

Original scientific paper

THE SCALE AND EFFECT OF PUBLIC INVESTMENTS IN FLOOD CONTROL INFRASTRUCTURE IN SERBIA FROM 2009 TO 2021

UDC 626/627

Milica Marković, Jelena Marković Branković

Faculty of Civil Engineering and Architecture, University of Niš, Serbia

Abstract. *Flood control structures play an important role in saving lives and property during floods, especially due to climate change issues. The construction, reconstruction, and rehabilitation of hydraulic structures are compliant with their maintenance and are performed periodically and preventively in order to achieve their required functional safety. However, over the years, investments in flood protection, i.e. the reduction of possible damage caused by the harmful effects of water, mostly implied investments in embankments. Investments in high dams are insufficient in terms of their importance, structure complexity, and failure risk.*

Key words: *water management, investments, hydraulic infrastructure, flood control structures, high dams*

1. INTRODUCTION

Investments are a necessary requirement in the permanent human effort to control natural forces and use them to meet needs as efficiently as possible.

Water is the basis for the development of sociological, economic, and ecological activities of an area [1]. In the near future, according to world experts, countries that invest the most in hydraulic infrastructure will be the leaders of economic development on the global water market. It is believed that this market will replace the oil and gas market [2].

People have had a fear of water and what water can do since ancient times. In the light of climate changes, both issues have gained public attention.

Hydraulic infrastructure is the most critical infrastructure. It provides water with the required quality and quantity to users, and also protects from the harmful effects of water [3].

Received October 7, 2021 / Accepted December, 29, 2021

Corresponding author: Milica Marković

Faculty of Civil Engineering and Architecture, Aleksandra Medvedeva 14, 18106 Niš, Serbia

E-mail: milica.markovic@gaf.ni.ac.rs

Flood control structures play an important role in saving lives and property, especially due to climate change issues.

The construction, reconstruction, and rehabilitation of hydraulic structures are compliant with their maintenance and are performed periodically and preventively in order to achieve the required functional safety.

However, over the years, investments in flood protection, i.e. the reduction of possible damage caused by the harmful effects of water, mostly implied investments in embankments. Investments in high dams are insufficient in terms of their importance, structure complexity, and failure risk. The paper analyzes investments in hydraulic infrastructure in the area of narrow Serbia in the period 2009-2021.

2. UNDERSTANDING HYDRAULIC INFRASTRUCTURE MANAGEMENT

Hydraulic infrastructures fall under the category of civil engineering, along with other structures which are used to perform activities related to water resources management.

Hydraulic structures are classified into several categories: river training structures, flood control structures, erosion control structures, irrigation canals, hydraulic structures for water consumption, wastewater conveying and treatment, water protection, and water monitoring.

Flood control structures are embankments with related structures (locks, pumping stations), bank protection, piers and water retaining channels, dams and reservoirs with related structures, retentions, and others.

The maintenance of hydraulic structures which are public property implies construction, reconstruction, rehabilitation, the regular and investment maintenance of hydraulic structures on public property, land improvement, preserving and taking care of their intended use.

Integrated water management is a set of measures and activities aimed at maintaining and improving the water regime, providing the necessary quantities of water of the required quality for various purposes, the protection of water from pollution, and protection from the harmful effects of water [4].

Dams and reservoirs are hydraulic structures of special importance in the flood defense system.

3. BASIC FLOOD PROTECTION REGULATIONS IN SERBIA

Water resources management is the responsibility of the Republic of Serbia. The Republic of Serbia manages water resources through the Ministry of Agriculture, Forestry and Water Management (its operational body is the Republic Water Directorate) and other competent ministries, bodies of the autonomous province, bodies of the local government unit, and public water management companies [1].

The basic law that regulates issues related to surface and groundwater is the Law on Waters from 2010.

Directive 2000/60/EC of the European Parliament and of the Council, establishing a framework for Community action in the field of water policy, and Directive 2007/60 / EC of the European Parliament and of the Council, on the assessment and management of floods, are basic regulations at the European Union level in the field of flood protection.

In Serbia, the harmonization of legal regulations in that area with community law is in progress.

The territory of the Republic of Serbia is a single water area, divided into 5 water areas.

