PROSTHETIC ECOLOGIES

ALTERNATIVE STRATEGIES FOR THE LEBANESE COASTAL RIVERS' SYSTEM

Sandra FREM
Architect, Urbanist
platau | platform for architecture and urbanism

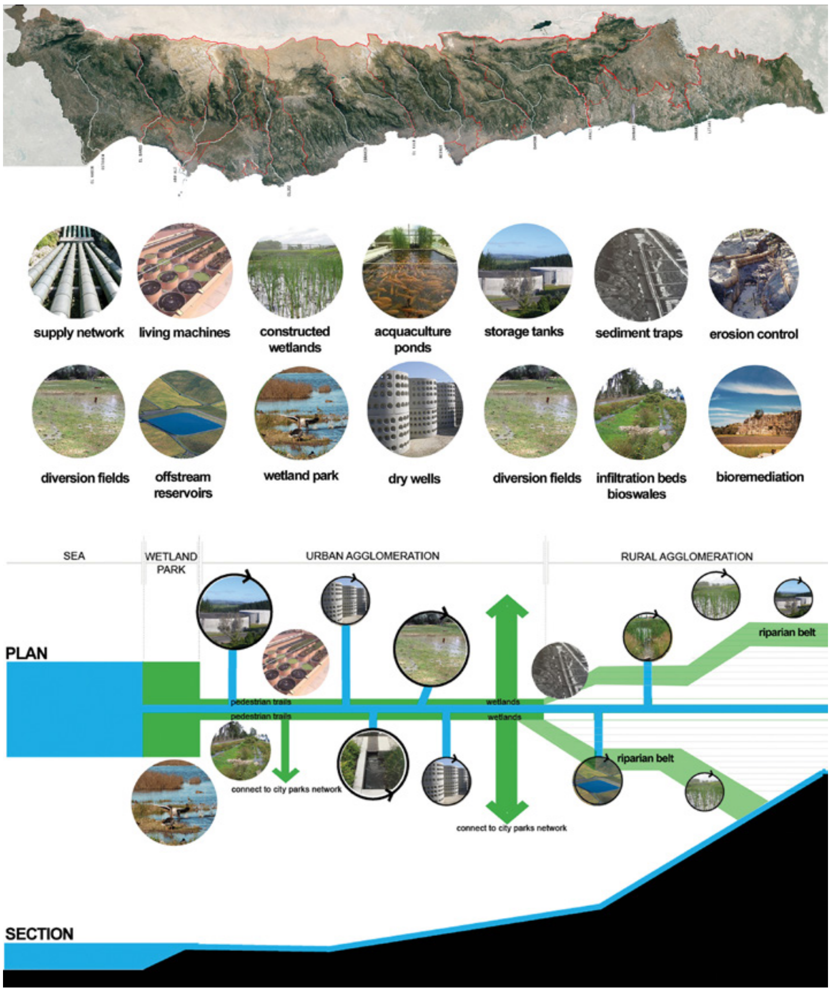

Figure 1

INTRODUCTION

This paper focuses on the Lebanese coastal river system as a strategic place that remains. Comprising a total of seventeen rivers, this system is currently undergoing major urban stresses and physical amputations, such as the tightening of floodplains, the discontinuation of hydrological systems, and a loss of river space to urban development; a predicament worsened by an unraveling water crisis and an outdated approach to water infrastructure (Figure 1).

The paper opposes the ongoing approaches to waterworks on coastal rivers, which are resulting in massive infrastructure such as concrete channels in lower basins and dams in upper basins. Not only does such infrastructure erase the local ecologies and cultural landscapes which they inscribe, but their mono-functional design does not adapt them to shifting hydrological, social and climatic conditions. Furthermore, their centralized modes of governance are leading to their technical failure, including high implementation costs, high risks in case of failure and no possibility for water reclamation. Considering the abovementioned challenges, and recognizing water and open space as increasingly valuable resources for the future, the paper proposes a "prosthetic" approach that rethinks the rivers' role as an answer to some of the coast's intricate challenges, combining water harvesting and water reclamation with opportunities for public space and new ecologies, all embedded in an open space landscape framework (Figure 1).

