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SMALL URBAN STREAMS IN ENHANCING CITY RESILIENCE – THEORETICAL PERSPECTIVE AND THE POSSIBILITIES OF USE IN THE CITY OF NIŠ, SERBIA

Abstract

Within an integrated planning approach, urban streams are a valuable natural resource with strategic significance for creating resilient cities. This paper explores the revitalization of small urban streams within sustainable development practices, and discusses the manifold benefits that it brings about. Best practice examples are presented to illustrate how watercourse revitalization improves flood mitigation and stormwater treatment, strengthens urban ecology, diversifies recreation options, and enhances visual appeal of the waterfront. These experiences are used to establish urban planning and design guidelines for revitalization of small streams in the City of Niš. The results of this study should help with both setting up policy framework and implementation in planning practice.

Keywords: stream revitalization, urban planning and design, flood protection, ecology, recreation

МАЛИ УРБАНИ ВОДОТОЦИ У ПОВЕЋАЊУ ОТПОРНОСТИ ГРАДА – ТЕОРЕТСКИ ОКВИР И МОГУЋНОСТИ КОРИШЋЕЊА У ГРАДУ НИШУ, СРБИЈА

Сажетак

У оквиру интегрисаног приступа планирању, урбани водотоци су вредан природни ресурс са стратешким значајем за креирање отпорних градова. Овај рад истражује ревитализацију малих урбаних водотока у оквиру пракси одрживог развоја, и разматра многоструке користи које она доноси. Представљени примери добре праксе илуструју како ревитализација водотока ублажава поплаве, унапређује третман атмосферских вода, јача урбану екологију, диверзификује могућности рекреације и појачава визуелну привлачност приобаља. Ова искуства се користе за утврђивање планерских и пројектантских смерница за ревитализацију малих водотока у граду Нишу. Резултати ове студије би требало да помогну у постављању законодавног оквира и имплементацији у пракси планирања.

Кључне ријечи: ревитализација, планирање и дизајн, заштита, поплава, екологија, рекреација

1. INTRODUCTION

Urban planning is based on the way in which human interactions shape physical space. The concept of Integrated Planning comprises a system of interlinked actions that bring about a lasting improvement in the physical, social, and cultural conditions of a city or an area, covering a wide range of interrelated aspects - from governance, economy and planning, to physical infrastructure, sustainable buildings, climate adaptation and environment [1]. Planning for disaster risk reduction is an integral part of urban planning nowadays, since basic hazard and risk mapping represent a preliminary planning instrument that guides further development.

In adapting to climate change and increasing the overall resilience of urban areas to natural disasters, flood protection is one of the crucial topics. Flood protection is mostly, but not solely, an engineering issue. The role of urban planning in protecting urban areas from flooding is gaining increasing importance nowadays. As stated by Ramboll [2], the main constraints on implementing sustainable urban stormwater management and environmental management in a changing climate are not technological, but they rather involve shifts in vision, policy, design, and the urban planning culture. In urban planning documents, small streams in urban areas often do not get enough professional attention. Additionally, they seem to be out of sight even with the local community, which is unaware of their great potential. Aside from flood protection and generally improved urban hydrology, restoration of polluted, neglected and devastated urban streams may come with a range of ecological, social and economic benefits [3]. Some of them include: improved water quality, enhanced biodiversity, diversified recreation options, mitigation of urban heat, improved public health, appealing urban landscape, and reduced costs associated with repair of erosion and flood damages.

Many cities around the world are exploring options to capitalize on the potential of small urban streams in addressing the climate change challenges and improving the resilience of urban areas. This paper discusses the main urban planning and design principles and approaches in the revitalization of small urban watercourses worldwide, and examines their potential use in shaping the post-socialist urban landscape in the City of Niš, Serbia. With a population of approximately 260.000 inhabitants (2011 Census), Niš is the third largest city in Serbia and a typical post-socialist city of medium-size. The City of Niš has a very rich water potential in small streams and creeks that is quite underused in environmental, social and economic terms [4]. Contemporary integrated planning approaches have not yet been comprehensively reviewed and implemented in urban planning policy and practice.

It is the standpoint of this research that the revitalization of small urban streams would bring manifold benefits to the City of Niš, and increase the resilience of its urban area. Therefore, the main goals of this paper are: (1) to determine the benefits that the process of revitalization of small urban streams brings about to urban areas; and (2) to establish urban planning and design guidelines for revitalization of watercourses that should help in retrofitting small urban streams in the City of Niš.

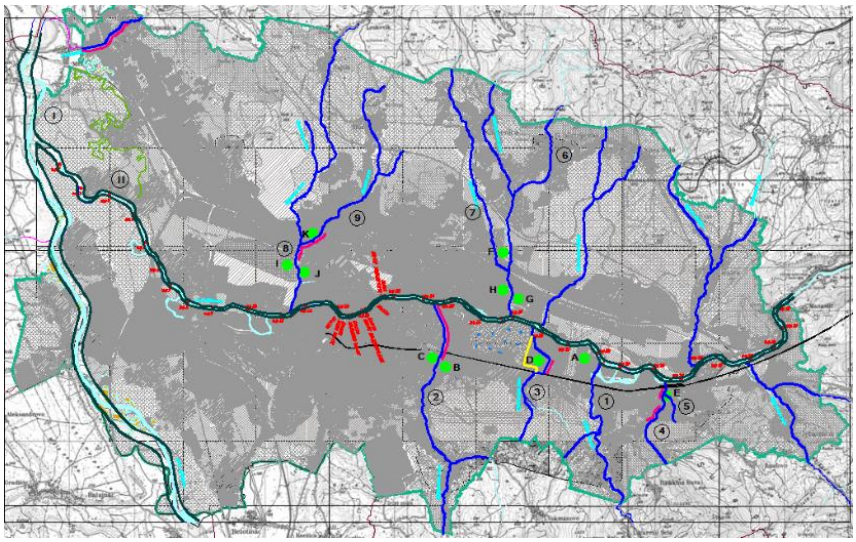
2. MATERIALS AND METHODS

This paper explores revitalization of small urban streams by using empirical research and review of relevant literature. The methodological framework is conceptualized on description and analysis of best practice examples of stream revitalization, with the synthesis of study findings subsequently used as a baseline for formulating urban planning and design guidelines for the City of Niš scenario. Particular cases of good practice were chosen to best reflect the benefits of stream revitalization, and involve comprehensive completed projects whose effects can be evaluated. The City of Niš makes a suitable research polygon due to its significant “blue” natural capital in small waterways.

Aside from two major watercourses (Nišava and Južna Morava), there are also twenty-one small urban streams in the territory of the City of Niš, which is the area covered by the Master Plan (MP) of Niš 2010-2025 [4]. Two of them are waters of the first order (Toponička and Kutinska River) and the rest are waters of the second order[7]. The localities that are endangered by flood waters from small urban streams are established in the MP of Niš 2010-2025 [5] (Figure 1). This paper explores the potential for increasing the resilience of these flood hazard zones. Therefore, research focus is set on nine small urban streams that pose a flood disasters risk to communities in Niš urban area: Kutinska River, Gabrovačka River, Suvodolski Creek, Kovanlučki Creek, Suvobanjski Creek, Matejevačka River, Brenička River, Rujnička River and Humski Creek. The effect of these

[7] According to the Water Law of the Republic of Serbia (2018), in line with their importance for water management, surface waters in Serbian territory are divided into waters of the first and second order.

watercourses on rural settlements, beyond urban border, is not evaluated in this study. Characteristics of small urban streams and related flooding issues are determined on the basis of field investigations, the use of various legislation, satellite photo images and available data from internet sources. Review of standing planning documents provided the information on planned land uses in watercourses adjacent areas, which are relevant for the proposed guidelines.



