POSSIBLE ENGINEERING SOLUTIONS FOR THE COMPLETION, RECONSTRUCTION AND MODERNIZATION OF THE IRRIGATION INFRASTRUCTURE

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Abstract: *The purpose of this report is to propose possible engineering solutions for the construction, reconstruction and modernization of the existing irrigation infrastructure in our country . These solutions can assist beneficiaries in the application process for the Rural Development Program 2014-2020 under sub-measure M4.3 "Support for investment in infrastructure related to the development, modernization or adaptation of agriculture and forestry". In order to achieve this goal, the state of the existing irrigation infrastructure has been analyzed and the specifics of the irrigation systems in our country have been assessed. Based on this several model systems of different type and construction were selected. For some of the irrigation fields, possible technical solutions concerning their completion, reconstruction and modernization have been analyzed.*

Keywords: CONSTRUCTION IRRIGATION SYSTEMS, RECONSTRUCTION, MODERNIZATION, TECHNICAL SOLUTIONS

1. Introduction

Hydro-meliorative infrastructure is fundamental to economic development, demographic growth, social development and higher standard of living for a country. Therefore, a great deal of attention should be paid to this sector and to improve, reform and modernize its current state.

In our country the existing irrigation infrastructure was built sinse 1960s to 1980s. It reaches up to 1.2 million ha, then begins a sharp decline. It includes a total of 236 irrigation systems and a significant number of irrigation fields with a total area of 740 000 ha, 168 dams and water bodies with a total capacity of 3.1 billion cubic meters of water, 168 irrigation stations, 6435 km of open channel and 9269 km of underground pipeline network [1].

At present, most of the irrigation systems in Bulgaria are managed by the State Trading Company "Irrigation Systems" SSC, which has the task of maintaining and exploiting the state water and melioration fund for the capture, storage, distribution and sale of irrigation water agricultural crops.

A small part of the total area (39 289 ha) is served by 106 irrigation associations, which manage an irrigable area of 30 073 ha.

According to data from "Irrigation Systems" SSC and from studies conducted by a team of experts at the World Bank in 2014, the irrigated areas amount to 433 526 hectares, of which 247 300 are gravitationally supplied and the remaining are supplied by pumps and the real water is supplied only 22 000 - 27 000 ha.

On some of the areas intended for irrigation are built drainage networks with open channels or with underground drains, as well as 94 pumping stations for pumping drainage.

The inefficient use of the existing irrigation infrastructure in our country is due to the poor technical condition of the transport-distribution network; equalizers, pumping stations as well as the internal distribution network, which is mainly made of asbestos-cement pipes. Large quantities of metal fittings and equipment are stolen from the facilities on the grid and pumping stations, closed pipe networks are deliberately destroyed. To reduce the financial burden of the operating company, part of the equipment of the pumping stations, as well as a large number of steel pipes, were handed over to scrap.

In line with the state of the irrigation systems and facilities, the priorities and measures formulated in the current programming period 2014-2020 under the Rural Development Program as well as those developed by the World Bank and endorsed by the Council of Ministers in August 2016 "Common Strategy for Management and Development of Hydro-melioration and Protection against Harmful Effects of Water " gives us reason to expect the preparation, implementation and management of investment irrigation projects concerning reconstruction and modernization of irrigation systems and facilities [2] [3] [4].

The rehabilitation of irrigation infrastructure will not only increase the competitiveness of farms but also ensure effective, rational and environmentally sound management of available water resources.

This report aims to offer engineering solutions for the completion, reconstruction and modernization of model irrigation systems. These solutions will help beneficiaries under the Rural Development Program 2014-2020 , sub-measure M4.3 "Support for investment in infrastructure related to the development, modernization or adaptation of agriculture and forestry".

In order to achieve this goal, we analyze the technical parameters of the irrigation systems and equipment built in our country; selection rules have been defined and model irrigation systems have been selected for which engineering solutions for construction, reconstruction and modernization have been proposed.

2. *Methods of study*

The research is done in two aspects: analytical and experimental. The main research methods used are:

- An analytical method, on the basis of which are analyzed the technical parameters of the irrigation systems and facilities built in our country.

- A field survey method based on which field studies have been conducted to study and collect data needed to analyze the state and possible solutions for the completion, reconstruction and modernization of model irrigation systems.

