



## Multilevel rivers for contemporary urban spaces From research to design solutions

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### **ABSTRACT**

The paper is part of the debate and experimentation on architectural and urban design resilient to climate change and investigates the possibilities of reusing riverbeds in important cities in the southern Mediterranean and Middle East areas such as Genoa, Malaga and Isfahan.

These riverbeds, due to climate change and a series of hydraulic works, are today characterized by a strong variability of the water level and abandonment, even if they represent central areas of the urban structure available to host contemporary public spaces of cities through innovative design solutions.

In this perspective, the paper contributes to the debate with a review of theoretical references and recent international practices and a comparison of three selected case studies (Bisagno-Genoa, Guadalmedina-Malaga, Zayanderud-Isfahan) that have been the scope of didactic design experimentations in the framework of international workshops promoted by Sapienza University in collaboration with other Universities.

**Keywords:** water, multilevel-river, public space, urban regeneration.

**Thematic clusters:** 2. City and Environment.

**Topic:** 1. Environment, landscape, resilience and climate change.

## 1. Introduction

The current territorial and urban agenda is characterized by climatic, environmental and anthropic challenges (OECD, 2020; IPCC, 2022). On the one hand, the main issues refer to the protection of fragile territories, landscapes and settlements; on the other hand, the uses, performance and efficiency of architectural artefacts and urban furniture constitute a fundamental theme in the urban planning and architectural debate (Iacononi, 2022).

In this perspective, urban planners are asked to give answer to the following question: how can we make cities more resilient and able to counter and mitigate climate change and its consequences, both in the short term of the emergencies and in a long lasting perspective of sustainability?

Even if many urban contexts still face relevant criticalities, the policies concerning the urban planning and design of river basins and the safeguarding of river landscapes have marked great achievements in Europe (EC, 2013, 2021). In many cities around the world, the reconfiguration and renaturalization of the river banks is considered an excellent driver of urban regeneration and is supported by political agendas (White, 2010). The projects of the Emscher park, the Bilbao river, Madrid Rio, Quai de Seine and Seine City Park, as well as the many projects in the Netherlands illustrate the central role of rivers in relation to the upcoming urban challenges (Gasparrini, 2015; Ravagnan & Poli, 2017).

Furthermore, even if the most advanced experiences are confronted with the management and regulation of an excess of rainwater in other parts of the planet, in many contexts such as Southern Europe and Middle East, the issue often relates to the scarcity of water. A shortage that is causing substantial modification of the landscapes as well as of the way in which the urban space is lived.

In this context, the riverbeds are central areas of the urban fabric available to accommodate a range of activities and public spaces of contemporary cities through the design of solutions capable of transforming the condition of water level variability from a problem into an opportunity for the construction of dynamic landscapes and identity places (De Cesaris 2022). Upgrading the water system and reactivating the relationship between waterways and urban space are, in fact, actions that can now play a crucial role in the regeneration of our cities and water is a key element of regeneration in the ecological transition era.

In particular, it is possible to transform the water crisis into an opportunity for integrating public spaces, structures and facilities as systems for production of clear energy or free time urban spaces, open air museums, able to enhance citizens creativity and to point out the power of art and architecture as a driver of inclusion and social innovation (Borja & Muxi, 2001). The variations of water level can thus become a characterizing element of the urban landscape (Ravagnan & Poli, 2017).

According to this strategy, the defensive approach related to the great works, masterpieces of modern engineering – based mainly on regimentation and canalization such as dams and embankments – can be overcome by an adaptive approach related to a series of water infrastructures supported by nature-based solutions (Sgobbo 2018). Due to their smaller scale, these design solutions can be scattered all over the territories; often they are also able to hybridize with other functions, setting aside their mono-functional status (De Francesco, 2020).

