

Increasing Sustainability Using the Potential of Urban Rivers in Developing Countries with a Biophilic Design Approach

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Abstract—Population growth, urban development and urban buildup have disturbed the balance between the nature and the city, and so leading to the loss of quality of sustainability of proximity to rivers. While in the past, the sides of urban rivers were considered as urban green space. Urban rivers and their sides that have environmental, social and economic values are important to achieve sustainable development. So far, efforts have been made at various scales in various cities around the world to revitalize these areas. On the other hand, biophilic design is an innovative design approach in which attention to natural details and relation to nature is a fundamental concept. The purpose of this study is to provide an integrated framework of urban design using the potential of urban rivers (in order to increase sustainability) with a biophilic design approach to be used in cities in developing countries. The methodology of the research is based on the collection of data and information from research and projects including a study on biophilic design, investigations and projects related to the urban rivers, and a review of the literature on sustainable urban development. Then studying the boundary of urban rivers is completed by examining case samples. Eventually, integrated framework of urban design, to design the boundaries of urban rivers in the cities of developing countries is presented regarding the factors affecting the design of these areas. The result shows that according to this framework, the potential of the river banks is utilized to increase not only the environmental sustainability but also social, economic and physical stability with regard to water, light, and the usage of indigenous materials, etc.

Keywords—Urban rivers, biophilic design, urban sustainability, nature.

I. INTRODUCTION

TODAY, cities, especially those in developing countries, are faced with an ever-increasing population and as a result with the build-up increase. Nowadays, 40% of populations of developing countries are residing in cities and this figure is expected to reach 51% by 2020 [3]. In the current process, three quarters of urban population growth occurs in developing countries and leads to the great growth of the cities that have the least capacity to adapt to such growth. The cities in developing countries are faced with the immense challenges posed by population growth. A population who needs more

shelter and better services, but their income is not enough to get them [3]. These cities are the main cause of instability in the world, in all cities, the needs of citizens are of a widespread dimension that involves many aspects, including environmental, social, cultural, economic and physical. To respond sustainably to these needs, all the potential in the city and its nature should have been used. One of these potentials existing in some cities is urban rivers. Urban rivers and surrounding areas are a good opportunity for progress in accordance with the sustainable development of the city. These areas that have played an important role as an urban green area in the past, nowadays are faced with several problems. Urban river banks can however play a significant role in balancing a city and nature. One solution to revitalize and use the potential of these spaces and attending simultaneously to the environmental, social, economic and physical dimensions to increase the city's sustainability is utilizing the biophilic approach in designing them. According to this approach, nature, natural details and the everyday relationship with nature, are of the basic concepts that can be very helpful in designing urban river banks to enhance city sustainability.

II. SUSTAINABLE DEVELOPMENT

The beginning of the destruction process to the natural ecological balance has been referred to the industrial revolution in 19th century in developed countries. The exploitation of natural resources for excessive production strategies and the struggle for global economic manipulation, besides the vast acceleration of the urbanization process, led to a break in the global ecological balance [20].

Until the 1950s, during the development of industrialized countries, limited attention was paid to environmental preservation. In many countries, residual provisions were the first environmental regulations [5], [13]. With population growth, increasing human use of natural resources and the many problems that humans face due to the inappropriate use of nature and natural resources, the issue of sustainability and sustainable development was raised. In 1980, sustainable development was approved by the International Union for the Conservation of Nature, but remains within the reach of environmental advocates [23].

Finally, the United Nations General Assembly organized the World Commission on Environment and Development. And from that time on, the plan of work for 21 prisons was prepared for the future of humans, which emerged as a

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sustainable development work plan for the 21st century [8]. It was the first document in which the concept of sustainable development (SD) was suggested as a strategy to seek a balance between economic, social and ecological factors [2], and eventually, for the first time, the definition of “Sustainable City” was presented in 1994. In relation to Sustainability and SD, and sustainable cities, several definitions are expressed that some of them are referred to below.

According to the Brundtland Report, SD “is to meet the current needs of the world without compromising the ability of the next generation to meet their needs. Sustainable Development is human-nature interaction across the globe” [32].

In his book, “Sustainable Development,” Michael Radcliffe states that “The concept of sustainable development is an indisputable fact that ecological considerations can and should be applied in economic activities. These considerations include the idea of creating a reasonable environment in that development claim, in order to advance the quality of all aspects of life, is challenged” [28]. According to Man and E. Cox, SD is “The process of equitable and equitable improving economic, a social, cultural and technological condition. This development proceeds in a direction that does not infect ecosystems and does not lead to degradation of natural resources” [15]. In fact, SD has a wide and varied dimension, so it is necessary to pay attention simultaneously to the environmental, social and economic dimensions.

