The implementation stages, results and recommendations of the PEER Project 4-356

Risk management and assessment of water resources of the Amudarya River Basin under condition of climate change and construction of large reservoirs

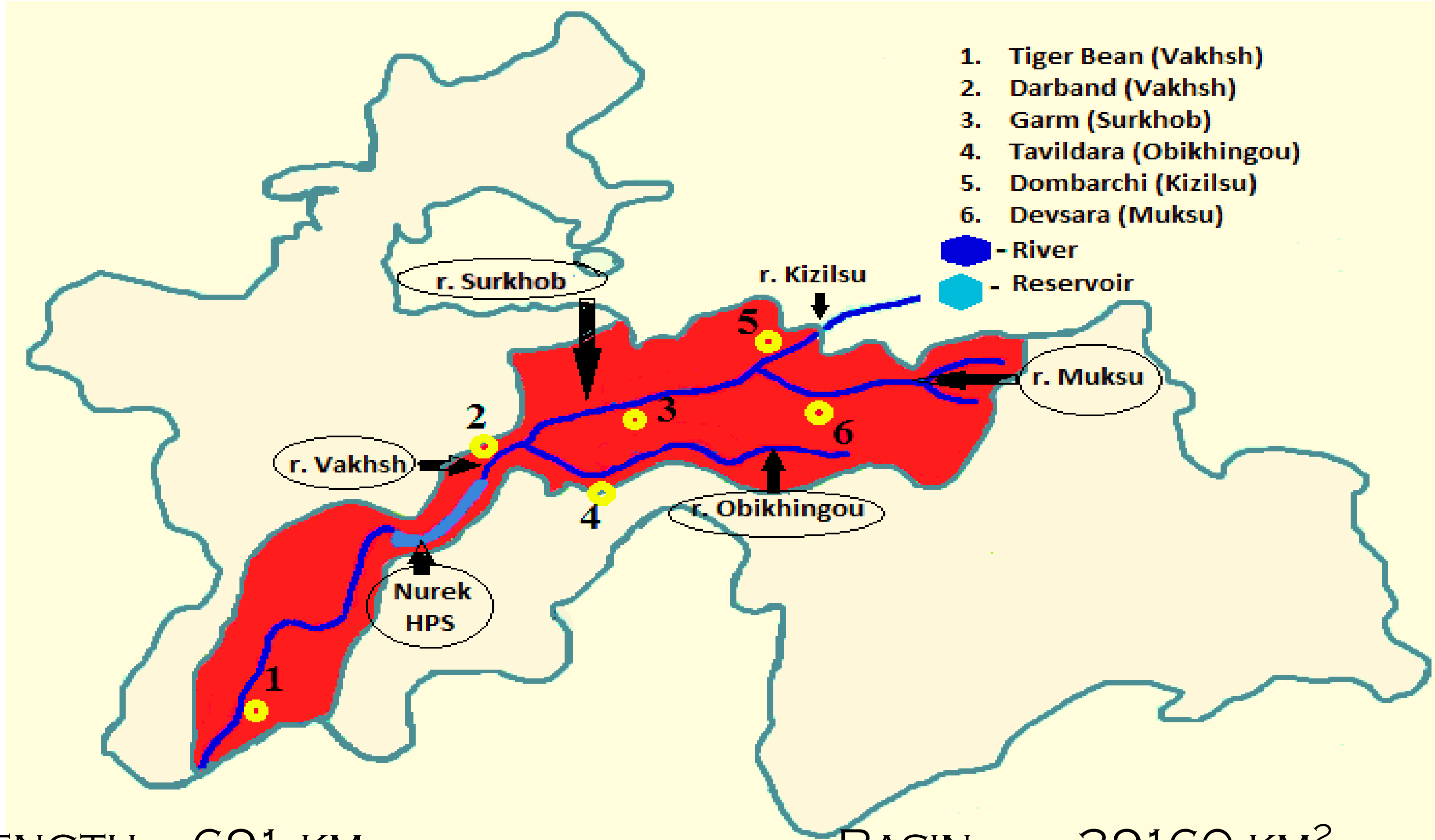
Inom Normatov
Institute of Water problems, Hydropower and Ecology AS Republic of Tajikistan

Email:inomnor@gmail.com

INTRODUCTION

The presentation covers the following aspects:

- Hydrological characteristics Vakhsh River and its tributaries
- Hydrochemistry of Vakhsh River and its tributaries
- Meteorological Conditions of the Vakhsh River Basin



LENGTH - 691 KM BASIN - 39160 KM^2

DISCHARGE (AVER) - 2273 M^3/SEC

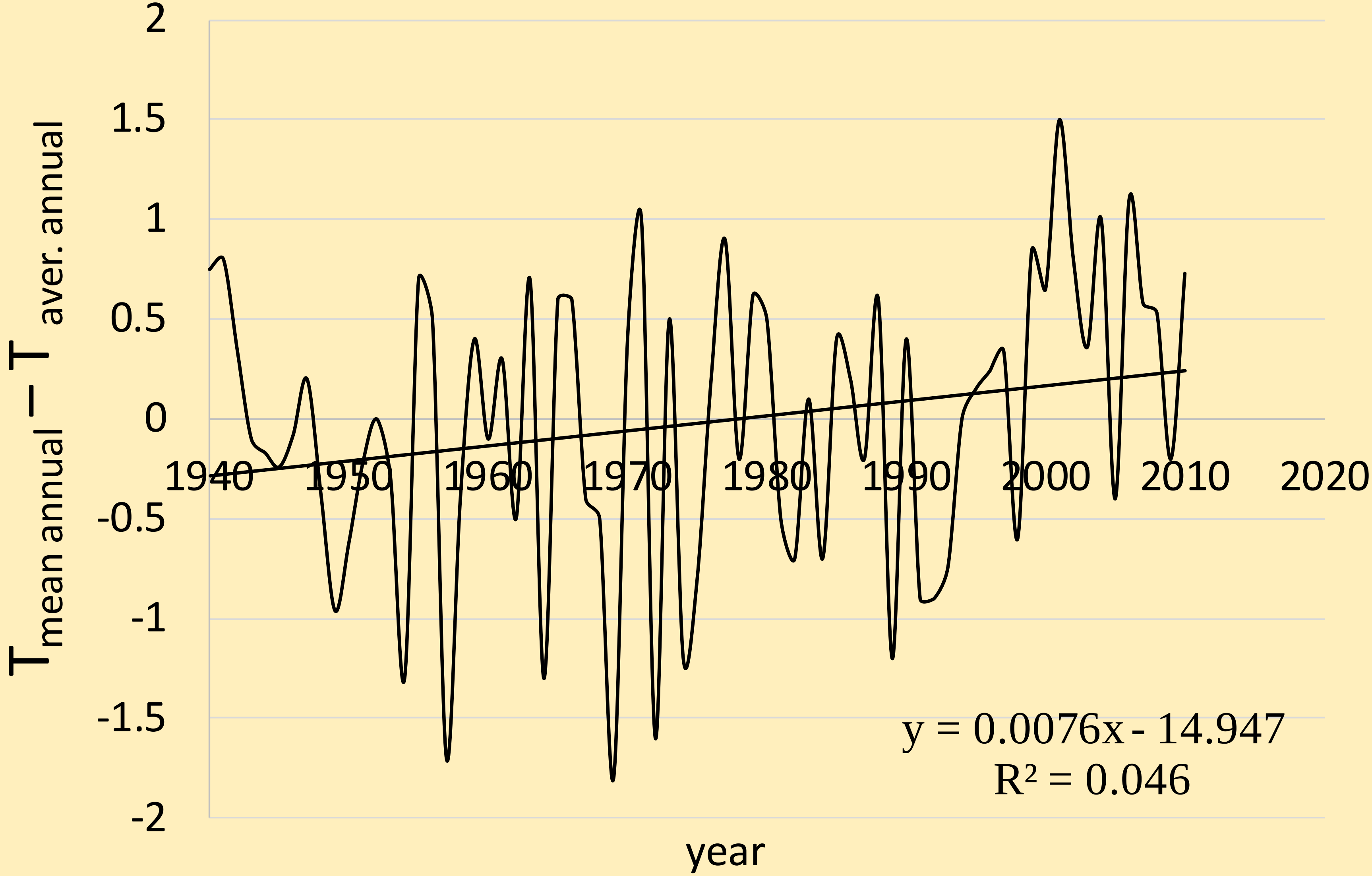
GLACIATION AREA (4685 M) - 3856 KM^2

TRIBUTARIES - SURKHOB, OBIKHINGOU ELEVATION- 1151 M

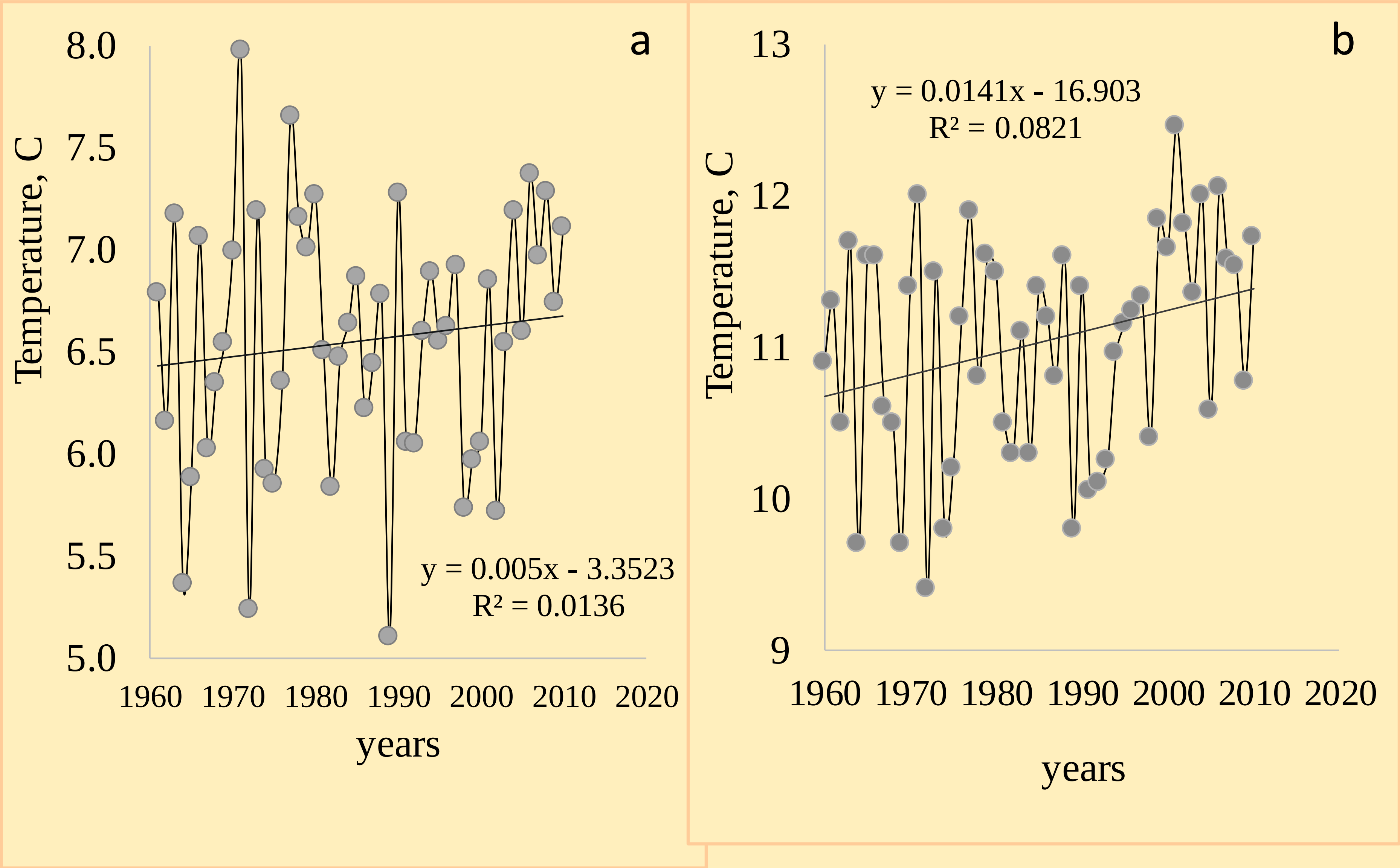
METHODOLOGY

- the Lyakhsh meteorological station -Kyzilsu river basin
- the Tavildara meteorological station -Obikhingou river basin
- the Garm meteorological station - Surkhob river basin

