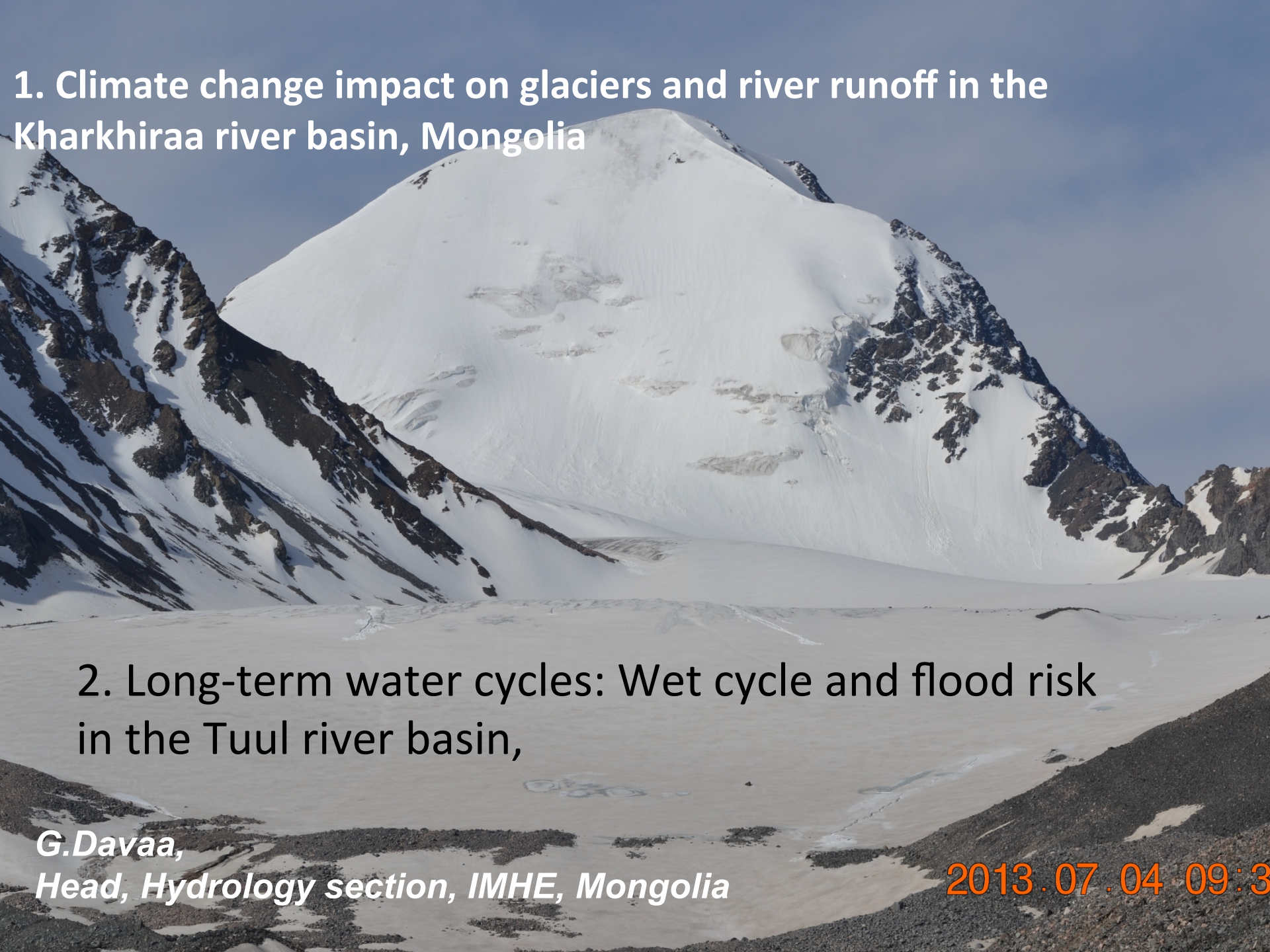


1. Climate change impact on glaciers and river runoff in the Kharkhiraa river basin, Mongolia

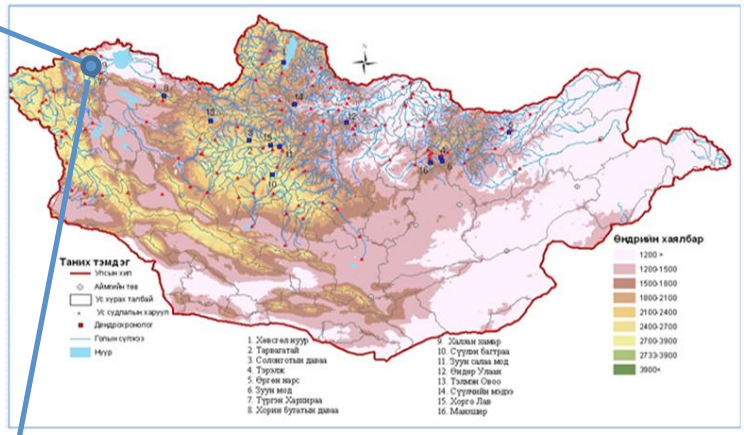
2. Long-term water cycles: Wet cycle and flood risk in the Tuul river basin,

G.Davaa,
Head, Hydrology section, IMHE, Mongolia

2013.07.04 09:3

	Turgen river	Kharkhiraa river
Area, km²	2038	3226
Lenght, m	128093	124470
Slope	0.014	0.018
Glacier area, km²	7.02	48.32
Forest area,km²	238.1	112.78
Protected area, km²	530.8	270.3

	Soum name	Area, km²	Basin area,km²	Basin area,%
Kharkhiraa river	Bokhmurun	3703.5	14.72	0.40
	Ulaangom	1109.3	978.08	88.17
	Turgen	2169.5	44.51	2.05
	Khovd	2676.9	6.77	0.24
	Tarialan	2784.3	1706.22	61.29
	Naranbulag	5225.3	255.04	4.88
Turgen river	Davst	3295.2	220.76	6.70
	Bokhmurun	3703.5	149.52	4.05
	Ulaangom	1109.3	77.199	6.96
	Turgen	2169.5	1644.11	75.78
	Davst	3295.2	166.98	5.07



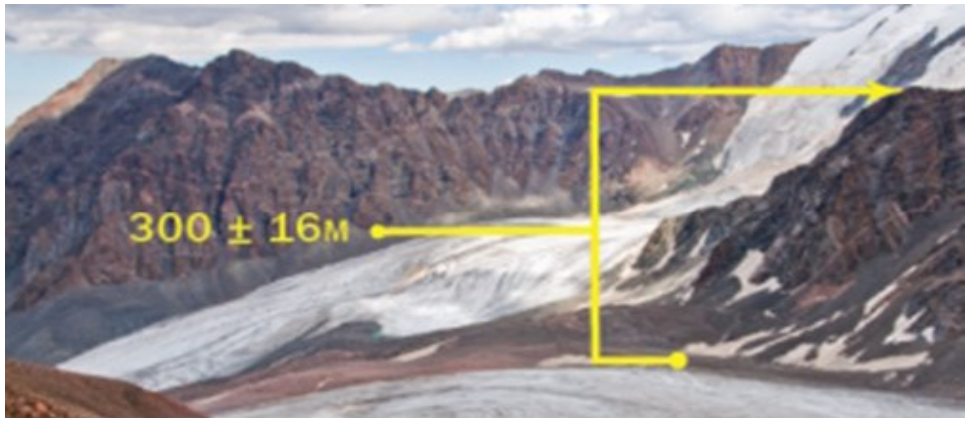
Location of Kharkhiraa and Turgen Mts. and river basins, Altai Mts., Mongolia

