Water Usage and the Feasibility of Water Fees Along the Lower Reaches of the Ili River: The Case of Bereke Village

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Introduction

The development of irrigation agriculture along the lower reaches of the Ili River is dependent on the Kapchagai man-made reservoir (28 cubic km maximum capacity), built along the middle reaches of the river in 1966 and used for water storage since 1970. This reservoir serves two purposes, to act as a source of hydroelectric power generation, and to provide a stable supply of irrigation water. Since its inauguration, water resource utilization has increased along the lower reaches of the Ili River. As a result of this, water inflow into Lake Balkhash has gradually decreased, affecting the lake's natural environment and water system.

The word Balkhash means "muddy water" in the Kazakh language. Like its name, the water in the Ili River's mouth becomes remarkably clouded because the western area of the lake, into which the river flows, is shallow. Lake Balkhash is divided into a western area and an eastern area by the Saryesi Peninsula (21 km length) and the Uzunaral Strait (4 km length). The mouths of the Ili, the Karatal, the Aksu, and the Lepsy rivers, which flow into the lake, are situated on the southern shore. The inflow from the Ayaguz and the Tokrau rivers, whose mouths are located on the north shore, has low volume. The lake's drainage basin area is approximately 400,000 square km in Kazakhstan and nearly 101,000 square km in China. There is no downstream river from Lake Balkhash. Therefore, the lake's water level is dependent on the balance between evaporation and precipitation plus river water inflow. Annual evaporation is approximately 1,000 mm and annual precipitation is around 200 mm. Therefore, decreases in river inflows bring about a decrease in the lake's water level.

The water level has decreased by 1.8 meters, from 342.3 meters in 1970 to 340.5 meters in 1987. When the water level was 342 meters, the lake's surface area was 18,200 square km, the maximum length was 614 km, the maximum width was 74 km, the maximum depth was 27 meters (in part of the eastern area), the average depth was 6 meters and the water volume was 106 cubic km. When the water level was 340 meters, the lake's surface area was 14,120 square km and the water volume was 72.7 cubic km.

Since Lake Balkhash is shallow and lacks an outflow river, the decrease in water levels has resulted in a deterioration of water quality along with a decrease in water volume. Although the salt content was 1.21 grams per liter in the western area and 3.85 grams in the eastern area in 1970, in 1987 it increased to 2.02 grams in the western area and 4.83 grams in eastern area. Moreover, the amount of dissolved nitrogen in the river's water has increased. Large amounts of nitrogen fertilizers have been used in irrigation agriculture; therefore, the drainage water from irrigated fields contains nitrogen ingredients. When the overall irrigation area increases, the overall level of nitrogen ingredients inflow rises. In this report, however, the contamination issue will not be examined; instead, water usage, especially the volume of water used, will be investigated.

The gross annual inflow from rivers into Lake Balkhash is 24.5 cubic km of which the Ili River accounts for 78.2 percent. The utilization of water resources in the Ili River basin increased from 2.3 cubic km in 1970 to 5.0 cubic km in 1982. The greater part of usage is for agriculture. Certain amounts of used water resources do not flow back into local rivers. The reasons behind this water loss are the following: evaporation from the surface of rice paddies and the Kapchagai man-made reservoir; leakage of water from canals; and the disappearance of drainage water into deserts because of imperfections at the end of drainage canals. Such "missing" water amounted to approximately 1.9 cubic km in 1982.

Moreover, the irrigated area increased considerably at that time. We can see the irrigated area of Alma-Ata province and Taldy-Kurgan province, which nearly coincide with Lake Balkhash's drainage basin. The irrigated area in Alma-Ata province was 239,400 ha in 1970 and 335,300 ha in 1988, an increase of 95,900 ha. Similarly, in Taldy-Kurgan it increased from 229,200 ha to 300,400 ha, a rise of 71,200 ha.

The development of irrigation in the Akdalinsk area along the Ili River's lower reaches began in the 1970s. The following is a brief overview of the situation in Bereke Village, located in the Akdalinsk irrigation system.

Bereke Village - History and Agricultural Production

Bereke is the name of a Kazakh aul (nomadic residence). It is situated in the Ili River basin about 40 km northwest from Bakanas Town, which is the center of the Balkhash District (*raion*). There is a sovkhoz and a stockbreeding complex in Bereke.