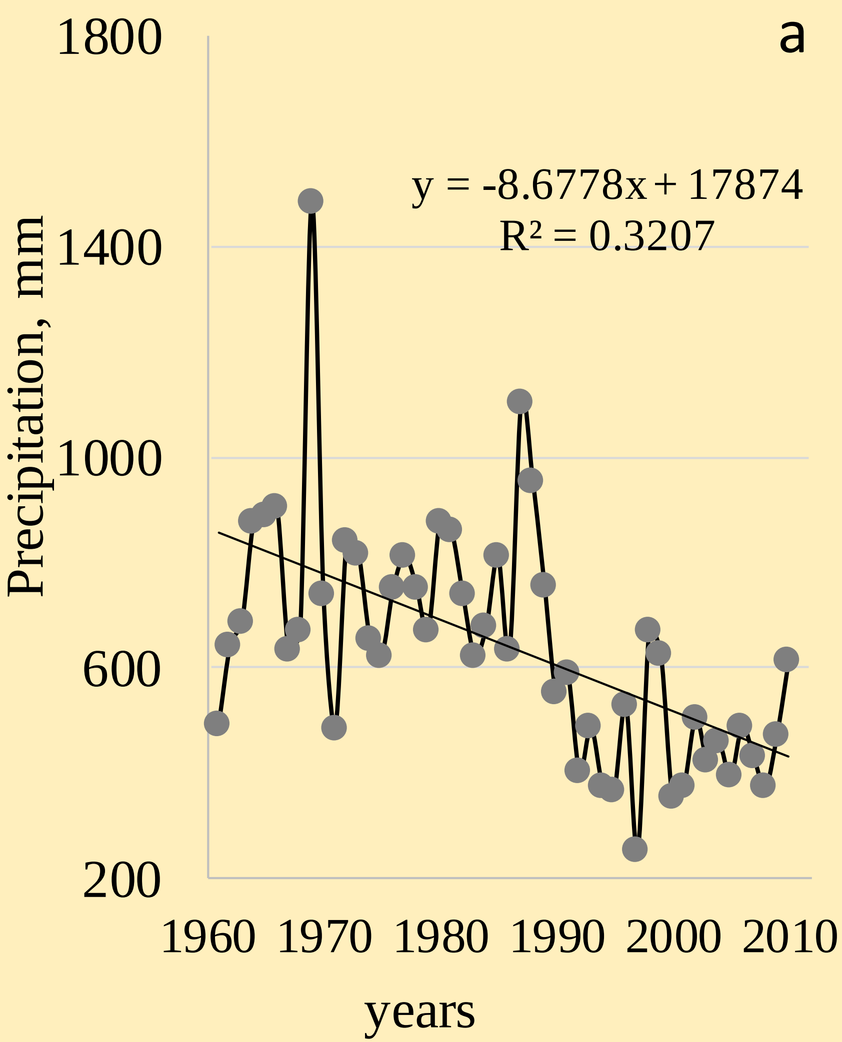
Dynamics of the temperature change in the Vakhsh River Basin (Garm Meteorological station)

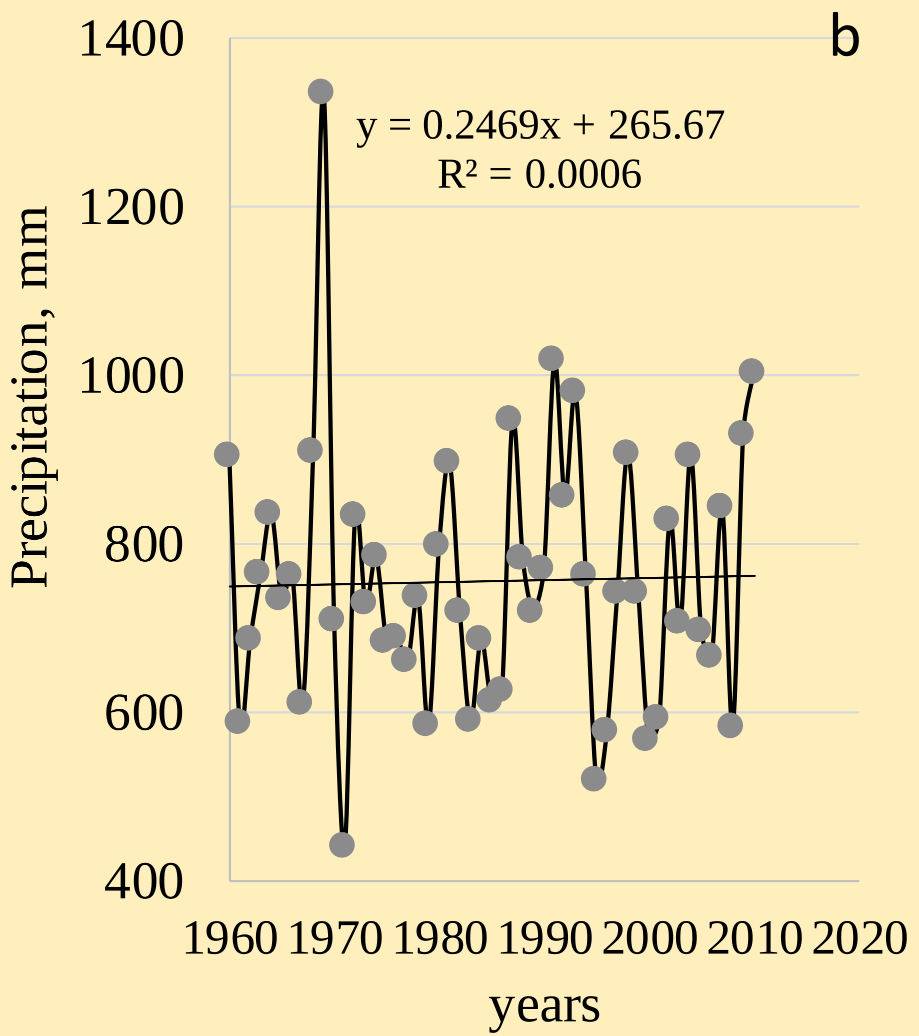


Annual average temperature according to meteorological station Lyakhsh (a) and Tavildara (b) for the period 1960-2018

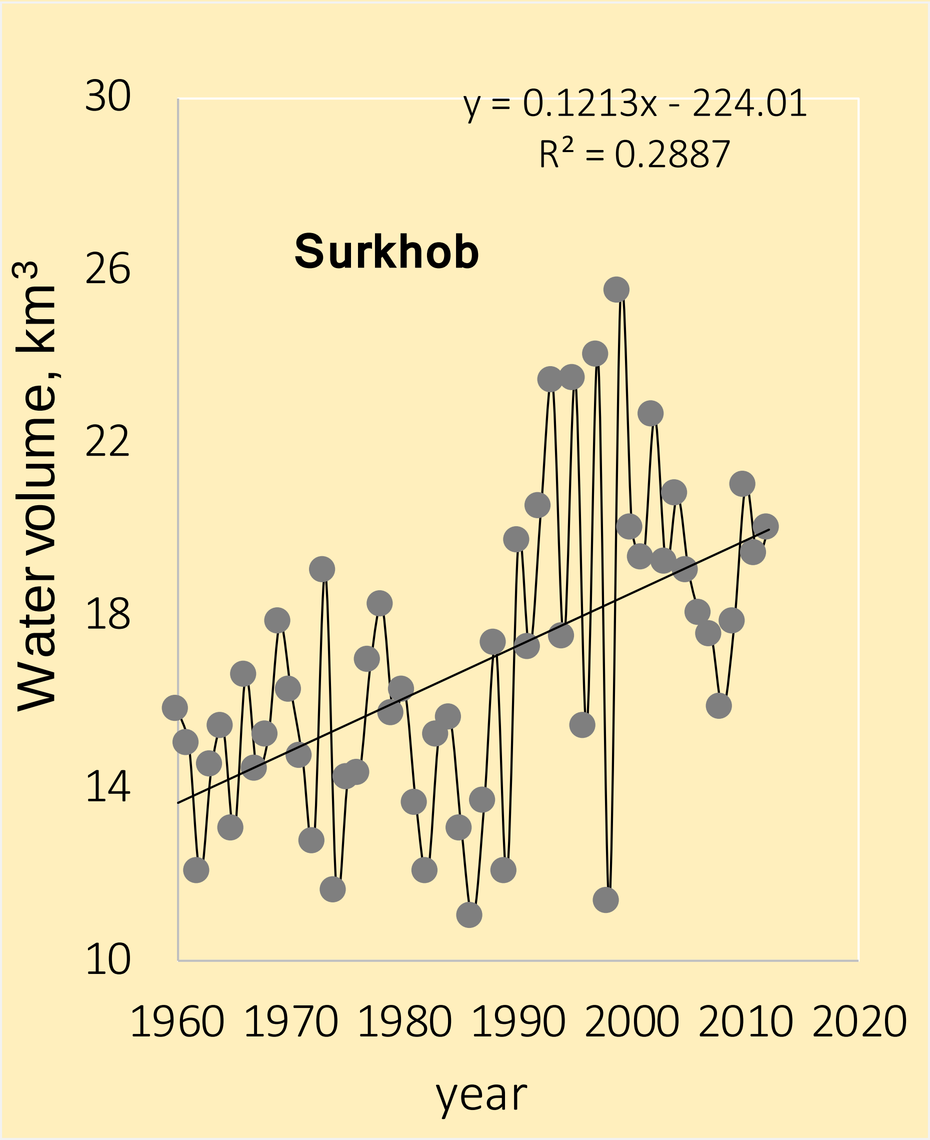


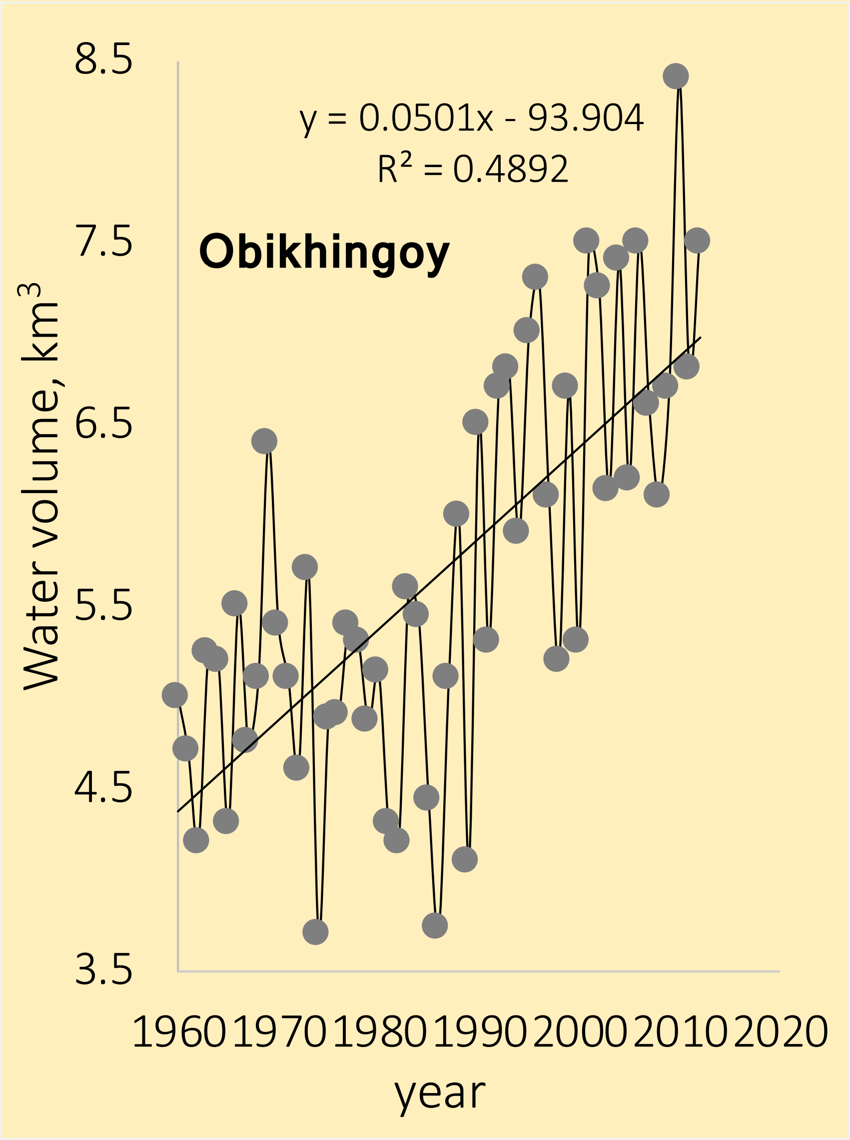
Annual average precipitation according to meteorological station Lyakhsh (a) Tavildara (b) for the period 1960-2018





