# Stormwater Management as a Green Solution to Support Environmental Quality: A Case Study from Serbia

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## 1. Introduction

The effects of climate changes are among the live questions in Serbia nowadays. Looking at the air temperature in Serbia in the time period between 1950 and 2008, we can see the growth trend of annual mean air temperatures for approximately 1.2 degrees C, as well as 2 percent growth in mean annual precipitation. If certain measures are not taken for the purpose of climate change mitigation, it is expected that the air temperature will grow drastically until the end of this century, especially during the summer periods (4 to 5 degrees C). Precipitation reduction is also expected, and in the springtime it could reach up to -30 percent (Ministry of Environment, Mining and Spatial Planning & the National Agency for Spatial Planning, 2011). Although the overall quantity of downfalls will be reduced, at the same time, European Environment Agency (EEA) predicts growth in number of extreme rainfalls – showers, which can easily cause floods (Despotović, 2009). This problem is endangering the environment and can cause great pollution if the quantity and speed of storm-water is not regulated in time. This paper will deal with the subject of floods within the wider issue of climate changes, which can be mitigated or prevented through storm-water management.

For years in Serbia, storm-water was drained away from urban areas through underground pipe-based infrastructure networks and released into the rivers without any treatment. Water management had no influence on urban landscape development. In the esthetic, social and ecological sense, storm-water was not recognized as a resource in the landscape. Nowadays, in Europe, Northern America and Australia, a new approach is being used for the storm-water management, enabling it to become an integrated part of urban landscape, and thus helping the overall improvement of urban quality and becoming the key factor in fighting climate changes.

In its aspiration to reduce the effects and consequences of climate changes and to improve its practice in the field of water management, Serbia begun with the harmonization of its regulations with the international ones. Therefore, different policies were either initiated or already came into force. All of them are, however, aimed at fostering sustainable and climate-responsible development in the country.

## 2. Storm-water Management and Spatial Development in Serbia

Significant factor in Serbian state policy is its tendency and priority to become a member state of the EU. At the end of 2009, Serbia officially applied for the EU membership, and by signing the Stabilization and Association Agreement, committed to harmonizing its laws with those of EU which, among others, include laws on sustainable development, climate change impacts and water management.

In Europe, legislation for sustainable decentralized storm-water management is quite advanced. The EU member states have started with implementation of Water Framework Directive (WFD) in all the sectors related to water management, including storm-water management. This directive promotes integrated water management with respect to principles of sustainable development, and puts the environment in focus (European Parliament, 2000). The key goals of the new European policy, defined by Water Framework directive are the following (Srbijavode, 2006-2008):

- Overall protection of all the waters with the implementation of the principle of integrated management;
- Reaching the objective of good water status within the time period of 15 years from the moment of WFD adoption;
- Fostering collaboration and communication;
- Integral river basin management, with special regard to areas divided by interstate borders;

During 2011, Serbia adopted new Law on Water, which is in line with the European legislation, WFD and a number of other European directives on water. The law is based in the contemporary principles of water management and it provides the basis for all plans and projects dealing in any way with water (Ministry of Agriculture,Trade, Forestry and Water Management, 2010).

### *Spatial Development Plan*

The Spatial Development Plan of Serbia for the period 2010-2020 incorporates in its concept principles of the integrated water management, climate change mitigation and adaptation, and in addition, provides the foundation for every regional and local plan and program.

From the perspective of climate changes, the main goal is to include them into strategies as a factor of sustainable development and environment, and to develop sustainable climate change risk management system in the Republic of Serbia. On the other hand, concerning water, the goal is unified regulation, protection and use of water at the Serbian territory, appropriately embedded into surroundings and in compliance to other users of space. Operational goals are in line with WFD and other directives on water in the EU, and are achieved through water resources infrastructure (Ministry of Environment, Mining and Spatial Planning & the National Agency for Spatial Planning, 2011).

- Complex protection of water and harmonization of goals of water resources, as well as goals of ecology and development;
- Integrated water management within the managing systems at the level of bigger river basins;
- Real economic policy which enables self-financing of the water sector.

