Urban River Rehabilitation as an Integrative Part of Sustainable Urban Water Systems

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1. Introduction

It is indisputable that cities have been comprised essential place today throughout the world. By the industrial development particularly, the world is becoming increasingly urbanized. In 1900, only 160 million people, one tenth of the world's population were living in the cities. By the 2000s, more than half of the world has been living in urban areas. As Boone (2006, p.36) states, "the future of the world is urban, and the problems that cities and their environments face must therefore be addressed". While the urban population throughout the world grows, and the climate change is been lived, the effects of urbanization on water resources and rivers are increasing. The current problems with urban rivers in general are closely concerned with achieving eco-efficiency of urban water system and rivers.

Cities are playing a vital role in our societies. In difficult economic times, more than ever before, it is essential to re-invest in our cities' infrastructure and environmental improvement. After being neglected for decades, since the second half of the 20th century, with more attention given to sustainability of resources, an awareness has grown of the vital role of urban rivers as a resource for humans and a lifeline for cities. As a result of the problems associated with urban rivers cannot be isolated from the water system; a new approach was developed for the last decades, one that is integrative, taking the problem of rivers within the water system. Aiming to create sustainable cities, there is a concentration on the development of many transformation projects including urban waters.

In this regard, the paper aims to better understand the challenges on urban rivers in the meaning of its integration to urban water system. To be able to clarify the challenges, the discussion extends into the old and emerging paradigms. The discussion is supported by major practices on rivers and comparative analysis on them conducted. Evaluating Porsuk River as a case, Turkey in accordance with the contemporary context, provides a framework on the dynamics of new approaches in Turkey as a final outcome. Before it, urbanization and water as a starting point is being addressed below.

2. Urbanization and Water

Water constitutes the basic source of life and its availability in adequate quantities and qualities is necessary for people, economic production and ecosystems. The process of evaluating water-related interventions and projects is critical in the context of sustainable planning. Water resources are also under extreme pressure today in whole world. The resulting problems have given rise to the activities, which reflect the growing interest about them and their management. Besides, water is significant for economic and socio-cultural reasons as well as a scarce natural resource.

In every period of history, water affects the creation of cities and it is affected by urbanization as well. Rivers, streams, creeks and brooks as kinds or flowing freshwater courses, have a long-standing relationship to urbanization since the ancient civilizations. Settlements have at the water's edge such as springs, streams, rivers, and lakes. The availability of sufficient clean water determines whether lands can be used for many purposes. As Adler (2007) states, waterfront areas have been among the first lands to be developed, because proximity to water was useful for navigation, irrigation, industry, defense etc. Girardet (2004) stated as well, via being close to these areas, people could draw water easily. In other words, industry, agriculture, and residential development cannot occur without adequate supplies of water (Goodman, 1984, p.136).

Early civilizations extending from Egypt to India had settled along the rivers. After those, Helens, Romans, Byzantine, Asia Minor, and Islamic cultures respectively had developed several advanced civilizations in which the water is a crucial part of their culture. Modern cities keep on the interdependency of urban areas and rivers, while generating new scopes and adding challenges. Urban areas with the process of industrialization have become the cores of attraction. Yet, a fast-growing proportion of cities have been breeding many problems as well. One of the effects of urbanization is altering water cycle and causes various environment impacts.

As it is seen, rivers have been standing as the lifeline of cities, however past practices after industrialism we have polluted them, and covered them up. They became marginalized waterscapes from the urban life. As an example, the scenes as river water quality deterioration and emerging bad-smelling rivers have been seen in developed cities such as London and Boston after the industrial revolution about a hundred years ago. Between 1860 and 1960, London's River Thames was become having a sewer status. As the city's main sewage-treatment facilities were improved, the tideway has been cleaned up broadly (National Geographic website, Urban Fishing, 2010). Since the second part of the last century, for healthy, ecological, physical, etc. reasons, urban rivers have been started to rehabilitate. In recent decades, with more attention to sustainability and quality of life, there is a greater understanding of the vital role of urban rivers and riverfronts.

