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Sustainable Management of Water Resources in Urban Areas as an Integrated Part of Urban Planning: the Case of R. N. Macedonia

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Abstract. Urban planning plays a key role in the global response to climate changes and their impact on water resources. Therefore, management of water resources and their consideration in sustainable urban planning is a challenge for planners that will be increasingly emphasized in the future. In this paper, a comparison is made between the current situation in the city of Gostivar in R. N. Macedonia and the situation planned with the General Urban Plan in order to perceive the possibilities for greater consideration of water resources in urban development. It is concluded that, in the specific case, in urban planning, there are opportunities to improve water resources management, as an important segment of sustainable urban development. Full integration of water resources management in the urban planning process in urban areas is therefore recommended in order to create conditions for sustainable urban development.

Keywords: Spatial Planning, Sustainable development, Urban areas, Water resources.

1 Introduction

Urban planning is a large-scale concept referring to planning and development at social, spatial, infrastructural, architectural, environmental and economic levels. As an interdisciplinary activity, it determines the purpose and the manner of land use [1,2]. Urbanization as a global phenomenon is transforming rural areas into increasingly urban ones [3]. Today, 3% of the Earth's land area is occupied by urban areas, and by 2030, 60% of the global population is expected to live in cities [4]. In such areas, with a large concentration of population and often uncontrolled growth, sustainable development becomes more important and, at the same time, more difficult. One of the challenges that it will face in the future are climate changes and their impact on water resources [5,6].

In view of the above, the purpose of this paper is to understand the level of integration of water resources management in the process of urban planning and to present the specific example of the city of Gostivar, R. N. Macedonia.

2 Management of Water Resources in Urban Areas

Water resources management represents an activity involving assessment, control and conservation of water resources, including planning and design, maintenance, monitoring and administration of water resources systems. It is aimed at ensuring social well-being, economic prosperity, preservation of the environment with simultaneous sustainable management of water resources [7, 8]. There are limitations to the availability of water and therefore water has a significant quantitative and qualitative impact on the dynamics and balance of the ecosystem and the biosphere as a whole. Current statistics and estimates show that the world will face a 40% gap between demand and available water supply by 2030, while on the other hand, hydrological uncertainty and extreme weather events - floods are considered to be the biggest threats to the global stability [9].

In the world, there are various applied options of water management in urban areas, such as: "Best management practices" (BMP) or "low impact development" (LID) in the United States, "sustainable urban drainage systems" (SUDS) in the UK and “water sensitive urban design” (WSUD) in Australia, “water oriented city planning” (WOCP) in Canada and other [4]. It can be said that the relations between urban planning and water have already been perceived all over the world: Surface water, groundwater, wastewater, etc. An increasing attention has been paid to the so-called "ecological urbanism" according to which cities should adapt to the changing human needs and water is an important variable to be considered in urban planning [8]. In their study, Thorsby et al., at a neighborhood scale in the city of Detroit, applied a calibrated EPA Stormwater Management Model to investigate the potential flood mitigation benefits of the Green Stormwater Infrastructure -GSI. GSI has shown to improve water quality and flood mitigation potential [12]. In another study [13], through applying a cellular automata-based rapid scenario screening framework, the performance of green infrastructure strategies across an urban catchment in Melbourne City Centre (Australia) has been observed. It is concluded that an intensive application of green infrastructure could substantially reduce flood depth and velocity in the catchment. A good example of integrating water resources management into urban planning is the concept of “Sponge Cities” [14]. Sponge cities are cities that easily adapt to changes in the environment whereat, in some way, they function as a sponge, i.e., absorb and purify rainwater and use the stored water when needed. The concept of sponge cities has four main principles, namely: urban water resources, environmental water management, green infrastructure and urban absorbing roads [15]. So, the concept of sponge cities is intended to change the way of urban planning by inserting more green areas in urban areas. With its successful implementation, the concept will result in more efficient land use, increase of green areas, conservation of rivers, wetlands and other city water bodies, control and storage of atmospheric water during extreme rainfall, etc. [14]. Another example is the Shanghai - China, where wide streets with paved sidewalks are being built so that rainwater can enter the soil beneath them. Roof green spaces are being increased and water tanks are being retained above the buildings to prevent flooding and to collect more water for reuse [16].

