

The environmentally-efficient canal district design respecting urban context

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Abstract. The following paper discusses the development of the work-flow that can be used in practice for the urban environmentally-efficient attraction points design and restoration. We developed the work-flow on the basis of the example of the design of canal district restoration in the heart of the city of Bangkok. The reference concept was developed in the scope of the International Workshop of Urban and Architectural Design X edition, organized by Politecnico di Milano and Chulalongkorn University. The design ideas developed in this project are present in the study. In this article we discuss the importance of water districts restoration from environmental, social and economic points of view. The introduction of the work-flow of the canal district design that has its aim to meet the existing urban context and all the important requirements is important for designers and urban planners, since it can help to resolve a number of questions that have to be properly studied. The importance of introduction of GIS and digital twin technologies to the landscape restoration projects is as well discussed.

1 Introduction

An importance of water in city is very hard to overestimate. Inland urban waterways might enhance wellbeing, broadening the variety of places and experiences. Such waterways are considered as therapeutic blue spaces [1]. Water is crucial for not only sustaining social and cultural relations through its numerous interactions with humans, but also sustaining biological life, in short, it has a socio-natural materiality [2]. Water canals have many ecological functions such as habitat and biodiversity maintenance, they provide a lot of ecosystem services for human society [3].

The canal districts may account for flood protection [4,5], waste management in waterways [6, 7], provide additional supply of water to soils [8], reduction of soils contamination that would influence their hydro-physical properties [9-12], reduction of small-particle air pollution [13] and reduction of urban heat [14, 15] by the introduction of the cooling effect of the stream, increased vegetation and increased wind speed.

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In fact, problems such as insufficient green land, lack of waterways, excessively-concentrated populations and large amounts of artificial thermal sources all make cities into heat islands [16-18]. The heat island effect in a city refers to a phenomenon in which the temperature in a city is higher than the temperature in the neighboring rural areas. The heat island effect has become one of the most significant concerns for modern urban planners and designers [15]. Increased wind velocity that is produced by waterways presence can reduce the heat island effect, leading to comfortable outdoor temperatures [16]. It brings significant improvements to urban thermal environment [19-21].

It becomes evident that design and restoration of waterways, canal districts and riversides, especially in cities built in hot climates with dense population and car traffic is an environmentally-efficient strategy that also brings a number of social benefits. However, in order to realize a project of canal district design or restoration, a number of questions have to be properly studied. In our article we introduce a work-flow that was developed on the basis of the realized workshop project of canal district restoration in the city of Bangkok, “The case of Klong Rob Krung” [22].

2 Materials and methods

In this section we are going to discuss several case-studies that we studied in order to develop the project and introduce the workflow. The case studies have their aim to show the issues that redevelopment of canal districts deals with and the benefits that were obtained with the adoption of environmentally-efficient strategies.

2.1 Restoration of Cheonggyecheon in Seoul, South Korea

Several important urban projects have changed the Soul’s landscape from an auto centric to the one that values the quality of life of its people and the importance of ecosystems [23]. One of them is the Cheonggyecheon Restoration Project. The main idea of this project was to demolish a lately constructed highway that was erected on the section of the historic Cheonggyecheon Stream in order to restore the canal.

The realization of this project has created both ecological and recreational opportunities along the area in the center of Seoul. The overall restoration design covered water level control in the river, design of 22 bridges, and design of sewer system. The benefits achieved by this project can be summarized as follows [23]:

Environmental: flood protection that can sustain flow rate of 118 mm / hr; increase of overall biodiversity by 639%; reduction of heat island effect (5% on average increased wind velocity, 4°C on average reduced temperature along the stream compared to a parallel district); reduced small particle air pollution by 35%.

Social: increased by 15.1% bus ridership and 3.3% subway ridership; attraction of 64 000 visitors per day on average to the district.

Economic: increased number of working people in the area by around 0.8% because of introduction of local business to the area that attracts visitors.

2.2 Turia River Bed Restoration in Valencia, Spain

The Valencia flash flood in lower Turia River basin happened in October 1957 [24]. The flood has emptied the river basin. In the late 70s the landscape architecture competition was launched by the city administration to recover a morphology of the former river basin.

Nowadays, as it passes through the city of Valencia, the old Turia riverbed is a big urban park that allows different leisure activities, consistent with the contemporary concept

of sustainable city that is active, healthy and participative. In this longitudinal space that runs through the city, natural elements play a leading role to connect leisure, mobility (walk or cycle) and sports [25]. The project introduced a green park into the area. The canal of river Turia crosses the park and feeds the inner reservoirs. Terraces along the park create pathways throughout the park connecting different points of the landscape that differ in the elevation levels. The project itself creates a recreational area around the canal, enabling a number of ecological and social benefits in the area.