Borrowing from the medical behavior of prosthetics, artificial limbs that replace missing body parts in order to yield resilience, the approach proposes the deployment of multi-functional water structures along the coastal rivers that remedy the different types of stresses, in addition to harvesting and reclaiming rainwater and wastewater independently. As they are situated in the upper and lower basin of the coastal rivers, the different structures are more easily upgraded and controlled at the municipal level, allowing local water reclamation and reuse for the respective towns, and creating closed water loops that meet future water demand. Coming in different soft typologies, the proposed water structures act as prosthetics that adapt to site-specific conditions, providing local scales of public realm, communal experiences and water reclamation that large infrastructures lack. Through the collaborative efforts of the small-scale structures, the overall network will yield ecological resilience and integrated water management to each watershed system.

The paper takes the Beirut River lower basin, the Beirut River upper valley and the Bisri River Dam as test sites for the abovementioned approach, demonstrating how a catalogue of small-scale prosthetic structures can be integrated into different scenarios as alternatives to concrete canals, dams, and as water-harvesting grounds that preserve the spaces that remain.

FROM LIFELINES TO BORDERLANDS TO PLACES THAT REMAIN

Situated between the Mediterranean Sea and Mount Lebanon, the coastal rivers' system organizes the linear territory in successive adjacent watersheds, with the rivers acting as hydrological lifelines that drain Mount Lebanon of snow each year and recharge the aquifers. Since the fifteenth century, such rivers came to play an important socioeconomic role, as watermills that allowed the processing of grains into flour became hubs for commercial and social encounters.

This socio-ecological metabolism changed drastically in the mid-twentieth century, when fast-paced urban development overlaid the system's lower basins, casting major stress on the rivers as they became the physical limits and administrative boundaries that separated municipalities, cazas, and governorates. At first, the river valleys transformed into spatial borderlines where unwanted land uses and social groups were allocated, such as industries, agriculture, highways, and refugee camps, with no further consideration for their cultural past and ecological potential.

Today, coastal rivers are witnessing another turning point, as the open space along their watercourses is becoming rare and coveted for real estate speculation in urban areas like Beirut, Antelias, Nahr El Mott, but also in the suburban towns of their upper basins, making them the last open sites on the coastal territory that are in dire need of preservation for an ecologically well-functioning coast.

RE-SCALING INFRASTRUCTURES: FROM CENTRALIZED MODELS TO DECENTRALIZED NETWORKS

In response to the already established water crisis plaguing the coast, the current water harvesting and management infrastructure, such as dams and flood mitigation canals superimposing the Lebanese coastal river system, consists of large-scale waterworks that are causing ecological, social and economic harm to both rural and urban territories. This is the case for the lower basins of Nahr Abou Ali, Nahr El Mot, Nahr Antelias and Nahr Beirut that were canalized as a way to control floods, and the upper valleys of Nahr Ibrahim, Bisri, Janneh, Balaa, Brissa, "harvested" through dams that will be completed within the next few years, just when the major dams of the twentieth century are being decommissioned in other parts of the world.

In addition, water supply and treatment infrastructure, such as pumping stations, water supply pipes and wastewater treatment plants, is being controlled by centralized entities such as the Council for Development and Reconstruction (CDR) with regards to its design and implementation, and the Ministry of Water and Energy in terms of its governance. Due to their central locations and losses in the piping network, such systems come with high energy consumption, high operating costs and low delivery efficiency. Because of their central governance, they have unequal modes of distribution between source and network, and no option for the treatment or reclamation of used water. In addition, the current water supply infrastructures rely exclusively on primary water-harvesting sources such as rainfall and water tables, sources that are no longer sufficient to meet present and future water demands.

The aforementioned issues pose an urgent need to resort to secondary sources like water reuse and reclamation, all while reconsidering the scale, role and reach of this infrastructure.

While water supply piping networks are essential to maintaining the large scale operated by central agencies, structures like wastewater treatment plants, water-reclamation structures and rainwater-harvesting structures should be considered in their planning, design and governance at the municipal scale. This change to networked small-scale structures will allow these typologies to combine performative roles with social and ecological benefits, like local water reclamation, and communal recreational spaces.