According to the evidence and studies, cities are considered as the main cause of instability in the world. More than 50% of the world’s population will soon be living in cities, contributing to a massive consumption of global resources [21]. Girardet mentioned that the world’s cities occupy about 2% of global land surface, but they use 75% of the world’s resources and release about the same percentage of global waste [6].

The definition of the concept, which was first presented in 1994, states that a “Sustainable City is a city in which the people and the business of that city continuously work to improve the natural environment, artistic environment and cultural environment at the local and regional levels, while their actions are in a way that always supports the goal of sustainable development.” Capello defines the notion of a sustainable city as “a concept . . . which stimulates a balance between economic progress, social equity and environmental quality” [24].

Moughtin and Shirley have presented the following model based on the components of SD. The integrated figure places the three elements in their correct relationship; economic activity is subsumed within society because it is one of many forms of social activity. Social life is then placed within the environment, because all activities take place within an environment of some sort (Fig. 1) [21].

Due to the definitions of SD and in completing the definitions provided for a sustainable city, urban sustainability is also defined in other forms: “the factors to improve and enhance the qualities of life in a city include ecological, cultural, political, social and economic components, and

improving leads not to shift and put the burden and responsibility to the next generations. In the interaction with each of these factors and the elements shaping the urban space, urban planning could be able to develop balanced equilibrium in order to be in balance and compatibility. In this case, the urban system has been operating in a sustainable way” [9]. Rodgers argues that the concept of inner sustainability of a city is one that must be able to meet the social, economic, cultural, political, physical, and environmental objectives of its inhabitants. He states that the attributes of such a city are the same access to basic services for all citizens, the beauty of the city in terms of art and architecture, creativity in human activities, efficiency of using natural resources, and minimum ecological effects, diversity, density, integrity, mobility, and dynamics [36], [9].

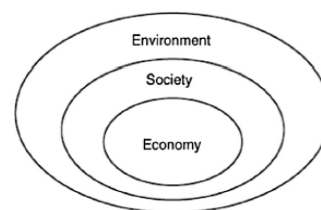


Fig. 1 The integrated model for sustainable [21]

Generally, attitudes about SD are divided into four main axes:

- 1) Attention to objective aesthetics,
- 2) Attention to the aesthetic and perceptual aesthetics,
- 3) Attention to the functional aspects, and
- 4) Attention to environmental issues [7].

In the research entitled “Using analytical approach SWOT-fuzzy in choosing sustainable strategies for District 1 Ray” [31], after studying various researches on the development of sustainability indices, like the studies of Francesco di Castro, urban sustainability indicators were classified into four general sections as: social, economic, environmental and physical parameters:

TABLE I
 COMPONENTS, STANDARD, AND SUSTAINABILITY INDICATORS [31]

Sustainability component	Standard	Indicator
Environmental	Good air quality	Air pollutants
	Preservation of social resources	Urban Growth
	Good water quality	Water pollutants
Social		Social Security
		Justice
		Association
		Identity
Economic		Mental and psychological safety
		Maximize the use of economic potential
		Emphasis on creating diverse economic activities in the city
Physical		Land value
	Permeability	Physical connection
	Access quality	Intuitive communication
	Facilities and Services	Riding and Walking Access
		Municipal facilities and equipment
	Public facilities	

III. BIOPHILIC DESIGN APPROACH

The term biophilic is derived from Biophilia, which is composed of two components Bio and Philia. Kellert's study found the following:

“Biophilia is a term that stems from Greek roots meaning 'love of life'. It was coined by the social psychologist Erich Fromm and popularized in the 1980s as Edward O. Wilson pioneered a new school of thought focused on this concept, which he defined as “the urge to affiliate with other forms of life”. Wilson’s Biophilia Hypothesis asserts that people need to contact with nature and with the complex geometry of natural forms, just as much as they require nutrients and air for metabolism” [10], [27].

Biophilic design is the good design that is in the building, the site, the city and at the regional scale. It also has natural and non-natural elements. The basic feature of the concept of biophilia requires designers to put nature at the heart of their work. Today, according to surveys, it has been observed that the constant association of man with nature improves the happiness and level of efficiency in working environments [14]. In the definition of the city of biophilics, it is emphasized that it does not mean a green city. The existence of nature in the broadest sense is necessary, but it is not the adequate condition.

