Regeneration of the Mithi River: a knowledge transfer based design approach to increase resilience in metropolitan areas

Abstract: Since the second half of the twentieth century Mumbai has been characterized by an extremely high density of population. Due to the alterations of the soil and to climate tropical condition, today, when heavy rain occurs during high tide in the Mithi River basin area, most of the banks of the river are under sea level. Concrete flood walls are continuously built by the local government whereas in the past awareness of the risk of flooding led to the development of practices for risk management. Traditional elements like “maidans” (typical squares) and “talaos” (water holding tanks), usually looked upon as lacking urbanity, can be part of a new strategy to rethink design. Reestablishing a closed water cycle to keep the balance of the ecosystem by a multi-scale design approach is today priority for the improvement of resilience. The proposal focuses on both “natural areas” and “urbanized areas”, buildings and open spaces.

Flooding, water management, resilience, public space

Background
Today the increased frequency of disasters such as floods is heavily affecting urban contexts worldwide with serious consequences on economies and population. In the last decades western countries started investigating possible solutions to the urgent need to develop a strategy to face climate change and global warming consequences. In 1988 the Intergovernmental Panel on Climate Change (IPCC) established by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP), produced thorough assessments on all aspects of climate change and its impacts, aimed at formulating realistic preparedness, mitigation, adaptation and response strategies. The fifth assessment report released in 2014, focuses on adaptation in order to reduce damage from impacts that cannot be avoided in a short-term view and mid to long-term mitigation strategies to decrease the global warming threats. In the field of urban regeneration and buildings retrofitting, the report highlights the linkage between the development of resilient societies and the main topics of sustainable design. The challenge is to recognize and implement positive and timely decisions in a domain where a complete knowledge is impossible (1). Furthermore, starting from the recognition of the limits of an approach purely based on resources preservation, and following the concepts of a resilience-based urban and environmental regeneration, a widespread holistic and multi-scale vision has taken place, incorporating the environmental issues into every decision and action concerning the transformation and management of the built environment, from strategic policies implementation, to urban and territorial planning, to construction technologies and process innovation. The need for such a different approach is evident in Mumbai, where the huge and fast increase in population density stressed the territorial and urban system until a crash point. It is hard to identify this point in the timeline, but recent events showed all the limits and risks of the conventional approach. In 2005 a destructive flooding caused in Mumbai the death of 500 people, with 250.000 houses damaged and a total estimated loss for two billion USD particularly concentrated in the Mithi River catchment basin which constitutes 16% of the total city area (2). Even in a context where economic growth aspirations guide the physical and societal transformation processes,
every planned and unplanned action aimed at reshaping the urban environment must start to consider the carrying capacity of the ecological system. Each human-environment interaction has to be rethought in a resilience based perspective, where “resilience” means the capacity of a system to recover from any occasional perturbation and the measure of the ability of that system to balance ecological and human functions (3).

**Mumbai case study**

The fragmented landscape of contemporary Mumbai is the progressive result of 300 years of human actions aimed at transforming and adapting the local natural environment to the people needs. Unfortunately, the lacking of a long time vision and the absence of awareness about the negative consequences of an uncontrolled urban growth has produced dramatically negative effects. In XVIII century the British colonial government started to transform the territorial geography and landscape morphology to optimize resources deployment and commercial exchanges of Mumbai, which was only populated by coastal fisheries villages before. Planned operation to improve the north-south connections within the original system of islands caused the reclamation of swamplands and deeply altered the hydrological path, especially in the Mithi River basin area where artificial lakes where built in the north side for water collection and channels were created to drain the excess of water from the inland areas to the sea. Furthermore huge amounts of water were being collected and distributed by surface pipes (used until today and still part of the Mumbai landscape) within a large net substantially different from the traditional water management based on on-site rainwater collection and reuse and aquifer exploitation by a well system. In the XIX century the water request has impressively grown as a consequence to the massive immigration from rural areas due to environmental, economic and political issues. In few decades the Mithi river was inglobated in a continuos urbanized path, as seen in image 1, where the informal sector represent a huge percentage.

![Image 1: Reconstructions of morphological transformation in Mumbai based on previous studies, historical maps and aerial views: a) original configuration; b) XVII century; c) early XX century; d) present day.](image)