The most water-related problems in cities are basically; water pollution caused by industrial, domestic and agricultural reasons, urban runoff, floods etc. Water pollution can be traditional (point-source) way such as industrial and domestic based or nontraditional (non-point source) way such as agricultural and runoff based. The conversion of landscapes from pervious to impervious surface's (buildings, roads, and parking lots) reduces the infiltration rates and increases the runoff rates. Urban runoff picks up a variety of pollutants such as atmospheric dust, asphalt automotive discharges, metals, bird/animal fasces etc.) (Xiao et al, 2006). And discharge it to urban rivers. Besides those, floods, stream enlargement, higher stream velocities, increased sediment load, and decreased ability to support aquatic life occurs as other main effects of urbanization on streams (Center for Watershed Protection, 2010). Challenges beyond the rehabilitating physical conditions of streams have being experienced on the rivers and riverfronts recently.

Restoring urban rivers and riverfronts in a broader sense and integrated way gain importance within an increased focus on sustainable practices. The last 20 years, it is seen as burning several paradigms or movements those are related to sustainable living in urban areas. In these circumstances, considering urban rivers and urban water system were affected by the new approaches such as eco-efficient practices. In the following section, relevant concepts and definitions are given before evaluating recent best practices.

3. Relevant Concepts and Definitions

In connection with the discussion mentioned in the previous section, urban rivers have been subject to rehabilitation. Rehabilitation projects on urban rivers can aim at reduction of negative conditions, reduction of their harmful effects on the environment, increase of sanitation, improvement of their use in provision of clean water to the residential areas, building of an efficient waste water system, and creation of reserve water areas etc. At this point, it is wise to clarify definitions and concepts relevant to the treatment types of *urban rivers*.

Some of the most commonly used concepts in literature in the subject area of upgrading treatment types of running waters are *rehabilitation* and *restoration*. The literal meaning of *restoration* is bringing back to life, of something that has faded with age or been damaged, and the process of putting something, such as a piece of art or a building, back into its original condition ("Restoration (1)", 2010). At this point, definition is turning into a former position, rank; restitution for loss, damage; a putting or bringing back into a former, normal, or unimpaired state or condition ("Restoration (2)", 2010). *Rehabilitation* means to restore to a former state (as of efficiency, good management, or solvency) or to restore or bring to a condition of health or useful and constructive activity ("Rehabilitation", n.d.).

The main difference between restoration and rehabilitation is that the aim is to return the object to its original condition in restoration while this is not the case for rehabilitation. Still, it is interesting to note that in environmental and ecological literature, these concepts are used interchangeably. In architecture and art, restoration is more often used in case of singular buildings while rehabilitation encompasses an aerial scale.

In case of *river restoration,* the process aims to return the water to its original condition including all aspects like water quality, morphology, organic life, riverbed, and the like. It also entails improving the degraded points, and this is a near impossible achievement. River restoration activities may range from a simple removal of an unpleasant condition, which constrains natural stream function (e.g. repairing a damaged culvert), to stabilization of stream banks and to installation of *stormwater management* facilities, such as riparian zone restoration and constructed wetlands ("Stream Restoration", 2010). There are many types of practices such as dam removal, levee breaching, modified flow control, vegetative methods for riverbank erosion control, channel reconstruction (Shields et al, 2003).

"*River rehabilitation* is the return of a degraded stream ecosystem to a close approximation of its remaining natural potential" (Shields et al, 2003, p.575). That is, by alterations, additions or deductions, implementation of new technology and engineering practices, the main characteristic features of the river including its historical, cultural, and functional values and features may be returned to its natural state in rehabilitation. Most of the literature on *river rehabilitation* involves straightening and deepening of rivers. For example, over the 90% of streams in lowland countries of Europe has been channelized. Rehabilitation works appear to take place at two scales: small and huge projects. The largest planned rehabilitation projects in Europe have taken place on the Rhine River, the Danube River. The major evidence of success of these massive projects, which cost many billions of dollars, has been the return of salmonid fish to the streams (Rutherfurd et al, 1998).

The term *stream restoration* is used in US commonly; in UK the term *river reclamation* is used instead of stream restoration. This term describes a set of activities that help to improve the environmental health of a river or stream. Improving health is indicated by expanded habitat and reduced stream bank erosion. Enhancements also include improved water quality via techniques such as reduction of pollutant levels, and achieving a self-sustaining flow regime in the stream system that does not require periodic human intervention, such construction of flood control structures ("Stream Restoration", 2010).