In this perspective, the paper contributes to give answer to following research questions:

- Is it possible in the contemporary era to reconcile technical infrastructure and urban space?
- Is it possible to define new water landscapes along riverbanks and seashores, new kind of elastic and adaptable landscapes?
- Can the remodeling of the soil, through excavation and fill works, define a new “multilevel topography”?

## 2. Methodology

### 2.1 Aim of the paper

In this framework the aim of the paper is:

- to investigate the possibilities of restoring an urban role to the river even with less water and to identify reversible solutions valid both in times of river flooding and dry periods;
- to pinpoint sustainable strategies to bring water back to flow along river in a vision of a better management of water resources;
- to identify a set of actions capable of reconciling technical infrastructure and urban space even in countries characterized by drought and water resource scarcity.

## **2.2 Methodological approach**

The paper illustrates the results of an articulated academic activity held at Sapienza University by the authors, in the framework of two international workshops promoted by Sapienza University in collaboration with other Universities. The adopted methodology links research and experimentation on three selected case studies (Bisagno-Genoa, Guadalmedina-Malaga, Zayanderud-Isfahan), combining preliminary seminars held by professors and scholars and a design experimentation held by the students.

The first workshop, entitled “A new life for Zayanderud” (coordinated by Alessandra De Cesaris e Ghazal Farjami) has been organized by Sapienza and Daneshpajohan Pishro Higher Educational Institute (DHEI) Esfahan (online) from 7<sup>th</sup> September 2021 to 15<sup>th</sup> October and has involved 14 students.

The second Workshop, entitled “H2O Multilevel rivers. Climate change and urban spaces. Multilevel rivers for contemporary challenges” (Coordinated by Alessandra De Cesaris, Andrea Iacomoni e Chiara Ravagnan) has been held at Sapienza from the 19<sup>th</sup> to the 23<sup>th</sup> of September, 2022, with the involvement of 30 international students, organized in three groups (Malaga, Genova, Isfahan).

The workshops have started with international seminars that have been held as a preliminary activity, with the contribution of international professors and scholars, which have illustrated the scientific and cultural background developed in research activities related to theoretical and methodological references for the urban and environmental regeneration of rivers in the face of climate changes. The main topics and approaches are synthesized in the introduction of the paper.

The second part of the workshops have developed a design experimentation held by the students supervised by the coordinators of the workshop, focusing on a multi-scalar design framework that considers the river as an urban guideline for the urban and environmental regeneration of the contemporary city as well as a multi-level public space to face the variability of water and the landscape fruition. The analysis and design proposals are illustrated in the following paragraph 3.

The conclusion illustrates the closing remarks supported by the comparison of the three case studies and the design experimentation, suggesting references for integrated and multi-scalar design solutions for urban regeneration in the face of climate change.

## **2.3 Results**

The results relate to design solutions that enable to face the variability of water, considered as an opportunity and that foster a better integration of urban sections of dry rivers, in order to increase the resilience of cities in the face of climate change, improving people’s quality of life in urban areas characterized by dryness and water scarcity.

In particular, the study and experimentation carried out show the possible definition of common guidelines and design solutions in order to face global issues. At the same time, the attention to the specificity of urban and territorial contexts points out how resilience is linked to the study of local morphological and landscape characteristics.



Fig. 01 Views of Guadalmedina (Malaga), Zayanderud (Isfahan), Bisagno (Genoa)

### 3. Cases study analysis

#### 3.1 Malaga. Breaking the wall

##### 3.1.1 Guadalmedina. From problem to opportunity for Malaga

Malaga is localized in the South of Spain in the Comunidad Autonoma de Andalucia, along the Costa del Sol.

The city was born and developed with its port between the Mediterranean Sea and the so called Montes de Málaga, nowadays recognized as a Natural Park. The main rivers of Malaga are the Guadalhorce and the Guadalmedina, whose name means "river of the city".