PROSTHETIC TYPOLOGIES

Through multiscalar strategies that move from the territory to the town scale, the following framework proposes different strategies of arrangements, depending on their context.

Beirut River Canal[1]

In the case of lower basins that intersect dense urban contexts such as the Beirut River Canal, the strategy comprises three systems of water treatment and

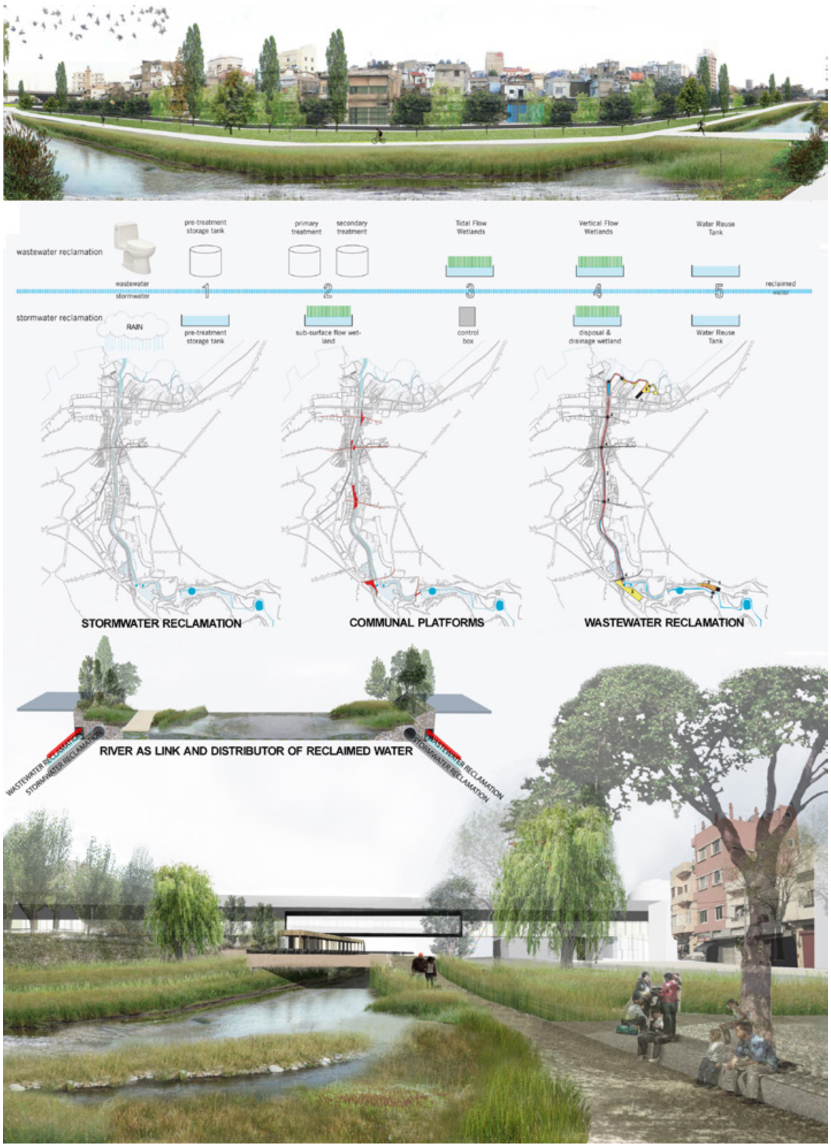

Figure 2

reclamation, organized in an integrated open space framework (Figure 2).

Firstly, a storm water storage network that is directly linked to the river: Water structures can take a variety of design forms (dry wells, off-stream reservoirs, infiltration beds and diversion ponds), allowing public programs to be implemented on top of them: pedestrian and bike trails, playgrounds, communal agriculture and freshwater fish lakes. In addition to reclaiming water in capacities of up to 200,000 m3, such a storage system becomes an alternative flood mitigation apparatus that allows for decanalizing the river, replacing the high channel walls with lower banks and opening the river corridor to the city.