Kondolf et al (1991, p.39) state that "the success of *stream restoration* will depend upon development of a multifaceted management plan to include floodplain regulation, stormwater management from urban areas, and control of sediment input from urbanizing areas. Lacking such a plan, channel restoration efforts are likely to fail". At this point, a review of some terms is needed. "*Stream restoration* differs from 'river engineering', a term which typically refers to alteration of a water body for a non-environmental benefit such as navigation, flood control or water supply diversion; and 'waterway restoration', a term used in the United Kingdom describing alterations to a canal or river to improve navigability and related recreational amenities." ("Stream Restoration", 2010).

River restoration and river rehabilitation (and stream as well) are the concepts that are not sharply separated from each other in practice. In the literature, even in the same article, these two concepts may be used instead of each other. These two concepts have one thing in common; both are geared toward improving the ecosystem of the damaged river or stream. Shields (2003) expresses the parallel view; according to him, stream rehabilitation and stream restoration express the same thing. By the way, while considering their origins, some differences are noticed:

"Restoration is directed towards recreating the pristine physical, chemical and biological state of rivers. In its purest sense, it means a full structural and functional return to a pre-disturbance state. Renaturalisation or naturalisation describes the naturalistic way of bringing (river-) ecosystem back to a natural state but without targeting the really pristine, pre-disturbance state. Rehabilitation indicates a process, which can be defined as the partial functional and/or structural return to a former or pre-degradation condition of rivers, or putting them back to good working order. It is dedicated to the ecologic state (biological, hydromorphological and physico-chemical) by structural and partly non-structural measures" (Schanze et al., 2004 cited as Saraiva et al, 2008, p.931).

In cities, according to pattern and density of the urban part, the rehabilitation techniques should be implemented in different ways. "In less densely developed locations where riverbanks are not lined by buildings, the river might be restored to a more attractive meandering geometry through the application of fluvial geomorphology principles" (Fleming, 2009, p.191). This approach results in a more stable river whose waters move more slowly, and it also creates a more attractive environment for people and its habitat (Fleming, 2009).

It may be asserted that rehabilitation is a more contemporary approach to creation of a new, healthy ecosystem sustaining the basic riparian characteristics of the river through 'repair'. By the statements above, the prefix 're' for repairing rivers are seen in the frame of cleaning the water and decreasing the impairments around a river in general. The success of traditional rehabilitation is generally measured by whether or not the river is able to sustain its achieved health level, by its own natural activities without necessitating interference by humans. In this study, the term rehabilitation has been adopted as it more effectively expresses the kind of upgrading currently implemented. Yet, the recent implementations have tended to broaden their treatments. Below, the changing aspects of *urban river rehabilitation* are discussed.

4. Urban River Rehabilitation, Changing Aspects and the Best Practices

With the rapid urbanization of 1950s and 1960s particularly in developing countries, the first intervention to rivers in cities was to *prevent floods*. Floods have taken place since ancient times, so preventing techniques such as planting of vegetation, terracing to slow down landslides, building of channels to divert the river have been used ever since. The traditional approach emphasized *enlargement and straightening of the river* and building of high banks. Straightened concrete channels have been used to achieve flood control. However, this approach did not prove very effective in controlling floods as certain failures were experienced, such as in San Lorenzo River. In some cases, designers of channelization projects have overestimated or underestimated roughness by ignoring the effects of sediment. Consequently, the traditional implementations thereby have appeared to control flood, but they may fail to perform properly (Kondolf et al, 1991).

Increasing pollution with increasing population especially in developing countries in face of inadequate infrastructure raised public awareness of water borne epidemics. One artificial remedy was *isolation of rivers from public* as water quality of urban rivers became poorer in time owing to ineffective environmental measures. “A foul, stinking stream is hardly an amenity, so isolating such waters in underground conduits was no doubt seen as a positive step” (Kondolf et al, 1991, p.36) within traditional approach. However, as with the deficiencies of traditional implications and through increased environmental awareness, improving the water quality and *daylighting* of these buried channels have become a focal point for efforts to restore districts (Kondolf et al, 1991).

