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ASSESSMENT OF LAND MANAGEMENT AND IMPLEMENTED PROJECTS IN THE MUGHAN PLAIN

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Abstract. The Mugan Plain is a vast, flat area of strategic and agricultural importance located in southeastern Azerbaijan, between the Kura and Araz rivers. This article analyzes the natural and geographical features of the Mugan Plain, including its topography, climate, soil, and water resources. It examines the large-scale land reclamation and water management projects implemented in the Mugan Plain, particularly during the tsarist period, to develop cotton production. Information is provided on the problem of soil salinization resulting from the rapid expansion of cultivated areas and on the construction of drainage systems to prevent it. The article also examines the construction and operation of the Jafarhan experimental station, as well as errors made in the design and implementation of collector and drainage systems. The Mugan-Salyan water supply system and its operating mode, the purpose of constructing the Main-Mil-Mugan collector, and the significance of these infrastructures in terms of water use regulation are discussed. The article also provides a detailed analysis of why irrigation and drainage systems have not performed as intended over the past 40 years. Finally, it provides extensive information on proposed measures to efficiently use arable land and water resources.

Keywords: canal, irrigation water, aquifers, collector, water yield, soil loss, efficient use

Key findings: The natural conditions of the Mugan Plain have made irrigated agriculture the dominant form of land use. Rapid agricultural expansion caused soil salinization due to inadequate drainage systems. Major water management infrastructure has played a key role in regulating water use, but has not functioned effectively for decades. The article examines the problems in detail and puts forward ideas and proposals for the sustainable use of land and water resources and the modernization of irrigation and drainage systems.

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1. Introduction: The Mugan Plain covers the territory from the state border with the Islamic Republic of Iran, along the right bank of the lower reaches of the Kura and Araz rivers, to the Caspian Sea (Fig. 1). The territory is divided into the Talysh-South Mugan Plain, the North Mugan Plain, covering the vast delta of the Araz River, and the Salyan Plain near the mouth of the Kura River [1, 4]

Fig.1. Schematic plan of the Mugan Plain in 1869

On the Mugan Plain, the slope of the earth's surface decreases towards the Caspian Sea. On the Salyan Plain, it is about minus 22.0–28.0 m. In general, the height of the earth's surface on the Mugan Plain fluctuates between minus 28.0 m and plus 10.0 m.
The climate is of the semi-desert, dry-steppe type. The average monthly air temperature is 14.0–14.50 °C. The maximum temperature is 42.00 °C, and in frosty weather - minus 26.00 °C. The average annual precipitation is 250–300 mm, and the average annual evaporation is 1000–1200 mm (Table1).

Table 1. Natural and Geographical Features of the Mugan Plain

Parameters	Indicaters
Geographical Location:	Located in the southwestern part of the Kura-Araz Lowland
Area:	Approximately 450,000 hectares
Climate Type:	Dry subtropical (hot summers, mild winters)
Average Annual Precipitation	250–350 mm
Main Soil Types:	Gray-brown soils, gray soils, and solonchaks
Main Water Sources:	Kur and Araz Rivers, groundwater

Harvesting on the Mugan Plain without irrigation is impossible. Starting from the end of May, with warming, the normal development of plant root systems ceases due to a lack of water in the upper soil layer. If water does not reach the cultivated lands, fertile lands become unsuitable for human use. Arable lands are valuable when there is irrigation water [2,3,4].

Historians of the 19th century described the Mugan Plain as a green steppe and a sparsely populated region in the first spring months. Chroniclers who visited the Mugan and Mil Plains in the summer months called this region a desert. The Mugan Plain is a vast territory, the surface of which is so smooth that in summer you can see apples fallen on the ground from afar. In autumn and winter, the formation of a green cover turned it into a wintering place for people engaged in cattle breeding [1,2,3].

The Mugan Plain includes the territories of the Saatli, Sabirabad, Bilasuvar, Salyan, Neftchala and partly Imishli districts. Human food products are created when arable land comes into contact with water: “Soil + water = forage plants = wildlife = harvest.”

