AGRICULTURAL RECLAMATION: PAST, PRESENT AND FUTURE

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Contents

Summary

It is possible to state that reclamation has served to develop human culture; it is one of the most ancient spheres of activity, through which humankind was given the opportunity to prosper. Creation of reclamation systems was always evidence of a powerful state, and destruction of reclamation systems, during wars or through inappropriate operation, resulted in the failure of states.

In ancient times reclamation was complex, i.e. reclamation systems were constructed in such a way that they were able to regulate not only water, but also nutritional, thermal and other environmental factors. Modern reclamation systems do not always have such properties, since only the water factor is generally controlled. Proceeding from the ecological law that all environmental factors are equivalent for a plant, it is possible to assume that creation of the regulation systems of complex reclamation permits (by not less than 30 to 50%) significantly increased production of crops on reclaimed lands. This will help to reduce the imbalance between the increasing population and the area of reclaimed land.

It is expedient to develop a system of adaptive agriculture on reclaimed lands, while

taking into account not only possible acclimatization to external natural conditions and productive forces, but also the reclaiming action of sown plants. The better the plant and the whole biotic aggregation feel, the greater reclaiming effect they exert, adapting the conditions of the external environment to their requirements. Here the adaptive properties of plants are also revealed.

Thus, the system of complex regulation should be multi-factor, i.e. it should regulate the water, thermal and nutritional regimes of soils, and it should be self-contained.

The regulation systems of complex reclamation are dialectically stipulated products of human interaction with the environment, developed during man’s prolonged attempts to increase the productivity of natural biogeocenoses. Such systems are likely to prevail in future.

In conditions of changing climate, agricultural reclamation can help to stabilize food production, to reduce the rate of desertification, and to maintain biodiversity.

1. Reclamation in the past. Retrospective reclamation development review:

Between the sixth and third millennia B.C., the major valleys and foothills of three great rivers of Africa and Asia—the Nile, the Euphrates and the Indus—were developed for agriculture.

Research by the Russian geographer and historian L.N. Gumilev, in connection with population increase, showed that the area of idle land favorable for agriculture in the foothills was shrinking at that time. People left and moved farther afield, into the droughty steppes, or went to the plains, which were periodically inundated by floodwaters. In the arid zones and the hot dry steppes, grasses (family Graminae) could not grow without artificial irrigation.

Agriculture was very problematic, as all three of these major rivers frequently burst their banks, periodically inundating large areas, and often for months at a time. The crops were either often swamped by floods or burned by the sun after the flood receded. Hence, the harvests here were much poorer than in the favorable conditions of foothills, even though no sufficient nutritional input was provided.

Many centuries had to pass until the inhabitants of the great river valleys overcame the problems of rational management of floodwaters for agriculture. Depending on the local natural conditions, different methods were adopted.

In the Nile valley, the floods began in June and the water stayed until October. Waters were held back on the fields by earth banks (in modern terminology, it was a sort of firth irrigation and water retention system). Water was collected within embankments, and a prolific silt precipitated, after which the water was drained, and the silt left behind retained sufficient moisture for the whole period of grain crop cultivation. Furthermore, the silt itself was a perfect fertilizer. This was probably the first example of a combined water and fertilizer management system on reclaimed lands. The thermal regime was also improved, since the soil was cooled by water evaporation.

Normally in spring, the river flooded the Lower Euphrates valley from time to time.

When this happened, the water was diverted into special water-storage reservoirs, from whence it could be periodically fed to the fields during times of growth.

Another method was used for taming the river in the Indus valley in the middle of the third millennium B.C.

At first, reclamation systems were adopted not in the whole river basin, but in individual fields. Later, the irrigated areas expanded as neighboring communities began to cooperate, and great progress was made. This great achievement was due to the inhabitants' high degree of organization and cooperation.

Agricultural reclamation over a wide area required a high level of organization to coordinate the work of many workers towards a single plan; this was one of the major achievements of early civilizations.

