Concepts of steppe landscape arrangement and runoff management in the agrarian-social megaprojects

S V LevykinORCID 0000-0003-9499-9939, A A ChibilevORCID 0000-0002-6214-1437,
Yu A GulyanovORCID 0000-0002-5883-349X, A A Chibilev(jr.) ORCID 0000-0003-1109-6231,
G V KazachkovORCID 0000-0001-6779-8334, I G YakovlevORCID 0000-0003-0497-8566,
O A GroshevaoORCID 0000-0002-5858-0277

Institute of Steppe of the Ural Branch of the Russian Academy of Sciences, Orenburg, Russia

E-mail: stepevedy@yandex.ru

Abstract. In the XX century, the USSR developed and realized agrarian-social megaprojects to arrange steppe agrolandscapes and control water resources to resist droughts. The first ideas emerged in the XIX century; its realization happened in the second part of the XX century. The study of the interconnection of steppe egaprojects and their system consequences is urgent under the projective style of development. An analysis of the integral impact of megaprojects on the steppe zone has a special significance, at the first line, to reduce the ecological expenses of future projects. We paid particular attention to the general conclusion taking into account little known and new facts. It promoted to specify a role and significance of fundamental science in developing ideas and in the practical realization of megaprojects, their scientific and organizing heritage, first of all for steppe science. We emphasized the scientific-organizing heritage of a megaproject of the river flow transfer and discussion about its renaissance. The project's fundamental idea left a deep imprint in the development of real science in Orenburzhie dealing with the actions of steppe conservation has turned 150 years; official closing of the Soviet project of redistribution of the Ob water flow has turned 35 years. Due to increasing irrigation of the Arctic accompanied by the Arctic Ocean desalination that is disastrous for the climatic system and an increase of a water deficit in Central Asia, the idea of redistribution of the water runoff becomes more topical. The most typical steppe region - Orenburgskaya oblast is an epicenter of all steppe megaprojects; it is considered a model according to the evaluation of their consequences and heritage.

1. Introduction

The climatic challenge intensifies a water deficit in arid regions. In most post-Soviet space, crop productivity was not increased principally; trends to the high expense of space, soil, and water per unit of output have remained. A stable tendency to desalinization of the Arctic Ocean became to show due to an increase of the Siberian river flow that threatens transformations of ocean currents with unpredictable global climatic consequences. Also, we can notice the impoundment of the forest-steppe in West Siberia. A contrast between over-watering in the Arctic and a water deficit in the Trans-Volga–Ural steppe region and Central Asia increases. On this background, the idea of redistribution of the rivers flow from the Arctic Ocean's basin to the Aral Sea' basin becomes more urgent [1]. The concept of inter-basin redistribution of fresh water was initially Russian. It has been the 150th-
anniversary of its publication this year, and there is a 35th-anniversary of the closing of the Soviet megaproject regarding a part of the Ob runoff transfer to the Aral Sea basin (1968-1986) [2, 3].

In this connection, we consider this megaproject in the united system with "Stalin's Plan for transformation of nature" (realization of Dokuchaev-Kostychev-Williams' concept) as hypertrophy of its water component. The experience of development, fulfillment, evaluation of landscape-ecological consequences, and the scientific or another heritage of the Soviet megaprojects is necessary to understand the nature of a current state of agrolandscapes, scientifically-grounded rationalization of steppe land use with adaptation to climatic changes, and other challenges.

"Stalin's Plan for transformation of nature" (the further – the Plan) and the project of redistribution of the Ob water flow to the Aral Sea's basin (the further – the Transfer) left a considerable scientific heritage, launched the new stage in steppe science development: the Transfer, not being introduced, promoted to developing fundamental science along the supposed route, including Orenburgskaya oblast – the most typical steppe region that is model, according to the megaproject consequences.

