SOVIET IRRIGATION POLICY AND THE INTENSIFICATION OF ECOLOGICAL PROBLEMS

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Abstract: This article examines the historical development, economic logic, and ecological consequences of the irrigation and agrarian policies pursued by the Soviet Union in Central Asia, based on the principles of historicism, comparative analysis, and cause-and-effect methodology. It provides a detailed analysis of the policy of cotton monoculture, the construction of large canals and water facilities, the excessive exploitation of the water resources of the Amu Darya and Syr Darya, the historical roots of the Aral Sea crisis, the social and economic consequences of ecological problems, and the restoration measures undertaken during the years of independence.

Keywords: Soviet irrigation policy, cotton monoculture, Central Asia, Amu Darya, Syr Darya, Aral Sea, ecological crisis, soil salinization, desertification, water resources.

1. Introduction

A glance at the pages of history reveals that many of the tragic episodes of human civilization have stemmed from aggressive attitudes toward nature. Central Asia occupies a special place in this regard: in its vast steppes and arid climate, water has for centuries been the most precious resource. Yet in the twentieth century, the centralized economic policies of the Soviet Union disrupted this natural balance and laid the foundation for one of the world's largest ecological disasters in the region.

The Soviet state transformed Central Asia into a territory serving two primary economic functions: cotton — the main industrial raw material — and a source of hydroelectric power. To achieve these goals, massive irrigation systems were constructed, river flows were redirected, and new lands were reclaimed. As a result, the overwhelming majority of the waters of the Amu Darya and Syr Darya were consumed for irrigation, initiating the desiccation of the Aral Sea[1].

The scientific significance of this article lies in its analysis of Soviet irrigation policy not only as a historical phenomenon but also as a direct cause of

[1] Micklin Philip P. The Aral Sea Disaster // Annual Review of Earth and Planetary Sciences. – 2007. – Vol. 35. – P. 47.

today's ecological problems. Through historical analysis, it demonstrates how political decisions produced ecological consequences, how the ecological neglect of a centralized economy led to systemic degradation, and what lessons can be drawn from these experiences.

2. Main Part.

With the consolidation of Soviet power in Central Asia in the 1920s, the issue of economic specialization became central. The Bolshevik leadership, particularly the Political Bureau under Stalin, adopted a strategy to transform Central Asia into the primary source of textile raw material — cotton — for Soviet industry. This decision carried not only economic but also political significance: by binding the local population to cotton monoculture and making them dependent on the center for food and industrial products, the regime sought to strengthen political control[2].

The forced collectivization carried out between 1929 and 1933 completely destroyed the traditional agricultural system of Central Asia. Hundreds of thousands of peasant households were merged into kolkhozes and sovkhozes. According to the research of historian Robert Conquest, collectivization caused major social upheavals in Central Asia, including mass mortality among nomadic Kazakhs who resisted the surrender of their livestock and fled. In Kazakhstan alone, between 1931 and 1933, thousands of families perished or were forced into migration[3].

In the new economic system, cotton was cultivated according to state-imposed plans, and its price was artificially kept low. This system tied the livelihood of rural populations entirely to the will of the state. According to the data of academic Edward D. Sokol, by 1940 more than 50 percent of Central Asia's arable land was allocated to cotton, while grain and other food crops were reduced to such an extent that the population of the region was condemned to live under constant shortages[4].

During the Soviet era, irrigation construction in Central Asia reached a scale unprecedented in world history. Between 1950 and 1980 alone, more than 1,000 large and medium-sized canals, a network of over 45,000 km of water channels,

[2] Obertreis Julia. Imperial Desert Dreams: Cotton Growing and Irrigation in Central Asia, 1860–1991. – Göttingen: Vandenhoeck & Ruprecht, 2017. – P. 128

[3] Conquest Robert. The Harvest of Sorrow: Soviet Collectivization and the Terror-Famine. – Oxford: Oxford UniversityPress, 1986. – P. 196.

[4] Sokol Edward D. The Revolt of 1916 in Russian Central Asia. – Baltimore: Johns Hopkins University Press, 1954. – P. 88.

and more than 80 reservoirs were built in the region. As noted in the monograph by V.A. Dukhovny and V. Sokolov, in 1950 the area of irrigated land in Central Asia amounted to 4.5 million hectares, but by 1990 this figure had exceeded 8 million hectares[5].

One of the largest projects was the Great Karakum Canal, whose construction began in 1954. With a total length of 1,400 km, this canal carried water from the Amu Darya to the arid regions of Turkmenistan. While technically an impressive feat of engineering, the canal also created enormous ecological problems: because it lacked concrete lining, water losses reached 35–45 percent, raising groundwater levels and intensifying salinization across vast areas.

