” as advertised by proponents. As the map in Figure 27 shows, frequent water level fluctuation will affect large area, likely cause massive erosion and make most of reservoir banks hardly usable for humans and livestock. On windy days water currents will pick up sediments from the bottom filling water with particles. The shallow waterbody with rotting vegetation at the bottom, will accelerate breeding of bacteria, algae and invasive water weeds and that will likely contribute to deterioration of water quality. Stagnant water will be ideal breeding place for mosquitoes and other organisms transmitting diseases. Increased humidity may alter the regional micro-climate and make heat less tolerable in summer, and in winter the stretch of open water downstream from the dam may present a health hazard for local workers and surrounding population, as happened at many hydropower dams in Siberia. Since mercury from illegal gold mining will be washed downstream and accumulate in the reservoir, exotic and native fish that will populate it is likely to be toxic. Other generic environmental impacts are summarized in a table in Annex 1.

In addition to generic environmental consequences of reservoir creation we need to highlight that both “Monhydroconstruction” and Prestige Group selected locations for the reservoir of high natural value, possessing exemplary biodiversity properties and already targeted for special protection status. The Prestige Group reservoir plan would affect Gun Galuut Nature Reserve – home to 38 fish species and many endangered waterbirds ([www.argalipark.com](http://www.argalipark.com)). “Monhydroconstruction” selected the Toono Uul area as their potential dam site, a location identified by The Nature Conservancy as high priority for future expansion of protected areas system in Eastern Steppe. In this area TNC scientists selected the 1,054 sq.km. of Kherlen River valley with surrounding mountains because it features 6 important ecosystem types in good natural condition and with many species of mammals, amphibians and reptiles that are typical of Eastern Steppe (TNC 2011). TNC selected these areas for biodiversity conservation at the request of the Mongolian government and it is now the basis for conservation planning by the Mongolia Ministry for Environment and Green Development.

As for negative socio-economic consequences, the dam option would have a big impact since it displaces people from reservoir site and significantly contributes to desiccation of downstream pasture areas all the way to Dalai Lake. The population estimate for the affected area is about 130-150 thousand people, many of them-traditional Mongolian herders. Sectors of economy likely suffering the most would be livestock breeding, fisheries of Dalai Lake, nature tourism and especially fishing tourism. In general the controls over benefits related to resources of the river will be redistributed from local people to reservoir managers and corporations participating in private-public partnership formed to implement this project.

On the policy side, the two greatest risks are likely rising corruption and seriously increasing national debt since this project cannot happen without state investment. The JETRO Study shows that this development is not likely to happen without investment of substantial public funds. A recent study from Oxford University shows that on average the cost of large dam construction worldwide have systematically been much higher than initially planned and that construction typically lasted 2-3 times longer than planned.(A.Ansar 2014)

The discussion above shows that, although every water supply scenario may have significant environmental and social consequences to be considered, a scenario that involved a large dam is likely to have much greater negative consequences and has a the potential to completely destroy the natural river ecosystem and harm Dalai Lake Ramsar wetland which having a deep impact on the communities upstream and downstream of the dam

#### **11.4 IMPACTS OF WATER CONVEYANCE INFRASTRUCTURE**

In addition to the impacts of water intake facilities, we also need to assess various environmental impacts of the conveyance infrastructure itself:

Impacts from installation of pumping stations, access roads and power lines are likely to have localized impacts at the scale of several hundreds to thousands of hectares, and could impede surface connectivity in due to access roads

The impacts of a 500-1000 kilometer long pipeline system are more noticeable, because, during construction (and sometimes operation) they affect a long route and dissect many pastures. However, if the pipeline is installed underground and movement across the pipeline is unimpeded it is less likely to have significant long-



lasing environmental impacts. The Erdenet City water supply from the Selenge river is a good example of such pipeline.

**5.3: Gunii Hooloi Borefield, Pipeline and Relationship to Ephemeral Watercourses**

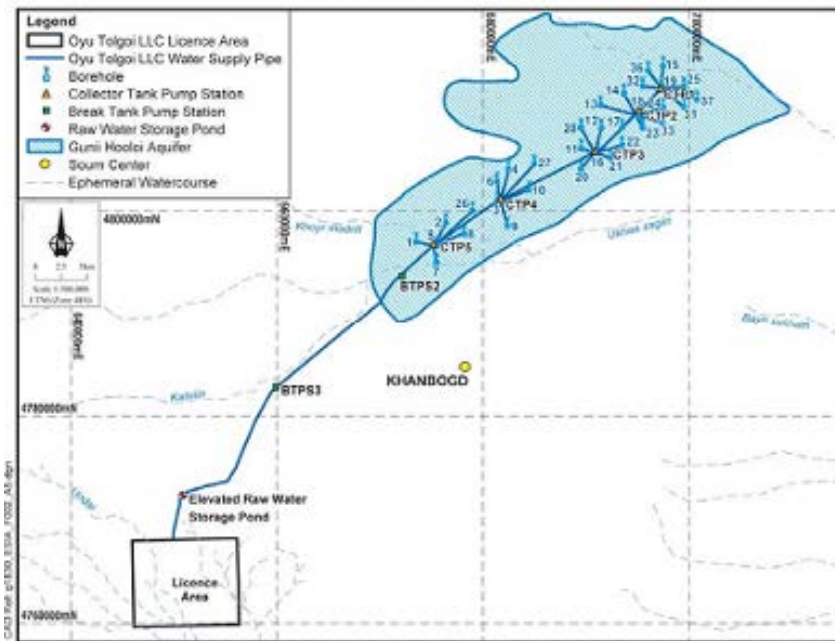


Figure 28. Oyu Tolgoi water supply pipeline. (Adopted from the draft OT ESIA )

The Gunii Hooloi water supply system built by Oyu Tolgoi mining enterprise in South Gobi has had a more permanent impact. The main pipeline is 70 km long and has an elevated service road, electricity transmission lines and other supporting infrastructure consolidated into a single corridor. The land along this corridor is largely owned and controlled by the OT Company is fenced and regularly patrolled and therefore creates a permanent barrier for herders and wildlife. 85 herder families have been recognized as affected and requiring compensation, and 11 of them have been resettled by 2011. Even five years after construction, the OT Company is still trying to resolve disputes with several herder families whose lands were dissected by the 70-kilometer pipeline.

The Kherlen-Gobi pipeline system would span at least 700 kilometers, and given that the destination areas have much greater human population density than in Southern Gobi, construction of the transmission system may directly affect anywhere between 1000 and 5000 families (5000 -25000 people).



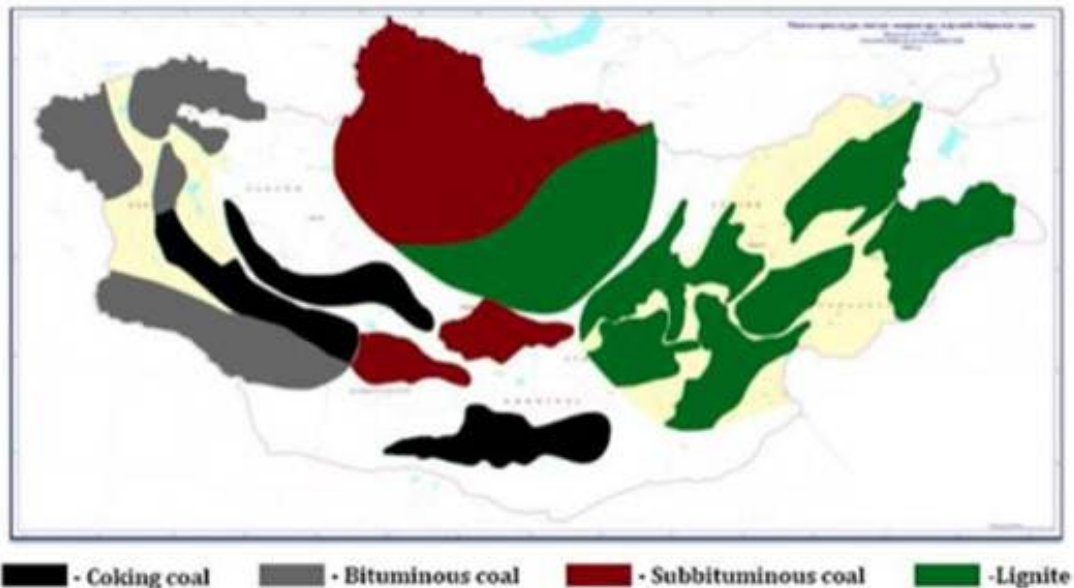
Pipeline construction. Hulunbuir, Inner Mongolia (RwB archives)

## 12 IMPACTS FROM COAL INDUSTRY AND OTHER SECTORS

Planning of future water management in Kherlen River Basin requires consideration of the full spectrum of future developments that affect river ecosystem.

Considerable information is available in Mongolia on the impacts of copper and gold mining on environment and community. However, in the Kherlen river basin these activities are very limited and there do not seem to be any plans for their expansion. On the other hand, there are major expansion plans for the development of coal deposits and related industries in Kherlen River Basin and adjacent Gobi desert region. Practically all planned operations require massive amounts of water and many are bound to lead to severe water pollution.

### COAL RESOURCES



Source: *Mineral Resources Authority of Mongolia*

Figure 29.. General distribution of coal (source: Mineral Resources Authority of Mongolia)<sup>3</sup>

### 12.1 WORLD-WIDE ENVIRONMENTAL IMPACTS OF COAL INDUSTRY

Coal is arguably the dirtiest energy source in terms of pollution and the leading source of greenhouse gases. Coal mining destroys land, pollutes thousands of kilometers of streams and brings massive environmental damage to

<sup>3</sup> <http://seekingalpha.com/article/310682-coal-in-mongolia-investing-part-ii>

communities. Pollution from coal plants produces dirty air, causes acid rain and contaminates land and water. Health problems associated with coal pollution include childhood asthma, birth defects and respiratory diseases.

1. Coal combustion is a major source of CO<sub>2</sub> and CO emissions into the atmosphere => global warming and greenhouse effects. Global warming is leading to widespread climate changes like desertification and loss of coral reefs. Coal-fired power plants are the largest contributor to the greenhouse gas emissions that cause climate change. In 2010 global coal production reached 7,228.712 million tons, coal consumption reached 7,238.028 million tons. More than 60 percent of the coal consumed was used to generate power.
2. Acid rain is formed when the nitrogen and sulfur dioxides released from coal combustion react with other elements in the atmosphere to form nitric and sulfuric acids. These acids then attach to water and fall to the ground as precipitation. Acid rain has the greatest impact on aquatic ecosystems like lakes, rivers, and wetlands, by lowering the pH of the water. Acidic water holds aluminum better than neutral water and leads to aluminum poisoning for crayfish, clams, fish, and other aquatic organisms. A similar problem of aluminum reaching toxic levels occurs in terrestrial ecosystems as well. Aluminum toxicity inhibits plants' ability to take up water and strips the soil of other vital nutrients. Without these nutrients plants are susceptible to damage from extreme temperature changes, insect parasites, diseases, and inhibited reproduction.
3. Pollution of aquatic ecosystems (thermal and chemical) around the mining site and thermal plants by machines, water pumped from mining pits, ash and dust.
- 4 Severe impacts on water balance (on groundwater levels and river flows) in coal-producing and thermal power generation river basins because of water consumption beyond local capacity and dewatering mining sites.
5. Ecosystem fragmentation by mines and associated infrastructure: reservoirs, roads, railroads, ports, etc.
6. Massive destruction of landscapes by mining, waste and roads and little restoration as the consequence the risk of flooding and erosion because it takes away obstacles that would normally limit it.
7. The health impact of coal emissions has recently become obvious in China, where this air pollution contributed to 1.2 million premature deaths in 2010, according to the Global Burden of Disease study, published in The Lancet, a British medical journal.
8. Radioactive pollution - coal ash from coal-burning is one of most important and ubiquitous sources of radioactive pollution (uranium, thorium, potassium, their radioactive decay products including radium) as well as heavy metals such as mercury. Burning coal in boilers to create steam for power generation and industrial applications produces a number of combustion residuals. Naturally radioactive materials that were in the coal mostly end up in fly ash, bottom ash and boiler slag. These residuals are called TENORM--Technologically Enhanced Naturally Occurring Radioactive Materials--because burning removes the coal's organic constituents, concentrating the trace amounts of naturally occurring radionuclides.

It is no surprise that there is growing movement among scientists and decision-makers to "let coal stay in the earth". Much of the enormous Mongolian coal deposits are good candidates for being left undeveloped.

## 12.2 COAL MINING AND WATER

In coal mining surface water is mainly used for coal selection (washing), the breaking up of layers (hydraulic fracturing), the cooling of machinery and steam heating during winter months, irrigation for re-vegetation projects, road sprinkling (dust suppression) and other uses. Of these, coal selection uses the largest amount of water. Water used inside the mine is mainly used for sprinkling to settle dust, the cooling of machinery, fire prevention and steam heating during winter months. Water used for general consumption is mainly used in office complexes, residential compounds, activity centers and residential areas that surround the mining complex. (Wang Hai et al.,2008; Wu Zhihong, 2009).

As a **transportation** alternative to trains or trucks, coal slurry pipelines are sometimes used for large volumes of coal over great distances<sup>4</sup>. Recent studies have proposed slurry pipelines as a cost effective and environmentally friendly alternative to rail or transportation for the Tavan Tolgoi mine<sup>5</sup>. A large spill in early 2014 in West Virginia and various other coal slurry related disasters illustrate the environmental risks associated with this transportation method. Depending on the grade of the pipeline and other factors coal is brought into suspension at mixture of approximately 50% water by weight. This means that for each ton of coal at least one ton of water would be required for transportation.

To assess water consumption we summarized estimates for various industrial coal-related processes and will be further use these figures in water balance calculations. Estimates are based on best available data from China, which by now has very strict standards for water use and which is likely to be primary source of water technologies and equipment used in Mongolia.

Environmental impacts from coal mining are extensive. Greenpeace East Asia estimates show that for each ton of coal mined, 2.54 m3 of groundwater is rendered unusable. In areas where coal mining is conducted, groundwater levels fall and the original flow of groundwater is interrupted. This decrease in water supply leads to desertification around mining zones, a drop in the health of surrounding soils and decreased agricultural production. This is especially true of open-pit coal mines, which leave behind waste rock and coal dust that increase the acidity of rain water and release other harmful materials, which flow into aquifers and pollute groundwater. Research shows that in northwest China, for every ton of coal produced, nearly 7 m3 of water is polluted (Greenpeace East Asia. Thirsty Coal report, 2012).

Coal is extracted to be used domestically and for exports. Within the Kherlen river basin Baganuur (Tov), Chandgana (Henti) and Aduunchuluun (Dornod) are three major coal mining operations. In the Gobi region Shivee Ovoo and Tavan Tolgoi are two biggest coal deposits potentially supplied by planned water pipeline. Together they represent the majority of coal resources to be exploited in Mongolia in next 25 years. Projected coal extraction from Mongolian mines planned for 2030 exceeds 100 million tons annually and most of this production will happen either in mines of Kherlen River basin or in mines supplied by proposed Kherlen-Gobi water transfer. The projected water demand from mining will be anywhere from 30 to 100 million cubic meters annually, if we apply modest Chinese consumption norms.

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<sup>4</sup> <http://ota-cdn.fas.org/reports/7817.pdf> A Technology Assessment of Coal Slurry Pipelines, March 1978, NTIS order #PB-278675

<sup>5</sup> <http://www.erina.or.jp/jp/Research/dlp/2013/energy/5Ena.pdf>

**Table 7. Expected Water Consumption by Coal Industry (Chinese data).**

Industrial Process\Product	Water used per unit product (ton) Minimum estimate	Maximum estimate	Figures for Inner Mongolia
Coal extraction	0.25	2,5 m <sup>3</sup>	0,9
Coal selection (washing)	0.7	3,2	2,5
Electricity generation	0.2 ( m <sup>3</sup> /sec/GW/year)	0.9	0.6
Coal to oil	11	16	12
Coal to gas	6.9 (ton/1000 m <sup>3</sup> )	10	8-10
Coal to methanol	10	15	
Coal to olefins	20	26	22
Coal to glycol	9,6	26	
Coal to DME	12	23	
Coal to fertilizer	6	10	
Coal based synthetic ammonia	6	<b>8</b>	

Sources: : 《榆林市国民经济和社会发展第十二个五年规划纲要》；《2010 年榆林市政府工作报告》；《2010 年陕西省水资源公报, Pucheng Clean Energy Chemical Company, all Sources provided by Greenpeace East Asia 2014 )Coal Thermal Power Plants

Thermal power generation also consumes large amounts of water. Eight to ten new thermal power plants with combined capacity of up to 4-5 GW were listed by Ministry of Energy as approved projects in Kherlen basin and in water-transfer areas. These plans are bound to consume at least 15 million tons of coal annually. (D.Dorjpurev. Ministry of Energy presentation at Mongolia Coal Conference, February 2014).

According to ADB by 2025 water consumption of thermal power plants of Mongolia with total capacity of 2,5 GW will reach 55 million cubic meters per annum (ADB 2014). This roughly gives us 22 million m<sup>3</sup> water consumption per 1GW capacity per annum or 0,7 m<sup>3</sup>/sec. so it is slightly more than average for Inner Mongolia.

Aggregated water consumption of these plants alone is likely to be anywhere from 80 to 100 million cubic meters annually. (See Table Xx) . At least half of this demand could be supplied from Kherlen river.

There is also a proposal for an additional 4,800 MW export-oriented thermal power plant at Shivee-Ovoo, so projects could be scaled-up in the near future if an upgraded transmission line connects Mongolia to China. If built, this would double water consumption for energy generation.

Thermal power stations are also significant sources of air and water pollution, which is obvious to anyone who lived in Ulaanbaatar where soot and solid waste (coal ash) from power plants is a major problem. The total water use for soot removal at a million kilowatt power plant is estimated to be 0.4-0.5 m<sup>3</sup>/s and would comprise half the plant's total water use. Furthermore, waste water from this procedure is of very poor quality with high treatment costs and little possibilities for reuse, leading to pollution of both ground and surface water. After water comes in contact with soot and ash, it is no longer able to support life and cannot be reused. It contains large amounts of calcium oxide and serious buildup of deposits in piping. Alternatively it is possible to use dry

methods of soot and ash removal, which would not require any water, but are considered less effective by the industry experts ( Greenpeace East Asia. Thirsty Coal report, 2011).

**Table 8. Summary of new thermal power plants proposed along Kherlen river and in water-transfer areas.**

(Source of data: D.Dorjpurev. Ministry of Energy presentation at Mongolia Coal Conference, February 2014)

CHP name	MW	Coal MTA	WATER million m3/year
<b>Baganuur</b>	350-700	3	15,4
Tsaidam nuur	600	1,5	13,2
<b>Booroljuuchin</b>	600	2,5	13,2
<b>Chandgana</b>	600	3,16	13,2
Erdencogt	600	2,97	13,2
<b>Aduunchuluun</b>	100-300	0,25	6,6
Shivee-Ovoo	270	0,7	5,94
Tavan Tolgoi	700	1,42	15,4
Total	4370	15,5	80-100

Cooling is the most water intensive part of thermal power production primarily due to losses to evaporation. A million kilowatt thermal power plant uses approximately 75,000 tons of recirculated water per hour, of which recharged water accounts 2,250 tons of this amount. The cooling process also often leads to serious thermal pollution of streams and especially lakes used as cooling reservoirs. The most effective way for plants with recirculating cooling systems to save water is to change to air cooling. Air cooling is a method by which air expelled from a steam turbine is cooled through the use of air, surface and mixed heat exchange systems. So far Mongolia has only one small 18 MW power plant that uses air cooling in South Gobi. If all proposed thermal power plants use water cooling according to best Chinese standards, they would require 22 to 90 million cubic meters annually.

### 12.3 COAL-BASED CHEMICAL INDUSTRY

Recently coal-to-gas and coal-to-liquid projects have become extremely popular among developers in Mongolia due to the global rise in oil prices. While these projects could serve many purposes they are highly water intensive.