2. Problem setting

After a series of "wheat fever" at the end of the XIX century, the first complex agroecological crisis happened in the steppes of European Russia. It was represented by droughts, bad harvests, and dusty storms. Consequences were so large-scale that they shocked the public, workers of culture, the scientific community—the Russian philosopher V.S. Soloviev, in unison with L.N. Tolstoy, D.I. Mendeleev, openly compared steppe droughts with Batu Khan's invasion [4]. A social order to develop an agrarian-social megaproject for ecological restoration of the suffered territories emerged. Forward Russian scientists suggested the comprehensive answer for this challenge [5, 6]. But in the Russian Empire, this project did not take place. Only a line of scientific stations was organized for ecological optimization of steppe landscapes. The authorities supported peasants to resettle the other side of the Volga River to West Siberia and Kazakhstan's best lands in the frame of "Stolypin's reform" (1906-1913). Thus, Dokuchaev's project concerning Russian steppe beautification approved on some scientific stations remained only the plan, but virgin land reclamation was realized. The problems of stability and productivity of agriculture were not solved, but the challenge's sharpness was managed to be leveled up to droughts returning in the 1920s and the 1930s.

Implementing collectivization and realizing the project of the Salskaya tselina, the USSR authorities faced problems of the bulk yield stability, droughts, and dust storms' impact that were no less urgent than in the XIX century. We should note that science, already Soviet, was ready for this challenge. V.V. Dokuchaev's fundamental doctrine was improved and developed by using P.A. Kostychev's heritage, V.R. Williams' works regarding an optimal structure of crop rotation and agricultural lands; it was added by K.A. Temiryazev's studies regarding plant feedbacks on droughts. As a result, a complex of agronomical measures – ley system cultivation – Dokuchaev-Kostychev-Williams' Complex (the further-the Complex) has emerged in the middle part of the 1930s. It became a basis of the Plan with primary ideas of forest plantations, soil structure restoration, flow management, and agriculture culture [7, 8].

The pastoral challenge in the steppe zone was so large-scale that the government, based on the Complex, developed a scale project for agrarian beautification of the country's principal agricultural regions – forest-steppe and steppe.

In the research, we consider agrarian-social megaprojects as projects directed to overcoming challenges to agriculture from the drought side and increasing of gross yield as a general criterion of the success with planned and the whole execution period of realization about ten years, involvement from a million people with coverage about of 100 million ha and landscape transformation no less than 30 million ha: Plan, Virgin Land project, Transfer, post-Soviet Land reform. There were these projects which left enormous landscape, ideological and scientific heritage. It has a principal significance to avoid failures of the past in new projects concerning the arrangement of Russia and the steppe zone. In this paper, we discuss Plan and Transfer.
3. Materials and Methods
The convergent principle of scientific study, steppe-centric approach, and field studies materials were used in the study. Also, comparative-historical and comparative-typological analysis, answering data, expert assessment methodologies, and the logical method were employed.

4. Results and Discussion
The megaproject approach has historical and geographical preconditions. The Russian engineering ideas of megaprojects happened in the XIX century; their realization took place in the Soviet period. Among megaprojects from GOERLO (1920-1935) to BAM (1974-1984), the most critical projects, from the point of view of steppe science, were Plan, Virgin Land campaign, Transfer, post-Soviet Land reform as it were they which defined the modern idea and agricultural specialization of the steppe zone and left invaluable scientific heritage and experience.

In this paper, we consider the realized Plan and Transfer remained only the project. They were close to each other by orientation to agroecological beautification of already developed lands, mainly arable areas, and we pay paramount attention to a water component. In condition with it, let us underline that V.V. Dokuchaev's fundamental doctrine regarding the arrangement of steppe landscapes emphasized, in the first line, the management of a local water flow and supported some transformism. The Transfer, in our opinion, is the management of a water flow, but inter-basin. At present, on the whole, these views have not lost topicality, but realization demands to take into account all preceded experience of the megaprojects in the steppe zone.

4.1. Plan
The Plan was founded on the Complex base as a response to the drought of the 1930s. The Soviet government resolutely started to introduce the new complex: the appropriate resolution was approved in 1938 [9]. The project began to planting large areas of field protecting forest belts, but the war interrupted it.