The challenge of biophilic design is to address landscape defects and contemporary structures by creating a new network to provide a satisfying experience of the influence of nature inside the environment [11]. According to Mohamed, “Biophilic Design incorporates green building ideas, but considers that true sustainability must include quality of life issues involving human physiological and psychological-health and well-being. So, biophilic design incorporates elements derived from nature in order to maximize human functioning and health” [20].

Some of the rules of the biophilic design are:

- constant and sustained conflict with nature,
- focus on the adaptation of human beings and nature (during the time of evolution, health, and compatibility),
- to promote sensory attraction into unique places and places, and
- promoting positive interactions between man and nature (enhances an extended sense between humans and nature).

Biophysical planning, expresses the creative combination of green urban design with the involvement of outer life, protecting and restoring green infrastructure from neighborhoods to biodiversity, and even includes higher levels [35].

Lehmann expressed 15 Guiding Principles for Biophilic Urban Planning as: 1. weather; 2. Renewable energy for the non-emission of CO₂ gas; 3. a city without waste; 4. water; 5. landscape, garden and urban biodiversity; 6. Sustainable transportation; good public space; 7. local and sustainable materials with low energy consumption; 8. aggregation and retrofitting of existing parts; 9. buildings and green parts using

passive design principles; 10. programs to create lively communities, healthy with mixed use; 11. local food supply chain; 12. cultural heritage; identity and sense of belonging; 14. education, research and awareness; and 15. strategies for cities in developed countries [16]-[18].

Biophilic City Criteria:

- Adopt infrastructure policies such as increasing the percentage of green areas in the city, the number of used images, shapes and forms of biomorphic in architecture of the city and visible in the city, the amount of plant and animal species in the city, use of flood-prone areas as public spaces,
- Behavioral policies and life style such as raise the percentage of pedestrians’ journeys, amount of the activities in environmental organizations and clubs, per capita urban park going every month,
- Change in people's attitudes such as educating people, increasing the number of residents who can identify different plant and animal species, and who take care of nature, and,
- Strengthen social systems and people participation, and non-visible connection with water [19].

TABLE II
 THREE TYPES OF EXPERIENCES WITHIN THE BIOPHILIC DESIGN
 FRAMEWORK [12]

Experiences of space and place (Indices of spatial composition of the natural environment that refers to human health and consciousness)	Indirect experience of nature (A show or a picture of nature)	A direct experience of nature (real connection with environmental characteristics in built environment)
views and life insurance disorder	pictures of nature	natural light
integration and simplicity	natural materials	weather
transitional spaces	natural colors	water
	simulated natural air and light	green space
mobility and access	natural shapes	animals
cultural and native belongings	age, change, and time development	natural landscapes and ecosystems
	biological forms	

Browning, Ryan and Clancy presented the following 14 model framework for understanding and the possibility of a mix of rich diversity of strategies embedded in the built environment:

TABLE III
 BIOPHILIC DESIGN FRAMEWORK [4]

Spatial nature (space shapes in satisfactory nature need to see the immediate nature)	Similar nature (indirect, organic and non-live memorials of nature)	Nature inside space (the physical and transient presence of nature in a space or place)
View	biological patterns and forms	visual relation with nature
safe place	material connection with nature	Non-visual relation with nature
mystery	order and complexity	non-rheumatic sensory stimulator
risk/ danger		fluctuations in air and heat flow
		presence of water
		dynamic and emitted light
		connection with natural systems

IV. URBAN RIVERS

Most human civilizations are formed alongside large rivers. Primitive humans living along rivers learned to respect and appreciate them in order to use these natural resources in an optimal way. Today, the existence of a river, in addition to many the benefits, including the supply of water for drinking, agriculture, industry and energy production, plays a major role in living and dynamic cities [34]. Today, human beings have realized that in order to prevent or to reduce the harmful effects of any change in the process of natural rivers and to rebalance the river, the physical laws governing the processes must be found and the subsequent changes resulting from any corrective work must be anticipated. In other words, the designer should have an ever-increasing emphasis on the developmental balance of the river to work with the river, not just to work on it [30].

Various river types:

- 1) Rivers locating on the side of the main structure of city.
- 2) Rivers that go through the main structure of the city and are more dry and seasonal.
- 3) Rivers that have been formed recently as a result of the city growth and do not have a role in the city's main formations.

The various types of changes, reforms, and violations of rivers are as follows:

- Road construction along the river,
- River modification and repair works,
- Bridge building on the river, and
- Construction of urban amenities-services on the river [30].