Use of river water for large-scale irrigation at that time in history (i.e. the Stone Age and Bronze Age) was possible only in places where the soil was soft enough, the river banks were not too steep and rocky, and the current was not too fast. Therefore, because of these physical conditions, even in the subtropical desert-steppe, steppe and forest-steppe zones, many rivers, including the Tigris (adjacent to the Euphrates), the Arax and Kura, Syr Darya and Amu Darya, etc., could not be the basis of irrigation civilizations until much later (Gumilev, 1989).

The efficacy of irrigation was highest in places where deep sediment from floodwaters formed the soil. Crops began to flourish when plough tillage was introduced (first by donkeys and later by oxen). This technology remained virtually unchanged for several millennia.

It was by the end of the fourth millennium BC in Egypt and Sumer (southern Mesopotamia) that crop yields multiplied greatly, by a factor of ten or even twenty. This meant that every farmer could produce much more than was required for his own needs. This led to favorable developments in cattle breeding, which in turn led to an even greater rise in people's living standards. Each community was able not only to support its workers but also the disabled and dependents, e.g. children and old men. They were able to create a reserve of foodstuff and to free a part of the workforce from agricultural labor.

At this time, specialized crafts began to appear: pottery, weaving, shipbuilding, stonecutting, tinsmithing, etc. Thus, the development of agricultural reclamation served as the beginning of commercial production development.

In due course, reclamation systems were developed, and areas were expanded. In the fourth millennium B.C., several smaller canals were created to take water from each of main river watercourses, and by constructing a system of weirs and reservoirs it became possible to hold the water back for regular irrigation of the fields during the whole growth period.

It is necessary to note that not only irrigation, but also drainage was developed at this time, and there were separate irrigation and drainage floodplain systems. By controlling the prolific silt precipitation, they also achieved a measure of regulation over nutrient supply. We can safely say, therefore, that at the earliest stages of its development, agricultural reclamation was complex, with systems to control water supply, nutrient supply and, to a certain extent, the thermal regime of agricultural lands. As a result of this progress, crops increased and it was possible to accumulate foodstuffs.

Qualified specialists were required for construction and maintenances of the reclamation systems, during their operation, and these functions (e.g. canal construction and clearing, and construction of other earthworks) were generally accomplished (according to Gumilev) not by slaves, but by community members. Each free adult was obliged to spend, on average, one to two months each year on these works, throughout the history of ancient Mesopotamia. Free community members also carried out the basic agricultural operations, e.g. tillage and sowing.

Archeological examination of traces of the most ancient settlements in Lower Mesopotamia has revealed that the process of improving the local reclamation systems was accompanied by removal of small settlements of family farms. These people moved into city centers, where the main temples, with their rich barns and workshops, were situated. The temples served as centers for inventories and management; from here, on behalf of the leading officials, traders traveled to other countries to exchange the food and textiles of Lower Mesopotamia for timber, metals, and slaves.

At the beginning of the second quarter of the third millennium B.C., the densely populated areas around the main temples were enclosed with town walls. By about 3000 to 2900 B.C., temple facilities had become so complex and extensive, that records of their economic activities became necessary, and as a result, written language was generated. Over about 500 years, a written system of characters resembling subjects was transformed into an ordered system of information transmission. This was achieved by about 2400 B.C.

Thus, it is possible to state that agricultural reclamation also provided the stimulus for development of human culture.