Secondly, a storm water treatment network of constructed wetlands and bioswales that clean urban runoff using biological processes: Linear wetlands provide the ecological and pedestrian continuity of river corridors, expanding to become wetland parks and estuaries at the Mediterranean Sea. Overlaid with dense tree canopies that provide shade, these landscapes will become microclimatic corridors that significantly reduce the urban heat island effect (UHI) and air pollution, reaching out to connect to other green spaces in their respective cities.

Finally, a living machines' network that treats and reclaim wastewater: Locally situated in each municipality instead of the government's proposed central water treatment plant at the Bourj Hammoud Waterfront, these structures will occupy smaller footprints, and combine mechanized primary and secondary treatment using microorganisms, with tertiary treatment through wetlands and aquaculture ponds, and allow local water reclamation for each municipality using gravity instead of pumping.

At the intersection between the upper and lower basin, sediment traps will be deployed to reduce sediment deposit in the lower basin. This prosthetic typology engages existing economies, such as nearby construction factories in the Mkalles industrial city, allowing the latter to clean the traps regularly, in return for free sand and gravel. Through embedded piping and linear wetlands, the river infrastructure is the common link between the different structures, and redistributes the reclaimed water to the municipalities of Beirut, Bourj Hammoud, Sin EL Fil, Furn El Chebbak and Dora as an alternative water supply.

As a result of such an approach, Nahr Beirut and rivers in similar conditions will become ecological corridors, spreading the amenity of open green space throughout their respective cities, and recreational areas that improve the quality of urban life.

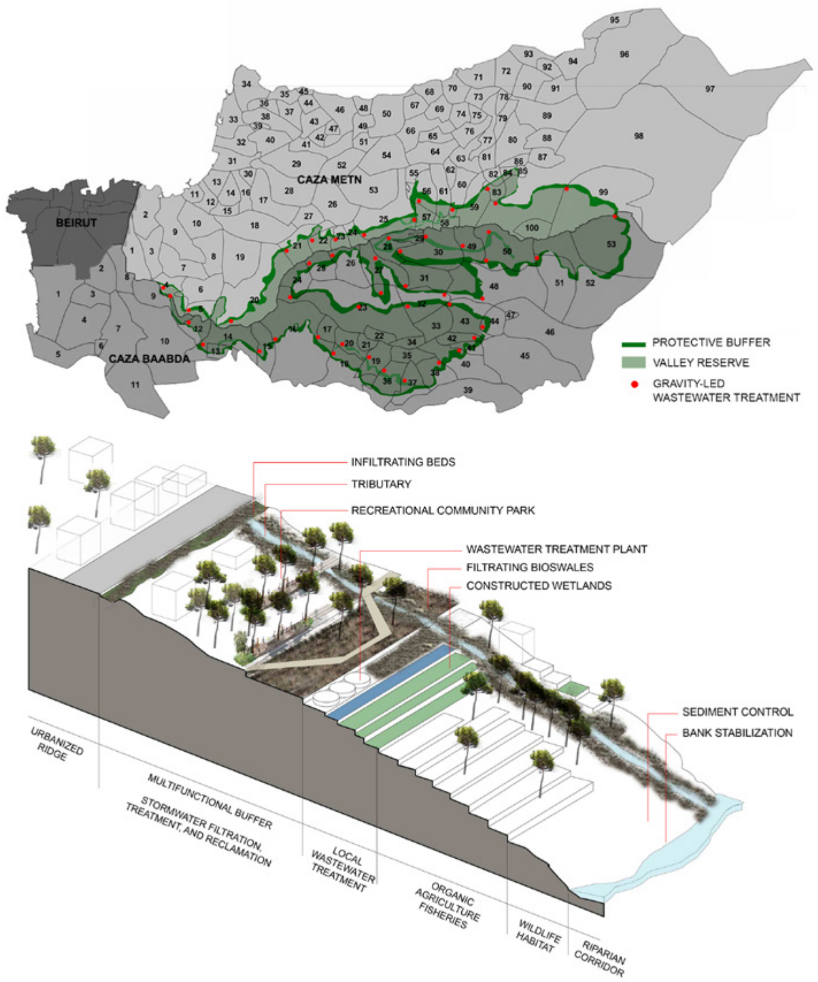

Figure 3

Beirut River Valley

In urbanized upper basins such as the case of Beirut River Valley, the river will evolve into natural reserves, protected by a riparian buffer which involves remediative and harvesting processes, that draw a separation line between built edges and protected non aedificandi space. (Figure 3)

In each municipality, the buffer width fluctuates depending on the program and adjacent land use. Situated in favorable topographic conditions, prosthetic structures are deployed within the buffer to filter and protect the river tributaries while integrating different processes such as wastewater treatment and reclamation using vertical flow wetlands, stormwater treatment through bioswales and infiltrating beds; and in cases of specific contamination, intensive bioremediation sites as a transition phase.