Taking into consideration new data on climate changes and the fact that the water sector is under the greatest threat from climate changes, according to the Spatial Development Plan of Serbia, the concept of spatial development of water resources is based on (Ministry of Environment, Mining and Spatial Planning & the National Agency for Spatial Planning, 2011):

- The effect of climate changes on the availability of natural resources – water resources, biodiversity, wood and other ecosystems with an aim of planning sustainable development and ecologically acceptable activities in the areas sensitive to climate changes;
- Spatial database development and information on local and regional climate changes, including the information on extreme climate phenomena and natural hazards, vulnerability of certain areas, which would be used in spatial and urban planning;
- Introduction and appliance of new measures for preserving and protection of water resources in the context of evaluation of climate change effects and adjustment to changed conditions;
- Application of conventions, standards, good practice and experience of the EU regarding inclusion of climate factors into the spatial development planning process;
- Adjustment of cross-sectoral coordination, governmental institutions and local community participation in raising awareness about necessity to include climate change issues into the sector strategy.

Storm-water is being treated only indirectly within the Spatial Development Plan of Serbia. Its value as a resource is recognized in the ecological sense, while in the social and esthetic sense, its potential is yet to be fully discovered. As it is stated in the Spatial Development Plan of Serbia, one of the conceptions of water resources is related to the fact that all the water resource systems should be adjusted optimally to ecological, social and other surroundings (Ministry of Environment, Mining and Spatial Planning & the National Agency for Spatial Planning, 2011). This is the subject planners and designers in Serbia should be dealing with in the future.

Serbia started the integration of new approaches at the national level, which is the usual and necessary practice. Still, at the same time, at the local level there are a number of local initiatives which represent creative ways of fulfilling and improving process of creation of new strategies and plans. As in many other spheres of urban development, local initiative is of great importance here, and can contribute greatly to facing this challenge successfully (Bajić Brković, Sretović and Brković, 2012).

Interesting project is developed as a result of work done by a team of experts from various disciplines. It is the project for rainwater catchment system on the Kumodraž stream. It was made by Faculty of Civil Engineering, and financed by Belgrade Land Development Public Agency. It is not a part of common practice – instead, it is multidisciplinary approach to problem solving, and is regarded as a pioneering project in Serbia.

## 3. Case Study

### *Kumodraž Stream*

Kumodraž stream, with catchment area totalling approximately 8km2, is one of the few (partially) preserved small urban streams in Belgrade. This fact, together with its location within city of Belgrade, gives a great value to it, as well as an opportunity for development.