The Hydrological Characteristics of Tributaries and Vakhsh River





The increase of water volume of the Vakhsh river and its tributaries- Surkhob and Obikhingou rivers, as shown on the above slides in tune with the statements that currently there is a reduction of glaciations area of Tajikistan, probably due to an increase in the overall temperature of the background in the region and changing precipitation patterns.

Thus, the increase of water volume in rivers and reduce the amount of atmospheric precipitation in river basins give reason to believe that in the Vakhsh river basin continued reduction of the area of glaciation

- In the Surkhob river basin intensively melting small glaciers of the Northern slopes in the Western part of Peter Great ridge

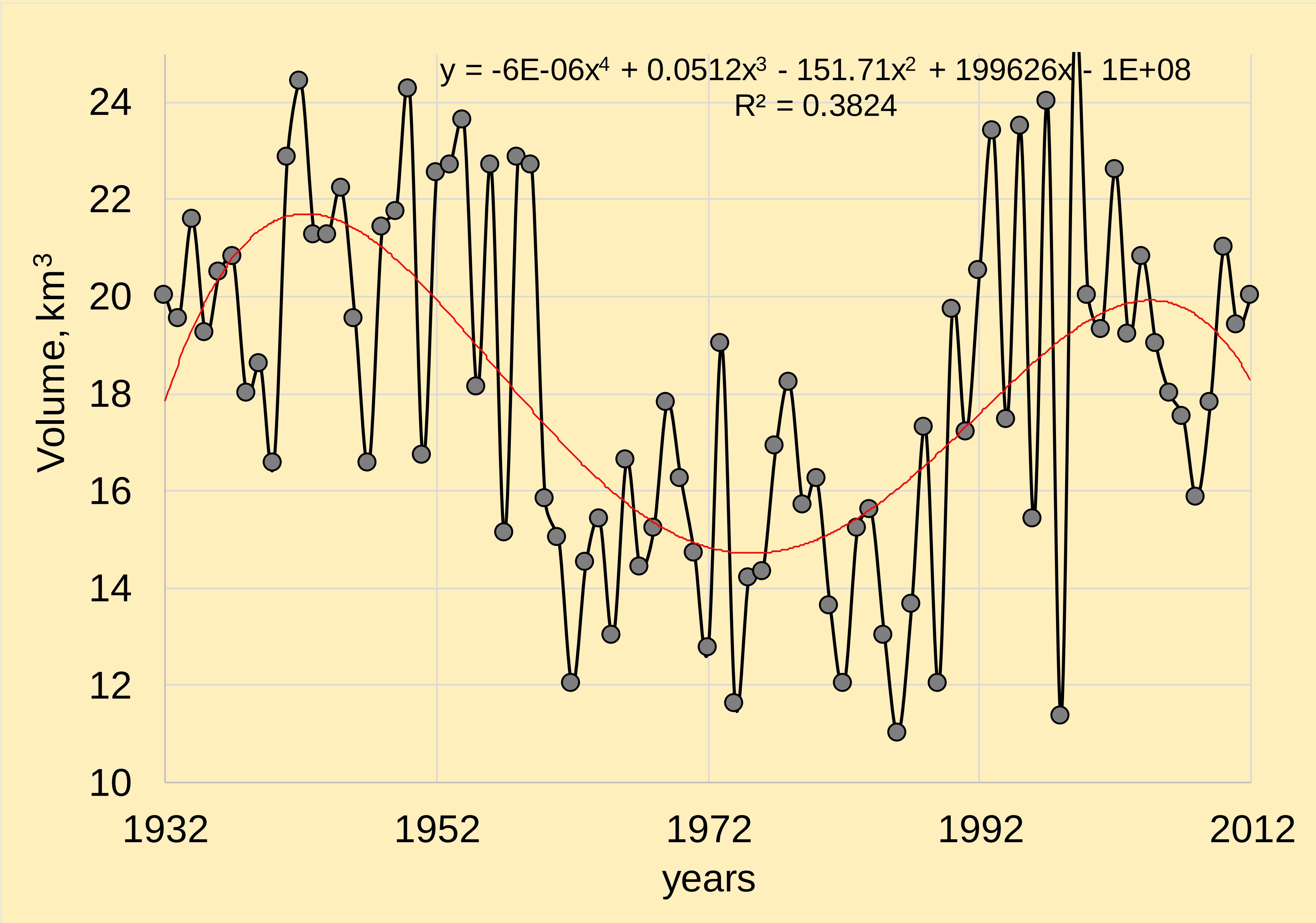
- On the Southern slopes of Alay ridge, glaciation decreases slower

- In the Obikhingou river basin intensively melting the largest glacier Garmo. During the XX century it became shorter by almost 7 km, having lost more than 6.0 km^2 area

- Currently glacier retreats at an average speed of 9 m/year, the surface settles due to the melting of up to 4 m/year.

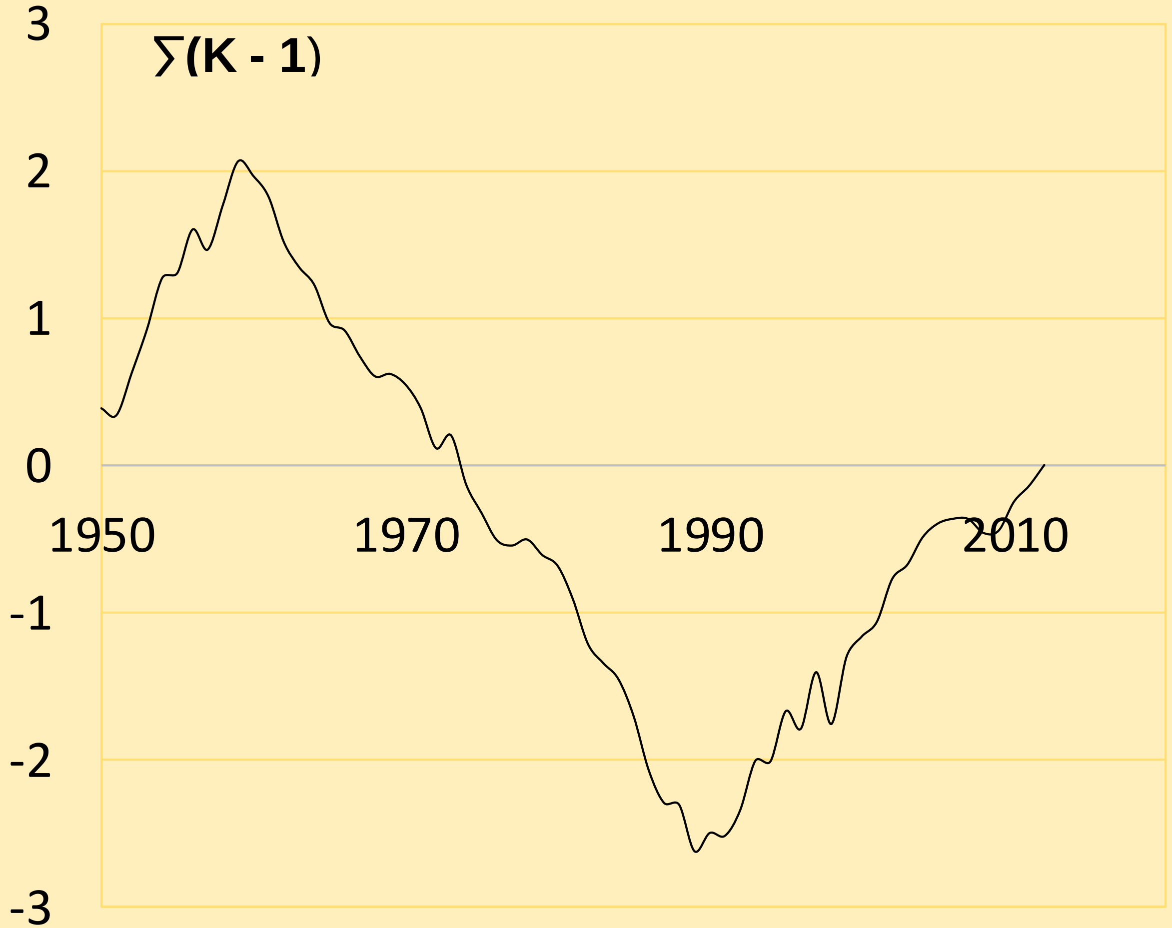
- Another glacier in the same basin - Skogach retreats annually on 11 m.

