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Review Article

RECOMMENDATIONS FOR IMPROVING THE RELIABILITY OF HYDRAULIC STRUCTURES IN THE ON-FARM NETWORK

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Abstract
The article examined and evaluated the technical condition of hydraulic structures in the Water Users Association (WUA) with the goal of rational use of available water resources in Central Asia, including the Republic of Uzbekistan, and minimizing the negative impact on the environment. The study examined 297 hydraulic structures in 10 WUAs in the Ferghana (upper), Namangan (middle) and Samarkand (lower) regions of the Republic of Uzbekistan, of which 193 water-measuring structures and their negative impact on the environment were identified. According to the above analysis, the average service area of a water-measuring device in a WUA is 152 hectares, and in accordance with the rules it is recommended that the service area should be between 50-60 hectares. At the same time, scenarios were developed for decommissioning on-farm canals and their hydraulic structures with a logical connection between the main causes of the structures and their causes. WUAs having problems were analyzed and recommendations for their safe and reliable operation and maintenance were provided.

Keywords: Water resources, ecology, water users' association, construction, hydraulic engineering, accident scenario, water metering, water distribution unit, reliability, safety.

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INTRODUCTION

Currently, the rational use of water resources is one of the key issues for sustainable economic development in the region, including the Republic of Uzbekistan. In the republic, large-scale measures are being taken to extend the life of hydraulic structures (HS) in irrigation networks, as well as to develop safety criteria for failure and reduce operability [1, 2].

One of the main problems in the country is the lack of water metering and water distribution needs of crops. WUAs created according to the hydrographic principles of water management in the republic, currently make up 1503 units [3]. WUA plays a big role for the equitable distribution and management of water, as well as reducing the negative impact of hydraulic structures on the environment, resulting in the maximum yield for crops.

A number of scientists on the management, design, repair and operation of hydraulic structures, including A.A. Gvozdev, P.I. Vasiliev, Yu.I. Konov, Ya.N. Chirkov, T.E. Mirtshulava, N.Yu. I. Carro, N.T. Kaveshnikov, V.V. Bolotin, A.G. Vasilievsky, D.V. Stefanishin, V.A. Solnyshkov, S.G. Shulman, A.I. Weinberg, A.B. Vasiliev, L.A. Zolotov, Ivashchenko, N.S. Rozanov, G.I. Chogovadze, L.A. Uralov, L.N. Hikoya, M.R. Bakiev, A.A. Yangiev and others conducted research work.

Scientists like A.A. Ashrabov, B.A. Askarov, H.A. Akramov, H.U. Dambarov, R.K. Mamajonov, Sh.R. Nizomov, Sh. Sh. Shajalilov, A.A. Khujayev, S.Yu. Yusupov, T.R. Rashidov, S.R. Razzakov, M.T. Orazbaev, A.A. Abdusattarov, R.A. Abdukarimov, A.D. Dusmatov carried out a number of scientific studies on the safety of hydraulic structures and their impact on human life. They made recommendations based on studies conducted over the years [4, 5, 6, 7, 8, 9, 10, 11].

The aforementioned research work of scientists was carried out in order to minimize damage to hydraulic structures in large channels and damage, as well as safety criteria. No engineering work was carried out in connection with the accident and the refusal of work by assessing the technical condition of hydraulic structures on the on-farm canal for serving water user associations.

The main problem in the work is that the technical condition of hydraulic structures in WUA irrigation and drainage systems does not correspond to risk. In particular, there are no gates in the water distribution unit, the passport is not properly designed, the irrigation systems are poorly cleaned, there is no water meter structure, if any, it does not meet the requirements. Also, water is not an uneven distribution in the upper - middle and lower part of the irrigation network along the entire length. No modern irrigation technologies are used, the water use plan is not based on crop demand [12, 13].

The main objective of the study is to analyze the technical condition of on-farm canals and their hydraulic structures and develop measures for their reliable and safe operation.

To achieve this goal, it is necessary to solve the following tasks:

- Study of the technical condition of hydraulic structures;
- Analysis of damage to hydraulic structures;
- Development of emergency scenarios for the destruction of hydraulic structures;
- Development of measures for the reliable and safe operation of hydraulic structures.

RESEARCH METHODS

During the research work, field research methods were used to assess the technical condition of hydraulic structures, determine criteria for the safe operation of hydraulic structures, and analyze statistical data [14, 15, 16].

RESULTS AND DISCUSSIONS

The study was conducted in Samarkand (WUA "Khujabuston Suv Tarmogi", "Damhasa Arigi", "Karshiboy Mirob", "Toylok-Zarafshan" and "Samarkand"), Namangan (WUA "Turakurgan", "Pungan" and "Shirinsuv Yangiyer") and Ferghana region

(WUA "Kuvasoy Yangier obi hayot" and "Chashmai Sufon") [17]. The following problems were identified in field studies:

1. Poor technical condition of the channels.
2. Not a fair distribution of water.
3. Channel expansion due to excessive water intake.
4. Large filtration of water in the channel.
5. Damage to water meter structures.
6. Filling canals and hydraulic structures with mud.
7. Lack of protective zones in the channel, etc.