Border of MP of Niš 2010-2025 area
Localities endangered by flood waters (A-K)
Large watercourses
Small urban streams (selected 1-9)
Regulated stream
Newly planned stream route

I Južna Morava, II Nišava, 1. Kutinska River (8 km), 2. Gabrovačka River (5,5 km), 3. Suvodolski Creek (4,5 km), 4. Kovanlučki Creek (3 km), 5. Suvobanjski Creek (1 km), 6. Matejevačka River (7 km), 7. Brenička River (7 km), 8. Rujnička River (9 km), 9. Humski Creek (8,2 km).

Figure 1. *Watercourses in the City of Niš with selected small streams and length in MP area. Source: Authors' drawings on the MP of Niš 2010-2025: Infrastructure - Plan of regulation of watercourses*

3. URBAN PLANNING AND DESIGN GUIDELINES FOR INTEGRATING SMALL URBAN STREAMS

Guidelines for the urban planning framework that are elaborated in this chapter are summarized around the following crucial points [6]: (1) *Flood protection*, (2) *Urban ecology*, (3) *Recreational areas*, (4) *Appealing urban landscape*, (5) *Sustainable mobility*, (6) *Community engagement*, and (7) *Risk management*. Tools and strategies of urban design that are used in stream revitalization, are discussed within each of the established topics.

3.1. FLOOD PROTECTION

Enabling effective flood protection in urban areas first of all implies implementing linear and retention measures along the stream. Both of these measures can be viewed as active flood protection or structural measures, which are mainly proposed and developed by hydrological engineers. This chapter discusses flood protection from an urban planning perspective. The City of Graz is, for example, implementing comprehensive flood protection measures through the Streams of Graz program (2006), a program for the restoration of small watercourses, where both linear and retention measures are coordinated with spatial planning.

Linear measures against floods are established in order to control the water regime, while retention measures imply the construction of retention structures. Linear protective measures include widening of the streambed, raising the embankment or the adjacent terrain, removing discharge obstacles and pruning streamside vegetation to remove the narrow passes [7]. Sometimes, linear measures alone are sufficient to safely conduct the water flow to the recipient, without endangering the surrounding areas. In other cases, it is necessary to provide an upstream flood retention basin, in order to safely drain flood waters down the stream. Retention areas and flood plains are zones along the watercourses into which floods may spread without presenting a hazard [7]. Retention basins decrease the discharge to a certain extent, thus enabling the downstream sections to better cope with

flood waters, preventing the stream outflow from its riverbed and mitigating flood risk. Zones of undeveloped land are very difficult to find in densely built urban areas, so retention basins are often constructed outside of urban areas, where more open space is available. Developing wetlands and parks in retention basins is suggested as the appropriate choice for the landscaping of these areas. Wetlands planted with native plants increase the detention capacity of flood waters and help with water cleansing, while parks enable controlled flooding and provide a useful amenity for the community. Given the scarcity of open space along the watercourses, it is imperative that these zones are retained without any development, and dedicated for retention purpose.

Deculverting enclosed/piped streams is a critical measure against flooding. Throughout urban history, small urban watercourses were often hidden in culverts and pipes and buried underground, to make way for new developments and expansion of urbanized areas [6]. Nowadays, cities around the world are increasingly attempting to restore buried streams. The process of reopening streams is often referred to as "deculverting" or "daylighting". Daylighting consists of exposing some or all of the flow of a previously buried stream by creating a new streambed, and may include the creation of ponds, wetlands or estuaries [8], thereby re-establishing the natural stream structure. Particularly extensive activities on reopening buried rivers and streams are undertaken by the City of Oslo within the project Oslo Reopening Waterways [9], as an integral part of climate change adaptation plan to make the city resilient to flood risk.

Implementing contemporary integrated stormwater management approaches, complemented with the elements of blue and green infrastructure, is the final instrument of urban planning and design that is considered to be of great significance in preventing flooding. Namely, increasing urbanization has resulted in the increase of paved surfaces in urban areas, which are usually impervious, and thereby alter both the quantity and quality of surface runoff water [10]. In terms of quantity, less water is infiltrated and more runs off at the surface, which affects the physical structure of streams and rivers, and may cause flash flooding. Regarding the quality, most of the water runoff nowadays contains pollutants caused by human activities (hard metals from roads, roofs and paved surfaces, lawn chemicals from fertilization). When these hard materials enter the rivers and streams, they cause water pollution and endanger the biodiversity. Therefore, new strategies and approaches[8] have been developed in the last couple of decades to mitigate the impact of stormwater runoff and pollutant loading. All of these contemporary approaches are based on similar concepts - they integrate the hydrological cycle into urban design, use natural processes that result in the retaining, filtering and absorbing stormwater, along with evapotranspiration or re-use of stormwater, in order to reduce flood risks, protect water quality and biodiversity, and improve urban recreation options [11, 12, 13, 14].

In stormwater management, the role of "Blue-Green Infrastructure" (BGI) is becoming increasingly important as an alternative to conventional pipe-based stormwater management in cities [15]. BGI connects [4]: (1) the blue component, which refers to urban hydrological functions, such as watercourses (rivers, streams) and still waters (lakes, ponds), and (2) the green component, which entails vegetated areas in urban environment, such as urban forests and meadows, parks and protective greenery. Typical BGI elements for stormwater management found in waterfront areas involve bioswales, cleansing biotopes/rain gardens, retention and detention swales and lakes, infiltration trenches, etc. Aside from them, permeable pavement and drywells are also technical elements for stromwater management that may be used in waterfront areas. By reintroducing natural processes within the built environment, BGI also strengthens urban ecosystems and improves quality of life [2].

3.1.1. Best practice illustration - Hølaløkka Waterpark, Oslo, Norway

Hølaløkka Waterpark is a waterway rehabilitation projects undertaken in Oslo, when a 300 m-section of formerly culverted Alna River was reopened. The aim of the project was to combine a technical water management system, where ecological and hydrological needs are met, with a design that maximizes the potential of an appealing outdoor space [16]. Water management concept implies directing rainwater into an open canal, returning water to the surface, cleansing it from pollutants and releasing back into the Alna [16]. First, the river enters a restored and widened riverbed in the corner of the park, and is next released into a natural settling basin (Figure 2). Then, the river moves through small waterfalls and flows into an open swimming pond in the middle of the park, which holds back flood waters. The adjacent meadow serves the double purpose of an informal relaxing

[8] Most prominent stormwater management approaches involve Best Management Practices (BMP) and Low Impact Development (LID) in the United States of America, Water Sensitive Urban Design (WSUD) in Australia and Sustainable Drainage System (SuDS) in the United Kingdom.

area and a flood meadow [16]. Finally, the river goes through the a wetland area, which is developed in for stormwater treatment.

Stormwater management of the adjacent industrial buildings and traffic areas is combined into the river system [17]. The run-off from the roof, surface and roads is first conveyed via surface drainage to a cleansing biotope area. Here, the pollutant break-down from the stormwater run-off occurs, and rainwater is cleansed through a multi-layered substrate. Then, the water is released to a subsequent newly created wetland with detention capacity, which treats polluted stormwater and holds it back for slow release. After the project was completed, a significant reduction of pollutants was confirmed, a trend which is expected to increase and stabilize in the long run [16].