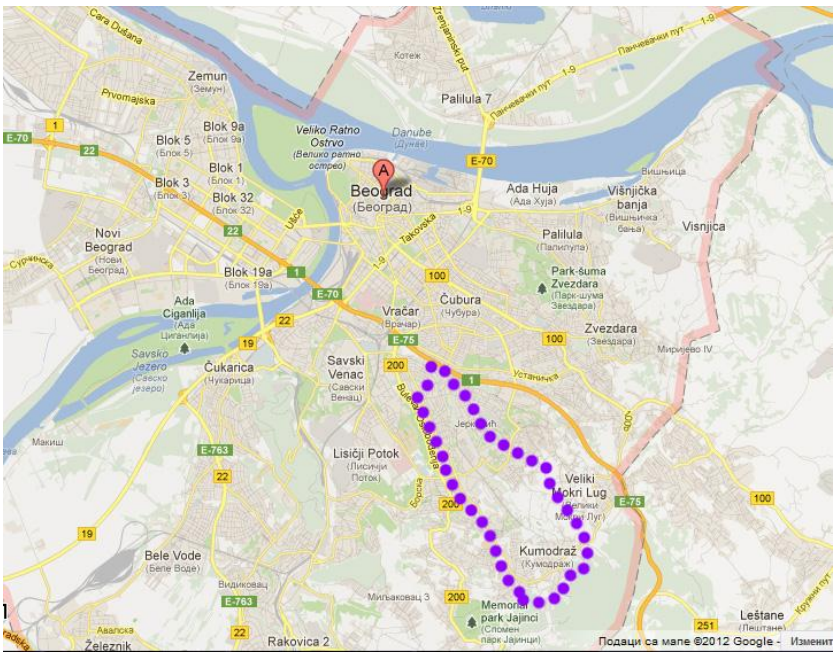


*Figure 1 - The position of Kumodraž in Belgrade (Source: Google Maps)*

The region around the middle and lower course of the Kumodraž stream is densely populated, and the area surrounding the middle course is also used for industry. The lower part is particularly densely built – over 40% of surfaces are impermeable (Despotović, 2009), which makes any significant change in the urban structure very unlikely.

The area surrounding the upper course is less populated, with wide-open spaces. This region has a great potential for development. However, whole Kumodraž stream region is comprised of unplanned settlements, and this is especially true in its upper course, where the majority of buildings are not built according to the plan (Despotović, 2009).

In accordance with past practice, the lower course of the waterway is hidden, i.e., the stream is designed as wastewater collector system – it flows through underground pipe, and the water is mixed with storm-water runoff and sewage (combined sewer system).

The upper part of the stream flows almost completely unregulated for approximately 2km, as a surface water. Unfortunately, unregulated as it is, it accepts large amounts of wastewater, water from landfills in the vicinity, livestock farms, and storm-water runoff.

### *Project Description*

The main goals of the project are:

- Disburdening the existing sewer collection system in the lower part of the stream course,
- Establishing a separate system for sanitary sewage and storm-water runoff,
- Collecting/catching urban runoff water as efficiently as possible, using special-designed storm drains on larger crossroads and steeper streets,
- Preserving stream's natural flow, streambed and riparian area in the upper course,
- Using wetland technology for water treatment, and
- Opening-up the possibility to use open green spaces in the area for recreation.

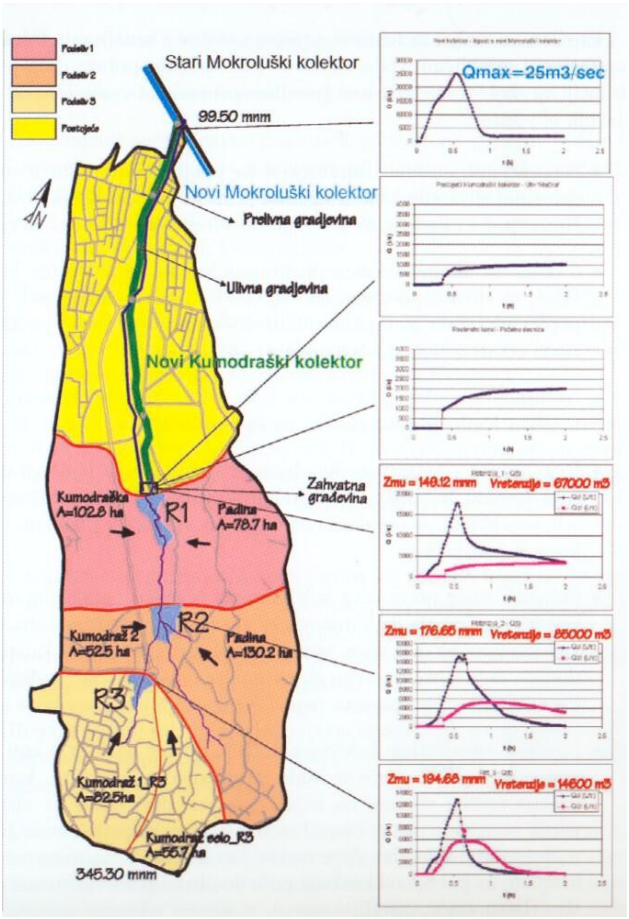


*Figure 2 - The proposed solution for the Kumodraž stream basin (Source: Despotović, 2009)*

In the lower course, the plan is to direct water in two **separate pipelines** – newly proposed storm sewer line will run parallel to the old combined sewer line, and accept the urban runoff water from the lower area of the Kumodraž stream catchment area, as well as surface water upstream that enters into it. Rainwater runoff will be treated in the oil and sediment separators before being transported through New Mikrolug main storm sewer line, and finally discharged into the Sava River. Furthermore, an additional open channel is proposed, that runs parallel to two main pipelines (storm-water and sewer) to help collecting the excess of storm-water, and prevent combined sewer overflows.

