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Urban River Landscapes

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<http://dx.doi.org/10.5772/56156>

1. Introduction

The importance of urban rivers have always been recognized [1-6] for water resources, protection of nature, fisheries and recreation in view of their considerable contributions to landscape [3, 7]. In addition, rivers have certain definite environmental, social, cultural and economic values, as well. They are used by humans on a wide variety of purposes such as drinking water, irrigation, industry, power production, transportation, flood control, fishing, boating, swimming and aesthetic enjoyment [8].

Rivers have many functions like providing connection between landscapes and communities and they also gather people around the same idea for a creative and sustainable environment. People from all parts of society should and also private and public stakeholders should be included in the development of river management plan in order to find effective solutions for the use of natural resources [8].

There is an apparent interaction between cultural level of societies and the use of water in all fields [9]. Many cities in the world have been established along the river banks [6, 9-10]. For instance, many civilizations settled along the Euphrates- the Tigris Rivers in Mesopotamia, the Nile in Egypt, the Ganges in India, the Indus in Pakistan and the Huang-Ho in China throughout the history [11]. The current examples of cities include the Thames in London, the Seine in Paris, the Tiber in Rome, the Vltava in Prague, the Danube in Budapest [12-13], the Hudson in New York, the Yarra in Melbourne [6] and Turkish cities as the Seyhan in Adana, the Yeşilırmak in Amasya, the Asi in Antakya, the Tigris in Diyarbakır, the Meriç in Edirne, the Porsuk in Eskişehir and the Bartın River in Bartın [9].

On the other hand, besides their advantages, this kind of settlement also has some disadvantages. Floodplains are susceptible to dangers of flooding in relation with the human and natural activities. Loss of life and property and damages to wildlife habitats can be cited among the risks caused by civilization on water sides [10]. Past uses of rivers and social tendencies are effective on the present condition of rivers. Despite the unsatisfactory

conditions of water sources in many parts, the increasing efficacy of sewage treatment systems provides new opportunities for inhabitants and improvement of rivers in morphological and economic sense. For attaining a normal level of life quality along river banks, necessary consideration and importance should be given to flood control systems and water quality in urban areas. In this regard, there is an increasing concern in the world over rivers in urban areas in terms of green spaces, urban ecology and life quality [14]. The major part of works conducted on urban rivers has been carried out in North America (mainly the USA), Asia (mainly China) and Europe (mainly western Europe) [6].

In this chapter, the main emphasis has put on the understanding of floodplain resources, principles for an ecologically sound riverfront design, baselines of urban water rehabilitation and some samples of urban river landscape throughout the world. In line with the obtained results, certain recommendations have been made for planning of urban river landscapes in Turkey.

2. Floodplain resources

2.1. Understanding floodplain resources

In this section, floodplain natural resources are introduced with an explanation of floodplains, watersheds, ecosystems and natural communities.

A typical river corridor has several features brought by geological and hydrological processes effective on landscapes (Figure 1). The **river channel** wanders through the landscape, carving through the terrain and depositing sediment on places where it goes. Sediment deposits and depressions on water banks might form **wetlands**, which are always or periodically flooded with water [10].

Floodplains are the areas bordering rivers and streams. These parts in river valleys are frequently defined as areas where the likelihood of flooding is high in a given year. Therefore, the term of "100-year" flood is used to define the flood with 1% of occurrence possibility in any given year (Similar definitions can be expanded to include 25-or 50-year floods). As a river goes downward in an area, it may leave **terraces**, formed in time as the river flows at higher elevations. These landforms are part of a larger river corridor and play an extremely important role in the functioning of floodplain ecosystems [10].

Floods are natural outcomes of river ecology. Therefore, it is important to be ready for floods. The job of flood experts is focused on determining the size of floods in statistical terms to present the frequency of water flow that passes through a stream channel in a certain period of time. The frequency of floods is calculated as the time between the same or greater levels of floods. For instance, a 10-year flood is used to represent the event of flood occurring about every 10 years. Based on this calculation, there is a 1-in-10 change of occurrence for a 10-year flood. Historical data is considered in calculation of flood frequencies such as 10-year flood, 25-year flood and 100-year flood. From this regard, there is a 1-percent chance of occurrence for a 100-year flood event for any given year, and

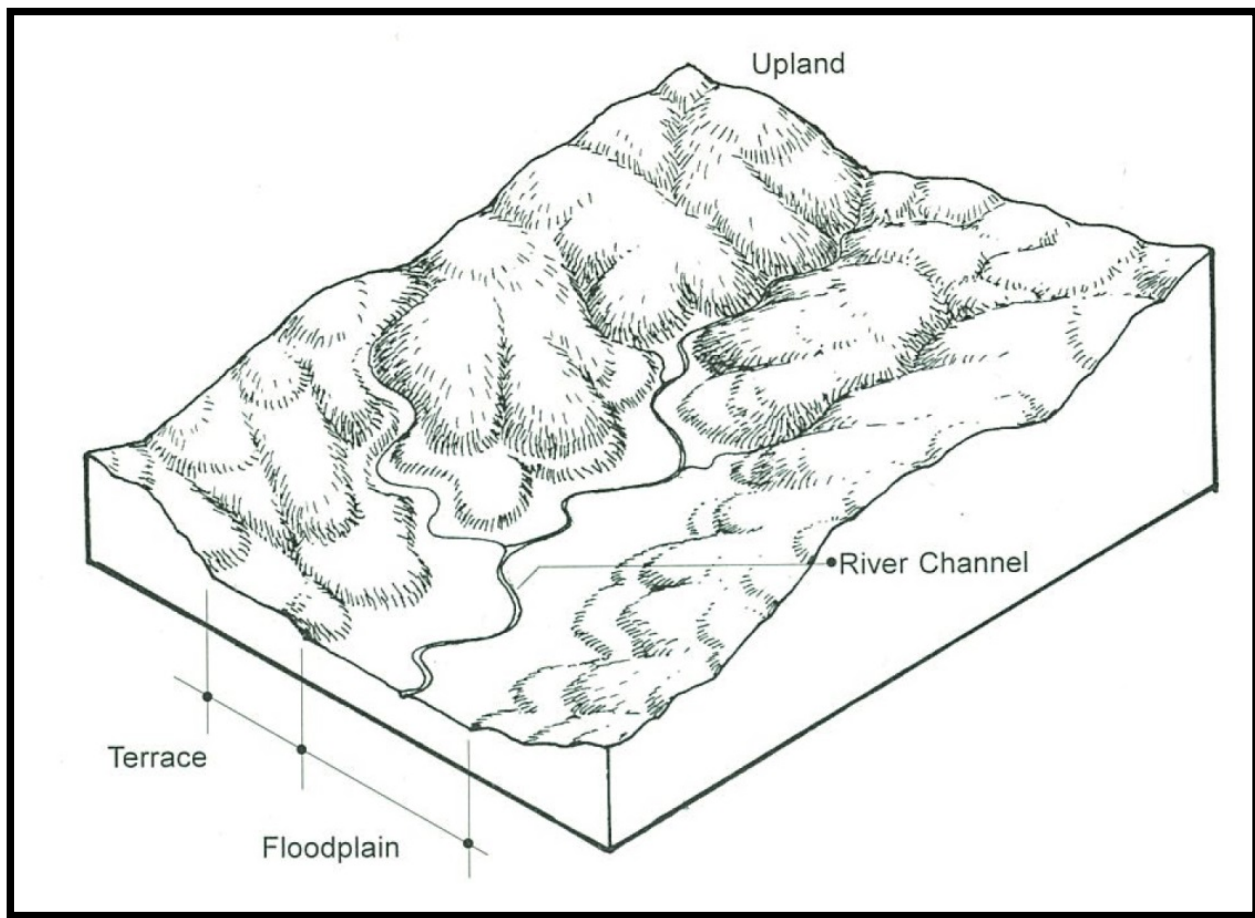


Figure 1. Major physiographic elements of a typical floodplain [10].

similarly, there is a 5-percent chance of occurrence for a 20-year flood event. Many factors including the years of high rainfall and changes in land use are effective for the frequency of these flood events [8], (Figure 2).