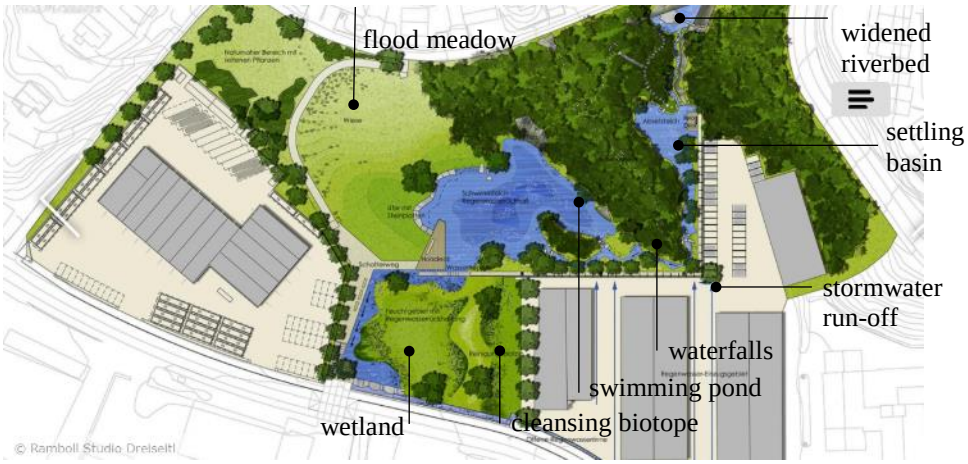


Figure 2. *Hølaløkka Waterpark landscape plan and amenities*

3.2. URBAN ECOLOGY

Strengthening urban ecology represents a vital aspect in revitalizing small urban streams, which often involves implementing elements of BGI. Renaturation of the watercourses implies creating new habitats in revitalized watercourses and adjacent urban green spaces. The main goal is to make both the streams (blue component) and the green areas surrounding the watercourse (green component) as natural as possible, in order to enhance biodiversity of the area and create new habitats for fish, insects and birds. In the process of stream renaturation, it is therefore advised to plant native, site-specific vegetation and introduce local aquatic species.

Another important planning measure that improves urban ecology concerns developing natural self-cleaning systems, where natural soils and plant life improve water quality by filtering pollution. Such systems are based on nature's own self-purification of water through planted wetlands, pools and various BGI elements. Positioning these elements in upper reaches of the stream enables cleaner water for the downstream sections.

3.2.1. Best practice illustration - Teglverksdammen project, Oslo, Norway

In the project of reopening a 650 m-section of Hovinbekken stream in Oslo, a large-scale biological cleaning system and a spectacular recreational space called Teglverksdammen was created [6]. This natural cleaning system that filters incoming waters consists of several sedimentation basins, a small lake (large pond), three dams, streams with rapids, and high-density native vegetation in shallow waters that act as wetlands [9] (Figure 3). Untreated water from the culverted stream flows into the first section of the restored reach, Tennisdammen. It consists of two pre-treatment settling pools and permeable thresholds with emerging macrophytes, and retains most of the sludge, suspended particles, as well as the associated nutrients and pollutants [18]. From here, the water runs into a section with riffles, pools, dense emerging macrophyte vegetation and permeable thresholds. Next, the water flows into the first wetland, which transitions into the largest pond called Teglverksdammen, and again transitions to the second wetland. Finally, the water enters the last sedimentation pond in the reach, Grensedammen. Within this system, the sediments settle and the water is filtered through rocks and vegetation. The east side of the pond is hilly and vegetated as a riparian zone, while asphalt and concrete surfaces are located at the west side. After reopening the stream, the City of Oslo monitors water quality at Teglverksdammen, and the results indicate the potential for purification [19].

The revitalization of Hovinbekken at Teglverksdammen has enabled the development of a clean habitat to native species and rejuvenation of local biodiversity. In all projects of reopening watercourses, including this one, the City of Oslo attempts to maintain the aquatic habitat and

surrounding environment in their natural state. Restoring aquatic and terrestrial ecology with native species involves [9]: (1) planting only native vegetation in water networks and adjacent land, which includes marsh marigold, purple loosestrife, yellow iris, bulrush, reed canary grass and common alder; and (2) creating natural bottom substrates for invertebrates and fish. The restoration projects are also recovering migration paths for fish, which has enabled breeding and population growth of migratory fish in the region.

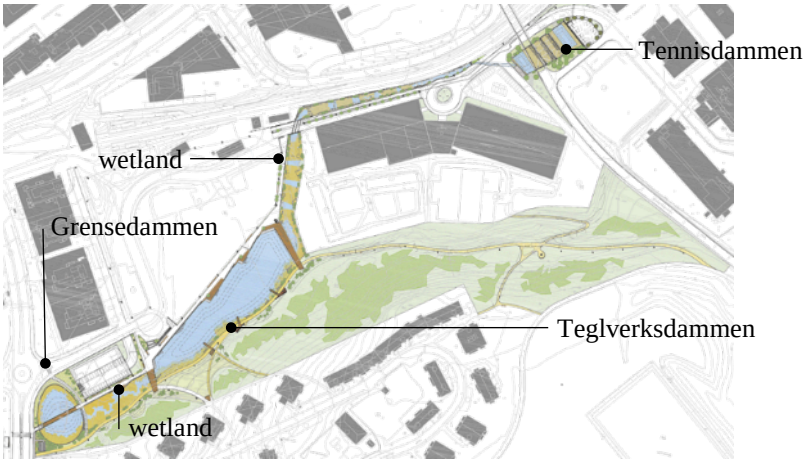


Figure 3. *Teglverksdammen landscape plan.*

3.3. RECREATIONAL AREAS

When creating recreational areas along the streams and their adjacent surfaces, these areas should be developed as nature-like zones for both active and passive recreation for all user categories. A renatured stream that creates park-like environment with rich vegetation and various amenities, enables widely-practiced recreation in the river landscape. Suggested amenities include playgrounds for children, sport fields and hiking trails for younger adults, and various types of open spaces for strolling, gathering and rest for adults and the elderly (walking and bicycle paths, fitness areas, sitting areas, plazas, squares, waterfront decks, etc.). An additional benefit that the implementation of various amenities for outdoor activities brings to recreational areas, is creating opportunities for social interaction. Large number of people is attracted to such diverse settings, and social contacts are more easily established.

In shaping the recreation area in the waterfront zone, suggested design implies enabling easy user access to the stream itself. This is achieved by designing stairs that lead all the way down to the water, and thus enable a close encounter with nature, which is a particular attraction for children. An important design guideline concerns the provision of adequate lighting to enable recreation in the evening. A well-designed lighting plan for the recreation area will improve public safety.

3.3.1. Best practice illustration - Bjerkedalen Park, Oslo, Norway

Bjerkedalen park is situated along Hovinbekken stream in Bjerke neighbourhood in Oslo. It is located in the middle of a residential urban area that used to have few public spaces. Restoration project involved reopening 300 m of the formerly culverted stream, with the main aim of improving water quality, preventing floods and creating new green areas [20]. At the same time, all these actions improved the overall urban landscape and created an attractive recreational area, with various amenities for outdoor activities (Figure 4). A terraced park pavilion, which is conceptualized as the focal point of the area, contains an amphitheater with a view, a café and a large outdoor terrace [21]. In the central area of the park there is also a basketball court, while the sand volleyball court is located in the corner of the park. The central promenade and new smaller trails meander through the park alongside the stream, with maximum 5% slopes. The stream canal in the central park area is shaped with green stepped edges. In the southern part of the park, a 3 m deep bathing pond is created, along with a sandy beach. In wintertime, the pond is used as an ice-skating rink. Children's playground is positioned near the kindergarten. Green areas include 2,5 hectares of lawn and 5 hectares of flowering meadow, with planted 50.000 perennials [21].

This park also plays an important role in stormwater management, since it functions as a retention basin during extreme weather events. Rapids, ponds and small waterfalls increase the appeal of the area and a create a habitat for aquatic species. Bjerkedalen Park has become the focal point of the Bjerke District and a natural meeting place. The project also brought about social and health benefits

to the residents, such as the improved access to urban green space, increased opportunities for social interaction and gained amenities for recreation and exercise [20].

