AGRICULTURAL SCIENCES

THE LAW OF AGRICULTURAL LAND RECLAMATION IN MODERN REALITIES: MISSION AND DEVELOPMENT TRENDS

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Abstract

Based on a retrospective analysis of the mission and development trends of agricultural land reclamation, within the context of assessing crop water demand standards within the «impact-change-consequences» triad, trends and directions of changes in natural processes were identified. Within this ideological framework, a law of agricultural land reclamation and four of its most important consequences for understanding ways to ensure the environmental sustainability of agricultural lands were formulated. These consequences open the possibility of conducting a comprehensive assessment of the state of river basin watersheds, which are the spatial bases for population and economic activity, and developing a unified program for their improvement within the context of the triad: ecology (ensuring the quality of the human habitat), economy (increasing the purchasing power of society), and society (improving the well-being of the population).

Keywords: melioration, agricultural land, water consumption, agricultural crops, law, consequences, soil, means.

Introduction. Science is a system of organized knowledge, the validity of which is verified and continually refined through social practice. Within its framework, the world is understood through concepts and categories, using logical thinking based on the materialist theory of knowledge. Concepts reveal the essence of natural phenomena and processes, generalizing their essential characteristics across temporal and spatial dimensions, where the most general and essential properties, structures, and interrelations of phenomena of reality and knowledge are reflected in the fundamental categories of science.

The history of the development of nature management science is a path of self-knowledge in a changing world, an understanding of the driving forces behind its development, and a unique marketing of its potential for the development of human civilization, which is formed and functions on the basis of the laws of the philosophy of «negation of negation», which is one of the fundamental laws of dialectics, characterizing the direction, form, and results of development processes.

Concepts and categories form the logical framework of the scientific theory of nature management and conservation, within which its empirical focus-the reclamation of agricultural land-is formed and functions, defining a system of values and designating the object of influence. Such values are currently humans and their habitat, and the object of influence is the soil, as the main component of the landscape biosphere as a whole and as the primary means and object of labor in agricultural production [1], with recognition of their equal importance in terms of the triad: ecology (ensuring the quality of the human habitat), economics (increasing the purchasing power of society), and society (improving the well-being of the population) [2] .

The reality highlighted here for cognition and practical activity, as follows from A.N. Kostyakov's definition, is viewed exclusively through the prism of the «problem-solution» and «goal-means» relationships. The problem is unfavorable natural conditions, its solution is their radical improvement; the goal is the most efficient use of land resources, and the means is a system of organizational, economic, and technical measures. [3]

The combination of three possibilities - a clear expression and delineation, on the one hand, and on the other, the expansion of the «fields» of values for Man, allows A.N. Kostyakov to take another important step - to give the melioration of agricultural lands a pragmatic status, as a geo-ecological limitation – «it is necessary to keep nutrients in the biological cycle in every possible way and in no case allow the acceleration of the geological cycle of water and chemical elements, thereby preventing pollution and deterioration of the natural environment» [4] .

Within the framework of this ideological view, methods for regulating the biological water consumption of agricultural crops were developed, based on a comprehensive accounting of the input-output elements of the water balance in the «soil-plant and surface layer of the atmosphere» system, as a reflection of the law of conservation of energy, since the process of heat and moisture exchange at a specific point in space over a known period of time is characterized by a balance of energy input and output.

The total biological water consumption of agricultural crops, including water consumption for plant transpiration and physical evaporation from the soil surface, which is the main element of the water balance in the «soil-plant and surface layer of the atmosphere» system, is determined using empirical models as a function of climatic indicators [5-11]:

$$BWCAC_i = BC_i \cdot f\ (AT_i;\ RB_i; AHD_i;\ WSE_i)\ (1)$$

where $BWCAC_i$ is the total biological water consumption of agricultural crops, mm; BC_i is the biological coefficient; AT_i - air temperature, °C; RB_i- radiation balance, kJ cm^{-2}; AHD_i - air humidity deficit, mb; WSE_i

- evaporation from the water surface (mm), determined for individual months using N.N. Ivanov's formula:

$$WSE_i = 0{,}0018 \cdot (25 + AT_i)^2 \cdot (100 - RAH_i), \quad (2)$$

here RAH_i - is the relative air humidity, %.

