“Water infrastructure and economic security of regional socio-economic systems: evidence from Ukraine”

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WATER INFRASTRUCTURE AND ECONOMIC SECURITY OF REGIONAL SOCIO-ECONOMIC SYSTEMS: EVIDENCE FROM UKRAINE

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Abstract

The correlation between the development of a regional economy and the degree of infrastructural development of a country or its territory is a common practice. Considering this, the paper is aimed at studying the impact of water infrastructure on the economic security of regional socio-economic systems in order to develop a water security system for them. A variety of threats against key waterworks can seriously undermine the national economy and water security of regions and cities. Thus, the study analyzes the process of transformation of water infrastructure in the context of ensuring the economic security of regional socio-economic systems. It offers the definition of such categories as "water infrastructure" and "water security of a regional socio-economic system" to formulate a relevant economic policy in Ukraine based on world experience. The study proves the need to attribute water infrastructure to the critical infrastructure sectors of Ukraine and its regions, based on the best world practices in managing water resources and protecting the water infrastructure itself from technogenic, physical, and cyber-physical threats. According to the study results, conceptual bases for ensuring the economic security of regional socio-economic systems are developed, which differ in view of the water security system of the regional socio-economic system, giving priority to the engineering and technical infrastructure of a region.

Keywords region, infrastructure, water, security, development, sustainability

JEL Classification Q25, R11

INTRODUCTION

The existence of a direct correlation between the development of a regional economy and the degree of infrastructural development of a country or its territory is a common practice for modern economists and scientists. Extremely relevant is the subject of infrastructural development of the world countries, as well as Ukraine and its regions; this encourages the study of water infrastructure functioning in Ukraine and the regional systems to improve, first of all, the well-being of the Ukrainian population. Based on this, theoretical and methodological issues of defining "water infrastructure" and "water security of regional socio-economic systems" as separate categories are among the urgent scientific tasks of regional development. The important objective is to study the best world practices in managing water resources and protecting the water infrastructure itself from technogenic, physical, and cyber-physical threats to find the ways of attributing the water infrastructure of Ukraine and its regional systems to the critical infrastructure sectors. It should be noted that the correlation between national economic security and water security is increasingly recognized in many countries. Various threats against key waterworks can seriously undermine the national economy and

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water security of regions and cities. Therefore, it's important to develop a water security system for regional socio-economic systems.

At the 7th World Water Forum in Daegu, Korea, the World Water Council demonstrated the growing need for investment in large water infrastructure schemes as means of stimulating national growth (World Water Council, 2016). Based on this, this paper aims to study the impact of water infrastructure functioning on the economic security of the regional socio-economic systems in order to develop water security system of such systems.

1. THEORETICAL BASIS

1.1. Literature review and theoretical bases of water infrastructure functioning

Ukrainian scientists argue that it is necessary to distinguish the infrastructure related to water use and to pay special attention to the issue. They also emphasize that water supply is a strategic factor in Ukraine's national security (Symonenko, 2016). Many scientists state that the water security system is a life-supporting basis for demographic and socio-economic development. Water scarcity and water contamination have a lesser impact on the economic system than water disasters (Su, Gao, & Guan, 2019; Jensen & Wu, 2018; Gunda, Hess, Hornberger, & Worland, 2019).

For example, the State Regional Development Strategy of Ukraine for the period till 2020 approved by the Resolution No. 385 of the Cabinet of Ministers of Ukraine as of August 6, 2014 determines "the impact of global trends of spatial development, which cannot be avoided by Ukraine" (Cabinet of Ministers of Ukraine, 2014); among them are financial and economic crisis, scarcity of resources (first of all, water resources), growing food demand on the global scale, and focus on the territories being the largest food producers.

Ukrainian scientists studying the subject of infrastructure development are divided into two areas. One group of scientists consider infrastructure as a set of industries defining the relationships associated with the production of goods and the provision of services aimed at creating conditions for the effective functioning of economic entities in the "production and consumption" system. Besides, to reveal the understanding of the importance of infrastructure for the socio-economic system of a region, the industry approach is used, according to which they distinguish between transport and logistics infrastructure, educational infrastructure, communication infrastructure, etc. Other researchers consider the functioning of the regional infrastructure depending on the development of each infrastructure component separately and, therefore, the infrastructure of a region is identified with market infrastructure. As a part of this approach, the following infrastructure categories are presented: production (roads, warehouses, communication systems, ports, etc.), social (schools, higher educational institutions, theaters, stadiums, hospitals, etc.), financial, informational, and commercial infrastructures.