The largest proposed project envisions massive export of synthetic gas to China. A MoU was signed in October 2014 between Sinopec and the Ministry of Mining for the development of a coal gasification plant. This project will require an investment of \$30 billion, and its four units will have a combined annual capacity to produce 15 billion cubic meters of gas from 50 million-80 million tons of coal. In May 2014 the Water and Hydropower Survey and Design Institute of Inner Mongolia started the development of the water supply for Mongolia Coal to Gas Project. For an annual production of 15 billion cubic meters of gas the project will consume 150 million cubic meters of water, or 400 thousand cubic meters per day, and at least 25% of this production is likely to be based at Baganuur. Other locations have not yet been identified, but it is reasonable to expect that the majority of those facilities to be based in the eastern part of Mongolia due its proximity to the Chinese market.

### Project objectives and resources

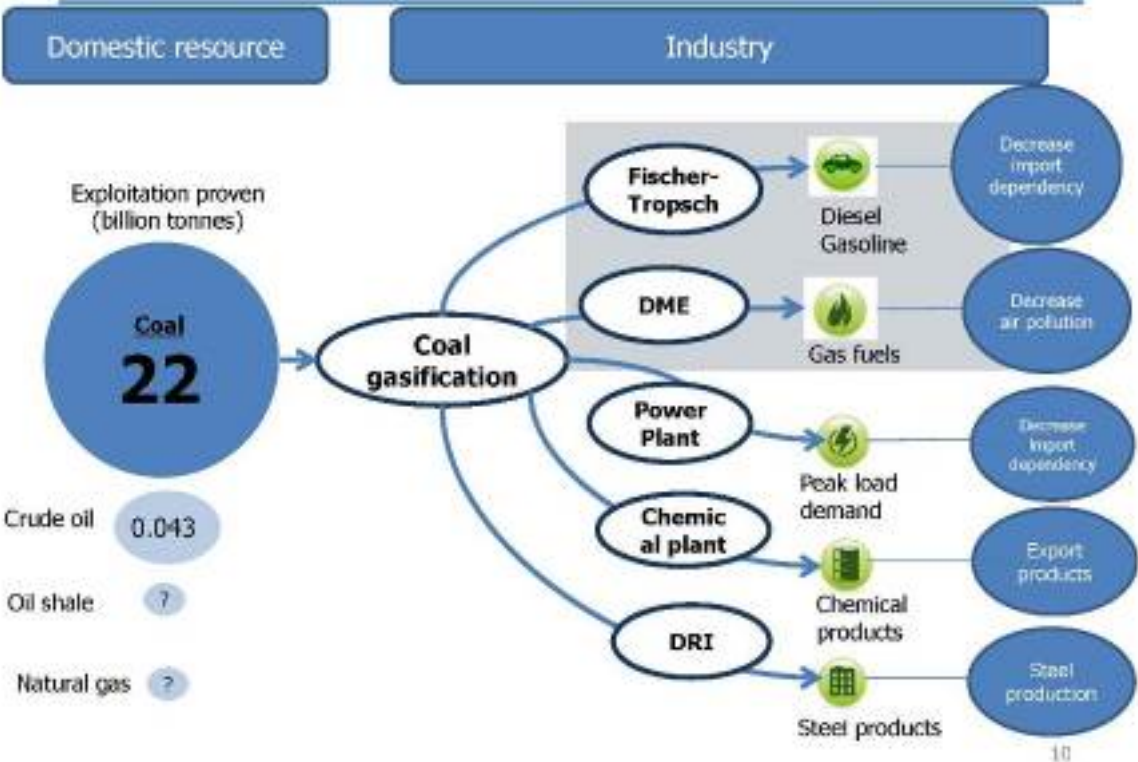


Figure 30 Possible directions of coal-chemical industry in Mongolia. (Baganuur CTL Presentation. Coal Mongolia Conference. February 2014)

There are also coal-chemical projects under development that would produce gasoline and other chemicals. The Korean MCS-POSCO proposed coal to liquids project at Baganuur is seeking to use 7 million tons of coal to produce 450,000 tons of diesel, 90,000 tons of gasoline and 100,000 tons of DME (Dimethyl ether) annually. Such facility is estimated to require 7 to 12 million tons of water annually. (<http://en.mongolianminingjournal.com/content/57104.shtml>).

Table 9. Comparison of water use in different coal chemical processes. Source: Pucheng Clean Energy Chemical Company (Greenpeace East Asia 2013)

Coal to...	Coal consumed (ton of coal/ton of chemical)	Water consumed (ton of water/ton of chemical)	Electricity consumed (KWh/ton of chemical)	Carbon Emissions(ton of CO2/ton of chemical)	Unit cost production (RMB/per ton of chemical)
Methanol to Olefin (MTO)	7 - 8	50 - 60	1500 - 2000	10 - 12	6000 - 7000
Methanol to Propylene (MTP)	8 - 9	38 - 45	2200 - 2500	10 - 12	7000 - 8000
Oil (Indirect Method of Production)	4 - 5	15 - 17	300 - 400	7 - 10	2200 - 3200
Natural Gas	3.5/1000m <sup>3</sup>	8 - 10/1000m <sup>3</sup>	200-300/1000m <sup>3</sup>	>10/1000m <sup>3</sup>	1000 - 1200/1000m <sup>3</sup>
Methanol	2 - 3	12 - 15	300 - 400	3 - 4	1300 - 1700
Dimethyl ether	3 - 4	14 - 18	500 - 600	4 - 5	2000-3000

The Mongolyn Alt Corporation (MAK) proposes to build a 300MW power plant and a CTL plant that would produce 400,000 tons of synthetic gasoline per year at the Aduunchuluun Coal Mine near Choibalsan. Water consumption of this facility is estimated at 4-6 million tons of water annually.

Asgad Energy LLC, established by Ascot Energy of Singapore and Hulaan Coal, a Canadian company, plans to carry out underground coal gasification (UCG) based on three coal deposits (Sharyn Gol, Shivee Ovoo, and Tevshiin Gobi) of Hulaan Coal. Water demands of this project are currently unknown.

Coal derived chemical industry is far from being a green industry as it is marketed by its proponents. It produces and releases into the environment hundreds of toxic substances and has environmental effects, many of which are not sufficiently studied. In Ordos (Inner Mongolia), China, the Shenhua Corporation has developed the world’s largest Coal-to-Liquid model project that releases industrial wastewater containing a complex mix of 76 organic chemical contaminants of which only a small fraction could be identified to a high degree of reliability using standard laboratory analyses. Compounds include Dichloromethane, Xylene, Cresol and other toxic and carcinogenic substances (Greenpeace East Asia. Thirsty Coal 2. Shenhua Water Grab.2013).

Broader environmental impacts from associated industries and infrastructure should be also taken into consideration in environmental impact assessments. The Mongolian Water Law wisely prescribes not to grant licenses for water supply unless a credible scheme for wastewater treatment and disposal is also presented.

Due to huge environmental risks associated with all developments associated with the large-scale coal industry in Mongolia, it would be hugely important to conduct a strategic environmental assessment for the entire coal sector. The piecemeal approach which is currently followed by dozens of corporations that are already active in Mongolia may lead to serious environmental and economic damage. The Kherlen River basin has a high likelihood to be severely affected due to the concentration of coal industry and attempts to develop the water supply to coal industry in the Gobi desert.

Neighboring regions in China provide ample examples to learn from. Initial plans for development of 16 giant coal-energy bases in water-deficient regions of north and northwest China were based on poor environmental planning and have partly failed due to water deficits and massive protests against environmental destruction in



Inner Mongolia in 2011. Nowadays Chinese and international investors seriously examine the environmental sustainability of any proposed coal industry projects.

As this chapter illustrates the coal industry is bound to become the largest water-consumer in Mongolia and in the Kherlen River basin in particular. It is also the major polluting industry. Experience of neighboring China could be used to build safeguard against the worst impacts and mitigate negative consequences.



*Coal mines in the Dauria steppe, Hulunbuir. (by E.Simonov)*

## 13 . FUTURE WATER BALANCE AND CLIMATE RISK

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### Where did the River go?



*Dry Ulz River at Erentsaav, Russia-Mongolia border in 2007 (by V.Kiriliuk)*

### 13.1 POSSIBLE HUMAN USE OF KHERLEN WATER RESOURCES BY 2030

The latest Mongolian IWRM Study projected that by 2021 the highest possible annual demand in Kherlen basin would be 77 million m<sup>3</sup> an additional demand of 90 million m<sup>3</sup> was expected in three basins in the Gobi, which are targeted by water transmission projects (Umnugovi, Dundgoi and Dornogovi). That study, however, was based on extrapolation of general consumption trends and based on 2010 statistics.

Our study supplements this by performing express-assessment based on data from planned economic development projects.

While we lack detailed data on groundwater resources in the Kherlen River basin to develop full water balance for the future, most of groundwater resources in the Kherlen River basin are subsurface sources directly connected to the surface water and therefore not “independent variables” in the water balance.

As for Gobi-based water consumers, the limitations on water delivery are defined by the design characteristics of the inter-basin water transfer to those areas. It is worth mentioning that the water transmission into Gobi planned by Monhydroconstruction far exceeds the projected demand in Gobi in 2021 predicted by the 2012 IWRM Study. The Prestige Group assessment indicates that even with water transmission, local groundwater reserves of the target Gobi areas will still contribute about 50% of local consumption.

One big unknown variable is the percentage of water that is returned to the river as wastewater, but most lines in the tables below represent consumption rather than overall water use, and in a hot dry climate wastewater usually evaporates rather than returning to water bodies.

By compiling the best available data on water demand in tables 6 and 7 and information on various water users from previous chapters we developed tentative water balance estimate for the Kherlen river basin in Mongolia by 2030. This target year was chosen because most currently planned economic projects are expected to be fully operational by then. The table below includes only well-documented water-supply facilities and industrial units. It does not include assumptions on water demand by other potential users for which we do not have sufficient information. We did not make estimates for water use in China both due to lack of data on future projects and to the fact that data we have for Mongolia show that China simply has no chance for equitable use of Kherlen waters due to planned severe exploitation in upstream areas in Mongolia.

**Table 10. Potential water consumption in Mongolia portion of Kherlen River Basin and adjacent Gobi Regions by 2030**

Demand by 2030	Scale	m <sup>3</sup> water per unit product	Annual water demand, min. (million m <sup>3</sup> )	Annual water demand max. (million m <sup>3</sup> )	Notes on sources and assumptions
Existing (and projected) consumption in Kherlen River Basin	110,000 people in Mongolia 35,000 in China		24	30	Mongolia IWRM Study predicts less than 6 million m <sup>3</sup> growth in municipal and livestock water use by 2021,
Gobi mining industry – clients of Kherlen-Gobi pipeline	3-6 mining centers	lump figure from engineering designs	50	120	Monhydroconstruction claims transfer of 100-120 million m <sup>3</sup> . Alternative figures by Prestige 47-70 million m <sup>3</sup>
Evaporation from reservoir surface if Kherlen-Gobi project includes it	Reservoir surface 60-100 km <sup>2</sup>	Water loss due to evaporation 850-1,300 mm	50	130	Smaller reservoir surface 65 sq.km, Larger reservoir surface 100 sq.km Maximum figure also takes into account possible evaporation increase in warmer and drier years.

Demand by 2030	Scale	m <sup>3</sup> water per unit product	Annual water demand, min. (million m <sup>3</sup> )	Annual water demand max. (million m <sup>3</sup> )	Notes on sources and assumptions
Water use in coal mining and selection (wash)	Baganuur 15-35 mill. ton Aduunchuluun 5 mill. ton Chandgana 4-10 mill. ton	1 m <sup>3</sup> /ton	25	50	Chinese estimates range between 0,5 and 3,0 m <sup>3</sup> /ton –so we used quite conservative norm of consumption. Only mines inside Kherlen River Basin considered.  Mining volume estimate is conservative.  IWRM Study suggest 21 million m <sup>3</sup> increase by 2021 for all mining
Thermal energy expansion	4-5 GW( up to 10 GW if export)	0.6 - 0.7m <sup>3</sup> /sec/ GW/year	40	100	Part of CHP water supply may come from groundwater
Sinopec Coal to Gas Project	25-50% of 15 billion cubic meters.	7-10/ 1000 m <sup>3</sup> gas	25	75	Given that Chinese consumers are east of Mongolia, quite likely more than 50% of CTG production could be placed in Eastern Mongolia.  Part of Sinopec CTG water supply may come from groundwater.
Baganuur CTL	450,000 ton of diesel, 90000 ton of gasoline and 100,000 ton DME	11-22	7	12	More projects of this type could be planned at other coal deposits such as Chandgana Tal.
Aduunchuluun CTL	400,000 ton of synthetic gasoline	11	4	6	
Possible irrigation in Kherlen River Basin	18,000-30,000 ha could be developed in Kherlen valley	2,000/ha	36	60	Monhydroconstruction and Prestige Group estimates could be exaggerated. IWRM Study predicts 20 million cubic meters in 2021
Oil industry	Volumes unknown				Daqing Oil operates in Lower Kherlen in both countries and is likely to use water to pump oil.
<b>TOTAL</b>			<b>261</b>	<b>583</b>	

### 13.2 POSSIBLE CLIMATE CHANGE IMPACTS ON KHERLEN WATER BALANCE

We will use predictions described in Chapter 8 to assess possible impacts from climate change around 2030-2050.(see Table 9).

First of all, increase in evaporation that exceeds expected increase in precipitation will lead to corresponding loss of water from reservoir surface. This loss is comparable to consumption by Baganuur CTL plant.

Expected reduction in river flow by 18-23% gives much greater losses in flow at Underkhaan (closest gauging station downstream from reservoir). This loss would exceed water transmission capacity of proposed water diversion pipelines to Gobi.

Together these two losses would make additional 25 -45% to predicted water consumption for economic use.

Many other factors in changing land-use may increase future losses, for example, changing grazing intensity and pattern may lead to change in evapotranspiration and subsequently amount of water reaching the river. (Byambakhuu 2011). However, we cannot here predict those additional possible changes. Just two types of losses added together will lead to possible reduction of annual average river flow by another 115-155 million cubic meters. In dry years of natural climate cycle losses are likely to be disproportionately more pronounced than in relatively wet years.

**Table11. Possible water loss due to climate change.**

	Scale	Station	Annual water loss, min. million m <sup>3</sup>	Annual water loss max. million m <sup>3</sup>	Notes on sources and assumptions
Increase of evaporation from reservoir surface	Possible increase by 40-120 mm	dam	2,6	12	Reservoirs' is 65 and 100 square km.
Climate change impact on river flow	Possible flow decrease by 18-23%	dam	112,4	143	
<b>Cumulative loss from climate change</b>			<b>115</b>	155	
<b>Grand total - consumption plus loss</b>			<b>261 +115 =376</b>	<b>583+155 =738</b>	Those figures are valid downstream from Choibalsan, at Underkhaan consumption is expected to be 80-110 mln cubic meters less.

The last table (Table #12) is compiled to describe the flow volume of Kherlen River discharge in different parts of the basin in years with varying probability of occurrence. Figure 31 shows how predicted minimum and maximum consumption and climate change losses correspond with river flow volume. Two assumptions are made - that all water withdrawn does not return to the river, and that no river-independent groundwater aquifers are available in Kherlen River valley. If we assume the opposite - that whenever applicable 50% of local withdrawal goes back into river basin, then in maximum withdrawal scenario we would "save" 70 million cubic

meters of wastewater annually. Some sources state that Kherlen river basin aquifers can produce 40 70 million cubic meters annually, but those are likely alluvial groundwater connected to river flow.(WRG 2030, 2014).

**Table12. Kherlen river annual flow and limits for withdrawal suggested by Mongolian hydrologists.**

Annual Flow Volume. Probability of occurrence, P,%	Baganuur	Underkhaan	Mongolia-China border	Flow into Dalai lake	
Average annual flow	683	623	530	480	In maximum consumption scenario Kherlen river does not flow into China.
P=75% (once in 4 years)	495	463	394	345	China will not be getting 50% of natural flow at the border at lowest predicted level of consumption.
P=90%(once in 10 years)	251	240	204	183	
P=97% (once in 30 years)	204	189	160	142	So 2030 consumption exceeds total flow roughly by 80-300%
Environmental limit of water withdrawal P=97%	12 (<6% upper reaches)	15 (<8% at middle reaches)	19 (<12% at lower reaches)		Consumption exceeds allowable withdrawal by 1200%-2800%

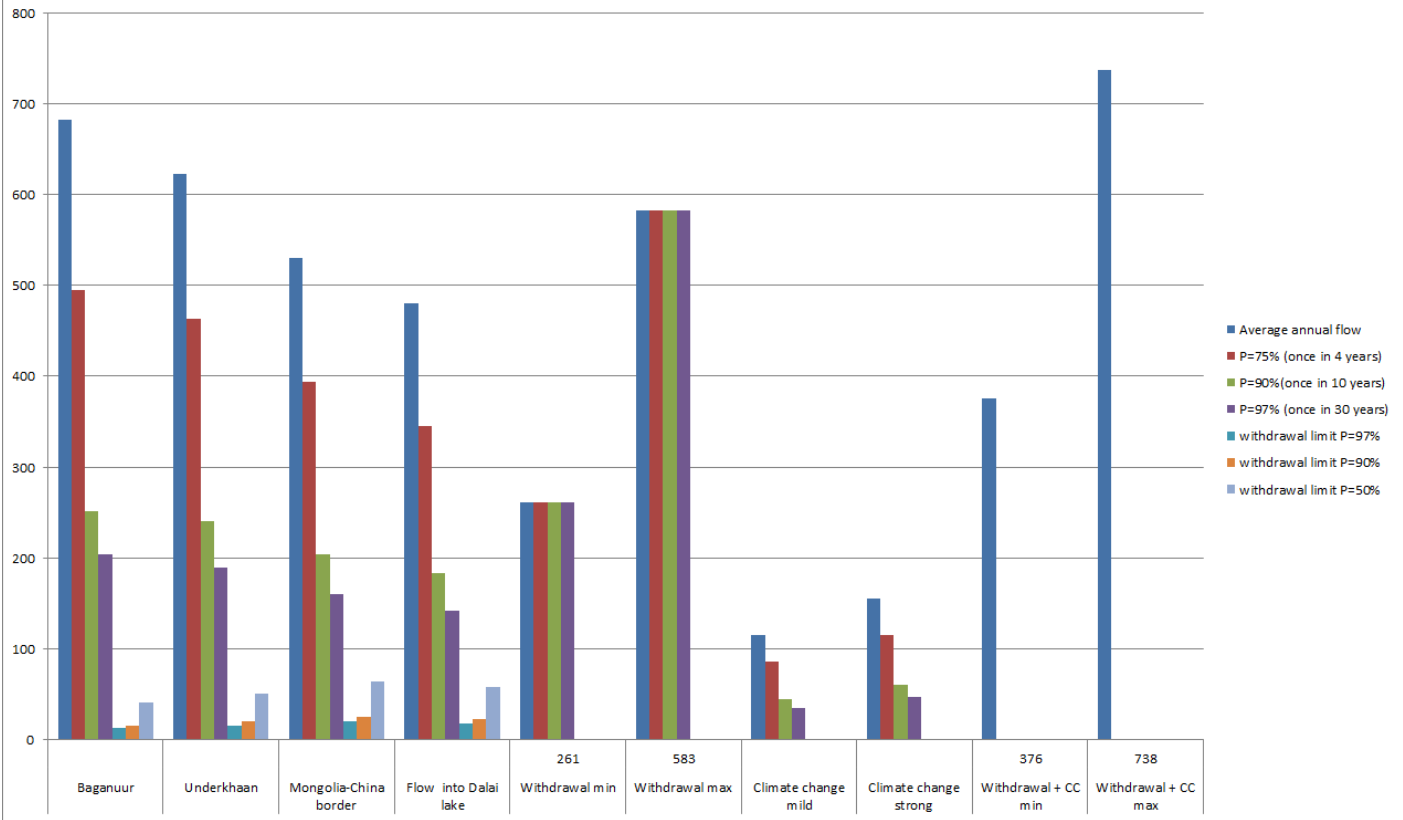


Figure 31 Kherlen river annual flow and predicted water consumption and loss due to climate changes by 2030

### 13.3 CONSEQUENCES OF DUAL IMPACTS FROM EXCESSIVE WITHDRAWAL AND CLIMATE CHANGE

Tables in this chapter and Figure 31 above highlights several important aspects:

- 1) Already announced development plans in Mongolia are likely associated with water consumption that practically equals the total available water resources (annual flow of Kherlen River).
- 2) Cyclical change in flow volume typical for Kherlen River makes such demands unrealistic to be fulfilled during dry phases of climate cycle.
- 3) Planned demand exceeds withdrawal allowable according to environmental norms suggested by Mongolian scientists by 1200%-2500%. It is completely unrealistic to sustain environmental health of river valley and satisfy this demand.
- 4) Half of consumption comes from economic activities within the Kherlen basin and 50% of projected demand consists of long-distance water transfer and associated water losses from reservoir. Given that realistic water management calls for drastic reduction in projected consumption it is reasonable **to cancel plans for water transfer** and then proceed with optimization of development plans within the basin.
- 5) Water evaporation losses resulting from maximum development of one reservoir would be roughly equal to those resulting from flow reduction due to climate change basin-wide.
- 6) Downstream reaches of the river in China and Dalai Lake Ramsar Wetland are severely threatened by planned development beyond repair by any imaginable mitigation measures. Even minimal consumption estimates result in water supply to Dalai Lake being reduced by 60%-75%, which likely may lead to disappearance of that Ramsar Wetland.
- 7) Even if all environmental norms and climate change effects are neglected, according to international customary law water at the border should be equally divided between countries. Even with "minimum demand scenario" China would not be able to get 50% of natural flow in year with P=75% and will likely not receive any flow in years with P=90% or drier.