After the war, the Plan restarted as a response to the drought of 1946 [10]. This agrarian-social megaproject was oriented, mainly, to forest-steppe and steppe of the European part of the USSR, including Orenburgskaya oblast, but toughed upon Altaiskiy krai. From our positions, the main point of the Plan is dual: smoothing unfavorable conditions in forest-steppe and steppe, and an increase of farming culture and its efficiency through management of the steppe water component: the building of the complete network of wind-protecting mega-woodland belts along large rivers and finished the field protecting forest improvement framework, regulation of a local flow, bring up perennial grasses to a quarter of cultivated fields.

As with every Soviet agricultural project, the Plan has the social component: improvement of employment terms of the rural population, providing additional resources, including water and biological, smoothing climatic conditions. The Plan was intended for 17-20 years. It was designed to create the most extensive system of woodland belts in the world with an extent of over 5 thousand ha and an area of 118 thousand ha. Also, it should be formed a network of field protecting belts with an area of 5.7 million ha under the support of 570 forest reclamation stations. The Plan strove to build more than 40 thousand ponds, to allocate a quarter of cultivated lands for perennial grasses with the development of virgin lands, to improve technological discipline and culture of farming [7, 11, 12]. As known, from 1949 to 1953, the Plan parameters were reached to a half: 2.3 million woodland belts were created, perennial grasses occupied a quarter of cultivated areas, thousands of ponds and reservoirs were built. Megaproject rashness of realization influenced the quality of labor and the selection of forest cultures.

Orenburzhie, though located on the south-east edge of European Russia, according to a scale of the realized measures, became the epicenter of the Plan. The principal components of the afforestation complex were formed, including one of the largest state forest shelterbelts, "The Vishnyovovaya mountain – the Caspian Sea" [13]. Regional specific was that kolkhozes and sovkhozes should realize the main volume of woodland belts (about 280 thousand ha). And about 50 thousand ha of the belts
should be planted for the expense of the public resources, especially in the Buzuluksky Pine forest in
lands of the forest fund. About 330 thousand ha of woodland belts should be planted; this initiative
was realized at 70%. In Orenburgskaya oblast, the system of 90 thousand ha field-protecting belts can
be recognized as the principal landscape heritage of this project [14, 15].

We should note that in the period of the most active stage of the Plan realization, domestic
geography approving it, on the whole, indicated the necessity to pay attention to conservation of
natural forest plantings in steppe regions, aboriginal species, and natural vegetation no less than
artificial plantings [13].

Realization of this project promoted to development of fundamental sciences, first of all, connected
with forestation. The Dzhani-bekskiy scientific station was founded for experiments on desert
forestation.

After the USSR government's change, the Plan was stopped: the grass rotation system was
criticized and practically forbidden, forest reclamation stations were closed, and treatment for
woodland belts was ceased. No more than 0.65 million ha of forest plantings remained from 2.3
million ha by the end of 1956. It was the end of the main stage of the Plan's practical fulfillment
(1949-1953); this megaproject was not completed practically to a half and rapidly lost the already
created. It was replaced by principally another megaproject – the Virgin Land Campaign (1954-1963).

It is remarkable that principal components of the Complex, first of all, conservation of low-
productive arable lands and large scale fodder-grass cultivation, were employed in North America
after the "Dust Bowl" for ecological prairies restoration; the main anti-erosion measures were fulfilled
in the 1930-1950-s [16, 17, 18, 19].