The other separate pipeline is the old main sewer line which will be left as it is, and which will continue to perform its function, i.e., to receive sewage from existing combined sewer system that is installed in the area of the lower course of the Kumodraž stream. In addition to this, it will also accept the water that overflows from the newly proposed storm sewer line, and from the new open channel. The existing pipeline is connected to the Old Mikrolug main sewer line which leads to a sewage treatment facility (Despotović, 2009).

In addition to the newly proposed storm sewer line, it is being planned for a separate system for sanitary sewage and storm-water runoff to be established in the area around middle and upper course, where no sewer system is installed at all (Kumodraž village, Kumodraž I, II and Padina).

The proposed additional infrastructure in the lower part of the stream should alleviate overburdening of the existing sewer collection system by increasing the system's capacity, improving water quality, and preventing future combined sewer overflows by separating sanitary sewage from storm-water runoff.

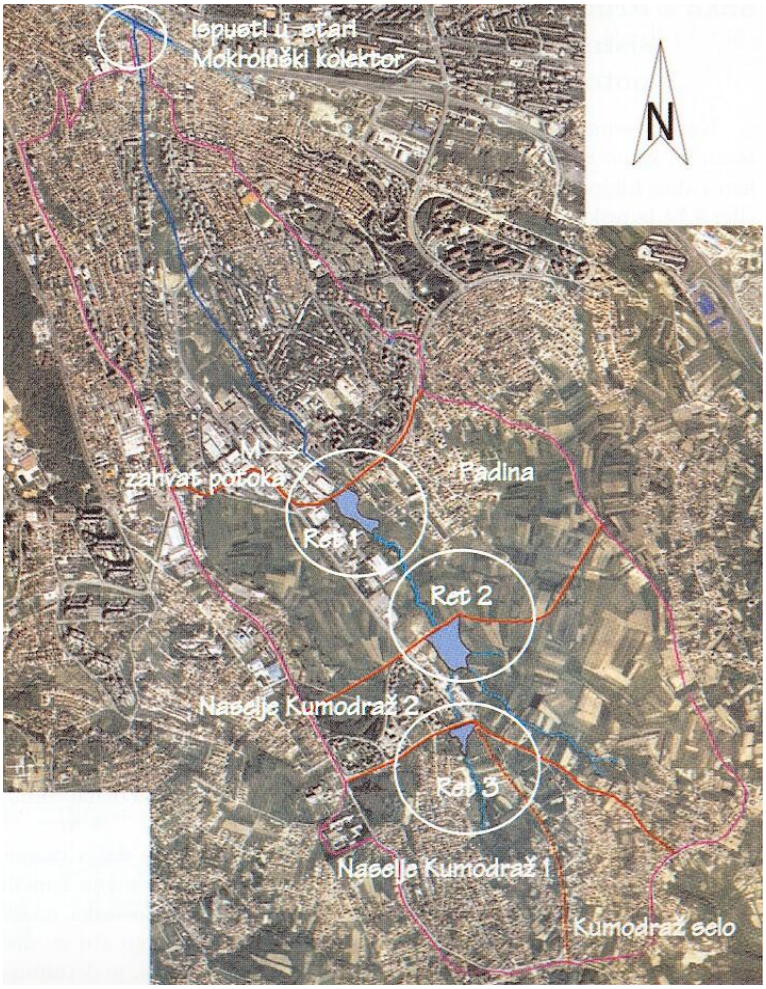


*Figure 3 - The three retention basins (Source: Despotović, 2009)*

Apart from the additional infrastructure in the lower course, the key features of the proposed solution are the **construction of three retention basins**, the **preservation of the surface flow** in the upper part of the stream, and the **use of wetland technology** for water treatment. The construction of 3 dammed surface retention basins is being planned in the upper course of the Kumodraž stream, in which the storm-water runoff will be channelled, collected and accumulated, in order to manage the discharge of the water downstream (Despotović, 2009).