Trends of the Vakhsh River Runoff for the period 1932-2017



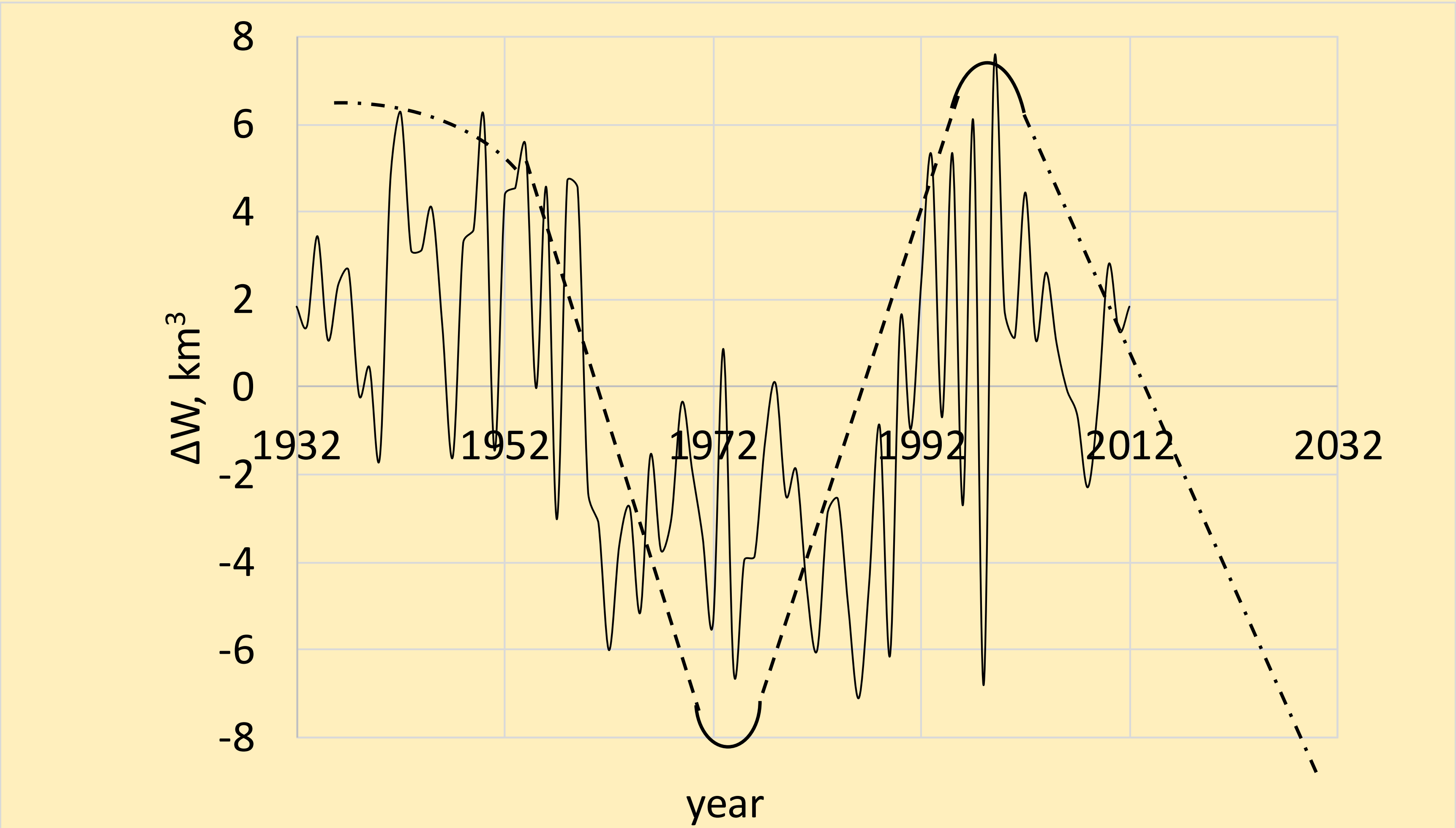
For allocation of periods with high and low water content are used differential integral curves of average annual discharge.

The use of differential integral curves give a vision of cyclical fluctuations without the effect of the displacement of the boundaries between the phases of the cycles of low and high duration

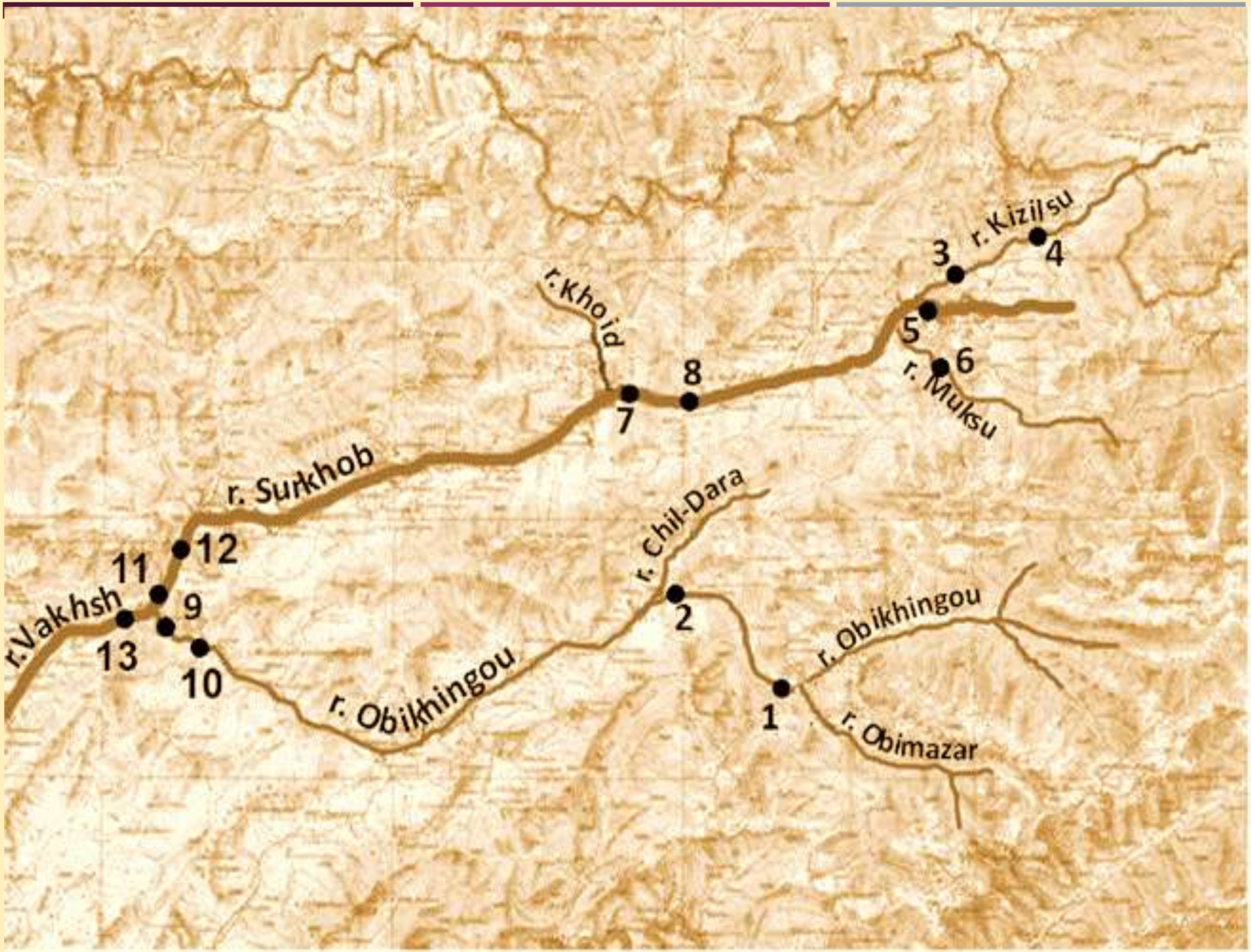


The water volume change of the Vakhsh River for the period 1932-2018

It should be note that the appearance of cyclicality in the water flow of rivers allows predicting future scenarios of changes in the water flow of the river. From the slide can see that the harmonic law changes the Vakhsh river volume of water for the period 1932-2012. Hence, the continuation of the right part of the harmonics may indicate the volume of water by 2030.

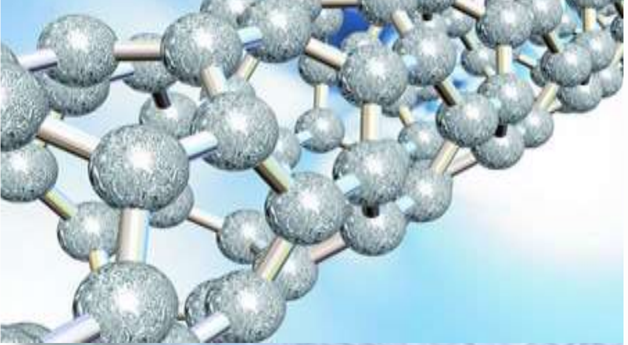


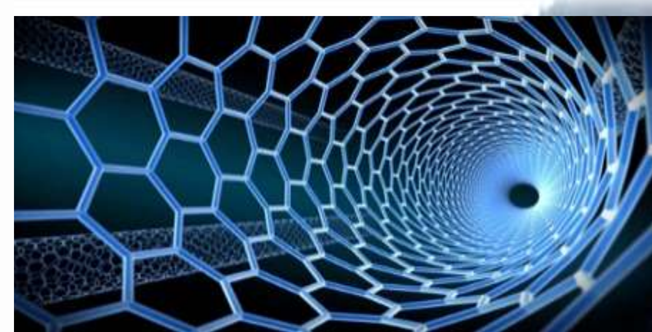
Scheme of sampling of water from the Vakhsh River and its tributaries