In this regard, it is necessary to pay attention to one most important condition, which is practically not taken into account in the melioration of agricultural lands - this is the activity of the total biological water consumption of agricultural crops ($BWCAC_i$), namely the deficit of biological water consumption of agricultural crops ($\Delta BWCAC_i = BWCAC_i - AP_i$, where AP_i is atmospheric precipitation, mm), which perform important environment-forming, transforming and partially ecological functions, and cannot be arbitrary, but is always limited by the action of laws, the totality of which forms a set of fundamental provisions for the melioration of agricultural lands.

In the process of active development of agricultural land reclamation in certain regions of the world, a paradoxical situation has arisen, related to the fact that the development of irrigation, as an environment-forming system, has been considered for thousands of years a powerful stimulus for the well-being of the population of arid territories, and in Central Asia in the 20th century, it was irrigation that became the cause of the activation of the process of secondary salinization, which led to the deterioration of the environmental and economic situation in the region.

The characteristic feature of the development of agricultural land reclamation, as one of the most important factors in the intensification of agricultural production in the 20th century in Central Asia, required a radical solution to combat secondary salinization of irrigated lands. In 1964, the Resolution of the All-Union Scientific and Technical Conference on the issues of combating salinization and improving the melioration state of irrigated lands in Central Asia was adopted, based on the construction of drainage and a leaching irrigation regime, recognized as the main measure to combat salinization on irrigated lands [12], which provided for the creation of a leaching irrigation regime on irrigated lands, with an intensity of 20-30% of the net irrigation norm, ensuring the creation of downward flows of moisture in the aeration zone for desalination of the upper soil layer, and drainage was supposed to ensure the removal of the leaching part of the irrigation norm and maintaining the groundwater level at a depth of 2.5-3 meters [13], but this measure had a serious side effect, since the indicated circumstances are not causes, but consequences, and the fight against consequences inevitably leads only to a worsening of the situation.

Thus, the change in worldview in the field of standardization of total water consumption of agricultural crops ($WCAC_i$), namely the deficit of water consumption of agricultural crops ($\Delta WCAC_i$), opened a «Pandora's box», which is a source of grief and misfortune, which led to the formation of a pyramid of water consumption standards for agricultural crops in the 20th century in time aspects:

- the first period before 1960, where highly productive meadow-gray soils and gray soil-meadow soils with a close occurrence of groundwater were used for irrigation of lands, which ensured the preservation of the natural hydromorphic regime and full water circulation, which made it possible to reduce to a minimum the values of irrigation norms and the impact on the natural environment, which is determined by the formula of A.N. Kostyakov [3]:

$$SAN_i = CYAC_i \cdot SWCAC_i - (PRMS_i + APGS_i); \quad (3)$$

where $CYAC_i$ is the yield of agricultural crops, t ha^{-1};$SWCAC_i$ - specific water consumption of agricultural crops, mm t^{-1}; $APGS_i$- atmospheric precipitation during the growing season, mm; $PRMS_i = APNV_i \cdot ARCAP_i \leq SMRLMC_i$ - productive reserve of moisture in the soil at the beginning of the growing season, which can be used by plants, mm; $APNV_i$ - amount of precipitation outside the growing season, mm; $ARCAP_i$- coefficient of accumulation and preservation of precipitation in the soil by the beginning of the growing season; $SMRLMC_i$- moisture reserve in the meter-thick soil layer corresponding to the lowest moisture capacity, mm;