The definition of 100-year floodplain is considered as the basis in the U.S. National Flood Insurance Program. The boundaries of this zone are drawn by associating the discharge data and flow elevations to the topography of the stream valley. In this program, two main zones are defined: the first of which is **floodway**, lowest part in floodplain where flood flows deepest and most frequently; and the second of which is **floodway fringe**, an area on the margin of regulatory floodway and less frequently and lightly flooded in 100-year flood. Settlements along regulatory floodway are not found qualified for flood insurance; on the other hand, settlements on floodway fringe are qualified for insurance if a certain amount of flood proofing is established (Figure 3) [15].

A developed landscape is confined to the river channel or wider flood-channel. Buildings and roads are flooded in the event of a 10-year or 100-year flood, which is not a pleasant situation for users and residents, but their inconvenience should be compared with other considerations. The preventive efforts for flood events are quite costly from both financial and environmental considerations, and it is also possible that these events will worsen the downstream flood problems [16].

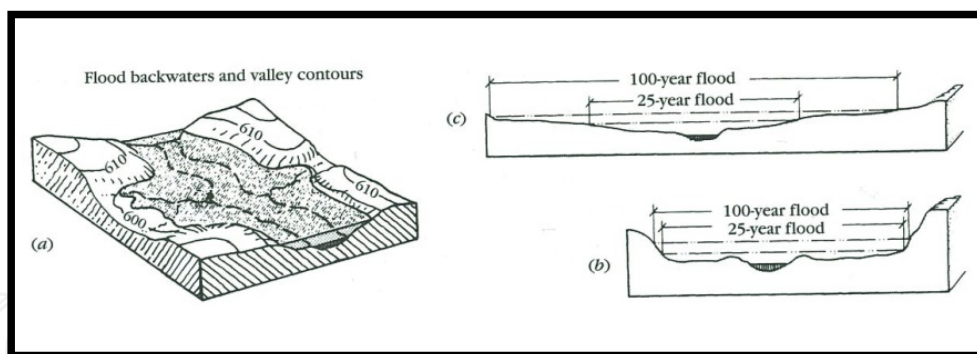


Figure 2. Flood backwaters in relation to valley contours. (b) The influence of valley shape on the extent of the 25-year and 100-year floods [15].

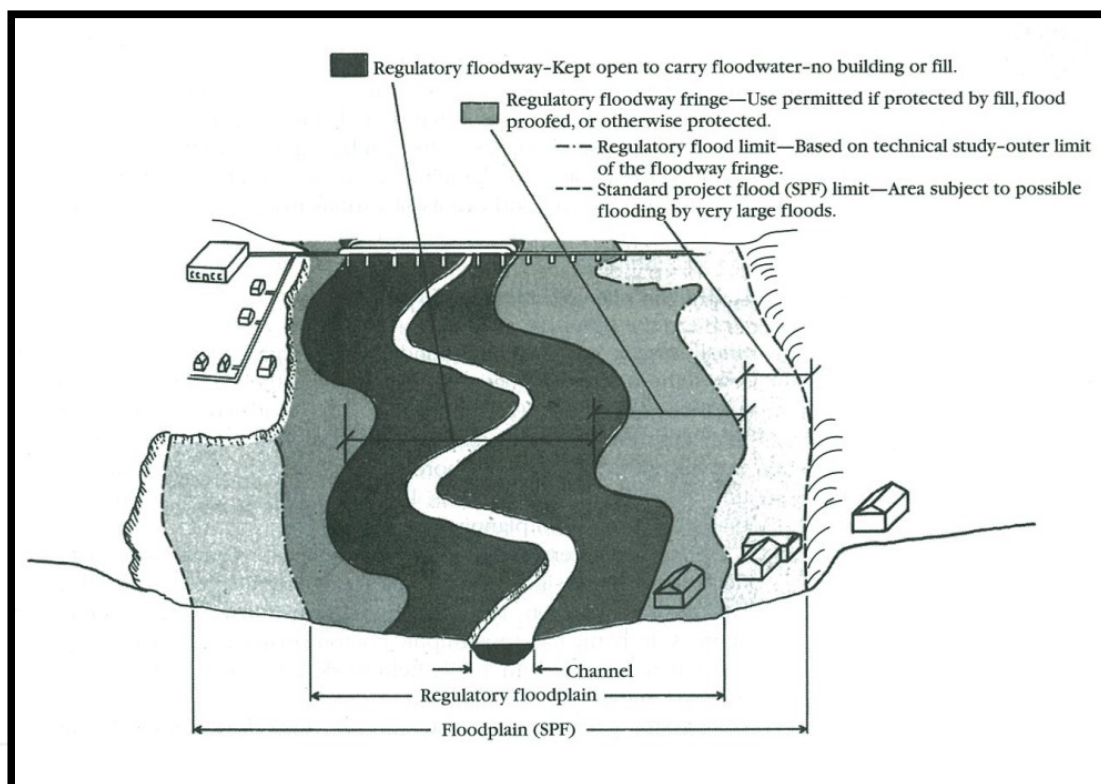


Figure 3. Presentation of the regulator floodway and floodway fringe by U.S. National Flood Insurance Program [15].

As a solution, management of flood events can be integrated into the land-use planning system. The present and recommended contours for each flood event can be drawn for each town:

- Half-year: natural reserves, playgrounds, gardens;
- One-year: needless car parks, light traffic roads, flood-tolerant buildings.
- 25-year: many roads and car-parks, the ground floors of needless buildings.
- 100-year: large urban areas, excluding hospitals or other essential services [16]. The effective areas of river form the overflow boundary, which was evaluated considering the following studies in the literature on landscape planning: [2, 4, 8, 10, 15-21].

Watersheds: Watersheds have an important place in understanding and managing the resources in floodplains. **Watershed** is an area drained by a river and its tributaries. Different watersheds are separated with ridges or divides. Similar to floodplains, they are formed in time with the effects of various climatic, hydrological and geological processes. On the other hand, watershed differs from floodplain with its much larger size, and therefore, it can be more difficult to manage because larger areas are usually covered by various municipalities that have different governments and land-use strategies. However, it should be understood that upstream uses of land and water in a watershed have negative effects on downstream areas and bring along the potential for increased flooding [10] (see Figure 4).

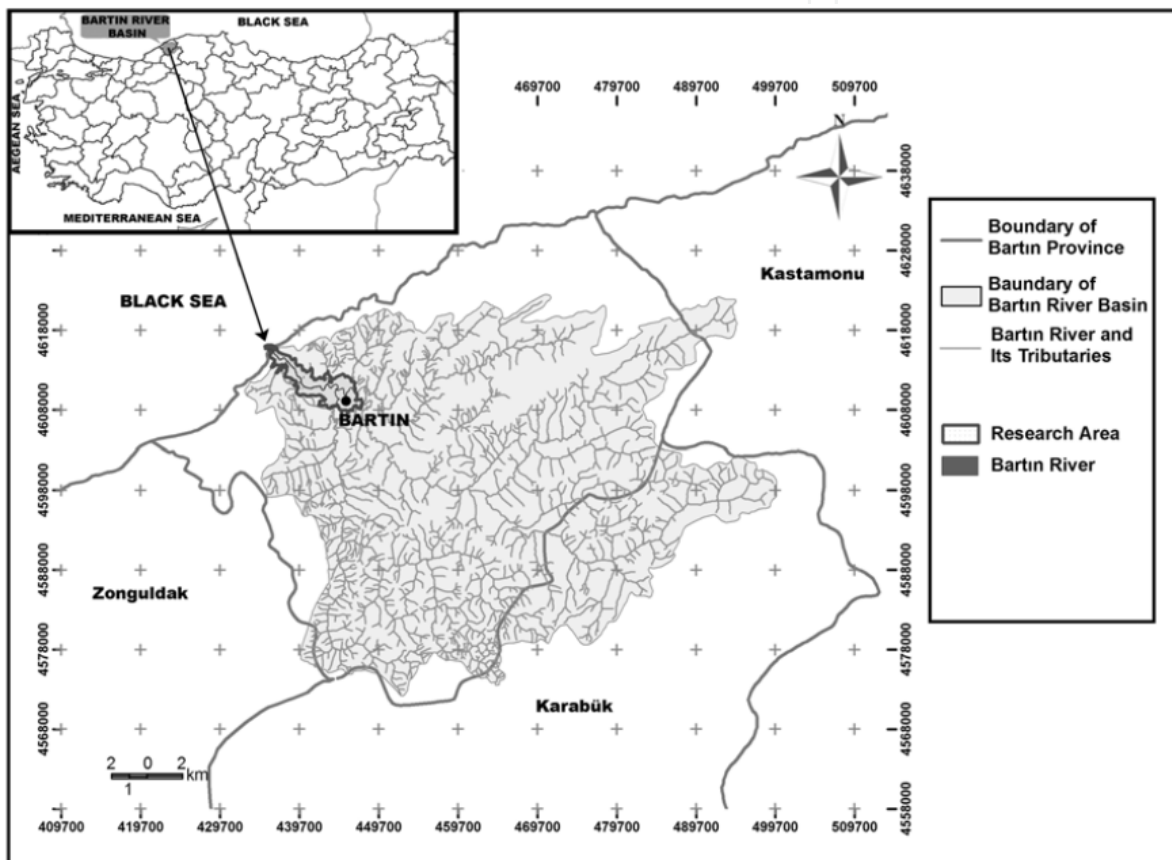


Figure 4. The Bartin River Watershed and stream orders [4, 9, 22].