In 1979, the sovkhoz, which was named "25 years of virgin land development, (*XXV let tseliny*)" was constructed as a typical rice production farm. Its principal crop was rice; other crops included barley, wheat, fodder (mainly alfalfa), sunflower, watermelon, tomato, etc. At first, 5000 ha of rice paddies were planned. The construction cost was 39,263,000 rubles. Before its construction, groves of Saksaul and tracts of desert extended as far as one could see and sheep grazed in Akdalinsk.

The stockbreeding complex has 1,203 head of cattle and 153 horses. There are 30 workers. According to its 1992 financial statement, it had a loss of 297,000 rubles on earnings of 2,807,000 rubles and expenses of 3,104,000 rubles.

In 1992, Bereke's population was 1,669 (842 males and 827 females). There were 380 children under the age of 7. There were 96 people aged 65 years or older. There were 353 students attending school. There were 348 households. Most of the households had one or two cattle and four or five sheep. Nearly 90 % of the village's population was Kazakh. It was a young village.

The village's total area is 15,462 ha. In 1992, the amount of irrigated farmland was 5,172 ha, of which 2100 ha were rice paddies. According to the 1993 sowing plan, rice cultivation amounted to 2,100 ha, barley 600 ha, wheat 500 ha, and fodder 1958 ha.

The crop rotation was mainly the following: first year - rice, second year - rice, third year - barle y or alfalfa, fourth year - alf alfa. This sovkhoz had 101 tractors, 67 combine harvesters and 53 trucks. There were 450 workers, 32 of whom belonged to the administration department. There were five work groups (*brigada*) and one work unit (*zveno*) in the sovkhoz. 15 workers drove machines.

The fifth smallest work group managed an area of 710 ha of which rice amounted to 325 ha, barley 140 ha, sunflower 75 ha, and alfalfa (*liutserna*) 170 ha. The managed area was divided into seven sections. The first three sections were used for rice; the fourth and fifth sections were used for barley, the sixth section was used for sunflowers, and the seventh section was used for alfalfa.

From 1990 to 1992, the sovkhoz's financial results were in the black. The earnings and expenses in 1990 were 13,273,000 rubles and 11,813,000 rubles respectively; in 1991, 24,373,000 rubles and 20,110,000 rubles respectively; in 1992, 70,609,000 rubles and 60,903,000 rubles respectively. According to the sovkhoz's director, Mr. Amangerdy, the construction costs were recouped in ten years. In those days, only rice and barley from the sovkhoz were purchased by government orders (*goszakaz*).

In 1992, the rice production was only 7,980 tons (unhulled rice) due to unfavorable weather. The average yield was 3.8 tons per ha. In addition, 16 % of rice production was abandoned as waste. Government orders for rice were 5000 tons. Seed rice for the following year was 800 tons. Therefore, there was a surplus of 903.2 tons.

The following Table shows main crop production results in Bereke from 1981 to 1985.

Although the gross sown area and gross yields for the first five years increased smoothly, the average yields fluctuated because of unseasonable weather. When these figures are examined, it is questionable whether the director's assertion that the construction costs were recouped in ten years is true or not.

Table 1.

	1981	1982	1983	1984	1985
gross sown area (ha)	2,189	3,077	3,654	4,154	4,769
in which rice (ha)	1,800	2,000	2,030	2,500	2,850
barley (ha)	200	780	750	800	1,100
fodder(ha)	—	117	379	398	590
gross yields					
rice (ton)	4,000	4,118	6,212	8,925	9,092
barley (ton)	347	1,285	1,275	1,000	1,446
fodder(ton)	—	385	1,406	1,350	1,263
average yields					
rice (ton/ha)	2.22	2.06	3.06	3.57	3.19
barley (ton/ha)	1.74	1.65	1.70	1.25	1.31
fodder (ton/ha)	—	3.29	3.71	3.39	2.14
delivery to government					
rice (ton)	3,055	1,851	3,986	4,290	6,381
barley (ton)	309	932	911	733	1,170
proceeds					
rice (thousand rubles)	1,039	905	1,375	2,282	2,765
barley (thousand rubles)	43	198	222	168	210

Water Use and the Irrigation System in Bereke

Balkhash District is situated in an arid and desert region along the Ili River. Annual precipitation in Bereke is approximately 200 mm. It is cold and snowy in the winter. There is less than 20 mm monthly precipitation during the summer season. Therefore, rice cultivation depends on irrigation water whose source is the Ili River.