However, the research activities carried out in Ukraine are fragmented and are mainly related to the production, technological, and environmental aspects of enterprises of the production and economic infrastructure, as well as to some aspects of social infrastructure development, problems of forming market infrastructure in Ukraine, etc.

This study proposes to consider the regional infrastructure as a system of elements of secure livelihood for the regional socio-economic system (RSES) necessary for the functioning, reproduction, and development of its economy, which allows giving priority to the development of engineering and technical infrastructure. So, the global trends of economic development and the current state of the investment activity in the field of the centralized water supply and water disposal in Ukraine enable to give priority to the development of engineering and technical infrastructure (from a functional point of view) as the most important life-sustaining infrastructure for the regional socio-economic system (RSES), since the engineering and technical infrastructure is specifically related to water use (Li, Su, & Wei, 2019; Fedulova, Dubnytskyi, Source: Authors' systematization.

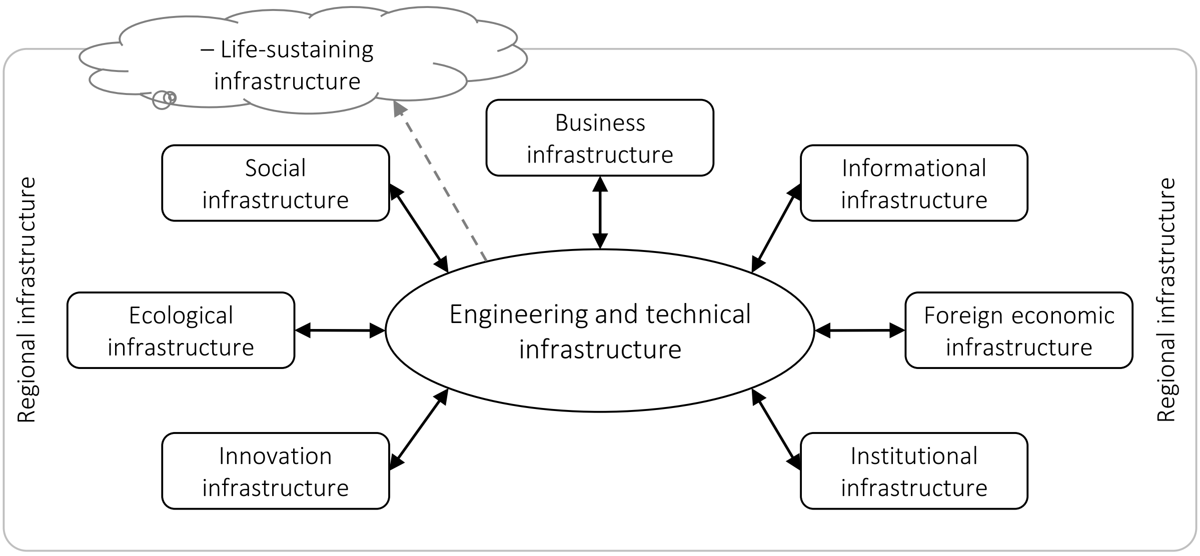

Figure 1. Composition of the regional infrastructure by function

Komirna, & Naumenko, 2019; Gerlak et al., 2018; James & Shafiee-Jood, 2017; Srinivasan, Konar, & Sivapalan, 2017). The composition of the regional infrastructure with the focus on prioritization of the engineering and technical infrastructure in the region is presented in Figure 1, which shows that the engineering and technical infrastructure and other types of infrastructure are components of the regional infrastructure. However, engineering and technical infrastructure, which is a life-sustaining one, significantly affects all other components of the regional infrastructure, since it is related to water supply and water use in the region.

For example, the Government of Australia, while promoting the development of water infrastructure throughout the country, has established the National Water Infrastructure Development Fund, which, on behalf of the Government, has initiated the detailed planning necessary to ensure the country's water supply security and the benefits of regional economic development for Australia, as well as environmental protection (Australian Government, 2019).

For the water sector to remain competitive, it should be efficient, economically viable, and transparent for consumers (Morris & McGuinness, 2019; Gurung & Martínez-Espiñeira, 2019; Krueger, Rao, & Borchardt, 2019; Jaramillo & Nazemi, 2018). Benchmarking projects in Germany are the main tool for the stable and dynamic development of the sector (Wirtschafts- und Verlagsgesellschaft Gas und Wasser, 2015).

At the 7th Annual Specialized Infrastructure Week-2019 in the United States, it was noted that the obsolescence of water infrastructure remains a threat to people and communities. Obsolete water infrastructure cannot withstand the challenges facing humanity in the 21st century. It is necessary to modernize the country's water supply system and optimize water production (MECO, 2019).