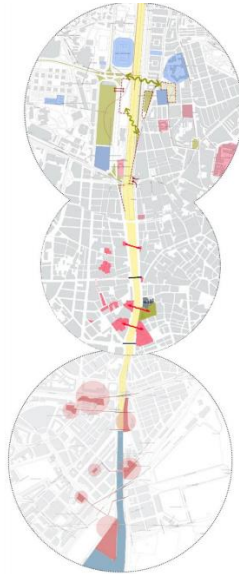
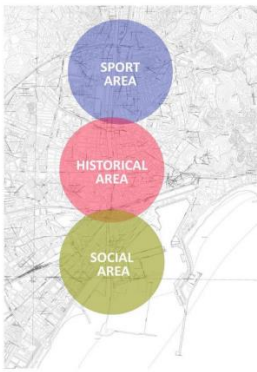
This hydrographic system is part of the Andalusian mediterranean basin between the mountains and the coast. The abruptness of the orography has determined very pronounced slopes next to the urban area of Malaga. This aspect, weakened by the characteristics of the said slate terrain, easily disintegrated by atmospheric agents, explains the enormous amount of drag historically brought by the rivers into the urban area, located at the end of a steep valley, at the mouth of the Guadalmedina. This problem has been strengthened by the deforestation of the Montes de Malaga, cut down for the cultivation of the wine, leaving the city defenseless against the storms. (Duran Valsero, 2020).

After historical floods in 1661, 1764 and 1786, and a series of minor events in 1901, 1902, and 1905, the flood of September 1907 occurred (without rain in the city) when an avalanche of water and mud from the Guadalmedina basin rushed over Malaga. The avalanche of water and mud first knocked down many bridges. The river quickly flooded the neighborhoods of El Perchel and La Trinidad and many other lower areas of the city. During the catastrophe, twenty-one people were drowned, and many others were injured. The waters reached up to five meters high. Relevant works were built to prevent new floods in Malaga: on the one hand, reforestation and on the other hand, the construction of dams and reservoirs (Olmedo Checa, 1999).

Many works for reforestation were carried out along the last century, starting in particular from 1919. The last government initiative aimed at increasing the forest area of the Guadalmedina basin was carried out by the Malaga City Council in 2002, with the expropriation of almost 400 ha on the right bank, which were reforested in collaboration with the Ministry of the Environment. The first dam of El Agujero was built after the flood of 1907, in order to retain the waters of the great autumnal avenues of the Guadalmedina. Years later in 1983, the Limonero Reservoir was built, leaving the old one unusable (Olmedo Checa, 1999). These artificial equilibrium let the river dry until today.

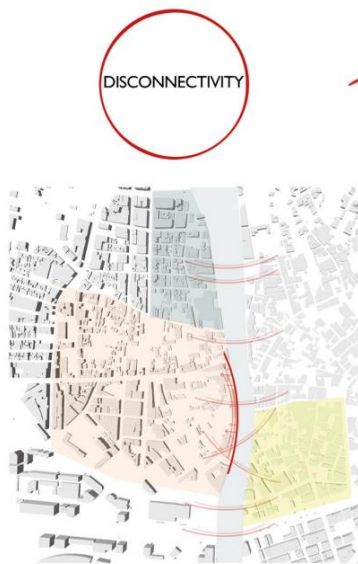
The degradation of the riverbed and the abandonment of this corridor represents a scar in the urban physical and immaterial networks. The urban fragmentation caused by the abandonment of the river is exacerbated by the long wall along the river. This wall cuts the physical and perceptive connections between the two sides of the city, contributing to the imbalances between the high urban quality and identity of the historic centre and the deprived contexts of the east bank (Ayuntamiento de Malaga, 2011).