2. Materials and methods. The history of irrigation and land reclamation activities carried out by the population living mainly along the banks of the Araz and Kura rivers in the Mugan Plain dates back to ancient times. Local residents directed water into canals, which they drew during the spring floods. Using the water reserves accumulated in the canals and ditches, they irrigated the crops they grew several times. These canals, which remained dry during the rest of the year, were called "dry ditches". In later years, water wheels installed on the rivers were used. Camels, horses and oxen were used to drive the wheels. In the second half of the 19th century, there were about 4,000 water wheels in the Mugan Plain [9,10].

Mechanical irrigation of the Kura River began in 1900 with a pump installed near the city of Salyan. In 1904, 5 pumping stations brought from Germany and England were located on the banks of the Kura River. In 1915, 50 thousand hectares of cultivated land were provided with irrigation water by about 100 pumping stations installed on the banks of the Kura River, of which 25 thousand hectares were used for growing cotton.

M. Avdiyev wrote in his work "Mugan-Salyan Plain", published in Baku in 1927: "In the 1860-1870s, there was not a single settlement in the middle part of the Mugan Plain where the population lived permanently. Lands suitable for cultivation served as a temporary place of residence for people engaged in cattle breeding in the winter months [2,3].

The Mugan Plain was annexed to the territory of the Russian state according to the Treaty of Gulistan, concluded between Tsarist Russia and the Islamic Republic of Iran in 1823. By the end of the 19th century, cotton, considered the main raw material for the textile industry developing in Tsarist Russia, was mainly purchased abroad. Beginning in 1861, the selling price of cotton in the world increased by about 4-5 times, and the Tsarist government, having assessed the current situation, began research and exploration work in Azerbaijan and the Central Asian regions in order to increase cotton production within the country [7,9].

Researchers assumed that the Mugan Plain had favorable natural conditions for cotton harvesting due to the receipt of water from the Araz River and the construction of canals.

Thus, in 1900, melioration and water works began to increase cotton production in Azerbaijan. In accordance with the colonial policy, priority was given to attracting labor, mainly from Russia, to the Mugan Plain, located on the border with the Iranian state. For the complete development of territories with fertile lands, a policy of settling Russians among the population of the same nationality was carried out [2,7,8,9].

In the Mugan Plain in 1900-1915, the main canals of Sabir (Upper Golistin), Mursalli (Lower Mugan), Narimanov (Middle Mugan) and Azizbekov (Upper Mugan) were built, through which water from the Araz River flowed (Fig. 2)

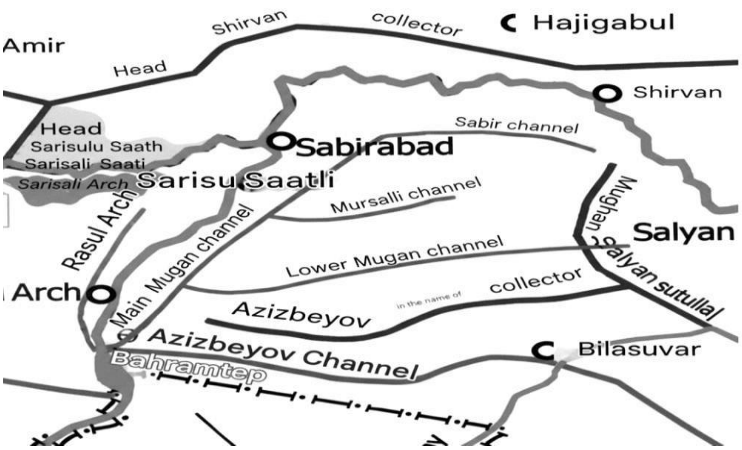

Fig.2. Schematic plan of the Mugan Plain in 1970

Under the influence of these canals, in 1917, 26.5 thousand hectares of cultivated land were provided with irrigation water for growing cotton. The total length of canals laid in the river bed was 297.2 km. The canals were laid mainly using manual labor and other tools, which was due to the physical strength of the builders. New settlements and villages were created for the workers. In 1900-1915, 14 villages with a predominantly Russian population were built in Northern Mugani, and 20 in Southern Mugani, which were given Russian names [6,9,10,11].