Klara Ramm (2019), the Head of the EurEau Committee on Economics and Legal Affairs, indicates that it is time to invest in the European water infrastructure. Water and sanitation sectors are an important part of the European economy. This sector's investment needs are high and will remain high, as follows from specific features of this sector. In many countries, it is difficult to maintain infrastructure only at the expense of tariffs; as a consequence, infrastructure is rapidly aging (Ramm, 2019).

1.2. Focus on critical and sustainable water infrastructure

According to participants in the Aspen Dialogue, the traditional definition of water infrastructure in the 19th and 20th centuries focused mainly on the physical structures associated with the supply and distribution of drinking water, as well as the col-

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lection and disposal of wastewater and stormwater. This definition, which ends at the pipe outlet, is too narrow. Experts emphasize the need to define the "sustainable water infrastructure of the 21st century", which includes the traditional components of the technogenic or artificial infrastructure and natural infrastructure, such as rivers, lakes, streams, underground water-bearing formations, wetlands and watershed divides, which deal with water use (Bolger, Monsma, & Nelson, 2009).

The US Environmental Protection Agency defines the concept of "sustainable infrastructure," namely, "infrastructure supporting the economic activity and public confidence to drinking water and wastewater treatment through multifactor protection using the effective means to ensure security with less vulnerability and minimization of consequences of any revealed violations and threats, and acceleration of response and restoration" (United States Environmental Protection Agency, 2018).

The experience of the United States is interesting, which states that the Agency's mission should be to provide and implement national leadership to improve the effectiveness of the water sector (prevention, mitigation, recovering of hazards elimination).

The practice of implementing the concept of sustainable infrastructure is proposed at three levels (United States Environmental Protection Agency, 2018):

1. Sustainable water supply infrastructure – support for water treatment and sanitation systems, treatment plants and other infrastructure that provides water-related services.

2. Sustainable water supply and water disposal systems – control of utilities and water-related systems.

3. Sustainable communities – activation of water supply and sanitation services in promoting a wider range of community goals.

The water sector development goals are based on the approved concept of "sustainable infrastructure" and the water supply and wastewater treatment sector's mission.

When conducting a sustainability analysis for urban systems in China, it was found that assessing the activity of treatment plants had the greatest impact on the sustainability index of the entire system. This analysis shows that the general sustainability index primarily depends on the scale of the system and weather conditions (Dong, Du, Li, Zeng, & Bledsoe, 2018).

Researchers from Colombia indicate that growth in the infrastructure development in Colombia will require not only attracting new entities and financial resources, but also linking environmental variables to the project structuring, especially the funding process (González Ruiza, Arboledab, & Botero, 2016). Such a policy should lead to redirecting investments and financing to market mechanisms that generate innovative financial products with elements contributing to sustainable development (Bocken, Short, Rana, & Evans, 2014). Consequently, the transition to the development of sustainable infrastructure projects should be associated with the formation of policies related to climate changes, adding funding mechanisms appropriate to sustainable development.

In the USA, water infrastructure is a part of the critical infrastructure sectors subjected to cyber-risk. There are 16 critical infrastructure sectors in the United States. As estimated by the Department of Homeland Security in 2015, threats to water infrastructure facilities ranked the fourth in size (8.5%) after the power sector (15.6%) and critical production (32.9%). It is susceptible to cyber-attacks and transport infrastructure (7.8%) (Clark, Hakim, & Panguluri, 2018).

Following the interpretations of the critical infrastructure of the US Department of Homeland Security (2019), the Centre for the Protection of National Infrastructure (UK) (2019), Federal Office for Information Security (Germany) (2019), and Government of Australia (Australian Government, 2019), one can compile a general list of industries most often related to the critical infrastructure and associated with physical security and cybersecurity.

To some extent, the same is true for most countries: power engineering (nuclear power industry is often included separately); natural resource management (in particular, oil and gas sector); water resource management (including water supply and water disposal); transport; food industry; health protection; telecommunications; financial and banking systems; governmental agencies.

There are also international initiatives, such as the European Critical Infrastructure Protection Program (Commission of the European Communities, 2006).

In today's global and digital economy, water supply and sanitation systems are susceptible to various attacks, ranging from pollution with deadly substances to physical destruction, toxic damage, and cyber-attacks. As a result, many diseases and accidents can occur, as well as the termination of the provision of public services to citizens, which will lead to a decrease in the health of the society and its economic stability. Besides, water infrastructure is prone to natural disasters.

In today's economy, advanced technologies allow to automate processes, collect and store information, perform analytics, and present operational data in real-time. Developed countries use water control systems. Thanks to this digitalization of management, scientists began to qualify the water infrastructure as critical, which is susceptible to various threats, including cyber-attacks on such objects.