STRATEGY



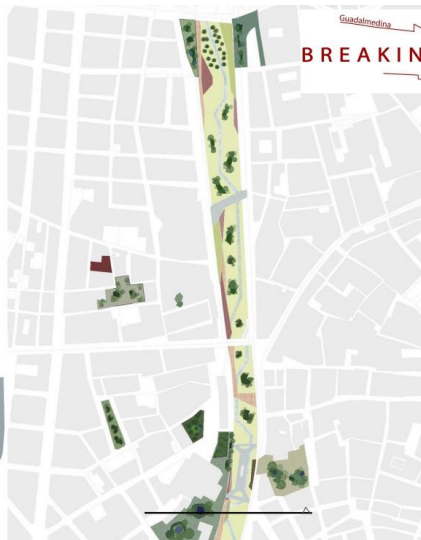
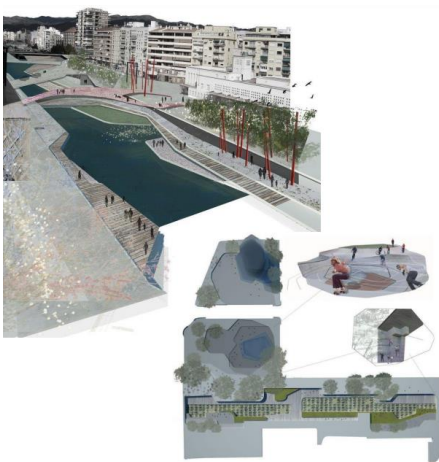
Guadalmedina  
**BREAKING THE WALL**  
 وادي المدينة

Fig. 02a The urban strategy. Authors: N. El Hayek, D. Incesu, G. Leonetti, O. Ozbay, M. R. Amal Riffi



Guadalmedina  
**BREAKING THE WALL**  
 وادي المدينة

Fig. 02b The reconnection of the city across the river. Authors: N. El Hayek, D. Incesu, G. Leonetti, O. Ozbay, M. R. Amal Riffi



Guadalmedina  
**BREAKING THE WALL**  
 وادي المدينة

Fig. 02c The river as a multilevel public space. N. El Hayek, D. Incesu, G. Leonetti, O. Ozbay, M. R. Amal Riffi

In accordance with the national debate and the agenda on ecological transition and green infrastructure, the Local Authority has launched a project of regeneration that considers the river as a strategic component for urban and environmental regeneration. The interest of the authority confirms the importance to intervene in such urban contexts and opens a reflection on the role of the river as a guideline for integrated urban regeneration.

### 3.1.2. *Integrated challenges along the river. Reconnecting the nature, the city and the citizens*

In this context, the debate and experimentation promoted in the framework of the International Seminar and Workshop "H2O" (Juncal, 2022) have pointed out some planning and design strategies, based on the paradigm shift from the relevant artificial engineering interventions of the dams to a new water sensitive urban design approach. The main challenge is to give back to citizens the riverbed as a multifunctional public space related to an urban strategy based on the functional and morphological features of the urban fabric (Fig. 2a), with the specific role of mending the urban networks (Fig.2b), "breaking the physical and perceptive wall" along the river banks that contributes, together with the abandonment of the river, to the fragmentation of the city. The project is supported by natural based-solutions for the resilience of the city that consider the possibility to bring back a water system in the riverbed (Fig. 2c).

The urban design solutions point out three main approaches:

- *the river as an ecosystem and a green infrastructure* (EC, 2013), starting from a partial renaturalization of the river banks and a possible re-introduction of a small quantity of water in the riverbed, combining semi-natural elements with new nature-based solutions fostering adaptation to climate change, resilience to environmental risks (urban heat, runoff, pollution, sea level rise) and collective wellbeing fostered by natural elements.

- *the river as a guideline of urban morphology and landscape* (Gasparrini, 2015), implementing demolitions of the wall along the River Guadalmedina next to the main urban axes, mending horizontally and vertically the city and the river, through multi-levels pedestrians paths and public spaces as possible "fils rouges" of a unique and complex urban experience, based on the walkability and bikeability (Ravagnan & al, 2022).