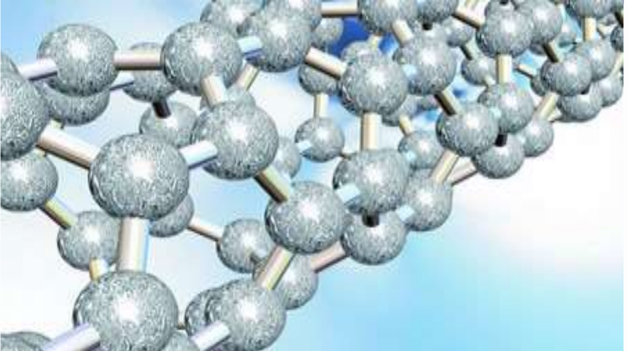


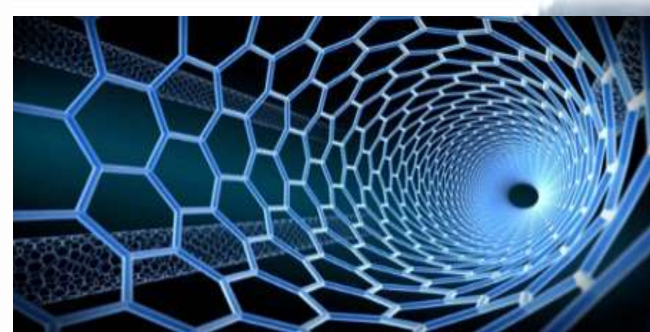
H2


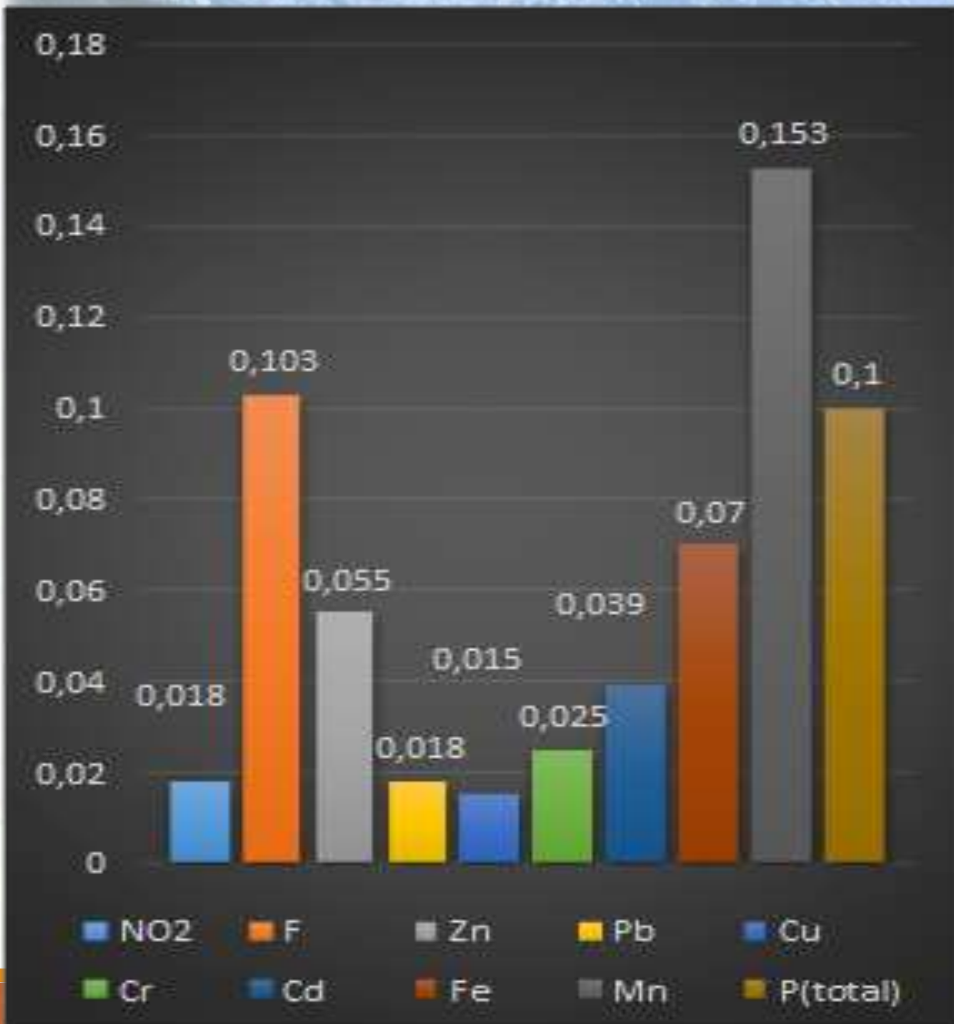







H2




0,18
0,16
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0,015
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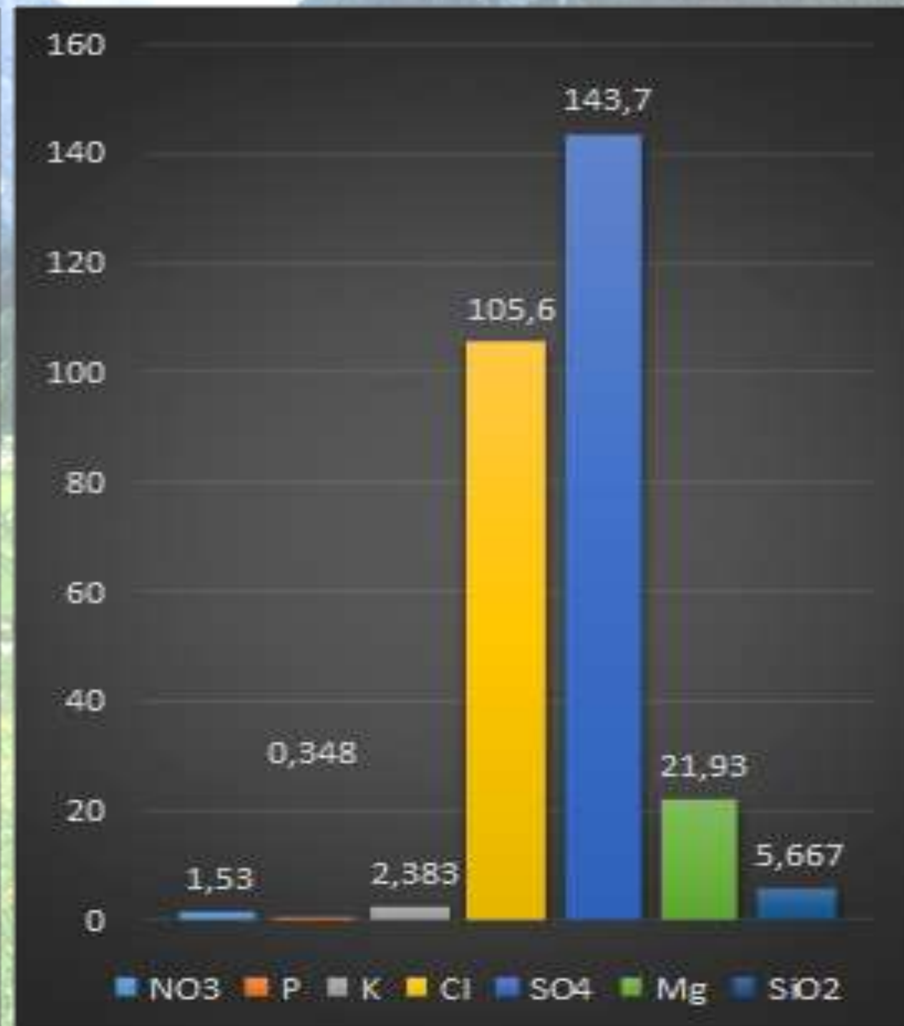
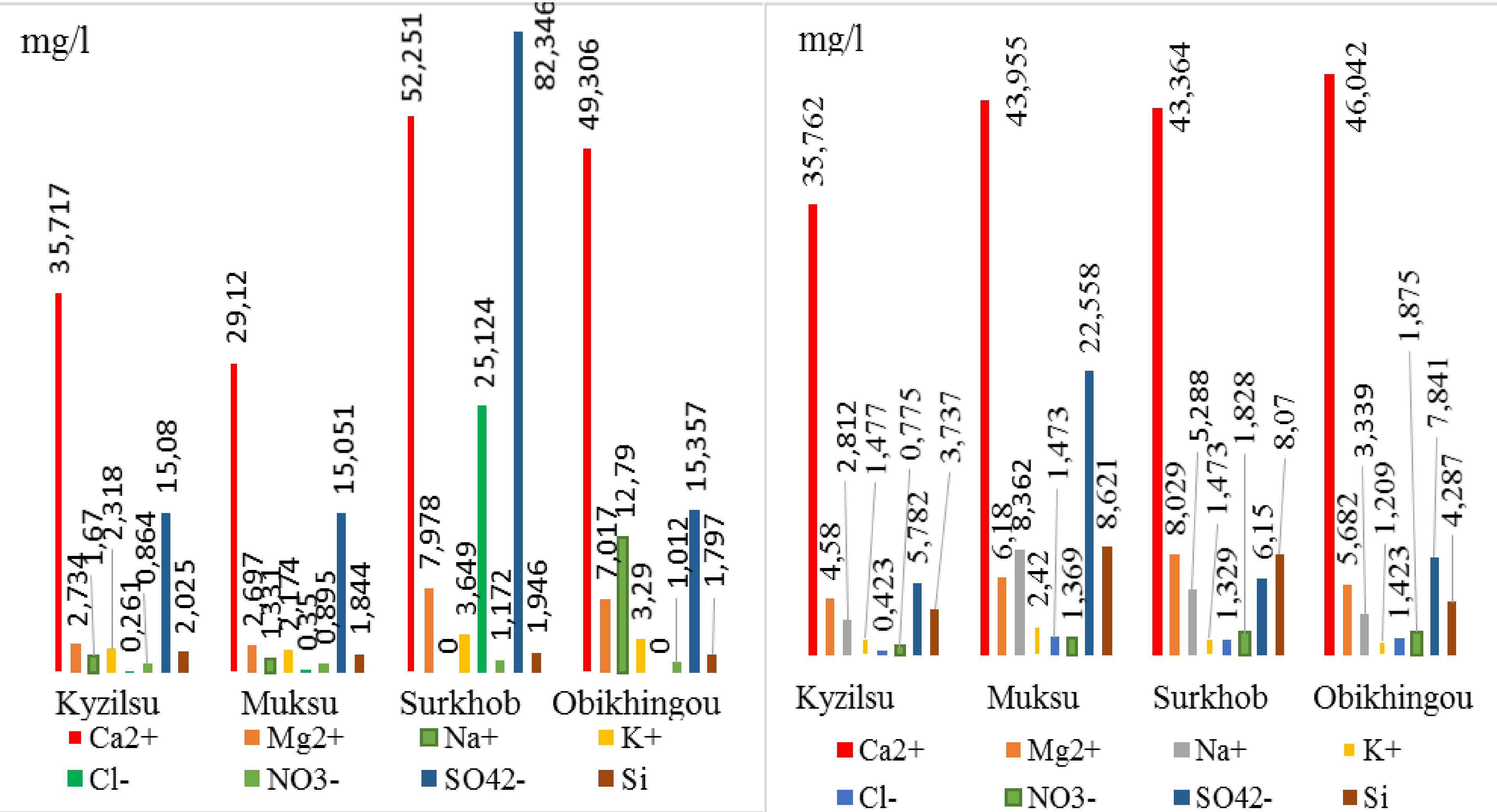
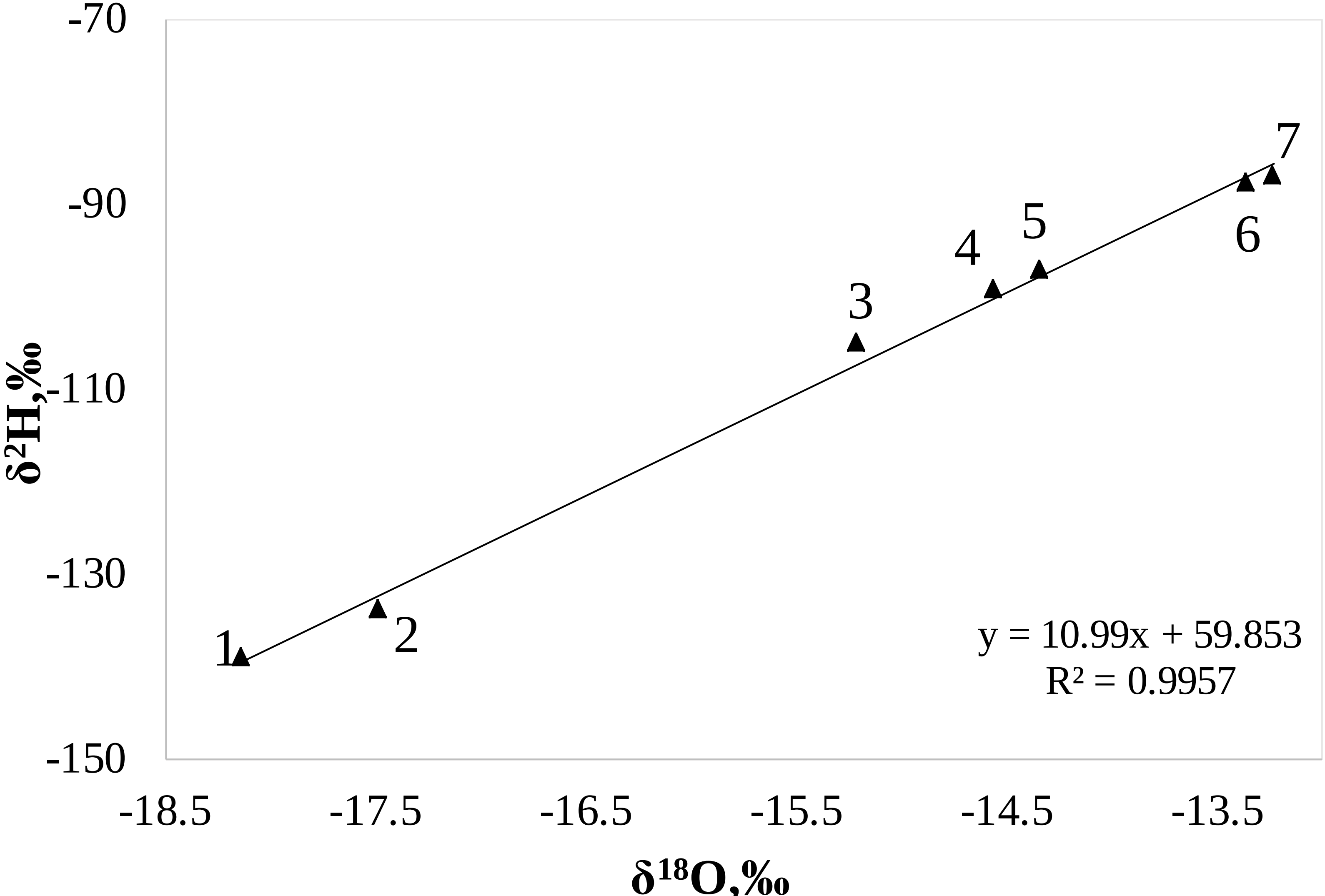
NO2
F
Zn
Pb
Cu
Cr
Cd
Fe
Mn
P(total)