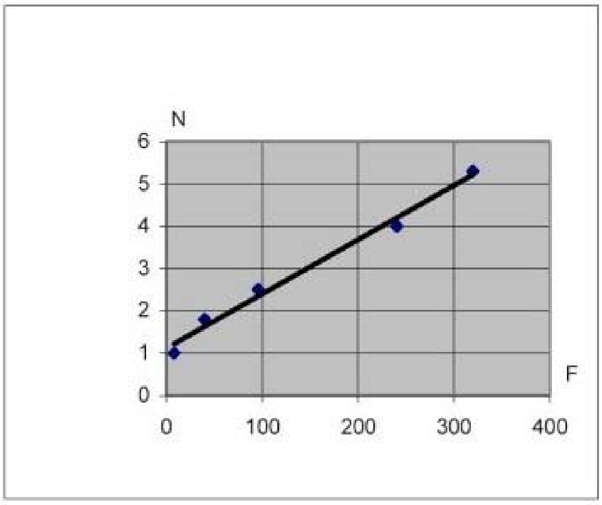

Figure 1. Dependence between the irrigated area in the World (F) and the population on the Earth (N).

Although the ancient world had irrigated areas comprising hundreds of thousands of hectares, widespread development of reclamation was not achieved until much later.

Over the last hundred years there has been a straight line relationship between irrigated area and world population, i.e. irrigated area per capita remains constant, approximating to 0.07 ha per inhabitant of the globe (see Figure 1). In other words, about 14 people rely on the production from every irrigated hectare.

Figure 2 shows the curve of increase in the area of irrigated land in the nineteenth and twentieth centuries.

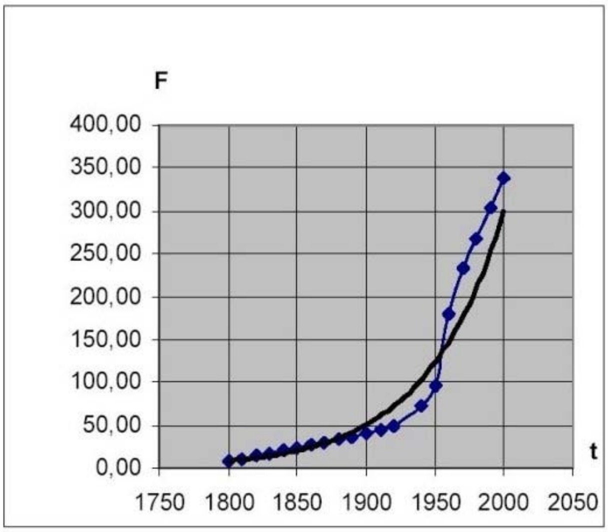

Figure 2. Increase in the global area of irrigated land

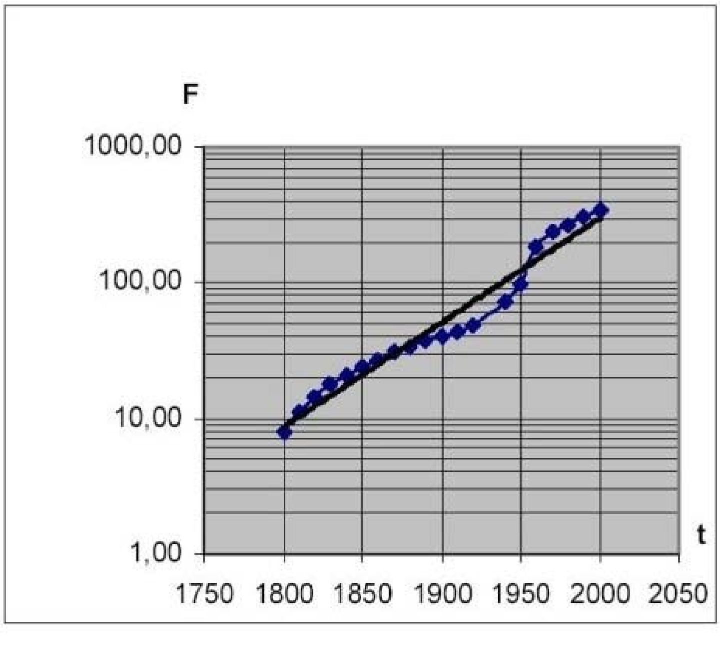

Figure 3. Increase in the global area of irrigated land, on a logarithmic scale.