Below is a photo of the water distribution unit in the Samarkand region (Figure 1). In accordance with the study of the work of the hydraulic engineering structure, the following problems were identified, such as difficulty in supplying water below the channel of the located farm (Lapas Yuldashev farm), water disputes between the Oysuluv Mardieva and Lapas Yuldashev farms, difficulties in water distribution between 5 farmers, as well as the problem of irrigation 83 hectares of land farming 17 hectares of personal land population.

Figure. 1. Condition of water distribution point

According to the results of a study of 10 WUAs, it was determined that there are 193 water-measuring structures, of which 142 water-measuring structures are in need of repair. To determine the serving area of one water-measuring device, the slope of the terrain, the point of water intake of the farm, and the area of the irrigated plot were taken into account. The actual service area of 1 water measuring device is 71 - 280 ha, that is, an average of 152 ha. The service area of one water-measuring device according to the standards should be from 50 to 60 hectares (Figure 2) [17].

Figure. 2. View of water measuring structure

To assess the safe and reliable operation of the canal and its hydraulic structures, scenarios of their failure were developed.

The main types of failure are listed below for technical reasons on inter-farm channels (Figure 3).

- Damage to the on-farm channel.
- Violation of the technical condition of the hydraulic structures on the inter-farm channel.
- Reduced channel bandwidth.
- Violation of the operating mode of the channel.
- Construction malfunctions.
- Large water loss in the canal.
- Shortcomings in the project.

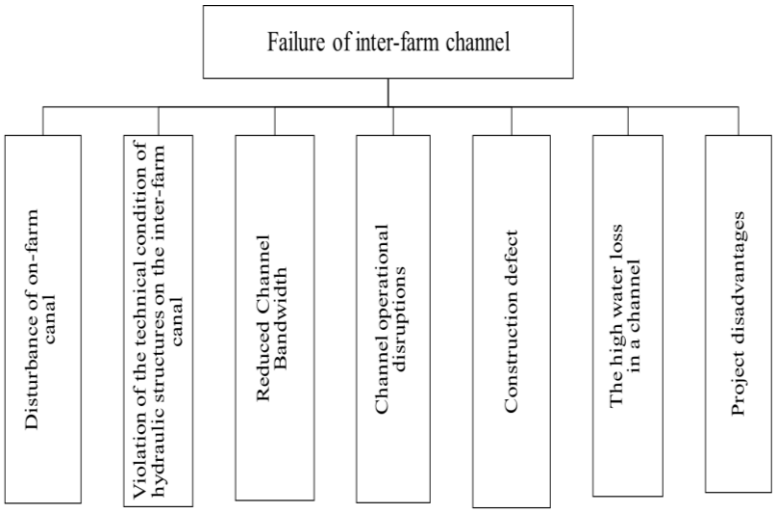

Figure. 3. Inter-farm channel technical failure scenario

The reliability assessment of the inter-farm channel is based on the theory of reliability of complex systems. Taking into account unforeseen factors based on the construction of a failure scenario, it usually leads to the synthesis of parametric

reliability solutions. When constructing a failure scenario, logical relationships are established between causes and effects and the main factors that arise as a result of the main event (technical failure of inter-farm channels).

Hydraulic structures on inter-farm canals must be analyzed based on random development scenarios, which can have disastrous consequences for building destruction (failure) scenarios.

When calculating the reliability of a structure, it is divided into individual structures, its constituent elements. The calculation is based on established quantitative characteristics of sequential elements, from simple to complex.

Irrigation systems are associated with the failure of hydraulic structures, can even be caused by the failure of one structural element [18, 19, 20].

The probability of failure (malfunction) of an element or the entire hydraulic structure can be determined by the following formula (1):

$$F(t) = \frac{n(t)}{N_0} \quad (1)$$

where, n (t) - the number of deviations of the elements of the structure over time t;

N_0 - total number of elements.

According to the results of the studies, external surveys and operational data on the law of the change in the probability of failure of elements of hydraulic structures can be represented in the form of graphical relationships. Based on these relationships, the probability distribution of the failure of the structure element (such as continuous random variables) obeys the normal law F (t) (Gauss law) and can be expressed as follows (2):

$$F(x) = e^{-\frac{(t-1)^2}{0,3183}} \quad (2)$$

where, t - service life of elements of hydraulic structures.

The working and malfunctioning state of the structure of the structure is opposite to each other, the following equation should correspond (3):

$$\mathrm{P}(t) + F(t) = 1 \quad (3)$$

where, P (t) - no failure (normal operation) of hydraulic structures;
F (t) - probability of failure of hydraulic structures.
The probability of failure of hydraulic structures over a period of time from 0 to t_0 is determined as follows (4):

$$\mathrm{P}(t_0) = 1 - \frac{n(t)}{N_0} = 1 - F(t) \quad (4)$$

where, n (t) – number of construction elements rejected over time t.
The on-farm channel technical failure scenario is shown in Figure 4.