It follows from the research that after the completion of the construction of 4 main canals, it was predicted that 162.3 thousand hectares of cultivated land would be provided with irrigation water in volumes corresponding to the need for water, but the harvest was only collected from 26.5 thousand hectares. Thus, the water level in the Araz River regularly rose during the summer months. Since the corresponding hydraulic structures were not built at the water intake points of the main canals, the entrances were temporarily closed with wood and other materials to prevent water from entering the canals. After the water level in the river dropped, it was necessary to clear the canal entrances from accumulated sediment. It took about 20-30 days to complete this work manually. Due to delays in the irrigation regime during cotton cultivation, problems arose in the development of crops. Crop plants were destroyed or seriously damaged at the initial stage, and the expected yield was very low. Lebedev N.A. In his work "Irrigation Management of Mugani", published in Tbilisi in 1918, he wrote about the Lower Mugan Main Canal (now Murselli): "The residents of the Lower Mugan main Canal's influence zone are dissatisfied and unhappy…, there is not enough water, the untimely provision of fields with irrigation water in the required volumes has become chronic, there has not been a single year when irrigation was carried out according to the norm" (Mustafayev *et al*., 2025; Ahmadova *et al*., 2025; Mustafayev, 2012; Mustafayev, 2015; Mustafayev *et al*., 2022; Zhapayev *et al*., 2023).

After the overthrow of the tsarist government in Russia in 1917, a certain part of the forcibly displaced Russians, taking advantage of the uncertainty that arose before 1920, returned to their native lands.

An average of 8 centners of crops were harvested from one hectare of cotton crops. In 1921, 552.7 thousand hectares of cultivated land were irrigated on the territory of the Republic of Azerbaijan. Cotton was grown on 124 thousand hectares of irrigated land, of which 36 thousand hectares were in the Mugan Plain, 35 thousand hectares in the Shirvan Plain, and 23 thousand hectares in the Mil-Karabakh Plain [2,3].

The foundations for the use of tractors on irrigated lands were laid in the Mugan Plain. In 1923-1925, 18 thousand hectares of land were cultivated by tractors imported from America, Germany, and Czechoslovakia. The first tractor base in the Soviet Union was created in Mugan. In 1926, the Mugan Land Reclamation Construction Department was created, which carried out land reclamation construction in Mugan.

3. Results and discussion. During the period of effective use of arable land in the Mugan Plain, that is, in the first years of the 20th century, a decrease in the yield of crops was observed from year to year. In 1901–1904, specially created commissions conducted ground research and established that the process of salt accumulation began in the upper part of the soil in cultivated areas used by plants. It was from these years that the term "soil salinization" began to be used in melioration. The main cause of soil salinization was the irrigation of cultivated areas. Under the influence of irrigation water supplied to cultivated areas in excess of the norm, infiltration waters from canals laid in the river bed, and water seeping into areas along the river during the spring flood, the process of salt accumulation in the plant layer began as a result of groundwater with a mineral content of 5–50 g/l, located at a depth of 3–4 meters from the surface of the earth, approaching the surface of the earth. Over the years, the degree of soil salinization has increased. As a result, the yield of cultivated plants decreased year after year [8,9].

Thus, a more complex problem arose – land reclamation in cotton-growing regions, the solution of which required large funds. To flush saline soils of salts, it was necessary to build collector-drainage systems and carry out large-scale flushing works.

Specialists of the tsarist government began implementing the project in Turkmenistan in 1912, and in 1914, in the territory of the village of Jafarhan, now the Saatli district. The implementation of the project was suspended due to the First World War. In Soviet times, the construction of the Jafarhan drainage system station was completed in 1929-1931 (Fig.3).