The other important feature is the preservation and improvement of natural flow, streambed and riparian area in the upper course of the Kumodraž stream. In this way, the environmental qualities of the stream will be preserved, while at the same time the retention and capacity to receive water will be improved, which is especially important during heavy rainfalls. The stream will be completely preserved upstream from the 3rd retention basin, while the part between the 1st and the 3rd retention basin will be regulated to a certain extent. However, the

natural functioning of aquatic and riparian ecosystems will be mimicked and matched as closely as possible (Cvejić et al., 2002).

The project proposes construction of new wetlands, and revitalization of the existing riparian vegetation in floodplains. The three retention basins and the riparian area around the stream will feature constructed wetlands, which will be used for sediment control and water treatment using aquatic and wetland plants. This helps treating the scattered "diffuse" sources of pollution present in the area, by using natural physical, chemical, and biological processes to remove contaminants from wastewater, and protect the soil. Furthermore, the newly constructed lakes and wetlands are to be part of the city-level green and blue pathways and can be used for recreational purposes (Cvejić et al., 2002).

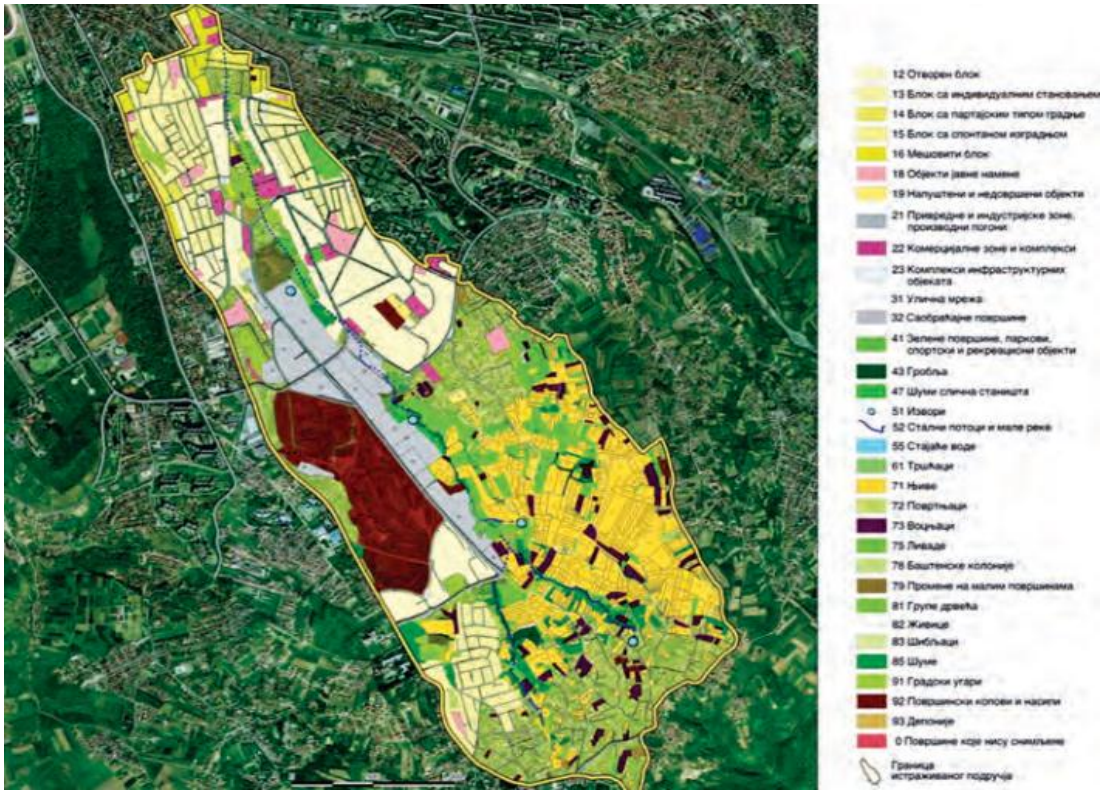


*Figure 4 – Map of biotopes in the Kumodraž stream reagion (Source: Tutundžić et al., 2010)*