In 2013, the US Department of Homeland Security developed a protection algorithm for all critically important infrastructure sectors, which was documented in the National Infrastructure Protection Plan. Importantly, the field of water security in managing the infrastructural provision of the territories is formed by three factors: physical, cybernetic, and human factors (US Department of Homeland Security, 2019).

In Germany, growing automation improves the safe control and monitoring of water plants. However, dependence on information technology systems contributes to the growth of cyber-attacks (Wirtschafts- und Verlagsgesellschaft Gas und Wasser, 2015). Both Germany and the USA are the countries rich in water resources, unlike Ukraine. In light of such a comfortable situation and careful use of available water resources, water supply and water disposal in these countries are ensured in the long term.

It is assumed that the water industry of the future will be primarily energy efficient and smart. Software solutions are key components of Water 4.0 for Smart Water, including automation. With their help, it is possible to generate relevant data for the water industry and perform data analysis based on facts throughout the entire life cycle of the system (Siemens, 2019).

Critical infrastructure, namely the systems of water treatment, water distribution, generation, and distribution of power, is vital for the well-being of society. Such systems are usually large, complex, and interconnected. A cyber-attack on one of these systems can affect the other (Mishra, Palleti, & Mathur, 2019).

Of course, each country has its interpretation of the concept of critical infrastructure. In Ukraine, there is no single public list of critical infrastructure elements, but there is a solid framework consisting of various laws, resolutions, and decrees.

Currently, the draft Law of Ukraine On Critical Infrastructure and Its Protection has been submitted to the Verkhovna Rada of Ukraine. This Law provides the solution to issues, in particular, regarding the introduction of criteria and methodology for classifying infrastructure objects as critical infrastructure, as well as the procedure for their certification and categorization. The Concept for Creating the State Critical Infrastructure Protection System approved by the Decree of the Cabinet of Ministers of Ukraine dated December 6, 2017, stipulated that among the tasks to be solved there was the definition of unified criteria and methods for attributing infrastructure objects to the critical infrastructure, the procedure for their certification and categorization.

According to the National Institute for Strategic Studies (NISS) of Ukraine, the approach to certifying potentially dangerous objects adopted by the State Archival Service of Ukraine under the decree of the Ministry of Emergency Situations On Approval of the Regulations on Certification of Potentially Dangerous Objects No. 338 dated December 18, 2000, is the most suitable for solving the tasks of protecting critical infrastructure. Based on the US experience, the experts of the National Institute for Strategic Studies

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(Sukhodolia et al., 2017) offered their vision of critical infrastructure objects in Ukraine (Table 1).

Table 1. Critical infrastructure list proposals

Source: Compiled based on Sukhodolia et al. (2017).

Critical infrastructure sector	Main institutions responsible for the security and operation of sector facilities
Fuel and energy complex	Ministry of Energy and Coal Mining of Ukraine Security Service of Ukraine Ministry of Internal Affairs of Ukraine State Service of Special Communication and Information Protection of Ukraine
Transport	Ministry of Infrastructure of Ukraine Ministry of Internal Affairs of Ukraine
Life-sustaining networks	Ministry of Regional Development, Construction, Housing and Communal Services of Ukraine State Emergency Service of Ukraine
Communications and data transmission	Ministry of Internal Affairs of Ukraine State Service of Special Communication and Information Protection of Ukraine
Financial and banking sector	National Bank of Ukraine Ministry of Finance of Ukraine State Service of Special Communication and Information Protection of Ukraine Security Service of Ukraine
Public administration and law enforcement authorities	State Protection Service Security Service of Ukraine Ministry of Internal Affairs of Ukraine
Security and protection complex	Ministry of Defense of Ukraine Security Service of Ukraine Ministry of Internal Affairs of Ukraine
Chemical industry	State Labor Service of Ukraine Security Service of Ukraine
Emergency services and civil protection	Ministry of Health of Ukraine State Emergency Service of Ukraine
Food industry and agricultural complex	Ministry of Agrarian Policy and Food of Ukraine

Researchers consider the critical infrastructure in Ukraine as a set that includes systems and resources, both physical and virtual, which support functions and services, the violation of which causes the most serious negative consequences for society, the country's social and economic development, and national security.

Unfortunately, Table 1 shows that the water treatment and water disposal sector is not listed, although the USA, UK, Germany, and Australia attribute the water treatment and water disposal sector to critical infrastructure related to physical and cybersecurity. Based on the best practices of advanced countries, this position is considered a mistake.