Unlike the common practice of many countries where water professionals and urban planners and architects work together to manage water as an integral part of the

city [10, 11], water management is not a component of the urban planning process in R. N. Macedonia. This is due to the professional difference between hydrologists, who mainly deal with natural sciences, and urban planners who, in designing urban plans, pay more attention to the economy and social aspects of urban environments.

3 CASE STUDY: The City of Gostivar

3.1. General Plan of Gostivar and Water Resources Management

In the R. N. Macedonia, the spatial plans of the Republic, the regions, the areas of special interest, the municipalities and the city of Skopje represent plans at a higher level of planning. Urban plans including a general urban plan, a detailed urban plan, an urban plan for a village, an urban plan for an out-of-town settlement and urban plans for areas and buildings of state importance represent plans at a lower level of planning [19].

General Urban Plans (GUP) are valid for a period of 10 years. The GUP for the city of Gostivar for the period until 2021 was adopted in 2016. It will be valid until a new GUP for the city is adopted. The purpose of the GUP for Gostivar is landscaping and organization of the space by determining zones of purposes divided into blocks throughout the city, determining the system of street network-roads, planning the primary infrastructure network (water supply, sewerage, electricity and telephony), regulating rivers, protecting monuments and monumental units, etc. Regarding management of water resources, the GUP for the city of Gostivar covers part of the activities referring to the infrastructure plan, the system for the primary water supply network, the infrastructure plan, the primary network system for fecal and atmospheric sewage, the wastewater treatment plant plan, the quality of drinking water, the regulation of rivers (Vardar river, Banjeshnica river) and the irrigation canals (Table 1).

- **Infrastructure plan, system for the primary water supply network**

The city of Gostivar and the suburbs are supplied with drinking water and water for sanitary needs through a gravity system-water supply system using the source of Vardar river in the village of Vrutok, with a flow of 1000 l/sec. The water supply system developed gradually with the growth of the population and consequently the increased need for additional water quantity. The water from the spring comes unprocessed, i.e., chlorinated only at the catchment which is sometimes not sufficient to achieve the required standard water quality. During the periods of heavy rains, it becomes muddy and has a specific odor. It is especially important to note that the water supply system has no tank space. According to the GUP of Gostivar, a treatment plant is planned to be built in order to achieve potable water of good quality. Based on hydro-technical analyzes performed within the GUP, it has been concluded that there is a shortage of water in the city and the surrounding area. The deficient water is planned to be taken from a new source and brought to a filtering station by a special supply system. The treated water is planned to be distributed to consumers through the distribution network, which will be turned from a branch system (open system) into a ring system (closed system) composed of interconnected rings to achieve water circulation and thus eliminate bottlenecks throughout the city [20].

- **Infrastructure plan, primary network system for fecal and atmospheric sewage**

The sewerage system in Gostivar is a parallel separate wastewater system. Namely, there is a special system for the drainage of fecal waters and a special system for accepting and drainage of atmospheric waters. It is only half of the city that is covered by the sewer system, i.e., about 60% of the city area. The other part, including a large number of villages, solves this problem by septic tanks.

The general configuration of the city is such that it slopes from west to east and from north to south, i.e. from south to north towards the Vardar river, which defines the scheme of the sewerage system. According to the documentation basis, part of the GUP of Gostivar, major sewerage moves were performed on the main roads, joining them with side arms. Wastewater is collected by collectors connected to the main collector and is discharged into the Vardar river without treatment. It should be noted that there are other cities and villages on the riverbanks downstream Gostivar, to the Aegean Sea, which is the Vardar river recipient, with a total population of more than a million. Also, there are agricultural areas that use the water of the Vardar river.

Atmospheric water from both parts of the city is also discharged through special systems into the river at several places. In the General Urban Plan of Gostivar, a new complete solution of the sewerage system in the city is proposed for the period until 2021 and final population of 55,000 (through the newly urbanized zones). The atmospheric sewage follows the fecal sewage and ends in the Vardar river [20].