160
140
120
100
80
60
40
20
0
1,53
0,348
2,383
105,6
143,7
21,93
5,667
NO3
P
K
Cl
SO4
Mg
SiO2

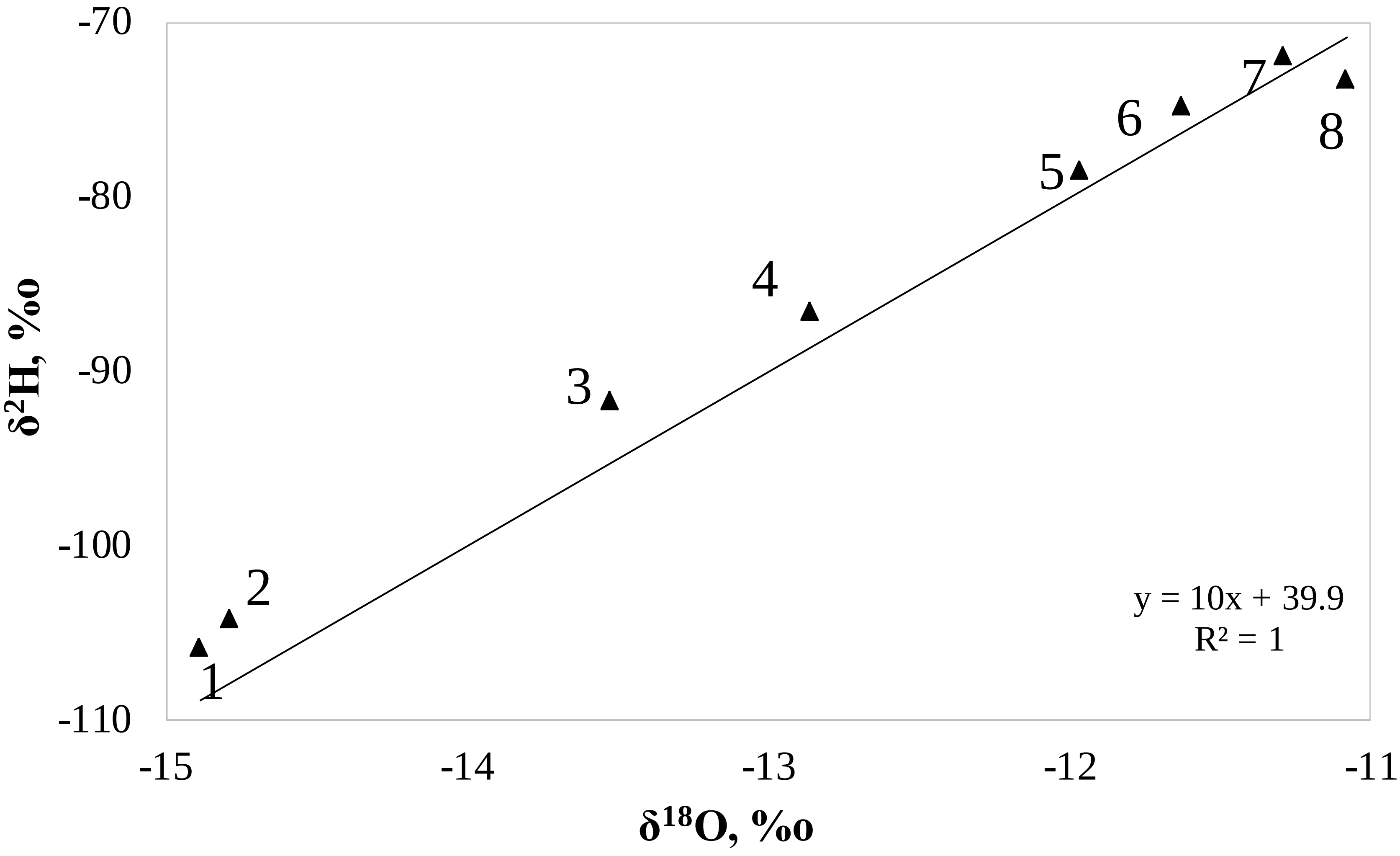
The results of chemical analysis of the waters of the tributaries of the Vakhsh river (a) and groundwater basins of these rivers (b)



Isotopic composition of water in the Vakhsh River and tributaries:
1, 2- Garmo glacier; **3** - Surkhob river; **4** – Vakhsh river; **5** –Obikhingou river; **6** – Kyzilsu river; **7** – river Muksu



Isotopic analysis of spring (**1, 3, 4, 5**) and underground waters **(2, 6, 7, 8**) the basin of the rivers Muksu, Kizilsu, Surkhob, Obikhingou, accordingly



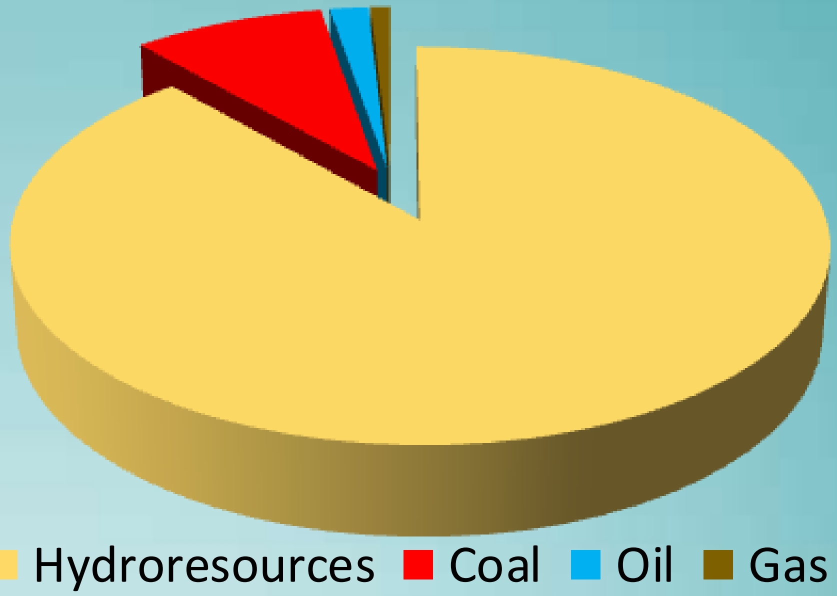
Conclusion

- For the period 1960-2017 it is observed that the water objects in the Vakhsh river basin is vulnerable to climate change.
- The increasing of the river water volume is the result of small glaciers melting.
- Using the cyclical change in the Vakhsh River water volume its value by 2030 is predicted
- The basins of the investigated rivers there are no stationary sources of pollution
- Formation of chemical composition of water is mainly due to the leaching of mineral rocks.

❖ Based on isotopic analyses observed: the main tributaries of the river Vakhsh (Surkhob, Obikhingou) have a glaciers feeds

❖ the reservoirs of underground waters of the Muksu river basin in period of the snowmelt accumulate glacial melt water. In the dry turn to water supply sources of the Muksu river

Reservoir → Microclimate → Agriculture



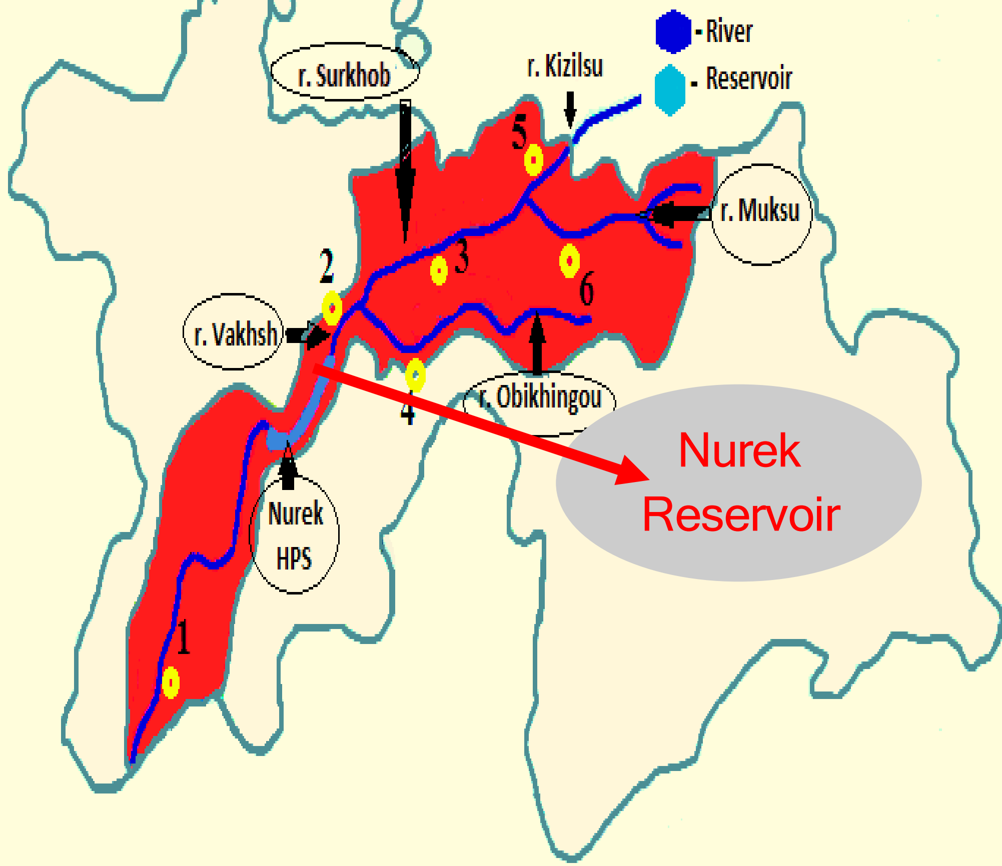
Republic of Tajikistan:

Hydropower resources - 527 Bln. kWt·h

Now used only - 5%

In perspective- construction many middle and large HPS with reservoirs

Vakhsh River Basin



Mirror area at the optimum highest mark of the water surface of the reservoir	**98 km^2**
Volume: full	**10.5km^3**
useful	**4.5 km^3**
Depth: maximum / average	**270 / 107 m**
The length of the coastline of the Reservoir	**234 km**
Water level at highest mark of the water surface of the reservoir	**910 m**

Efficient use of water flow to generate electricity depends on three main factors:

- the dynamics of changes in the volume of the reservoir
- the choice of the most optimal mode of operation of hydroelectric power plants
- hydrological forecast of water inflow

The Hydropost of Komsomolabad which measures the Vakhsh River water discharge is located at a distance of 70 km from the Nurek reservoir.

The lateral inflow from the Komsomolabad Hydropost to the Nurek hydropower station can reaches several tens of cubic meters per second that is more than 5% of the total inflow to the reservoir.

Direct measurements of lateral inflow were carried out only for several years in the 80s of the last century. Currently, it is not measured.