Figure 4. *Bjerkedalen Park landscape plan and amenities.*

From the aspect of urban design, improvement of the overall aesthetics of space in revitalizing urban streams enhances the experience of users. Visual appeal of a waterway landscape can definitely be enhanced by creating a park environment. This implies introducing both greenery (green component) and additional hydrological features beside the stream (blue component). Green surfaces should dominate in spaces adjacent to waterways, in comparison to paved areas. Natural soils and natural surface cover absorb less sun radiation and emit less urban heat, and are therefore advised in waterfront areas in order to create favorable microclimate. Aside from the quantity of greenery in a renatured stream area, their quality and diversity also represent important design issues. It is suggested to implement diverse types of greenery within meadows, open grassy areas, flower beds and parks. In some stream revitalization projects, implementing additional water elements in areas adjacent to the stream is advised, as a tool of urban design that enhances the overall quality of the project. In shaping the appealing urban landscape, a variety of water features such as lakes, ponds, dams, canals, rapids and waterfalls, can bring added value to the aesthetics of the waterfront.

3.3.2. Best practice illustration - Arkadien, Winnenden, Germany

Arkadien Winnenden is a regeneration project developed on the site of a former factory, along Zipfelbach stream in Winnenden. Zipfelbach stream has also been ecologically restored. Together, these interventions resulted in the Arkadien being one of the most sustainable and cohesive neighborhoods in the world. Urban design is based on mixed architectural typologies, appealing Mediterranean color concept, “shared streets” and water sensitive urban design [22] (Figure 5). High quality of the streetscapes is achieved with dominantly pedestrian character, even though vehicular traffic is possible. The concept of shared circulation implies that the site is accessible for vehicles, but with reduced speeds. Parking options are provided in an underground garage, limited street parking, carports, and individual parking spots positioned between gardens on the unique load-bearing planting substrate. Pavement includes recycled granite, and permeable concrete pavers and asphalt. The appeal of the streetscapes is enhanced with generous planting. Street corners are envisioned as mini-plazas for social interaction and children’s play.

The stunning lake is the focal point of this development. It manages flood waters from both the site itself and the adjacent stream Zipfelbach. The lake also acts as a rainwater detention basin. It captures and filters rainwater in a stepped system, cleanses it through natural plant processes, before overflowing to a flood meadow and slow releasing to the stream. A major part of the precipitation at the site is captured, and re-used in toilets, fountains, and irrigation. The use of permeable pavers and the innovative use of structural bearing soil substrate for garden-like parking spaces, has reduced the impermeable surfaces to only 30% of the site [23]. All of the stormwater management elements - retention lake, flood meadows and permeable surfaces, jointly contribute to the reduction of flooding in the local urban catchment. The planting concept uses locally native species, which support birds and bees. The stream’s park integrates play areas, cycle routes and flood meadows. The creation of this vibrant ecological neighborhood has managed to foster social stability and

community feeling. Affordable housing prices are making the ecological and sustainable home an available option for everyone's budget.

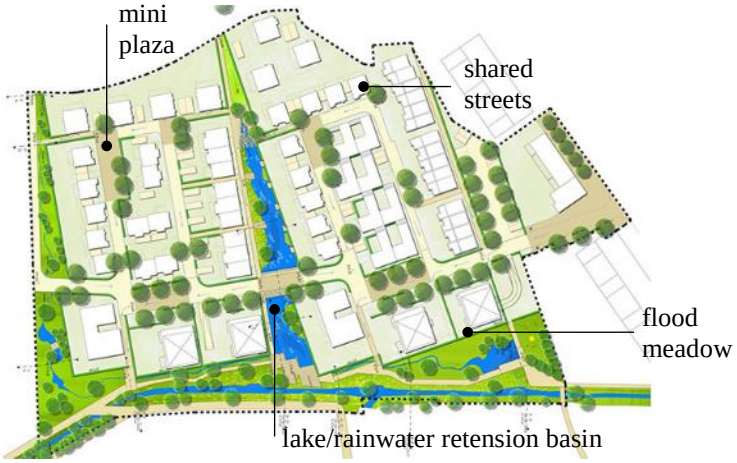


Figure 5. *Arkadien landscape plan and amenities*

3.4. SUSTAINABLE MOBILITY

Implementing sustainable mobility solutions is an imperative in planning resilient urban areas. These transportation options are fostered in contemporary development because of their benefits for the environment and public health. Small urban streams, and watercourses in general, play an important role when tracing routes for sustainable mobility. From the standpoint of urban planning and design, it is advised to develop bicycle and pedestrian pathways made of permeable material along the streams. Sustainable mobility routes are best fitted within the city BGI grid, which is created by interconnecting various natural open spaces in urban areas with green or blue linear pathways. In shaping the city transport infrastructure, it is also vital to inter-link bicycle and pedestrian pathways with the city transportation network, in order to enable a variety of transportation options.

3.4.1. Best practice illustration – Alna Trail, Oslo, Norway

The City of Oslo has developed a comprehensive plan for a network of walking and cycling paths, and a number of routes have already been completed. The longest of these inter-connected paths runs along the course of Alna River, and is called the Alna Trail. Alna Trail was developed within the Grorud Valley Project, whose main aim is oriented towards sustainable urban development, environmental upgrades and improvement of the quality of life [24]. Additionally, efforts to strengthen the Alna were anchored in the Municipal Sector Plan for the Alna Environmental Park. This plan facilitates reopening and environmental improvement of Alna and its tributaries, from Alna Lake to the fjord, along with the creation of blue-green infrastructure.

The 10 km long Alna Trail starts at the forest edge at Ammerud, and runs along Alna River until Svartdalen area (Figure 6). Alna Trail now represents the longest stretch of inter-linked walking trails and green spaces along the course of Alna River. The path first goes through Grorud Park, which was inserted into the existing green corridor along reopened river. It is of vital importance for the trail that the main barriers for pedestrians and cyclists in the Grorud Valley were removed, thus enabling continuous flow. One of the major obstacles on the route was the railway line. With the construction of the 40 m long underpass called Haugen Gate, strolling along the Alna Trail was enabled without detouring. Also, in routing and shaping the Alna Trail, the signposting was improved. Next, Alna Trail passes through the Hølaløkka Water Park and its attraction Leir Waterfall. This waterfall, which used to be hidden behind a concrete dam, was also reopened, and the access to it is significantly improved. The next park along this trail is Alnaparken. Further west, the trail continues as a universally designed gravel road through a lush natural area called Fagerlia. The entire section is well signposted, giving people the opportunity to choose several alternative paths. Finally, one of the most interesting segments of Alna Trail is a section through the Svartdalen nature area. A unique feature of this project is a 250 m long wooden boardwalk, which meanders above the river near the Ekeberg escarpment [24]. By the Nygård waterfall, one of the biggest waterfalls in the Alna, the trail crosses a new suspension bridge.

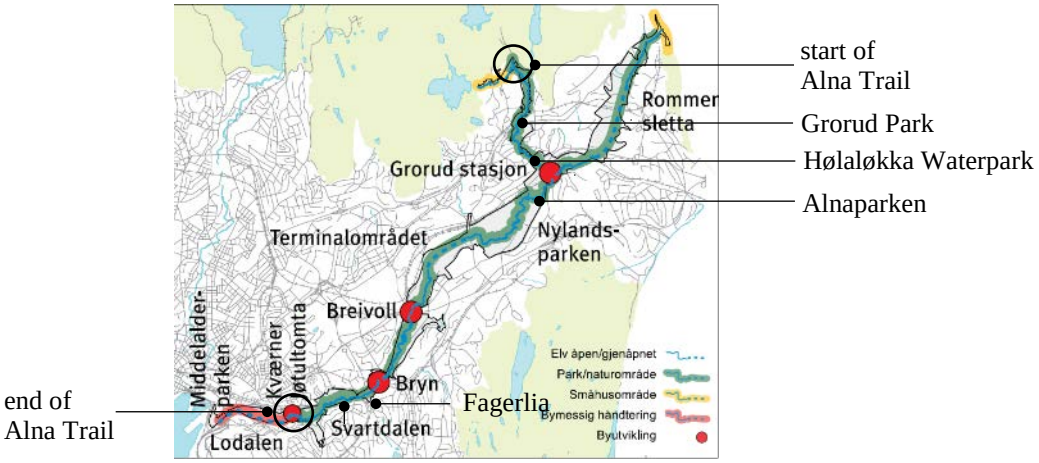


Figure 6. *The route of Alna Trail, in Alna Environmental Park*

3.5. COMMUNITY ENGAGEMENT

Revitalizing small urban streams can be an important tool for cities looking to profile their image as a resilient community with sustainable design solutions. Aside from institutional and political support in implementing "blue-green" projects, significant efforts are required in obtaining broad civic support and involving the community. Particularly, small urban streams often seem to be neglected, devastated and forgotten, until a flood event occurs [4]. Therefore, in the urban planning process, community engagement is of crucial importance.