The Turia river bed restoration caused a considerable rise in humidity (possibly due to the size of the water jets). The Turia Gardens is one of the main entry channels for breezes into the city, which has a great impact on the overall heat reduction in the district [26].

2.3 Chicago Riverwalk Redesign

Over the decade the role of the river has been evolving with the Chicago Riverwalk project – an initiative to reclaim the Chicago river for the ecological, recreational and economic benefits of the city [27].

The idea of the project was to expand the pedestrian spaces and create a series of under-bridge connections between blocks. The design accounts for the control of the annual flooding and water level control [28].

2.4 Summary of Case-Studies, Border Conditions Definition

As it can be seen from the discussed case-studies, the starting point of a canal design project is often driven by the idea to recreate a historical landscape which will suite the existing architectural context. Apart from that, the project developers try to bring to life social and environmental benefits that the development of such a project would provide to the city. From the discussed case-studies, it is seen that canal district design might account for flood protection, reduction of heat island effect, reduction of small-particle air pollution, it creates attractive public spaces, creates waterways and pathways that might account for the development of important connections in the city, etc.

This analysis allows us to establish starting border conditions of the canal district restoration project, that have to be respected by designers and architects:

1. Meet historical context;
2. Meet urban/Architectural context:
3. Meet economic, social and environmental requirements that are necessary for the area.

3 Results and discussion

In this section we are going to focus on a project of Klong Rob Krung canal restoration in Bangkok, Thailand. The project “OASIS in the heart of BANGKOK” was created in the scope of International Workshop of Urban and Architectural Design X edition, organized by Politecnico di Milano and Chulalongkorn University.

3.1 Problem Definition: Historical Recreation

Bangkok is developed along the Chao Phraya River and the canals system by the eastern bank of the river determined the landscape of the city. The Khlong Rob Krung canal originally constituted the fortified limit of the city. The canal was closed in the first half of 20th century since water transportation was mostly developed following Chao Phraya River.

The problem of population growth in the city of Bangkok starting from 1970's caused a number of issues, such as extremely increased resources use and waste production. This caused the pollution of canals that in return created a harmful influence onto health and overall environment of local habitants [22].

3.2 Problem Definition: Urban and Architectural Context, Problems of The Area

In the first phase of the design it is important to understand the architectural and urban context, as well as state the issues that present state causes.

Within the project 3 areas with different functionality along the canal have been highlighted: recreational, residential and commercial. To meet urban context, the project has to enhance the use of functionality of each area and highlight the areas of increased interest in the pedestrian proximity of the canal. Each area has its problems that have to be mitigated with the realized project. The fig. 1 shows how the areas along the canal are split and their problems at the present state.



Fig. 1. Areas of different functionality along the canal and problems at present state.

3.3 Design Phase: Potential of The Area Definition

In the pedestrian proximity of the canal there are several important places of increased interest, including local government building (indicated as #1 in fig.2), historical Buddhist Temple that is around 500 years old (#2), Rajamangala University (#3), Historical post office building in the public park (#8) and others, see Fig.2.



Fig. 2. Places of increased interest in the pedestrian proximity of the canal.

Being surrounded by such places, the canal might become a very important pathway that would create the connection between important city places. Such a connection would probably enhance economic benefits growth of the area because it would attract tourists. The achievement of this design goal is similar to the one achieved by the Turia riverbed restoration project (as discussed in the section 2.2) and Chicago riverwalk redesign project (as discussed in the section 2.3).

3.4 Design Phase: Potential Environmental Benefits

As in case of Cheonggyecheon restoration (as discussed in the section 2.1) and Turia riverbed restoration (as discussed in the section 2.2), the design of the canal would provide several ecological benefits to the area. Being represented by Tropical savanna climate (Aw) according to Koppen climate classification [29] with dense population, Bangkok internal districts suffer from heat island effect and air pollution. The restored canal district would potentially decrease the heat island effect creating an internal ecosystem with increased wind-speed over the water surface, reduced small particle air pollution. Additionally, the canal would provide the water level control for flood protection.

3.5 Concept Design

The emphasis of the project was done by authors on the connections. The project's aim was to link major nodes of the area with 3 public green zones through green corridor built along Bang Luong canal: Chaloe Phrakiat Forest Park from the right bank of the river Chao Phraya (indicated as #1 in fig.3), Public park as the starting point of the Bang Luong canal (#2) and Rommaninat Park with important cultural heritage in the heart of project site (#3), see fig.3



Fig. 3. Green connection concept design.