## 3.2 Genoa and Bisagno. Multilevel river connecting the multilayer city

### 3.2.1 *Genoa and the Bisagno*

Genoa is a city with a particular conformation, squeezed between the mountains and the sea, it is structured in a small strip of land that is distributed from Levante to Ponente. Precisely because of the presence of the mountains, it is rich in watercourses with a predominantly torrential regime; the largest courses being the Bisagno River and the Valpolcevera Stream (Fantoni, 2020).

These two streams lap the historic centre, one of the largest in Europe, which in part still has portions of the walls, and other important areas (Caraceni Poggi, 1981). These include the old harbour, which highlights the city's fundamental relationship with water and various specialized buildings of contemporary and historical architectural value, some of which also interact with the area of the river.

It is worth dwelling on the relationship woven over the centuries by this city with its river, a kind of osmosis, where from time to time it is one or the other that takes over, one over the other or vice versa. The Bisagno cuts longitudinally the city, giving its name to the valley itself, fed by the tributaries flow: the Streams Lentro, Canate, Geirato, Torbido, Molassana, and Ferreggiano.

With its water in the Middle Ages mills were driven, furnaces were fed, and fields were irrigated. The Bisagno also has separated the territory not only from a physical point of view but also from a functional one; for many centuries in fact the right bank has been cultivated fields while the left bank was rich in forests (Rosso, 2014). A bipartition that was also reflected in the plain, with the higher part accommodating the city within the walls and at the opposite end the fields, interspersed at times with religious buildings, which were, over time, the focus for later expansions.

With nineteenth-century modernization, which would involve many Italian cities, the various parts merged. The valley area would initially house specialized buildings, then develop the various urban districts – partly as a result of the administrative annexations of the late 19th century – until the creation of Greater Genoa in 1926. In this period there is a saturation of the valley due to population growth and postwar speculation, with interventions also affecting the River, as the cementing of some intermediate sections and much of the Foce (the mouth of the river).

The Bisagno, as previously mentioned, has a torrential regime and for most of the year is dry, but is capable of sudden flooding, which is a constant risk for the administration and citizens (Savio, 2013). In fact, the cement works that have reduced the riverbed and the reduction of flooding areas have accentuated the damage caused by the many successive floods over time.

To control its flow, making this part of the city safe, work is underway to build the Spillway: a large underground tunnel that will intercept, once completed, the water of the Bisagno River in the area to the north, diverting it to the sea, alongside the Foce. It works with channels inside the embankments, which direct water, during major events, into the spillway.

### *3.2.2 Multi-level river. Connecting the multi-layer city*

The 'resilient city' is achieved by planning innovative social, economic and environmental responses that enable it to adapt (modifying) in the long run, to the stresses of the environment and history (Iacomoni, 2019). Thus, the Workshop followed various themes to define design proposals; in particular, it questioned the new-found configuration of the River which, thanks to water control with the construction of the Spillway, will increasingly present itself as a water-free space, representing an interesting opportunity for environmental re-functionalization (Iacomoni, 2022).

The entire stretch of the Bisagno River is about 25 km long, but the workshop focused the major intervention in the urban section, which not only influences the built area but also mobility, services, and the provision of public spaces (Delbene; Giberti, 2016). The riverbed was conceived as a new public space, with flexible areas, internal and aerial routes that intercept the mobility of the new Genoa PUMS – Genoa's Urban Plan for Sustainable Mobility that envisages a series of measures for the implementation of public mobility alternatives to the private car – connecting the various local parts that can integrate wider routes, both in relation to water, green spaces, new buildings and new socialization spaces. In the Bisagno area the construction of an elevated monorail, with drop-off stations at street level, is planned thanks to PNRR funding.

The intervention, therefore, was configured with special attention to the topography of this multilevel city (Fig. 03a), with its strong altitudes and reduced public spaces, in which several functions are often concatenated in overlapping places. The river becomes a new type of connection that, with its public spaces used as parks, recreational or for socialization, as well as places for art exhibitions, relates with the upper part of the creek through vertical connections.