Cultural programs are layered 'lightly' onto the system to provide a variety of recreational experiences. The reuse of the reclaimed water can happen at the local scale through small scale pumping; through natural gravity to reinforce productive landscapes in the valley- like terraced agriculture or fisheries; or alternatively, can be exchanged with adjacent municipalities situated at lower levels in return for power.[2] (figure 3)

The first phase of implementation is to allocate all undeveloped land within the buffer to be protected. To incentivize this process, landowners will be given transferred FAR for redeveloping land outside the buffer.

Complementary design and management will ensure the riparian buffer success. By breaking down the territorial strategy into manageable municipal scale, it is easier to build accountability and a sense of ownership. Each municipality will have a program responsible for overseeing the protection of its buffer corridor.

As towns become smaller in size in the upper basin, prosthetic structures become entirely natural, allowing

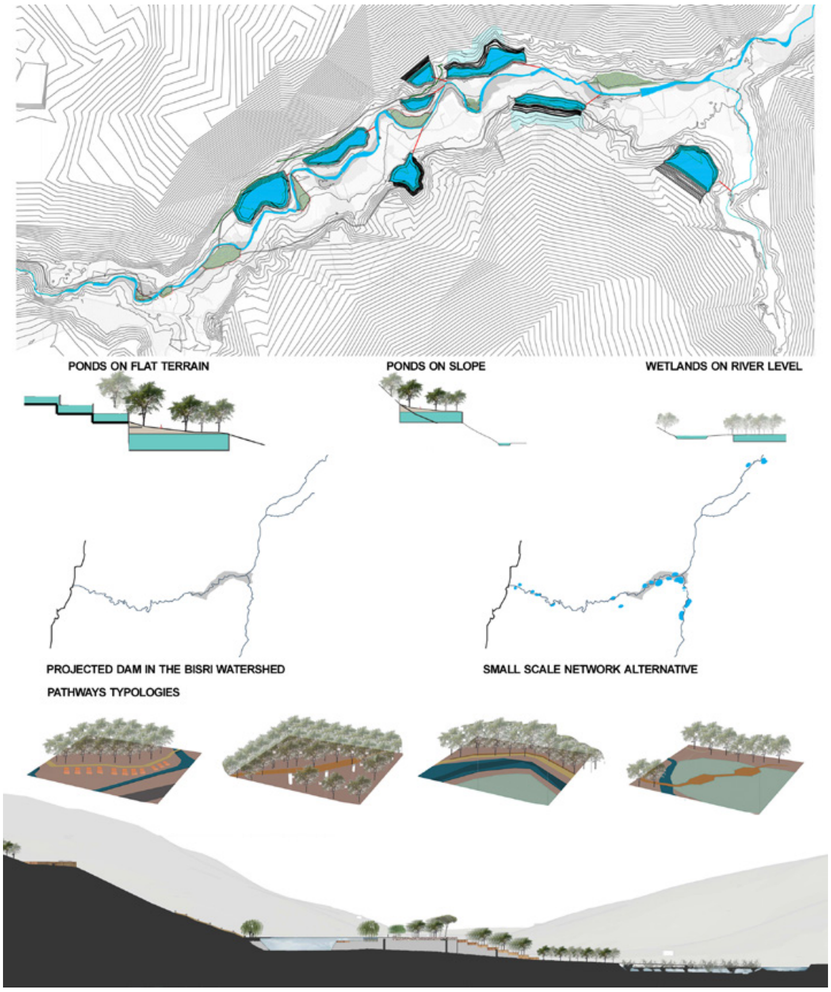

Figure 4

for local implementation and management through their low cost and low maintenance.[3]

Bisri River Dam[4]

At the emplacement of projected dams, such as the case of the Bisri River Dam, the prosthetic network combines rainwater harvesting with retention ponds, seasonal dams and wetlands, as alternatives to the massive dams proposed by the government (Figure 4)

Working with topography, each pond location was identified, and located offstream with channels that bring water from the river by gravity.