Natural Resources and Ecosystems: Not only the hydrological features of landscape but also the geological characteristics have an important role in determining the type of vegetation in the area. There are a number of plant species grown in floodplains and adapted to the specific conditions of soil types and water flow cycles, which are the characteristics of river corridors. In turn, vegetation becomes important to determine how water flows in land and it is an indispensable factor in the management of erosion and sediment deposits that can alter the appearance of the landscape [10].

The living and non-living components of natural floodplains are interrelated with each other and create a dynamic system where one helps another to maintain the properties of

the environment to sustain them in a mutually supportive cycle. These interrelated systems forming both commercial and recreational sides of physical and biological worlds are known as **ecosystems**. These components of floodplain ecosystem work together in storing and conveying floodwaters, protecting water quality, preventing erosion and sustaining rich habitats of fish and wildlife. The recognition of these relations among hydrological, geological and biological characteristics of these systems, one can comprehend how changing one character can significantly change an entire system [10].

Natural Communities: There can be many different **ecological communities**, groups of plant and animal species existing together in a certain area along the floodplain and its adjacent landforms. Various types of plant species in an ecological community might need the same type of soil or level of soil moisture available only in a particular area in the floodplain. Wet meadows, bottomland hardwood forests, and riparian shrub wetlands can be cited among the examples of such communities. Landform, soil and plant types present in a certain part of floodplain can identify the boundaries of these ecological communities [10].

2.2. Natural resources and functions of floodplain

The three main categories of floodplain resources and functions include water resources, biological resources and societal resources (Table 1) [10].

2.3. Multiple uses of floodplain

Different levels of settlement development and disturbance to natural systems have various effects on natural resources. For instance, the management objectives can be different for an already fully developed floodplain community than a community with large open spaces [10].

There are four main levels with corresponding considerations [10].

- **Urban Areas:** The floodplain in an urban community is probably highly developed already. Restoration of natural areas and the relocation of structures particularly threatened by flood hazards are included in the management options for these areas.
- **Suburban Areas/Urban Fringe:** Urban fringe areas are frequently threatened by great development pressures, but there might be enough open spaces to work with. Effective planning is of critical importance in these communities, and a special focus can be put on maintaining existing open areas along waterways and restoration of vegetation.
- **Rural Areas:** Agricultural communities have different concerns of floodplain. The large open spaces in the floodplain of these areas are an advantage. In these areas, management strategies should focus on controlling erosion and excessive nutrient loadings, as well as vegetation of stream banks to restore natural ecosystem functions.
- **Wild-lands:** The natural system in these communities with very low-density development and much more open spaces should already be functioning. In these areas, there is the opportunity to safeguard floodplain functions at the outset and to maintain valuable habitats and superior water quality.

| | | |
|-----------------------------|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Water Resources | Natural Flood and Erosion Control | <ul style="list-style-type: none"> - Provide flood storage and conveyance - Reduce flood velocities - Reduce peak floods - Reduce sedimentation |
| | Water Quality Maintenance | <ul style="list-style-type: none"> - Filter nutrients and impurities from runoff - Process organic wastes - Moderate temperature fluctuations |
| | Groundwater Recharge | <ul style="list-style-type: none"> - Improve infiltration and aquifer recharge - Reduce the frequency and duration of low surface flows |
| Biological Resources | Biological Productivity | <ul style="list-style-type: none"> - Support high rate of plant growth - Maintain biodiversity - Sustain the integrity of ecosystems |
| | Fish and Wildlife Habitats | <ul style="list-style-type: none"> - Provide breeding and feeding grounds - Create and improve waterfowl habitat - Protect habitats of rare and endangered species |
| Social Resources | Harvests of Wild and Cultivated Products | <ul style="list-style-type: none"> - Improve agricultural lands - Provide sites for aquaculture - Restore and improve forest lands |
| | Recreational Opportunities | <ul style="list-style-type: none"> - Provide areas for active and passive usage - Provide open spaces - Provide aesthetic pleasure |
| | Areas for Scientific Study and Outdoor Education | <ul style="list-style-type: none"> - Support cultural resources (historical and archeological sites) - Provide opportunities for environmental and other studies |

*Adopted from: A Unified Program for Floodplain Management, 1994.

Table 1. Natural resources and functions of floodplain [10].

3. Principles for an ecologically sound riverfront design

The following three main parts in this section demonstrate concrete examples of principles in planning and design (Table 2) [21].

| GENERAL PRINCIPLES | |
|-----------------------------|-----------------------------------------------------------------------------------|
| General Principle 1: | Ecological targets and economic development targets should be mutually beneficial |
| General Principle 2: | Protect and restore the characteristics and functions of natural rivers |
| General Principle 3: | Regenerate the riverfront as a human realm |
| General Principle 4: | Compromises are necessary to achieve multiple objectives |
| General Principle 5: | Obtain broad participation in the process of planning and designing riverfront |

| PLANNING PRINCIPLES | |
|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Planning Principle 1: | Demonstrate characteristics of the city’s unique relationship with the river in the riverfront design |
| Planning Principle 2: | Know the river ecosystem and plan for a scale larger than the riverfront |
| Planning Principle 3: | Because rivers are dynamic, minimize new floodplain development |
| Planning Principle 4: | Provide public access, connections, and recreational opportunities |
| Planning Principle 5: | Celebrate the river’s environmental and cultural history through public education programs, riverfront signage and events |
| DESIGN PRINCIPLES | |
| Design Principle 1: | Protect features and functions of natural river |
| Design Principle 2: | Buffer sensitive natural areas |
| Design Principle 3: | Restore riparian and in-stream habitats |
| Design Principle 4: | Use nonstructural alternatives to manage water resources |
| Design Principle 5: | Reduce hardscapes |
| Design Principle 6: | Manage stormwater on site and use nonstructural approaches |
| Design Principle 7: | Balance recreational and public access targets with river protection |
| Design Principle 8: | Incorporate information about a river’s natural resources and cultural history into the design of riverfront features, public art, and interpretive signs |

Table 2. Principles for an ecologically sound riverfront design [21].

3.1. General principles for an ecologically sound riverfront design

Five general principles set the stage for the success of planning [21].

3.1.1. Ecological goals and economic development targets should be mutually beneficial

Public and private developments build a sense of connection and stewardship for the river by attracting people to the waterfront live, eat, shop, relax, recreate, and participate in cultural events.

Healthy and functioning river systems are appealing and attractive to residents and businesses. A society engaged in enjoying riverfront features and activities also cares about the long-term sustainability of river systems. Communities have started to understand the appeal of a more natural riverfront for residents and visitors. Apart from touristic advantages, there are some other benefits as well, including cost-effective flood control, improved water quality, reduced infrastructure costs and increased property values and tax base.

3.1.2. Protect and restore the characteristics and functions of natural rivers

Rivers provide their regions with some natural benefits of critical importance and therefore that must be protected. Natural characteristics of river like meanders, backwaters, wetlands, and gradually sloped banks have important ecological functions. There are also benefits for inhabitant such as cleaner water and flood storage. It might not be possible to restore these features in many urban areas, but even a little effort can bring about a positive effect. Environmental improvements can be achieved on even the most heavily impacted rivers.

3.1.3. Regenerate the riverfront as a human realm

There could be some obstacles including physical, political, social and economic barriers for a riverfront project to overcome and increase public use and enjoyment of these public resources. There have been many successful projects designed to include spaces that specially accommodate parks, walkways, docks, and special events such as concerts and festivals. In a good riverfront design, the need of all neighborhoods, ages, and cultures in the community should be taken into account. Community members should be enabled to experience the river closely. In turn, these physical and visual experiences will help creating lively and diverse places to encourage a sense of community and an appreciation for nature.