*Horses on dry lake bottom (by V.Kiriliuk)*

## PART III. ENVIRONMENTAL SAFEGUARDS FOR KHERLEN RIVER

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*Kids on Erguna-Argun River. Hulunbuir, Inner Mongolia (by D.Hanisch)*

## 14 CUMULATIVE AND STRATEGIC IMPACT ASSESSMENT

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### 14.1 CUMULATIVE IMPACT ASSESSMENT

**A Cumulative impact assessment (CIA)** of water supply projects is needed. In the case of Kherlen-Gobi Project impacts from the planned water supply scheme and other water management activities should be assessed in the following distinct impact areas:

- Gobi areas from which groundwater supply is provided to locations serviced by the project;



- Gobi areas with mining and industrial sites serviced by the project;
- Transmission pipeline corridor
- Location of proposed alluvial water intakes ( or alluvial water intake and reservoir) and their immediate vicinity;
- Downstream areas in Kherlen River valley to the river mouth
- Dalai Lake Ramsar wetland of international importance.
- Upstream areas in Kherlen River basin ( likely relevant only in case of dam construction)

Cumulative impacts to be considered in the CIA come from the following sources:

A-Planned Kherlen-Gobi water conveyance project;

B- Groundwater supply systems which this project supplements;

C- Other industrial projects planned to get water supply from Kherlen river;

D- Other sectors using the same water source (municipal, livestock, irrigation, etc.)

E – Projected changes in natural environment due to global warming and other factors in Gobi and Kherlen River Basin;

Tables on water balance in Chapter 13 presents a rough list of impact sources.

The assessment of cumulative impacts of water infrastructure should incorporate a study of environmental flows in the Kherlen River-Dalai Lake ecosystem as related to flow of water, sediments and nutrients, following a methodology of which has been thoroughly discussed in WB publications ( e.g. Hirji and Davis, WB 2009).

Potential cumulative impacts to be assessed and mitigated likely include the following aspects:

- Impacts on natural hydrological regime (dynamic of groundwater regime and flow regulation in rivers),
- Impacts on natural temperature and ice regime;
- Impacts on sediment and nutrient transport, erosion and physical formation of aquatic habitat, especially Selenge Delta –Ramsar site;
- Threat of exotic species invasion in human-altered habitats;
- Changes in accumulation and release of chemical pollution;
- Impacts on productivity and composition of aquatic ecosystems;
- Impacts on aquatic and wetland species, in all parts of life cycle, their abundance, distribution,
- Impacts on terrestrial ecosystems, flora and fauna

- Impacts on large fish migrations in Kherlen River system (e.g. Taimen, Arctic Grayling, Lenok, etc.)
- Impacts on Dalai Lake Ramsar wetland of international importance
- Impacts on critical and non-critical natural habitats downstream.
- Cumulative impact of present and future development and water infrastructure on water quality
- Impacts and implications for future water use and development in the Kherlen river basin
- Impact on human settlements, existing infrastructure etc.
- Impacts on livestock industry, fisheries, tourism; irrigation, etc.
- Impacts on transportation (navigation and river roads//crossings in, winter)
- Impacts on other economic activities downstream from reservoirs
- Loss or damage to public health and//or safety

A cumulative impact assessment (CIA) of water supply is a very important procedure to be carried out either as stand-alone exercise within Strategic environmental assessment (SEA) framework.



*Herders camp on Argun River (by Simonov)*

## 14.2 . STRATEGIC ENVIRONMENTAL ASSESSMENT FOR KHERLEN-GOBI WATER TRANSFER PROJECT

So far the problem is that water supply proposals are poorly coordinated and planned and that limits of allowable change in environmental system are not sufficiently studied. In reality losses associated with those developments are not sufficiently articulated and quantified, while benefits are often exaggerated. As a result Mongolian decision-makers and public do not have clear and transparent information for sound decision making. This poses great risks to the environment and increases risk of failure of development projects.

**A** strategic environmental assessment of the Kherlen Gobi Project and all abovementioned development plans should be conducted to create a roadmap for development options in the Kherlen River Basin and the adjacent Gobi region. Noting the transboundary nature of the Kherlen, this decision making process should not be limited to Mongolia alone.

The proposals to transport water from northern Mongolia to the South seemingly rely on “excess water” being available for extraction. According to a 2010 position paper on water transfers issued by Australia Environment Agency, project feasibility depends on a range of factors, including:

- the reliability of rainfall and flow patterns in selected donor basin
- the current and likely future availability of water in northern Mongolia in the light of climate change
- the current and potential future uses of the North's water resources
- the practicality of capturing and storing water before being diverted
- environmental, cultural, economic and political risks and considerations

This framework is fully applicable for the Kherlen-Gobi Project. In fact the previous chapters show that each of the questions above is very problematic.

We therefore propose that the following key challenges to the Kherlen-Gobi Project be analyzed:

- Uncertainty regarding unsatisfied demand after 2020 and willingness of mining industry and other consumers to pay for such supply
- Costs high compared to other water-supply options
- Conflicting demands with a large number of stakeholders (e.g. competition for water between industrial projects, agriculture and needs of local population)
- Manageability and risks of a highly centralized supply solution, high likelihood of cancelation or relocation of every individual industrial project, Great uncertainty regarding natural drought cycle and its modifications by climate change
- Social impacts, especially in downstream areas and high mitigation//compensation costs
- Environmental flow requirements for the Kherlen River, and diverse impacts on aquatic and terrestrial ecosystems;
- Cumulative impacts of all water withdrawals on Kherlen River and Dalai Lake Ramsar Wetland of International Importance
- Need for international consensus with neighbors and conventions’ parties

The strategic assessment should create the framework for designing and evaluating possible development scenarios in water sector against wide array of interrelated costs, benefits and limitations in economic, environmental, social and political spheres. Analysis of a wide array of available alternatives lies at the heart of strategic assessment. Table below presents logical sequence of questions to examine Kherlen-Gobi Water Transfer Project, but a similar set of questions should be asked regarding other large-scale projects requiring water.

Table 13. Key questions to be resolved by Kherlen-Gobi SEA <sup>6</sup>

Problem/issue/aspect	Key inquiry	Option A	Option B
<b>Part 1.</b>	<b>Local supply in Gobi vs long distance water conveyance</b>		
0.1) Consider sustainable population//economic growth limits and conditions in South Gobi and Kherlen Basin.	Define limiting conditions to human activities and water consumption the Gobi can sustain (see WB SGR REA)	<p>Limitations to simultaneous human activities in South Gobi clearly set in planning. Industrial processing facilities placed in more developed water abundant regions (e.g. Selenge Basin).</p> <p>Comparison with option to place processing facilities in more water-abundant areas (e.g. Darkhan, Erdenet, etc.)</p>	Unlimited growth in Gobi far beyond sustainable capacity of the region encouraged. Water transfer at largest scale. Mitigation and compensation costs to be paid to population, businesses and China for deteriorating conditions in Gobi and Kherlen Basin.
0.2.)Consideration for limitations imposed on economic development and human environmental conditions by water deficit in Kherlen basin induced by water transfer alternatives	Assess comparative benefits/necessity for society from water use in various sectors (environment, livestock industry, tourism, coal chemistry, thermal power, mining, food/irrigation, processing of mining products) and particular large projects.	Water supply to human activities in the Kherlen Basin receive priority in development plans due to their natural proximity to water source and historic rights of local population.	Water allocation to human activities done strictly on merits of cost-benefit analysis with no priority for local uses.
1.1) Ensure sufficient	Where are affordable water sources	Evaluate Gobi groundwater	Evaluate Gobi Groundwater

<sup>6</sup> **Description simplified: in reality some issues have much more than two possible solution options**

sustainable water supply in South Gobi for 4-6 decades.	located? Whether centralized government-sponsored solution is more reliable than decentralized measures carried out by companies.	resources available for next 50 years.  Evaluate technology for water saving and recycling.	resources PLUS surface water conveyance system.  Evaluate technology for water saving and recycling
1.2) Acceptable level of environmental impacts and mitigation costs	Degree and geography of projects' negative impacts and mitigation measures and associated costs. Imposing environmental limits on volume, timing and dynamics of water withdrawal based on environmental flow study for respective waterbodies.	Assess environmental limits for water withdrawal for individual aquifers in Gobi and environmental monitoring requirements.	Assess environmental limits for water withdrawal for individual aquifers in Gobi and environmental flow norms for Kherlen River basin and Dalai Lake. Develop environmental monitoring requirements.
1.3.) Acceptable level of social impacts and mitigation costs		Impacts on ecosystems and population confined to Gobi, but possible higher intensity than B (need study).  Aimags in question: Sukhbaatar, Dornogovi, Umnugovi, Govisumber.	Impacts spread both in Kherlen River Basin and pipeline route AND Gobi (from groundwater extraction)  Aimags in question: Henti, Tuv, Sukhbaatar, Dornod, Dornogovi, Umnugovi, Govisumber.
1.3.) Economically viable option	Whether and under what conditions and assumptions water conveyance system would be economically viable supplement to groundwater supply.	Evaluate water supply options available to Gobi industries without intervention from the state.  Assess how groundwater/surface water prices presently arbitrarily	Evaluate amounts subsidized from other governmental revenues and likely consequences for national debt.  Assess costs and risks of water pipeline construction at

		differentiated by the government influence economic efficiency of projects	cost exceeding USD 1000000/km to individual customers and consequences of individual project cancellation to overall pipeline system.
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<b>Part 2.</b>	<b>Dam and reservoir vs infiltration water intake (or other water intake options)</b>		
2.1.) Ensure minimization of project costs not compromising system's reliability.	Development of reservoir for surface water intake vs using infiltration water intake from subsurface water of river floodplain	Locations, costs and reliability of infiltration water intake systems	Locations, costs and reliability of reservoir on Kherlen River (likely combined with infiltration water intake systems)
2.2.) Energy generation/ consumption options	Developing hydropower plant or only securing water supply. Compare costs and reliability	All energy comes from CES, hydropower not developed.	Part of energy produced by hydropower (if and/or when hydrological and environmental conditions allow).
2.3) Water Supply: customers, their needs and ability to pay	What quantity/quality of water each category of customers' needs and how much they are willing to pay for supply. Treatment requirements along the route.	Supply just to Gobi mining sector	Supply to a wide range of mining sector processing of mining products, coal power plants, irrigation, settlements, etc.
2.4) Changes in flow regime and water	Proponents of the reservoir claim that unlike infiltration water intake it	Assess in what years and seasons water demand	Assess whether reservoir can in all years and seasons

availability	can ensure continuous flow regulation satisfying requirements of environmental flow, continuity of water supply to all users in the basin and other conditions.	conflicts with environmental flow and what are the means to resolve it (store water in Gobi, develop flood impoundments off the main river, etc.)	satisfy requirements of environmental flow, continuity of water supply, equitable water sharing. ( <i>JETRO and RwB built models indicating reservoir will likely fail</i> )
2.5) Environmental impacts from a single project.	Reservoir vs infiltration water intake. Comparing intensity and diversity of impacts on Kherlen River ecosystem and ecosystems along transmission and in Gobi area.	Impacts on river ecosystem from infiltration intake (mainly impact on low in-stream flows).	Likely greater and more diverse negative impacts on ecosystems from reservoir, some of them could be mitigated with high additional investment. (assessment of additional loss through evaporation from reservoir, impacts on flow regime, sediment transport, temperature, fish migration, inundated areas, etc.).
2.6) Cumulative impacts on Kherlen River –Dalai Lake ecosystems from Kherlen-Gobi and other water supply and industry development projects.	How Kherlen-Gobi Project impacts act in combination with other water supply projects. How could all water infrastructure in Kherlen River meet Environmental Flow requirements developed for Kherlen River basin?	Water withdrawal with infiltration intake likely to be responsible for 20-30% of overall water consumption and mainly impacts flow regime.	Water withdrawal with reservoir could be responsible for 50% of water loss and has diverse negative impacts and complicated interrelation with impacts from other water –consuming projects.
2.7) Comparing social impacts	Number of people negatively affected by the project and compensation, mitigation cost.	Resettlement/ compensation mainly along the pipeline.	Resettlement/ compensation in inundated and downstream areas AND along the pipeline.

2.8) Geopolitical implications	Dialogue with China on downstream impacts and water rights.  Fulfilling obligations under international conventions.	The only issue: % of water withdrawal that could be guided by reasonable environmental flow standards (best if mutually agreed) and equitable division of the rest.	Highly necessary due to need to assess diverse potential impacts of dam construction on shared river system and Dalai Lake
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<b>Part 3.</b>	<b>Placement and dimensions of facilities</b>		
3.1) Location of water intake	Choosing water intake location based on system requirements and minimization of expected negative impacts.	Choosing closest locations with resources sufficient in most years and storing water elsewhere (in Gobi, on the route) for water-deficient years.	Choosing most reliable locations with resources sufficient annually under any circumstances.
3.2) Size of water intake	Deciding on size based on system requirements and minimization of expected negative impacts	For example, if reservoir is chosen, water supply objective may require much smaller reservoir with a dam several meters high.	For example, Hydropower plant likely requires huge reservoir with multi-year regulation capacity and a dam 20+ meters high
3.3) Pipeline route	Distance vs. reliance on existing infrastructure	Most direct route with least pumping effort to save construction costs.	Serving more soum centers and relying on existing power transmission and road networks
3.4) Water conveyance system	Storing water for emergencies vs increasing reliability of pipeline or	Water reservoirs for emergency and dry years (tanks, storage	Two parallel pipes ( as in Erdenet)



security/reliability	both	ponds , groundwater storage, etc.)	
<b>3.5.-3.xx)</b> Other engineering options			
<b>Part 4.</b>	<b>Management and timing options</b>		
4.1.Financing options	Design proper financing scheme	Partly private investment and IDA, etc.	Governmental Loan
4.2.Ownership options	Agree on ownership structure and related responsibilities	BOT arrangement, other PPP arrangements, etc.	State-owned enterprise, etc.
4.3.Timing options	Whether, planning for the project should be based on presently available knowledge or postponed till important baseline conditions are fully clarified.  Whether implementation of project should be harmonized with planning for water infrastructure undertaken by mining companies.	Planning should be postponed until results of South Gobi groundwater management system are in place and water supply potential is known.	Water conveyance system should be planned now and plan should be re-evaluated and adjusted when new knowledge is ready
4.4. Sequencing options	What is the sequence of studies and actual construction activities.	To build pipeline and infiltration water intake first and then if need arises in greater after transfer - build a reservoir (see Kherlen – Gobi) JETRO study.	To build reservoir first and then if viable –build pipeline.

## 15 . WATER MANAGEMENT ALTERNATIVES IN THE LIGHT OF CLIMATE ADAPTATION.

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In a strategic assessment an even greater number of options than that mentioned in previous chapter will be compared against each other. In this paragraph highlight the most obvious and promising direction for alternative analyses that should be evaluated regardless of whether or not any strategic assessment is conducted.

### 15.1 THOROUGH ASSESSMENT OF GOBI GROUNDWATER AND ENVIRONMENTAL LIMITS TO ITS USE.

The World Bank in 2009 proposed a “Southern Mongolia Infrastructure Strategy” which contained the following key statements on groundwater:

- *Initial development of the region should rely on abstraction of groundwater reserves.*
- *There is sufficient groundwater potential in Southern Mongolia to accommodate demand growth at least until 2020, when it could reach 350,000 m<sup>3</sup>/day. (For comparison: 2012 IWRM Study predicted 250000 m<sup>3</sup>/day in high demand scenario for 2021)*
- Estimated groundwater potential is 500,000 m<sup>3</sup>/day under conservative assumptions, including: 300,000 m<sup>3</sup>/day of rainfall recharge; and depletion of selected non-renewable fossil aquifers by 40-60% over at least 25 years.*
- Lowering of the water table in deep aquifers, potentially affecting the condition of shallow aquifers. This could pose some of the most serious threats to the region’s ecology if it is not carefully monitored. If negative effects of water abstraction are observed in a particular location, alternative sources of water supply will need to be considered.*
- *Decentralized groundwater supply would have investigation and capital costs in the order of \$260 million, compared with over \$500 million for one pipeline from Orkhon or Kherlen river ( Clarification: presently expected costs for any of two water transfer projects exceed \$1 billion).*
- *Over the next decade, more detailed studies are required to determine the extent of groundwater potential:*
- such studies are likely to reveal additional exploitable water resources.*
- studies will also determine if at some stage the conveyance of surface water from the Orkhon or Kherlen rivers is **economically justified.***
- *Resources (at least \$2.5 million for a three year startup phase) should be allocated to a groundwater management authority;*
- To conduct detailed studies of water availability in areas of expected demand*
- To monitor the impact of aquifer abstraction on surface water and the local environment*
- To manage and enforce rights to water abstraction*

The East Asia and Pacific Sustainable Development Department of the World Bank also commissioned the thorough “Groundwater Assessment of the Southern Gobi Region”. (Tuinhoff and Buyankhishig 2010)

This Assessment included comparison of long-distance water transfer and groundwater supplies highlighting the fact that in contrast to decentralized groundwater supply surface water option is a large centralized engineering scheme and cannot be realized by incremental investments in several steps.