The water infrastructure is specific in its content. It cannot be supported by traditional means of ensuring information security, since it contains highly specific elements, such as dispatch control systems and data collection, human-machine interfaces, programmable logic controllers, etc. Responsibility for ensuring industrial cybersecurity is somewhat blurred, which is an additional problem. Automation engineers often consider information security tools an obstacle that can adversely affect the technological process (Voytov, 2015).

2. RESULTS

This study is based on the hypothesis stating the need to explore the impact of water infrastructure on the economic security of regional socio-economic systems to develop a water security system for the above regional systems. To test this hypothesis, the process of transformation of water infrastructure in the context of ensuring the economic security of regional socio-economic systems is analyzed.

Having examined the literature on water resources and infrastructure problems provided by other countries, it was found that organizations, such as the US Department of Homeland Security (2019), The Centre for the Protection of National Infrastructure (UK) (2019), Federal Office for Information Security (Germany) (2019), and the Government of Australia (Australian Government, 2019), used the water infrastructure category. This term is not reflected in any documents in Ukraine and is not used in the scientific literature. A long time ago, the world community began to talk about the problems associated with the management of water infrastructure in the face of increasing the physical and cybernetic risk of development.

Water management of a region in Ukraine divides water infrastructure into three areas:

- water and sewage utilities (including industry);
- water reservoirs and main canals; and
- hydraulic facilities of reclamation systems (interfarm facilities).

National reclamation systems are not subject to regional management. Besides, water reservoirs and main canals are not subject to the regional management, because they are of national importance and are only located in the territory of the region. The scope of water and sewage utilities objects is the most regulated.

Given the trends and definitions described above, for clarification, it is proposed to understand the category "water infrastructure of RSEC" as a two-component structure represented by a part of engineering and technical infrastructure directly related to water management of a region and water resource potential of a territory, which interact on the triple basis of economic, social, and environmental sustainability.

Some researchers propose a "hypothetical grid city model" for implementation in China. The model was developed to link the technical parameters in urban water infrastructure systems with socio-economic changes such as population growth, living conditions, and end-use of water (sustainable cities and communities) (Zhang, Liu, Wang, Dai, Baninla, Nakatani, & Moriguchi, 2019).

It should be noted that many institutions in Ukraine are more or less responsible for the operation of water infrastructure facilities. However, none of them performs the function of protecting the infrastructure from physical and cyber-physical threats, as is the case with the US Department of Homeland Security.

At the national level, such institutions are:

1. Cabinet of Ministers of Ukraine: legislative function.

2. Ministry of Regional Development, Construction, Housing and Communal Services of Ukraine deals with the problems of comprehensive socio-economic development of regions, construction, and architecture of regions, housing and communal services of regions. In the water sector, this is mainly control over the availability of devices for metering drinking water and effluents, development, and implementation of the mechanism of concession or lease of objects in the domain of water supply and water disposal. Performs control, regulatory and statistical functions. The Department of Life-sustaining Systems and Housing Policy has a water and sewage utilities unit.

3. Ministry of Infrastructure of Ukraine deals with the problems of transport, mainly railway, marine, and river transport, as well as motor transport, aviation, and postal services, the problems of innovative development of the mentioned industries; performs control, regulatory and statistical functions.

4. National Commission for State Regulation of Energy and Public Utilities (NCSREPU): In the water sector, it deals with tariff regulation, licensing of activities in the domain of water supply and water disposal; ensures energy security; performs control, regulatory and statistical functions.

5. Ministry of Ecology and Natural Resources of Ukraine deals with environmental protection, provision, within its competence, of ecological and radiation protection, biological and genetic security. In the water sector, it deals with the environmental problems of water resources, development of water management facilities, water supply intake limits, use of water and limits of discharge of pollutants into water bodies; develops rules, regulations, and standards in water management and land reclamation; performs control, regulatory and statistical functions.

6. State Agency of Water Resources of Ukraine deals with ecological problems of water resources, controls water management situation and operation of water reservoirs, recording the quality of surface waters of rivers engaged in permitting activities; performs control, regulatory and statistical functions.

7. Security Service of Ukraine and the National Security and Defense Council mainly perform security and protective functions in the country.

At the regional level, such institutions are:

1. Regional state administrations – local executive authorities, which subordinate water

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and sewage utilities of a region, ensure implementation of the state policy in the field of housing and communal services (including the sector of drinking water and public water supply, heat supply, price and tariff formation, payments for utility services), housing policy, settlement improvement, household waste management, and disposal, in the field of construction, development of engineering and transport infrastructure, engineering protection of territories, construction industry and building materials branch, as well as in transport, road management and construction in the region. Perform control, regulatory and statistical functions.