All surface waters on the territory of Republic of Serbia are classified into waters of the first and waters of the second order.

The public water management company manages hydraulic structures for river regulation and flood protection on waters of the first order.

Hydraulic structures for river regulation and flood protection on waters of the second order and other water structures for erosion and torrent control that are public property are managed by local government on whose territory the structures are built.

4. INVESTMENT IN FLOOD CONTROL INFRASTRUCTURE IN SERBIA, 2009-2021

In Serbia, river training structures and flood protection structures which are public property are considered structures for protection against the harmful effects of external waters (external flood protection): embankments and regulated riverbeds: 3.700 km, an irrigation network of 25.800km, 200 pumping stations, and 59 dams with reservoirs with space to retain flood waves.

These structures protect towns, settlements, industrial areas, infrastructure, and agricultural land.

The most important precondition for the successful implementation of a flood defense for the protection of defended areas is to ensure the functioning of regulatory and protection structures, which is achieved through preventive work on regular and investment maintenance of regulated rivers and structures in riverbeds, embankments, dams, and reservoirs.

The maintenance of hydraulic structures for erosion protection and torrents and the maintenance of riverbeds outside the defended areas also have a preventive character.

From 2009 till 2021, investments in structures for protection against the harmful effects of water have changed (Fig.1).

After the catastrophic flood events in 2014 and 2016, and later in 2017, 2018, 2019 and 2020, within the state reconstruction programs, numerous emergency rehabilitation works were successfully completed at over 550 critical sites, which contributed to the improvement of the stability and reliability of flood protective structures regarding the state before the mentioned flood events [5].

If we compare the investments from 2010 and 2011, i.e. 2014 and 2015, we can see a jump initiated by damage due to catastrophic floods. Significantly small investments were noted in 2009 and 2013. This indicates an investment trend related to flood damage reduction. The problem is that investment should not follow natural catastrophes, it should prevent them. Prevention is the primary measure for protection against floods and torrents and all these measures have been conducted within passive flood control.

In the last three years, public investment has increased four times compared to the ten-year period (Fig. 1).

Investments in water structures for flood protection have yielded results and the occurrence of floods has been significantly reduced in recent years.

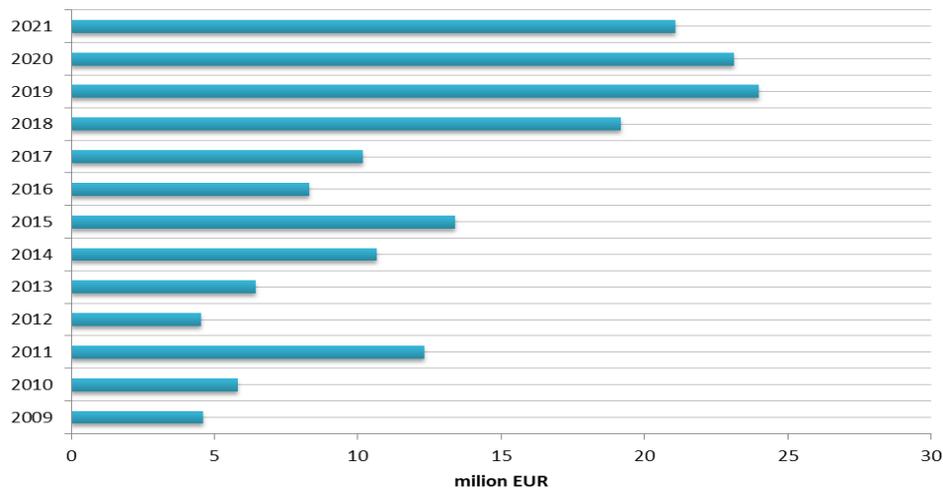


Fig. 1 Total investments in flood protection structures in Serbia, 2009-2021

However, passive measures do not affect the water regime, i.e. they cannot reduce the peak of the flood wave. Reduction of the peak of the flood wave is achieved by active measures, by constructing multi-purpose dams and reservoirs, small dams and retentions. In this context, active flood protection measures should be promoted as much as possible.

If we look at the fund distribution, we can see that most of the funding is oriented toward passive measures. Investments in the maintenance of the existing flood control infrastructure is about 50% of the total investment funds (from 40 to 62%), of which only 7 to 0.9% were allocated for investment maintenance of dams and reservoirs, structures of the highest risk (Table 1 and Table 2).