As seen in Figure 2, the irrigated area increase can be approximated to an exponential dependence. In the 1960s, the rate was slightly higher, and in the 1980s it slowed. It is visible if we create a logarithmic graph (Figure 3).

In the future, the rate of increase of irrigated land must slow down, as the total irrigated area will be limited by water resources and suitability of the land.

The global area of drained land is smaller than the irrigated area, and, as at 1995, totaled about 200m ha.

The Greek historian Herodotus first described the drainage of agricultural lands more than 2000 years ago. According to his description this system was created for collecting water after high river floods. In the Middle Ages, in northern Europe, drainage systems became widespread, along with the extensive development of new agricultural land and drainage of urban land, particularly during the tenth century in the Netherlands and Great Novgorod of Russia.

Thus, it is possible to say that agricultural reclamation is one of the most ancient spheres of human activity, and one which enabled humankind to prosper. Construction of large reclamation systems was always evidence of a powerful state, and destruction of reclamation systems, during wars or due to inappropriate operation, contributed to the failure of states.

2. Trends in the Development of Agricultural Reclamation

Reclaimed land areas, in particular irrigated land, comprises about 10-15% of the ploughed areas of the Earth, but they are responsible for about 30% of the production (in money terms). Hence, in order to supply the growing population with food, a constant input of new reclaimed land is required, in addition to intensification of agriculture on existing reclaimed land.

According to UN experts, to resolve the global food problem, the irrigated area should be increased by 0.5% annually. At the same time, to ensure stable agriculture, the distribution of irrigated lands, in terms of natural-climatic zones should be in excess of 20 to 25% in the arid zone, 10 to 20% in dry steppe; 5 to 10 % in steppe, and 1 to 5% in forest-steppe (Prof. B.S. Maslov).

Nowadays, vast irrigated areas are located in India, China, Pakistan, Egypt, Iran, USA, and Russia. Apparently, lack of available water resources will remain the principle limiting factor in the expansion of irrigated land. This applies to all the relevant countries, except for Brazil and Russia.

Undoubtedly, the scale of new reclamation development will depend on population increase and global climate change, but the quantitative increase of irrigated and drained land will become less important than the quality of agricultural reclamation.

As described above, in ancient times reclamation systems were complex, i.e. they were constructed in such a way that they were able to control not only water, but also nutritional, thermal and other environmental factors. Modern reclamation systems do not always possess such properties, because basically only the regulation of water flow is controlled. Using ecological principles, it is possible to believe that creating more sophisticated reclamation systems will permit significant increases in crop production (not less than 30-50%) on existing reclaimed lands, and this can reduce the gap between population growth and creation of new areas of reclaimed land.

Today, the concept of complex reclamation regulation is sufficiently developed. The systems have been proved, and in future, their area and importance can only increase.

We will now consider in more detail the different kinds and methods of agricultural reclamation. Table 1 sets out the methods and objectives of regulation, including hydraulic engineering, climatic, technical crops, edaphic, chemical, agricultural and forest reclamation, phyto-reclamation, reclamation of water used for irrigation.

Reclamation type	**Reclamation kind**	**Reclamation methods**
I. Hydraulic engineering reclamation	1. Drainage	Water removal, drainage
	2. Irrigation	Sprinkling, surface watering
	3. Humidifying	Water retention
	4. Watering	Water supply to the territory
	5. Flood-control (flood protection)	Water-storage reservoirs, dams construction
	6. Hydraulic forest reclamation	Forest irrigation
	7. Water reservoirs reclamation	Water reservoirs clearing
	8. Soil-saving	Ravine reinforcement
	9. Mudflow protection	Mudflow protection structures
	10. Landslide protection.	Decrease of watering, ground reinforcement.
	11. Agro-reclamation	Narrow-cut plowing, roll contouring
II. Climatic	12. Snow	Snow retention on the fields, snow blackening to accelerate melting, snow clearing
	13. Thermal	Soil surface mulching
	14. Frost protection	Anti-frost sprinkling, fuming
	15. Artificial precipitates inducing	Cloud seeding with water-drop forming reagents
	16. Hot wind protection	Agro-forest reclamation, aerosol moistening.
III. Technical crops	17. Land surveying	Fields agglomeration, creation of fields with a uniform water regime and fertility.
	18. Soil surface reclamation	Stones, brush and low-forest removal from the arable lands, mossy tow removal, hummock finishing, grading
	19. Plowed soil layer reclamation	Buried stones and wood removal