2. Local governments deal with the redevelopment in a region and perform the control function.

3. Regional water resource management departments deal with the problems of ensuring the reliable operation of the state water management and reclamation complex; providing protection against the harmful effects of waters of settlements, production facilities and agricultural lands, minimizing the damage caused by them, etc.; implementation of integrated water resource management according to the basin principle, introduction of a public-private partnership mechanism to promote water protection, ensure the rational use of water resources and reclaimed lands. Perform the control function.

4. Water supply and water disposal enterprises perform the functions of ensuring water management needs of a region, ensure uninterrupted operation of water infrastructure, and are responsible for the quality of water resources.

From this study, it becomes clear that the functional state of water infrastructure in Ukraine is mainly determined by water supply and disposal companies themselves. Management and financing are carried out through water and sewage utilities of a region. However, no one performs the function of protecting these objects from increasing threats, as well as the function of monitoring their status, forecasting future suitability, and ensuring water security.

The scarcity of water resources in Ukraine, which is considered the poorest country in terms of water resources among European countries, is an important factor in the transition to the Sustainable Development Concept and defining the ways of functioning of sustainable water infrastructure in Ukraine (SIWI, 2017). According to the European Climate Change News website, "it is likely that Ukraine will suffer from water scarcity during the 21st century, as severe droughts are forecast by 2070, to be classified today as one of the 100-year phenomena" (Climate Change Post, 2019). An important factor in the transition to these trends is also the infrastructure support transformation. In Ukraine, the vast majority of depreciation of water infrastructure in the regions reaches 70-90%, and only in some regions is about 50%.

Given the processes of globalization of water problems around the world, as well as decentralization in Ukraine, it makes sense to introduce the category "water security of a regional socio-economic system" and interpret it as the ability of the regional economy to meet its own needs for water resources in the conditions of their scarcity, risks and impacts of multiple factors, taking into account the prospects for sustainable development. Considering this category, the study developed a water security system for the regional socio-economic system in Ukraine (Figure 2).

Figure 2 shows the implementation scheme of the Water Security System of the Regional Socio-Economic System (RSES) in Ukraine. The scheme lists the institutions of national impact on the regional support for water security of RSES. Institutions of indirect influence are depicted in a blurry color. Besides, there is a presentation of regional support for the water security of RSES.

The concept of water security is also determined by the functioning of engineering and technical infrastructure in the system of municipal economy and water and sewage utilities in a region.

Let the water security of the regional socio-economic system consist of (see Figure 2):

1) water security of a city;

2) water security of a person;

Source: Authors' development.