**Table 14 Conceptual comparison of groundwater and surface water transfer options. (Tuinhoff and Buyankhishig 2010)**

Option	Selling points	Issues
Groundwater supply	<ul style="list-style-type: none"> <li>• Estimated potential sufficient for the next 10–15 years + additional potential in deeper aquifers (not studied yet)</li> <li>• Available near the point of use</li> <li>• Lower investment cost</li> <li>• Phased implementation)</li> <li>• Security of supply (decentralized)</li> <li>• No transboundary issues</li> </ul>	<ul style="list-style-type: none"> <li>• Potential not fully known: continued investigations/mapping needed</li> <li>• Data and information scattered</li> <li>• Need for management, regulation and monitoring</li> <li>• Water quality often poor for domestic purposes: treatment needed</li> <li>• Mainly fossil water: mining</li> <li>• Energy supply may be costly at certain locations</li> </ul>
Surface water conveyance	<ul style="list-style-type: none"> <li>• One source (dam, reservoir) and intake</li> <li>• Secured quantity</li> <li>• Controlled supply along the pipeline</li> <li>• Constant water quality</li> </ul>	<ul style="list-style-type: none"> <li>• Resource sustainability (climate change, impacts, sedimentation)</li> <li>• High initial investment (no phased implementation)</li> <li>• Security of supply (back up storage)</li> <li>• User's commitment required (specially mining sector)</li> <li>• Transboundary issues</li> <li>• Feasibility of irrigation component (socially, economic)</li> </ul>

*It is unclear how the mining companies will be involved in the surface water conveyance projects or whether they are willing to make long-term financial commitments for the water delivery. For example, the Oyu Tolgoi has already invested in a groundwater supply system that will cover their water demands for the next 20-40 years.*

*As the main (downstream) clients of the system, miners will have an important say in the final feasibility of the water supply options. The quality of the water may be of minor importance for miners choice between surface and groundwater since most of the mine water is used for washing dust suppression, cooling water, and has low-quality requirements.*

*Feasibility issues to be addressed for surface water conveyance are the economic feasibility of large-scale irrigation, social and economic feasibility of the rural water supply delivery points along the pipeline, environmental impacts in and around the source river, transboundary issues, and agreements with the main mining companies on the quantities and price of the delivered water.*

*Groundwater extraction and surface water transfer are not two antagonist solutions, but the second may complement the first if groundwater potential is insufficient. Therefore assessments of environmental, social and economic impact and financial costs of schemes involving surface water conveyance should also take into*

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*consideration that similar impacts from groundwater extraction also take place simultaneously. If the government decides to go ahead with water conveyance it will add up to already inevitable costs of groundwater extraction.*

*The main recommendation of the Assessment is the phased development of a Groundwater management information center which will also contribute to the decision making process for investments in the conveyance of river water to the SGR. This work will take 2–3 years, provided that the institutional setting and structure is in place and sufficient human and financial resources are available. Surface water could be most needed where groundwater reserves are limited or constrained by environmental considerations, therefore, initial clarification of full groundwater potential and its distribution in SGR would provide necessary guidance on potential destinations for surface water conveyance pipelines. (Tuinhoff and Buyankhishig 2010).*

The World Bank statements above seem to propose a reasonable program of action, which makes decisions on initiation of long-distance water conveyance projects dependent on outcomes of a thorough groundwater exploration and management planning. However, ironically, the World Bank was the first institution to violate this valid principle. Since early 2012, the World Bank has supported, through MINIS Project ([www.minis.mn](http://www.minis.mn)), the development of a feasibility study for Orkhon-Gobi water transfer, which is done without due consideration of recommendations listed above. The component of MINIS Project that should have supported a “Groundwater management information center” has been postponed by more than two years and started only in 2014 with co-funding from Australia Aid Programme. Three separate basin authorities were established to manage water in Gobi only by early 2014, and none are operational water management institutions, and little contributions to further exploration and improvements groundwater management in Gobi have been made. Old Soviet maps and reports on groundwater exploration remain the most comprehensive source of information on this subject.

For example, the Choir and Sainshand areas according to the Mongolian groundwater expert Dr. Jadamba indicated that there is likely enough groundwater to support some sizeable industry. Old Russian hydrogeology maps seem to corroborate that assessment (Boishenko et al 1971). According to new 2014 exploration results, a rechargeable supply of at least 290 liters per second is available north-east from Sainshand. The planned supply to Sainshand industrial park was generously set at 560 liters per second, but since then the number of industrial facilities was reduced from 9 to 4. Ganbold Dogsom, head of the heavy industrial policy department under the Ministry of Industry and Agriculture, in early 2014 said in an interview that discovery of a large underground water deposit near Sainshand solved a water supply issue, the biggest challenge to the project.

The Choir area according to the same Russian map has much greater groundwater resources, but those aquifers have not been explored recently. However quality of water in Choir is very low with mineralization exceeding 1000 mg/l. This means that industrial development in Choir and Sainshand can be supported by local groundwater if the water demand of this development does not exceed certain limits.

Sustainably of local ground water supply could be facilitated by short to medium distance water conveyance by pipelines from areas with more abundant groundwater to large mines. Darkhan-Borundur and Gunii Hooloy – Oyu Tolgoi are examples of such supply systems.

The Kherlen –Gobi Scheme designed by Monhydroconstruction fully neglects the local availability of these groundwater resources. The water resource potential of the Gobi should be fully explored and its environmental sustainability tested, before any long-distance water conveyance schemes are planned.

## 15.2 LIMITING DEVELOPMENT IN GOBI, MOVING INDUSTRIES TO WATER.

As was clearly indicated in the World Bank paper of the South Gobi Infrastructure Development Strategy and reiterated many times since in various other assessments, there are many factors which will limit growth of economic activity and human population in Gobi. Those factors include, but are not limited to: harsh living conditions, lack of water resources, high cost of development, varying quality of resources and unstable resource market, etc. The only difference is that the government will either study the situation and create careful incentives for economic actors to focus on most necessary development objectives, or this will happen gradually in a “natural evolution” and likely with serious losses to the economy in the form of stranded assets and unfulfilled agreements.

We will limit our reasoning to water-related issues. Experience from northern China shows that it is possible to have large high quality coal deposits and still abstain from extracting it due to the absence of an affordable water supply. Most planned Chinese investments into the coal industry of Mongolia is explicitly based on the following reasoning: coal-rich China cannot afford deteriorate further its own environment, so it needs to buy coal-products abroad. The same reasoning applies to other mining products. Therefore in a place with such limiting environmental conditions as the Gobi one needs to put a clear and well thought-through cap on water demand and the environmental impacts from industries and associated settlements.

Therefore recurring attempts to plan water-thirsty industries (other than mines as such) in the Gobi are likely to be doomed in a long term. If processing in Mongolia is economically justifiable, then it is likely to be most justifiable in regions with sufficient water supply and well developed infrastructure. Given the huge volume of water needed for processing Darkhan-Erdenet in Selenge Basin may be more sustainable location for coking plant and steel-making factory than water deficient areas in Gobi. While those and other northern areas may be better suitable locations for processing, the full scope of environmental impacts and water resource tradeoffs will also need to be evaluated for those locations to compare them with Gobi options.

The story of Sainshand Industrial Complex (SIC) planning provides a good example of these risks. A massive industrial complex was planned to include cement plant, oil refinery, coking plant, DRI plant, CTL, copper smelter, wind farm and several other projects. Raw materials, including thermal coal, coking coal, iron ore, limestone and copper concentrate, would be transported to Sainshand, where they would be processed, in addition to metallurgical coke, iron ore pellets, reduced iron ore, copper anodes, sulphur acid and cement, which will also be produced on site. It was estimated that about 10,000 new jobs created under the project, requiring large-scale municipal development. In 2012 the Bechtel Corporation of the USA submitted the results of its feasibility study on Sainshand. These concluded that only four out of the nine plants planned to be built at Sainshand could possibly work, but would not be commercially profitable. These are the copper, iron, coke and cement plants, none of which would be able to make a profit without government subsidy in the form of total tax waivers. Various ministers in Mongolia have gone on record against the Sainshand Industrial Complex: according to B.Batkhuu, director of Policy Implementation Department at the Ministry of Mining , the Sainshand Industrial Complex was a mistake if judged its by economic merits. In September 2014 agreement was reached with China to build a railroad from Tavan Tolgoi to the Chinese border which will likely postpone railroad construction from TT to Sainshand vital for SIC. Going forward, the viability of any of SIC industrial proposals depends on the size of governmental subsidy. On one hand uncertainty and high costs of long-distance water supply system increases costs and vulnerability of SIC industries, but on the other hand lack of clarity with water demand in SIC, which

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planned composition changes all the time, makes planning a water supply pipeline too risky- it may be left without sufficient demand.

Mines are the only facilities that cannot be moved elsewhere and inevitably require local water supply. However, Mongolian politicians have already learned that there is no social or economic reason to develop ALL mineral deposits simultaneously. Only a small number of mines seriously contributes to the country's economic success. Besides, there could be other reasons not to develop, like lower quality of certain coal deposits, which could seriously contribute to carbon emissions. Therefore there should be careful evaluation which mines are to be developed in near future set limits to their water supply is one of criteria guiding such decisions. Policy requirements to use the best water-efficient technologies is another necessary measure for development in Gobi.

The Kherlen–Gobi (and Orkhon-Gobi) water transmission proposals for years have struggled to justify demand, with ever changing list of specific customers. Proponents put forward unrealistic promises to deliver water for irrigation, livestock breeding, settlements and "greenification", while even mining companies may have difficulties paying fair price for such water supply. Firms initiating such projects are working hard to create additional demand for excessive use of water in areas, where exactly opposite incentive is needed.

The Government of Mongolia needs to assess objectively the sustainability of and limits to development in arid regions:

- Analyze whether and how supply of surface water could offset/mitigate negative impacts of groundwater extraction in Gobi (on ecosystems, herder communities, etc.).
- Assess long-term impacts and incentives that additional water brings to the Gobi region.
- Assess policies and planning tools that help to limit development of water-intensive processing in water-deficient regions.

**The Southern Gobi Regional Environmental Assessment** points out that in addition to feasibility studies, environmental impact assessments, and other necessary preparatory work, they should be analyzed with respect to three “big picture” development planning concerns:

I. Sustainability of development in arid regions. Cities have formed along rivers and near coastlines of oceans and large lakes where water is available for drinking, irrigation, transport, and industrial use. There are few large cities in arid locales, and those that do exist, such as Phoenix, Arizona, and Los Angeles, California, depend heavily on imported water at considerable cost. Mongolia needs to be sure that the costs of maintaining cities that are in many respects artificial are justified and sustainable.

II. Transferring a significant fraction of the flow of two rivers to SGR will have impacts on the flow regime and consequently on the ecology of the rivers. These impacts may have implications for future water use and development in the exporting river basins. Planning must be done at a broad enough scale to reveal impacts and balance water needs for both ecology and economic activities in both the importing and the exporting regions.

III. Climate adaptation. Droughts are likely to be more frequent and to last longer. In view of the uncertainty in exactly what ways climate change will affect Mongolia, a precautionary approach is essential in making major natural resource allocation decisions such as allocating surface water for interbasin transfers. **(Walton, T. Southern Gobi Regional Environmental Assessment. WB/ 2010.)**

### 15.3 WATER SUPPLY IN FLUCTUATING CLIMATE OF MONGOLIA: INFILTRATION WATER INTAKES VS RESERVOIRS

One strong belief among Mongolian water resource officials, written into water management policies, is a necessity to shift from use of groundwater to surface water sources. Strong desire to use surface waters was clearly manifested in 2011 Order of the GOM #302, which prescribed to raise price of water resources from 50-100 to thousands togrug/cum, and made groundwater 2-5 times more expensive than surface water. The consequences of this reform for long-term water supply to various users and acceleration of water infrastructure development are very mixed. There is no doubt that in principle it was a good idea that scarce water of Mongolia should cost more, especially to industrial projects and it was as a promising idea that sources hard to replenish (isolated aquifers in the Gobi) should be more expensive to exploit than easily replenishable sources, but it was a bad idea to extend that principle to all groundwater disregarding its natural rate of recharge.

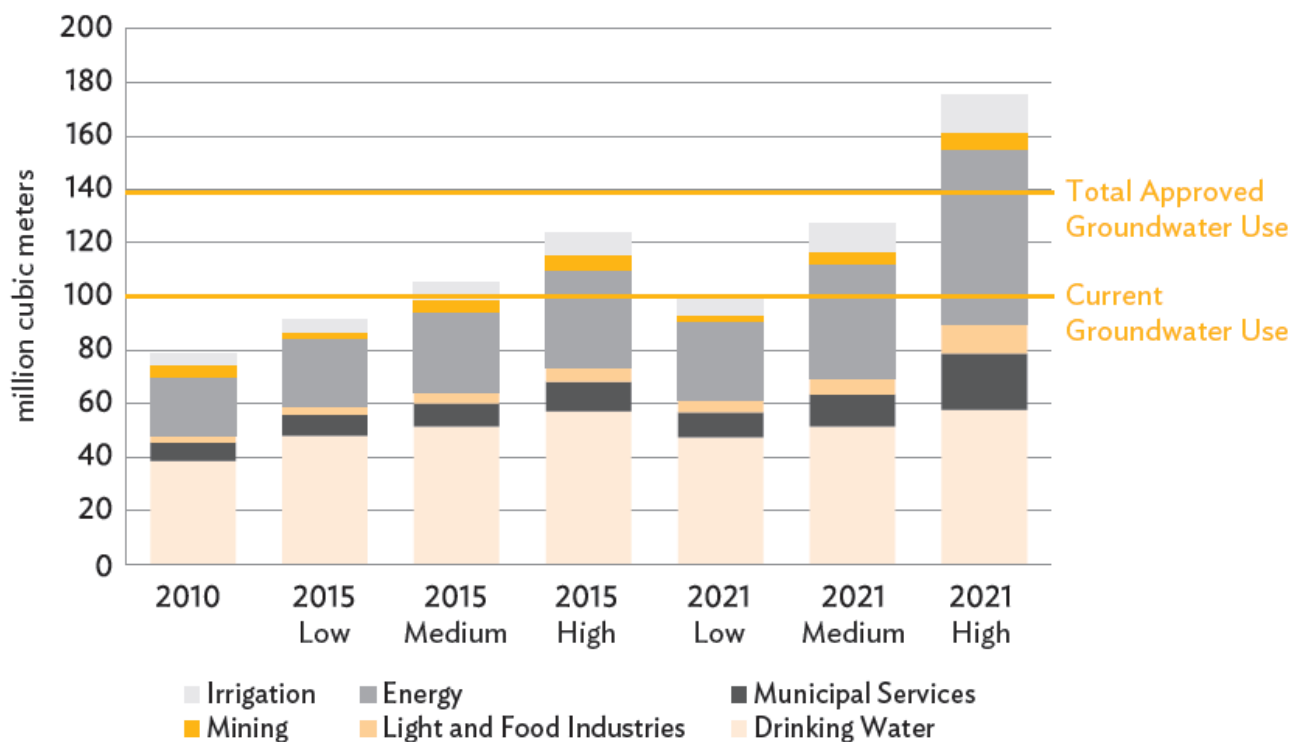
Engineering firms and their lobbyists intentionally mislead the government and public by declaring that “we need to balance Mongolia’s water supply which is 90% dependent on groundwater”. In reality in most aimags of Mongolia municipal, industrial and irrigation water supply come from shallow alluvial deposits directly and easily replenished from rivers, which makes abovementioned distinction between groundwater and surface water not realistic and misleading. At least 70% of water supply in Mongolia comes from subsurface flow of rivers which combines benefits of quick replenishment and continuity characteristic of groundwater with higher water quality due to filtering of river water through alluvium. The good news for the future is that such supply is also more resilient to seasonal and inter-annual flow variability and climate change. Mongolia has rich and largely very positive experience with subsurface water supply, illustrated by a few case-studies.

**Example 1. Ulaan Baatar City** in 2011 consumed 150-170 m<sup>3</sup> per day (56 million m<sup>3</sup> annually) and the infiltration water supply system along Tuul river has design capacity of 250,000 m<sup>3</sup> per day, that could be further extended to adjacent floodplains. It has served the city for decades and despite partial disrepair it could supply needs in all low flow years and seasons only with minor difficulties. However, if UB growth goes unchecked, water demand can grow 100% by 2020 to 300,000 m<sup>3</sup> per day and supply would need to be upgraded accordingly. Of course Ulaan Baatar is an extreme only case of megalopolis in Mongolia and no other city in the country experiences difficulties of similar scale.

According to Mongolian researchers there are many possibilities to manage water supply.

On the demand side there are opportunities to manage water use, -improve water use efficiency, stop leakage in the system. On the supply side the options that are being considered include plans to

- develop new groundwater supplies,
- develop surface water storage reservoirs, develop artificial aquifer recharge to increase supply in dry seasons, increase waste water treatment and re-use,
- build a water conveyance system from another ground water aquifer outside Tuul basin like Kherlen 150km, Zuukharaa 140km, Darkhan 230km . **(Narantsogtyn NASANBAYAR, 2011)**



Source: Government of Mongolia, Ministry of Environment and Green Development. 2012. Part 4: Water Supply Hydro Construction, Water Use and Demand. *Integrated Water Management National Assessment Report*. Volume 2. Ulaanbaatar.

Figure 32. Ulaanbaatar water consumption.

Recent proposals to supplement water supply with a reservoir in upstream Tuul have been cautiously viewed by domestic and international experts, for it may significantly harm important ecosystems and other water supply management options are less expensive and likely more reliable. Besides impact of upstream reservoir on downstream groundwater recharge has not been sufficiently studied. For example the 2011 Mongolia Water Authority report says that "erection of cascade basins along the main river to regulate runoff and prevent floods would be more appropriate than building a big dam" (Batimaa et al 2011).

**Example 2. The Erdenet Metallurgical Complex** in 2000 was responsible for half of all foreign trade and almost 25 percent of the government revenue in Mongolia. Among pipelines the Erdenet Metallurgical Complex water supply system is the most relevant time-tested example for future development. Three options: Erdenet local, Orkhon and Selenge river valleys were considered in the 1970s when choosing water supply source for Erdenet. Alluvial water resources of both Orkhon and Selenge valleys fully satisfied supply requirements, but Selenge floodplain option was preferred since it allowed for multiple use of associated infrastructure by other industries. By 1976 a water supply system was built with 14 wells each of 100 l/sec capacity extracting water from 45 –meter depth from alluvium under Selenge River. Besides the initial 14 pumps, it has a 60-kilometer pipeline with two parallel pipes and 3 booster pump stations that raise water 600 meters uphill under high pressure. The pipe is buried 3 meters deep and follows public roads. After recent replacement of pumping equipment and overall renovation, the system has capacity to pump 120,000 m<sup>3</sup> per day, but normally pumps only half of it according to needs. 47000 cum/day are consumed by the industrial complex without treatment, while the rest is treated to municipal standards for the Erdenet city. However even raw Selenge water filtered through alluvial sands most of the time meets drinking water standards. The environmental impact of this water supply system has never been formally evaluated but by our estimates it would be very low in comparison with other projects, given that it uses little water compared to the Selenge low flow volume and the fact that the pipeline follows public roads.



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Resulting production costs in 2012 were 500 togrug per cubic meter and water was sold for 700 togrug. Until 2012 Erdenet Complex has been paying modest water resource fee of 100 togrug per cubic meter, but this likely change drastically under the new law adopted in May 2012. If the infiltration water intake will be considered “surface water” (while in reality it is Selenge River subsurface water) then payment will be 900 togrug per cubic meter, but if it is considered “groundwater” then payment could reach 3700 togrug per cubic meter and annual water fee would become 66 million USD (2012 estimate without any operational costs) . At the time of our interview in 2012 there was no clarity which category will be assigned to this supply system by the government agencies.

**Example 3. Taishir-Altay water-supply.** The Taishir Hydropower Project on the Zavkhan River located in western Mongolia, that had significant negative environmental and social consequences downstream, has a reservoir with a pompous name of “Sacred Lake”, and is presently quickly filled by numerous landslides from its barren banks. In 2011 the Taishir-Altay water-supply pipeline was built from reservoir to quench thirst of the aimag center. It was designed by Prestige Group LLC, but contrary to official statements about a switch to “surface water” the water intake system uses not surface water of reservoir, but subsurface water from its banks. This practical and sound decision shows that clear advantages of subsurface water intake are fully recognized even by the biggest proponents of reservoir building.

The advantages of the reservoir building advertised by Mongolia Water Programme and promoted by several agencies and engineering firms should be rigorously reviewed and compared with other water supply options in specific conditions of Mongolia. Clear widely recognized disadvantages specific to reservoir option discussed elsewhere are:

- unavoidable /large-scale degradation of natural aquatic river ecosystem basin-wide;
- high costs of resettlement and mitigation of various negative impacts on population downstream
- very high capital expenditures for construction and high associated financial risks compared with other water management options.

When compared with the use of subsurface flow of the same river there is only one “decisive advantage” of reservoir building put forward by hydro engineers and officials: the ability to regulate flow seasonally and inter-annually to satisfy “all users” needs. There is considerable experience in the world showing that due to environmental, economic and technical reasons reservoirs very often fail to satisfy all users. Downstream population and ecosystems normally fall the first victim of resulting inequality. More often this happens in water deficient regions and in river basin with high natural variation of flow.