Participatory bottom-up approach is advised when gathering input data for the planning documents, along with integrating user's opinions in the vision for the waterfront area. When conceptualizing planning and design solutions, it is advised to promote healthy lifestyles, such as walking, cycling, exercising and establishing a contact with nature, along the revitalized streams. Designating streams as potential research polygon for local schools and health laboratories is another important measure. When presenting the plan to the public and elaborating on the proposed planning solutions, raising awareness on the significance of the streams is necessary, along with creating a positive image with the local population. After the plan is adopted, it is crucial to continue educating local population on different projects, so that their support is gained for realization of both proposed solutions and future interventions. These are all important actions that enable the local people to see waterfront areas as their own recreational space, the space that is theirs to love, maintain and improve.

3.5.1. Best practice illustration – Bishan-Ang Mo Kio Park, Singapore

Singapore is an example of a city where adoption of BGI is now extremely popular with citizens even though the support for BGI was originally institutional and top-down-driven. The successful BGI implementation in Singapore is partly due to a large public awareness campaign to overcome objections, while the other reason can be found in the huge success of Bishan-Ang Mo Kio Park as a pilot BGI project [2].

Bishan-Ang Mo Kio Park is a large regional park situated between two residential areas in Singapore. In the early 1980s, a concrete canal for the Kallang River in the middle of the park was built for flood mitigation, collecting water from the surrounding neighborhoods. In 2006, Singapore's national water agency Public Utility Board initiated the Active, Beautiful and Clean Waters Program, as a long-term initiative to transform the country's water bodies beyond their functions of drainage and water supply, into vibrant, new spaces for community bonding and recreation [25]. When Bishan Park was chosen to be a demonstration project for integrated water management that uses elements of green design, both the park and the canal were in need of restoration. Landscape design concept removed the 2,7 km concrete canal and introduced a small, meandering 3,2 km natural stream (Figure 7). During periods of intense rainfall, the green space adjacent to the stream receives excessive water and doubles up as a conveyance channel. Within the 62 hectares of redesigned park space various amenities are provided: three playgrounds (adventure playground with climbing facilities, water playground fed with naturally cleansed river water, and sand-filled bubble playground), two restaurants, Recycle Hill (new landmark, constructed by using the recycled walls of the old concrete channel), several ponds, a cleansing biotope, plazas, and plenty of open green spaces that serve as playing fields, fitness areas and event spaces. The stream provides natural cleansing of runoff through bioretention and filtration. Natural plants and soil in the

cleansing biotope purify the water from the stream and ponds. Today the park serves as a recreational space for the local residents and an opportunity to reconnect with nature.

Before revitalization, the responsibility for the park laid with the National Parks Board, and for the drainage channel with the Public Utility Board. With the implementation of integrated water management and BGI, the two agencies collaborated, which inspired similar inter-agency partnerships for other projects. The revitalization team was fully dedicated to the project, from the urban planning stage to the construction itself, convincing stakeholders, engaging experts and organizing art and education workshops with children [25]. Despite the fact that Bishan-Ang Mo Kio Park was not a community-driven effort, various stakeholders were working together on fulfilling multiple objectives. Even before the park was completed, the phenomenon of "self-policing" had been observed with locals, who were looking out for the cleanliness of the park and the safety of others [25]. The changed attitude and ownership towards the river park are nowadays best reflected in the activities such as regular meetings of self-organized interest groups, or field trips to the park organized by local schools. The holistic approach to this project recognizes that the park and the drainage channel are integrated and interdependent elements of ecological and social infrastructure [25]. The project Bishan-Ang Mo Kio Park is an inspiring example of an increasing civic responsibility towards water.

Figure 7. *Bishan-Ang Mo Kio Park landscape plan and amenities.*

3.6. RISK MANAGEMENT

Flood damage often cannot be prevented or reduced with structural measures alone (active flood protection). Therefore, passive/non-structural measures are also advised. From the standpoint of urban planning, they include performing risk analyses, developing forecast models and early warning plans, and integrating them into urban planning documents. Proper establishing of flood hazard zones in spatial and urban plans is particularly highlighted. Therefore, these areas should not be designated for development, or should be zoned as low-density areas where special building codes regarding flood protection apply (wet and dry flood proofing techniques). In this way, extensive damages can be avoided and safety of the population is enhanced. Another important point concerns informing the local population on housing options and personal protective measures in floodplain zones, via targeted campaigns. People inhabiting areas at risk of flooding, as well as users of public open space in riverfront areas, should be informed about the proper behavior before a flood event, along with conducting flood disaster drills. Promoting protective measures based on personal responsibility is also needed, because it educates local residents on what measures they should undertake to prevent or minimize the damage (i.e. insurance premiums).

3.6.1. Best practice illustration – Schöckelbach stream, Graz, Austria

The discharge measurements performed in 1997 on the streams of Graz, revealed that certain areas would be massively affected by floods having a return period of 30 and 100 years [7]. This includes both open spaces and areas that are already built-up, or designated as building ground. The hazard zone map drawn up by the Austrian Service for Torrent and Avalanche Control has also shown extensive settlements areas to be located in "red" and "yellow" hazard zones. In line with this information, a revision of the Master Plan was performed. All planned retention basins (primary and secondary options) are defined as priority areas for protective water management measures. Open areas within the existing high-water marks are identified, and they are designated as priority areas for the discharge of floods and as inundation zones [7]. In the land-use plan, retention basins and

retention zones are assigned the category “open space with special uses” and, in part, additionally designated as “reservation areas”.

For events of greater magnitude than a HQ100 event, the Streams of Graz program (2006) seeks to optimize alarm and contingency plans, in order to be prepared for flood disasters and to respond to them as early and as efficiently as possible. Alarm and disaster contingency plans establish the following [7]: (1) the timeframe at which the respective authorities have to be informed, (2) where relief teams are to be deployed, and (3) when the residents who are likely to be affected are alerted and evacuated, if necessary.