3.1.4. Compromises are necessary to achieve multiple objectives

Sometimes, there could be competing interests in urban waterfronts. Recreational trails and wetlands are often linked to waterfront condos and port facilities. It cannot be always possible to give special focus on economic development and environmental concerns on urban river banks. On account of the present structures, only a few cities can really achieve to create a fully natural river environment. On the other hand, a development project of riverfront to enhance economic livelihood of a city should not rule out natural features, compound riverfront damage, or limit public access. Communities of a riverfront should take advantage of integrating and balancing ecological, social and economic concerns, as well.

3.1.5. Obtain broad participation in the process of planning and designing riverfront

The design and planning processes of riverfront should obtain the participation of a wide variety of community members. The process should be extended beyond the identification of traditional stakeholders groups and include the neighborhoods that might not have used the riverfront in the past. There can be different needs of various neighborhoods and constituencies. Riverfront can be designed more lively, inclusive, and successful if these different priorities are taken into account. The participation of local officials, developers, and planning staff in public meetings should be acquired to ensure that everyone aims for the same vision, and that all important thoughts are known.

3.2. Planning principles

Some important aspects such as regional development patterns, natural and cultural history, flood control, public access, recreation and education should be taken into account in planning the revitalization of a riverfront. The five principles below must be incorporated into master plans and conducted by zoning and building codes, engineering standards and site plans and designs [21].

3.2.1. Demonstrate characteristics of the city's unique relationship to the river in the riverfront design

Any river city has a unique relation and a nested history with its river. There should a special feel and appearance of riverfronts that is directly associated with the history of city and inspires and celebrates city's character.

It should be known by inhabitants that the river in their city grants the identity of their region and also provides wildlife habitat, recreation, drinking water and jobs in their area. Once these values are appreciated by inhabitants, they become supporters for protecting and restoring their riverfronts.

3.2.2. Know the river ecosystem and plan for a scale larger than the riverfront

Planners must regard riverfront development from the aspects of the natural structures of river, which includes:

- Characteristics of the watershed (the land area drained by a river and its tributaries);
- The floodplain and the river channel with the structure of its bed and banks;
- Hydrology (water flows and timing);
- Water chemistry, and
- The biological needs of wildlife, such as insects, fish, amphibians, reptiles, birds, and mammals.

Another important point is to understand how the structure of a river has been altered and how it might change in the future. Rivers are affected by any events occurring in their watersheds and riverfront activity, in turn, they affect areas beyond the edge of river. Planners should not disregard the possible effects of design and activities of riverfront on all areas of the watershed.

3.2.3. Because rivers are dynamic, minimize new floodplain development

Rivers are in a constant change by their nature. For instance, spring flood elevations might exceed nonflood levels by 30 cm or more on some rivers and some rivers freeze in winter, while some others show little seasonal change. These natural variations can be considerably affected by the changes in upstream and the surrounding watershed, often causing

disastrous results. Extreme flooding events, often intensified by settlement developments in floodplain, are among the most destructive natural disasters.

Undeveloped and connected floodplains are of crucial importance for river health. Future developments on riverfront like trails and parks should be designed to minimize floodplain intrusions. From this regard, structures and facilities must be designed to ensure that there will be no release of contaminants during flooding, no decrease in flood storage capacity, and no flooding or other downstream impacts.

There should be no large permanent structure built in 100-year floodplain as they increase the size of resistant surface, aggravate runoff problems, and increase the risk of costly flooding damages.

3.2.4. Provide public access, connections, and recreational opportunities

Easy access is necessary to attract people to a riverfront. Another important point is visual connection to the river from nearby commercial and residential areas. Physical and visual access should not be confined only to the selected neighborhoods or businesses along the redeveloped river. Riverfronts might offer many recreational usages, like bicycling and bird watching. Riverfront communities should be provided with areas or facilities offering a large variety of usage possibilities.

Whether it is through wading, fishing, launching a boat, or sitting on the riverfront, people should be given opportunities to touch and interact with the river in appropriate locations. Economic revitalization projects on riverfronts like new developments of mixed-usage with housing, restaurants or cafes and open spaces become more successful when visual and physical access to the water is included.

3.2.5. Celebrate the river's environmental and cultural history through public education programs, riverfront signage, and events

Riverfronts have a rich human and natural history. Informative and path-finding systems can define the river, its environment and how river and city history are connected. Certain activities like educational and cultural programs, performances and public art events can be organized to attract people to the riverfront.

Ecological education is especially meaningful along urban rivers because most of the original forms of ecosystems have been damaged. Rivers can be used as a powerful tool in science and nature education thanks to their active and visually rich environments. Raising awareness of public about rivers and their natural systems will provide a sense of stewardship and connection to the history of rivers.

3.3. Design principles

Eight general principles set the stage for design success [21].

3.3.1. *Protect natural river features and functions*

The water flow and sediment supply are controlled by natural equilibrium in stable streams and rivers. However, dams and flood control systems have dramatically changed the structure of many urban rivers. Protection of natural river features and functions necessitates avoiding the use of new dams and other engineering solutions, such as a straightening, channelizing, or placing streams in underground pipes and culverts.

It might be possible to fully restore the ecological features and functions in most urban rivers and streams. However, there are many other opportunities for communities to protect the critical areas to provide a more natural riverfront. There are surprisingly rich and extensive predevelopment features in many urban rivers, including forested banks, fish and bird habitat, and wetlands. Preservation of these properties of natural watershed can also be cost saving.

3.3.2. *Buffer sensitive natural areas*

Buffer zones are areas situated next to a shoreline, wetland, or stream where development is restricted or prohibited. They facilitate the protection of ecological integrity of rivers, enhance connections between wildlife habitats, and allow rivers to function more naturally. A buffer network serves as “right-of-way” for a river or stream and it is an indispensable part of the stream ecosystem. Various sizes of buffers help protecting the natural areas close to rivers and streams, and especially fragile zone like steep slopes and wetlands.

They also reduce the impermeability of an area and filter sediments and storm-water pollutants like fertilizers and pesticides. They act like a filter and reduce the cost of water treatment systems by preventing pollutants from entering in the sources of potable water. Through the protection of open spaces along the river as buffer zones, storm-water and flood control can be achieved in a cost-effective way. Buffers also play an important role in reducing the risk of erosion caused by uncontrolled runoff and stabilize riverbanks with vegetation.

A well designed buffer zone helps protecting the quality of water and habitats for plant and wildlife. Buffers also provide shadow areas which decrease the temperature of water and thus protect aquatic habitat. With trees, shrubs, grasses and other native plants, they provide cover and food for birds, mammals, and other animals along the river. There are also benefits for humans as flourishing buffers are visually appealing and can often be used as greenbelts, parks and recreation areas.

On the other hand, the traditional norm of “attractive” can be abandoned to create buffer zones beneficial to river ecosystem. There is no advantage for biodiversity in keeping manicured lawns, formal landscape designs, and pruned shrubs as they frequently require the use harmful pesticides, and do not provide the food or shelter for wildlife.

3.3.3. *Restore riparian and in-stream habitats*

The restoration of riparian habitats requires taking other actions than simply replanting indigenous plants. First of all, watershed and regional factors should be considered by planners to establish healthy hydrological cycles and acquire a good quality of water. For example, the planted buffer zones must be created and maintained, stormwater must be controlled and cleaned, and new dams and reservoirs should be avoided or removed if possible. Similarly, the good management of in-stream flows from reservoirs and dams must be provided to protect wildlife habitat.

Also, new researches can be conducted on upstream and downstream natural communities in order to identify possible restoration areas and habitat types for fish, birds, and other animals. These areas should be taken into consideration by planners especially in larger river systems. Following the improvement of water quality and habitat, it will be possible to introduce native as well as new fish species to a healthy aquatic ecosystem.

3.3.4. *Use nonstructural alternatives to manage water resources*

In the past, hard engineering approach caused many damages on water quality and wildlife habitat and also triggered many flooding events. Therefore, a recent and “softer” engineering approach has emerged to offer protection from flood as well as restoration opportunities for natural river functions.