The forthcoming construction of the elevated monorail, along the Bisagno riverbank, with vertical connections at street level, becomes an opportunity to systematize all levels (Fig. 03b), from the riverbed, to the embankment, to the monorail. The vertical connections become multi-level plazas, both as belvederes over the city and as intermediate levels with play and exhibition functions, until they lap the lower level where, if water is present, it will still be possible to stand.

A new topographical condition is generated in the more urban section, continuing the implementation (Fig. 03c) of hybrid systems, generated by the need to gain space where the topographical nature of the landscape makes this difficult or by the need to move faster vertically.

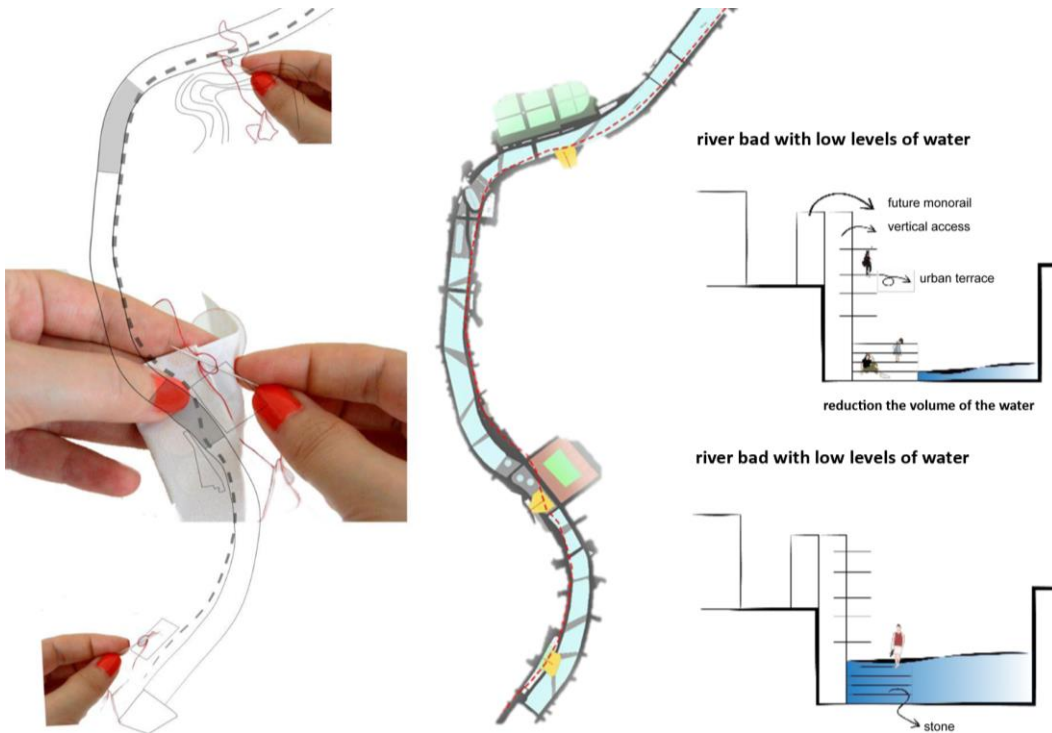


Fig. 03a connecting multilevel river. Authors A. Najafi, M. Seyed Abadi, A. Yousefzadeh, P. Salgoughi, A. Gol Mohammadi,



Fig. 03b multilevel city. Water, stadium and historical city. Authors A. Najafi, M. Seyed Abadi, A. Yousefzadeh, P. Salgoughi, A. Gol Mohammadi,



Fig. 03c multilevel public spaces. Art, sport, mobility. Authors A. Najafi, M. Seyed Abadi, A. Yousefzadeh, P. Salgoughi, A. Gol Mohammadi,



### 3.3 Isfahan: towards an elastic landscape of the Zayanderud

#### 3.3.1 *Isfahan and the criticalities due to a misconception of modernity*

Iran is an arid land where the shortage of water resources is causing enormous criticalities and significant migrations from the south to the north of the country. Critical issues that call for reflection on correct and sustainable water resource management and possible paradigm shifts towards alternative management strategies to those implemented in modernity according to an idea of progress that has entrusted water resource management exclusively to large engineering works (Alehashemi, Coulais, Hubert, 2020).