Through mid-20th century, most rivers were in natural condition with a few artificial structures. Rivers and streams were seen as sources of floods and sewer paths. Rehabilitation of urban rivers was taken up almost universally after the second half of the 20th century in particular. In 1970s, river management mainly focused on flood control (channelization) and water use. Thus, they lost environmental functions, ecological habitat, self-purification and riparian scenery. At those times, the approach was technical in nature and concentrated on the river itself, including measures like the widening and structuring of riverbed, structuring of banks, creating and/or connecting side channels, reconnecting backwaters, restructuring of longitudinal connectivity by removing barriers that cause habitat fragmentation for organic life and the like. The basic aim was to transform the river back into its natural state.

In early 1980s, floodplains of streams were occupied by parking lots, roads, farmlands and recreation areas etc. In the late 1980s, social needs emerged for *improvement of river environment* (water quality and aesthetics). To this end, walkways, cycling roads and green parks were created along certain sections of the river and rehabilitation was confined to the river and its immediate environment. Since 1990s, *ecological river improvement* techniques have been used (Kim, 2006). Main targets of river restoration changed from water quality of 1950s and 1960s, to enforcement of 1970s, to landscape and amenities of 1980s, to nature and ecosystem of 1990s, and finally to improvement of relationship between river and human of 2000s (Wada, 2010). Table 3.1 below summarizes this transition of river rehabilitation practices in time.

Period	**Transition of River Rehabilitation Practice**
Before 1850s	*Natural Stream* Most rivers were in natural condition.
1860s-1960s	*Sewer status stream* A few artificial structures existed.
1970s	*Flood Prevention Stream* River management mainly focused on the flood control (channelization). Rivers lost environmental functions, such as providing an ecological habitat, self-purification, and riparian scenery.
1980s	*Park Stream* Parks along urban streams were constructed. Most parks were constructed on the floodplains.
1990s	*Ecological river improvement* techniques have been employed to enhance the environmental function of the stream.
2000s	*The relationship between river and human,* nature and community improved.

Source: Adapted from Kim, 2006; and Wada, 2010

Table 1 Transition of River Rehabilitation Practice in Time

It has already been argued earlier in the study that traditional urban river rehabilitation involved technical measures in general. These measures were not only technical but also were limited to the problem zones, and some of them even can have negative impacts on the river habitat. The assertion at this point is that all these measures should be combined by other considerations, which are related to the city as an urban ecosystem. While the new approach has come into prominence with the late 1990s and the 2000s, it was indicated in the former section that the paradigms have been transformed. The table below expresses the transition urban water system has gone through.

The Old Paradigm	The Emerging Paradigm
Wastewater is a nuisance. It should be disposed of after treatment	***Wastewater is a resource***. It should be captured and processed effectively. It should be used to nourish land and crops.
Stormwater is useless. Stormwater should be conveyed away from urban area as rapidly as possible.	***Stormwater is a resource***. It should be utilized as a water supply. It should be infiltrated or retained to support aquifers, waterways and vegetation.
Demand is a matter of quantity. Amount of water required or produced by different end-users is the only parameter relevant to infrastructure choices. Treat all supply side water potable quality, and collect all wastewater for treatment.	***Demand is multi-faceted***. Infrastructure choice should match the varying characteristics of water required or produced for different end-users in terms of quantity, quality, level of reliability, etc.
One use (throughput). Water follows one-way path from supply, to a single use, to treatment and disposal to the environment.	***Reuse and reclamation***. Water can be used many times, by cascading from higher to lower quality needs. It should be subjected to reclamation treatment for return to the supply side of infrastructure.
Drainage oriented. Rapid conveyance of stormwater from premises by underground concrete pipes or culverts, curb and gutter street drainage	***Storage oriented***. Keep, store, reuse and infiltrate rainwater on site or locally, extensive use of rain gardens, drainage mostly on surface
Gray infrastructure. Infrastructure is made of concrete, metal or plastic.	***Green infrastructure***. Infrastructure includes not only pipes and treatment plants, made of concrete, metal and plastic, but also soils and vegetation, such as greenroofs.
Bigger / centralized is better for collection system and treatment plants.	***Small / decentralized is possible***, often desirable for collection system and treatment plants.
Limit complexity and employ ***standard solutions***. Small number of technologies by urban water professionals defines water infrastructure.	Allow ***diverse solutions***. Decision makers are multidisciplinary. Allow new management strategies and techniques.
Integration by accident. Water supply, wastewater and stormwater may be managed by the same agency as a matter of historical happenstance. Physically, however, three systems are separated.	***Physical and institutional integration by design***. Linkages must be made between water supply, wastewater and stormwater, which requires highly coordinated management.
Collaboration means public relations. Approach other agencies and public when approval or pre-chosen solution is required.	***Collaboration means engagement***. Enlist other agencies and public in search for effective solutions.
Community expectation of water quality. Distorted by hard infrastructure and past abuses such as buried urban streams, fenced off streams converted to flood conveyance and/or effluent dominated	***Daylighting and/or renaturalization*** of water bodies with ecotones (parks) connecting them with the built areas enhances the value of surrounding neighborhoods and brings enjoyment
Low resilience to extreme events.	***Surface drainage with bioswales or***