Table 1 Type of investments, 2009-2015 (million EUR)

Structure type / Year	2009	2010	2011	2012	2013	2014	2015
FCS regular maintenance maintenance	2,33	2,76	2,20	2,20	4,02	4,64	4,88
High dam maintenance	0,33	0,43	2,91	0,25	0,43	0,52	0,54
Irrigation system maintenance	0,00	0,00	3,23	0,91	0,96	1,84	2,08
Construction and reconstruction of FCS	1,38	1,53	1,88	0,69	0,67	1,00	0,50
Rehabilitation of FCS	0,33	0,36	0,83	0,23	0,58	1,08	3,29
Implementing FC measures	0,08	0,50	1,13	0,18	0,06	0,20	0,88
Erosion control	0,14	0,24	0,13	0,06	0,09	0,13	0,38

Table 2 Type of investments, 2016-2021 (million EUR)

Structure type / Year	2016	2017	2018	2019	2020	2021
FCS regular maintenance maintenance	4,00	5,23	8,75	10,92	11,25	10,64
High dam maintenance	0,25	0,09	0,31	0,43	0,83	0,67
Irrigation system maintenance	1,28	2,44	4,17	4,54	4,50	3,58
Construction and reconstruction of FCS	0,28	0,39	0,97	1,92	1,21	1,03
Rehabilitation of FCS	0,46	0,12	1,59	1,25	1,22	1,26
Implementing FC measures	0,42	0,08	0,42	0,92	0,83	0,01
Erosion control	0,14	0,04	0,06	0,11	0,11	0,11

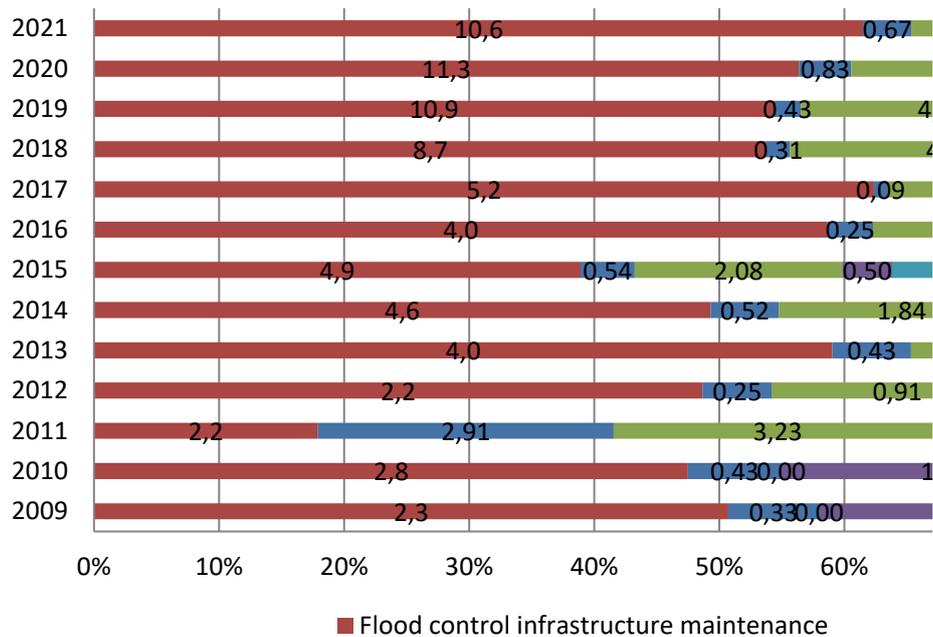


Fig. 2 Percentage by type of investment, 2009-2021

The exception is the year 2011, when an additional 1 million euros were allocated by urgent procedure for the revitalization of a dam after the catastrophic floods in 2010. This percentage has been hovering at 3% in recent years (Fig 2).

Insufficient funds have been allocated for the performance of protective biological and biotechnical erosion control works as well. In recent years, the percentage of allocated funds is less than 1%. The problem of changing the runoff coefficient due to erosion is especially noticeable in West Serbia, where we have continual flooding.