In order to realize this connection, the following design considerations were made:

Residential blocks besides the temple (#2 in fig.2) were suggested to be replaced with the green and open spaces, the group of buildings were suggested to be demolished to make the open spaces wider.

Along the waterline, amphitheater staircase was suggested to be introduced to promote a good access to canal for people visiting the temple or the government building. This would strengthen the touristic appearance of the place.

Different water levels were considered in design: seasonal and the daily water level swing – sinking staircase was suggested for people to access the waterline. The staircase was also designed in such a way that it would accommodate large number of people.

Constructed wetlands were suggested in the design to provide the access to vegetation for people walking on the ground level of the canal without disturbing the pedestrian pathways. Additional function is the water animal sanctuary that would enhance the biodiversity of the canal.

The perspective view and concept sections are shown in fig.4 and fig.5.



Fig. 4. The perspective view of the part of the canal between points 2 and 3 from fig.3 [22].

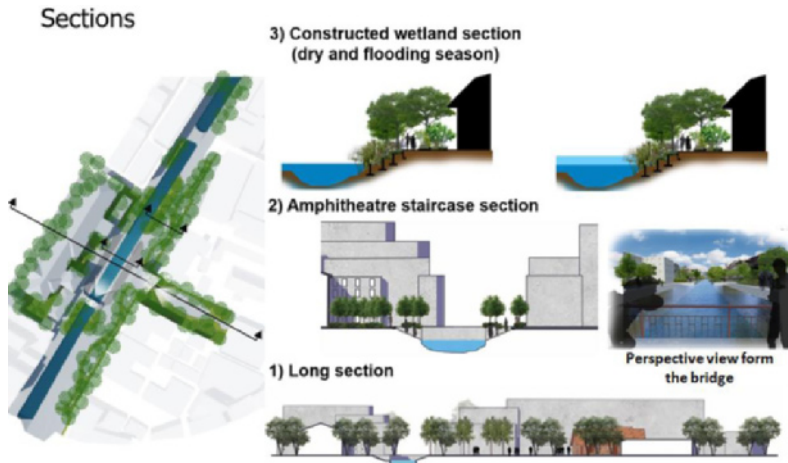


Fig. 5. The concept of the part of the canal between points 2 and 3 from fig.3 [22].

3.6 The Work-Flow Definition

Finally, we are able to establish a work-flow that would be useful for architects, engineers and designers to follow in the canal design concept creation and, in general, the urban environmentally-efficient attraction points design. The starting point, as discussed in section 2.4, is always a proper study of historical and urban context. After which the designers have to understand the issues that are crucial for the area from climatic, environmental, social points of view, as well as business and economy potential of the area. Meeting the necessary engineering, ecological, social and economic requirements, the design might change its form, however it is important to keep the concept close to the border conditions concept criterion.

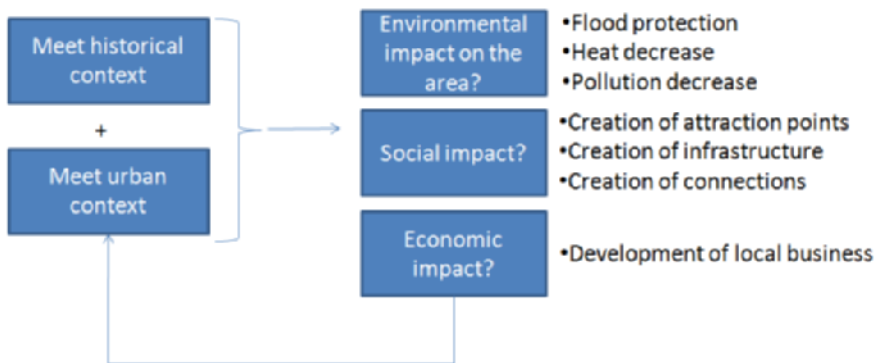


Fig. 6. The work-flow for the urban environmentally-efficient attraction points design.

4 Conclusion

The restoration of waterways, canal districts and riversides is an environmentally-efficient strategy that also brings a number of social and economic benefits to the area where the project is realized. In our study we discussed a number of questions that have to be properly studied in order to create a suitable and thoughtful concept. We introduced a work-flow that was developed on the basis of the realized workshop project of canal district restoration in the city of Bangkok and discussed case-studies of already realized canal restoration designs.

It might as well be important to control different parameters of a canal, such as level of water, pollutants content in water, water temperature, water flow rate, soil properties [30-42] and other parameters to properly manage the environment surrounding the canal district. In this sense, the adoption of digital twin technologies [43] of the area and GIS technologies [44-46] are useful to analyze the state of water and territory, forecast changes that might occur in the district and make decisions that would anticipate the further changes [18, 47].

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