- Treatment plant plan

Although an important process of wastewater treatment is performed in the treatment plants before the wastewaters are discharged into the recipient, there is no treatment plant in Gostivar. Urban wastewater and industrial wastewater end up untreated in the Vardar river. In the GUP of the city of Gostivar for the period until 2021, construction of a treatment plant outside the boundaries of the GUP, in the area of the village Chajle, Gostivar, is mentioned. The treatment plant would enable primary and secondary treatment of wastewaters. Primary treatment involves separation of coarse matter through grids, while secondary treatment involves separation of soluble and insoluble organic matter through tubular pellets and biofilters. After treatment, the purified waters will be discharged into the natural recipient, the Vardar river [20].

- Quality of drinking water

Drinking water quality is controlled in Gostivar every month. According to the results of the detailed analysis done by the Center for Public Health in Tetovo, in November 2019, it was concluded that the drinking water in Gostivar met the standards for drinking water [17]. However, the problem is the wastewater, which is discharged untreated into the Vardar river. In this way, many harmful substances enter the water, the most dangerous of which are coliform bacteria that reach the water through fecal waters and cause epidemics, then toxic and aggressive electrolytes, mineral acids and alkalis. The waters are also polluted by the wastewaters discharged from factories, heating plants and boiler rooms that contain sulfur, strong acids, bases, detergents, fats, oil, ash and slag as well as the wastewaters from refrigeration devices containing salt, sludge, phosphates, etc. There is no less danger of contamination of water surfaces with oil spills in various accidents. Water pollution is also increased by the deposition of solid waste along the bottom or ponds of river basins. This, inter alia, affects the biocenose and the breakdown of oxygen [20].

Table 1. Current and Planned status of the infrastructure related to water management

GENERAL URBAN PLAN for Gostivar for the period until 2021		
Status	Current	Planned
Primary water supply system		
Primary sewerage System		
Regulation of the Vardar river		
Regulation of the Banjeshnica river		

- **Regulation of rivers: Vardar river, Banjeshnica river**

The Vardar river is the longest and the most important river in the R.N. Macedonia. The total length of Vardar River is 338 km, 63.5 km, accounting for the Polog region and 3.28 km, accounting for the urban scope of GUP Gostivar. The Vardar riverbed in

the urban area is in the form of a double trapezoid. The minor trough is proportioned 19-20 m. The major riverbed proportioned 35.5m has also been regulated [20]. It can be said that, along its entire riverbed, the Vardar river has received an appropriate treatment in the urban area.

Banjesnica river flows through the planning scope of Gostivar within a length of 1250m. It passes through several blocks of the city and, in some places, it is covered. In the GUP, a 50m protection belt is planned for the water flow of this river [20].

- **Irrigation canals**

Several irrigation canals in the Polog valley flow through the planning scope of the city of Gostivar. There is a larger irrigation canal with a total area of 0.57 ha that flows from the village of Zdunje, passes through several places in the city of Gostivar and runs further to the village of Pirok, Tetovo [20].

4 Discussion

The existing water supply system is overloaded due to the increasing number of consumers in the city and its surroundings. At certain time intervals during the day, especially during the summer days, there is a lack of water in the upper zones of the city. Although the current water supply system does not provide an uninterrupted supply of good quality water, the measures proposed in the GUP of the city of Gostivar are still being implemented very slowly. The water consumption is increasing daily, despite the possibilities for multiple use of water in the recycling systems. A positive movement made in the area of water supply is the construction of four reservoirs in different parts of the city. In the case of water shortage, these have the capacity to provide the city with drinking water for 3-4 days.

The sewerage infrastructure is partially solved. Some interventions have been made at citizens' own initiatives, in small moves and connected to the fecal, i.e., the atmospheric sewerage of the city of Gostivar. The other part of the city has solved this problem by septic tanks. These waters are discharged untreated into the Vardar river, posing a threat to the environment.

The General Urban Plan of the city of Gostivar envisages only one treatment plant. The station will provide primary and secondary treatment for water purification, which is a mechanical and biological treatment of wastewater, providing an opportunity to protect the natural regime of the Vardar river.