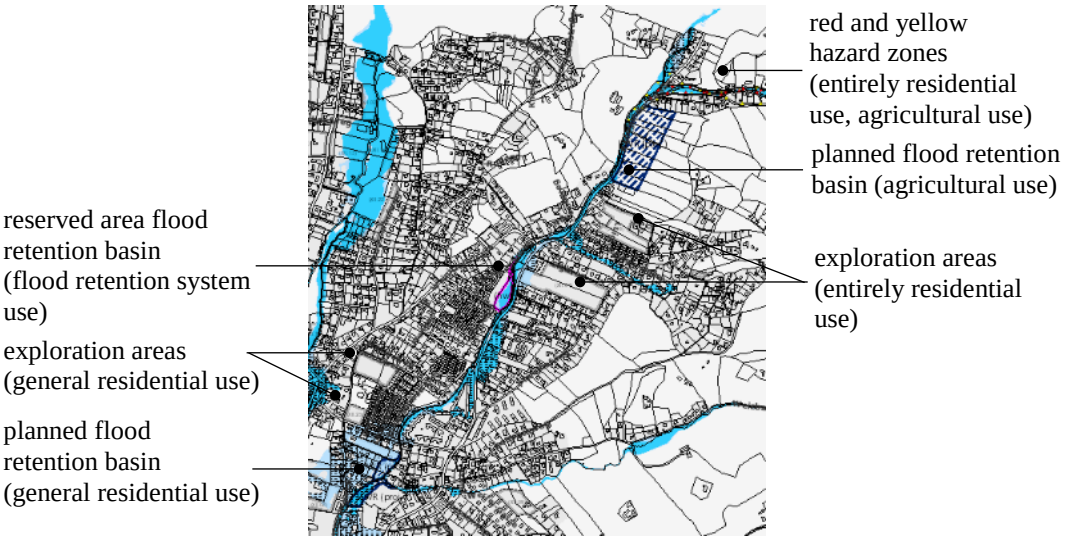


Figure 8. *Segment of the Schöckelbach stream: plan of flood runoff and danger zones, with designated areas for flood discharge and their land uses (Source: https://geodaten.graz.at/WebOffice/synserver?project=STEK-FWP-RLB&client=core&view=4_0_FWPL_DP3)*

4. INCREASING RESILIENCE TO FLOODING FROM SMALL URBAN STREAMS IN THE CITY OF NIŠ

4.1. SMALL URBAN STREAMS IN NIŠ – UNDERSTANDING THE CONTEXT

Erosion processes and torrential floods are among the most prominent natural hazards in Niš area. Small urban streams in Niš city territory significantly contribute to flooding due to their abundance and torrential character [4]. Aside from these natural factors, issues such as poor maintenance and waste disposal are characteristics of all small watercourses in Niš area, and often amplify water outflow to surrounding areas. Watercourses of the first order are under the jurisdiction of the Republic Public Water Management Company “Srbijavode”, while the City of Niš - Directorate for Agriculture and Rural Development is responsible for the watercourses of the second order. Public Water Management Company “Erozija”-Niš is in charge of the protection of land from erosion, torrents and the harmful effects of water. Green areas in Niš urban area are maintained by the Public Communal Company “Mediana”. It is often that the jurisdictions of these various companies regarding small streams are overlapping, and responsibility is transferred among them. This results in poorly maintained small watercourses, with plenty of debris and overgrown wild greenery that reduces the riverbed flow profile. The situation is additionally worsened with residents’ habits of disposing household waste into streams. Therefore, large amounts of debris and waste are carried with the flow, and often result in narrowing the flow profile of the streams. When it comes to community engagement in stream maintenance, the public has participated in several actions of cleaning small urban streams. These actions were organized by the Municipalities of the City of Niš and socially responsible companies, and jointly performed with the City’s Public Communal Companies. Some of them include the cleaning of Gabrovačka River in 2017, and the cleaning of Gabrovačka River, Rujnička River and Humski Creek in 2019.

An important ecological issue concerns sewage pollution from households, the week legislation regarding large industrial polluters, and poor on-site control of implemented regualtions. Water quality in Niš is monitored for the watercourses of the first order. Out of 9 selected streams in this study, the data on water quality is therefore available only for Kutinska River. According to the Report [26], Kutinska River has a mixed-excellent to poor ecological status from the physical-

chemical aspect, and poor ecological status from the microbiological aspect. Given the amount of waste disposal in the watercourses in Niš area, along with low ecological awareness of residents, similar poor ecological status regarding microbiology can be assumed for the remaining 8 small streams. From the physical-chemical aspect, poor ecological quality is expected in streams with adjacent production uses and large traffic areas.
Relevant data on the streams selected for this study, including main issues of concern regarding the flooding from a particular stream, is provided in Table 1.

Table 1.Selected small urban streams in the City of Niš (area of the MP of Niš 2010-2025)

Stream	**Main flooding issues and flood events**
No 1. Kutinska River	- Floods 2004, 2012, 2014, 2018, 2021 - Unregulated riverbed with low throughput upstream of the railway - Torrential floods affect hydrological regime of Nišava River - Unplanned single-family housing infiltrates waterfront area - Unresolved land rights as an impediment for watercourse regulation - Numerous small tributaries, flooding outside of urban border
No 2. Gabrovačka River	- Floods 1926, 1948, 2021 - Unregulated riverbed with low throughput upstream from the railway - Flooding from the upper sections of the river, next to urban border
No 3. Suvodolski Creek	- Floods 2014, 2021 - Displaced natural course of the stream - Mostly unregulated riverbed, shallow throughout settlement Brzi Brod - Culvert at the boulevard road increases sediment deposition upstream - Dense urban fabric close to the stream, no space to retain floodwater
No 4. Kovanlučki Creek	- Partly regulated riverbed, existing regulation insufficient - Partly culverted throughout settlement of Niška Banja - Debris reduces flow profile of the regulated riverbed
No 5. Suvobanjski Creek	- Floods 2019 - Unregulated riverbed, low flow profile
No 6. Matejevačka River	- Surface erosion throughout most of the basin - Flow profiles partially closed at bridges by deposits, shrubs and trees - Unregulated, narrow flow profile throughout settlement Donja Vrežina - Unplanned residential development along the minor (lower) trough
No 7. Brenička River	- Displaced natural course of the stream - Insufficient throughput of the newly formed riverbed section that is conveyed into Matejevačka River - Unregulated riverbed partially enclosed by deposits, shrubs and trees at the culvert in Brenica and at the bridge in Kamenica, narrowed profile
No 8. Rujnička River	- Partly regulated riverbed, existing regulation insufficient - High level of groundwater in settlement Šljaka - Insufficient throughput capacity downstream of the boulevard road
No 9. Humski Creek	- Partly regulated riverbed - Unresolved land rights as an impediment for watercourse regulation - Insufficient throughput of unregulated sections through Donji and Gornji Komren, and of regulated section through Ratko Jović settlement
Sources of data: [4, 5, 27]	

4.2. URBAN PLANNING AND DESIGN GUIDELINES FOR RETROFITTING SMALL URBAN STREAMS IN NIŠ

Some planning measures for flood protection are provided in the MP of Niš 2010-2025 and in Plans of General Regulation (PGRs) of various city municipalities. Even though these planning documents support the creation of the BGI to some extent [4], the implementation of planning solutions is quite slow and does not involve contemporary watercourse management approaches. Therefore, this chapter explores potential additional urban planning measures, as well as tools and strategies of urban design, which should help in revitalizing small urban streams in the City of Niš, in line with

the main goal of flood protection. The guidelines also take into account other relevant topic for increasing the resilence of urban areas where small streams flow.

Constructing flood retention structures. Implementation of flood retention basins is not envisioned in the City of Niš teritory. Planning documents should consider these retention measures along the streams that are prone to overflowing their riverbed in the entire course of the waterway. This is particularly advised for the streams that: (1) have considerable longitudinal fall in the upper section, and flooding occurs beyond the urban border, and (2) have numerous tributaries, such as Kutinska River. Flood retention basin should be provided in the upper sections of the watercourse in order to retain floodwaters and reduce the amount of flow downstream. The availability of undeveloped land next to the urban border facilitates such endeavors, and planned adjacent uses (*Forest, Agriculture*) allow for such development along this stream. Assigning the use "open space - reservation area" in planning documents is essential to safeguard these zones from any kind of future development. Developing wetlands or flood meadows is the suggested planning and design measure for retention basins outside of urban area.