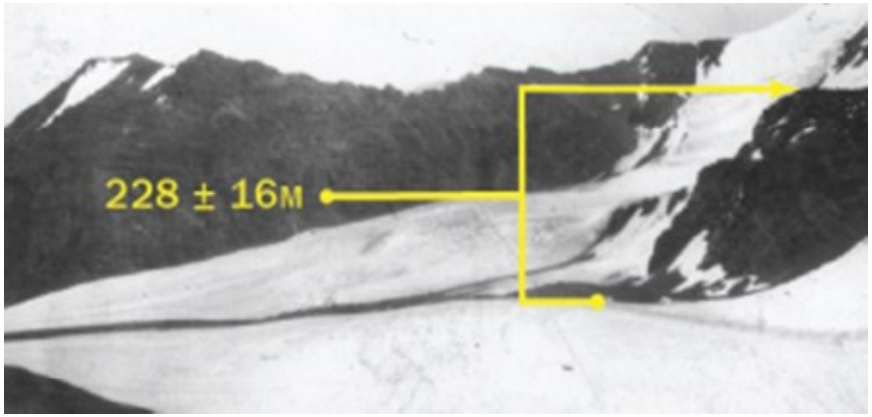
The Kharkhiraa, Turgen river basins and the Uvs Lake valley experience the hottest, coldest and driest climate conditions among any place on Earth at similar latitudes. These basins create a mosaic of glacier tops, high mountainous tundra, alpine meadows, coniferous forests, intermountain steppes, and finally the lowland Gobi desert steppe.

Photos taken by D.A.Karruthers in 1910 and U.Kamp in 2010

in 2010

in 1910





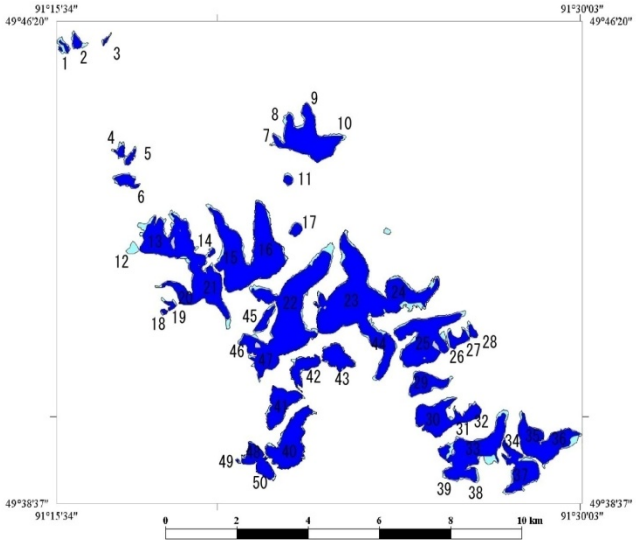
The glacier has retreated by 600 m and down wasted by 72 m during this 100 years.

Used data and methods

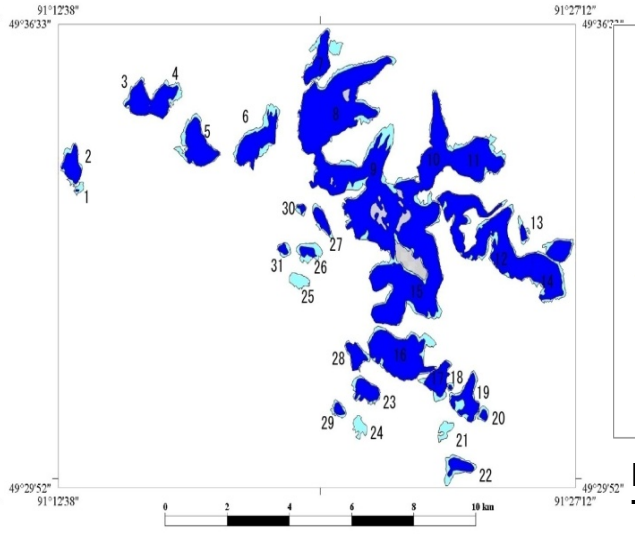
- Observation data on glacier mass balance
- Observed hydrological data of the Kharkhiraa and Turgen streams
- Current climate data from meteosations in the basin
- Topographic and Remote sensing data (LANDSAT ETM) for glacier areas
- Regional empirical equation for glacier volume vrs. area and for glacier melt vrs. altitude in the Altai
- Simulated and projected with regional climate model results under A1B GHG scenarios
- SMR model calibration and verification of daily discharge of the Kharkhiraa river

- The RCM initial and boundary data is obtained from ECHAM5-GCM, which is shown comparatively most good skill for representing Mongolian climate (P.Gomboluudev, 2013).

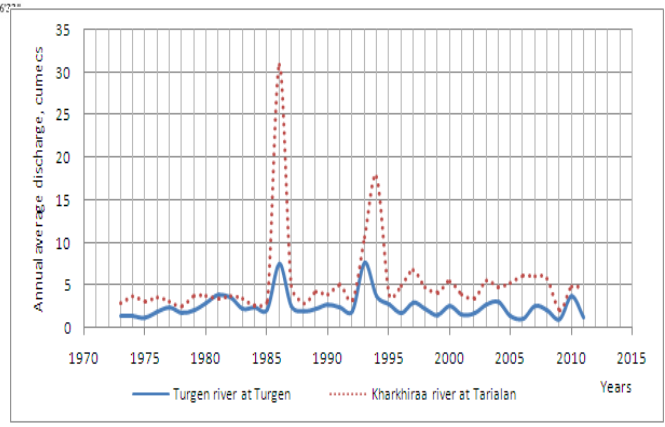
Current changes of glacier areas and water regime



Glacier area of the Turgen Mts. in 2000 and 2010 (LANDSAT data)

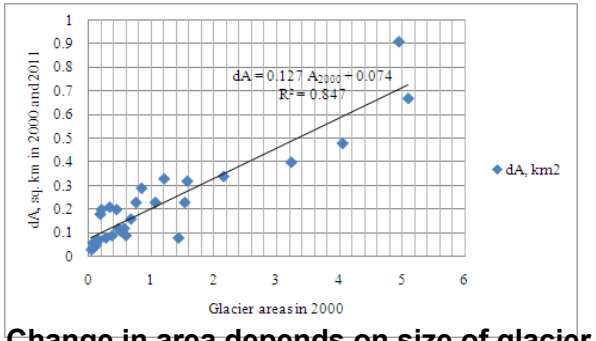


Glacier area of the Kharkhiraa Mts. in 2000 and 2010 (LANDSAT data)

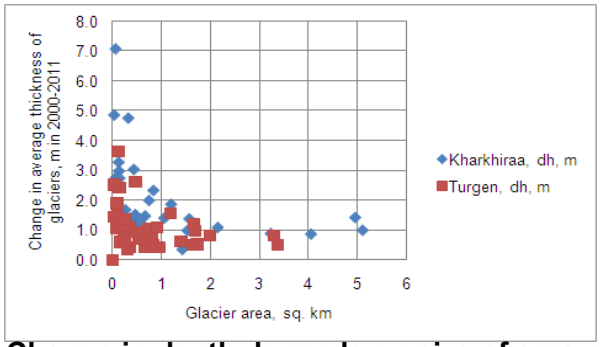


River flow variation of the Kharkhiraa and Turgen rivers

Data source	Total glacier area in Kharkhiraa Mts.	Kharkhiraa Mts. glacier area in Kharkhiraa river basin	Total glacier area at Turgen Mts.	Turgen Mts. glacier area in Kharkhiraa river basin	Total glacier area in Kharkhiraa river basin
Topographic map, scaled as S1:100000	**64.20**	**6.74**	**45.06**	**24.15**	**30.89**
Landsat ETM+ 25/6/1992	**39.18**	**4.31**	**36.10**	**18.98**	**23.29**
Landsat ETM+ 10/9/2000	**34.06**	**3.62**	**31.27**	**16.69**	**20.31**
Landsat ETM+ 4/07/2002	**33.15**	**3.49**	**37.75**	**19.70**	**23.19**
Landsat ETM+ 29/8/2010	**31.20**	**3.19**	**29.41**	**15.71**	**18.90**
Landsat ETM+ 6/08/2011	**26.73**	**2.43**	**27.49**	**14.63**	**17.06**