From the analyzes made within the frames of the GUP, the water resources throughout the urban areas, the atmospheric and the surface waters are mainly regulated. The main question that arises is how much and with what dynamics the authorities will realize the planned activities.

With the GUP, the management of water resources covers only the elementary activities from the management of water resources.

5 Recommendations

Water can serve as an excellent entry into the transition to a new urban agenda by engaging authorities and citizens in reconnection with the natural water cycle [18]. Analyzing the current situation and the situation planned with the GUP, the

recommendations that should be taken into account when preparing urban plans in terms of water resources, as shown in Figure 1, can be summarized as follows:

- Water should be considered as one of the basic elements of urban planning. In this regard, the correct layout of industry, urban and other pollutants of watercourses and sources of drinking water is of a great importance. For this purpose, for the city of Gostivar, it is recommended to prepare a cadastre of existing pollutants, wastewater discharges and treatment plants;
- Treatment plants located in several places in the city and the surrounding area should be constructed to ensure safe and efficient treatment of all wastewater. More green areas are to be provided. Atmospheric water in paved and built urban areas cannot be absorbed into the ground. This water that flows through the city streets in the form of surface water is to be collected by an atmospheric sewage (fecal) and discharged into the nearest recipient. During heavy rains, the city streets are flooded due to the non-existent atmospheric sewage and the insufficient capacity of the existing fecal sewage that collects these waters. When rainwater falls onto natural green areas, the soil and the plants absorb and filter it. In this way, stormwater is cleaner and the risk of flooding is reduced. Therefore, green areas are necessary for urban environments since they provide cleaner air and water as well as flood protection;
- In the already built parts of the city, green roofs can be planned for some of the existing and newly planned buildings. Green roofs are part or all of the roofs covered with green areas planted in a waterproof membrane;
- A system for collection, treatment and use of rainwater should be constructed to provide a certain amount of clean water and protect the urban environment against floods. The water can be used for drinking, cleaning, fire fighting and so on;
- A space for construction of retention tanks for collecting storm water should be planned. These will enable irrigation of the park and other green areas of the city as well as cleaning of the streets;
- Two separate water supply systems should be planned: one for drinking water and one for technical water, which can be used especially in the industrial and green areas of the city, for hydrants to be used for cleaning streets and fire fighting;
- Self-opening barriers should be installed along the part of the Vardar river that passes through the urban area;
- The concept of "green-blue infrastructure" should be implemented. This concept refers to the use of green areas in urban areas while also using the benefits of water resources management. A well-organized green-blue infrastructure can help address urban and climate challenges.

Fig. 1. Recommendations for integrating water resources management in urban planning

6 CONCLUSION

One of the basic tasks of urban and spatial planning is to provide sufficient quantities of good quality and hygienically healthy water as well as wastewater disposal from urban areas. In countries where the implementation of urban plans is accompanied by many problems, such as R. N. Macedonia in general and the city of Gostivar in particular, it is difficult for water resources management to monitor the implementation of urban plans. It is a reality where, while a certain urban plan is being adopted, the circumstances on the ground are changing and the conditions on which the plan is based are no longer valid. The GUP of the city of Gostivar, which is the focus of this paper, can serve as a concrete example. The development of this plan started in 2011. The plan was adopted in 2016 and yet many things that should have been started, such as the sewerage, have not been implemented on site. In addition, the work problems of the relevant institutions, the insufficient cooperation between the competent authorities and the existing legal framework complicate the situation. A different way of urban planning is needed, namely, a more flexible and open one, which can envisage urban growth of the space and planning of infrastructure facilities accordingly. To achieve this type of planning, several levels of change are needed: to strengthen the institutional cooperation of all stakeholders, to equip the urban planning departments with appropriate staff and urban planning professionals and, at

the same time, to consult and actively include hydraulic engineers. In this way, there will be more holistic approaches that will integrate the management of water resources in the process of urban planning. Urban planning and water resources management must be carried out parallel with the development of settlements. Since water is the key element of life, sustainable urban development cannot succeed without sustainable management of water resources. Water resources management in urban areas should be fully integrated into the urban planning process.

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