Creating meandering river flow. Widening and deepening the streambed, raising the embankments and removing discharge obstacles are linear flood protection measures that are already envisioned in planning documents for all analyzed streams. However, this research suggests creating meandering river flow for streams of prominent torrential character, such as Kutinska River, Suvodolski Creek, Kovanlučki Creek, Matejevačka River and Humski Creek. In tracing the stream route, the natural course should be favored, as opposed to straight, linear watercourse regulation. This enables better renaturation of the stream and calms the flow during heavy storm events. Additionally, for watercourses with significant slope, control dams are an excellent tool which allows flow deceleration and retention, and prolongs infiltration time. Natural meanders should easily be implemented along the listed streams with torrential issues within the uses *Sport, Protective greenery, Park/Landscape greenery, Recreation, Public square*, but can also be developed within the uses *Agriculture* and *Education*, if open space exists in large complexes of educational use. Displacement of the natural riverbed, which was already performed for Suvobanjski Creek and Brenička River, has resulted in flooding issues of those streams and their tributaries, and should be avoided in future actions. Therefore, the new linear route for the regulation of Suvodolski Creek proposed in planning documents (Figure 1), which alters the stream's natural course, should be reevaluated, and keeping the natural watercourse route needs to be reconsidered.

Deculverting enclosed/piped streams. The issue of culverts on small urban streams is partly reviewed in planning documents, but only for those short, culverted segments at intersections with the railway or a traffic road. In such cases, increasing the throughput capacity is proposed with widening the culverts or opening new ones. This research further suggests reopening the closed canals of Kovanlučki Creek through the settlement of Niška Banja and creating a more "natural" look for the stream.

Developing natural self-cleaning systems. Strengthening urban ecology and renaturation of small urban streams in Niš territory is a crucial measure for achieving resilience of the city. Given the unknown ecological status of small urban watercourses of the second order in Niš territory, and with week regulations in mind, sampling of these waterways and determining their water quality should be the first step in strengthening urban ecology. This research suggests developing natural self-cleaning systems with various BGI elements as a vital measure in improving water quality along Kutinska River, which has an established poor ecological status. Wetlands, pools and natural settling basins along Kutinska River, as elements of natural self-cleaning systems, could be implemented on available land within the following uses: *Sport, Protective greenery, Industry* and *Agriculture*.

Revitalizing native habitats in the waterfront. Restoring aquatic and terrestrial ecology with native species is the second important step towards the ecological city. Creating new habitats and wildlife in both revitalized watercourses and adjacent urban green spaces is advised for all small urban streams in Niš territory.

Implementing integrated stormwater management approaches and BGI elements. This research suggests implementing bioswales, cleansing biotopes/rain gardens, retention and detention swales and lakes, and infiltration trenches, as natural elements for treating stormwater run-off, in waterfront zones of all selected streams. These BGI elements can be implemented as independent features, or may represent an integral part of a wider entity on adjacent land, such as parks or other recreational areas. If BGI elements for stormwater treatment are implemented individually, then they may be considered in densely built urban areas along the streams, where available space is limited. In this research, it is the case of the lower reaches of Gabrovačka River, Suvodolski Creek throughout settlement Brzi Brod, Kovanlučki Creek throughout settlement Niška Banja, Matejevačka River throughout settlements Matejevac and Donja Vrežina, and both Rujnička River

and Humski Creek throughout settlement Ratko Jović. Linear bioswales can be implemented within watercourse regulation, since they do not require extensive surfaces. This implies remodelation of existing riverbeds that are lined with stone in cement mortar, and renaturation of the streams. The remaining BGI elements may be implemented in areas adjacent to the watercourse, depending on the availability of undeveloped land. In these settlements along the streams, aside from BGI, it is also suggested to use permeable pavement and drywells for collecting and retaining stormwater. These two technical elements for stormwater management, along with infiltration trenches, can also be located within individual plots in the waterfront areas of listed settlements, thus reducing the risk of flooding.

Creating floodable parks and sport-recreation areas. Creating floodable recreational areas in the streams' adjacent surfaces, with various amenities for outdoor activities (playing fields, fitness areas, trails, event spaces, sitting areas, plazas, squares, waterfront decks), is advised in zones of undeveloped land along all selected streams. Given the fact that these recreational areas require more extensive surfaces, BGI and other technical elements of stormwater management may be fitted here. In that way, these zones will also serve as retention areas for flood management. Additional water features would add significant value to the aesthetics of the waterfront. When creating a park environment, it is suggested to introduce both: (1) diverse greenery, within meadows, open grassy areas, flower beds and parks, and (2) additional hydrological features, such as lakes, ponds, dams, canals, rapids and waterfalls. Along analyzed small urban streams, the following potential sites for implementing floodable recreational areas are identified in planning documents:

- Kutinska River: (1) in the settlement Nikola Tesla upstream from the railway, land use *Protective greenery*, and (2) in the upper section of the river in the settlement Nikola Tesla, land use *Sport*, where existing football stadium is located.
- Gabrovačka River: (1) area of existing sport fields in the midstream section (Široke padine street), land use *Sport*, (2) next to the railway, land use *Park/Landscape greenery*, and (3) before the confluence to Nišava River, land use *Recreation*.
- Suvodolski Creek: (1) upstream of the railway in the settlement Suvi Do, land uses *Protective greenery* and *Park/Landscape greenery* and (2) in the upper steam section in the settlement Suvi Do, where sport fields are located, land use *Sport*.
- Kovanlučki and Suvobanjski Creeks: (1) area above the railway (flood hazard zone E), land use *Sport*, and (2) in the midstream of Kovanlučki Creek, throughout settlement Niška Banja, land use *Park/Landscape greenery*.
- Matejevačka and Brenička River: (1) area upstream of the highway (flood hazard zone F) along both Matejevačka River, land use *Protective greenery*, and Brenička River, land use *Recreation*, and (2) area before the confluence with Nišava River in the settlement Donja Vrežina (flood hazard zone G), land use *Protective greenery*.
- Rujnička River and Humski Creek: (1) area along Humski Creek upstream from the highway, in the settlement Donji Komren; since green spaces are limited to very small areas in this densely built settlement, it is advised to use other types of open space that can accommodate flood waters: planned area encompassing open space of a *Kindergarten* complex, open space of a *Healthcare facility*, and *Public square*, and (2) area along Humski Creek, just before merging with Rujnička River, in the settlement Ratko Jović, land use *Sport*, (3) area just before the settlement Šljaka along Rujnička River, land use *Protective greenery*.

These interventions should help in retaining stormwater, and thus with preventing flooding in lower reaches of the stream, particularly in the flood hazard zones A-K established in the MP of Niš (Figure 1). Floodable spaces along Kovanlučki and Suvobanjski Creeks would contribute to stormwater management and enable deculverting of closed canals in Niška Banja.

Developing sustainable mobility routes. Tracing bicycle and pedestrian pathways made of permeable material along all selected streams is a suggested measure. These green-blue linear trails should connect suburban settlements on the stream route with Niš urban area, and should lead all the way down to the main BGI corridor along Nišava River. Inter-linking these pathways to the city transportation network is another important action in achieving sustainable mobility.

Applying flood protection zoning and building codes. In the MP of Niš, most of the flood-endangered sites are already developed, or designated for development, except for localities F (planned as undeveloped) and G (undeveloped, planned for development), both along Matejevačka River. It is assumed that the proposed measures for revitalizing small urban streams would reduce flood hazards. However, when it comes to residential use in the areas prone to flooding, in the cases of selected streams, only low-density areas should be zoned. This implies detached and semi-detached dwellings, to ensure that 60% of plot area will be permeable. Regarding the other uses in

flood hazard zones, it is suggested to prescribe the percentage of green areas and permeable pavement on the plot. Special building codes should also be prescribed, involving wet and dry flood proofing techniques.