Underground stormwater conveyance can handle only smaller storms, infiltration is low or nil, fast conveyance results in large peak flows	***bioretention.*** In addition to storage and infiltration, increases dramatically resilience of the watersheds to handle extreme flows and provide water during the times of shortages.

Source: Adapted from Mitchell, 2006; and Novotny, 2010

Table 2 Characteristics of 'Old' and 'Emerging' Paradigms of Urban Water Systems

Classic urban water cycle includes surface waters, groundwater, rainfall, precipitation, evaporation, transpiration, pervious surfaces (as the components of natural hydrologic water cycle); and stream flow, water supply, surface runoff, storm drainage, storm sewers, wastewater etc. "The current model of urban water systems, and their corresponding infrastructure, originates from the 19th century and are questionable from the perspective of cost effectiveness, performance and sustainability. It is generally recognized that there is a need for change in the way we manage urban water; and cities are now faced with difficult future strategic decisions" (Vairavamoorthy, 2009, p.3).

Now, rivers and streams in cities are not seen as urban infrastructure elements; they are now becoming important themes for the rehabilitation of nature ("Urban Fishing", 2010). There are lots of urban river rehabilitation programs and projects around the world such as London Rivers Action Plan, Emscherumbau Plan, The Blue Network, The Zurich Stream Daylighting Program, Restoration of Besòs River, Funan River's Comprehensive Revitalization Project, Singapore River Planning, and Porsuk River Rehabilitation. Table 3 demonstrates these practices that contain urban water system as a substantial component.

Project Name, City, and Year	Descriptions of Rehabilitation Projects
London Rivers Action Plan - London, UK- Since 2002 (target year: 2015)	The plan aims to restore *Thames* tributaries of 15 kilometers of to their natural state, creating a more sustainable city, as well as reducing the flood risk and improving the environment for all. River Thames itself is already considered today one of the world's cleanest metropolitan tideways. Once a biologically dead river, in 2010 it won the world's biggest environmental prize.
Emscherumbau Plan - Emscher, Germany- Since 1990	The mining history of the Emscher region shapes the urban character of the Emscher basin in the Ruhr valley. The '*Emscherumbau Plan'* has been in force since 1990 and advocates the rehabilitation of all water bodies within the Emscher catchment basin, aiming at a sustainable use of water and providing for the future needs of the region.
The Blue Network, Brussels, Belgium	The program aims at the restoration of several urban river courses in the Central Brussels Region. The program is aimed at restoring hydrological, ecological, visual and recreational functions of the river corridors.
The Zurich Stream Daylighting Program, Zurich, Switzerland - 1988	A clean-water concept for separating of uncontaminated water from sewage channels was extended into a stream restoration concept. The goal was to 'daylight' as many streams as possible, realigning them on the surface so as to increase ecological and recreational values within the urban area of the *city of Zurich*.
Restoration of Besòs River - Barcelona, Spain - 1999	*Besòs River* is a torrential river flowing through the urban area of *Barcelona*. It has been named the most contaminated river in Europe during the 1970s and 1980s. Since the mid-1990s, however, the river has been in the process of recovery. The design of a meandering low flow channel within the floodway is dealt with. Constructed wetlands to improve water quality were planned for the floodplain on both sides of this channel.
Funan River's Comprehensive Revitalization Project - Chengdu, China -	The biggest venture of the project is The Living Water Garden, a 5,9 acre (about 2,4 ha) park on *Funan River*. The river passes through the center of *Chengdu*, a city of nine million. The Park workings started in 1996 and finished in 1998. since the park opened, it has become the most popular park in the whole city. In the park there are pumps, settling ponds, reconstructed wetlands, natural