One of important disadvantages of reservoir building in Mongolia is the additional loss of water by evaporation from reservoir surface, which in many aimags is close to or exceeds 1000 millimeters a year. In the case of the Kherlen such loss equal, or even exceeds, the intended water supply volume. Evaporation may increase in this century by at least another 200 millimeters due to global warming and this may increase water losses proportionally. Finally, the only period when flow regulation by reservoir theoretically may have some additional benefits for water supply is long sequence of hot dry years in dry phase of the climate cycle. It is likely that evaporation is higher than average precisely in this period and therefore the reservoir may contribute more significantly to water shortage.

## 15.4 WATER SUPPLY ADAPTATION MEASURES IN FLUCTUATING CLIMATE

Other solutions should be assessed to solve generic problem of periodic water deficit, that prevents continuous supply. Experiences with the Ulaan Baatar water supply shows that such deficit is likely to occur in spring after a sequence of dry years. There are number of readily available solutions such as impoundment facilities for temporary water storage, artificial groundwater recharge, alternating use of surface and groundwater sources and demand-side management, etc.

### Impoundment facilities

The JETRO study explored an option of impoundment facilities located in floodplain off the main stem, that could be filled during high water period and impoundments created along pipeline route and at final pipeline destinations near mines:

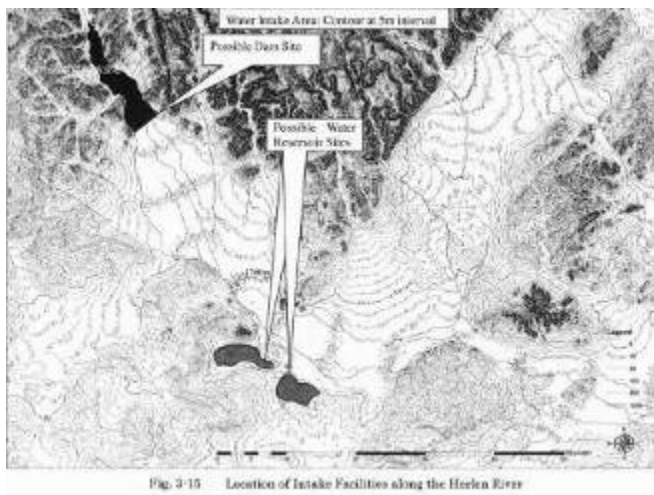


Figure 33. Location of impoundment in Kherlen River floodplain in comparison with reservoir. (JETRO Study)

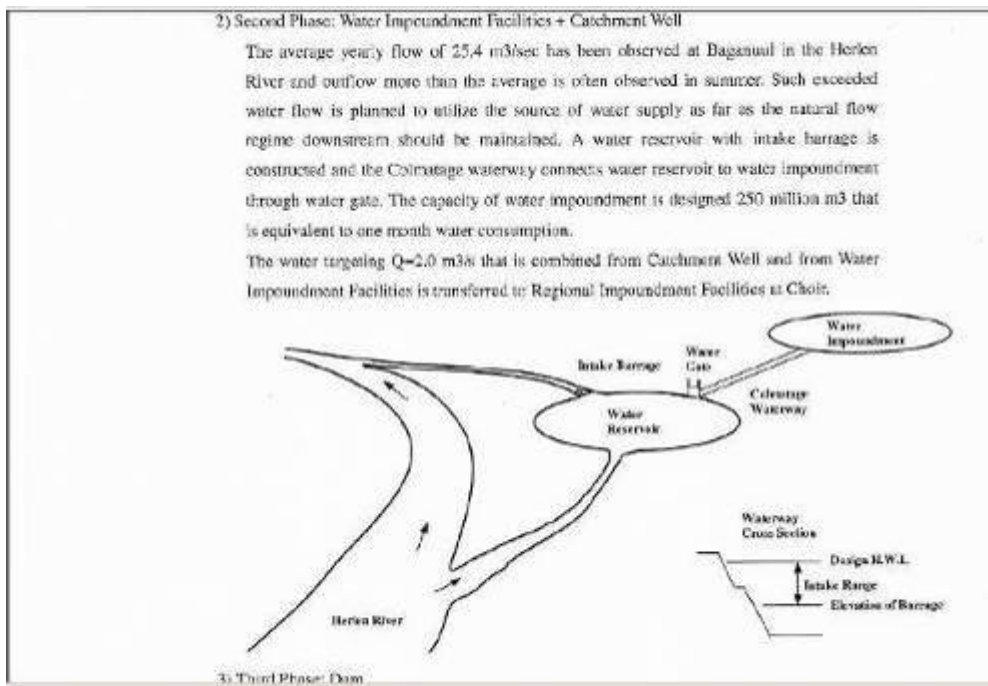


Figure 34.. Principal scheme and description of impoundment in Kherlen River floodplain in. (JETRO Study)

This idea was partly realized at Oyu Tolgoi that has developed relatively small “Laguna” impoundment to ensure stable water supply in case of emergency.

An artisanal version of such impoundment is employed by local people in South Gobi, who build small mud and stone dams in drying stream valleys and capture rainwater during torrential rains typical for Gobi. They store water for several months or years and use it for irrigation and cattle until it dries out. (Ulzi Lochin. Hydro engineer from Khanbogd ,pers.comm). A substantial shortcoming of such solution is high speed of evaporation and drainage losses from the impoundment.

### **Artificial recharge of aquifers**

Artificial recharge is the process whereby surface water is transferred underground to be stored in an aquifer. Water can be added to the aquifer by infiltration (via structures such as ponds, basins, galleries and trenches) or injection via wells. There are many potential sources of recharge water including stormwater (excess or redirected), treated wastewater and water from watercourses or aquifers. Underground water storage is an efficient way to store water because it is not vulnerable to evaporation losses and it is relatively safe from contamination. Internationally, artificial recharge is becoming an increasingly recognized form of water storage and conservation. Artificial recharge is being used in at least 32 states in the U.S. and at least 26 countries worldwide. This technology is still underutilized and together with proper groundwater management, artificial recharge can contribute significantly towards maximizing the use and sustainability of available water resources.

As climate change makes seasonal precipitation and surface flows increasingly erratic, the need for improved storage techniques has become more acute than ever. Experts agree storing water underground is far more efficient than storing water in surface reservoirs.

For example in the state of Arizona in the southwestern United States, aquifer recharge has already emerged as important tool to battle chronic water scarcity. In 2006, for example, the state’s Tonopah Desert Recharge Project became operational, with a goal of storing 185 million cubic meters of water annually. Using 19 recharge basins spread out across 83 hectares, the project allowed surface waters to slowly refill the underlying aquifer, with progress measured by monitoring wells. Within three years, the operation had successfully stored 600 million cubic meters of water underground, exceeding expectations and improving the area’s water security. When water was required again at the surface for irrigation or municipal use, wells and pipelines were used to pump the recharged groundwater as needed. (<http://wle.cgiar.org>).

Wherever hydrogeology conditions allow artificial recharge Gobi aquifers may be assessed as auxiliary safeguard measure given high temporal variability of natural water availability both in Kherlen River and in the Gobi region itself.

### **Alternating use of surface and groundwater sources.**

This solution envisions of holistic management of surface and groundwater supply. The solution is logical: during high flow periods water derived (within environmental flow limits) from (sub)surface water sources supply consumers and replenish aquifers. This is easily done by simple infiltration water intakes in floodplain alluvium. Then during low flow periods (sub)surface water supply stops and local aquifers are used to provide water to consumers.

### **Demand management in concert with climate cycle**

This group of solutions is united by the idea to adapt human activities to natural water flow variability during climate cycles. The main conflict in climate adaptation is between linear growth of production in human systems and cyclical availability of natural resources, water being prime example. So, mining, processing and other water consuming activities could be organized in a way that their water consumption fluctuates with seasonal and inter-annual change in water variability.

According to 2030 Mongolia WRG sufficient water supply is a key challenge in the Southern Gobi region to say nothing of protecting the unique ecosystem. Thus, appropriate and financially viable technologies for re-using water and treating wastewater need to be identified and used. Appropriate and financially sensible technologies for re-using water and treating wastewater need to be identified and used. Some companies are willing to invest in environmentally friendly technologies but have problems identifying technologies appropriate for their purposes. (WRG 2014)



**Hulunbuir coal-chemical complex uses waters of Hailaer River. Inner Mongolia.(by E.Simonov)**

## 15.5 ECOSYSTEM-BASED ADAPTATION PLANNING

### Adaptation planning methods

Kherlen is the most important river of Daurian steppe with many local, national and global values. Water management planning should proceed without haste in transparent and participatory manner, keeping in mind strategic objectives of sustainable development and preservation of resilient and rich natural environment.

In 2013 a new Water Management Authority was created to assist protection and sustainable water use in Kherlen River Basin. We hope that this new institution with a seat in Baganuur will take into account our data in compilation of Kherlen River Basin Management Plan (BMP) that should ensure protection of unique free-flowing river from its source to mouth.

According to WRG 2030 recommendations, the key focus areas for future water resources management work include improving the data basis and scientific understanding of water resources in Mongolia, undertaking a hydro-economic analysis to identify a range of cost-effective, practical solutions and priorities, leveraging the potential of water economics in order to design incentives for sustainable water resource management, working towards organizational and institutional clarity of responsibilities and strengthening capacities at all levels of the government and, finally, to support setting up a multi-stakeholder platform with priority work streams for inclusive decision making and efficient knowledge transfers. Addressing these focus areas will provide a solid basis for and enable sustainable water resources management, with which Mongolia can achieve its social and economic growth aspirations. (WRG 2030, 2014). These are all valid recommendations. However WRG 2030 and other industrial lobbyist downplay importance of sustaining ecosystem integrity and ecosystem services to people and pay insufficient attention to risks related to climate. Meanwhile ecosystem-based adaptation plan should become an important part of Kherlen River BMP.

Numerous works describe results of research by Mongolian and international scientists on likely climate change and risks arising from climate fluctuation (see Chapter 8). Unfavorable changes are expected in reduction of river flow, increase in extreme drought and floods, warming of rivers, etc. Based on this research results vulnerability analysis should be undertaken both for human systems and ecosystems of the basin.

Vulnerability" refers to the incapacity of a community or ecosystem to "absorb" through self-adjustment the effects of a change in their environment. It refers also to the incapacity to adapt to such change, which is a risk for the community. However, vulnerability can be reduced by the "response capacity", i.e. the attributes of the ecosystem and the strategies used by the population to reduce climate risks and to resist and recover from the damages caused by such events.

•The resulting CC risk will be a product of the relation between threat, vulnerability and response capacity:

$$\text{Risk} = \frac{\text{Threat} + \text{Vulnerability}}{\text{Response Capacity}} \text{ (Altiera 2013).}$$

Adaptation plan that is designed on this basis is an interconnected system of measures and safeguards incorporated into Kherlen River BMP to reduce vulnerability of the river basin and communities living there.

Because of the uncertainties over the impacts of climate change on the water environment, where possible robust measures that can cope with a range of future climate conditions should be chosen for the Adaptation plan. The following types of measures should be prioritized taking into account the transboundary context as well:

**Win-win options** – cost-effective adaptation measures that minimize climate risks or exploit potential opportunities but also have other social, environmental or economic benefits. In this context, win-win options are often associated with those measures or activities that address climate impacts but which also contribute to climate change mitigation or meet other social and environmental objectives. For example, encouraging the efficient use of water, and particularly

hot water in mining and coal industry is a win-win option, reducing demand on water resources and also mitigating climate change by reducing carbon emissions from water heating;

**No-regrets options** – cost-effective adaptation measures that are worthwhile (i.e. they bring net socio-economic benefits) whatever the extent of future climate change. These types of measure include those which are justified (cost-effective) under current climate conditions (including those addressing its variability and extremes) and are also consistent with addressing risks associated with projected climate changes. For example, promoting good practice in pasture management to limit the risks of erosion is a no-regrets option;

**Low-regrets (or limited-regrets) options** – adaptation measures where the associated costs are relatively low and where the benefits, although mainly met under projected future climate change, may be relatively large. For example, constructing drainage systems with a higher capacity than required by current climatic conditions often has limited additional costs, but can help to cope with increased run-off as a result of expected climate change impacts;

**Flexible adaptation options** – measures which are designed with the capacity to be modified at a future date as climate changes. Influencing the design of an alluvial water-intake, so that its withdrawal capacity could alternate depending on the phase in climate cycle .

**Measures to improve resilience** -aim to reduce the negative effects of climate change and variability on water resources management by enhancing the capacity of natural, economic and social systems to adapt to the impacts of future climate change. Resilience is often enhanced by diversification into activities that are less inherently vulnerable to climate. Measures to improve resilience target long-term developments, such as switching to crops that are less water-demanding or are salt-resistant. (UNECE 2009). Possible algorithm for assessment of adaptation plan suggested by UNECE presented in Table13.

While many measures are fairly simple and straightforward, they also could be grouped under systemic management plan to address certain typical situation. We present a drought management example from Spain, which is likely relevant both for Kherlen River basin and for Mongolia in general.

### **Lesson from Spain: An example of preparation measure – Drought Management Plans**

Drought Management Plans (DMPs) are useful and efficient tools to manage water resources under drought episodes. They describe appropriate measures to apply according to harmonized national drought indicators and prioritise uses to protect water ecosystems under water stress situations. DMPs aim to guarantee water availability required to sustain population life and health, to avoid or minimize negative drought effects on the ecological status of water bodies, especially on the ecological water flows, avoiding any permanent negative effects, and to minimize effects on public water supply and on economic activities, according to the prioritization of uses established by water policies and river basin management plans.

The Spanish legal framework specifically refers to drought in the planning process, and determines measures to address droughts for public administration and stakeholders. During unusual droughts, the Government may adopt exceptional measures, even if concessions (rights of water use under certain conditions) have been granted. Such measures may include the building of emergency infrastructures, as for instance drought wells.

The new legal framework deals with drought planning and management through modifications introduced in the Water Act. For instance, the Government may authorize the River Basin Authority to set up Water Interchange Centres (Water Banks) to enable user rights to be waived by voluntary agreement. The National Water Plan Act states that the Ministry of Environment must establish a global Hydrological Indicators System (HIS), and River Basin Authorities must prepare Drought Plans and submit them to respective River Basin Councils and Environment Ministry for approval.

The HIS was elaborated using different parameters (inflows, outflows and storage in reservoirs, flow river gauges, precipitation and piezometric levels) for each management system. In addition, a General Guidance Document was developed by the Ministry of Environment to facilitate the process of developing Drought Plans. According to such guidance, when preparing DMPs authorities should:

- Include indicators that will provide a quick drought status early enough to act according to the forecasts of the Plan;
- Provide information on the resources system and its vulnerability;
- Provide knowledge of the demand system and its vulnerability towards droughts, organized by priority degrees;
- Present structural and non-structural alternatives to reduce drought impacts;
- Measure the cost of implementing measures;
- Adapt the administrative structure for its follow-up and coordination among the different administrations involved;

- Discuss Plans, results and follow-ups with all interested parties, ensuring full public participation to avoid social conflicts. Basin Authorities have been able to elaborate plans according to their specificities, declare the drought status according to the HIS threshold, and initiate measures included in the Plan depending on the gravity of the phenomenon. The main mitigation measures included in the Plans can be grouped into different categories: structural measures (new pumping wells, new pipes, use of new desalination plants, etc.) and non-structural measures (water savings by applying restrictions to the users, increase in the use of groundwater, etc). The Directorate General for Water coordinated jointly with the River Basin Authorities (RBA) the elaboration and approval process of Drought Plans, after completing their Strategic Environmental Assessment processes. Based on the HIS thresholds, monthly maps of the drought situation in the different management units within each Spanish basin are being developed, and can also be found in the Ministry's web-site.

Source: Spanish Ministry of the Environment and Rural and Marine Affairs(2007), adopted from UNECE 2009

**Table 15 Evaluation of adaptation measures**

CRITERION	INDICATORS/SUB-CRITERIA	QUESTIONS TO BE ASKED
<b>Effectiveness of adaptation</b>	Adaptation function	Does the measure provide adaptation in terms of reducing impacts, reducing exposure, enhancing resilience or enhancing opportunities?
	Robustness to uncertainty	Is the measure effective under different climate scenarios and different socio-economic scenarios?
	Flexibility	Can adjustments be made later if conditions change again or if changes are different from those expected today?
<b>Side-effects</b>	No regret	Does the measure contribute to more sustainable water management and bring benefits in terms of also alleviating already existing problems?
	Win-win (or win-lose)	Does the measure entail side-benefits for other social, environmental or economic objectives? For example, does it <ul style="list-style-type: none"> <li>• Contribute to closing the gap between water availability and demand?</li> <li>• Affect the delivery of other water management objectives (e.g. river flow)?</li> <li>• Create synergies with mitigation (e.g. does it lead to decreased GHG emissions)?</li> </ul>
	Spill-over effects	Does the measure affect other sectors or agents in terms of their adaptive capacity? Does the measure cause or exacerbate other environmental pressures? Does the measure contribute to mitigation?
<b>Efficiency/costs and benefits</b>	Low-regret	Are the benefits the measure will bring high relative to the costs? (If possible, consider also distributional effects (e.g. balance between public and private costs), as well as non-market values and adverse impacts on other policy goals)
<b>Framework conditions for decision-making</b>	Equity and legitimacy	Who wins and who loses from adaptation? Who decides about adaptation? Are decision-making procedures accepted by those affected and do they involve stakeholders? Are there any distributional impacts of the climate change impacts or of the adaptation measures?
	Feasibility of implementation	What barriers are there to implementation? <ul style="list-style-type: none"> <li>• Technical</li> <li>• Social (number of stakeholders, diversity of values and interests, level of resistance)</li> <li>• Institutional (conflicts between regulations, degree of cooperation, necessary changes to current administrative arrangements)</li> </ul>
	Alternatives	Are there alternatives to the envisaged adaptation measure that would e.g. be less costly or would have fewer negative side-effects?
	Priority and urgency	How severe are the climate impacts the adaptation measure would address relative to other impacts expected in the area/river basin/country? When are the climate change impacts expected to occur? At what timescales does action need to be taken?

## River Basin Management Planning Participants

All affected parties should be consulted in decision-making on water management , including:

- Communities and other land and water users along the Kherlen river in Tuv, Sukhbaatar, Henti and Dornod provinces of Mongolia and in Right Barga Banner of Inner Mongolia, China;
- Mongolian-Chinese-Russian Dauria International Protected Area , that includes Dalai Lake National Nature Reserve administration;
- Ramsar Convention Secretariat overseeing wetlands of international importance;
- China authorities and agencies, including Water Resources Ministry, Ministry of Environment, Ministry of agriculture (manages fisheries) and Forest Service (manages wetlands).
- Conservation NGOs, institutions conducting ecological research, human rights groups and other relevant sources of expertise.

## Ecosystem-based adaptation

“Ecosystem-based adaptation is the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help *people* to adapt to the adverse effects of climate change.” This definition comes from the Convention on Biological Diversity’s Second Ad-hoc Technical Expert Group on Biodiversity and Climate Change. Ecosystems play an important role in climate adaptation. Forests, for instance, can retain water, thus slowing down run-off, and wetlands/floodplains have a buffering effect against floods and droughts. Healthy ecosystems can thus increase resilience. Conservation and restoration of ecosystems should therefore be an integral part of adaptation strategies.

Management, conservation and restoration of ecosystems, that is informed with climate variability and expected climate change, can maintain and restore ‘natural’ infrastructure such as wetlands and forests, whilst reducing biodiversity loss, and maintaining or enhancing ecosystem function. Furthermore, such approaches can improve the resilience of biodiversity and ecosystems to climate change so that they can continue to provide a full suite of ecosystem services. This is particularly important for sustaining natural resources on which vulnerable communities depend for their subsistence and livelihoods, and for providing alternative livelihoods in the face of climatic uncertainty. Such approaches should have a clear and robust monitoring system to track benefits to communities vulnerable to climate change. (GEF 2012).

The capacity to build an ecosystem’s resilience depends on the socio-cultural context (organization, governance, traditional knowledge, etc.) which nurtures the ecosystem. It depends also on the capacity to react, mobilize and adapt to the changes of the human groups who manage the ecosystem. A social-ecological system is vulnerable when it has lost its resilience, which means losing the capacity to respond and adapt. (Altiera2013).