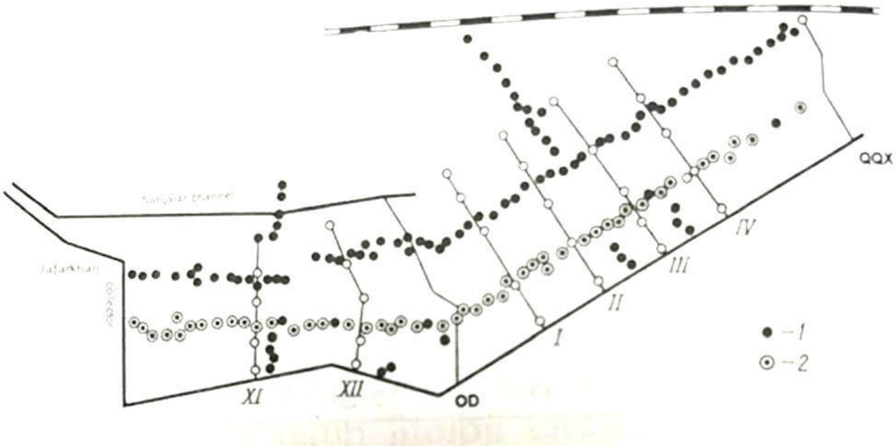

Fig.3. Schematic plan of the Cafarkhan experimental station

Based on the results of the research conducted at the Mugan experimental field, the construction of collector-drainage systems began throughout the Mugan Plain. It should be noted that mainly open-type drains were built on the plain

The results of numerous studies conducted in subsequent years showed that serious shortcomings were made during the capital flushing. Salt water collected from drains built in certain areas of Mugan was collected in collectors and discharged to neighboring areas. That is, in a certain part of the territory, the soil was cleared of salts, and in another part, it caused soil salinization. This process lasted from 1931 to 1953. The construction of the Mugan-Salyan water collection collector, which will discharge drainage water built on the Mugan Plain into the Caspian Sea, was carried out in 1950-1953 and was put into operation in 1953. The collector's impact area was 172 thousand hectares (Fig. 4).

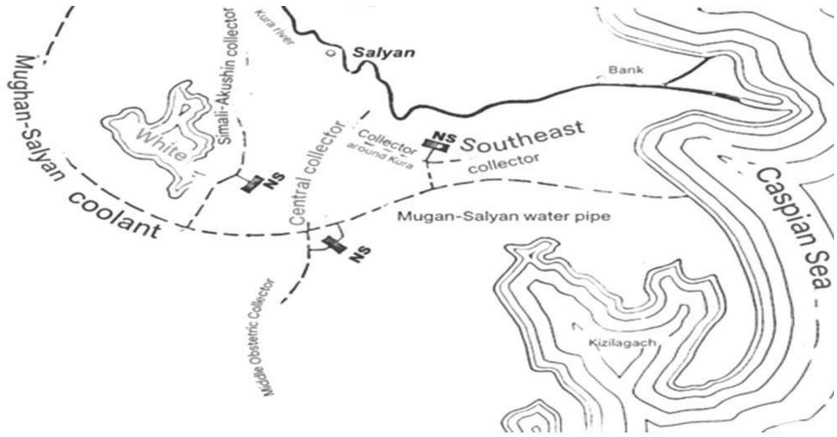

Fig.4. Schematic plan of collectors built on the Mugan-Salyan plains

The Mugan-Salyan watershed, starting from Northern Mugan, passes through the Middle Akushin Highlands and is discharged into the Caspian Sea by a pumping station built in the village of Sarygamysh in the Neftchala district.

The length of the watershed is 875 km, the water flow at the beginning is 21.0 m³/sec, at the mouth, 36.0 m³/sec. The total water flow at the pumping station is 21.0 m³/sec.

Since the watershed, 56 km long, up to the pumping station is semi-dugout and semi-fill, certain problems are observed in this section. Since 1970, the volume of melioration activities carried out on the Mugan Plain has increased from year to year, so the average annual flow rate at the pumping station was observed in 1954 at the level of 6.7 m3/sec, in 1959 - 12.3 m3/sec, in 1968 - 22.73 m3/sec, in 1970 - 27.19 m3/sec, in 1978 - 55.03 m3/sec. When considering the average observation data by month during the year, it becomes clear that in March 1968, the flow rate was 93.7 million m3, and the average monthly flow rate was 34.98 m3/sec, which is 60 percent more than the pumping station indicators (21.0 m3/sec). Since 1962, in the 3-4th months, the process of rising water level along the length of the reservoir towards the source was observed, as a result of which the reservoir did not operate in accordance with the design indicators. That is, the groundwater level in the adjacent territories rose. The process of soil salinization in the plant layer began on arable lands. Professor Alimov A.K. presented observation data on the average annual groundwater level and its mineralization in the territories affected by the Mugan-Salyan reservoir in the 1930s-1990s in tabular form.