3. Results and discussion

The analysis of the technical parameters of the country's irrigation systems and facilities gives the following results:

Of the 5,441 km of main and secondary canals operated by "Irrigation Systems" SSC, 75% of them are lined. The condition of the cladding (concrete slabs) is poor due to the aging and frosting of concrete, destruction due to hydrostatic pressure of the groundwater, not keeping furies, and in some cases the cladding is missing. In the canal network there is a significant amount of moisture-bearing vegetation which also destroys the lining. The slopes are overgrown, and sludge, sand, or tile pieces are deposited on the bottom, caused by uncovered channels or damaged areas up the net.

The cast-lined channel network is in better technical condition, and the on-site cladding restricts the growth of vegetation and prevents the erosion of the slopes. The deterioration of the integrity of the cladding in places is due to the quality of the construction and

the materials used, as well as to the lack of maintenance over the years.

The equipment of the transport-distribution network (floodgates and their lifting mechanisms, water dispensers, water level regulators, etc.) are made of steel and to prevent thefts, the employees of the exploitation company are forced to install and dismantle them in the beginning and end of each irrigation season. All of this leads to serious depreciation of the equipment and destruction of the equipment to which it is mounted.

The management of water distribution in the grid is poor. To measure the water quantity, level gauges are used. Most major channels are manually operated by floodgates, requiring multiple intraday adjustments to maintain the required water level. Secondary water canals are built in such a way as to require a high water level in the primary ones. For this reason, maintaining high water levels in these channels is accompanied by high technological and filtration losses.

Asbestos-cement pipes are heavily dampened and do not withstand the design working pressure. The network does not have stopcocks, airbrakes and others.

Fig. 1 *Concrete pipes*

Of the existing 612 items. equalizers, 512 pcs. are lined. Their main problems are related to their coatings, filtration losses and accumulation of deposits.

The technical condition of the pumping stations depends on the irrigation system considered and the predominant way of feeding it. Many of the existing pumping stations are currently being destroyed.

Ownership of the internal distribution network, including third-line pipelines and pipelines is not very clear and they are unofficially maintained by "Irrigation Systems" SSC. The problems in this network are the same as the primary and secondary channels. As far as water distribution is concerned, water is diverted by improvised means such as sandbags, boards, etc.

The analysis of the technical parameters of irrigation systems and facilities in our country shows an urgent need for further construction, reconstruction and modernization of the same, as according to a study of the World Bank experts, the necessary capital expenditures amount to more than one billion euros [4]

Fig. 2 *Damaged pipelines*

At present, the most favorable impacts are expected to be achieved under the 2014-2020 Rural Development Program, Area 5A "Increasing Water Efficiency in Agriculture", namely: Measure M4 " Investments in tangible assets ", Sub-measure 4.3 aimed at supporting investments in irrigation and drainage infrastructures.

However, the envisaged financial resources under this measure are extremely insufficient and it is necessary to prioritize the projects for completion, reconstruction and technical improvement of the irrigation systems and facilities to them. In order to select certain irrigation systems and to prepare effective projects for them, an analysis covering the following aspects: technical studies, management, social, environmental and financial conditions should be analyzed, analyzing different options and their economic efficiency under specific conditions.

The technical studies need to be considered: location of the irrigation system and its facilities; service; water supply, production structure, irrigated area, way of water supply, transport network, transport network efficiency, distribution network, distribution network efficiency, irrigation equipment, irrigation system efficiency.

Analyzing:

- The natural and climatic conditions (geography, climate, soils, water resources).
- The ecological characteristics in the area of the irrigation system, incl. general assessment of the state of the components of the environment, ecological characteristics of the land fund, characteristics of the landscape, etc.
- The available production resources, incl. land resources, production structure (cultivated crops, irrigated crops, average yields, crops crops budget, including the income part obtained in value terms as a result of crop yield and labor cost, seeds and fertilizers and plant protection products, water for irrigation, fuels and lubricants, repair and maintenance of agricultural machinery, depreciation, taxes, fees, insurance, etc., possibility for sealing of irrigated areas).
- Available service staff (number, qualification, experience).
- The material-technical and technological base, incl. available buildings, machinery, facilities, condition and production capacity.
- Possible technical solutions for reconstruction, reconstruction and modernization of the existing irrigation system and its facilities..