As a consequence of the urban population increase and of both planned and unplanned transformations, the water body lost its original role as part of the natural ecosystem becoming an open drain. After the 2005 flood the emergency due to the high pollution levels, the risk of flooding and the risks connected to sanitation problems became central in the local and international debate. One of the main issues is related to the tropical climate of Mumbai which determines high rainfall concentrated in a very short period of the year. Flood risk is constantly increasing due to population growth and the consequent reduction of natural
draining surfaces, as well as to the local effects of climate change, with a significant increase of precipitation extremes in the monsoon season. The drainage system has become insufficient and the ongoing reclamation actions constantly reduce the size of the river, altering its natural course. The constant expansion of informal settlements and land reclamation processes dramatically increase the potential impact of seasonal floods. Besides flood risk, this condition determines negative effects on the inhabitants of Mithi River area, such as serious health diseases due to contaminants and transport problems due to the extreme urban density. Many studies have been published, aimed at facing both flood and pollution issues. After the 2005 flood, based on Chitale Committee report recommendations (4) and other studies carried out since 1975, MMRDA (Mumbai Metropolitan region Development Authority) and MCGM (Municipal Corporation of Greater Mumbai) were instructed to undertake decisive actions along the Mithi River shores. Some structural measures were carried out on the river course like widening, deepening, rock removal, construction of concrete retaining walls and gabion walls (for the area where mangroves still exist). Those actions have been implemented only to increase the carrying capacity of the river during the rainy season and to define certain boundaries all along the river course. Other recommendations, concerning the recovery of the urban ecosystem, the preservation and restoration of the hydrological system of small rivers, ponds and soaking areas, have been completely ignored up to the present day (5). In addition, relocation measures have been undertaken only in informal settlements, thus exacerbating the conflict related to the right of access to basic needs. Physical and non-physical barriers between formal and informal areas, infrastructures and urban space have not been removed, and in most cases have been strengthened. Nothing has been done to create continuity in public space and to restore ecological paths. Over the last decades there has been a widespread research effort on how to support the hydrological homeostasis of an ecosystem, meaning the state of dynamic self-regulation of the essential hydrologic processes and functions to sustain its viability and avoid changes that would destroy it. Decentralized management of water resources based on rainwater reuse and infiltration through impervious surfaces reduction have become major keywords also in extremely densely populated and urbanized areas of the western world (6). This interest has grown due to the ever-increasing demand and the economic, social and environmental conflicts connected to water use, to natural hazards and the rising risks connected to the global warming and climate change. Some researches have been conducted about water infiltration benefits and water reuse also in the Mumbai surroundings, as in case of Seawood Estate in Navi Mumbai where a pilot project was successfully undertaken in a private residential area (7).

The study presented in this paper aims to explore new possibilities for urban landscape renovation in the Mithi River estuary area, developing a strategy that connect the decentralized management of water resource with public space regeneration actions. Recent European studies on resilient landscapes and the Indian traditional water management approach are combined to propose a strategy to recreate a metabolic cycle for water to reduce flood risk and other connected hazards. From one side it is essential to re-establish a list of
priorities for the official redevelopment of the formal city, while on the other the informality has to be taken into account as a component of the city landscape, investigating its potential to contribute in building-up a new and resilient scenario. In this perspective, existing elements of the Mumbai landscape which are usually looked upon as informal or lacking of urbanity can be part of a new strategy to rethink design (8). Talaos (traditional water harvesting tanks) and maidans (public squares introduced in the colonial period) but also separation walls, water pipes and more recent skywalks (elevated pedestrian paths) can be read as segments of a blue and green network. At the same time they can be source of inspiration to define design principles for the new elements of the resilient public space. The design proposal starts from the assumption that planning actions in Mumbai must take into account the stratification generated over time through additional and not systematic actions.

The design approach is structured into complementary sections, involving underground, ground and over ground existing elements that need to be interconnected or rethought to work as a system to improve the overall urban quality. The project is developed according two complementary strategies: the ecological restoration of the river banks that includes residual natural areas and the urban retrofitting at the district scale of the areas surrounding the Mithi River estuary, from Mahim bay to the city airport (image 2). The approach for the residual natural areas (characterized by the prevalence of pervious surfaces) deals with the daily tidal variation of water level in the estuarine region that today is perceived as cause of discomfort. During the monsoon season the expected water level may rises up to more than five meters above sea level and concrete protection walls are ineffective or even dangerous. Moreover inaccessibility of the river banks emphasizes the misperception of the river as a separate entity in the city landscape. The proposal for these zones supports the principle of protection and

Image 2: Proposed strategy steps: a) improvement of the ecological function and of the accessibility of the existing vegetated areas; b) recovery/introduction of wetland areas to increase the river clean-up process; c) introduction of soft engineering measures and integration with public spaces; d) introduction of soft engineering measures to preserve mangroves areas and reconnection with the public space system; e) rehabilitation/delocalization of informal communities located in high risk areas; f) interconnection of public spaces integrating measures for water infiltration/collection/reuse.
ecological restoration of the existing green areas with the aim to absorb and balance the seasonal river variations. Ecological restoration, as defined by Society for Ecological Restoration, aims to recreate a previous state of the natural ecosystem that was lost or an expected condition that would have been developed naturally (9). In such a compromised scenario like the Mithi River basin, the original state of the hydrographic system is very hard to recover because of the massive presence of infrastructures and built areas. Nevertheless, a restoration strategy for the river edges is suggested here to recover the original function of the existing humid areas to support the physical environment and ecological processes. Constructed wetlands introduction contributes to improve the self capacity of the river in removing pollutants, as already successfully demonstrated by many projects realized in compromised areas all over the world (10). In the Mithi River case compatible functions are investigated (image 3) combining constructed wetlands with the insertion of public spaces for different uses. Guidelines provide also design criteria and construction principles for special buildings (non residential) to be realized in the proposed buffer zone.