The prominent heritage of the Plan is the forest reclamation framework, but the gigantism of the
project did not promote quality of works and reasoning of culture selection. Instead of adapting local
species to specific conditions of growing in the steppe, we could notice an ardoir to elm introduction.
Landscape divided by strips and a wall of forest cultures, which was diverse, was created instead of
the mosaic landscape of the steppe type. Showing a high acclimation rate, elm was short-lived and
remained hard-to-remove dead standing trees. This project's lesson is the consequence of large-scale
elm introduction: having displayed itself as the very tenacious species, it occupies fallow lands
moving from woodland belts at every opportunity. In Orenburgskaya oblast, it can be seen in the south
part of Syrt, especially in the Cis-Ural region along terraces of the Ilek River covered so-
ils of light
composition. Consequently, agricultural forest reclamation complexes left by the Plan demand either
maintenance or monitoring and control against self-afforestation. Undoubtedly, from the hunting
sector's point of view, woodland belts and elm savannahs are productive hunting grounds, especially
for hare, fox, partridge, etc. However, an economic and agro-ecological balance is significant.

Rapid plowing of tens of millions hectares of virgin and fallow lands in the arid conditions of the
steppe zone not only provoked the strongest dust storms but considerably exacerbated a water deficit
of arable lands, first of all, plowed again in South Ural, West Siberia, Kazakhstan, and Central Asia.
The USSR's new authorities reacted to a new agro-ecologicchallenge reviving the forest reclamation
and water components of the Plan. They decided to intensify a water component adequately to a new
turn of droughts and principally increased arable lands. The further initiatives of the Soviet
government against droughts and large-scale measures in the struggle with soil erosion promoted to
consider the period from the end of the 1960s to the middle part of the 1980s as a Renascence of some
kind, but without grass rotation system, with the actualization of the idea regarding inter-basins
redistribution all without rough transformism.

4.2. Transfer

The idea to transfer the Ob and Irtysh flows in the Aral Sea's basin is older than V.V. Dokuchaev's
concepts. It matured in the epoch of the general rise after the abolition of serfage and an agrarian
initiative's activization, including resettlement to new lands characterized by a water deficit. The
initial plan consisted of a real turn of the Ob River to the south for the full filling of the Aral and
Caspian Sea's hollows [2]. This initiative initially was a utopia due to two reasons: overwhelming economic expenses and an unavoidable ecological catastrophe in the lower reaches of the Ob basin.

As the plan addition, in 1947, V.A. Obruchev and Sh. Ch. Chokin raised an issue to transfer a part of the Siberian river flows to Kazakhstan and Central Asia. They offered a more radical project to turn the Ob river to the Aral Sea's basin through the building of a reservoir with an impoundment of 25 million ha [20].

The USSR's government developing forest reclamation and water components of the Plan decided to intensify the water component by inter-basin transfer of water resources. In 1968, Gosplan and AS USSR started to work out a proper project, and in 1970, the target value was identified: 25 km$^3$ water from the Ob River or about 7% of its annual flow to the Aral basin. The development of this project activated fundamental geographical studies. In 1973, specialized scientific centers were organized in the Institute of geography AS USSR and the Institute of water problems. The government commission was established in 1974, and “Soyuzgidrovodkhoz” was organized in 1978. In totality, 180 scientific and scientific-project organizations took part in the project.

The project works in Orenburzhie began under the leadership of A.S. Khomentovskiy, the corresponding member of AS USSR, in 1974. The project studies promoted to complex research not only Orenburgskaya oblast but the neighboring areas of Kazakhstan that later served as a basis to consider this territory as the Orenburg-Kazakhstan ecoregion. The Orenburg team projected two variants of a line of the drainage way, conducted large-scale projective works. In 1975, it was evident that inter-basin redistribution of a flow is not only a matter for the future, but under technologies of that time, it conjugated with extremely high ecological expenses. The accent was moved to management of the local flow; the idea of 1932 concerning the Guberlinskoe reservoir construction on the Ural River was actualized. There was a prospect to transfer about 10 km$^3$ of the Ob water to the Ural River, i.e., doubling the Ural River's annual flow that would allow irrigating about 1-1.2 million ha of cultivated fields. 150 thousand ha in the south-west of Orenburgskaya oblast was supposed to be irrigated by the disposal of the Volga River's water. They planned at the expense of 1-1.2 million ha of irrigated lands practically to double gross yields of the main agricultural products, including grain from 5.2 to 9.2 million tons. The recoupment period of investments should be 5-7 years [21-26].