Managerial aspects need to be addressed: a survey of beneficiaries to apply for funding, motivation of the participants in the investment process; project manageability throughout the life cycle; cooperation between the different institutions. The following questions should also be answered: what are the available human resources serving the irrigation system; is it necessary to create new organizational forms; Are additional qualified staff and support staff needed, etc.

The social aspects cover the study of the labor activity of the population, the amount of income and the standard of living, taking into account that improving the state of the irrigation systems is aimed at increasing the income of farmers.

The financial aspects of selecting a project for the completion, reconstruction and modernization of an irrigation system are limited to assessing the feasibility of the project from the point of view of the individual water user on the basis of the farm budget. The reality of financial analysis is ensured by properly defining revenue and cost over the lifetime of the project.

From an economic point of view, a project implementation analysis is needed to determine its contribution to the development of our country's overall economy, and whether this contribution is sufficient to justify funding.

The most important indicator for determining the efficiency of the reconstruction, reconstruction or modernization of each irrigation system is the profit generated by them. Therefore, to

evaluate the effectiveness of the investment project it is necessary to use different methods, including:

- Static assessment methods, which serve as a reference point in the initial stages of the development of such projects. On the basis of these indicators, the "pay-back period for investments" and the "cost-effectiveness of investments"

- Dynamic evaluation methods that serve to compare revenue and costs that are accounted for throughout the life of the project. The alignment of revenue and expenditure over time is achieved by comparing and discounting them. These methods refer to 'Net Present Value'; 'Internal rate of return'; 'Ratio: Revenue-expenditure'; "Annuity method"; 'Residual Value Method'; 'Investment Redemption Period'; "Discount efficiency ratio". The criteria for evaluating and ranking projects by these methods are given in Table 1.

Table 1: *Criterion for the effectiveness of investment projects assessed using dynamic methods*

№	Dynamic evaluation method	Criteria for evaluating and ranking projects
1	Net Present Value	Be positive. The bigger the project is more efficient.
2	Internal rate of return	The higher the internal rate of return on the profitability of alternative investments, the more efficient the project
3	Accounting rate of return	Be larger than one
4	Annuited method	The higher the annuity value, the more effective the project is
5	Residual value method	The project with the highest net value is the most effective
6	Payback period	Its value does not exceed the economic life of the project
7	Profitability index	Be larger than one

For the needs of the choice between the individual investment projects, the estimates of the various indicators of their financial analyzes can be used.

It should be kept in mind that projects must be comparable to each other, which means that their characteristics have to be calculated at the same discount rate and the same investment and reporting period of investment income to be used a methodology for determining revenue from irrigated agriculture. The latter condition is very important because the cultivation of agricultural crops and the effect of their irrigation are different in the different regions of the country.

The effective application of the above evaluation procedure implies precise and clear criteria for ranking and investing in individual projects.

From the analysis of the technical parameters of the irrigation systems and facilities built in our country, as well as on the basis of the developed methodological guidelines for the prioritization of irrigation systems for reconstruction, reconstruction and modernization, different modeling and designing irrigation systems have been selected. number:

- Irrigation system on the territory of the village of Tsalapitsa (Figure 3)

The irrigation system was built in 1976. The irrigation water is drawn from the Maritza River through a pumping station and is pumped into an open channel leading to the Tsalapitsa pumping station. From this pumping station, direct pumping is made up of the areas in the land of the village. Tsalapitsa. The irrigation field is divided into four crop rotation areas: field I - 588dka, field II - 634 dka, field III - 613 decares, field IV - 648 decares. Areas are irrigated with pots with certain characteristics. The main and distribution pipelines are made of ethereal diameters Ø 400 mm and Ø 250 mm.

Fig. 3 *Scheme of Tsalapitsa irrigation field*

- Manole drainage-irrigation system (Figure 4)

This irrigation system was built in 1975. The system has a bilateral effect and has been designed to grow rice crops. The irrigation and drainage grids are made of exposed concrete channels lying on a sandy pad and lined with stone lining.