- the second period (1960-1965), when there was an intensive growth in total and specific water consumption, with the aim of creating «comfortable» conditions for obtaining a «record» harvest from agricultural crops, that is, the concept of «biological irrigation norm» (SAN_i) appeared [6; 8; 9]:

$$SAN_i = BPC_i \cdot MC_i \cdot \textstyle\sum_{i=1}^{N} SAHD_i - (\, PRMS_i + APGS_i); \quad (4)$$

$$SAN_i = BPC_i \cdot MC_i \cdot \textstyle\sum_{i=1}^{N} SATD_i - (\, PRMS_i + APGS_i); \quad (5)$$

$$SAN_i = BPC_i \cdot MC_i \cdot \textstyle\sum_{i=1}^{N} WSE_i - (\, PRMS_i + APGS_i), \quad (6)$$

where BPC_i and BLC_i –biophysical and biological coefficients of water consumption of agricultural crops; MC_i - microclimatic coefficient; $SAHD_i$- sum of average daily air humidity deficits for the calculation period, mb; $SATD_i$- sum of average daily air temperatures for the calculation period, mb; WSE_i- evaporation for monthly time intervals according to N.N. Ivanov, mm; N_i - duration of the billing period, days or months;

- the third period (1965-1975), where, in connection with the development of low-productivity and secondary saline lands, in order to regulate and manage the salt regime of the soil of irrigated lands, it was recommended to increase the biological irrigation rate by 20-30%, that is, the concept of «soil-reclamation irrigation rate» ($SAIN_i$) appeared [14], which is determined by the formula of F.F. Vyshpolsky:

$$SAIN_i = IRISIL_i = (IRFHSR_i - WCIF_i \cdot CGWCAC_i \cdot CGSM_i)/RCSSSR_i, \quad (7)$$

where$IRISIL_i$ - irrigation rate ensuring the meliorative well-being of irrigated lands, m^3 ha^{-1}; $IRFHSR_i$ - irrigation rate (net) under favorable hydrological and soil-meliorative conditions, m^3 ha^{-1}; $WCIF_i$- total water consumption by the irrigated field, m^3 ha^{-1}; $CGWCAC_i$- coefficient taking into account the share of possible participation of groundwater in water consumption of agricultural crops; $CGSM_i$- coefficient taking into account the size of permissible participation of groundwater in subirrigation when its mineralization changes; $RCSSSR_i$ - melioration coefficient, taking into account the degree of salinization and salt release of soils in the aeration zone;

- the fourth period (1975–1995) was characterized by the conversion of automorphic soils into hydromorphic and semi-hydromorphic ones, which contributed to the activation of secondary salinization on irrigated lands. The discharge of drainage water into rivers led to an increase in the mineralization of river water in the Central Asian region, which required an increase in biological irrigation rates to enhance the leaching regime by 40–60%. Thus, the concept of «meliorative-leaching irrigation rate» ($MLIR_i$) [15] was introduced, which is determined by the formula of S.F. Averyanov:

$$MLIR_i = (BWCAC_i - AP_i) \cdot \langle [1/(1 - \overline{GM_i})] \cdot \{[(\overline{IWM_i} - 1)/\overline{GD_i}] + 1\} \rangle; \quad (8)$$

$$\overline{GM_i} = GM_i/\ PSSM_i; \overline{IWM_i} = (IWM_i/PSSM_i \quad (9)$$

$$\overline{GD_i} = GD_i/(HDP_i \cdot SP_i); \quad (10)$$

where GM_i is the groundwater mineralization; $PSSM_i$is the permissible mineralization of the soil solution; $IWM_i$is the mineralization of irrigation water; $GD_i$is the depth of groundwater; $HDP_i$is the hydrodispersion parameter; SP_i is the soil porosity;

- the fifth period since 1995, a decrease in the overall and a sharp increase in specific water consumption, against the background of the desire to stabilize specific water consumption on the basis of environmental regulation of water requirements of agricultural lands [16; 17; 18], based on the principle of energy balance of heat, moisture and nutrients, taking into account natural regimes, which is determined by the formula of M.I. Budyko [19]:

$$ETAL_i = (RBAL_i - THF_i - HFIS_i)/\ IHVO_i \rightarrow \quad (11)$$

$$ETAL_i = RBAL_i/IHVO_i \rightarrow \quad (12)$$

$$\Delta ETAL_i = (RBAL_i/IHVO_i) - (\ PRMS_i + APGS_i), \quad (13)$$

where $ETAL_i$is the reference evapotranspiration of agricultural land;$RBAL_i$ - radiation balance of agricultural land; $IHVO_i$- latent heat of vaporization; THF_i- turbulent heat flux; $HFIS_i$- heat flux into the soil.