The flow to the lower reaches is adjusted by the Kapchagai man-made reservoir, which is situated along the middle reaches of the Ili River. Irrigation water diverted from the Ili River is conveyed through a principal canal; the sluice gate is situated in the southern suburbs of Bakanas, on the river's right side.

The length between the sluice gate and Bereke is approximately 67 km. Bereke is situated at the end of the principal canal. Its construction was started in 1977 and finished in 1981.

The department of water resources in Balkhash District manages the canal. The date for starting the water's intake for irrigation is decided at a conference, usually held in Bakanas, among hydro-engineers (*gidromeliorator*) from each sovkhoz. Water intake usually begins during the first ten days of May and finishes in the first ten days of September.

The demand for water is estimated by calculating the standard water requirements for each crop and the area of land being irrigated. The volume of required water is presented to the water resources department. The department requests the sovkhozes to submit the water requirements before the irrigation begins. Then, the department assigns the maximum water limits to the sovkhozes. For example, Bereke's assigned volume was 0.1521 cubic km in 1993.

In Bereke, Mr. Tulegnov Ashimhan, a hydro-engineer, and his two assistants, estimate the anticipated water demand for each main distribution canal. They operate the canal distribution facilities and consult with an agricultural engineer (*agronom*) about the cultivation plan.

The principal canal becomes the main canal in Bereke because it is the end of a principal canal. The four distribution canals deviate from the main canal. The field irrigation canal, field ditch and on-farm irrigation facilities are operated by an agricultural engineer. Agricultural workers are under his control.

Surface drainage water runs into the main drainage canal, which runs around Bereke and into the Ili River, 30 km downstream from Bereke. Unfortunately, both the irrigation canal and drainage canal are almost completely unlined and their beds are just like sand dunes.

The rice production system in Bereke is called the Krasnodar system, which was developed in the Ukraine and south Russia. It peculiarities lie in the placement of the irrigation ditch, drainage ditch and rice paddies.

The field irrigation canal is parallel to the field drainage canal and the field ditch is parallel to the field drainage ditch. The field irrigation canal and the field ditch cross at right angles. The size of one field is usually 2 or 2.5 ha (145 m $\times$145 m or 125 m$\times$ 200 m). The average length between the field irrigation canal and the field drainage canal is approximately 1,000 m. The undulation differential between the field irrigation ditch and the field drainage ditch is about 0.5 m. The embankment around the field is large; its height is approximately 1 meter and its width at the bottom is about 4 m and its width at the top is about 1 m.

From the second ten days of April to the first ten days of May, each rice paddy is cultivated and leveled off. Natural or chemical fertilizers are put into the rice paddy; for example, ammonium sulfate, cattle dung and alfalfa as a green manure.

By this time, the irrigation water and atmospheric temperatures begin to rise. The rice seeds are planted directly into the dry field by machine, and then irrigation water runs into the rice paddy. In the early stage of irrigation, the rice paddy's water depth is low, increasing in proportion to the rice's growth. Until 20 days before harvesting, the average water depth is kept at around 25 cm.

As the leveling in many rice paddies is not good, we can see that the water depth of half the field is 40 or 50 cm while the water depth of the other half is 0 or 10 cm in the same field. Sometimes the rice paddy's water is replaced by fresh irrigation water to wash out the soil's salinity.

According to Mr. Tulegnov Ashimhan, construction planners decide the irrigation efficiency in Bereke's fields at 60%. This means that the on-field water requirement/supplied water for the distribution system in Bereke is 60 %. The remaining 40 % is lost in the distribution system.

Planned water requirements from the second ten days of May to the last ten days of August were decided on every crop for each distribution canal in 1993. For instance, the planned water requirement for rice was 3,100 mm, barley or wheat 395 mm, alfalfa 755 mm, and so on. But as a practical matter, alfalfa and barley are not irrigated by water according to the agricultural engineer.