1996	water purification system, various plant species, steps going down to the river to provide public access, and various sculptures as public arts to raise awareness of the pollution in the Funan River. Received funding 20 million US dollars for 6 km of the river path from European Community in 1996.
Singapore River Planning, Singapore, Singapore -Beginning of 1990s	Once the lifeline of the nation, the river was the economic artery of *Singapore* where pioneers lived and worked together. Starting in the 1880s, there was heavy traffic on the *Singapore River* due to rapid urbanization and expanding trade. By late of 1970s, the government was starting to take action to clean up the river. Key points of 1990s' restoration are water purification, and river development unified with the city. After purification, land value was raised, fish returned to river, some catchments were opened to the public for boating and swimming. The 2nd theme covers that waterfront is a key for high-quality of life: sand beaches have been created in riverbeds, paved walking trails have been prepared on the both side of Singapore River, old shops and warehouses have been repaired into restaurants and cafes.
Porsuk River Rehabilitation - Eskişehir, Turkey - 2001	*Eskişehir's Porsuk River*, which passes through downtown area, was restored in 2001 the Eskişehir Metropolitan Municipality under a package project. Eskişehir Urban Development Project has 3 phases: preventing flooding damage with restructuring riverbed, renewing canals and urban water system infrastructure, improving a tramway system. These main objectives were reinforced by creating parks and walking ways nearby the river, renewing old bridges and building new bridges on the river, setting up designs for boats and gondolas within 10 kilometers on the river, attaching river with major urban parks and with an artificial beach. Porsuk now attracts attention from some Turkish cities and even from abroad. Renewing water system infrastructure involves renewing the wastewater treatment plant, renewing clean water treatment facility, reinforcing drainpipes and water supply pipes.

Sources: Conradin, 2004; EBB, 2010; "London Rivers Action Plan", n.d.; "London Rivers Are to Be Restored", 2009; Martín-Vide, 2001; Park, n.d.; "Restoration of Singapore River", n.d.; Schanze et al., 2004; Stein, 2009; Yuen, n.d.

Table 3 Some Major Urban Rivers and Rehabilitation Efforts on Them That Contain Urban Water System

In addition to the cities above, Malmö (Sweden) is also a good example to water-centric eco-efficient cities. One of the greenest cities in Europe, Malmö, is highly related to tackling with high-level water and stormwater management. Stormwater management was great problem in Malmö. In addition to anticipating climate change, the sewage system was old and had no enough capacity for growing population. Canals are part of the rainwater collection system in neighborhoods. Almost all buildings have renewable energy. In Malmö, "The trend […] is to replace traditional planning procedures with a more integrated structure to city planning with water, green structure, and waste plans, developed alongside the masterplan" (Eran, 2001, p.163). As considering the institutional framework of the project, the municipality plays a significant role, and the project was conducted as a comprehensive package project.

As it is shown in best practices around the world, several experiences claim that river rehabilitation can be the correct approach to face the increasingly threat of flood hazards, together with nature conservation, recreation, water quality, etc. River rehabilitation proves to be not only desirable, but even economically rewarding, despite the efforts it may require in terms of changing land-use patterns (EEA, 2010). The following section addresses a best practice in detail from Turkey.

5. The Rehabilitation of Porsuk River, Turkey

Porsuk River is flowing through the city of Eskişehir in the region of Central Anatolia in Turkey. Until the end of the 1960s, inhabitants of Eskişehir fished, had fun on the shores, and learned to swim in the Porsuk River. However, later it transformed into an open sewer owing to discharged industrial and household waste. Starting from the late 1960s, the Porsuk River became a veritable open sewage and dumpsite due to industrial and domestic wastes, and connection leaks in urban sewage and rainwater lines. The stream, running through the city, also caused ground liquefaction-related hazards for the basis of surrounding buildings as a result of water leaks. The fact that some parts of its bed were filled by the former municipality administrations for creating parks, posed an overflow risk for the city (EBB, 2010). EGM has played an important role in planning and implementation of the restoration efforts on Porsuk River.