The efficiency of Hydropower station - maximization of power generation

The criterion efficiency - specific water consumption for the production of one kilowatt-hour of electricity:

$$q = \frac{367}{\eta \times H}$$

H - Water pressure, m

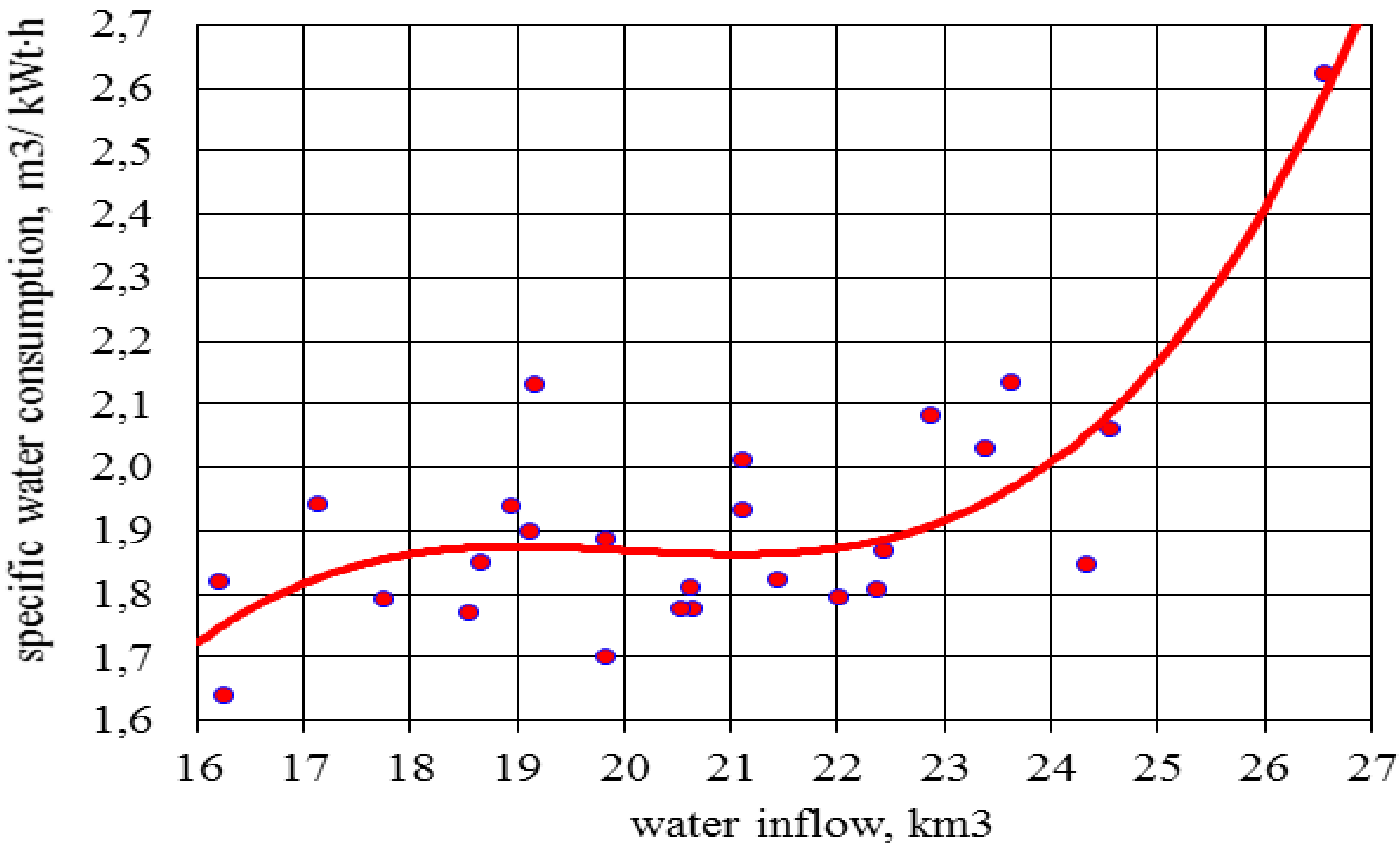
For Nurek HPS:

H = 230 м η = 0,866

Respectively:

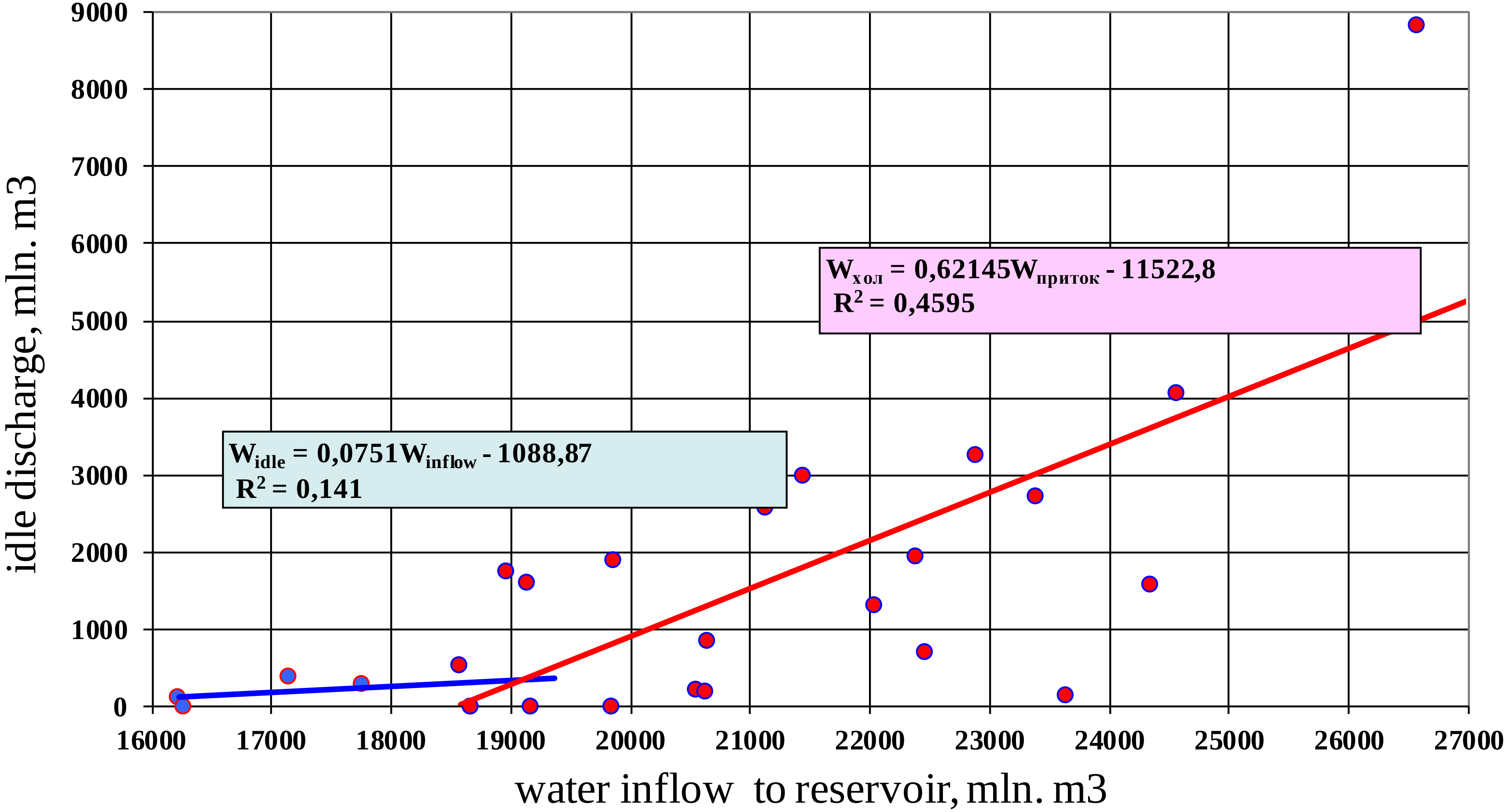
q = 1.84

Dependence of the specific water discharge on the generation of electricity from the inflow of water into the reservoir



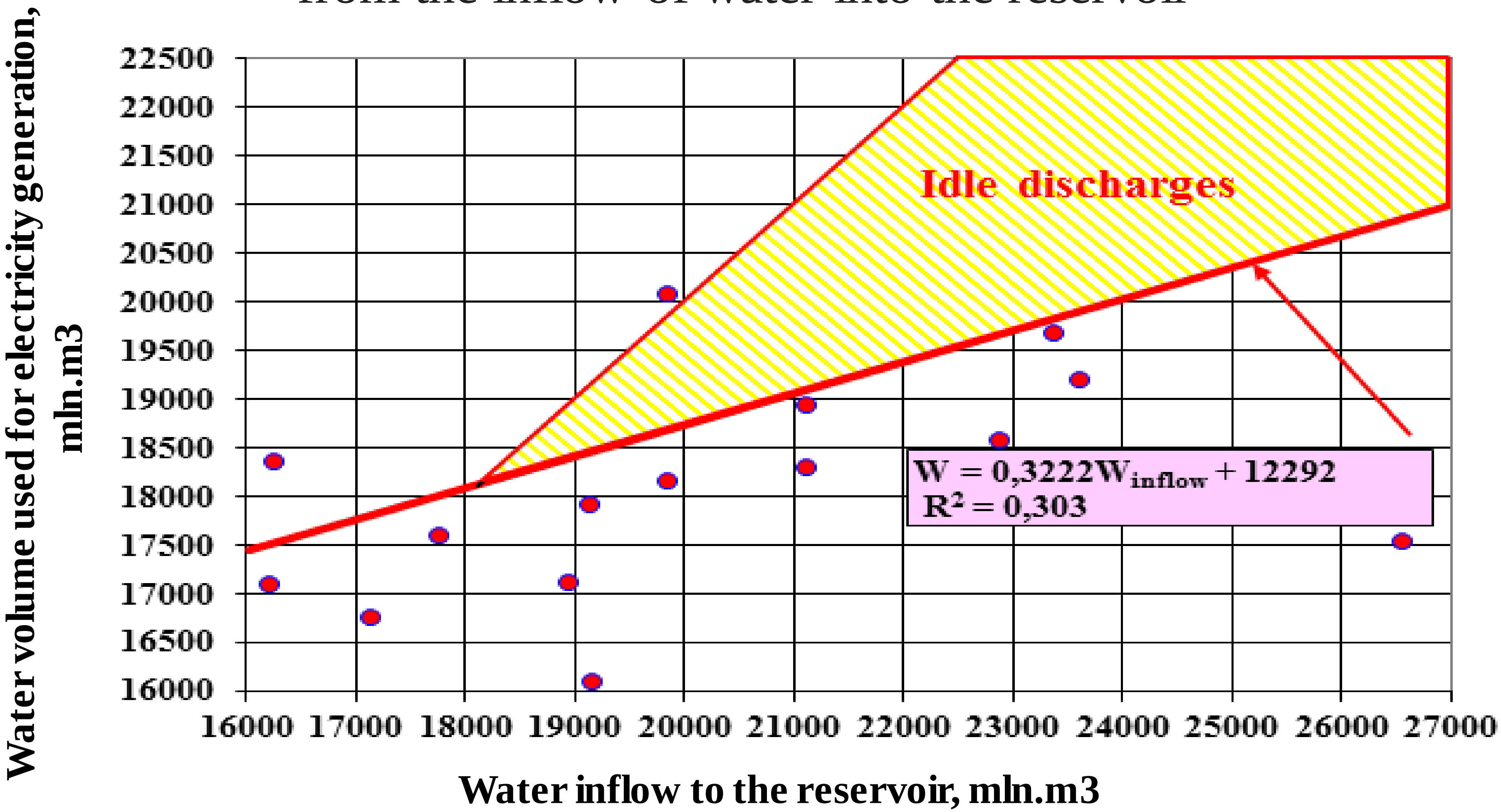
it is very important to note that in this slide there is a very large variation of **q** values for the same values of the inflow. For example, in the range of inflow **19÷20 km3** per year there are points (that is, years) in which **q = 1, 69 and q = 2.13.** It is impossible to explain it only by idle discharges. This suggests that, on average, for the considered period and especially in some years, the Nurek HPS hydroelectric power station was operating inefficiently.

Dependence of the idle discharge from inflow water to the reservoir



from the figure on the slide shows that only 18-19 km3 inflow water to reservoir at HPS without idle discharge used.