When considering the indicators given in the table, it becomes clear that in 1930, the average depth of groundwater on the Mugan Plain was 3.84 m, average mineralization was 37.15 g/l, and in 1980 these indicators were 1.78 m in depth and 22.6 g/l in mineralization. That is, over the past 50 years, the depth of groundwater has increased by 2.0 m, and mineralization has decreased by 14.55 g/l.

Since 1930, the area of irrigated land on the Mugan Plain has increased, and the groundwater level has approached the surface due to the influence of irrigation water and filtration water from canals. The decrease in mineralization is due to the influence of drainage systems put into operation. Studies have shown the need to build a new collector on the Mugan Plain to discharge mineralized water collected from drainage systems into the Caspian Sea. Construction of the Main Mil-Mugan Collector began in 1984 (Fig.5).

Fig.5. Schematic plan of the section of the Main Mil-Mugan collector passing through the Mugan plain

It is planned that this collector will start in the Shamkir region on the right bank of the Kura River and will drain water from the collector-drainage systems of the Kura-Araz plain into the Caspian Sea.

The length of the collector in the upper reaches is 59 km: the first section was completed in 1994, to the Araz River, with a length of 52.7 km; the second section was completed in 2000, and the third section, with a length of 31.7 km, to the junction with the Mil-Karabakh collector, was put into operation in 2006

In connection with the connection of the Mugan-Salyan water pipeline to the Main Mil-Mugan collector in the upper reaches of the first section, the operation of the pumping station in this section was stopped. Thus, the consumption of electricity allocated to the pumping station ceased. The problem caused by the long-term rise in the water level in the upper section of the Mugan-Salyan aqueduct has also been eliminated (Table 2).

Table 2. The economic and environmental impact of the reclamation measures was assessed using the following indicators

Indicator	Before Project	After Project	Percent Change
Soil salinity level (g/L)	4.8	2.1	-56%
Groundwater depth (m)	1.2	2.4	+100%
Crop yield (c/ha)	18	32	+77%
Irrigation efficiency (%)	45	68	+23%

Since the beginning of the construction of the Main-Mil-Mugan collector (1984), its upper section has been in operation for 40 years. 25 years have passed since the construction of the section 20-30 years. Thus, the existing drains, culverts, and collectors in the influence zone of the Main-Mil-Mugan collector no longer function in accordance with the design parameters. Almost the majority of melioration structures built on the Mugan plain need reconstruction. Water losses from the canals of the existing irrigation systems amount to about 50 percent. Due to the fact that the irrigation and collector-drainage systems are built in an open way, the existing arable land is used inefficiently. 60-80% of the land in the cultivated areas is saline to varying degrees. The average depth of groundwater is about 1.2-1.5 m.

4. Conclusions. The conducted research and observations show that the technical condition and operation of the existing irrigation and collector-drainage systems in the Mugan Plain limit the possibilities for the efficient use of land resources. In this regard, to increase the productivity of cultivated lands and improve the melioration condition of the lands, it is proposed to implement the following measures:

Improvement of irrigation canals: To prevent water losses in open-type irrigation canals, it is necessary to reconstruct the main and field canals using modern technologies, and design field canals using a closed structure. It is necessary to limit the use of surface irrigation methods and expand the use of progressive irrigation technologies, such as drip and rain irrigation

Modernization of drainage systems: To effectively drain ground and surface water entering the territory, it is necessary to build drains and field culverts of a closed structure, which will create conditions for putting additional crop areas into operation.

Reconstruction of auxiliary hydraulic structures: Outdated hydraulic structures on existing collector-drainage and irrigation systems must be reconstructed in accordance with modern technical requirements, and control systems must be automated.

As a result of the implementation of these measures, more efficient use of arable lands of the Mugan Plain will be ensured, the melioration condition of the lands will be improved, and agricultural productivity will be increased.

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Data Availability. The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Conflict of Interest. The authors declare that they have no competing interests or conflicts of interest.

Ethical Approval. This article does not contain any studies involving human participants or animals performed by any of the authors.

Informed Consent. Not applicable.

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