In Table 1 and Table 2 we can see that special importance is given to investing in the maintenance and construction of new irrigation systems.

It is important to point out that the only stable sources of water for irrigation are multi-purpose reservoirs created by high dams. During the design process, part of the useful volume of the reservoir is intended for irrigation.

As the reservoirs were built more than 50 years ago, a revision of water quality and quantity in the reservoir is necessary.

The risk of failure of old dams increases due to changes in the hydrological regime. In that context, modified dam release operations should be performed in order to obtain historical flood protection levels [6].

With the current funds, appropriate maintenance and revitalization of dams and reservoirs are not possible.

5. CONCLUSIONS

All decisions about future investments in flood control structures should be carefully analyzed due to the climate change impact on flood risk [7].

In recent years, in the field of flood protection in the countries of the European Union, the emphasis has been placed on preventive action and flood risk management. In accordance with the Floods Directive, this problem needs to be approached in a different way in Serbia, and some adjustments should be made that will lead to a reduced risk of floods and possible harmful consequences.

The risk of new damage in already flooded areas is significant primarily due to insufficient construction of protection systems, an insufficient level of protection, non-compliance with other infrastructure facilities, and unplanned use of the river bank in protected areas.

The capital projects for the reconstruction of protection systems in the most endangered areas of Serbia are of special importance for investments.

Planned structural measures - works, for which significant funds have already been allocated from foreign sources of financing, are based on the application of integrated conceptual solutions for protection.

Regular and investment maintenance of dams and reservoirs which function in flood defense is of special importance for their functional readiness.

Nevertheless, investments in regular and investment maintenance of high dams are insufficient compared to investments in other parts of the flood protection system.

Due to the long-term lack of financial resources, maintenance on a number of high dams has been reduced to a minimum, which has decreased the functional safety of these capital facilities. Therefore, there is a visible risk of accidents that could endanger human lives and property in the downstream area.

High dams are structures of the highest risk, constructed more than 50 years ago. It is necessary to invest in the revitalization of these structures in order to achieve their full functionality and to extend their service life.

REFERENCES

1. The Economic Benefits of Investing in Water Infrastructure, Value of Water Campaign, 2017
2. Freire-González, J., Puig-Ventosa, I. Effects of the hydraulic infrastructure on economic growth: evidence from Catalonia. *Sustain. Water Resour. Manag.* **2**, 199–206 (2016). <https://doi.org/10.1007/s40899-016-0052-9>
3. The United Nations World Water Development Report 2021, Valuing Water, UNESCO World Water, Assessment Programme, ISBN 978-92-3-100434-6, UNESCO, 2021
4. Water Law, Official Gazette of the Republic of Serbia 30/10, 2010
5. Annual business program, PMWC “Srbijavode”, 2009-2021
6. Boulange, J., Hanasaki, N., Yamazaki, D. et al. Role of dams in reducing global flood exposure under climate change. *Nat Commun* **12**, 417 (2021) <https://doi.org/10.1038/s41467-020-20704-0>
7. De Bruin, K., & Ansink, E. (2011). Investment in flood protection measures under climate change uncertainty. *Climate Change Economics*, 02(04), 321-339. doi: 10.1142/s2010007811000334

PROCENA I UTICAJ JAVNIH INVESTICIJA U VODNE OBJEKTE ZA ZAŠTITU OD POPLAVA U SRBIJI U PERIODU 2009-2021

Vodni objekti za zaštitu od štetnog dejstva voda imaju važnu ulogu u spašavanju života ljudi i imovine. Ulaganja u ove objekte mogu biti investiciona u smislu izgradnje, rekonstrukcije, sanacije i održavanja hidrotehničkih objekata, koja se usklađuju sa redovnim održavanjem i izvode se periodično i preventivno u cilju postizanja njihove potrebne funkcionalne sigurnosti. Međutim, godinama unazad su ulaganja u hidrotehničku infrastrukturu uglavnom podrazumevala dominantna ulaganja u nasipe i obaloutvrde. Ulaganja u visoke brane nisu dovoljna s obzirom na njihov značaj, složenost konstrukcije i rizik usled rušenja.

Ključne reči: *upravljanje vodama, investicije, hidrotehničke konstrukcije, vodni objekti za odbranu od poplava, visoke brane*