It has acquired a wide acceptance as an alternative to hard engineering-bioengineering (also known as soft engineering)- among the departments of civil engineers and public works [19].

In this soft engineering approach, the same performance standards as hard engineering are achieved; at the same time, it is possible for bioengineering to use plants and other natural materials to simulate natural forces, and in this way, to control floods, maintain water quality, provide access to recreation, reduce erosion and create wildlife habitat.

3.3.5. *Reduce hardscapes*

Hardscapes are such places as roads, parking lots, sidewalks, driveways, paved paths, rooftops, and other impermeable surfaces that prevent rainwater from filtering through soil and replenishing rivers and stream as groundwater. Nearly half of all stream flows are provided by groundwater. This percentage can increase to a much higher level during drought periods [23].

The urban rivers are also adversely affected by these impermeable surfaces of hardscapes as they do not absorb stormwater. In fact, they result in considerable increases in the volume and velocity of rainwater runoff. Another adverse effect of paved surfaces is their contribution to pollution as they washes surface oils, fertilizers, heavy metals, bacteria, and other contaminants into river and streams.

Through the reduction of hardscapes and installation of natural landscapes, it can be possible to restore natural watershed functions, filter pollutant, and prevent erosion of

banks and channelization of streambeds. The replacement of hardscape with soft, permeable surfaces, such as native grasses, shrubs, and trees in older, industrial or abandoned riverfront areas will improve environment from both aesthetic and ecological aspects.

Planners must minimize the amount of hardscapes if they cannot be avoided. The reduction of hardscapes in new development projects can offer cost efficiency for local governments, developers, and homeowners. It is expensive to install and maintain infrastructure- roads, sidewalks, sewer liner, curbs and gutters, and parking spaces.

3.3.6. Manage stormwater on-site and use nonstructural approaches

An ecologically designed riverfront can capture, store, and infiltrate stormwater, or otherwise, naturally treat and release it. Wildlife habitats and aesthetic value can also be obtained through systems with natural process, such as wetlands and bioswales (small linear wetland planted with riparian and water-tolerant trees). These natural systems can be used to replace the old stormwater pipes and other engineered infrastructures, most of which give high volumes of untreated stormwater directly into rivers and streams.

3.3.7. Balance recreational and public access goals with river protection

Riverfront communities should be provided with facilities with as many recreational usage as possible; on the other hand, some conflicting usages should be balanced (e.g. between power boats and birdwatching platforms) and possible overuse of the river corridor should be managed.

3.3.8. Incorporate information about a river's natural resources and cultural history into the design of riverfront features, public art, and interpretive signs

Ecological interpretation and education is especially meaningful along urban rivers because most of the original forms of ecosystems have been damaged. The history and function of rivers may not be known well by the public. A conscious and well-informed society will understand the river ecology and regeneration potentials and know how to use their river safely; therefore, communities should be informed about water quality issues and hazards to swimming and boat navigation.

4. Baselines of urban water rehabilitation

It is a new approach to improve ecological functions of waters and maintain their anthropogenic use at the same time. In the past uses of waters, human usage was dominant over all other uses of water. And, this had certain effects on ecological properties and restricted the consistency with other uses. In the recent times, there have efforts on the rehabilitation of urban rivers to reverse the adverse effects on ecology including the changes in hydromorphological properties and water quality, which considerably affected the availability and biodiversity of aquatic habitat [24].

Water rehabilitation involves cultural works as well as ecological issues in urban areas, which requires the consideration of social, economic and aesthetic aspects of issue. A good balance has to be established among all targets with respect to the sustainability principles. And a special consideration should be given to ecological concerns by the requirements of the Water Framework Directive (WFD). The site-specific conditions are effective in the creation of this balance that has to be established among these diverse and often competing requirements [24].

Considering this background, there are different scopes of rehabilitation, which can be summarized as follows [24]:

- **Restoration:** Restoration is aimed at reviving the pristine physical, chemical and biological states of rivers. In its simplest form, it requires a full structural and functional recovery of a pre-disturbance state.
- **Renaturalisation or naturalisation:** Renaturalisation or naturalisation represents a natural method of recovering the natural state of a (river-) ecosystem without really aiming the pristine, predisturbance state.
- **Rehabilitation:** In rehabilitation stage, it is primarily aimed to recover the partly functional and/or structural conditions of rivers or enabling a functional condition. It is generally considered with regard to ecologic state (biological, hydromorphological and physico-chemical) through structural and partly non-structural measures.
- **Enhancement:** Like its lexical meaning, enhancement is the improvement of the present state of rivers and its surrounding areas. In this stage, it is aimed to evaluate the ecological, social, economic and aesthetic properties.

Two terms have a special importance in the URBEM (Urban River Basin Enhancement Methods) research project: one of which is the rehabilitation in its all sense including partial functional and/or structural recovery of the former or pre-degradation conditions. The other is enhancement including the social, economic and aesthetic properties in a wider viewpoint. Actually, the term of rehabilitation would apply better to the inevitable constraints of urban rivers than the term of restoration. It cannot be always possible to obtain a pristine state of rivers in towns and cities. It becomes more appropriate to use the term of enhancement when the rehabilitation of urban waters is considered in a more comprehensive way for sustainable urban development. This involves the ecological, social, economic and aesthetic multifunctionality of urban waters with their riparian areas. Ecological conditions are given a special importance in enhancement despite in contrast to the background of the WFD [24].

It is not always possible to make a distinction between the economic advantages of restoring riverfronts and the value of restoring rivers themselves. The protection of watershed and restoration of upstream could be more effective than the activities of ecological design on riverfront. On the other hand, it cannot be forgotten that the efforts of restoring riverfront could be more effective on river condition in general [21].

However, the past experiences have demonstrated that the restoration of rivers and ecologically sensitive redevelopment efforts can have the following advantages [21]:

- The improvement of water quality and cost effective cleanup and treatment of drinking water sources.
- The moderation of damages of flood and the costs of flood control systems.
- Low costs of stormwater management systems.
- Low costs of sprawl and related infrastructures.
- Reactivation of the downtown riverfront with new opportunities for housing, offices, and commercial services that attract new residents, businesses and visitors.
- Creation of new job opportunities for residents in the construction and commercial businesses.
- Provision of recreational opportunities, open spaces and park areas.
- Higher values of property and new tax revenues.
- Acquiring funds from state and federal governments, volunteers and broad financial support.

5. Case studies

5.1. Some samples of urban river landscape throughout the world

5.1.1. *The Mississippi River*

The places where Mississippi River pours in Minneapolis Minnesota State of USA and Mexican Gulf and the river course in Baton Rouge and New Orleans in Louisiana were investigated.

The views of riverfront in Minneapolis are given in Figure 5-6 below.

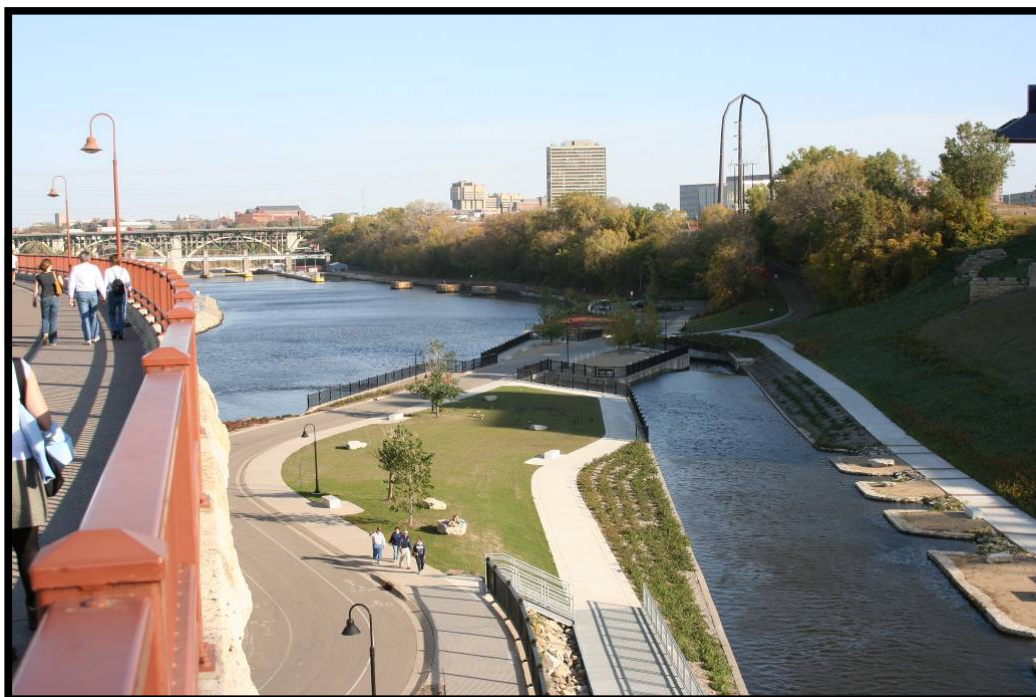


Figure 5. The view of Minneapolis Riverfront District, Minneapolis, Minnesota-USA (Original, 2006).