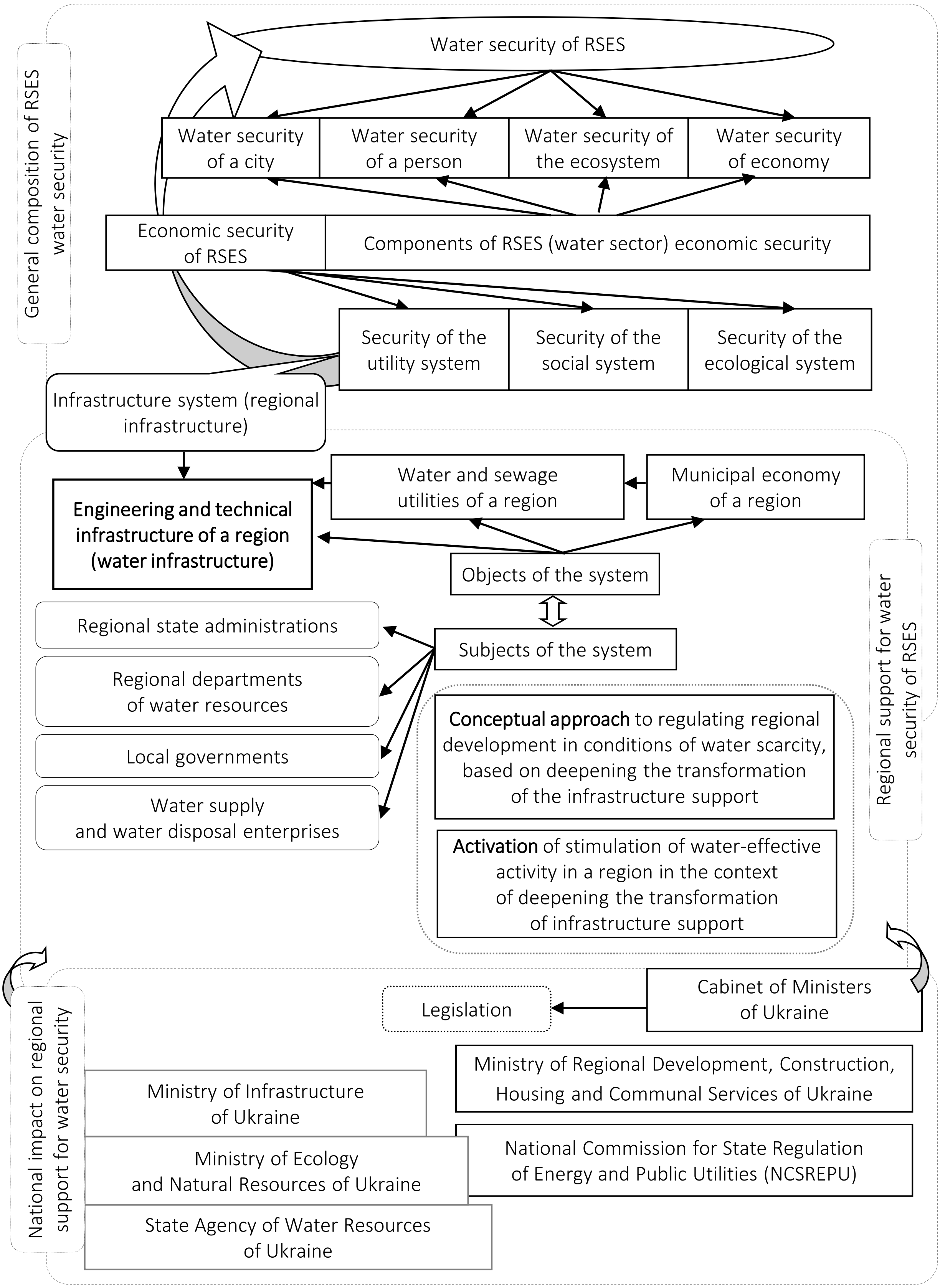

Figure 2. Water security system of the regional socio-economic system in Ukraine

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3) water security of the ecosystem; and

4) water security of the economy, which is part of the economic security of the region.

Guided by a system approach, this study considers a region as a regional socio-economic system with the interconnected functioning of three subsystems (Fedulova & Komirna, 2017) (see Figure 2):

- utilities system;
- social system; and
- ecological system.

These subsystems are interconnected and affected by external and internal threats. By exercising managerial influence, we must achieve the results such as sustainability, stability, independence of the system, self-development, predictability of threats, and an increase in the timing of crisis phenomena.

When managing the development of regional socio-economic systems, it is necessary to remember that when entering the regional management system, one faces various risks, dangers, and uncertainties, including risks associated with water use and water consumption.

Water infrastructure should be considered as a strategic factor in ensuring the economic security of regional socio-economic systems.

Economic security of RSES can be represented as a set of subsystems being part of it, namely (see Figure 2):

1) security of the utilities system, which is the functioning of the economic system and the infrastructure system. Security of utilities system includes infrastructure support for the region;

2) security of the social system, which is the functioning of the social system, political system, cultural environment, and education system;

3) security of the ecological system, which is represented by the system of environment and resources.

Regional support for the water security of RSES has its management objects and subjects for this system. The objects include engineering and technical infrastructure, as well as the economies involved in the operation of the infrastructure – water and sewerage utilities of a region and municipal economy of a region, in the system of which there are water and sewerage utilities (see Figure 2).

The area activity of the municipal economy and the water and sewage sector of a region is regulated in Ukraine by the Ministry of Regional Development, Construction, Housing and Communal Services of Ukraine and the National Commission for State Regulation of Energy and Public Utilities (NCSREPU). The concept of the domain of centralized water supply and water disposal (sewerage) is defined by the Laws of Ukraine On Drinking Water, Public Water Supply and Water Disposal; On Housing and Communal Services; On Natural Monopolies; and On State Regulation in the Domain of Communal Services. Other policies and procedures are currently in force.

A framework for regional support for the water security of RSES should be developed. The same applies to a conceptual approach to regulating the regional development in conditions of limited water resources in Ukraine and stimulating water-effective activities in the region in the context of deepening the transformation of the infrastructure support (see Figure 2). Ukraine needs a balance between the amount of food that is planned to be produced locally, using available water resources, and the volume of food import, which, in turn, consumes water from other sources (Fedulova et al., 2018).

3. DISCUSSION

The main idea of the transition to the conceptual approach to regulating the regional development in conditions of limited water resources in Ukraine is the activation of processes to stimulate the water-effective activity of the region, taking into account the equivalence of providing different generations with natural resources, the need for greening economic activities in terms of water resources and ensuring balanced use of these resources and reducing water intensity of the Gross Regional Product (GRP).