Figure 1 A View from Porsuk River in the City Centre
Source: Produced by the Author

For the rehabilitation of the Porsuk River which was reported to be one of the most polluted waters of Europe in 2002 by the Organization for Security and Cooperation in Europe, a large scale project was prepared and incorporated into the EGM (Eskişehir Greater Municipality) *Urban Development Project* of Eskişehir city (EBB, 2010). EGM concluded a loan agreement by applying to the European Investment Bank in 2001 with a package project titled 'Urban Development Project'. The components of the project are as follows: Component 1: *Tram project*, Component 2: *A project for reducing the damages of disaster*, and Component 3: *The renewal of rainwater, drinking water and sewage lines* of Eskişehir Water and Sewage Administration (EWSA) and the establishment of domestic waste treatment plants (Bilgili, interview, 2010).

Eskişehir's Porsuk River was restored in 2001 with credit from the European Investment Bank (EIB). In order to prevent flooding damage and pollution, the Eskişehir Metropolitan Municipality spent $50 million of the $250 million credit from the European Investment Bank to restructure the riverbed (Yüzbaşıoğlu, 2009). The EIB has been granting loans for individual projects since its foundation. The Urban Development Project of Eskişehir is a package project. It was first in 2001 that EIB granted a loan for a package project (Bilgili, interview, 2010).

The objectives of Component 2 are (1) *the establishment of overflow section*, (2) *the construction of 24 vehicle and pedestrian bridges* over the Porsuk, and (3) *The renewal of irrigation channels.* The reinforcement of bridges is of essential importance in order to avoid interruptions in the transportation flow at the time of an earthquake. Before the project, *the* *irrigation channels* had lost their water carrying capacities, the bottom had been loamy and the groundwater liquefaction had caused problems. Also, the urban area had been facing with water leakage induced problems. The irrigation channels gained certain section and underwent landscaping works (Bilgili, interview, 2010).

The discharge points for sewage and rainwater in the city seemed untended, unaesthetic and dirty. Therefore, all the lines within the Porsuk River were closed and sewage and rainwater systems were re-constructed. Rainwater tunnels were built on both the left and right side of Porsuk River. To sum up, the works performed by the municipality in Eskişehir for Porsuk River regarding to the water system involves;

- start of the construction of new wastewater treatment plant,
- revision of the city's domestic water supply system,
- re-construction of rainwater system throughout the city,
- construction of rainwater tunnels on both the left and right side of the river,
- overflow protection (space was created on both sides of the river for flooding),
- establishment of green areas without filling the river,
- pavement of water tunnels,
- construction of a dam for domestic water supply,
- clearance of a distance of 9,5 kilometers covered with mud.

6. Findings and Conclusion

Rivers have a dual nature of impact on human settlements in time with increasing population, urban growth and careless use of water. The discussion in this study is centered on the changing aspects of urban river rehabilitation through time. Most common measures in history were taken to control floods, and several technical applications were realized like planting of vegetation, building channels, dikes, dams and ponds etc. In view of the complexity and close interrelation of the problems, it was obvious that they could not be handled singularly and merely with structural upgrading techniques. It is no longer sufficient to attempt to preserve natural and manmade environmental element degradations and problems in the traditional manner. So, in recent years, the transition has been living while handling the problems related to rivers such as having more space for urban water system within the solutions.

Urban rivers provide various sources ranges from supplying potable water to enhancing economic and social life of the city, as well advancing the quality of life. As it is indicated in the paper, recent river rehabilitation efforts carried out offer many aspects while reaching eco-efficient namely here water-efficient urbanization. Today, creating a different picture we want to live for the urban areas is the challenge that we face with urban rivers. The discussion is supported by best practices of some major urban rivers and rehabilitation efforts on them conducted in the context of new understanding of rehabilitation. It is observed that local governments have a significant role to implement such projects. And the projects are most of the time directed at more than one fields and conducted as a package project. Urban river rehabilitation practices help make cities having efficient urban systems.

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