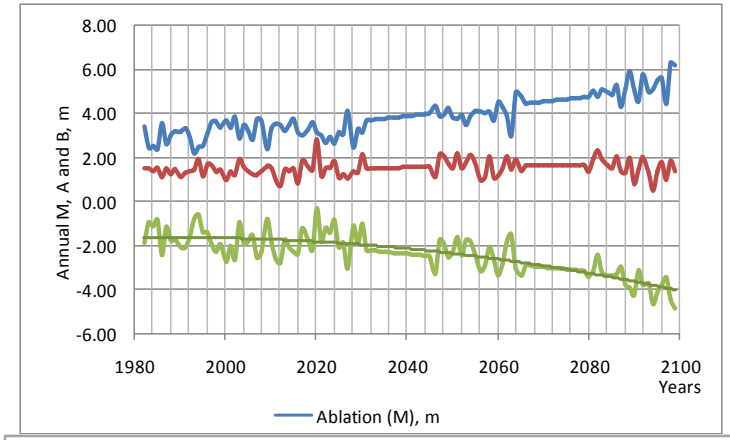
Change in area depends on size of glacier areas

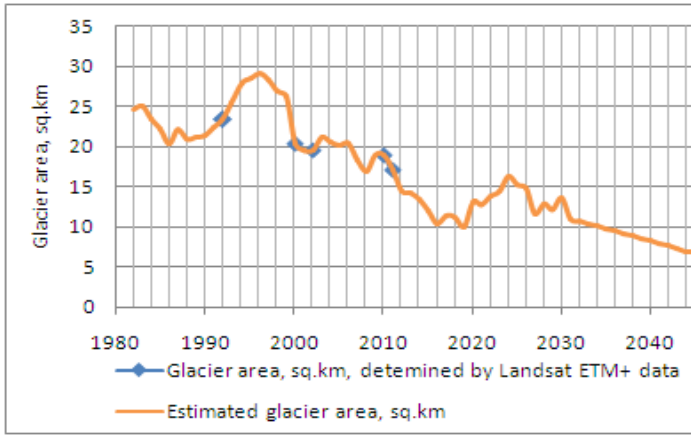


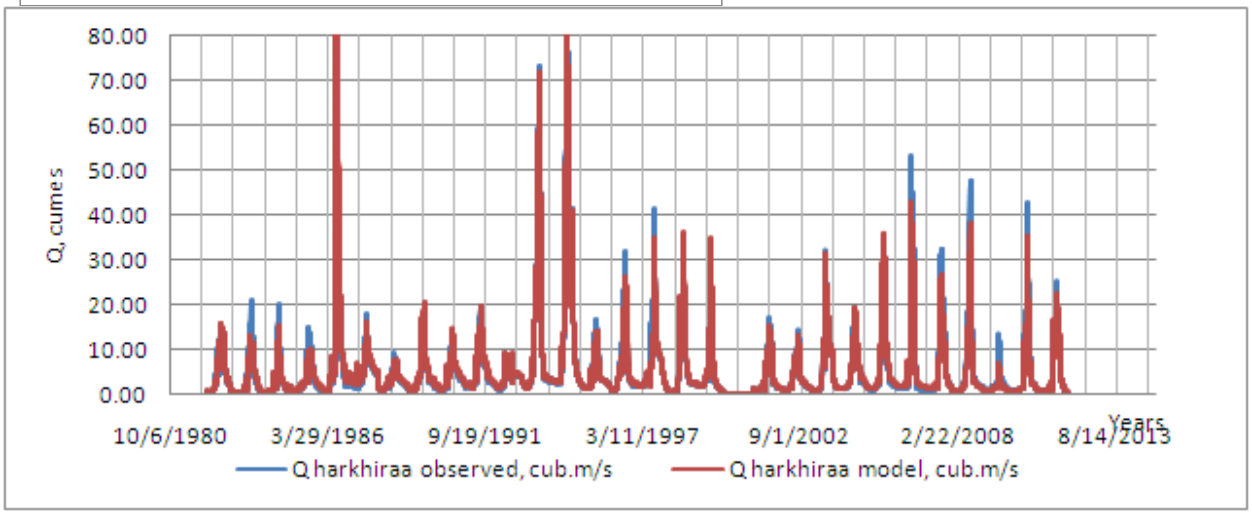
Change in depth depends on size of area of glaciers

Current changes in water regime and resources and future projections for Kharkhiraa R.

$$dA_{\text{Kharkhiraa river basin}} = 2.306\ B + 3.7$$



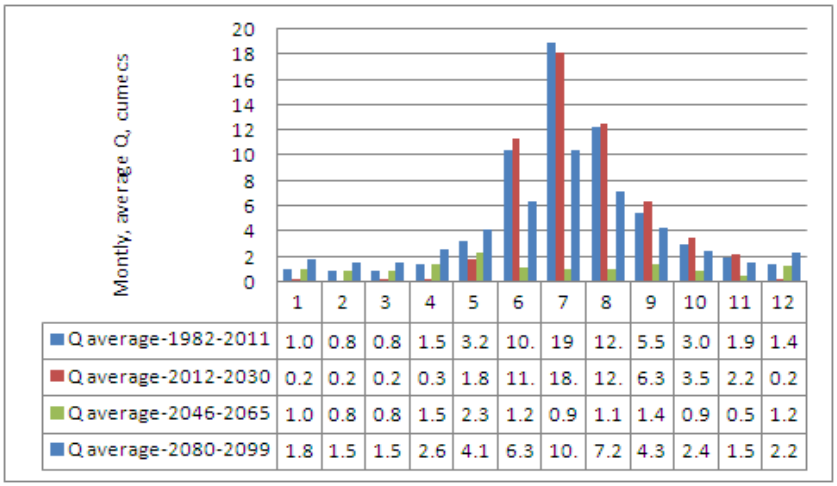




SMR model parameters were calibrated and verified with hydrological observation data of Tarialan hydro-station at Kharkhiraa River for the period of 1980-1999 and 2001-2010.

In our Kharkhiraa river case the efficiency criterion reaches the value of 0.98 the simulated discharge are close to observed discharge. The relative volume error RVE is quite small as 0.007 for the Kharkhiraa River flow simulation.