According to DIPA Ecosystem-based adaptation elements of any River BMP in Dauria should include:

- long-term field-based and remote-sensing monitoring of wetlands in the transboundary basins of Dauria to study ecosystem response to climate fluctuation;
- new protected areas planning and region-wide spatial planning to secure refugia and corridors for species movements;
- prediction of possible adverse impacts of water infrastructure and adjustment of water infrastructure schemes ;
- development of allowable limits of anthropogenic impacts to improve environmental flow requirements in changing climate conditions;
- better planning of land-use and water consumption;



- development of other climate adaptation measures increasing resilience of traditional activities of local communities; (DIPA. "Impact of climate change on ecosystems of Daurian ecoregion and ecosystem-based adaptations to them" Programme 2011. quoted after (Kiriliuk O., editor, 2012))

### **Lesson from Dauria International Protected Area: An example of adaptation-oriented monitoring system**

Multi-year research conducted by DIPA staff resulted in accumulation of considerable body of knowledge on ecosystems and species of Dauria and spurred development of new comprehensive ecological monitoring system that is oriented towards integration of science and development of sound science-based policies in conservation and natural resource management.

Now all activities are integrated into one program of research and nature conservation called "**Impact of climate change on ecosystems of Daurian ecoregion and ecosystem-based adaptations to them**".

The key outputs of the Project are the policy-relevant knowledge on the natural dynamics of ecosystems which can be part of the basis of sustainable development of the region including sustaining globally valuable biodiversity in the face of climate change.

The key element of the Program is a system of long-term ground and remote-sensing monitoring of wetlands in the transboundary upper Amur-river basin. Main tasks of the monitoring system are:

- 1) to study the influence of climate variability on the upper Amur basin wetlands;
- 2) to develop a scientific basis for sustainable adaptation of national and international politics of nature resources management to climate change and biodiversity conservation
- 3) to use monitoring results to guide development of specific adaptation measures.

The monitoring network includes more than 200 plots at floodplains and at lake shores on the territory of about 200,000 sq.km. (most of them are designed for monitoring both vegetation and animal populations). This wide network allows the Project to get data on spatial and temporal dynamics of ecosystems.

Careful analyses of ecosystems and populations of rare species in relation to natural and anthropogenic factors enabled DIPA workers to propose a number of conservation measures. These included: (i) an interconnected multi-level regional network of protected areas; (ii) programs for conservation of critically threatened species, and (iii) integration of economic development planning with conservation planning to achieve sustainability. DIPA personnel played key role in establishment of several protected areas: the Valley of Gazelles National Wildlife Refuge, Aginskaya Steppe Regional Wildlife Refuge in Russia and Onon Balj National Park in Mongolia. Further work on development of ecological network requires establishment of new protected areas, improvements and adjustments in protection regime and management of existing protected areas and development of explicit transboundary forms of protected areas.

Development of nature reserve network should provide for migration and breeding of species in all phases of region-wide drought cycle and preserve key hydrological features and all important refugia (fragmentation avoidance, promoting connectivity, and protection of climate refuge with especially resistant habitats). Riverine wetland conservation is an essential component in any basin-wide adaptation Programme and should first of all focus on protecting natural refugia during most unfavorable climate conditions and sustaining environmental flows.

Network design also requires understanding interplay of permafrost, fire regime, drought cycles, agriculture, infrastructure development in changing landscapes, with special attention to forest-steppe transition zone and freshwater ecosystems. Specific suggestions for establishment of new protected areas, improvements and adjustments in protection regime and management of existing protected areas and development of certain transboundary protected areas were made by DIPA to relevant authorities. (see Figure 35)

Source: (Kiriliuk O., 2012)

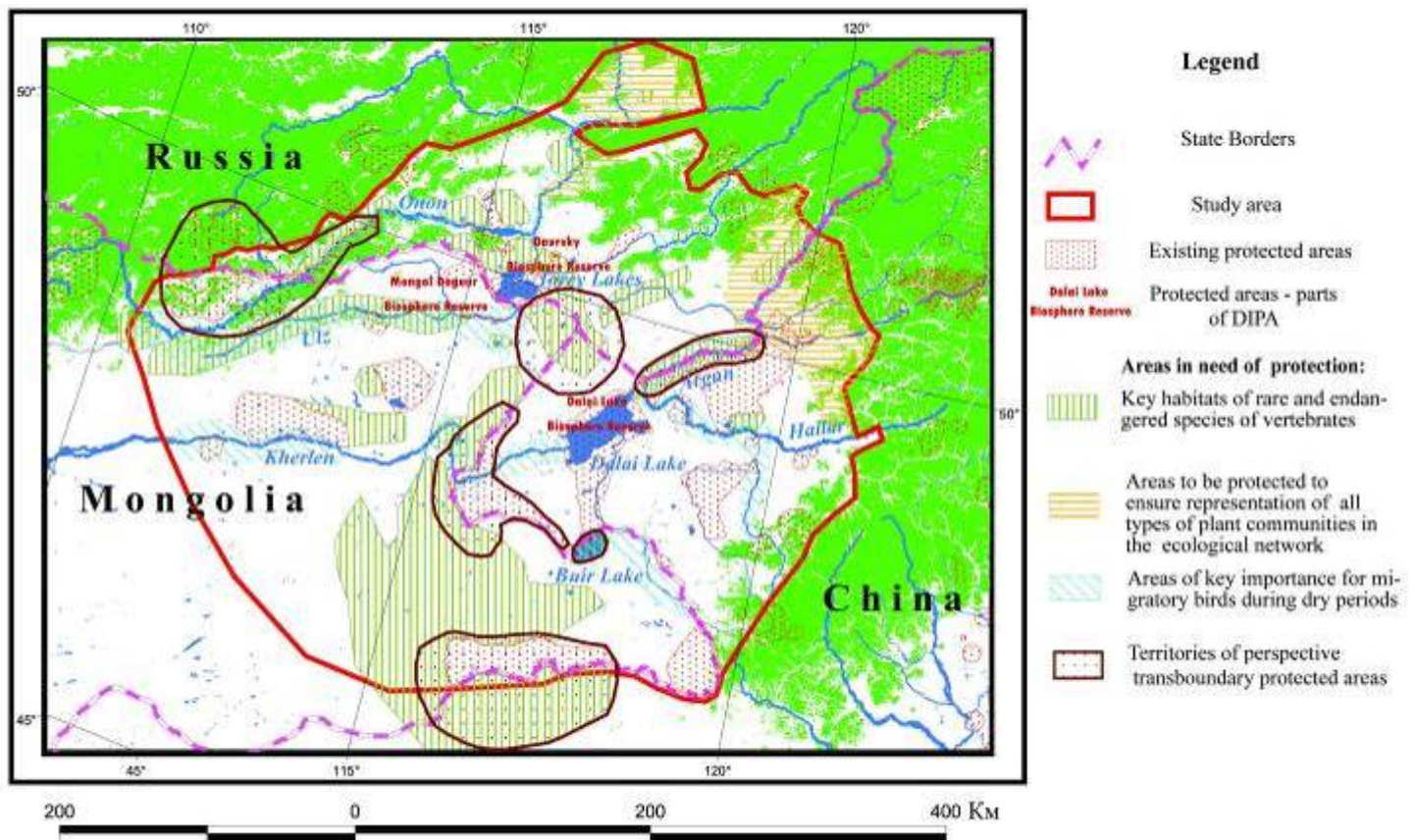


Figure 35.. Territories requiring establishment of protected areas in the Dauria Steppe Ecoregion (DIPA 2012)

Kherlen river floodplain is one of key ecosystems that provides resilience for any climate change scenario. However, since most of regional settlements are located along floodplain special efforts are needed to preserve it from overexploitation, especially overgrazing. It could be done by gazetting additional protected areas, which by now occupy less than 5% of 2900 sq.km. of this enormous wetland. Riverine wetland conservation is an essential component in any basin-wide adaptation Programme and should first of all focus on protecting natural refuges during most unfavorable climate conditions and sustaining environmental flows.

### Environmental flow norms - most necessary EBA measure in Dauria

Environmental flow: The water regime provided within a river, wetland or coastal zone to maintain ecosystems and their benefits where there are competing water uses and where flows are regulated (Dyson et al., 2008). Environmental flows describe the quantity, timing, and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems (Brisbane Declaration 2007). The goal of environmental flow management is to restore and maintain the socially-valued benefits of healthy, resilient freshwater ecosystems through participatory decision-making informed by sound science. Sound environmental flow management hedges against potentially serious and irreversible damage to freshwater ecosystems from climate change impacts by maintaining and enhancing ecosystem resiliency.

Environmental Flow norms should become key components of river basin management plan, ensuring that any human activity does not disrupt flow patterns sustaining river health. Environmental Flow norms should explicitly link hydrological characteristics and requirements of aquatic ecosystems, flora and fauna in all stages of climate cycle. Environmental limitations should be based on ecological requirements both of Kherlen river valley and Dalai Lake ecosystems. Similar norms safeguarding fragile Gobi ecosystems should be developed for various local aquifers there.

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Scientific research is being undertaken by DIPA on the environmental flow requirements for the transboundary Argun and Ulz rivers during different phases of the climate cycle. Considerations on selection of critical components and parameters of environmental flow in conjunction with water transfer proposals presented below.(see Table14. and Chapter 16)

**Table 16. Critical components and parameters of environmental flow (Kiriliuk et al 2011)**

	<b>Critical Components</b>	<b>Measurable parameters to be monitored</b>
I	<b>For Argun River:</b>	
1	Sustaining floodplain habitat for waterbirds and fish habitat , preserving meadow productivity	Timing of floods, flooding frequency, duration of rise and fall; Flooded area (wetted perimeter); Density and breeding success of indicator species of birds and fish; Area and productivity of meadows (ton/hectare) related to flooding frequency and magnitude.
2	Sustaining geomorphological processes	Reproduction of important stream habitats and meandering processes, braided channels. Frequency and magnitude of flow events necessary to reproduce habitat features Additional condition: limitations on length and location of embankments and other engineering structures
3	Biota survival in low flow periods and changing concentration of pollutants (minimal flow)	Timing, frequency and duration of low flow (and no-flow freezing) periods; Critical low-flow discharge ( still sufficient for survival of biota); Species composition, abundance and productivity of plankton and benthos, dynamics of fish populations, invasion of exotic species;
II	<b>For Dalai Lake:</b>	
1	Sustaining cyclical habitat dynamics	Fluctuation of water level (magnitude, timing, speed, frequency) Habitat succession and acreage and abundance of indicator species
2	Sustaining geochemical dynamics of lake ecosystem	Cyclical change in water chemistry (salinity, PH, etc) Succession and abundance in indicator species, absence of exotic species Additional condition: limitations on pollutant discharge through diversion canal

So far environmental flow regime of Kherlen river is managed by very general and insufficient guidance on water withdrawal limits. In 1999 Mongolian hydrologists suggested that water withdrawal should be limited by 6-12% of available flow volume in a given year ( Davaa et al 1999, See Chapter 13). This in a dry year with flow of 90% probability of occurrence (once n 10 years) means withdrawal from 15 to 24 million cubic meters per annum. The 2012 IWRM Study suggested that overall withdrawal in a year with average flow (P=50%)should not exceed 59,5 million cubic meters per annum, while in dry year (P=90%) it should not exceed 28,4 million cubic meters per annum, but no

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justification is available (quoted in WRG 2030, 2014). So as we see in last 15 years there was no significant advance in study of environmental flow requirements for Kherlen River, but it shows that current water use in the basin in Mongolia already approaches this limit in dry years (see Chapter 9).

We consider those figures for norms of withdrawal rather generous, not necessarily taking into consideration climate change impacts and ecosystem requirement for quantity and timing of flows, frequency of particular flow events. Studies in similar natural conditions in dry countries, such as Australia, have arrived to environmental flow norms in a similar range of 5-10% of a flow, but one cannot blindly extrapolate such figures to the other part of the world, without proper ecological study of relationship between flows and natural ecosystems and ecosystem services.

Lack of field observations is the greatest impediment to developing more robust environmental flow norms and this flaw could be overcome by developing combined remote-sensing and field-transect monitoring methods in transboundary wetlands. This will allow scientists to measure the effects of climate change and other impacts on water levels and ecosystem health, and will help improve water management for human use and economic development. Such research, when completed, may provide the technical foundation for harmonizing bilateral water management policies with Mongolia and China. Results could be used to promote the implementation of the existing Sino-Mongolian Transboundary Water Management Agreement and development of bilateral **Agreement on environmental flow norms for transboundary rivers of shared basins and provisions for sustaining natural dynamics of water allocation to wetlands.**(Kiriliuk et al 2011)

Poorly planned human activities initiated in anticipation of climate change (including some adaptation measures) may drastically hurt ecosystem much earlier and more severe than consequences of actual global climate change. Kherlen-Gobi long-distance water transmission project rightfully belongs to this category of human actions. It is quite clear

## Financial issues and examples of adaptation studies

As “natural infrastructures”, biodiversity and ecosystems have an important role to play in adaptation. Nevertheless, many ecosystems are endangered and at risk of losing this function. Mechanisms for valuation of ecosystem services can prevent further degradation and support restoration of ecosystems if they are included in cost-benefit analyses for adaptation measures. Various mechanisms, based on the “user pays” principle, can be deployed to finance biodiversity. Finance can be raised directly from certain uses of biodiversity, such as through the sustainable use or trade of biological resources, including goods such as the pharmaceutical, agricultural and industrial applications of biological resources. Finance can also be raised indirectly through services such as water provision, climatic regulation, water purification, tourism and scientific research. Such financing mechanisms operate at many levels, between and within countries, from and to governments, the private sector and local communities. Payment for ecosystem services (PES) is an innovative tool for rewarding ecosystem managers for their sustainable management practices, which increase ecosystem resilience and thereby contribute to climate change adaptation.

Finance can also be raised by making sure that charges are levied on economic activities which contribute to biodiversity degradation and loss, such as pollution taxes, land reclamation bonds and waste disposal charges according to the “polluter pays” principle. Governments can also explore conservation payments to encourage the conservation of habitat for endangered species. Special consideration should be given to areas with nature conservation status (e.g. Ramsar sites, Biosphere Reserves, World Heritage sites, Natura 2000 sites, Emerald sites, Important Bird Areas, etc., as well as national protected areas).(UNECE2009)

Governments should make full use of the multilateral funding mechanisms available to them to implement climate change adaptation. The main mechanisms for supporting adaptation are the GEF special funds for adaptation, the Adaptation Fund under the Kyoto Protocol, Official Development Assistance (ODA) and concessional lending.

One of examples of successfully secured funding from Adaptation Fund is the project "Ecosystem Based Adaptation Approach to Maintaining Water Security in Critical Water Catchments in Mongolia". The project focuses on Tes and

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Ulz basins. Unfortunately it fails to take into account transboundary nature of any of those basins. The Project's objective is to “maintain the water provisioning services supplied by mountain and steppe ecosystems by internalizing climate change risks within land and water resource management regimes.” This project applies the principles of Ecosystem-based Adaptation (EbA) to increase climate change resilience at a landscape level. EbA is broadly defined as “a range of local and landscape scale strategies for managing ecosystems to increase resilience and maintain essential ecosystem services and reduce the vulnerability of people, their livelihoods and nature in the face of climate change” (UNFCCC). Ecosystem based approach IWRM plan should be efficient to the local resident to adapt the climate change situation. Thus, the results of the research study on the river basin ecosystem services and values are the base of the planning. Project investments will alleviate vulnerabilities and dismantle identified barriers by implementing three interconnected components:

Component I: Integrated Strategies/Management Plans for target landscapes/river basins developed and under implementation.

Component II: Implementing landscape level adaptation techniques to maintain ecosystem integrity and water security under conditions of climate change.

Component III: Component III: Strengthening capacities/Institutions to support EbA strategies and integrated river basin management, their replication and mainstreaming in sector policies.

Rivers without Boundaries Coalition and Mongolia Critical water catchments EbA project reached an agreement that when the EbA project finalizes draft adaptation plans they will together invite DIPA staff to draft transboundary IWRM plan for Ulz River-Toreyskiye Lakes Basin.



Fieldwork in dry year on transboundary Barun Torey lake in Daursky Biosphere Reserve ( by V.Kiriliuk)

## 16 TRANSBOUNDARY RIVER ISSUES IN DAURIA.

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*Hailaer River-Dalai Lake Canal built in China to "confront climate change".*

### **COOPERATION THEORY**

Cooperation by riparian countries plays an essential role in the success of climate change impact assessment for transboundary river basins. In a transboundary situation, agreement should be reached on the models to be used and on a common scenario or set of scenarios on which the modelling should be based. This supports developing and streamlining a common understanding between riparian countries on the effects of climate change. This in turn will support the development of joint adaptation strategies for the benefit of all concerned parties. Transboundary cooperation has two main objectives. In the first place, it aims to prevent, control and reduce transboundary impacts when designing and implementing adaptation strategies and measures. In this way it ensures that unilateral measures do not have unintended effects in riparian countries, in particular that they do not increase their vulnerability. Beyond that, transboundary cooperation can help to enable more efficient and effective adaptation, since some measures that support adaptation in one country can be more effective if they are taken in another country. Transboundary cooperation on adaptation can widen the knowledge/information base, enlarge the set of available measures for prevention, preparedness and recovery and thereby help to find better and more cost-effective solutions. In addition, enlarging the area under planning enables measures to be located where they create the optimum effect. At the transboundary level, common objectives and goals should be defined and major planned measures discussed. Joint bodies are the natural forum for the process of developing and implementing adaptation strategies – from agreeing to

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their objectives to selecting, implementing and evaluating measures for the whole basin. However, the implementation of the measures agreed upon usually lies with the countries involved. In the transboundary context, riparian countries should focus on generating basin-wide benefits and on sharing those benefits in a manner that is agreed as equitable and reasonable. A focus on sharing the benefits derived from the use of water, rather than the allocation of water itself, provides far greater scope for identifying mutually beneficial cooperative actions. (UNECE 2009)

The Mongolia and China Government have signed Agreement of Transboundary Water in 1994. Within this Agreement regulates following Transboundary Waters of Kherlen, Khalkh, Bulgan rivers and Buir Lake. The Commission headed by Vice Minister of Ministry of Environment and Green Development of Mongolia and Vice Minister of Water Resources, China.

Key issue of Transboundary Water Cooperation with China are monitoring data exchange on transboundary rivers and the lake. The heads of Commission meet biannually in the Mongolia or China and discuss Transboundary Water Working Group reports for given year and resolve identified problems. \_ Transboundary Water Working Groups established by order of Minister of Environment and Green Development of Mongolia and Minister of Water Resources, China.

The working groups meets regularly once a year and exchange information about results of transboundary water activities of each side in the given year. The working groups consists of various water specialists from the government, scientific research Institutions and agency inspectors. (Tsend Badrakh 2011) Scope of Mongolian-Chinese cooperation in addition to water resources management includes aquatic biota and fisheries and the first joint fish survey of Buir lake identified two exotic species in 2013. This direction of joint studies is especially important for Buir Lake: while China possesses only 25% of lake shore the fisheries of the lake serve predominantly Chinese economy.

## WATER TRANSFER CASE-STUDY FROM THE ARGUN RIVER BASIN

Kherlen(Kelulun) and adjacent Khalkh (Halaha) River are two largest transboundary watercourses shared by Mongolia and China (*Figure 3*). They both belong to Argun (Erguna) transboundary river basin, where recently a serious transboundary water conflict emerged between Russia and China. Since it is very relevant to transboundary management of Kherlen River we will present it in detail (after Kiriliuk et al 2012).