The objective of implementing the above approach is considered as ensuring the ecologization on water resources of the economic activity within the framework of regional ecosystems (the introduction of water-effective technologies) and using the principle of balanced use of water resources together with a decrease in water intensity of GRP, at least to the average value in Ukraine.

To do this, the following tasks need to be performed:

- creating a regional system of indicators of water-effective RSES to support infrastructure and their use in the administrative management system;
- organizing access to information resources obtained in regional reporting systems and implementing activities under the programs of regional administrations;
- developing a system of indicators and a model based on them to determine and assess the degree of balanced development of a region;
- scientific justification of the water intensity of ecosystems in a region, determining the permissible limits of anthropogenic impact;
- laying the foundations for the transition to the implementation of a water security system (in information, legal, economic, educational, and training activities) and developing an algorithm for the actions of the RSES water security system;
- redirecting the region's economy to efficient water use and ensuring it by stimulating the region's water-effective activity in the context of deepening the transformation of the infrastructure support;
- creating a framework for recognizing the water infrastructure of regions as critical infrastructure to ensure adequate protection;
- providing the basis for decision-making on the development of regional socio-economic systems in the face of limited water resources under the influence of transformation of the infrastructure support.

The regional administration should act as a guarantor of the transition to a conceptual approach to regulating regional development in conditions of limited water resources. The approach should aim to stimulate water-efficient activities of RSES, which will ensure the reproduction of the water capital of regions and a high level of well-being of the population, as well as improve their mental and physical health.

The initial stage in organizing the regulation of regional development in conditions of limited water resources should be the creation of a system of indicators characterizing the level of consumption, nature of use, condition (quantity and quality), protection, restoration, and reproduction of water resources.

It is necessary to establish benchmarks to manage the transition to safe and then balanced development and evaluate the effectiveness of the use of funds and decisions. Targets and limits should be specific to per capita water consumption and per unit of Gross Regional Product.

Improving water security for a specific country or region can be achieved through food imports. Food imports can locally "release" for other purposes water used to grow crops in the home country. Many countries are heavily dependent on food imports since they do not have sufficient water resources to grow food (van Beek & Arriens, 2014). For example, in the UK, food imports account for almost two-thirds of the water consumed following the country's food needs (World Wide Fund for Nature, 2008). Of course, the desire to receive "virtual water" should not go against the national interests of other countries from which "virtual water" is imported (Bacon, 2017; Oki, Yano, & Hanasaki, 2017). If there is a shortage of water for production purposes in other countries, such economical relations should be avoided, as this will inevitably manifest itself in future global water security. Improving water security for any particular country or region should not be achieved by reducing the level of water security in other regions. Improving the country's water security through imports of "virtual water" should occur only due to the water security of exporting countries. A global analysis of this problem shows that in many countries, the relationship between national security and water security is becoming increasingly recognized.

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CONCLUSION

The study allows us to argue that there is a problem with supporting infrastructure at the regional level in Ukraine. Thus, it is proposed to give priority to the development of engineering and technical infrastructure as the most important life support infrastructure for the regional socio-economic system.

The proposal to recognize water infrastructure as critical at the state level in the face of growing physical danger and cyber-threats under the influence of global challenges for effective regional water use is relevant and proven. Almost all European countries and the United States have already developed and are implementing the concept of sustainable water infrastructure, recognizing the water sector infrastructure as critical at the country level. The study confirmed the need to attribute water infrastructure to the critical infrastructure sectors of Ukraine and its regions, based on the best world practices in managing water resources and protecting the water infrastructure itself from technogenic, physical, and cyber-physical threats.

The study determines that there are many agencies in Ukraine responsible for water management in the country as a whole and at the regional level. However, no institution monitors potential threats in the water sector and understands its importance. This situation is unacceptable in conditions of water scarcity in Ukraine and the globalization of water problems worldwide. For that purpose, the paper clarifies the conceptual and categorical framework of the influence of water infrastructure operation on the economic security of regional socio-economic systems. The categories "water infrastructure" and "water security of regional socio-economic systems" are defined in the real conditions of the Ukrainian economy based on the described international experience.

An important conclusion is that the correlation between national security and water security is increasingly recognized in many countries. Various threats against key waterworks can seriously undermine the national economy and water security of regions and cities. In this regard, the paper proposes a water security system for the regional socio-economic system in Ukraine.

Further research should be aimed at developing a method for assessing the level of water security in the development of a regional socio-economic system and determining its place in the economic theory, provided that there is a set of effective indicators for this assessment. International experience and modern methodology have led to the conclusion that it is necessary to introduce the water security system in the regions of Ukraine and to develop further measures to stimulate the region's water-effective activity in the context of deepening transformation of infrastructure support, taking into account the above approaches to solving new urgent and vital water problems.

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