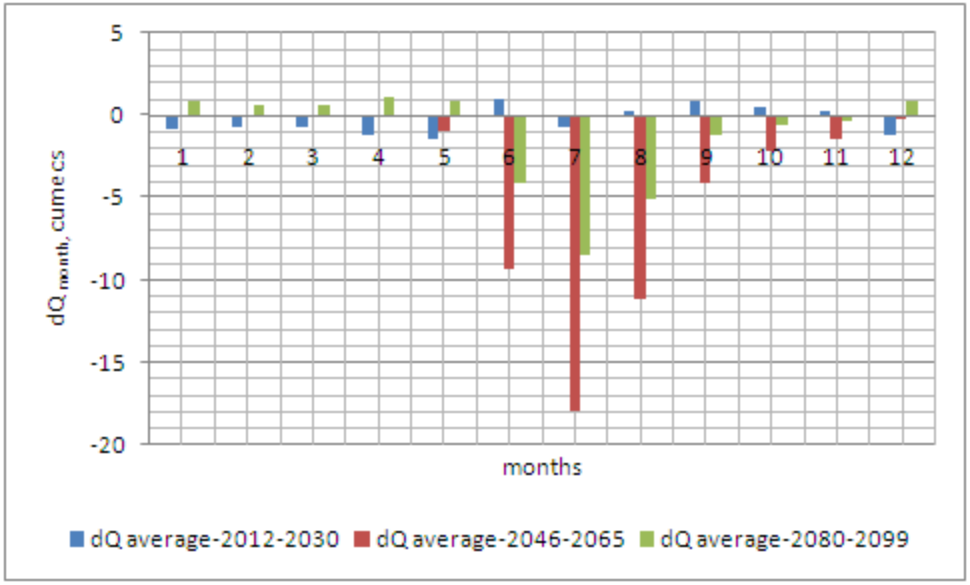
Current changes in water regime and resources and future projections Kharkhiraa river



	1	2	3	4	5	6	7	8	9	10	11	12
Q average-1982-2011	1.0	0.8	0.8	1.5	3.2	10.	19	12.	5.5	3.0	1.9	1.4
Q average-2012-2030	0.2	0.2	0.2	0.3	1.8	11.	18.	12.	6.3	3.5	2.2	0.2
Q average-2046-2065	1.0	0.8	0.8	1.5	2.3	1.2	0.9	1.1	1.4	0.9	0.5	1.2
Q average-2080-2099	1.8	1.5	1.5	2.6	4.1	6.3	10.	7.2	4.3	2.4	1.5	2.2

Current (1982-2011) and projected in future monthly average discharge values of the Kharkhiraa River at Tarialan hydro-station, ECHAM5-GCM, A1B (2012-2030, 2046-2065, 2080-2099)

Annual mean discharge of the Kharkhiraa River at the Tarialan hydro-station is projected to slightly decrease by 6.18 percents in the period of 2011-2030, significantly decrease by 76.9 percents in the period of 2046-2065 and moderately decrease by 24.0 percents in the period of 2080-2099 in comparisons with current, 1980-2010 discharges



Monthly average discharge will increase by 9.0 percents in the June, 2.2 percents in the August and slightly decrease by 4.0 in July, 2011-2030. In rest periods JJA discharges will decrease by 88.5-94.8 percents in 2046-2065 and by 39.3-44.9 percents in the period of 2080-2099 due to glacier melt and retreat.

Conclusions and recommendations

➢Water harvesting or building water accumulation “aside ponds” and aside reservoirs are highly recommended in the Kharkhiraa and Turgen river basin, especially in upstream area of Tarialan and Ulaangom soum area.

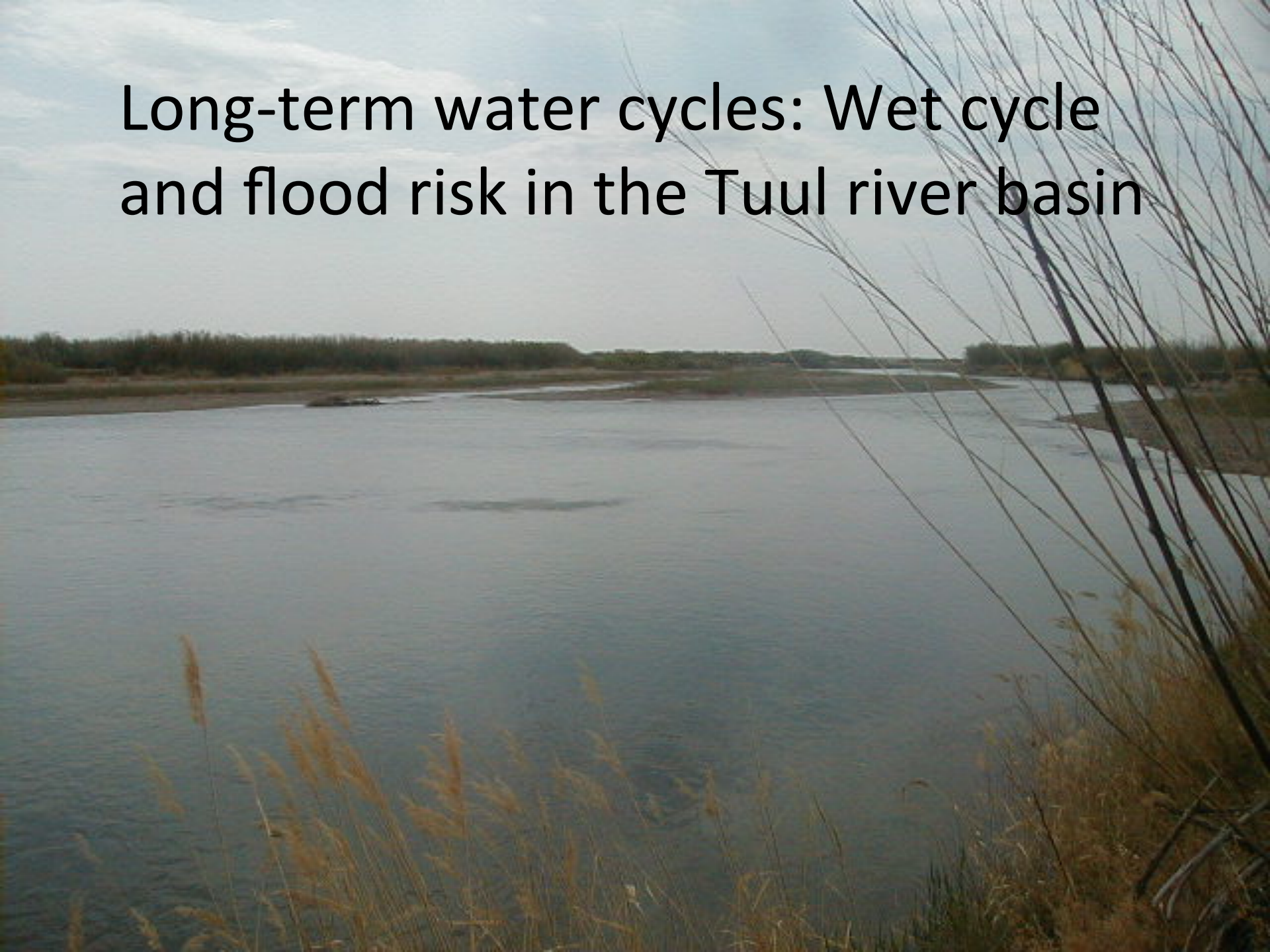
Natural aside lakes, located in the floodplain of the Turgen stream in the Kharkhiraa river basin