Thus, a retrospective analysis of the scientific basis for agricultural water requirements shows that, in the pursuit of record crop yields by creating favorable conditions for plants as objects of reclamation, science and practice have violated the fundamental principles of water conservation in nature management. Instead of seeking ways to prevent geological cycles in total water consumption, they have always sought to increase it, with the caveat of comprehensively regulating key environmental factors. As a result, having gained unprecedented power through agricultural land reclamation and, by defying the laws of nature, humans have driven themselves into a dead end, depriving themselves of prospects for development within the framework of modern civilizational paradigms. Irrigated lands have entered an active stage of "succession," where crop water requirements serve a destructive function.

The aim of the study is to substantiate the law of agricultural land reclamation based on the materialistic theory of knowledge and natural scientific concepts of modern ecological and economic mechanisms for the use of natural resources.

Materials and methods of research. Research materials are based on the analysis of the experience of agricultural land reclamation in previous years, within the framework of a comprehensive assessment of their activities in terms of the triad «impact - change – consequences», allowing to identify the trend and direction of activity-natural processes.

The research method is based on the materialistic theory of scientific knowledge, which recognizes socio-historical practice as the basis of knowledge and the criterion of truth, and generalizes the methods and techniques of science (experiment, modeling, analysis and synthesis).

Research results. Systematization and analysis of the research base demonstrate that agricultural land reclamation serves not only as a cognitive object with specific properties, nor is it limited to the territorial organization of water use and the interaction of system elements. It should also be considered an integral resource embodying the inherent attributes of the territory, a unique formation within the geosystem capable of self-organization and performing environment-forming, resource-containing, and resource-reproducing functions.

However, in the science of agricultural land reclamation in the last century, the main attribute of the fundamental nature of science was considered to be the presence of its own material object of knowledge, which would exist independently in a certain dialectical form of the movement of matter, which allowed the emergence of the terms «biological norm of water demand», «soil-reclamation water demand of agro-landscapes for the complex regulation of the main factors of plant life» and «reclamation-washing water demand of agro-landscapes for the regulation of the hydrogeochemical regime of soils and groundwater» in the technological processes of agricultural land reclamation, and taking into account the mineralization of irrigation water [20]. On the basis of these concepts, the «Enhanced standards of water demand for irrigation in the natural and climatic zones of the USSR» [21], «Irrigation standardization in the water management basins of Kazakhstan» [22] and «Assessment of the prospects for sustainable development of the states of the Aral Sea basin using model calculations» were developed, carried out in the Scientific Information Center (SIC) of the Interstate Coordination Water Management Commission (ICWC) [23], as well as the technology of irrigation of agricultural crops [24; 25], that is, these regulatory documents do not comply with such basic principles of agricultural land reclamation as «Increasing the biological and preventing the geological cycle of water and chemical substances» and, corresponding to the classification of the outstanding physicist Lev Landau, unnatural laws of nature and principles of nature management [26].

As a striking example of such a transformation of relations, we will pay attention to the drift of the concept of «water consumption standards for agricultural land or crops», which is fundamental in the empirical wing of agricultural land reclamation:

- the biological norm of water demand of agricultural crops is the volume of water consumed by an agricultural field for transpiration of plants and physical evaporation from the soil at a specific point in space over a known period of time, taking into account their biological characteristics;

- the ecological norm of water demand for agricultural land is the volume of water consumed by an agricultural field for soil formation, corresponding to the radiation balance at a specific point in space for a known period of time, characterizing the balance of energy and substances that ensure a balanced flow of biochemical and geochemical processes;

- the soil-ameliorative norm of water demand for agricultural land is the volume of water consumed by an agricultural field for the complex regulation of the main factors of plant life in the «soil-plants- surface layer of the atmosphere» system at a specific point in space for a known period of time;

- the melioration and leaching rate of water demand for agricultural land is the volume of water consumed by an agricultural field to regulate the hydrogeochemical regime of soils and groundwater in the «soil-groundwater-plants- surface layer of the atmosphere» system at a specific point in space over a known period of time.