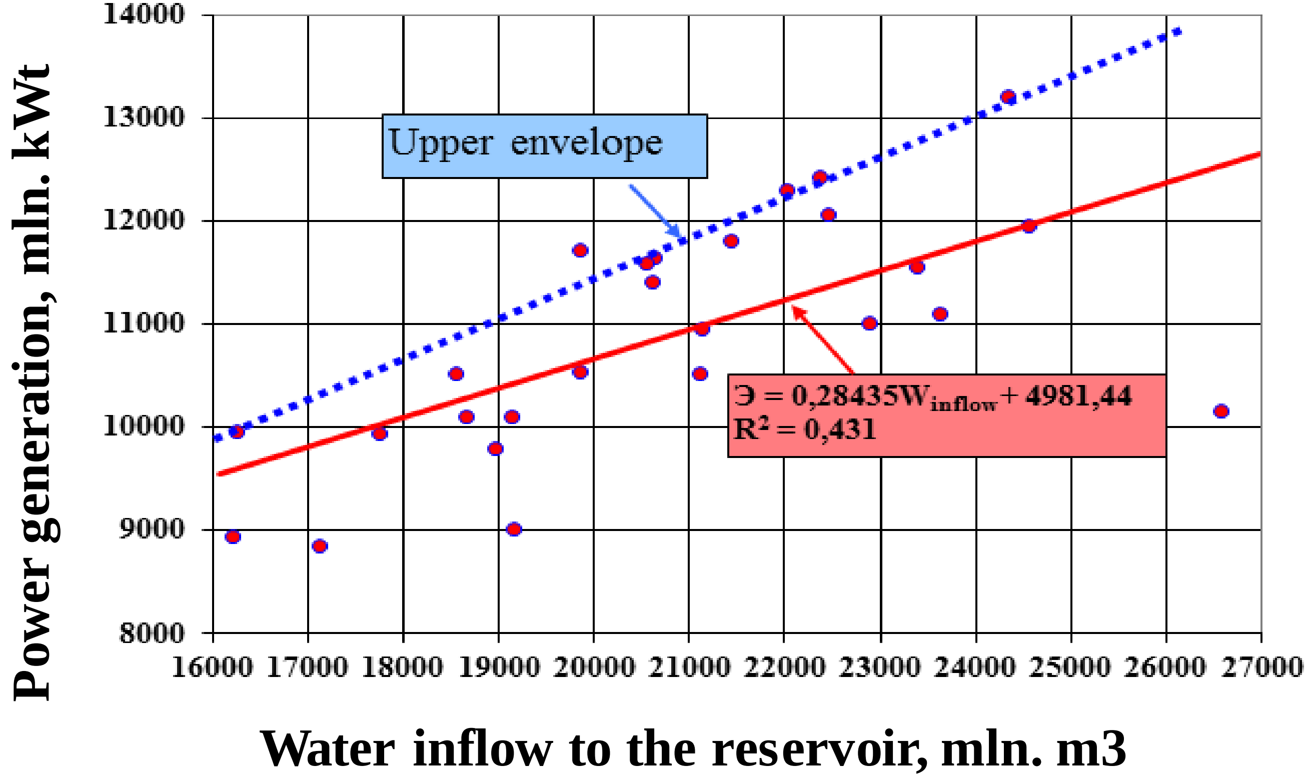
Dependence of the volume of water used to generate electricity from the inflow of water into the reservoir



For example, with a total inflow of 27 km3, the volume of useful runoff is already 21 km3. This shows that idle discharges with a reliable runoff forecast could be excluded at least at a total flow of 21 km3.

The decrease in electricity generation can be estimated in monetary terms. These economic losses are, in fact, the cost of a hydrological forecast.

The economic cost of hydrological forecast for hydropower



The figure shows both the average curve and the upper envelope of the dependence of the annual power generation of the Nuremberg HPP on the water inflow into the reservoir. The difference between them determines the loss of electricity due to inaccuracy of the hydrological forecast. These losses vary depending on the inflow from 0.5 to 1.5 TWt·h per year. For the long-term mean inflow 20 km 3 it is 1 TWt·h per year.

Conclusion

As the analysis of the results of the Nurek HPS shows, the efficiency of using water resources for power generation depends to a large extent on the accuracy of hydrological forecasts.

The cost of electricity losses due to inaccurate hydrological forecasts today, with an electricity tariff of **1 cent / kWt·h** already makes 10 million dollars, and further, at increase of tariffs to a normal world level **5 ÷ 10 cent / kWt·h** they will increase accordingly to 50 ÷ 100 million dollars per year

To a certain extent, these losses can be considered the economic value of the hydrological forecast at its 100-percent accuracy.

For establishment influences of Reservoirs on possible changes of Agroclimatic Resources we spend the analyses of climatic parameters of three districts with developed Agricultural branches (**Dangara, Fayzabad and Yavan**) adjoined to **Nurek HPS with reservoirs.**

Impact of Nurek Reservoir and Microclimate on irrigation norm for 1968-2017

Now for cultivation of agricultural grounds still use old norms of irrigation. For example, in Tajikistan for cultivation of cotton and Lucerne the following norms of irrigation are established.

- Cotton - 1100 m^3/ha
- Lucerne - 3000 m^3/ha

However during 1968-2017 meteorological conditions essentially changed

- ↓ T (°C) - 0.50
- ↑ Humidity (%) - 7.20
- ↓ Evaporation (%) - 17.00
- ↑ Precipitation (%) - 11.00

Unproductive losses of water more than **2000 m^3/ha**

1. Normatov P., Frumin G., Muminov A., Normatov I. The water isotope composition (δ2H, δ18O) of the transboundary Zeravshan and Vakhsh rivers and their tributaries // ***Geograph. Bull. 2017. №4 (43). P. 97–104. Doi 10.17072/2079-7877-2017-4-97-104***.

2. Muminov A., Kurbonov N., Normatov P. Study of Nurek reservoir impact on the meteorological conditions of agricultural districts of the Republic of Tajikistan // ***Sci. and New Tech. 2013.No.7. pp. 52-55.***

3. Normatov P., Normatov I., Muminov A., Narzulloev N. Ecological Aspects of the Transboundary Rivers Water Resource Management of the Central Asia //***Modern Env. Sci. & Eng. 2017, V. 3, No. 11, pp. 796-804 (ISSN 2333-2581)*****.**

4. Normatov I., Muminov A., Normatov P. The Chemical and Isotope Methods Application for Risk Assessment Contamination of the Main Tributaries of the Transboundary Amudarya River //***Intern. Proc. Chem., Biolog. & Env. Eng. 2017. V.101. No.16. pp. 113-120. DOI: 10.7763/IPCBEE***

5. Normatov I., Muminov A., Normatov P. The Impact of Water Reservoirs on Biodiversity and Food Security and the Creation of Adaptation Mechanisms // ***Intern. J. Env, Chem., Ecol., Geolog. & Geophys. Eng. 2016. V.10. No. 5. pp. 564-570.***

6. Normatov P., Markaev B., Normatov I. Monitoring of change of the Vakhsh river and tributaries hydrology in condition of climate change// ***Intern. J. Manag. & Appl. Sci. 2016. V.2. Is.10. pp. 55-58.***

1.

7. Normatov P., Muminov A., Normatov I. Interstate water resource risk management: Towards a sustainable future for Transboundary river basins of Central Asia// ***Proc. International Conference on Geography, Climate and Sustainability (ICGCS 2016), June, 26-27, 2016, Kuala Lumpur, Malaysia, pp. 108-115.***

8. Normatov P., Markaev B., Normatov I. Monitoring of change of the Vakhsh river and tributaries hydrology in condition of Climate change// ***Proc. International Conference on Natural Science and Environment (ICNSE), 21st-22nd August, 2016, Bangkok, Thailand, pp. 135-143***.

9. Normatov P., Armstrong R., Normatov I., Markaev B. Interstate water resource risk management: Towards a sustainable future for Transboundary river basins of Central Asia//***Proc. International Scientific-Practical Conference devoted to the summing-up of the "Water for Life" decade declared by the UNITED Nations, Almaty, Kazakhstan, September 22-24, 2016, pp. 227-241.***

10. Normatov P.I., Frumin G.T., Normatov I. Sh., Markaev B.A. Hydrochemistry and isotope composition of the Vakhsh river and tributaries // ***Proc. Rus. St. Hydromet. Univ. A theor. Research journal. 2018. Is. 50. pp. 81-87.***

11. Normatov P., Muminov A., Normatov I., Sadykov A. Risk Assessment and Risk management of accumulation of chemical pollution in seasonal snow and glaciers and their transportation by waterways // ***Proc. XVI World Water Congress, May 29 – June 02 2017, Cancun, Mexico. pp. 123-134.***

12. Normatov P., Normatov I., Markaev B. Modern State of the Transboundary Amudarya Main Tributaries// ***Proc. XVI World Water Congress, May 29 – June 02 2017, Cancun, Mexico. pp. 135-147.***

Now two dissertations are presented for defense:

Abulqosim Muminov. ***Geoecological assessment of surface waters and snow covers pollutions of the Vakhsh River Basin and Impact of water reservoirs on climatic conditions of coastal areas***

Bakhtiyor Markaev. ***Study of meteorological conditions, formation of the snow cover in the Vakhsh and Pyanj River Basins and their influence on the tributaries runoff***

NOTIFICATION OF CHAPTER ACCEPTANCE

February 06, 2018

Dear Professor Normatov,

On behalf of the Editorial Board, it is my pleasure to inform you that the manuscript titled:

Monitoring of meteorological, hydrological conditions and water quality of the main tributaries of the Transboundary Amu Darya River

has been accepted for publication in the book:

INTEGRATED RIVER BASIN MANAGEMENT FOR SUSTAINABLE DEVELOPMENT OF REGIONS

ISBN 978-953-51-5889-9

INTECH d.o.o. Rijeka

We firmly believe that your contribution will be of great importance for the scientific community.

RECOMMENDATIONS

Agencies of Hydrometeorology of the Committee for the Protection of Nature and the Environment under the Government of the Republic of Tajikistan:

To account of lateral inflow in the area from the Hydropost to the corresponding reservoir of Hydroelectric Power Station (HPS) and to increase the efficiency of the HPS units, it is necessary to increase the networks of meteorological and hydrological stations

Ministry of Agriculture of the Republic of Tajikistan:

- Taking into account the fact of the influence of reservoirs on the formation of the microclimate of the area, make appropriate adjustments to the norms of irrigation of agricultural varieties in the coastal areas to the reservoirs
- Stimulation of research and applied work on the selection of agricultural varieties resistant to climatic factors and easily adaptable to new meteorological conditions

Ministry of Water Resources and Energy of the Republic of Tajikistan:

Taking into account the efficient use of hydropower resources of rivers and taking into account the possibility of favorable orography of the same rivers for the construction of hydroelectric power stations with a reservoir, consider a scheme for the possibility of transferring water between rivers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«ОБ БАРОИ РУШДИ УСТУВОР


TECHNOLOGICAL SCHEME OF HYDROGEN PRODUCTION BY
ELECTROLYSIS OF WATER


Parameters used to calculate the chemical index and their weights


Число случаев с температурой t ≥ 40,0 °C по
десятилеткам, Худжанд


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КОНФЕРЕНСИЯИ ҶУМҲУРИЯВИИ ИЛМИ-АМАЛИ БАХШИДА БА
ДАҲСОЛАИ БАЙНАЛМИЛАЛИИ АМАЛ
«ОБ БАРОИ РУШДИ УСТУВОР (2018-2028)»
ТАЪСИРИ ТАҒЙИРЁБИИ ГЛОБАЛИИ ИҚЛИМ БА
КОМПОНЕНТҲОИ ЭКОСИСТЕМА
МОНИТОРИНГА ОКРУЖАЮЩЕЙ СРЕДЫ
РЕСПУБЛИКА ТАДЖИКИСТАН


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INTERNATIONA
WORKSHOP
RISK ASSESSMENT AND RIS
MANAGEMENT OF WATER RESOU
IN TRANSBOUNDARY RIVERS BAS
OF CENTRAL ASIA


Thank You for Your Attention