In Bereke, the quantity of irrigation water used in the field was calculated every ten days. The amount used for rice was high. The on-field water requirement in one year was 82.451 million cubic meters for 2,100 ha. The net requirement for rice was 3,926 mm per year and the gross water demand including distribution losses was 6,562 mm per year. This is very high, even with high evaporation and transpiration during the summer season, there is a difference between 3,100 mm and 3,926 mm. There are differences between the planned and actual results.

As the irrigation distribution canals in Bereke are unlined, large quantities of water seep from the canal bed into the ground. Even more irrigation water from the rice paddies percolates into the soil. Therefore, the groundwater level rises near the surface of the ground in the irrigation season. This has two effects, one good, one bad.

High groundwater levels and high soil water content has allowed crops to grow in non-rice paddies, which are not irrigated or less irrigated. But, for Bereke's houses and inhabitants, this water-logging is not beneficial. The soil moisture near the settlement was high; therefore, in 1987 the main canal near the settlement was lined with concrete panels (160 cm × 250 cm) ranging 1.5 km in length. The cost of construction was 1,240,000 rubles.

Moreover, water-logging causes salinity in the soil. We can see salt accumulation on the soil's surface in fields near irrigation canals. Keeping water in rice paddies is effective for leaching out the accumulated salt.

In 1985, the cultivated area of rice was 2,850 ha. In 1993, it was reduced to 2,100 ha. Its reduction was caused by a decrease in Bereke's water supply from the principal canal. What does this mean?

Perhaps, the department of water resources will decide to decrease the water supply for irrigation and ease the water inflow into the lake in order to deal with the fall in Lake Balkhash's water level. Or again, as the need for water for irrigation conflicts with the generation of electricity in the Kapchagai man-made reservoir, the reservoir's storage water volume will increase and the water supply for irrigation will decrease.

In the early 1990s, Lake Balkhash's water level rose to 341.2 meters. The amount of irrigation water taken from rivers decreased in Alma-Ata and Taldy-Kurgan Province. For example, in 1985 the water volume in Alma-Ata Province was 4.067 cubic km and that of Taldy-Kurgan was 3.597 cubic km. In 1990, it fell to 3.890 cubic km and 3.032 cubic km respectively. It is probable that the department of water resources imposed regulations on the water intake from rivers.

Environmental Preservation Measures and the Feasibility of Fees for Water Use

There are plenty of fish (carp, dace, catfish and so on) in Lake Balkhash. They spawn at hydrophytes in the delta area of the Ili River. Waterfowls, such as pelican, inhabit the lake. If the water level of the lake drops further, the delta area will dry up and the number of fish will decrease. The number of wild muskrat (*ondatra*) in the delta area has already decreased due to the drying conditions of the 1980s. Therefore, in order to protect Lake Balkhash's natural environment, the water level has to be sustained at more than 341.2 meters or the same as the present level. Let us examine measures to increase water inflow into the lake.

The measures at the village level are the following:

- Further reductions in the area of rice cultivation or a suspension of rice cultivation.
- Conversion of crops into wheat cultivation and fodder production, etc.
- Recycling of drainage water by pumping it for reuse.

Since rice cultivation requires large amount of water, the above measures are suitable for saving the village's water supply from the principal canal. However, it is important to raise the efficiency of the irrigation system.

Usually in this area, the efficiency of water delivery in a principal canal is 90%. As mentioned above, the irrigation efficiency in Bereke is only 60%. In essence, the system for delivering water is only 60% efficient. Therefore the irrigation efficiency system amounts to 54%, which means that approximately half the water intake from the river is lost. Almost all of the canals are unlined with waterproofing materials. It is necessary to repair on the canals.

At the district level, the district department of water resources can introduce the following measures:

- Freeze development of irrigation areas so that the water intake from rivers does not exceed the present volume.
- Decrease the water level of the Kapchagai man- made reservoir in order to reduce the volume of evaporation from the reservoir's surface. This will conflict with the need to generate electricity, however.
- Reduce the water intake from rivers. This step was adopted in the early 1990s.

The above measures can be directly regulated. On the other hand, there are measures that can be indirectly regulated to increase efficiency and save water resources; for example, fees, charges, subsidies, and so on.