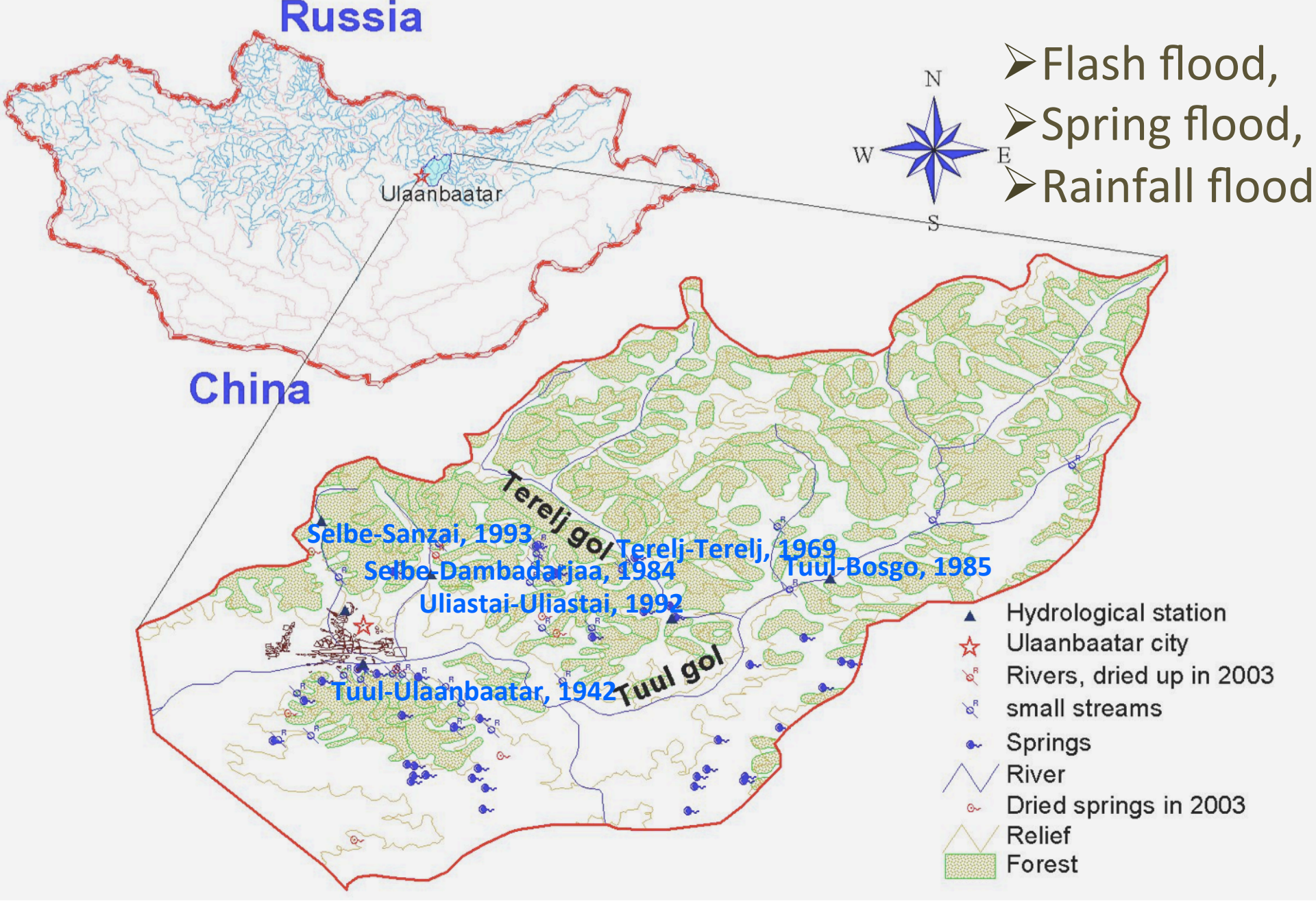
➢To increase irrigation efficiency and meet food security requirement in these basins, drip irrigation technology can be applied for vegetable and fruit production in Ulaangom, Tarialan, Turgen and Naranbulag soums. Feasibility study on integrated efficient irrigation and water resource development in the Kharkhiraa river basin including Tarialan, Ulaangom and Naranbulag soums is recommended.

Expected results and logical frame

- Mean annual in-stream summer 30 day low flow will be improved or maintained with increasing ecosystem resilience (reforestation, plantation, improved pasture and other nature resource management)
- Surface water quality and ground water recharge will be improved or maintained
- Grazing rate meets pasture carrying capacity
- Number of eco-regional EBA strategy programs will be fully operational
- Total hectares of riparian and wetland habitat will be restored with native vegetation within project sites
- All soums will be implementing watershed level EBA planning programs and combined with IWRM planning
- Total hectares of cultivated land demonstrating EBA friendly cropping methods in project sites will be increased.
- Total number of monitored wells increasing ground-water consumption efficiency in project sites will be increased.