In Isfahan, the construction of a dam some eighty kilometres west of the city diverted water to intensive crops in the east and left the *Zayanderud* riverbed (literally the river that brings life) completely dry; thus not only was the minute fabric of fields and gardens on the western outskirts of the city left without water, but also the *Madi* - the canals that branched off from and reconnected to the river. This system had defined the form of the Safavid city and fed the extraordinary garden system perpendicular to the river (*Chahr Bagh*). (Revault, 2022).

*Zayanderud* and *Madi*, thus constituted an identity element of the urban form; riverbanks, where water flowed with different flow rates according to the seasons, together with its bridges were one of Isfahan's public spaces.

Today, again in the name of a mistaken idea of modernity - which draws on Western models that are not compatible with the character of these places - an attempt has been made to compensate for the river's lack of water by planting its once bare banks with a linear park with exorbitant water consumption.

Nowadays, as we come to terms with a general shortage of water resources, it is a question of balancing agricultural and urban needs, and the needs of agriculture – which can and must be reconverted towards intelligent irrigation systems and low-water-consumption crops – must also be matched by those of the quality of urban space.

It is essential to avoid waste - and the English-style park created by aping Western models absorbs unsustainable amounts of water; it is necessary to reclaim white water and rainwater wherever possible (even if it rarely rains in Isfahan). The *madi* need to be revived and the dense urban fabric re-oxygenated, through gardens, for example, portions of water need to be returned to the river bed, giving the river back its urban role. It is necessary to think of viable solutions in the absence or presence of water, and finally, it is necessary to reflect on solutions to water emergency issues that can generate urban regeneration operations.

These are very briefly the considerations underlying the strategies and actions implemented in the two workshops with the aim of integrating water resource management, new services and urban public space (De Cesaris, Farjami 2022).

#### 3.3.2 *Soil modelling: towards an elastic river landscape*

The modelling of the soil of the riverbed - of a clayey nature with accumulations of stones that have formed natural islands over time - can represent a way of channeling the flow of water in some strategic points in relation to the urban fabric and the city's frontage on the river.

Through small excavations and embankments, water can be channeled into a series of basins along the banks. These basins, with their elastic boundaries, would define a landscape of high variability depending on the flow - even minimal - of the river; they could also host resting spaces, thus reactivating the city's relationship with water and its river (fig 4b)..

But the now dry river bed can also represent a resource of space in the very densely built-up central area. So we thought of small islands with gardens and services – to meet the needs that have arisen in contemporary society – islands with a basement that can be flooded at different levels (fig 4a)..

A flexible solution valid both in times of drought and in times of flood if one day the water should return in abundance.