Overall, in a market economy it is said that the collection of water fees from farmers as part of a maintenance cost would allow for the effective use of water. A fee on water usage has been introduced in every district of Kazakhstan. The Balkhash District imposed a fee of 0.02 tenge (Kazakhstan national currency) per 1 cubic meter of water use in 1998. If this fee were applied to the 0.1521 cubic km of water used by Bereke in 1993, it would amount to 3,042,000 tenge. The selling price of unhulled rice on the farm was 15,000 tenge per ton in 1998.

If the annual yield of unhulled rice were 8,000 tons, the gross selling price would be 120 million tenge. The key question is whether a fee of 2.54 % of the gross selling price will work as an economic incentive to promote more efficient water use. Due to Kazakhstan's economic crises, most water fees are still unpaid by farms throughout the country. Therefore, it is unlikely the fee will work due to currency shortages and inflation. Incidentally, the total water use in this district was approximately 0.75 cubic km in 1998, so the estimated total fee amounts to around 15 million tenge.

Furthermore, a uniform fee rate is not adequate to equalize the burden of each farm because of differences in the production functions of each field. In order to know the production function of water in each field, we have to investigate the soil's characteristics and salinity because soil with high salt content needs large amounts of water for leaching out the salt. Moreover, it is necessary to examine the actual efficiency of the irrigation system. Only then is it possible to estimate the volume of water demand for each field; but it is difficult to investigate each field.

In the end, the combination of a user-fee and subsidy would be the second best policy for promoting more efficient water use. On condition that the irrigation area's development is stopped, the standard volume of water intake could be allocated to each farm by reducing to some extent the existing water intake; for example, by 20%. Then, if the actual water use were lower than the amount allocated to each farm, a subsidy for saving water could be paid by the department of water resources. On the other hand, if the actual water use were higher, a charge could be imposed. It is important to make the charge higher than the subsidy. This way, the department of water resources can obtain the revenues to cover the subsidy. Finally, the department of water resources should allow farms to barter a charge for a subsidy. This system will encourage farmers to switch to more efficient crops and to repair the canal.

At any rate, in order to achieve effective water use in the field, it is necessary to prepare monitoring networks at the field level. Furthermore, not only the hydro-engineer and the agricultural engineer but also the direct water user, namely the agricultural worker, has to take part in the actual effort to promote more efficient water use and management. It means that they have to participate in the decision-making process regarding crop selection in irrigation agriculture.

Concluding Remarks

During the Soviet era, the authorities planned to convert 250,000 ha of desert along the lower reaches of the Ili River for agricultural development of which 110,000 ha were to be used for rice cultivation. During the first phase of the project, 43,200 ha were converted in the Akdalinsk area; of which 30,000 ha were cultivated and five rice cultivation sovkhozes were established. The total area of rice cultivation among them amounted to 12,500 - 14,200 ha.

The project to convert the rest of the 250,000 ha disappeared with the dismantling of the Soviet Union. From the beginning, the plan was regarded as unreasonable from the viewpoints of environmental protection and water resource capacity. If 110,000 ha were used for rice paddies, 7.9 cubic km would have been required, if using Bereke's 1993 standards. Since the irrigation system's efficiency is only 54%, 3.6 cubic km of water would have been lost. The water inflow into Lake Balkhash would decrease by that volume causing it to diminish in size. It may fall into the same trap as the Aral Sea.

The introduction of a market economy appears to promote more efficient use of water in rice paddies. As rice from China and Uzbekistan arrives in Kazakhstan due to the market economy, rice farms along the lower reaches of the Ili River have suffered from the competitors' lower production and transportation costs. Now, rice production is no longer as profitable. The market economy has created difficulties for rice producers in Balkhash District and Alma-Ata Province. For example, the cultivation area in Bereke village decreased to 1,600 ha in 1998 and the amount of farm workers has been reduced by 150 persons. The total area of rice cultivation in Akdalinsk area amounted to 12,500 - 14,200 ha at the be ginning of 1990. But the area of rice cultivation decreased to 11,600 ha in Alma-Ata Province in 1998. Alma-Ata's overall irrigation area was 335,300 ha in 1988, increasing to 394,300 ha in 1997. Although Alma-Ata's irrigation area increased, the area of rice cultivation has decreased.