With the construction of major canals such as the Amu-Bukhara, Amu-Karadarya, Southern Mirzachol, Great Fergana, and Northern Kyrgyz canals, nearly all potentially arable lands in Central Asia were converted into irrigated fields. However, these projects were often implemented hastily and without sufficient scientific study: hydrogeological conditions, soil permeability, and drainage requirements were inadequately examined. As a result, within a few years of construction, many newly reclaimed lands became salinized and unsuitable for cultivation. The construction of large reservoirs such as Toktogul (Kyrgyzstan) and Nurek (Tajikistan) also produced complex ecological consequences. These reservoirs submerged vast territories, forcing the relocation of hundreds of villages. At the same time, they became a constant source of disputes with downstream states over water distribution. As emphasized in the research of K. Wegerich, the water facilities built during that period were designed with the interests of a single republic in mind, yet they created systemic problems that affected the water balance of the entire region[6].

As cotton fields expanded, water consumption increased at the same pace. In the 1960s, annual water use in Central Asia's irrigation system was around 60 km^3, but by the mid-1980s this figure had exceeded 120 km^3 — doubling in just two decades. The bulk of this water was drawn from the Amu Darya and Syr Darya. According to the research of Philip P. Micklin, by the late 1980s seasonal flows in the lower reaches of the Amu Darya had virtually dropped to zero[7].

The technical efficiency of irrigation systems was extremely low. Most of the main canals were unlined earthen channels, resulting in water losses of 40–60 percent. Of the water that reached the fields, 30–40 percent seeped into the

[5] Dukhovny V.A., Sokolov V. Integrated Water Resources Management: Putting Good Theory into Real Practice. Central Asian Experience. – Tashkent: SIC ICWC, 2009. – P. 56
[6] Wegerich K. Hydro-hegemony in the Amu Darya basin // Water Policy. – 2008. – Vol. 10, No. S2. – P. 71
[7] Micklin Philip P. The Aral Sea Disaster // Annual Review of Earth and Planetary Sciences. – 2007. – Vol. 35. – P. 52

ground due to the absence of proper irrigation technology. As shown in the joint study by V.A. Dukhovny, V. Sokolov, and H. Manthrithilake, the overall efficiency coefficient of Central Asia's irrigation system was only 0.5–0.6, about half the global standard[8].

Excessive use of pesticides and mineral fertilizers also became a major source of water pollution. DDT, lindane, and other chlorinated organic compounds were widely applied against cotton pests. These substances entered the Amu Darya and Syr Darya systems through irrigation water and eventually reached the Aral Sea. As a result, concentrations of toxic substances in the sea water and sediments exceeded permissible levels by ten to fifteen times.

The consumption of mineral fertilizers likewise created ecological problems. In the 1970s, the amount of nitrogen fertilizer applied per hectare in Central Asia was among the highest in the world. Excess fertilizer returned to rivers through drainage water, enriching them with nitrates and phosphates. This led to excessive growth of aquatic plants and a decline in biodiversity. In the scientific work of N. Pala, N. Mirzaev, and G. Stulina, it is noted that the number of fish species in the Amu Darya delta decreased from 32 to 6 between 1970 and 1990[9].

The causes of the Aral Sea crisis cannot be attributed to a single major decision but rather to cumulative damage that accumulated over decades. As early as 1918, the Soviet government set the strategic goal of achieving "cotton independence" in Central Asia and drafted plans to expand irrigation systems for this purpose. In the initial decades, these plans were implemented on a relatively limited scale; the real acceleration of the Aral crisis began in the 1950s, particularly with N.S. Khrushchev's "Virgin Lands" campaign.

By 1960, the volume of water reaching the Aral Sea began to decline sharply. Until that year, an average of 56 km^3 of water flowed into the sea annually, but by 1970 this figure had dropped to 43 km^3, and by 1980 to just 9 km^3. From 1986 onward, the sea virtually ceased to receive any inflow. According to the fundamental research of Philip P. Micklin, the sea level began to fall by an average of 0.6 meters per year, and from the 1970s this rate increased to 0.8–0.9 meters annually[10]. The most tragic aspect of the Aral crisis is that the process was known to the Soviet authorities. In the mid-1960s, several Soviet hydrologists and

[8] Dukhovny V.A., Sokolov V., Manthrithilake H. Integrated Water Resources Management: Putting Good Theory into Real Practice. Central Asian Experience. – Tashkent: SIC ICWC, 2009. – P. 88

[9] Pala N., Mirzaev N., Stulina G. Pesticide contamination in Central Asia // Irrigation and Drainage. – 2004. – Vol. 53, No. 2. – P. 169

[10] Micklin Philip P. The Aral Sea Disaster // Annual Review of Earth and Planetary Sciences. – 2007. – Vol. 35. – P. 56.

ecologists issued warnings about the desiccation of the sea, but these warnings were ignored by the political leadership. As analyzed in the research of Michael H. Glantz, this case illustrates how ecological knowledge was subordinated to political objectives[11].