Long-term water cycles: Wet cycle and flood risk in the Tuul river basin

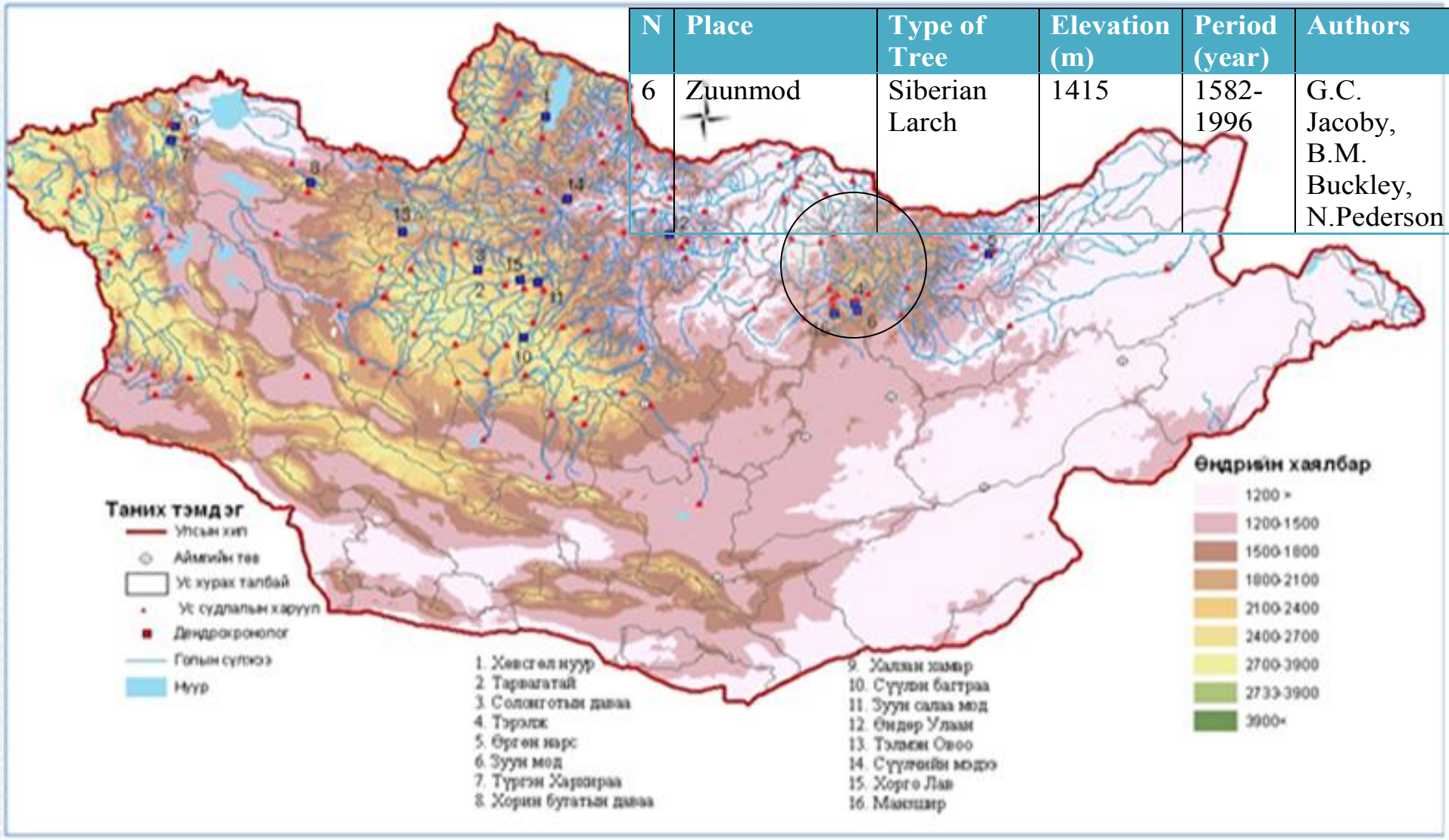




Location and geographical features of the Tuul River, Mongolia

Possible way to reconstruct past hydrological data

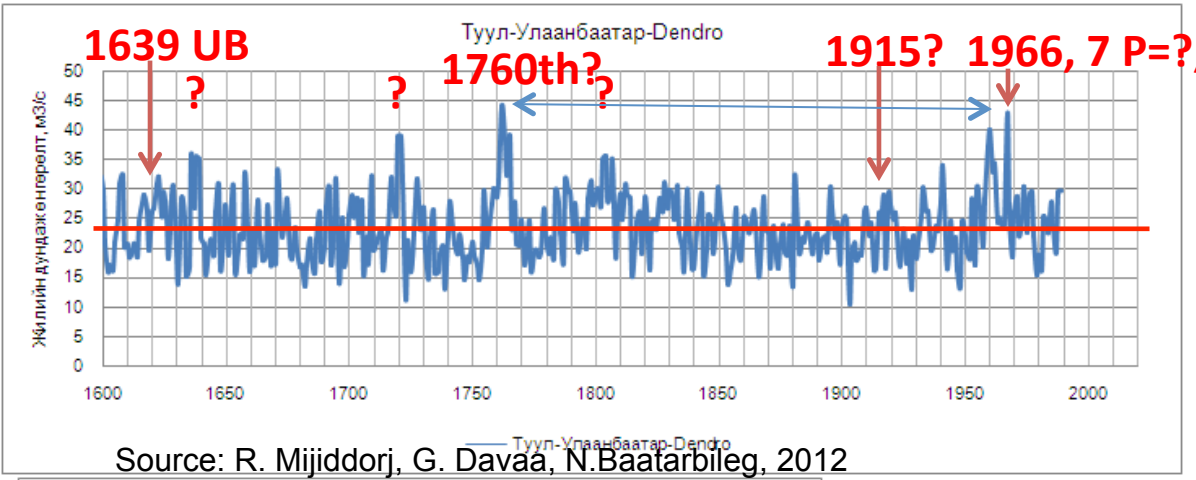
N	Place	Type of Tree	Elevation (m)	Period (year)	Authors
6	Zuunmod	Siberian Larch	1415	1582-1996	G.C. Jacoby, B.M. Buckley, N.Pederson



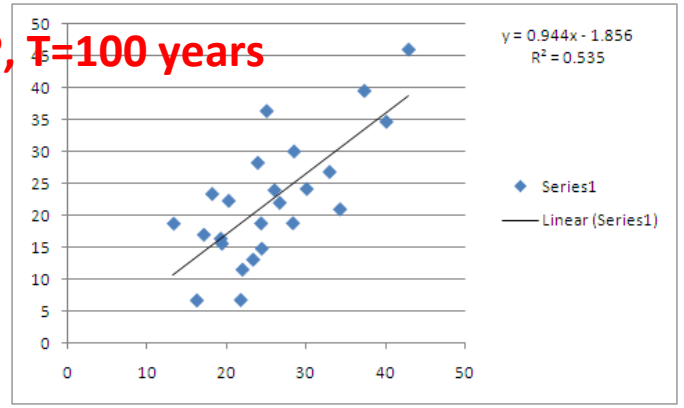
Location of dendro-chronological sampling points and hydrological stations, Mongolia

source: R.Mijiddorj, G.Davaa and Baatarbileg, 2013

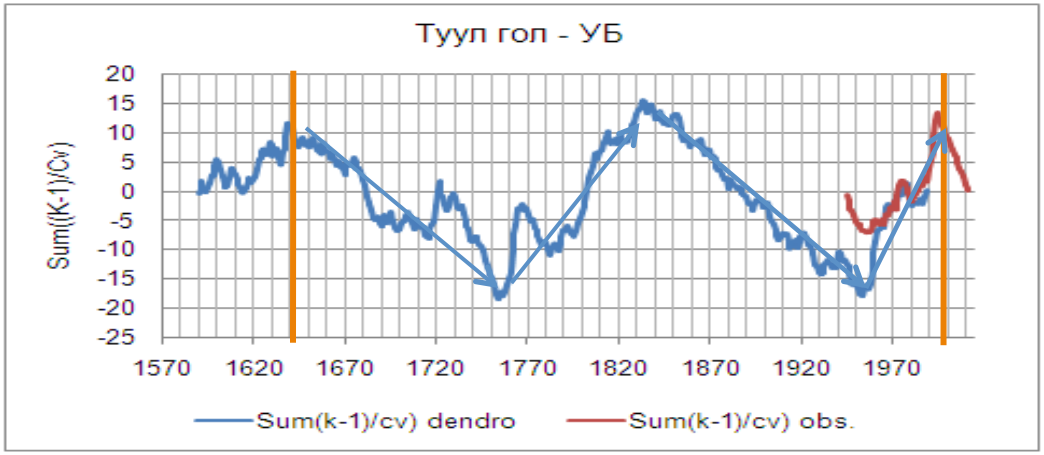
Observed and reconstructed: Tuul river flow variation