During the summer, there is plenty of solar radiation in Central Asia's arid areas; therefore, we can expect higher agriculture yields if we can get more water for irrigation. The over-development of irrigation agriculture has brought about the risk of exhausting the local water resources, however. This will give rise to conflict between water users, especially nations. On the national level of conflict in the Ili River basin, China has a predominant position because it holds a headspring. Kazakhstan has to maintain amicable relations with China in order to get enough water.

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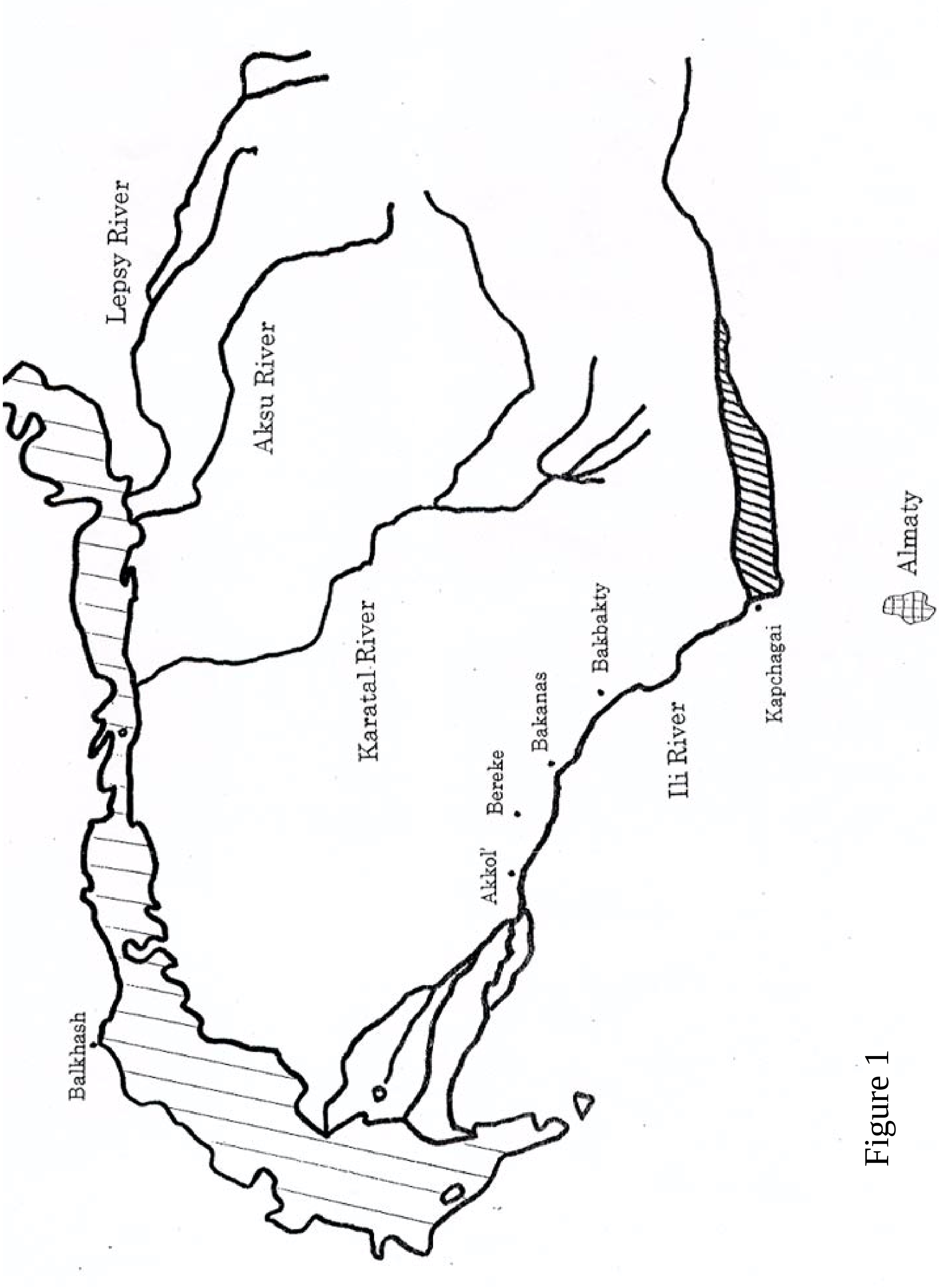
Lepsy River
Aksu River
Karatal River
Ili River
Balkhash
Akkol'
Bereke
Bakanas
Bakbakty
Kapchagai
Almaty