Along with urban rivers, the areas that confluence with the main driving axes which contain focal points (with trans-regional functional scale) and the open public green spaces must be identified. These identified spaces, according to the architectural design, landscape design, and urban design with a sustainable approach must create the general arenas of collective actions in combination with the existing focal points and the natural environment. And to meet the needs of citizens, the visual, social, economic, and ecological role of rivers must be emphasized in blending with the urban structure [33].

A. Designing Criteria of the River Bank with an SD Approach

As stated previously in Section II, SD attitudes include: Considering the objective, mental and perceptual aesthetics, the functional, as well as the environmental components. This attitude also should be considered in determining the criteria for designing urban river banks with an SD approach:

1. The Objective, Mental and Perceptual Aesthetic Component

Due to environmental issues, caution should be exercised in changing the design of rivers, but in the face of landscaping, relying on the principles of aesthetic objectives in city margins, there exist more freedom to act. In beautifying rivers, it is necessary to choose the appropriate strategy considering the type of river and the characteristics of each of them.

According to the mental and perceptual component in the design of the river route, these areas can have an important role in terms of relaxation, psychological comfort, communication between the individual and the space, and thus memories for individuals.

2. Functional Component

Creating multipurpose and multi-functional spaces that can be equipped by different users, possibility of outfitting the space to be used at different times as well as different occasions, the accessibility of facilities for different age and social groups, location of bridges according to pedestrians' needs, converting bridges to a place for having fun and contact with water rather than as just a place to pass through, employing of temporary and permanent awnings where necessary, and creating safe areas for swimming and sailing, will have a vital role in the revival and the dynamizing of river sides.

3. Environmental Component

The life of the plants and animals that are living in the river is fully dependent on the water. Attention to environmental factors, efforts towards the conservation of natural resources, the use of renewable resources such as solar energy, and compatible architecture with nature is one of the achievements of SD that has particular importance in the design of river banks.

Generally, the criteria for designing river banks include:

- Attention to objective, mental and perceptual aesthetic components such as the creation of diversity, individuation, balance, etc., attention to night lighting reflection, availability of access to water and so on.
- Attention to functional components such as the necessary facilities for the presence of different age groups and social groups, appropriate placement of bridges, and so on.
- Consideration to the environmental components such as topography around the river and to take advantage of these components in organizing a river bank, and limiting the removal of the soil adjacent to the river in order to prevent soil erosion [19].

V. EXAMPLES OF EXECUTIVE PROJECTS ALONG THE RIVER BANKS

The revitalization of river banks has been an attractive phenomenon in the process of urban regeneration since 1980. Fundamentals of development along the rivers can be expressed as follows: 1. reducing pollution, 2. redressing, 3. managing floods and runoffs, 4. restoring water to primary conditions in environmental preservation, and 5. protecting residents [26]. One of the projects related to urban river issues can be found in the Seattle executive projects. Restoring part of the Ravina River to the city level, the beautiful natural environment has been created as a result of the revival of the local vegetation near the residential area. The Ravina River, which passed through the underground routes in the early 1990s, was returned to the city level by a private company

[25]. Other examples are new efforts to revitalize the Los Angeles River, which is currently more like a canal than a natural river and which crosses almost all parts of the city, has a real potential to improve the quality of life for thousands of residents along the river through the creation of 239 green space projects [1]. In another project in Seoul, South Korea, in

a dramatic move that involved removing 8 km of a highway, the Chuan Quan River route, which was located under this highway, was opened. In addition to the environmental benefits, the project also had economic and cultural benefits [29].