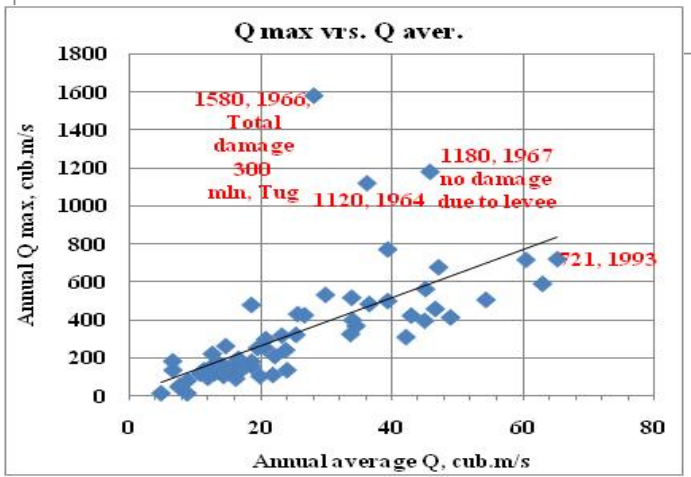


Source: R. Mijiddorj, G. Davaa, N.Baatarbileg, 2012



Q observed wrs. Q reconstructed for 1945-1968



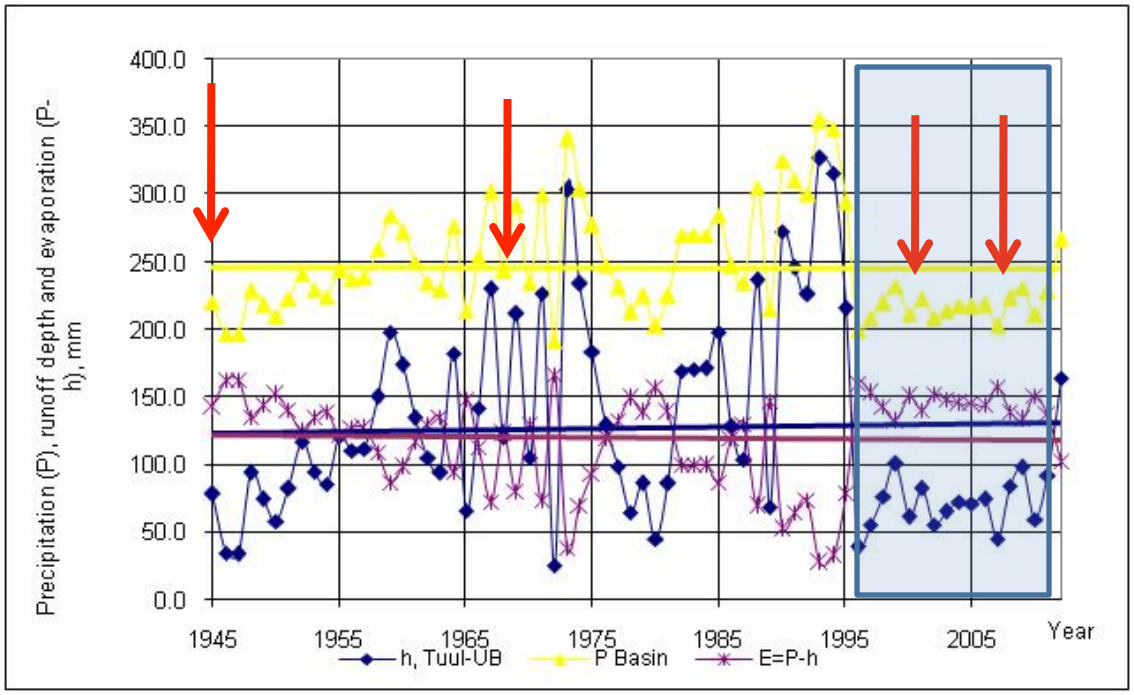


- ***Average duration of high flow periods is 30 years . T= 4-51 years***
- ***Average duration of low flow periods is 62 years . T= 9-121 years***
- ***Observed almost one cycle during the observational period of 1945-2014.***

What option (building reservoirs) is optimal for the Tuul river flow regulation?

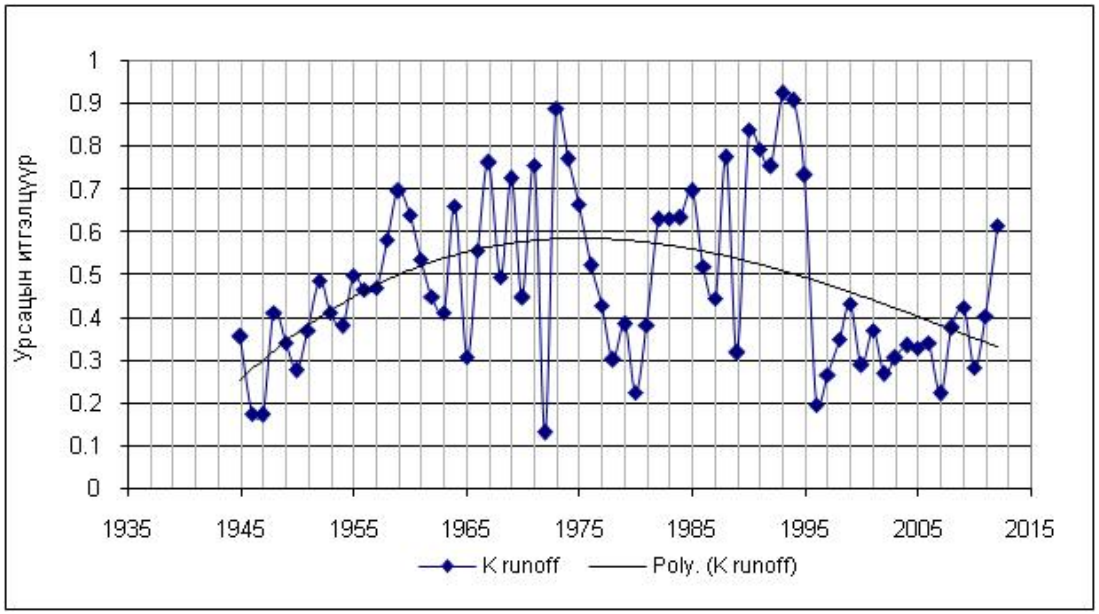
To what extent climate change will impact on the river flow?

Environmental flow requirements and standards?