Figure 1

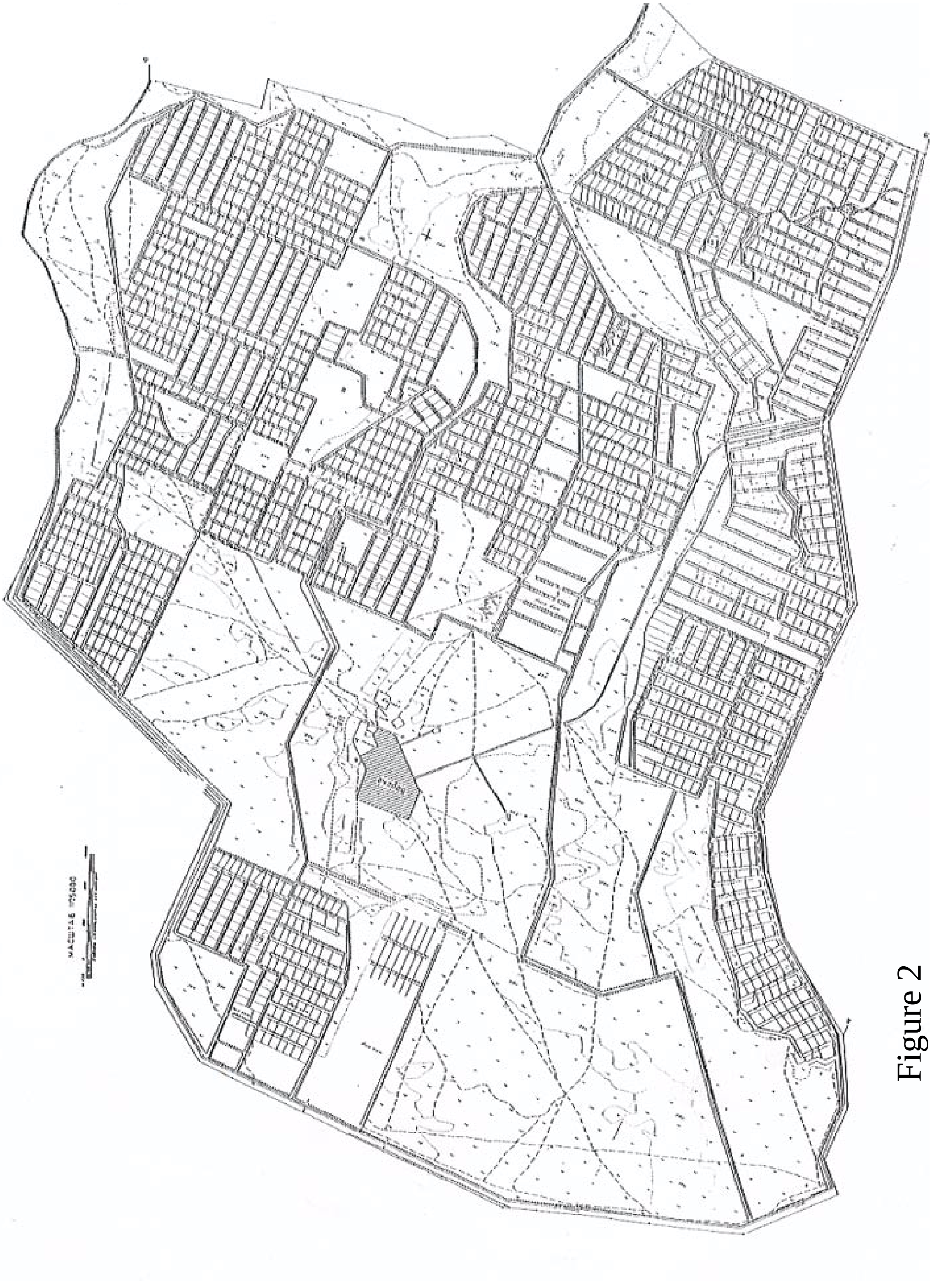

Figure 2