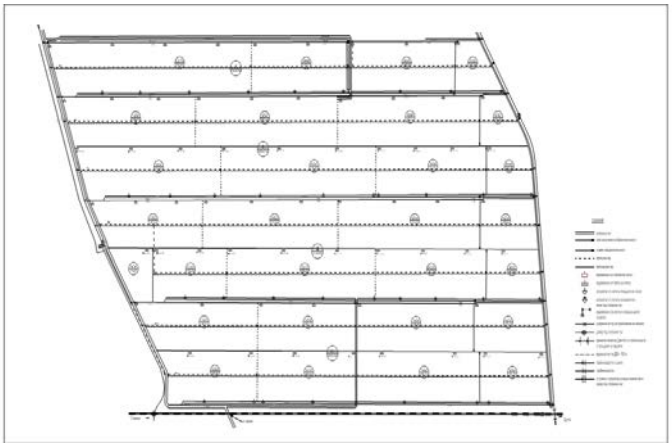

Fig. 4 *Manole drainage-irrigation system.*

- Irrigation system "Topolnitsa"

The irrigation system was built in early 1977 to grow orchards, cultural pastures and mixed crop rotation. The irrigation system consists of commercial canals, secondary water pipes, group channels, irrigation grooves, shaft exits, air shaft shafts and shaft end air hydrant. There is also a drainage network of drainage and water collection channels. The irrigation and drainage channels are made of ready-lined concrete slabs. Shaft exhausts and shaft end-air hydrants are made of a finished 100 cm concrete tube and a reinforced concrete cover. At the bottom of the shafts is an eternit tube fitted with an airspeed.

The main source of water is the Topolnitsa dam, from which the main irrigation channel "Lisichevo - Sandstone" supplies water to the irrigation system. The secondary water source is the Saedinenie dam, which serves to support the water resources when needed.

For the selected model irrigation systems, an information database has been collected and analyzed. location, agroklimatic zone, climatic conditions, available water sources and capacity of the water sources, way of water supply, transport channel network

(type, lengths, cross profiles, slopes, technical condition); distribution network (types, lengths, cross profiles, slopes, piping diameters, technical condition), network facilities and technical condition of the facilities, availability of irrigation equipment, cultivated crops, level of underground waters in the region, etc., based on which can be considered different engineering solutions.

Studies show that all three model irrigation systems have been built over 40 years ago, with the technology of implementation, the materials used and the structural elements for their construction being technically and morally obsolete. The age of irrigation systems and facilities has greatly influenced their efficiency, their efficiency, and water losses in different parts of the system. The eternity and concrete pipes of which the meshes are made are of low technical performance and a high degree of filtration which leads to large water losses. The coating of open channels is for the most part highly compromised. There is no maintenance of channel and operating bays. In all three irrigation systems there is a lack of basic maintenance personnel.

The envisaged engineering solutions for the construction, reconstruction and modernization of the model irrigation systems are aimed at:

The envisaged engineering solutions for the construction, reconstruction and modernization of the model irrigation systems are aimed at:

- Improvement of the exploitation and maintenance possibilities - purchase and installation of the necessary equipment (water meter devices, level regulators, closure bodies, operational control and management systems, etc.) and provision of access to channel network.

- Modernization of the transport-distribution network, incl. reducing filtration losses through the use of new materials and technologies and installing new facilities to ensure reliable water distribution. Coating with geomembrane and shotcrete is an excellent solution for removing the problems of filtration in the areas of the open network where the existing cladding is destroyed. With a special elastic sealant, it is necessary to repair the cracked lining sections.

- Introduction of an automated system with remote monitoring for modernization and automation of the beginning of the incoming channels, as well as creation of new information management capabilities, etc.

An economic analysis of the possible engineering solutions for each of the model irrigation systems is to be made.

4. Conclusion

Analysis of the technical parameters of irrigation systems and facilities in our country shows an urgent need for construction, reconstruction and modernization of the same. The financial resources provided for these activities are not sufficient and this necessitates the prioritization of individual projects.

The proposed methodical guidelines for ranking and financing of individual projects as well as the proposed engineering solutions for the construction, reconstruction and modernization of model irrigation systems will help beneficiaries when applying for funding under the Rural Development Program 2014-2020 , sub-measure M4.3 "Support for investment in infrastructure related to the development, modernization or adaptation of agriculture and forestry".

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