All-USSR's project works were finished in 1983 and underwent a State examination with the following indicators: a volume of transferred water – 27.2 km$^3$, from that a loss – 2.6 km$^3$ annually; to Russia – 4.9 km$^3$ annually; to Kazakhstan and Central Asia-19.7 km$^3$ annually; the arterial channel: a length – 2550 km, a width – to 200 m, a depth – to 16 m; irrigated lands – 4.5 million ha, including RF (mainly, in Orenburgskaya oblast) -1.2-1.5 million ha, in Central Asia – 3 million ha; expenses – 32.6 billion rubles, including the channel – 13.8 billion rubles; the execution period – 15 years; the recoupment period – 6-7 years [1, 3, 27].

The areas of irrigated fields look like insufficient considerable for the project of such scale a fortiori for the RSFSR. Instead of requested 10 km$^3$ water annually for Orenburzhie, 4.9 km$^3$ was approved for the whole of Russia to irrigated 1.5 million ha with an increase of gross yields of about 1-5 million tons. The rest 17 km$^3$ falling on Kazakhstan and Central Asia should irrigate only 3 million ha. The total effect of irrigation in the grain equivalent would hardly exceed 25 million tons. It is about 10% of the late-Soviet gross yield compared with an increase of gross profits after the finish of the main stage of the Virgin Land Campaign in 1954-1963.

Complex geographical studies conducted by Orenburg scientists during almost the decades, including researches along the arterial line of the channel, promoted to collect of the richest actual material specified a state of steppe and semi-desert landscapes of so-called the Middle region of the country and the steppe zone, and its soil and biological resources. As a result of the projective works, it was concluded that ecological expenses connected with degradation, salinization, and impoundment of lands, death of unique island pine forests in Turgay, and changes of the total hydrologic regime of the touched territories, undermined biological resources, first of all, sturgeon and outweighed a positive effect – the project was seemed to be ecologically unprofitable at that moment.
The participation in its development promoted the accumulation of a necessary experience to solve gathered ecological problems. The idea to establish the Institute of Steppe AS USSR (or its Ural branch) appeared in those years. Also, during field studies concerning the Gubelinskoe reservoir project in the arid 1975 on the foothills of South Ural, the Aytuarskaya steppe was discovered; after that, the idea to form "Orenburgskiy" State Natural Reserve has emerged [28].

The outcome of enormous research work in Orenburzhie and other RSFSR regions and KazSSR was the 50-volume technical-economic report on the transfer of the part of the Siberian rivers flow to West Siberia, Ural, Central Asia, and Kazakhstan. We should give credit to all numerous discussions, arguments, and State examinations under Gosplan USSR, where about a hundred famous scientists of the country participated [1].

As with every Soviet-social megaproject, the Transfer's launch and rolling back were conjugated with a change of the Soviet government. The epoch of Perestroika exacerbated the public discussion about the reasonability of such a project. In the background of intensified economic problems and departmental conflicts, the project was officially closed (halted) in 1986.

The conducted discussion promotes to draw the following outcomes:

1. The principal landscape heritage of the Plan is the Complex as the forest reclamation framework and system of artificial water bodies; the scientific and scientific-organizing heritage is the system of steppe scientific stations and established priority of woodland belts and artificial water bodies in the agroecological paradigm.

2. The Plan is not only years of its realization, but four historical stages as a minimum: the Complex development (1892-1936); the first attempt of completion (1938-1941); the principal stage of realization (1948-1953); rolling back (1954-1963); the Renascence of components (1966-1986).

3. A complex of afforestation measures, the introduction of a soil-protecting system of agriculture, management of a local flow reduced the sharpness of degradation of steppe arable lands. Still, it did not solve this problem for cultivated areas in a zone of particular agricultural risk.