Alongside the decline in sea level, the salt concentration of the water rose sharply. In 1960, one liter of water contained 10 grams of salt, but by 1990 this figure had exceeded 30 grams, causing the death of most fish species in the sea. In 1960, more than 40,000 tons of fish were harvested, but by 1986 the fishing industry had completely collapsed. This led to the loss of livelihoods for thousands of families and triggered a major social tragedy.

The newly formed dry seabed — the Aralkum Desert — became a source of salt and toxic dust. Scientific studies have shown that dust particles from the Aralkum can travel up to 500 km. According to the research of S.W. Breckle and colleagues, between 75 and 150 million tons of salt and dust are lifted into the atmosphere annually from the surface of the Aralkum. This dust settles on agricultural lands, alters soil composition, and reduces productivity[12].

The impact of ecological crisis on public health and demographic indicators was most evident in the Republic of Karakalpakstan. According to UNDP regional reports, child mortality in the Aral Sea region was 2–3 times higher than the regional average, while the incidence of respiratory diseases, anemia, and cancer exceeded national standards by 3–5 times. Medical studies confirmed that residues of DDT and other pesticides in water passed into breast milk, thereby harming the health of newborns[13].

Soil salinization became one of the main problems of agriculture. Due to insufficient reclamation measures, a large portion of irrigated lands became salinized and began to lose productivity. According to the research data of V.A. Dukhovny and V. Sokolov, by 1990 more than 60 percent of irrigated lands in Central Asia had been affected by varying degrees of salinization, and their average productivity was 25–35 percent lower than in the 1960s[14].

Biodiversity also suffered enormous losses. Forest and shrub ecosystems, as well as tugai woodlands in the Amu Darya delta, dried up due to reduced irrigation flows. Plant and animal species inhabiting the shores of the Aral Sea

[11] Glantz Michael H. Creeping Environmental Problems and Sustainable Development in the Aral Sea Basin. – Cambridge: Cambridge University Press, 1999. – P. 85
[12] Breckle S.W., Wucherer W., Liliya A.B., Aknazar N.O. (eds.). Aralkum — a Man-Made Desert: The Desiccated Floor of the Aral Sea (Central Asia). – Berlin: Springer, 2012. – P. 88
[13] UNDP (United Nations Development Programme). National Human Development Report: Uzbekistan. – Tashkent: UNDP, 2008. – P. 64
[14] 16. Dukhovny V.A., Sokolov V. Integrated Water Resources Management: Putting Good Theory into Real Practice. Central Asian Experience. – Tashkent: SIC ICWC, 2009. – P.108.

disappeared. The highly rare tugutak sturgeon (*Pseudoscaphirhynchus kaufmanni*) and other endemic species faced extinction. The number of bird species in the Amu Darya basin declined by half between 1960 and 1990.

Economic losses reached massive proportions. According to calculations for Uzbekistan alone, soil salinization and land degradation caused annual losses of 1.5–2 billion Soviet rubles in the agricultural sector. As noted in the research of Max Spoor, the capital investments required to modernize irrigation systems and eliminate water loss problems were estimated at 10–15 billion rubles in the mid-1980s, but the Soviet state never implemented these investments[15]. Ecological problems also accelerated population migration. From the late 1980s, migration rates from Karakalpakstan, Khorezm, and Turkmenistan's Aral Sea regions increased sharply. Alongside the loss of jobs in fisheries and agriculture, deteriorating ecological living conditions forced people to move to cities and other regions. This deepened the demographic crisis in the Aral Sea region, leaving many villages depopulated.

Although environmental protection was officially declared as state policy during the Soviet era, in practice these declarations proved powerless against the priorities of economic planning. From 1960 onward, the USSR adopted a number of environmental laws and established a system of nature reserves (*zapovednik*). Yet these measures failed to address the core ecological problem — the negative impact of massive irrigation and industrial systems on the natural environment.

Part of the Soviet scientific community did pay attention to ecological issues. From the 1960s, the Soviet school of hydrologists — including Boris Davydov, Apollon Davydov, and others — issued warnings about the potential consequences of the Aral crisis. However, these voices were dismissed by the political leadership as "anti-national economy" views. Political censorship within the Soviet scientific environment seriously hindered the development of ecological research[16].