While water use pattern in each of the 3 countries in Argun River basin is unsustainable and has its peculiarities, China has the key role in this basin due to greater population and economic activity. The water management component of the program "Revival of Old Industrial Bases in the Northeast China" in Inner Mongolia (2003-2030) contains detailed justification for the rapid water diversion and flow regulation in the Argun River basin (called Hailaer in the upper reaches), including construction of two large canals for water diversion and 5-10 reservoirs (Honghuaerji, Zhaluomude, Zhashuhe and others) (See #15, #12,#13 at Figure 40).. This will ensure water supply for growing cities (Hailaer, Yakeshi, Manzhouli), development of irrigated agriculture, building of thermal power plants that use local coal (Dayankuangqu deposit and 2 coal-fired power complexes in the valley of the Yimin River) and others. All water infrastructure projects are interrelated and implementation of one of them increases probability of implementation of other projects to deal with negative consequences. From 2003 to 2020 in four prefectures in the eastern Inner Mongolia a 10-fold increase in industrial water use was planned, mainly through the creation of coal energy complexes, as well as substantial growth of water consumption in agriculture and for the "environmental" purposes like tree planting in grasslands and converting lakes into reservoirs (arrangement of green spaces and "environmental transfer" into the Dalai Lake).

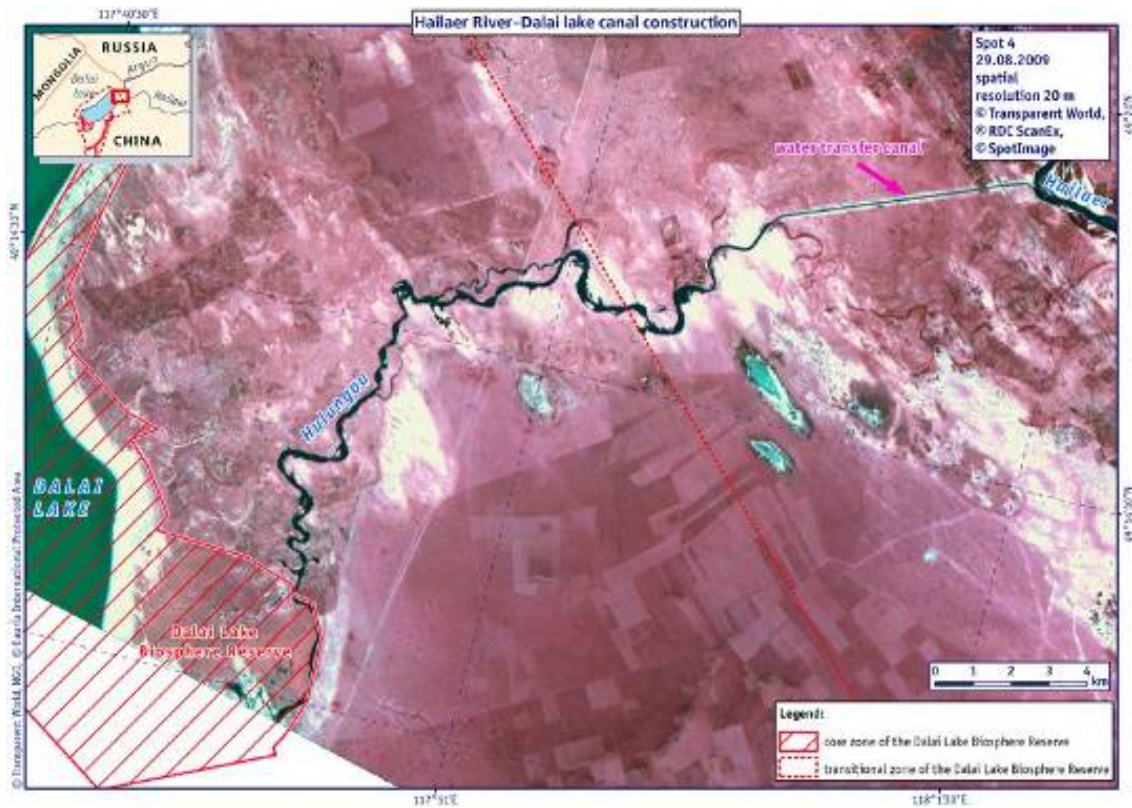


Figure 36. Water started flowing through Hailaer-Dalai Canal in August 2009. Image by "Transparent World"

Simultaneously China, anticipating further discrepancy between supply and demand, also develops programs for "water-conserving irrigation", air cooling systems and circulating water supply systems in industry, etc.

The planned increase in the annual average long-term water consumption only by the already built or approved for construction reservoirs in the Hailaer River basin would be up to 1-1,5 km<sup>3</sup>. In addition, the Hailaer-Dalai canal is designed to transfer more than 1 km<sup>3</sup> / year. In total this will make more than 60% of the average long-term run-off of the Hailaer -Argun River.

Hulun Buir Prefecture (Inner Mongolia, China) has completed construction of a canal to divert water from the Hailaer River (upper reaches of the Argun River) to Lake Dalai for "environmental purposes" (See #9 at Figure 40). The obvious purpose of the canal construction is to provide water for fish farming, tourist facilities, municipalities and mining industry. The stated purpose of its construction: "Safeguarding environmental health of Dalai Lake, saving it from drying".

Average annual flow of the Argun River in the place where the Argun-Hailaer River reaches the Russian-Chinese border is about 3.5 km<sup>3</sup> per year, and in dry period the river discharge hardly exceeds 1.5 km<sup>3</sup> per year. The projected average long-term water transfer was estimated at 1,05 km<sup>3</sup> without use of pumping and regulation by reservoirs upstream and should be proportional to flow volume in the river. If at a later stage the flow is regulated by water reservoirs and/ or installed pumping equipment, water allocation can be increased. At the length of 200-300 km downstream from the planned water intake, the Hailaer River is the only significant source of water for the Argun River.

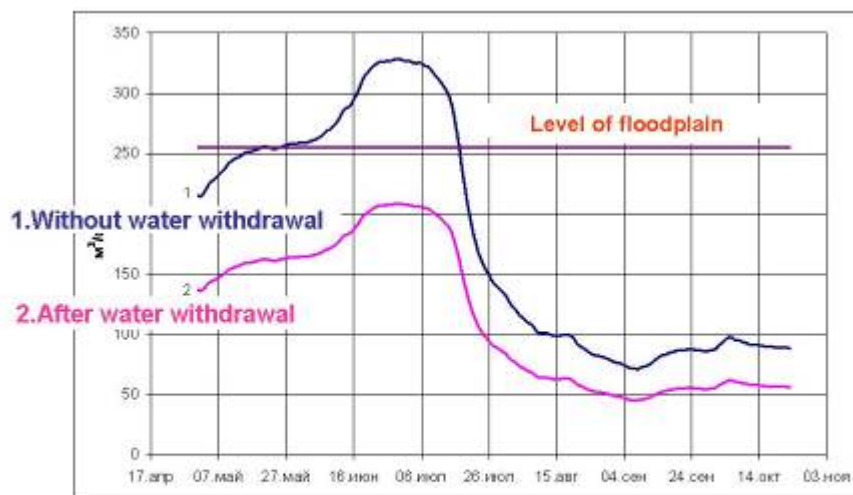
The water transfer project was suspended in summer 2007, after expression of concern from the Russian side at the official negotiations of the heads of two states. The matter was passed for discussion at the meetings of relevant water authorities, at which the Chinese Ministry of Water Resources expressed an unambiguous opinion that the canal construction is a purely internal matter of China, and it is not to be discussed at bilateral meeting.





**Water intake structure at Hailaer River. 2011**

At the same time in 2008 Chinese conservationists revealed a project of a pipeline to deliver water from Dalai Lake to large mining enterprise near border with Mongolia. The threat to Dalai Lake Ramsar site from mining was even mentioned in the Resolution X.13 of the COP10 of the Ramsar Convention in 2008. Construction of the canal diverting water from the Hailaer River should have been used as a new justification for the water allocation from Dalai Lake to many mines and factories around. Despite negotiations with Russia and concerns expressed by international organizations the Hailaer-Dalia canal was nevertheless built and started operating in August 2009. However the water pipeline to mines has never been built and new mine receive its water from alternative source -wastewater plant of Manzhouli city.



- 1. Water level dynamics in 2004 (P=50%) - 50 days of flooding**
- 2. Water level after withdrawal (P=50%) – no flooding**

Figure 37. Comparison of water levels in conditions of natural flow in 2004 (1) and such flow reduced by 1 cubic kilometer water withdrawal (2) in Argun River at Kuti village.

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The following consequences are possible as a result of water regime alterations in the transboundary part of the Argun River valley due to upstream reservoirs and canal:

1. Regulation of river flow disturb existing flood cycle, leading to drainage of wetlands;
2. River meandering will stop, natural braided channel will degrade, leading to degradation of wetland habitats structure;
3. Reduction of wetland areas along Argun-Erguna river threatens populations of migrating and nesting birds, including 19 globally threatened species listed in the International Red List;
4. Migration routes of certain animals will be disrupted in the entire area of Dauria steppes;
5. Flood control will disturb flooding and replenishment of soil with nutrients in floodplains, and thus will reduce the pastures and hayfields on which people's survival depends during droughts;
6. Aridization of climate in the Argun River valley will occur, which will worsen conditions for growing crops and cause desertification;
7. Concentrations of pollutants in the waters of the Argun River will increase; There will be worsened water supply conditions for Zabaikalsk settlement with the largest customs checkpoint, Priargunsky mining chemical factory, settlements along the river, etc.;
8. The deteriorating conditions will eventually force inhabitants of the settlements located in the border areas of China and Russia to move to other places.

Possible consequences of the water transfer for Dalai Lake in China may also be negative:

1. Increase of the inflow from the Hailaer-Argun River will lead to concentration of pollution in the lake, posing a threat to public health, fisheries and tourism;
2. Disturbance of the natural cycle of water level fluctuation will affect diversity and productivity of the lake that has been converted into human-made reservoir.

These negative consequences may take effect in the course of next 2 cycles in Dauria climate fluctuation (25-70 years), and in-depth study is needed to plan how to minimize damage resulting from this canal and new planned water infrastructure in Argun River basin.

Russia-China Agreement on Use and Protection of Transboundary Waters, which lacks clear mutual obligations and their implementation so far has not led to appropriate integration of water management across the borders. But it allows mutual inspections to water infrastructure in riparian country. In 2011 the Chinese side invited delegation of Russian officials to visit the canal and start discussion on consequence of its functioning. Chinese side expressed willingness to develop "environmental norms" for water intake into the canal, so that it does not significantly disrupt flow pattern in Argun River. For example a sound proposal was presented to allow the first and the last flood of the year to pass unimpeded downstream to Argun\Erguna river, while the Hailaer-Dalai canal gates would be closed. Since mutual inspections are largely fact-finding missions and are not followed by rigorous mutual control, there is no mechanism to ensure that such arrangement is implemented.

Although there is no systemic monitoring of canal construction consequences, but DIPA monitoring of wetland ecosystems has shown that it delayed and decreased flooding in 2010-2012. However in 2013 the whole Amur River basin experienced largest flood in a century and the floodplain of Argun river was fully inundated. This shows that, since Hailaer river has no reservoirs to redistribute the timing of flow, the floodplain ecosystems downstream from the canal get sufficient water in large flooding events (Figure 38)



Figure 38. Flood in August-September 2013 has prevailed over any water infrastructure impacts.

In 2011 the Chinese engineers confessed that water transfer into Dalai Lake has not resulted yet in substantial increase of water level, but they assumed that additional water helped to arrest increase in salinity at 1.6grams/l and by that saved local fish resources from natural decline. As available satellite data shows that from August 2009 to August 2013 lake area increased only by 50 sq.km (from 1774 to 1824 sq.km), while as 2013 flood started it increased by 300 sq.km and reached 2100 sq.km ( 230 sq.km short of its historic maximum of 2330 sq.km.). So, the largest flood temporarily soothed concerns that Chinese government has had regarding the other source of water for Dalai Lake - transboundary Khalkh river.

#### **KHERLEN VS KHALKH -NEW THREATS TO NATURE**

Khalkh river river's source is in the Da Xing' an mountains of Inner Mongolia, China. Lower river reaches mark boundary between Mongolia and China. By the mouth the river splits into two distributaries. The left one (Khalkh River proper) feeds the Buir Lake in Mongolia and next via this continues as Orshun Gol in Chinese territory. The right one **Shariljiin Gol** (Mongolian: *Шарилжийн гол*) runs directly into the Orshun Gol and mark China-Mongolia border (See Figure 39).

Khalkh has annual average flow of 1 cubic kilometer which makes it most important water source for two large lakes of Dauria- Buir and Dalai. As it forks the flow in Khalkh River emptying into lake Buir is greater than flow in Shariljiin Gol due to a sandbar existing in transboundary stretch. In dry years such as 2006-2010 flow in Shariljiin Gol ceased completely, while flow from Buir Lake into Orshun River also decreased dramatically, because of low level in the Lake. At bi-lateral water-management meetings China side insisted that Shariljiin Gol should be dredged to allow unimpeded flow of water disregarding the Buir Lake level. Some Chinese engineers blame their own predecessors who build a dyke on Khalkh River in the 1970s that allegedly provoked formation of a clogging sand-bar. However Mongolia side always have referred to "Nature's own way" and does not allow intervening into natural river geomorphology processes. History of other forking waterways such as Hailaer-Argun show that in recent past such distribution systems ceased to exist due to sand erosion and other geomorphological process. So if the Nature follows its own way Shariljiin Gol may cease to function in close future. (see #10 at fig.38 and Figure 40)



Figure 39. Khalkh River mouth and Orshun River origin from Buir lake. Google Maps..

There is another important plan threatening Khalkh River. Many years ago China began studies on diversion of 0.1 km of Khalkh river flow into to Xilingol Coalfields of Inner Mongolia (#11 on Figure 40). Songliaowei Basin Commission and China Water Ministry are normally against industrial use of such rivers - they argue that scarce water is for people not for industry. Hulunbuir prefecture also voiced its concerns and firmly stands against this project. Nevertheless feasibility studies are still underway, despite obvious difficulties of transporting water across mountains, because Inner Mongolia Autonomous Region fully supports such water transfer, that may help to develop their richest coal basin. Other alternative they explore is pumping brackish sea water from Bohai Sea. This situation in many respects reminds arguments around Kherlen-Gobi Water Transfer Project.

However there is an important potential link between Shariljiin Gol dredging and withdrawal of water from Khalkh river upstream. If Khalkh-Xilingol water withdrawal project is implemented now and causes greater water deficit, then remaining Khalkh waters will end up in Buir lake, while Shariljiin Gol and Orshun River will stay dry. If Shariljiin Gol is dredged beforehand, then Khalkh waters would likely still reach Dalai Lake via Orshun River, even if water transfer to coal-mining region is implemented. In such scenario Buir lake is at loss and its level will be dropping to unknown point.

Kherlen-Gobi water transfer has been discussed by China-Mongolia Water Commission many times and special joint field surveys were conducted along Kherlen river. China side always expressed firm belief that the Kherlen River and Dalai Lake would be seriously impacted by planned water transfer to Gobi in Mongolia. Songliaowei Basin Commission who participated in Working Group from China side also always stressed that building a reservoir on Kherlen River is the worst water supply option. such water supply method is no longer used in arid areas of China where evaporation is

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1000mm and more. Worst consequences of such scheme are expected both from reduced floods and reduced water flow during dry phase of climate cycle. Finally in 2013 China side was assured by Mongolia counterparts that Kherlen-Gobi project was shelved. (Songliaowei Basin Commission Engineers, pers. communication).

Now as Kherlen-Gobi Project has been again revived by Mongolian Government, there is a potential for a nightmare scenario of an agreement between China and Mongolia, who both are weary of transboundary water argument, and may simply sacrifice any environmental considerations for the sake of reaching political agreement. In this worst possible scenario China agrees that Mongolia diverts waters of Kherlen river to Gobi, while Mongolia allows dredging of Shariljiin Gol and does not object to Khalkh River transfer to Xilingol coalfields. Under such scenario Kherlen river and Buir Lake Ramsar wetland would likely suffer most negative impacts, closely followed by impacts on Dalai Lake Ramsar wetland and Khalkh River. Hopefully both countries have sufficient environmental safeguards to prevent such agreement from happening.

### **International cooperation on water and climate in Dauria.**

Uncoordinated water resource development aimed to secure water on the individual national territories would have devastating effects on the transboundary wetlands. While conflict is possible, the countries have different comparative advantages and have a lot of reasons to share experience and resources. There are hopeful developments in each country: China has strong National Wetlands Protection Policy and Action Plan that prescribes water allocation to important wetlands (2003). Russia adopted new Water Code prescribing development of “Standards of acceptable impact” (SAI) for environmental flows, as well as chemical, thermal, radioactive and microbial pollution (2007). Mongolia adopted a new law “Law on prohibiting mineral extraction in forest areas, river headwaters and water protection zones”(2009).

UNECE Guidance on Water and Adaptation to Climate Change provides countries with a good common adaptation framework and is supplemented with wider tool kit **developed under the Convention on the Protection and Use of Transboundary Watercourses and International Lakes**. From other multilateral conventions the Ramsar Convention is one of the most relevant policy tools in the Dauria transboundary basins where 5 wetlands located in Dauria Steppe are already listed under convention. The Ramsar Convention Regional Initiative approach provides a suitable framework for multilateral cooperation on transboundary water management and transboundary environmental flows for wetland conservation, but the three countries are slow to realize it.

One of the most needed international tools is the Agreement on environmental flow norms for transboundary rivers of Dauria river basins (Argun-Erguna, Kherlen-Kelulun, Ulz, Onon, Khalkh -Halaha, etc) and provisions for sustaining natural dynamics when planning water allocation to wetlands. Given interdependence of Mongolian and Chinese economies in the region it is worthwhile to develop cooperation on drought issues for:

- Fostering water efficient technologies and practices;
- Strengthening of a sustainable groundwater management strategy
- Evaluation of alternative strategic water resources (surface and groundwater)
- Assessment of alternative technological solutions (e.g. Desalinization; reuse of wastewater)
- Promoting indigenous practices for sustainable water use
- Development of a drought management plan

It is necessary to initiate the establishment of a Chinese -Mongolian intergovernmental commission on economic and ecological adaptation of nature resource management policies to climate change with the aim to ensure favorable

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environmental and political situation. The Commission is needed primarily for the development and implementation of water management regimes, mutual endorsement of economic projects that might have a significant impact on transboundary ecosystems, as well as for the joint application of best technologies and management practices.