## 4. Concluding Remarks

This storm-water system is integrated into urban landscape and serves the immediate surroundings and the community as for:

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|---|---|
| Environmental benefits<br>+<br>Climate change mitigation and adaptation | • Separation of rainwater and wastewater, and its treatment in bio-retentions, floodplains and wetlands, using completely natural processes<br>• Protection of the urban water quality, and soil<br>• Improvement of the natural water cycle<br>• Increase of greenery and open green spaces in the city<br>• Creation of green belts and green networks in the city (or region)<br>• Preservation of the natural water bodies, and its use to conduit storm-water runoff<br>• Preservation or improvement of the natural surroundings and environmental value of space<br>• Improvement of the urban wildlife diversity and habitat |

| | |
|---|---|
| Environmental + Social benefits | • Creation of the blue-green networks in and around the city (or region)<br>• Providing citizens with much-needed contact with nature |
| Social benefits | • Use of water, e.g. retention basins and open streams, to attracts people<br>• Creation of new green points in cities that can be used as recreational spaces and places for gathering of people<br>• Creation of new ambient values, and its use as a potential for the creation of (unique) public spaces<br>• Use of these systems and its promotion for the purpose of educating the population<br>• Raising public awareness about the importance of protecting and preserving the nature |
| Social + Economic | • Opening up the prospects for the improvement of local community<br>• Attracting citizens and potential investors by means of increasing aesthetic qualities of space |
| Economic benefits | • Defining flood zones is an important data for the urban planning and investment strategies<br>• Rising property value , i.e. retention basins are considered an amenity<br>• Use of local materials<br>• Exploitation of these systems is easy to manage<br>• Use of the existing infrastructure as efficiently as possible, and building-up on it in order to overcome its limitations |

In addition to the positive, negative effects are also possible, and they occur after the implementation and mostly depend on whether local population is well-informed and its culturological position. It sometimes happens that open storm-water systems, along with bioretention systems and preserved natural water streams are not accepted by local community because of its natural appearance which differs from well-ordered coastal and green areas, to which citizens are accustomed. Furthermore, a problem with mosquitoes is recorded, especially in the areas rich in water. For that reason, citizens and investors are sometimes not ready to accept such solutions. Moreover, since the systems are being based on plants, they are often very unpredictable and demand well-organized monitoring and maintenance. That is why their planning and designing should be done with much caution.

### *Sustainable Stormwater System and Urban Planning*

The project for rainwater catchment system on the Kumodraž stream represents the result of individual initiative, and is done by the experts coming from different fields who, through multidisciplinary approach, offered an alternative solution, unusual for the practice in Serbia. According to that experience, and for the reason of preventing problems which can follow the implementation, recommendations for planning these systems in Serbia can be defined:

- Water resources strategies and strategies related to climate changes should be integrated into urban plans. Planners have to be aware of the necessity of planning the green-blue network which includes several different systems, ranging from the ones occupying large areas – e.g. retention basins, to the ones at the street scale, such as swales, and their spatial requests and the manner in which they are connected.
- It should be pointed out that the key level for realization of such projects is the local level, since that is where the problems and changes are concentrated. Based on the experience of good international practice, these projects are most often initiated in local communities, and only later do they become parts of regulations and provisions, which is completely opposite from hierarchical organization of plans and the usual way of thinking in Serbia.