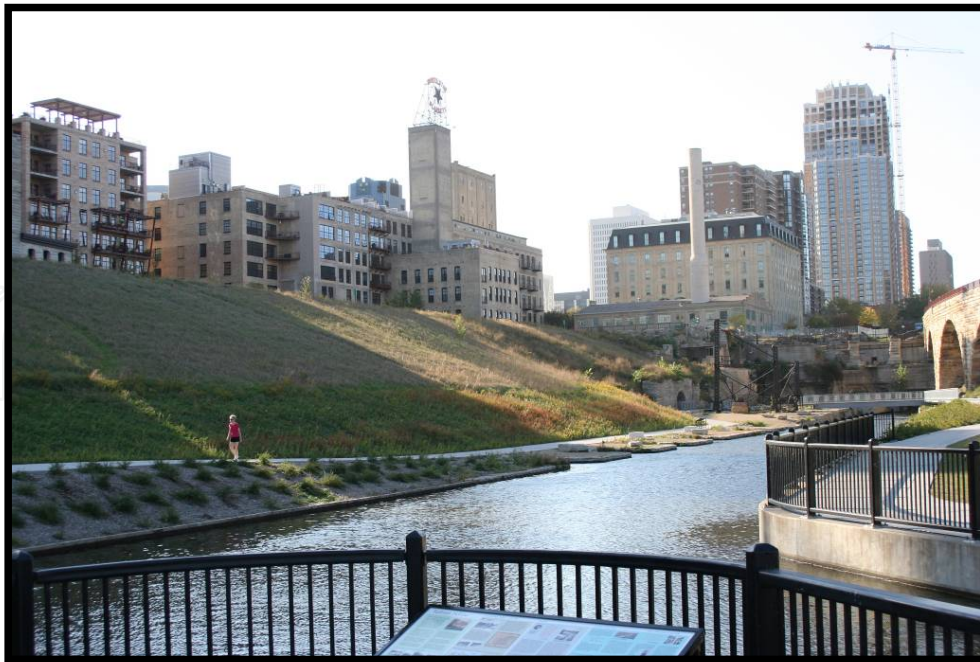


Figure 6. Minneapolis Riverfront District, Minneapolis, Minnesota-USA (Original, 2006).

The views of riverfront park areas along Mississippi River in Baton Rouge are given in Figure 7-8.



Figure 7. Park areas along Mississippi River in Baton Rouge, Louisiana-USA (Original, 2007).



Figure 8. The view of Mississippi River in Baton Rouge, Louisiana-USA (Original, 2007).

Views of fair and exhibition spaces along Mississippi in New Orleans are given in Figure 9-10.



Figure 9. Fair and exhibition spaces along Mississippi in New Orleans, Louisiana-USA (Original, 2007).



Figure 10. The view of Mississippi River in New Orleans, Louisiana-USA (Original, 2007).

5.1.2. *The San Antonio River Walk*

Streams and rivers were restored in a number of small towns and large cities to attract and improve a tourism economy [19].

The restoration of San Antonio River in San Antonio-Texas, known as San Antonio River Walk at present, has developed the tourism in the region to an extent to include the city in touristic places. The river has gained many additional downtown features such as continuous promenade following both sides of the river and shops, restaurants, and hotels facing the river. In the survey conducted on citizens of San Antonio in 1973, it was revealed that public had a strong positive response to the Project, which later even increased further to include more riverfront restoration. It was reported that almost all of the population (96.6%) believed that the restoration created a tourism attraction and an important part of population (80%) believed that the restoration provided economic advantages to the city [19].

The origin of River Walk was based on a flood prevention project developed following a devastating flood in 1921. The initial plan was aimed at locating the river in a larger underground culvert and paving the area into a street. This plan was adopted and considered to act like a channel to circumvent a downtown horseshoes bends in the river in order to avoid flooding in the area. And the bend was embellished by the Works Progress Administration (WPA) in 1939 [19]. San Antonio's riverfront is a small scale reminder of Amsterdam and shows the successful development of a very narrow water concourse into a major land-use development. Barges are available for various organizations to create a joyful entertainment atmosphere. The bridge element serves as a romantic element connecting sides of the city and creating an image, which allows the visitor to become completely involved with edges and land uses of the project [13].

With the San Antonio's River Walk, a wide variety of recreational opportunities as well as a very narrow drainage canal have been created [13], (Figure 11-12).



Figure 11. View of the San Antonio River Walk in San Antonio, Texas-USA (Original, 2007).



Figure 12. The San Antonio River Walk in San Antonio, Texas-USA (Original, 2007).

5.1.3. *The Nine Mile Creek*

The Nine Mile Creek extending from the Otisco Lake near Syracuse city north east to New York in USA to Onondaga Lake has a basin of 300 km² and 28,98 km in length. Fishery,

wetlands and riverfront forests are of special importance in the basin. The Nine Mile Creek provides an ideal habitat for trout production with its high quality of water and water temperature [25].

Wetlands play an important role in the protection of water quality of nine mile creek. At the same time, wetlands act like a tampon zone against floods. Various commissions (Save the Country Land Trust and Nine Mile Creek Conservation Council) actively work in the protection of many wetlands present along the corridor of Nine Mile Creek [25]. One of the unique characteristics of Nine Mile Creek is the forests along riverfront.

Just like wetlands in the basin, riverfront forests are also important for the protection of water quality of Nine Mile Creek. They control the erosion along the stream and provide food sources and shelter for most of the aquatic and fish species. The protection of all riverfront forests will positively affect the water flow and quality [25].

The important areas in greenway of Nine Mile Creek Corridor and their usages are as follows [25];

1. Baltimore Woods (trekking)
2. Disappearing Lake
3. Fishing lakes and park areas (fishing)
4. Martisco Station (historical site)
5. Camillus Valley Natural Park (trekking, fishing)
6. Erie Canal Park (trekking, fishing) (see Figure 13)
7. Canoeing and park areas (trekking, canoe access)
8. Camillus Forest Unique Space (trekking)
9. Onondaga Lake Wetlands (trekking)

In addition, the restoration application along stream is given in Figure 14.



Figure 13. Erie Canal Park in Syracuse, New York-USA (Original, 2006).

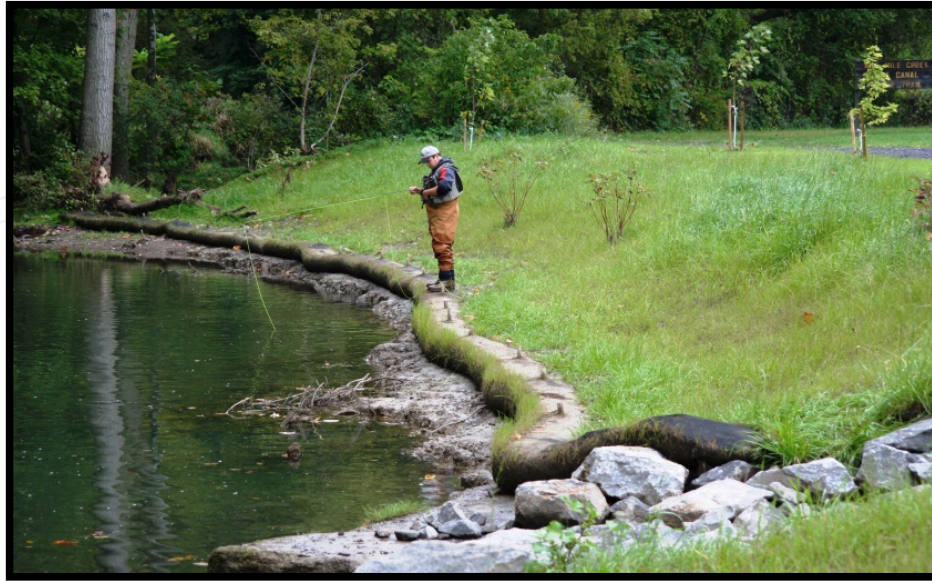


Figure 14. The Nine Mile Creek in Syracuse, New York-USA (Original, 2006).