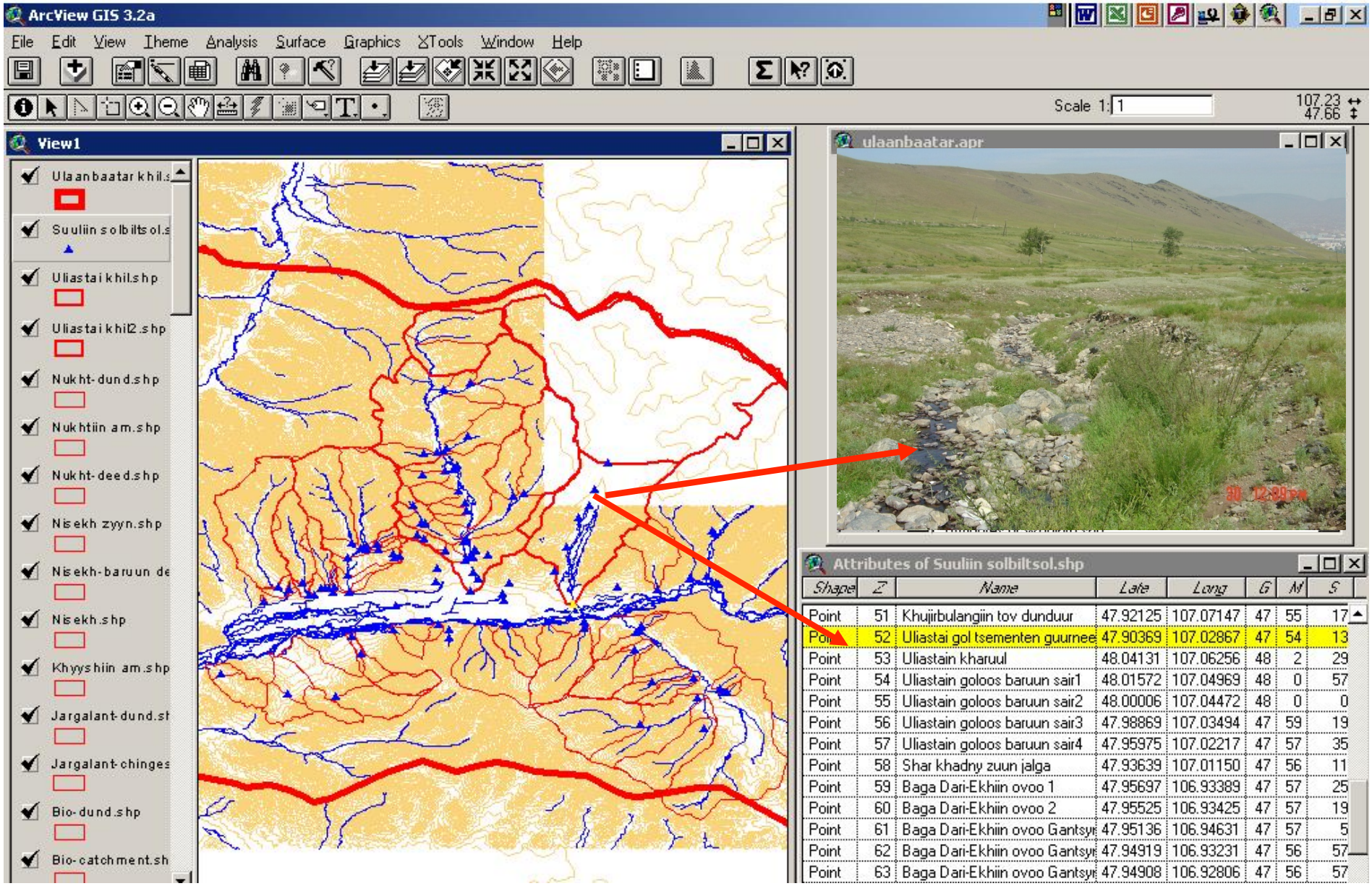


Dynamics of water balance elements in the Tuul river basin

Dynamics of runoff coefficient in the Tuul river basin




Levee constructed in 1966.
2008 4 26


ArcView GIS 3.2a
File Edit View Theme Analysis Surface Graphics XTools Window Help
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View1
Ulaanbaatar khil.s
Suuliin solbiltsol.s
Uliastai khil.shp
Uliastai khil2.shp
Nukht-dund.shp
Nukhtiin am.shp
Nukht-deed.shp
Nisekh zyyn.shp
Nisekh-baruun de
Nisekh.shp
Khyyshiin am.shp
Jargalant-dund.sh
Jargalant-chinges
Bio-dund.shp
Bio-catchment.sh
ulaanbaatar.apr
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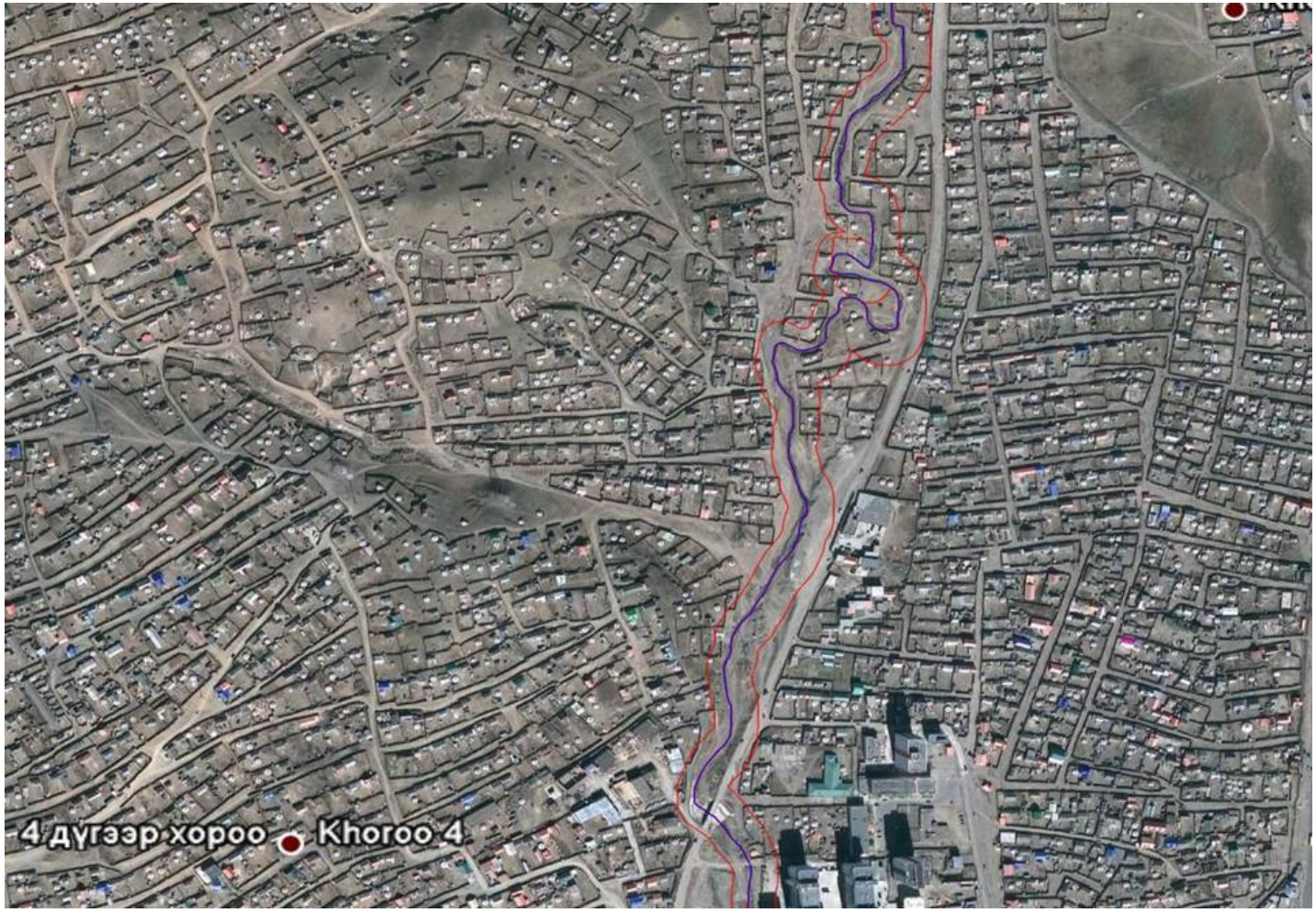
Shape Z Name Late Long G M S
Point 51 Khujirbulangiin tov dunduur 47.92125 107.07147 47 55 17
Point 52 Uliastai gol tsementen guurnee 47.90369 107.02867 47 54 13
Point 53 Uliastain kharuul 48.04131 107.06256 48 2 29
Point 54 Uliastain goloos baruun sair1 48.01572 107.04969 48 0 57
Point 55 Uliastain goloos baruun sair2 48.00006 107.04472 48 0 0
Point 56 Uliastain goloos baruun sair3 47.98869 107.03494 47 59 19
Point 57 Uliastain goloos baruun sair4 47.95975 107.02217 47 57 35
Point 58 Shar khadny zuun jalga 47.93639 107.01150 47 56 11
Point 59 Baga Dari-Ekhiin ovoo 1 47.95697 106.93389 47 57 25
Point 60 Baga Dari-Ekhiin ovoo 2 47.95525 106.93425 47 57 19
Point 61 Baga Dari-Ekhiin ovoo Gantsyr 47.95136 106.94631 47 57 5
Point 62 Baga Dari-Ekhiin ovoo Gantsyr 47.94919 106.93231 47 56 57
Point 63 Baga Dari-Ekhiin ovoo Gantsyr 47.94908 106.92806 47 56 57

2.Vulnerability of system (social, economical)

Dense settlement in flood prone area due to improper land use management, urban planning and poor public awareness are common problems.



These constructions are located inside flood protection levee extending northern shoe line of the Tuul river.

That indicates current situation of preparedness of Ulaanbaatar against flooding.

Strategic planning on protection of Ulaanbaatar against flooding was conducted in development stage.

Event study

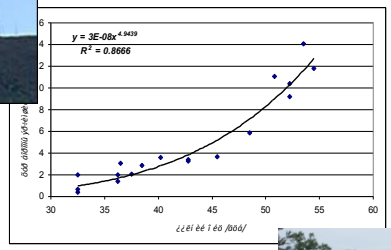
Weak flash flood, caused by 54 mm/hour, occurred in 18th July, 2003 in Ulaanbaatar.

BUT!!!! Flood damage

10 person dead, about 2 km paved road destroyed. 3 cars, 276 fence and gers seriously damaged and 30 families totally lost shelter. Total flood damage **is rather big**.

Flash flood along the dry bed western side of Mongolian TV

Rainfall observation by Radar or precipitation observation



Conversion of radar rainfall into rainfall on ground surface and use of quantitative rainfall forecasting products

Flood amount estimation, hydrological modeling and forecasting

Free passage of flood water through protection structures and reservoir operation

Mapping inundation area

Warning system

Conclusions

Due to climate change and anthropogenic impacts, there is **decline** of water resources and **change in flow regime and water resources.**

Change in rainfall pattern with heavy rainfall increase, causes more **frequent flash flood and river flooding** and less recharge to the ground water, **dropping GW water table**.

- **Climate change impact assessment on flow regime and resources in the Tuul river basin scale**
- **Development of adaptation options to CC in the basin scale**
- **Defining technological needs in river basin**
- **Environmental constraints and environmental flow standards in river basin.**


Thank You for your attention