4. A new stage of the Renascence of the Plan and Transfer's components is realized in China and Kazakhstan as megaproject "The Project to Transfer a Flow on the middle route" (it is notably that the idea emerged in the time of the Soviet Plan), "the Green Wall of China," "the Green belt of Nur-Sultan" (100 thousand woodland belts by 2020).

5. The late-Soviet project to transfer a part of the Ob River flow to the Aral Sea's basin, in reality, did not assume a turn of rivers. It was intended only to dispose of 27 km$^3$ annually or less 7% of the Ob River's annual flow. Criticism, emotions, and apprehensions were more than the project deserved. Still, it was inevitable reinsurance after well-known expenses of the Virgin land project and the total quality of works realization in the USSR.

6. The Orenburg region was in an epicenter of the considered megaprojects. Activation of research in Orenburzhie allowed in complex to look at the steppe zone's middle part – the Trans-Volga-Ural steppe region. Scientific grounds and convergent approaches laid in that period are developed by current steppe science.

7. All complex of the conducted studies regarding the Transfer promoted to the impetuous advance of geographical sciences in Orenburzhie, the outcome of which was the establishment of the Institute of Steppe UB RAS in 1996 that has turned 25 years.

8. The researches regarding the Transfer exposed contradictions and costs of the Soviet steppe land use, showed a real critical situation of landscape-biological diversity in steppes.

9. As a result of large-scale geographical studies in the Trans-Volga-Ural steppe region, Orenburg scientists managed to refute the established thesis that it was impossible to organize a full-fledged steppe reserve in the late-Soviet space due to a loss of steppe ecosystems.
5. Conclusion
The agrarian-social projects considered above promoted to development of fundamental geographical studies in the steppe zone. Tens and hundreds of scientific institutions and teams of which later regional scientific organizations were formed solved scientific problems in the frame of state missions. Thanks to the megaprojects, decentralization of fundamental science was realized; ecological awareness was created. The nature conservation movement activated the Transfer's criticism; scientific and public discussion became a usual event; the leadership experienced megaprojects' expenses and selected scenarios of development offered by the science.

We assume that if the Transfer had been realized by the tsar's or republican government in the first third of the XX century under that period's facilities, it would not have needed a necessity of the Virgin Land campaign. The Plan would not have been a particular measure as the megaproject and would be a stable agriculture standard. In this case, under all unavoidable ecological expenses, the probability for the conservation of a sizeable virgin steppe on chestnut soils by the present would be higher.

If the Transfer had taken place after the Virgin land megaproject, the brought Siberian water would have fastened arable use of these areas, not for dry-farming, but for irrigation. Thus, these areas would have withdrawn from the category of agricultural risks, but the Transfer would have led them to large-scale degradation due to salinization. The soil would be conserved, but as anthropogenic steppe solonetz to restore of that decades would demand.

It is quite possible that escalation of climate contrast, the further desalinization of the Arctic Ocean, siccation of Central Kazakhstan and Central Asia will make us return to the ideas of large-scale afforestation, management of a local flow, inter-basin redistribution of a water flow that has already happened in some countries, including China and Kazakhstan. Considering all trends and challenges, we cannot exclude the project of the Ob River's water transfer to the Aral Sea's basin to be activated. In the case of the project's actualization, it will be a global inter-governmental megaproject on the new technological level and new political conditions. In this work, we displayed that though the Soviet Transfer was a turn of rivers, ecological expenses were expected more than wins. We do not consider supporting the project reanimation on the former view. Still, we are ready to discuss variants and scenarios of dosed transportation of north waters to Central Asia through piping. To achieve success, we suppose principal to solve the problem as landed ownership, so an actual value of fresh water on the post-Soviet space. No matter how water is supplied, it should not be a means of compensation for irrational water consumption expenses. Water supply for commercial cultures should not be equal to humanitarian assistance of people suffered from lack of water. Also, it is crucial that the potential megaproject has to be lost political and ideological components. It should not create unnecessary natural-anthropogenic systems alien to the steppe and the biosphere on the whole and bringing few positive effects for the rural population.

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