5.1.4. *The Onondaga Creek*

The Onondaga Creek is a revitalization plan in 14.49 km length along the Syracuse city in New York, USA. This community-based revitalization plan designed for Onondaga Creek Basin provides guidance for widening social and economic opportunities along Onondaga Creek and improvement of habitat and water quality. It is aimed to obtain economic and ecological benefits as well as revitalization of the creek in Syracuse. The reduction of water quality along the creek, habitat changes and limited public access are the main problems related to the creek. Therefore, the following options can be realized to attract public attention to the Onondaga Creek again [26]:

- The efforts are still continued to increase the water quality of Onondaga Creek.
- Onondaga Creek Festivals were organized in 2004 and 2005 and there is a growing public interest.
- The construction of a walking trail from Armory Square of Syracuse City to Onondaga Creek is continued.
- Stabilization projects along riverfront reduce the sediment load in south tributaries of the creek.

It is quite important to provide functions attracting public preference with smart planning and restore the creek for a healthier environment in order to solve the environmental problems of the Onondaga Creek [26].

The views of Onondaga Creek across Syracuse City are given in the Figure 15-16.



Figure 15. The Onondaga Creek riverside park in Syracuse, New York-USA (Original, 2006).



Figure 16. The Onondaga Creek in Syracuse, New York-USA (Original, 2006).

5.1.5. The Trinity River Corridor

The Trinity River Corridor Project in Dallas City of Texas, USA is consists of flood protection, environment management, recreation, transportation and socio-economic sections. The project is investigated in 4 regions. The following recommendations were made for these 4 regions in the project [27];

1. In the region of “Dallas Floodway Extension”, construction of bank, wetland development, protection-improvement of area, restoration of river tributaries, fill area and public spaces within the boundaries of flood area,
2. For “Elm Fork Region”, walking trails, football field, green belts, improvement of underground drainage, banks, wetlands and recreational areas,
3. For “Dallas Waterway”, 2 ponds without canal connection, meandering river, water properties, wetlands, pavilion and walking trails, flood protection to create protected areas against flood water,
4. For “Great Trinity Forest”, green belt, other parks and green belts, Trinity River Corridor parks, ponds, suggested wetland connection, Elm Fork region protection study, and areas like banks etc. are suggested.

The Trinity River Corridor parks in Fort Worth-Dallas city are given in Figure 17-18.



Figure 17. The Trinity River Corridor in Fort Worth-Dallas, Texas-USA (Original, 2007).



Figure 18. The Trinity River Corridor parks in Fort Worth-Dallas, Texas-USA (Original, 2007).

5.1.6. *The River Isar*

Munich is located 80 kilometers to the north from the Alps in the Munich plain, a glacial and postglacial outwash of limestone gravel. There are only a few geomorphologic features of the plain affecting urban development except for the floodplain of the river Isar with its sequence of river banks and terraces. In spite of the homogeneous appearance of the area, it contains a wide variety of habitats reflecting the interconnected ecological conditions in the Munich plain. There are only small patches of natural woodland types which are predominantly oak and the cultural landscapes such as the once extensive grassy heathlands and fenlands in the northern Munich plain. The river Isar provides a wide green passage in south to north direction passing through the city [28] (see Figure 19).

The river Isar acts like a backbone of the green structure system of the Munich city. There have been many efforts to control the wild nature of this braiding alpine river with its sudden and large floods since the first establishment of the city. And the river has been largely exploited since 1889. The main driving forces of turning the river into a bed of concrete and build canals are the protection from flood and the generation of energy, which is known as “the white gold”. Almost all of the water (95%) was cut by such means. A large water reservoir was built in the Alps in 1959, which had a deep effect on the river dynamics. Afterwards, it helped to reduce the amount of gravel and sand carried by the river, which caused continual deepening of the river bed. On the other hand, the water quality of river was not good, which then created many problems for the bathing facilities in Munich. The river Isar was called by environmentalists as a “dead river” in 1980s, and there was an evident need for a reconstruction project. For this reason, Bavarian state and the city of Munich have taken serious actions since 1989. For instance, the contract of power generating



Figure 19. The River Isar in Munich-Germany (Original, 2007).



Figure 20. Gravel banks used for recreation in the River Isar in Munich-Germany (Original, 2011).

industry expired in 1993 and a renegotiation was required. Consequently, The main aim of the next planning and design processes was to increase the water flow rate from 5 m³/sec to 12 m³/sec. Accordingly, the “Isarplan” was developed in 1995, which was a comprehensive and detailed plan involving every aspects of the river. A very important decision was taken by the civil board of the city of Munich in 2000 for the urban section of the river. The project primarily aimed to restructure the dams on the river Isar, increase the retention capacity of the floodplain, regain the river and its banks as living spaces, including the possibility for

swimming without health risks and allowing natural dynamics to form and enrich the floodplain for wildlife [29].

There have been actions planned and carried out by public staff to cut trees in order to restore the dams, all of which faced strong criticism by local press in the beginning phase. However, their positive effects became apparent to public in the next summer. Consequently, the Munich citizens welcomed the second rebuilt section. The third section to redesign now provides the inner city with a prominent waterfront. Compared to the earlier sections, it has a different character in terms of morphology and function. Therefore, there is a need for well-planned and consistent solutions to improve the recreational, ecological and technical urban functions of the river. And for this purpose, there was an international competition in 2003 organized for teams of landscape architects, town planners and river engineers [29].

The Isar has a very high flow velocity and transports a huge quantity of bed load. The riverbed was improved before the rehabilitation with low drops to prevent erosion in the riverbed and reduce gravel transport. The efforts for creating a natural hydromorphologic process removed the hard confinement, replace the low drops by sills and created the input of gravel and boulders along the banks and as islands. These gravel banks will be relocated by natural processes in time. These areas are densely used by many people on recreation purposes in summer [24] (see Figure 20).

5.1.7. The Cheonggyecheon Restoration Project

The Cheonggyecheon Restoration Project is especially important as it is aimed to revive the historical and cultural environment of Seoul. This project is an indispensable part Seoul's urban planning but it is also a symbolic project to regain an important part of Korea's historical and natural heritage at the start of the twenty-first century. The capital city of Korea will become even more environmentally and human friendly once the project is finished. It is also expected from the project to create a new pattern for urban management in the new century and help boosting the image of Seoul [30].

The main targets of the Cheonggyecheon Restoration can be given as follows [30]:

- restoring history, culture and the environment in Seoul
- altering the look of city by removing repulsive structures and creating beautiful riverside landscape in downtown of Seoul
- presenting the historical and cultural heritages of Cheonggyecheon
- creating a new environmentally friendly Seoul
- reviving the economy in the downtown and northern Seoul.

The following recommendations are recommended by the Seoul Agenda 21 to construct different biological corridors and habitat network to create an eco-city [30]:

- connecting the axes of ecological green areas
- enhancing urban green areas (public sector)

- transforming rivers into natural places for flora and fauna.

With the restoration of historical areas, the modern era is harmoniously integrated with the 600 years old history of Seoul as the capital city of Korea. The restored Cheonggyecheon area will attract many tourists to Seoul from all over the world. In the project, a special focus is given to the improvement of the environment for living and business, and the project is expected to help Seoul to become the financial and commercial center of the East Asia. The new look of Seoul will also increase the expectations of Seoul citizens from the future [30].



Figure 21. Digital model of Cheonggyecheon linear park [31].

5.2. Some samples of urban river landscape in Turkey

5.2.1. *The Porsuk Creek*

The summary information is given below about the “Landscape Planning Project for Eskişehir Urban Course of Porsuk Creek” in the Central Anatolia supported by World Bank and prepared by Memlük [32].

The project involves the green areas to be formed as a result of planning and restoration of open and green spaces 10 km along the Porsuk Creek and irrigation canals.

Except for a part of 1.5 km in city center, the entire creek remains in the natural riverbed. This natural river bed is meandering and polluted. In addition, the rehabilitation of Porsuk Creek and its tributaries was brought to agenda due to flooding events and the necessary efforts were immediately started.