Understanding and systematically understanding the laws governing the functioning of soil as an object of reclamation, as well as plants as biological entities interacting with the soil-their habitat-combined with intuitive knowledge, can lead humanity to a deeper understanding of natural processes and to the development of a concept for managing the present based on predicting the future. This approach is key to ensuring the survival of not only human civilization but also the preservation of biological diversity on the planet.

Soil, considered an object of reclamation, must be perceived by plants as their environment and a primary factor in their life support, thus acting as a natural partner in biospheric interactions.

In this regard, it's necessary to address a crucial condition that's largely ignored in agricultural land reclamation. Its essence is as follows: any transformation of nature cannot be arbitrary, but is always constrained by objective laws, the combination of which forms a system of fundamental principles for agricultural land reclamation in the form of laws limiting its activities.

The Law on Agricultural Land Reclamation states:

«Any transformation of agricultural land must ensure the preservation of nutrients in the biological cycle with the goal of progressively increasing soil fertility and, under no circumstances, accelerate the geological cycle of water and chemical elements, thereby preventing pollution and deterioration of the natural environment». According to Zh.S. Mustafayev, this law has four key consequences that determine ways to ensure the environmental sustainability of agricultural land.

- the value guidelines for any transformation of agricultural land are people and their environment, and the object of influence is the soil - as the main component of the biosphere and the landscape as a whole, as well as the main means and object of labor in agricultural production.

- the interaction of the material and energy resources of the natural system, which determine the standards for water consumption of agricultural lands, should ensure an energy balance of heat, moisture and nutrients, taking into account natural regimes aimed at the targeted regulation of the direction and intensity of soil-forming processes;

- Any transformation of agricultural land is relatively irreversible and causes responses that affect its ecological and biological potential. Its increase is possible only if the lower threshold of the maximum permissible level of water demand ($ETAL_{mini}$) - plant transpiration, which ensures the formation of biological masses (PT_i) - and the upper threshold of the maximum permissible level of water demand ($ETAL_{maxi}$) - ecological standards for the water demand of agricultural lands ($ESWCAL_i$), ensuring the targeted regulation and management of soil-forming processes on irrigated lands are observed.

- any change in the water requirement of agricultural land, taking into account the cyclical nature of crop cultivation in crop rotation (crop rotation) and climate change, should not exceed the ecological water requirement standards of agricultural land ($ESWCAL_i$), ensuring the preservation of their ecological and economic potential.

This law and its consequences are crucial for the justification and practical implementation of agricultural land reclamation. They enable a comprehensive assessment of the condition of river basin watersheds, which serve as the spatial basis for population distribution and economic activity. On this basis, a unified program for improving the area is being developed, taking into account a triad of priorities: ecology – ensuring the quality of the human habitat; economics – increasing society's purchasing power; and society – improving the well-being of the population.

Based on the materialist theory of knowledge, the concept of «law» in science and philosophy reflects the existence of a necessary, essential, stable, and repeatable relationship between natural phenomena. In the field of agricultural land reclamation, this means that the patterns of natural processes can be systematized and used for the controlled transformation of land. In addition to the general laws of nature, such patterns include the law of agricultural land reclamation formulated by A.N. Kostyakov and Zh.S. Mustafayev, which specifies the principles of interaction between humans and the natural environment in agricultural landscapes.

Conclusions. In conclusion, it should be noted that the established agricultural land reclamation mission is reviving the law of agricultural land reclamation. However, the conclusions reached within the study do not claim to exhaustively cover all aspects of modern environmental management and conservation issues; they are largely debatable and intended primarily to provide scientific support for agricultural land reclamation. These approaches should form the basis of an updated system of regulatory and methodological documents governing the environmental justification of the design, construction, and operation of next-generation hydro-agrolandscapes.

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