IV. Edaphic	20. Structural	Addition of sand, clay and peat, soil structure-forming with chemical reclaiming reagent application, deep tallage
	21. Reclaiming	Quarry land, lake and sea bay bed development
	22. Sands reclamation	Water-holding capacity of soil increase, feeding organics (e.g. peat)
	23. Sedimentation	Creation of soil with the help of silt precipitation
V. Chemical	24. Soil acidity control	Liming, gypsuming
	25. Salt protection	Chemical reagents application, soil flushing, drainage
	26. Solonetz reclamation	Gypsuming, deep tallage, phyto-reclamation
	27. Oxidant	Oxygen-containing fertilizers application
	28. Fertilizing	Mineral and organic fertilizers application
VI. Agro-forest reclamation, phyto-reclamation	29. Erosion preventive	Forest shelter belts
	30. Anti-deflation (soil protective)	Biologic drainage, harrowing, planting beds and gaps control
VII. Reclamation of water used for irrigation	31. Irrigation water acidification	
	32. Sprinkling water chemical composition optimization	
	33. Warming cold sprinkling water	
	34. Sewage water treatment	

Table 1. Kinds and Methods of Reclamation (according to Prof. B.S. Maslov)

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Biographical Sketch

Shabanov, Vitaliy Vladimirovich, Doctor of Technical Sciences, Professor of the Moscow State University of Environmental Engineering, Academician of the Russian Academy of Agricultural Sciences V.V. Shabanov was born on June 27, 1937, in Moscow, into the family of hydrologist. In 1964, he graduated from the Engineering Department of the All-Union Institute of Extension Education in Agriculture; in 1991, he took the retraining course in Ecology at Moscow State University and got the diploma of Expert in Ecology

His scientific career started in the Yakutian Expedition of the Research Center of Moscow Institute of Hydraulic Engineering and Water Management, where he worked as a laboratory assistant and then junior researcher from 1956 to 1966. In 1966, he headed the works on the creation and maintenance of the automated system of water regulation on reclaimed lands in Byelorussia. From 1972 to 1987, he was the Head of the Laboratory of the Problems of Regulation of Water, Temperature, and Salt Regimes of Reclaimed Lands; since 1987, he has been a scientific supervisor of this laboratory. From 1981 to 1995, he headed the Chair of Multiple Use and Management of Water Resources. Since 1995, he has been a professor of the Chair of Amelioration and Rehabilitation of Lands of the Moscow State University of Environmental Engineering.

In 1969, V.V. Shabanov defended his Candidate Sci. dissertation on the feasibility of land reclamation measures; his Doctoral dissertation (1992) was devoted to quantitative methods of assessing and regulating the factors controlling crop development under conditions of reclaimed lands.

Scientific interests of Prof. Shabanov are connected with mathematical modeling of economic efficiency and environmental security of land reclamation projects, including the models describing the interaction between plants and environmental factors and the optimization of the use of water resources upon irrigation. His recent works were aimed at assessing changes in potential crop yields under various climatic scenarios and developing the methodology for monetary evaluation of environmental factors for land reclamation projects and optimization of investments.

Professor Shabanov is the author of more than 150 scientific works, including two monographs: "Bioclimatic Factors and Land Reclamation" (Leningrad: Gidrometeoizdat, 1973) and "Water Supply of Spring Wheat and Its Calculation" (Leningrad: Gidrometeoizdat, 1981). He is a co-author of two textbooks on the multiple use of water resources and related issues of environmental protection.