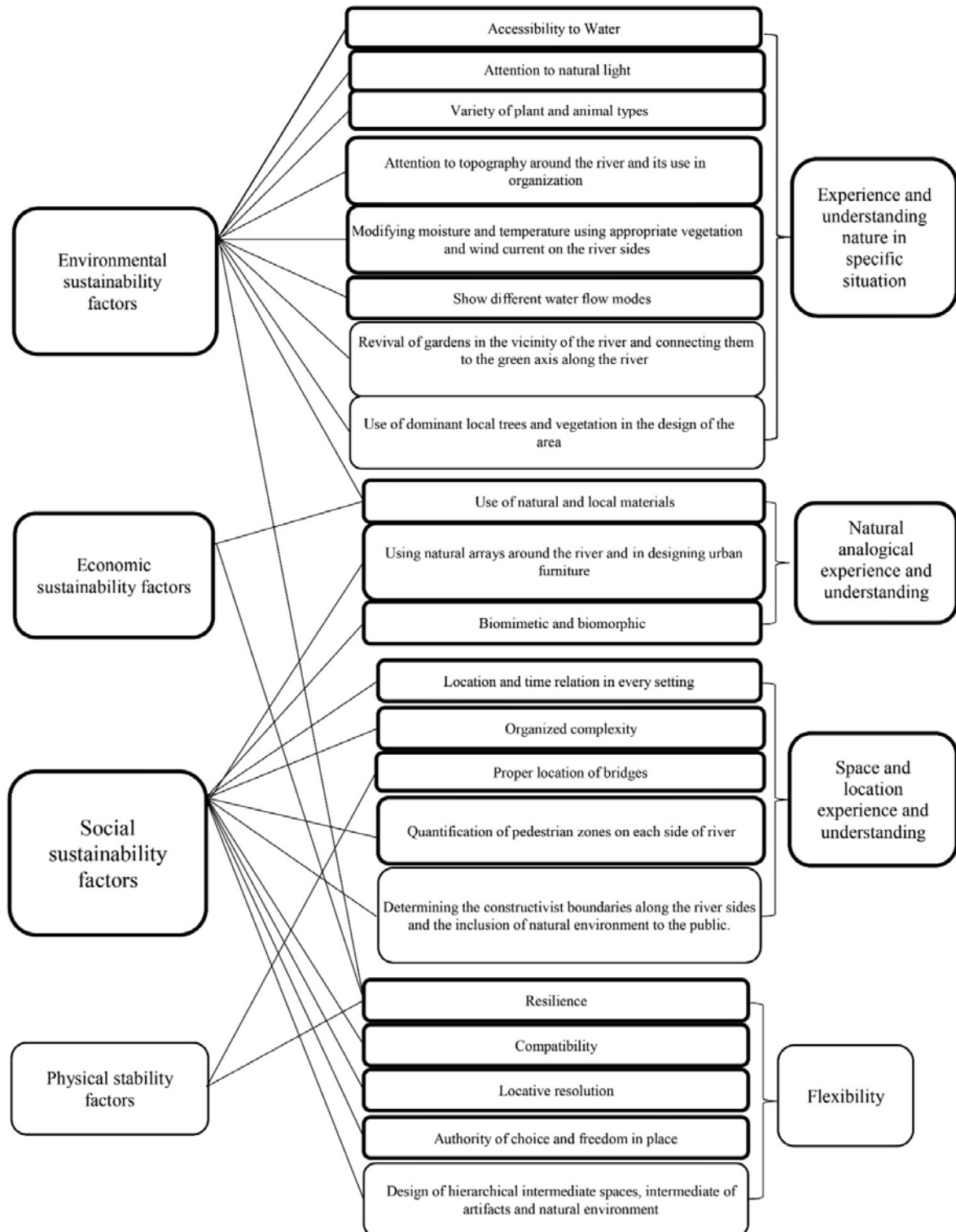


Fig. 2 The framework for designing urban river banks in developing countries with a biophilic design approach

VI. CONCLUSION

In terms of SD for river bank design, the following aspects should be considered:

- Identification of different types of river and choosing the appropriate strategy to deal with them,
- Identification of the existing ecosystem around the river bank and trying to preserve sustainable ecosystems such as forests and pastures,
- Environmental considerations,
- Pay attention to the issue of river sedimentation as well as soil erosion along the riverside,
- Attention to technical points of view in dealing with the river,
- Attention to water quality and how to use and store it,
- Protecting the river properly to prevent disturbance of the water, river edge, and surrounding vegetation,
- Paying attention to the cultural and historical aspect of the rivers and to revive their productive past in a new way, and
- Restoration and reconstruction of water structures (bridges, mills, etc.) for giving identity to the rivers [34].

In developing countries, the mere replication of theories and services of industrialized countries, regardless of rational foundation, creates friction against new phenomena in these countries. Since there are no substantiated theoretical concepts to deal with the issues of developing countries, careful considerations according to the cultural and social factors of these countries must be applied and SD debates are no exception to these considerations.

In general, taking into account the criteria and sub-criteria for designing river banks using a biophilic approach and their compatibility with the components of sustainability, the following framework is proposed to help utilize the city's river potential to promote city sustainability. In this regard the cultural and social factors must be considered in order to design the river bank in every city of the developing countries. Due to the economic constraints in most developing countries and the population growth of these countries utilizing the framework outlined in Fig. 2 for designing urban river banks can be effective.

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