As a result of these rehabilitation efforts, green areas have been formed on both sides of Porsuk Creek and its tributaries along the course within city center. Most of the large open and green spaces on both sides of creek and canal were rehabilitated. However, new riverfront tracts as well as open and green spaces created with the enforcement of new structuring and master plan are investigated in this study.

The main theme of the project is to encourage and incite well-qualified spatial construction with the new organization and rehabilitation of the creek and canals.

As a result of the surveys, the project and its surrounding area are concluded qualified with interesting characteristics. For this reason, open spaces within the project area have been vegetated and opened for limited public use. However, the construction of fairground, picnic and commercial spaces has been avoided.

Especially, the wet space property of the project area for flora is always emphasized. The main theme of the project is to develop a landscape approach for rehabilitation and enhancement of natural structure in the area. It is aimed to attract people to this area not only for entertainment but also to experience the nature and the conditions it provides.

Consequently, below is given the recommended structure for the project designed to embellish and revive the Porsuk Creek, one of the most important parts of Eskişehir and integrated with the city.

Citizens can freely walk in the green areas along the creek and experience the water-green coherence (Figure 22-23).



Figure 22. The Porsuk Creek riverside in Eskişehir-Turkey [33].



Figure 23. The Porsuk Creek in Eskişehir-Turkey [33].

In addition to forestation and vegetation, large grass-plots have been created for human use (for recreation purpose). In the project area, spaces with abundant structures have not been formed except for plazas.

Insofar as the master plan permits, walking trails and fortune balconies are given emphasis along the riverfront.

About every 100-150 m, steps between trail and canal paths are kept large enough to provide them with functionality of watching-thinking amphitheater. Rural-like fences are used to give picturesque appearance to the project area. Besides, a suggestion is made for trail forestation and canal vegetation.

With this project, Eskişehir comes into prominence as a city that offers modern standards of living comfort.

5.2.2. *The Bartın River*

The Bartın River flows through the Western Black Sea Basin in North Turkey. It is the only river in Turkey enabling 12 km of water transportation from the Black Sea to center of the Bartın City. Thanks to this feature, the trade made on Bartın River played an important role in the development of Bartın, which is the center of its region especially during the period of Ottoman Empire. Besides rich natural sources in Bartın City, there are also valuable cultural landscape characteristics in the city [34] (Figure 24-25). Due to these special properties of Bartın River both on regional and national scales. There are many advantages for next generations in protecting the landscape characteristics of Bartın River and landscape planning studies with regard to the rising population and urbanization pressure. The main

focus in these studies is to meet the growing demands of population and create protection strategies from the damages of flood and protect landscape characteristics of the Bartın River [9]. Therefore, landscape characteristics of Bartın River Floodplain Corridor should be evaluated and assessed to protect its valuable natural and cultural resources and to maintain balanced land use and development (Figure 26) [4].

In this study, urban and rural landscape characteristics of research area are determined at first through Geographic Information Systems (GIS), and then some planning principles and recommendations are used to address the factors which negatively affect the river landscape and will be important to reduce flood risk, improve water transportation and connect natural, cultural and historical environments of the Bartın River in order to protect landscape and develop tourism in the region. In the study area experiencing such destructions, necessary plans are developed to protect river landscapes. The main target is to restore the Bartın River and to develop strategies to transform the riverbank and urban enhancement areas. This study is expected to contribute to national and regional economies for a long time by creating a balance between preservation and land use as well as protecting landscape characteristics of the Bartın River [4].



Figure 24. View of the Bartın River in Bartın-Turkey (Original, 2007).



Figure 25. The Bartın River in Bartın-Turkey (Original, 2007).

A new method is developed by Cengiz [9] for determining and evaluating the landscape characteristics of Bartın River. This study can be seen as an example in planning the revitalization projects on urban river landscapes in similar hydrologic regions and further studies can be conducted based on the guidelines of this study [4].

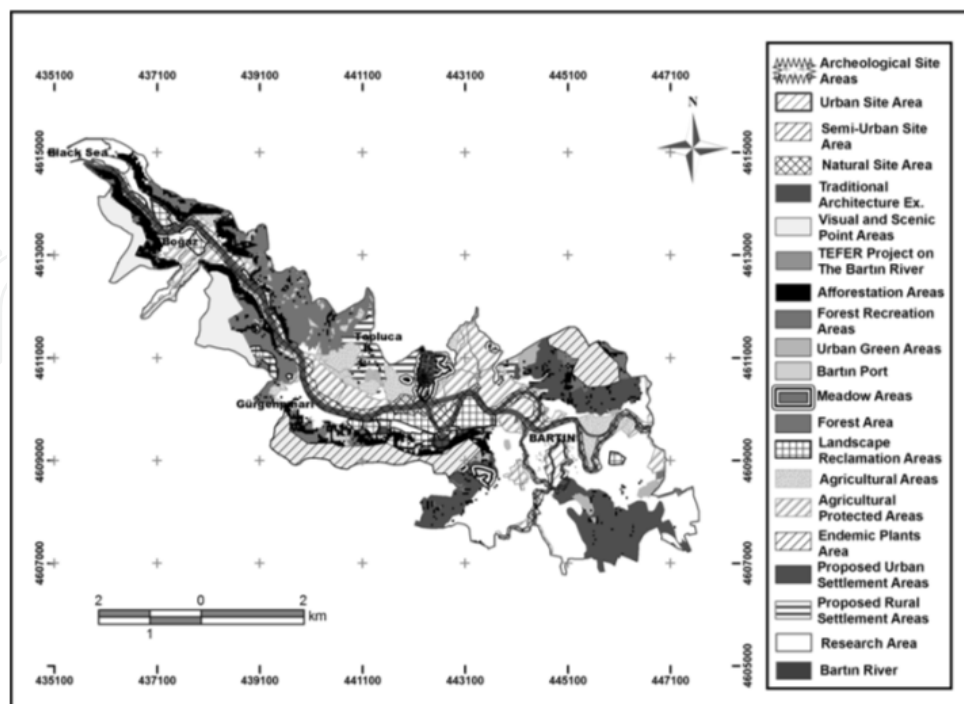


Figure 26. Alternative land use planning for the Bartın River Floodplain Corridor [4, 9].

6. Discussion

As stated by OECD [35] historical development patterns of urban centers have a general tendency of destroying ecosystem resources accounting for their own creation, development and typical characteristics. With well-planned restoration of urban river, multiple ecosystem services that have been lost or deteriorated can be recovered to some extent. Previous case studies have demonstrated the apparent benefits of these restoration works to human wellbeing such as health, economic value, life quality and contribution to regional renewal. In addition, through planning river management or urban developments for rivers with potential impacts on ecosystem, the adverse effects can be prevented or minimized and appropriate mitigation methods can also be determined to deal with damages to important and socially beneficial river functions. There has been a particular growing agreement on the value of ecosystem services for handling a wide variety of sustainability challenges including the demands of land use planning, agriculture and forestry, as well as carbon and microclimate management, and the management of fisheries, watersheds, biodiversity and tourism [5].

Base on the results of Cengiz et al. [4], the following recommendations are made for ecological planning of urban river landscape in Turkey.

- Natural and cultural landscape values of the river and historically important areas should be integrated with potential tourism centers in the region in order to improve river tourism and recreation. The main aims of river restoration studies are to provide ecological and economic benefits.
- Sustainable ecological characteristics of rivers and boundaries of flooding areas (2-5-10-25-50-100-500-year floods) should be determined and dealt with in the city development plans.
- It is important to evaluate urban open and green space systems of these areas for public benefit. Therefore, it could be possible to provide protection from flood risk through specifying flooding area boundaries on river banks and also to create modern recreational places for public use in city.
- Basin Management Plans and Urban Flood Risk Management Plans should be prepared with respect to the European Water Framework Directive (WFD). Afterwards, these plans should be considered in the city development plans.
- The main objectives should be to protect, develop and use the current landscape characteristics of the river and to hand them down the next generations.
- It is quite important to plan river landscape studies for protecting landscape characteristics and alleviating the effects of rising population and urbanization pressure in order to hand them down the future generations. The main aims of landscape studies planned on different scales should be to meet increasing demands of future population growth and develop strategies for the protection of the valuable valued landscape characteristics of the river basin. Otherwise, a multifunctional river can disappear from the city landscape as it happened in many other cities of Turkey.

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