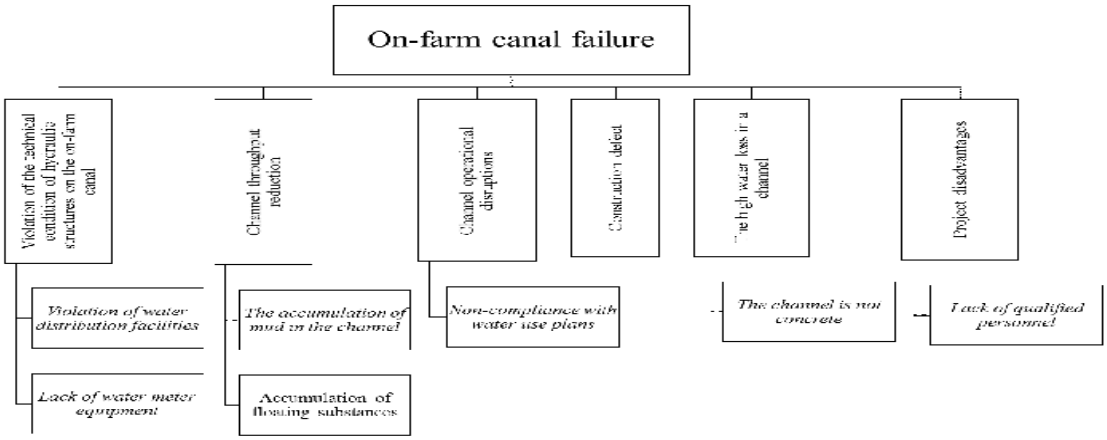

Figure. 4. Scenario of technical failure of an on-farm canal

The scenario of technical failure of a water distribution facility is shown in Figure 5.

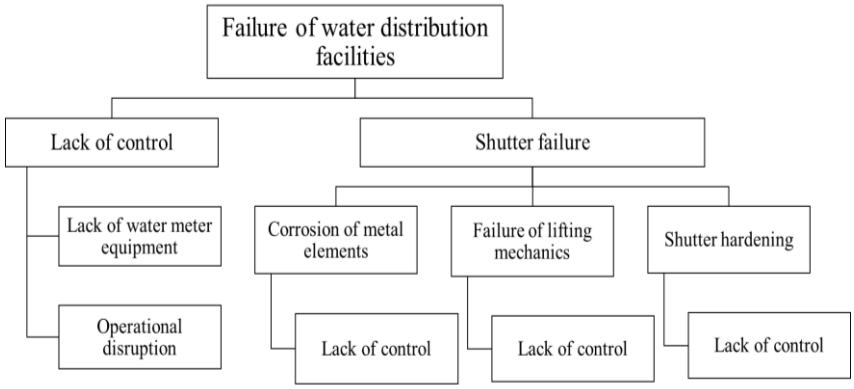

Figure. 5. Scenario of technical failure of a water distribution facility

As a result of field studies of WUAs, hydraulic structures, the following measures should be taken to ensure their safe operation:
1. Reconstruction of the canal, design of concrete pavement, cleaning the canal from excess debris and dirt.
2. Repair or construction of new gates, as well as equipping water distribution nodes with modern hydraulic structures.
3. Repair and construction of a water-measuring device (Figure 6).

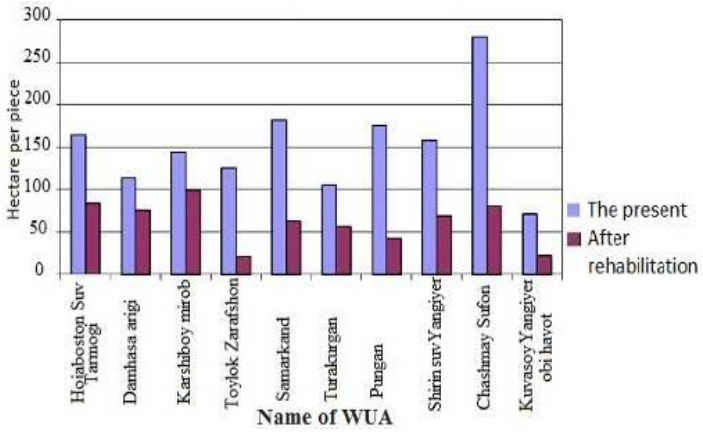

Figure. 6. Change in the area of maintenance of water-measuring structures.

4. Concreting channels, replacing earthen channels with trough irrigators.
5. Mechanical cleaning of channels, etc.

CONCLUSIONS

Based on studies to ensure reliable and safe operation of on-farm canals and their hydraulic structures, the following recommendations can be made:

1. Conducted field observations to assess the technical condition of hydraulic structures.
2. Developed scenarios for hydraulic structures in the event of an accident.
3. Measures have been developed for the reliable and safe operation of hydraulic structures at survey sites:

- Reconstruction of the canal, design of concrete pavement, cleaning the canal from excess debris and dirt
- Repair or construction of new gates, as well as equipping water distribution nodes with modern hydraulic structures.
- It was calculated and recommended to repair and build the required number of water measuring device (Figure 6).
- Concreting canals, replacing earthen channels with trough sprinklers.
- Mechanical cleaning of channels.

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