Wetlands were deployed in areas where the river used to flood. Each ponds and wetland can hold individually 900000m3. Located after the wetlands, seasonal dams can collect river water through small barriers made from plastic or steel and wood. Using the same combination of ponds/wetlands in numerous sites along the entire river, the whole system can reach a maximum of 20 million m3, roughly a quarter of what the dam can harvest, but on the other hand, the proposed structures will provide a series of active and passive recreational activities to the community and visitors, by having trails, gathering spots, open yards and platforms that surround the ponds; bringing a local ecological and communal value to the site, even though the water harvesting is catering to the large scale region.

CONCLUSION

Worldwide, practices in watershed management and water engineering are moving to integrated, soft and networked strategies, as such approaches are increasingly proving to be ecologically, economically and socially resilient. Such an approach advances a mentality and scale evolution in the perception, planning and governance of waterworks, and opens new possibilities for collaboration between municipalities around common boundaries, leading to a bottom-up integrated watershed planning.

In the different scenarios, resilient water infrastructure was deployed as a mean to preserve open space and water, as valuable resources for the future, and for the ecological and social welfare of river communities. The proposed decentralized systems advocate for decentralized models of governance, that will give autonomy to each municipality in harvesting and managing its resources. These models have already begun to be implemented in other infrastructural sectors such as solar energy, waste collection and recycling, and could expand eventually to the domain of water.

FOOTNOTES

1. Case study developed by the author as a graduate thesis in architecture and urbanism at the Massachusetts Institute of Technology. See Frem, S. 2009. Nahr Beirut: Projections on an Infrastructural Landscape. MS Thesis, Massachusetts Institute of Technology, Department of Architecture.

2. A suggestion made by Mr. Rached Sarkis in reference to the Remhalla water treatment and reclamation project.

3. That is the case of Remhalla Municipality's wastewater treatment, a pilot project of water treatment and reclamation completed in 2012, consisting of constructed wetlands on a municipal land to treat the town's wastewater, and resulting with a municipal tree nursery, that is irrigated from the reclaimed wastewater.

4. Case study by Rani Chamseddine (2017), developed during the final year project course at the American University of Beirut, Landscape Department, advised by Sandra Frem, Nayla.Al Akl, and Beata Dreksler. R.Chamseddine.

LIST OF FIGURES

Figure 1. Above, the Lebanese Coastal River system showing administrative boundaries (red) and rivers (white). Middle, a catalogue of prosthetic structures. Below, networks of water structures collecting storm water, treating wastewater, and distributing reclaimed water. Author: Sandra Frem.

Figure 2. Above, photomontage of the new canal along the Beirut River after the deployment of a supportive storm water mitigation system. Middle, mechanisms of storm water and wastewater treatment and reclamation in the dense urban contexts of the lower basins. Below, a typical plan and section showing non-prescriptive deployment of prosthetic structures along coastal rivers. Author: Sandra Frem

Figure 3 and 4. Above, alternative water-harvesting system for the Bisri River Dam. Middle: the Bisri River with dam, and with proposed alternative water system. Below: typologies of trails that overlay the water system. Author: Rani Chamseddine

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AUTHOR

Sandra FREM is an urbanist, architect, educator, and co-founder of platau | platform for architecture and urbanism. Her design research investigates resilient cities and systems, infrastructural landscapes, and the relationship between cities and water, more particularly in the Mediterranean context. In her practice, Sandra is interested in exploring new expressions of architecture and landscape, as well as leading urban initiatives, in collaboration with municipalities and NGOs, that propose meaningful transformations for streets, public spaces and territories. Since 2016, she holds an academic appointment at the American University of Beirut, where she teaches final-year projects in Landscape Design and Ecosystems Management.