For the urbanized areas a different strategy is suggested, mainly based on small-scale retrofitting measures. Today the water distribution service is discontinuous and insufficient all over the city and the increasing number of people requesting a daily water supply is worsening the situation. In addition, clean and potable water entering the urban system is discharged after usage contaminated by different kind of pollutants (organic or chemicals depending on the function it was used for). Unlike western cities, where most of that water is depurated in centralized systems before to be discharged, in Mumbai the sewer system is not adequate in size and distribution of the channels and lacking of centralized depuration systems. During the monsoon season the rainwater entering the sewer overload the system and affect the river water level. During the rest of the year the insufficiency and inadequacy of the sewer system causes severe sanitation risks connected to the open-air channels. Therefore decentralized water management systems introduction could improve the life condition for many reasons. From June to September, the rainy season, rain could be an efficient source of water for compatible uses with reduction in request of water from centralized distribution system. Then also the river level will benefit of a less amount of water coming from
urbanized areas and from sewers. Local storage elements will also extend the rainwater uses through time after the end of monsoon. During the dry season the decentralized management of water mainly concerns the depuration of wastewater (grey-water) for possible reuse. In these areas redevelopment strategies would necessarily include both buildings (existing and planned) and open spaces taking into consideration the runoff reduction through the interconnection of pervious surfaces. In the river basin, specific measures to improve the absorption of water, to collect rainwater and to integrate technologies for decentralized water purification and reuse are introduced with benefits also on the quality improvement of public spaces. A strategy based on the interconnection of ecologically efficient surfaces and on the logics of metabolic interaction among open space and buildings brings together many positive effects, dramatically changing the point of view in designing the city. The interdependence among built areas and open spaces aimed at improving life conditions in terms of better and wider access to water resources and quality of the urban environment would increase the general awareness about open spaces protection and maintenance, involving also “informal city members”. Furthermore in Mumbai a clear separation between areas depending on property and land use is usually emphasized and also public spaces are in many cases not inclusive (11). The introduction of mixed and compatible land uses could promote social interaction and even in case of drastic redevelopment or removal actions for slum areas imposed by the local government, the identified planning and design principles could guide the transformation and contribute to reduce conflicts.

Conclusions and research perspectives

Mumbai is a specific site in which the conflict between the logics of the natural environment and the requests of the society reached the highest level because of external forces deriving from global phenomena. The concentration of population in urban areas, the confluence of pollution sources and the increased request of resources deeply influenced the whole city territory. The presence of combined risks that have reached an extremely high level and the condition of rain concentration typical of tropical climate characterizes a scenario which is becoming more and more diffused also in countries of the temperate zone as consequence of climate change, worst affecting areas like the Italian peninsula, due to its own territorial conformation, to the localization of urban areas and the uncontrolled urban growth of the last 60 years. In Italy 81,9% of the municipalities are affected by high hydrogeological risk, meaning 9,8% of the total national territories with 4,1% of flood-prone areas (12). A National research on stormwater resilience of urban open spaces conducted by University of Naples Federico II deeply investigated the application of ecological restoration principles to increase resilience in urban environments of Campania, the third region of Italy for presence of high hydrogeological risk surfaces (19% of regional territory), especially in the eastern Neapolitan plain characterized by massive wetlands reclamation (13). Similarly to the Mithi River basin case, the introduction of constructed wetlands for the eastern Neapolitan plain was investigated as device for water purification, flood control, and conservation functions. The approach was directed to separate rainwater drainage systems from common sewers culverts, using green infrastructures also to give back quality to the dismantled areas derived
from the contraction of industrial activities in the plain. The vast wetland system suggested by the National research team, aimed at creating a network of green public spaces, is integrated within a system of canals and basins for the sustainable management of water flowing from Vesuvius in order to mitigate effects of rain peak, showing how a multilevel and multiscale strategy focused on green and blue layers can be effective for risk reduction and for redefining a local identity also in a monetary perspective. The parallel between the Mithi River and East Naples cases, and the recognition of possible common approaches even in such distant territorial contexts, show how global strategies deriving from transmigration of knowledge can be effective if adapted to local values, defining planning and design solutions based on the specific potential of the site for building a resilient landscape in which green and public spaces have a primary role in redefining a sustainable approach to the management of strategic resources as water and soil, thus leading to a resilient-based retrofitting of the urban system as a whole.

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