This research identified several tools and strategies of **urban design** that enhance the visual appeal of small waterways in Niš urban area. They include a thoughtful lighting plan for the waterfronts, shared streets with generous planting in stream adjacent communities, and a "natural" look for the stream with access to the water itself, where a contact with nature can be reestablished. These solutions should be primarily considered in the densely built settlements Brzi Brod along Suvodolski Creek, Donja Vrežina along Matejevačka River, and Ratko Jović along Humski Creek.

Community engagement needs to be significantly improved in the City of Niš. This involves educating local population on the significance of the streams, raising their ecological awareness, gaining community support through bottom-up approach and promoting waterfront areas as the recreational space for healthy lifestyles. Young population and health professionals should primarily be targeted in promoting campaigns, while designating streams as potential research polygon for local schools and health laboratories. Fostering the City's inter-company partnerships for stream revitalization projects is necessary. Joint actions imply various stakeholders working together on fulfilling multiple objectives and creating a positive image.

Regarding **risk management**, proper establishing of flood hazard zones is vital, followed by promoting protective measures based on personal responsibility (insurance premiums), as well as developing flood disaster warning systems and contingency plans.

5. CONCLUSION

Contemporary urban planning paradigms regarding watercourses are promoting the strategy of "living with water" rather than defending from it. Under the framework of integrated planning, this shift in vision, policies and urban design techniques points towards a very important role that small urban streams play in urban landscape. This paper discussed the topical issue of flood protection within sustainable development practices, from the perspective of urban planning and design.

In line with the first research aim, it can be stated that the revitalization of small urban streams provides valuable contribution to creating resilient communities. Benefits are achieved regarding flood protection, public health, social life, environmental impacts and adaptation to climate change. Best practice examples that were examined in this paper illustrate how the revitalization of small urban streams improved flood mitigation and stormwater treatment, strengthened urban ecology with better water quality and restored habitats, diversified recreation options, and enhanced visual appeal of the waterfront landscape.

This research also provided an insight into the "blue" capital in small streams of the City of Niš, whose potential is underused within urban planning policy and practice. Regarding the second research aim, the results of this study identified several key planning activities and elements of urban design that should help in retrofitting small urban streams into the existing urban fabric in Niš. Within urban planning measures, special attention should be given to contemporary integrated stormwater management, blue-green infrastructure, parks and recreation areas that serve as flood retention basins, urban ecology, and zoning and building codes in flood hazard zones. This paper also suggested some potential locales where floodable amenities with BGI elements could be applied, but a more detailed examination is necessary regarding their exact locations, size and design. Aside from planning measures, a series of actions is also proposed for profiling Niš as a resilient city, such as upgrading the design of waterfront areas, improving risk management and shifting the perception of the local community. Further studies should focus on creating the BGI grid in Niš territory, which integrates revitalized watercourses and sustainable mobility routes.

Finally, it can be concluded that given the strategic significance of small urban streams in shaping resilient cities, future development of waterfront areas should be guided within an integrated urban planning approach.

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LITERATURE

[1] "Blue green infrastructure: cloudburst management strategies for the District of Columbia". Internet: https://doee.dc.gov/sites/default/files/dc/sites/ddoe/service_content/attachments/BGI_Workshop_Final.pdf [Jan. 06, 2020]

[2] Ramboll. "Strengthening Blue-Green Infrastructure in Our Cities". Internet: https://ramboll.com/-/media/38fc23d12a5d47dcb7b3821716d69270.pdf, 2016 [Jan. 06, 2020]

[3] R. W. Lammers and C. Day. "Urban river restoration: bringing nature back to cities". Internet: https://ibe.colostate.edu/urban-river-restoration/, 2018 [Sep. 27, 2021]

[4] M. Dinić Branković, M. Igić, P. Mitković, J. Đekić and I. Bogdanović Protić, "Exploring the potentials of small urban streams in creating blue-green infrastructure in the City of Niš, Serbia", Proceedings of the International conference on Contemporary Theory and Practice in Construction XIV STEPGRAD, 2020, pp. 159-174.

[5] Urban Planning Institute of Niš, "Master Plan of Niš 2010-2025", *Official Gazette of the City of Niš*, no. 43/11, 2011.

[6] M. Dinić Branković and M. Marković, "Revitalizing small urban streams as an instrument of urban planning in creating resilient cities", *Facta Universitatis, Series: Architecture and Civil Engineering*, vol. 19, no. 2, pp. 193-205, 2021. https://doi.org/10.2298/FUACE211203015D

[7] "The Streams of Graz Program of Measures 2006-2015". Internet: https://www.wasserwirtschaft.steiermark.at/cms/beitrag/10960200/4570309/ [Oct. 21, 2021]

[8] R. Pinkham, *Daylighting: New Life for Buried Streams*. Rocky Mountain Institute, Old Snowmass, Colorado, 2000.

[9] "Oslo Reopening Waterways". Internet: https://ec.europa.eu/environment/europeangreencapital/wp-content/uploads/2018/05/Oslo_Reopening_Waterways.pdf [Jan. 06, 2020]

[10] M. Dinić Branković, P. Mitković, I. Bogdanović Protić, M. Igić and J. Đekić, "Bioswales as elements of green infrastructure – foreign practice and possibilities of use in the district of the City of Nis, Serbia", Proceedings of the 2nd International Conference on Urban Planning, 2018, pp. 347-356.

[11] https://www.encyclopedia.com/environment/encyclopedias-almanacs-transcripts-and-maps/best-management-practices [Jan. 14, 2022]

[12] https://www.epa.gov/nps/urban-runoff-low-impact-development [Jan. 14, 2022]

[13] https://www.melbournewater.com.au/building-and-works/stormwater-management/introduction-wsud [Jan. 14, 2022]

[14] https://www.netregs.org.uk/environmental-topics/water/sustainable-drainage-systems-suds/what-are-sustainable-drainage-systems/ [Jan. 14, 2022]

[15] L. Liu, O. Fryd and S. Zhang, "Blue-Green Infrastructure for Sustainable Urban Stormwater Management – Lessons from Six Municipality-Led Pilot Projects in Beijing and Copenhagen", *Water*, vol. 11, no. 10, pp. 2024, Sep. 2019, doi:10.3390/w11102024

[16] https://www.northernarchitecture.us/water-management/daylighting-of-alna-river-in-holalokka-oslo.html [Nov. 9, 2021]

[17] http://www.dreiseitl.com/en/portfolio#holalokka [Jan. 17, 2022]

[18] S. Burgess. "Development in phytoplankton assemblages, ecological status and purification effect in Teglverksdammen", Master's Thesis, Norwegian University of Life Sciences, 2018.

[19] D. Arnott. "Macroinvertebrate colonisation of a recently deculverted urban stream". Master's Thesis, Norwegian University of Life Sciences, 2017.

[20] https://una.city/nbs/oslo/bjerkedalen-park-and-reopening-hovin-river [Nov. 9, 2021]

[21] http://www.arquitectes.cat/iframes/paisatge/fitxa/9695 [Jan. 18, 2022]

[22] https://landezine.com/arkadien-winnenden-by-atelier-dreiseitl/ [Jan. 19, 2022]

[23] https://www.greendotawards.com/submit/upload/2007/large/3-460-11_ecological_city.pdf, [Jan. 19, 2022]

[24] "The Municipality of Oslo, Application for Candidacy to the Landscape Award of the Council of Europe 2016/17". Internet: https://rm.coe.int/16806f5e75 [Nov. 3, 2021]

[25] https://www.asla.org/2016awards/169669.html [Jan. 20, 2022]

[26] Vatrogas Institute. "Report on monitoring the quality of surface waters in the territory of the City of Niš for 2017/2018 - I Quarter". Internet: https://www.gu.ni.rs/kvalitet-povrsinskih-voda/?pismo=lat&print=print [Jan. 28, 2022]

[27] City of Niš, "Operational plan for flood defense in the City of Niš territory for watercourses of the II order for 2021," *Official Gazette of the City of Niš*, no. 8/2021, 2021.