- These systems are complex and they ask for participation of experts from different fields, and they need to be part of the integrated planning process.
- The process of planning needs to be transparent, and with goals which are clearly defined in the very beginning and which can be changed during the process because of the unpredictability of live systems. Monitoring and maintenance must be agreed upon in the phase in which goals are being defined.
- Public participation – i.e. participation of local community and interested parties in all the phases of planning – is mandatory, in order to avoid the problems of acceptance of these new systems and in order to adjust to culturological positions and local conditions.

### *Sustainable Stormwater Systems and Urban Design*

If the sustainable stormwater systems are planned, designed and maintained in a proper way, they can create a new identity and character of a city and can enhance the integrity of the landscape. In some cases they can become the driving force of the urban development.

Position of the Kumodraž stream and the location of its basin have the spatial potential for public space development at the city level. In the esthetical and functional sense, it should be designed as:

- **Space which promotes safety:** creating spaces safe for children and adults, with as easy approach to all facilities as possible; using shallow pools and different ways of slowing the water movement; pathways should be marked clearly.
- **Lively and dynamic public spaces:** dynamic flow of the storm-water, its occurrence and inlet, creation of waterfalls; developing different sounds of water which is flowing and hitting different materials; biodiversity makes the space more interesting; creating system entrances attractive.
- **Enrich the existing:** good quality integration into the existing structure, using the existing materials; using small, abandoned, undeveloped spaces and including them into the blue-green network.
- **Educative space:** clear marking, spaces envisioned for education; storm-water path tracking, visible systems for storm-water treatment; creating gathering centers.

### *Conclusion*

This example is a positive trend in the field of using stormwater as an amenity in the urban landscape in Serbia and it shows that it has the potential to be widely utilized. Also, this project is fully compatible with the demands of climate change and can solve the problems related to the sewer system and floods. This is the pioneer project in the responsible climate design in the area of the storm-water management. Generally speaking, this case can become a positive practice at many sites in Serbia.

## 5. References

Bajić Brković, M., Sretović, V. and Brković, M. (2012) "Low Carbon Urban Development in Serbia: Challenges and Opportunities at the Local Level", *Facta Universitatis, Series: Architecture and Civil Engineering*.

Cvejić, J., Despotović, J., Obratov-Petković, D. and Tutundžić, A. (2002) "Kompatibilnost alternativnih rešenja regulacije poplavnih voda i revitalizacija malih gradskih vodotoka", in Zlatanović-Tomašević, V. and Božović, B. (ed.) *Inženjerski rizik i hazard u urbanom sistemu Beograda*, Beograd: Udruženje inženjera Beograda i Skupština grada Beograda.

Despotović, J. (2009) *Kanalisanje kišnih voda*, Beograd: Građevinski fakultet Univerziteta u Beogradu.

Despotović, J. et al. (1998/99) *Idejni projekat odvodnih kišnih i upotrebljenih voda sa sliva Kumodraškog potoka*, Beograd: Građevinski fakultet Univerziteta u Beogradu.

European Parliament (2000) *Water Framework Direktive*, 23 Oct, [Online], Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2000:327:0001:0072:EN:PDF [1 Apr 2012].

Ministry of Agriculture,Trade, Forestry and Water Management (2010) *Zakon o vodama*, 7 May, [Online], Available at: http://www.mpt.gov.rs/postavljen/123/893-10.pdf [1 Jul 2012].

Ministry of Environment, Mining and Spatial Planning & the National Agency for Spatial Planning (2011) *Prostorni Plan republike Srbije 2010-2014-2020 (Spatial Development Plan 2010-2020)*, Belgrade: Službeni Glasnik Republike Srbije.

Srbijavode, P.W.M.C. (2006-2008) *EU Okvirna direktiva o vodama*, [Online], Available at: http://www.srbijavode.rs/voda-bez-granica-eu-okvirna-direktiva.htm [28 Jun 2012].

Tutundžić, A., Cvejić, J., Obratov-Petković, D., Bjedov, I. and Teofilović, A. (2010) "Kartiranje biotopa sliva Kumodraškog potoka u Beogradu", *Bulletin of the Faculty of Forestry*, vol. 101, pp. 163-176.

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