*A bridge across a river in Dauria, Tsagan -Ovoo,2013*

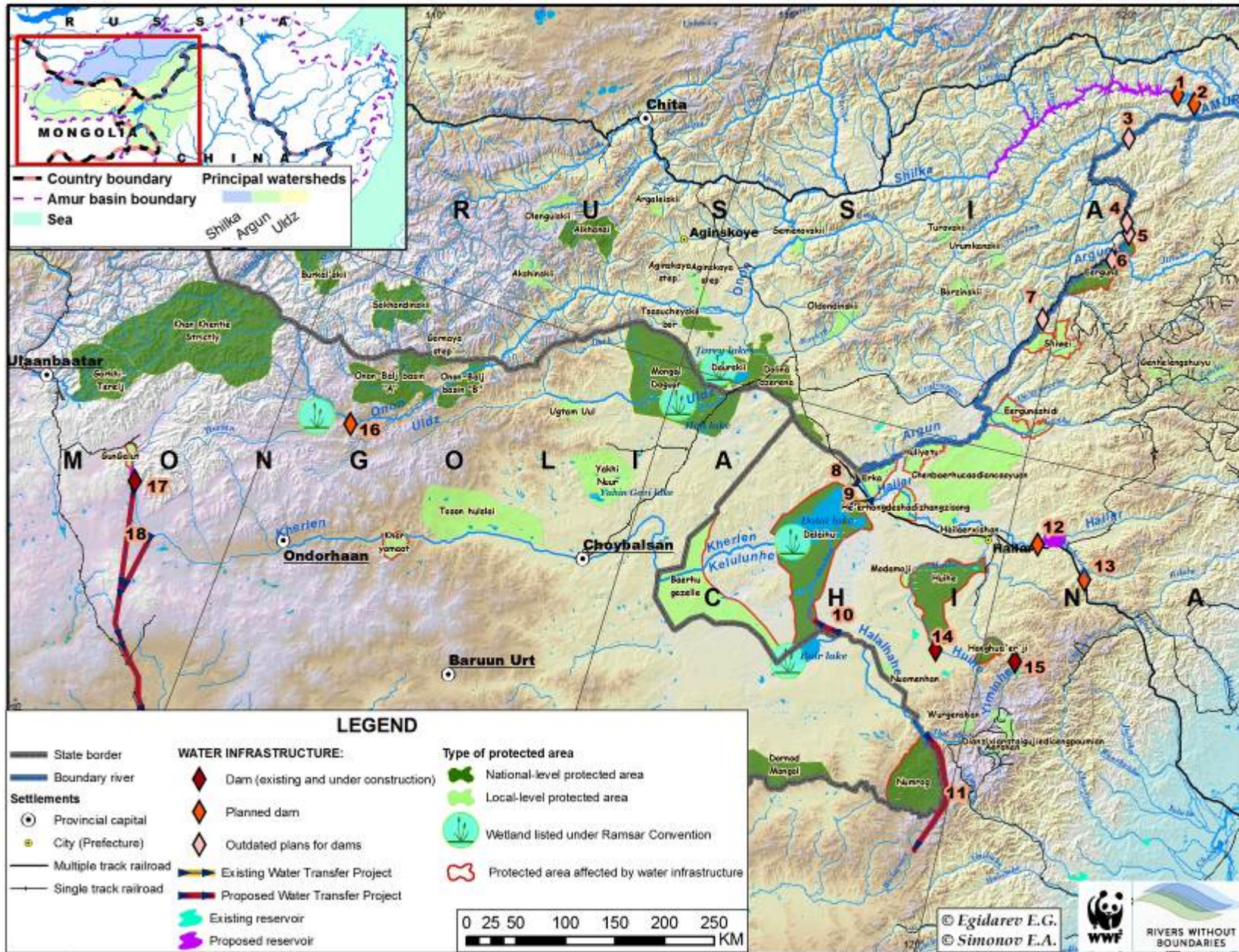


Figure 40. Existing and proposed water infrastructure in eastern Dauria. (Source: Kiriliuk et al. 2012)

**Table 17. Existing and planned water infrastructure in headwaters of Amur River in Dauria. (source: Kiriliuk et al. 2012)**

# on map	Name and Location	Reservoir volume in km <sup>3</sup>	Water Diverted Annually, in km <sup>3</sup>	Purpose	Notes
	<b>RUSSIA</b>				
	2009 withdrawal from the Argun River		0,009	Industry, agriculture, municipal supply	
1,2	Transsibirskaya Hydro on Shilka river	15	no	Hydropower, navigation,	Proposed by EN+ Yangtze Power in 2011
3-7	Hydropower cascade on Argun River	4 -20	no	Hydropower,	Proposed in Sino-Russian Amur and Argun Water Management Scheme in 1994.
	<b>CHINA</b>				
8	Xinkaihe Channel	no	No data	Water transfer from Dalai lake to Argun River	Built in 1960, fell in disrepair, active dredging from 2014 on
9	Hailaer-Dalai Canal	Dalai Lake serves as reservoir	1.05	Water supply to Manzhouli, Dalai Lake replenishment, irrigation	Built and functioning since 2009
10	Dredging of Shariljiin Gol from Halaha River to Orshun River that cuts off Buir Lake	unknown		“restoration of Dalai Lake and Orshun River”	Suggested in 2010-14 at Sino Mongolian negotiations
11	Water diversion facility to Xilingol mining operation, Khalhingol (Halaha) River		>0.1	Thermal electric power plant and water supply to industrial facilities	In 2010 –EIA held, not implemented yet
12	Zhaluomude Water Management System, Hailaer River	0.7	up to 0.5	Flood control, hydroelectric power, water supply, irrigation.	Project approved and financed by the Ministry of Water Management



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13	Zhashuhe -Yakeshi City Hydropower Plant,	0.1	0.05?	Hydroelectric power, irrigation	Project approved by the Ministry of Water Management, tender held in 2011
14	Huihe Reservoirs, Huihe River	0.1 and 0.2	0.1-0.2	Irrigation	Completed by 2006.
15	Honghuaerji Water Management System, Yimin River	0.3	0.2	Water supply, Huaneng Corporation thermal power plant, flood control, irrigation, etc.	Completed by 2010
	10 small reservoirs in Yakeshi area		>0.05	Multipurpose	In planning
	Daqiao and other reservoirs		>0.4	Water supply, irrigation	Project mentioned in long-term infrastructure plans
	<b>MONGOLIA</b>				
	Water withdrawal from Dauria Rivers		0.028	Industry, agriculture, municipal supply	data unreliable
16	Hydropower on Onon River	No data		Hydropower,	Listed in National "Water" Programme (2010)
17	Togos Owoo Reservoir for Kherlen-Gobi Water Transfer Project	0.6	up to 0,06	Supply to thermal power plant, coal washing, industry, irrigation, municipal	Feasibility Study by "Prestige Group" in 2010-2012
18	Kherlen -Toono Reservoir for Kherlen-Gobi Water Transfer Project	1,3	up to 0,12	Supply Sainshand Industrial complex and mining enterprises	Feasibility Study by "Monhydroconstruction" in 2013-14

## 17 CONCLUSION.

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Kherlen River unites Mongolia and China and empties into Dalai Lake -Wetland of international importance. This great river with tiny flow volume is of extreme importance for biodiversity and socio-economic stability of Dauria Steppe. We hope, this report is a timely warning for basin water management plans still being drafted for Kherlen River basin. Although plans are drafted for deep technological transformation of the whole Kherlen river system, there is enough time to consider more sustainable development options, more in line with anticipated climate change scenarios.

The Kherlen-Gobi Water-transfer schemes that have been promoted for years are associated with high risk of environmental disaster and international conflict, because:

- Already announced water consumption plans practically equal to the total available water resources (annual average flow of Kherlen River).
- Cyclical change in flow volume typical for Kherlen River makes such water consumption completely unrealistic during dry phases of climate cycle.
- Planned demand exceeds environmental withdrawal norms suggested by Mongolian scientists by 1200%-2500%. It is completely impossible to sustain environmental health of river valley and satisfy this demand.
- Half of consumption comes from economic activities planned within the Kherlen basin and 50% consists of long-distance water transfer and associated water losses from reservoir surface. It seems necessary to **cancel plans for Kherlen Gobi water transfer** and then proceed with optimization of development plans within the basin.
- Downstream reaches of the river in China and Dalai Lake Ramsar Wetland are severely threatened by planned development beyond possibility of repair by any imaginable mitigation measures. Even minimal consumption estimates result in water inflow into Dalai Lake being reduced by 60%-75%, which likely may lead to disappearance of that Ramsar Wetland.

Basin-wide Cumulative impact assessment (CIA) of all planned water supply projects and impacts from natural changes in Kherlen River basin should be carried out before any decision is made on specific large water engineering projects. Otherwise decision on Sainshand water supply (or other major supply project) may detrimentally affect development prospects for population of the whole Kherlen River basin. Worst from the range of possible climate change scenarios should be incorporated in the assessment. Assessment of cumulative impacts of all water infrastructure should incorporate provision for environmental flows in Kherlen River-Dalai Lake ecosystem as related to flow of water, sediments and nutrients.

Environmental Flow norms should become key components of river basin management plan, ensuring that any human activity does not disrupt flow patterns sustaining river health. Environmental Flow norms should explicitly link hydrological characteristics and requirements of aquatic ecosystems, flora and fauna in all stages of climate cycle. Environmental limitations should be based on ecological requirements both of Kherlen river valley and Dalai Lake ecosystems. Similar norms safeguarding fragile Gobi ecosystems should be developed for various local aquifers.

Strategic environmental assessment of the Kherlen Gobi Project and all associated development plans should be conducted to arrive at better roadmap for development options available in Kherlen River Basin and adjacent Gobi areas. Strategic environmental assessment should create framework for evaluating possible development scenarios in water sector against wide array of interrelated costs, benefits and limitations in economic, environmental, social and political spheres. Analysis of wide array of available alternatives lies at the heart of strategic assessment. The following directions for exploration of alternatives are already obvious:

- E. Thorough assessment of Gobi groundwater and setting environmental limits to its use.**
- F. Limiting development in Gobi, moving industries to water-abundant regions**
- G. Developing appropriate measures for managing water supply in fluctuating climate.**
- H. Preparing basin-wide climate adaptation plan**

After the results of strategic environmental assessment and cumulative impact assessment are incorporated into Kherlen River Basin Management Plan, there is a possibility to conduct environmental impact assessments for particular water-supply schemes.

All affected parties should be consulted in decision-making on water management, including:

Communities and other land and water users along the Kherlen river in Tuv, Sukhbaatar, Henti and Dornod provinces of Mongolia and in Right Barga Banner of Inner Mongolia, China;

Mongolian-Chinese-Russian Dauria International Protected Area, that includes Dalaihu National Nature Reserve;

Ramsar Convention Secretariat overseeing wetlands of international importance;

China authorities and agencies, including Water Resources Ministry, Ministry of Environment, Ministry of agriculture (manages fisheries) and Forest Service (manages wetlands).

Conservation NGOs, institutions conducting ecological research, human rights groups and other relevant sources of expertise.

Kherlen is the most important river of Daurian steppe with many local, national and global values. Water management planning should proceed without haste in transparent and participatory manner, keeping in mind strategic objectives of sustainable development and preservation of resilient and rich natural environment. We hope that our report will contribute to sound river basin management planning.



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Argun river near Genhe river mouth. (by Simonov)

## APPENDIX 1. IMPACTS CHECKLIST

RwB analysis based on available insufficient data cannot substitute for environmental impact assessment, which has not been done for Kherleen-Gobi water supply project, although this Scheme was drafted 6-10 times by different entities. Tables below relate generic environmental and social impacts to specific situation of for Kherleen-Gobi water supply project.

**Table 1 –Likelihood of generic negative environmental impacts in different parts of (Kherlen-Gobi) water supply project**

Environmental Impact type	I. Likelihood it results from use of aquifers in Gobi	II. Likelihood it results from alluvial water withdrawal and transmission	III. Likelihood it results from large dam with reservoir
<b>Disruption of free movement of aquatic animals</b>	None	Low: excessive withdrawal may contribute to temporary drying of the river in driest years in low flow months	High – blocks migration of fish and other organisms. Fish passages built to overcome this problem are usually fully ineffective on dams higher than 10 meters. As a result some species go locally extinct above or below the dam and some in the whole basin for they no longer can reach breeding areas upstream.
<b>Disruption of flow of nutrients and sediments</b>	None	Low or none	High– blocks or decreases movement of sediments and nutrients downstream. By slowing flows, dams allow silt to collect on river bottoms and bury fish spawning habitat. Silt trapped above dams, accumulates heavy metals and other pollutants. The river bed rises as the silt keeps building-up, increasing the vulnerability to riverside communities.
<b>Change of Natural Water Temperatures and ice regime</b>	Low – may add to it through change in flow volume in natural springs	Low – may add to it through change in flow volume	Medium to High - By slowing water flow, most dams increase water temperatures. Other bigger dams may decrease temperatures by releasing cooled water from the reservoir bottom. Fish and other species are sensitive to these temperatures irregularities, which often destroy native population. Cold water also disrupts riverside recreational activities in summer.
<b>Reduction in Flow Volume up to complete drying of a river</b>	Medium –High – some aquifers have low recharge rate and their levels drop. Some of them are	Medium –High may cause change in flow volume proportional to water diversion	Medium to High – in warmer and windier places huge amount of water evaporates from reservoir surface and less water flows downstream. Water is also lost to seepage in areas surrounding reservoir. Hydropower dams often completely stop river flow in off-peak

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		connected to groundwater and surface water and cause their levels to drop as well		hours.
	<b>Degradation and Reduction in riverine/riparian /floodplain habitat diversity, especially because of elimination of floods.</b>	None	Medium – massive water withdrawal may lead to decrease of high flows	High – Large Reservoir reduces flood pulse: floodplains do not get water and silt, backwater pools and oxbows are not cleaned by floods, braided channels simplify.  Floodplain ecosystem is degraded and no longer maintains diversity of most productive habitats.
	<b>Alter Timing of Flows</b>	None	None	By withholding and then releasing water to generate power or store water for transmission reservoir can destroy natural seasonal flow variations that trigger natural growth and reproduction cycles in many species.
	<b>Creating artificial waterbody with unnatural ecology</b>	None	None	High – reservoir with artificially fluctuating level is highly unnatural ecosystem unsuitable to most native river species.
	<b>Spread of invasive exotic species</b>	None	Low- possibility that new species will be transported by water transmission	High. With change in water regime and habitat structure dam operation facilitates introduction of exotic species.
	<b>Decrease Oxygen Levels in Reservoir Waters, build up of pollution and metrification</b>	None	None to Medium. Sometimes water withdrawal can significantly decrease dilution of pollution in downstream sections of the river	Medium-High. Warm stagnant reservoirs are contaminated by high levels bacteria and algae, while organic matter decomposes at reservoir bottom and release pollutants. Reservoirs often reduce water quality and can emit highly potent greenhouse gases like methane. Heavy metals accumulate on reservoir bottoms with sediments.
	<b>Decrease in native fish populations basin-wide</b>	None	Low	High. Most of Kherlen river system is frozen to bottom in winter and too warm in hot summers. Fish has to migrate from lower basin where it winters to spawning sites upstream. Dam built in between will abruptly decrease fish survival (at least in 800 kilometer stretch downstream of the dam).
	<b>Increase in Predator Risk and change of fish</b>	None	Low – lowering water levels may facilitate predation of some aquatic species	Medium to high – reservoir creation often results in build up of predator populations like pike, but then they eat up all prey and have a sharp decline. In reservoirs riverine fish communities (e.g. salmonids)



	<b>communities</b>			are replaced by lake fish (loach, carp).
	<b>Loss of terrestrial ecosystems</b>	Low to medium. If poorly designed plant communities of large areas may be affected by lowering water table	Low- small area of water intake and pipeline construction is affected	High – Reservoir floods meadows, forests and other habitats displacing many native species
	<b>Massive erosion and landslides</b>	None	None	Medium to High. Erosion happens due to water fluctuation in reservoir and lack of sediments and artificial flushes downstream from the dam . Around Three Gorges Reservoir giant landslides necessitated forced relocation of additional 500 000 people.  Erosion often activates downstream from the dam since water lacks sediment load.
	<b>Climate change</b>	Low-Medium - If poorly designed large areas may be affected by lowering water tables	Low-Medium. Iridizations of river valley may happen downstream from the point of withdrawal.	Low- High. Local climate changes around reservoir, but most change occurs immediately downstream with added humidity and fogs in winter due to unfrozen stretch of moving water below dam.
	<b>Increase in earthquakes</b>	No(?)	No	Medium-High. Large dams are known to increase magnitude and frequency of earthquakes, especially when reservoirs are filling or emptying relatively fast.
	<b>Dam\machinery kills aquatic life</b>	None	None	Dam water release structures kill fish and smaller organisms due to water pressure and direct cutting by turbine blades.
	<b>Faulty Design consequences and risk of breach or failure</b>	Low	Low	Medium-High. Dams often fail to release water at rates prescribed by agreed regulations, thus causing sudden flooding or drying of river valley. Many dams have collapsed, some causing huge human and material losses due to action of giant wave released downstream. In 2007 Zeiskaya Hydro in Russia could not hold the flood and washed away part of Ovsyanka village downstream.
	<b>Increasing disease - Health risks</b>	Low, may theoretically cause deterioration of sanitary conditions through reducing water available to local rural people.	Low, may theoretically cause deterioration of sanitary conditions through reducing water available to local rural people.	Medium. In warmer climates shallow reservoirs are best breeding habitat for vectors of various diseases like mosquitoes contributing to outbreaks of malaria, schistosomiasis etc. In colder climates some dams create damp unhealthy environment, especially harming in winter when people breath in ice particles formed due to unfreezing river surface.
	<b>Salinization and degradation of soil resources</b>	Medium	None	High. This will likely happen along reservoir margins as well as in desiccated floodplains downstream. some experts say it will only intensify already active

				salinization.
	<b>Limiting movements of wildlife, people and cattle</b>	Low-Medium	Medium	Medium-High. Reservoir will obstruct old river-crossings for 30-50 kilometers of its length. Ice cover downstream from the dam will be likely replaced by open water for some 10-several hundred kilometers downstream ( likely 10-30 km in case of Kherlen River)

**Table 2–Likelihood of generic Socio-economic and political impacts in different parts of (Kherlen-Gobi) water supply project**

	<b>Socio-economic problems</b>	<b>Likelihood it results from use of aquifers in Gobi</b>	<b>Likelihood it results from alluvial water withdrawal and transmission</b>	<b>Likelihood it results from large dam with reservoir</b>
	<b>Cost</b>	Low-Medium	Medium-High	High. In case of Kherlen dam option would add from 200 to 400 million USD to other costs of water supply project.
	<b>Low quality of supplied water</b>	High. Some deep aquifers in Gobi have very mineralized water containing toxic substances.	Low-such water from floodplain is cleaner than water directly take from the same river, because it is filtered.	Medium. Surface water is normally less clean than subsurface water.
	<b>Price of maintenance and decommissioning</b>	Low	Low.	High. When dam is no longer needed there is high cost of removing it and rehabilitating areas previously covered by reservoir water and often toxic sediments.
	<b>Loss of community control over water--transfer of control from local level to central government or corporate control</b>	Low-Medium	Low-Medium	High. Dam makes all residents of river valley downstream to depend on mercy of the reservoir operator who manages water releases.
	<b>Redistribution of wealth</b>	High	Moderate	High. The purpose of the dam is to take water enjoyed by all population and make it serve specific economic enterprises. Large dams do it at a scale much larger than other water

				infrastructure.
	<b>Displacement of local residents</b>	Low-Medium	None to medium. Hundreds of people could be affected by 500-10 km. pipeline route, but most of them not resettled.	High. Anyone who lives in place of created reservoir and subsurface inundation zone around it would be displaced and needs resettlement
	<b>Loss of livelihood (pastures, fisheries, etc.)</b>	Low-Medium	Moderate- may affect downstream communities, especially in dry years	High. Anyone who lives in place of created reservoir and subsurface inundation zone around it can no longer use these areas. In addition fish stocks are often decreased basin-wide and floodplain pastures desiccated for several hundred kilometers downstream. It is quite often that local fishermen relying on seacoast or lake where dammed river emptied lose rich fisheries or other source of livelihoods.
	<b>Influx of newcomers ( e.g. construction workers).</b>	Low	Low	High – construction requires many workers normally brought from different region or other country, which may cause competition and conflicts with local population
	<b>Corruption and ineffective spending of public money</b>	Medium	Medium-high	High. This is actually the dam is so much preferred option for officials and engineering firms – much larger portion of benefits go into their pockets and much more questionable expenditures are made. Large complex projects are very difficult to control, in contrast to building a well.
	<b>Increasing debt burden</b>	Medium	Medium	High. To build dams governments take loans and often cannot pay them back.
	<b>Increasing cost during construction</b>	Low	Low	High. Recent <b>study from Oxford University</b> shows that on average the cost of large dam construction worldwide has been twice larger than written into initially approved projects and construction lasted 2-3 times longer than planned. This is

				more than overspending and delays in case of lighter water infrastructure and roads.
	<b>Risk of stranded assets</b>	Low	Moderate-High -	Moderate-High. Likelihood that water supply system is no longer needed is high and for energy supply it is even higher. Harkhorin irrigation and hydropower system is a classic example: hydropower plan has been shut down and irrigation complex uses 10-15% of the originally irrigated area in Orkhon River Valley.
	<b>Potential for transboundary conflict and difficult negotiations</b>	None	Low-Medium. Customary international law envisions that each riparian country is entitled to part of transboundary water resource as long as it does not substantially harm the neighbor.	Medium-High. Dam has so many more consequences for downstream country than just a water withdrawal, that it is likely to create much greater controversy with neighbor country.
	<b>Threat to fulfilling obligations under conventions</b>	Low	Medium	High.  Both on Selenga and Kherlen there are areas subject to protection under international conventions. Harming ecological integrity of such areas normally goes against country's obligation under those conventions.



Herder's holiday at Moergol wetland. ( by Simonov)