The ecological neglect of centralized planning was not limited to water resources. Air pollution in major industrial cities, the burial of nuclear industry waste (such as at Kazakhstan's Semipalatinsk test site), and the failure to mitigate the ecological damage of the oil industry all reflected the broader attitude of the Soviet economic system toward the environment. As analyzed in the research of

[15] Spoor Max. Agrarian Transition in Former Soviet Central Asia: A Comparative Study of Uzbekistan and Kyrgyzstan // Journal of Peasant Studies. – 2004. – Vol. 31, No. 1. – P. 117

[16] Josephson Paul R. An Environmental History of Russia. – Cambridge: Cambridge University Press, 2013. – P. 178

Michael Carley and Ian Cristie, this situation is described as a "systemic linkage between centralized planning and ecological crisis."[17]

One of the most important conclusions in the historical assessment of Soviet irrigation policy is that economic development without consideration of ecological consequences cannot be justified. The short-term increase in cotton yields in Central Asia was "repaid" in the long term with the Aral catastrophe, soil salinization, and public health problems — damages ten to fifteen times greater. This case stands as one of the strongest global examples of the necessity of maintaining a balance between economic development and ecology.

In the years of independence, significant steps have been taken to mitigate the consequences of former Soviet irrigation policy. In 1992, Uzbekistan, Kazakhstan, Tajikistan, Kyrgyzstan, and Turkmenistan established IFAS and began moving toward a system of joint water resource management. The Kokaral Dam project (Kazakhstan, 2005), implemented with World Bank assistance, produced positive results in partially restoring the Small Aral. In Uzbekistan, afforestation programs in the Aral Sea region planted saxaul and other vegetation across more than 1 million hectares of the dried seabed[18].

Yet these reforms remain disproportionate to the scale of the problems. Technical modernization of irrigation systems, widespread introduction of water-saving agro-technologies, prevention of soil degradation, and raising regional water cooperation to a new qualitative level all remain urgent tasks. To fully overcome the ecological problems inherited from the Soviet legacy will require the efforts of several generations and vast financial resources.

3. Conclusion

The irrigation policy pursued in Central Asia during the Soviet era was, in terms of scale, one of the largest human interventions in the natural environment in history. Cotton monoculture and the construction of massive irrigation systems helped achieve short-term economic goals, but their long-term ecological, social, and economic consequences proved disastrous.

The desiccation of the Aral Sea became the most dramatic expression of this policy. The near disappearance of the world's fourth-largest lake within just thirty years is not only a regional but a global ecological tragedy. The roots of this disaster lie in political decisions that prioritized economic objectives over ecological consequences.

[17] Carley Michael, Christie Ian. Managing Sustainable Development. 2nd ed. – London: Earthscan, 2000. – P. 144
[18] Aladin N.V., Micklin P., Plotnikov I.S. Restoration of Aral Sea Ecosystem // Lakes & Reservoirs: Science, Policy and Management for Sustainable Use. – 2009. – Vol. 14, No. 4. – P. 325

Soil salinization, the reduction of river flows, the loss of biodiversity, and public health problems are all interconnected and long-term outcomes of Soviet irrigation policy, and they continue to affect the region today. Climate change is further exacerbating these problems.

From a historical perspective, the Soviet economic model's attitude toward ecology must be characterized as a systemic flaw. Centralized planning evaluated only quantitative economic indicators — cotton tonnage, hectares of irrigated land — while ignoring their ecological costs. This left subsequent generations with a massive ecological debt.

Scientific conclusions highlight several key lessons: first, the historical experience of Soviet irrigation policy demonstrates the necessity of mandatory ecological expertise in political decision-making; second, without regional water cooperation, the water problems of Central Asia cannot be resolved; third, modernization of irrigation technologies, water-use practices based on the principle of "accounting for every drop," and systematic measures against soil salinization must form the foundation of long-term ecological sustainability. These lessons are significant not only for Central Asia but for the entire world.

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10. Breckle, S.W., Wucherer, W., Liliya, A.B., Aknazar, N.O. (eds.). Aralkum — A Man-Made Desert: The Desiccated Floor of the Aral Sea (Central Asia). Berlin: Springer, 2012.
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14. Josephson, Paul R. An Environmental History of Russia. Cambridge: Cambridge University Press, 2013.
15. Carley, Michael, Christie, Ian. Managing Sustainable Development. 2nd ed. London: Earthscan, 2000.
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