## A NEW LIFE FOR ZAYANDERUD artificial floodable islands

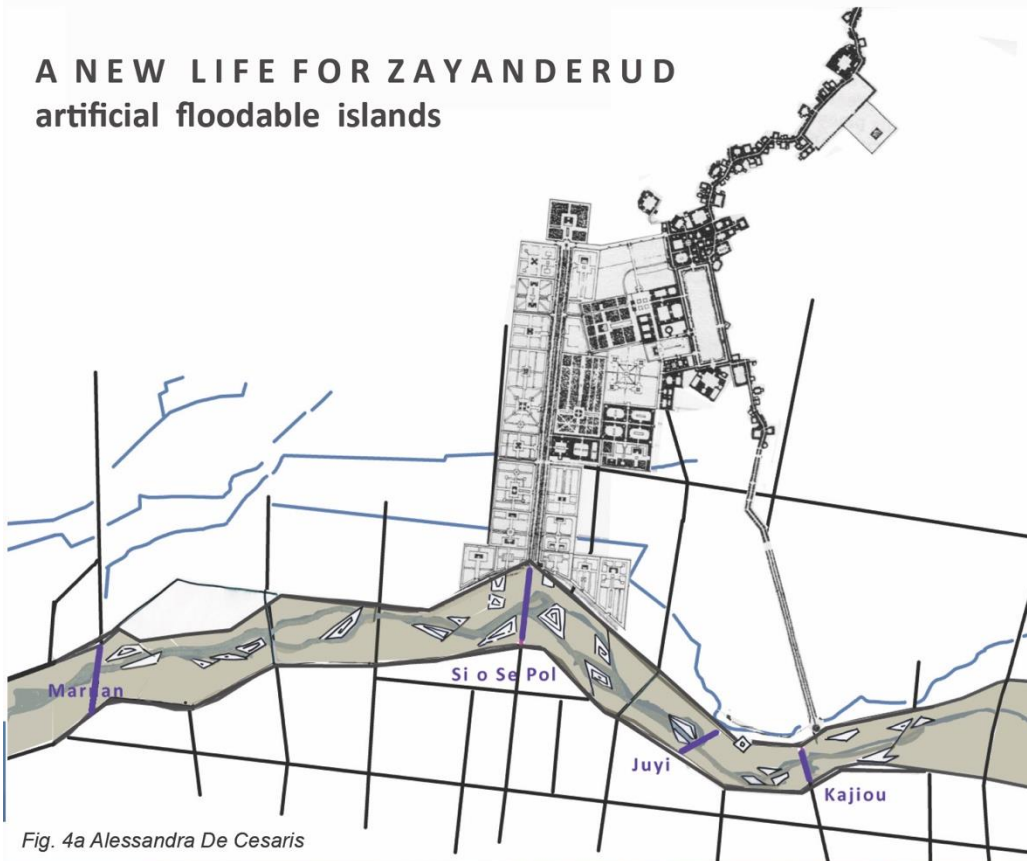


Fig. 4a Alessandra De Cesaris

## REFILL MADI AND ZAYANDERUD WITH PHYTODEPURATION WATER

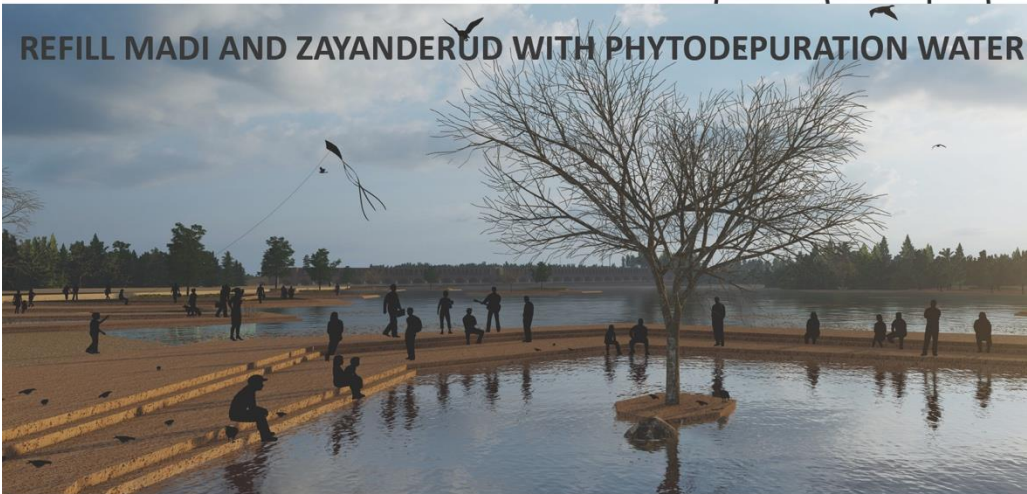


Fig. 4b Fatemeh Behrooz

## THE SYSTEM OF PHYTODEPURATION GARDENS

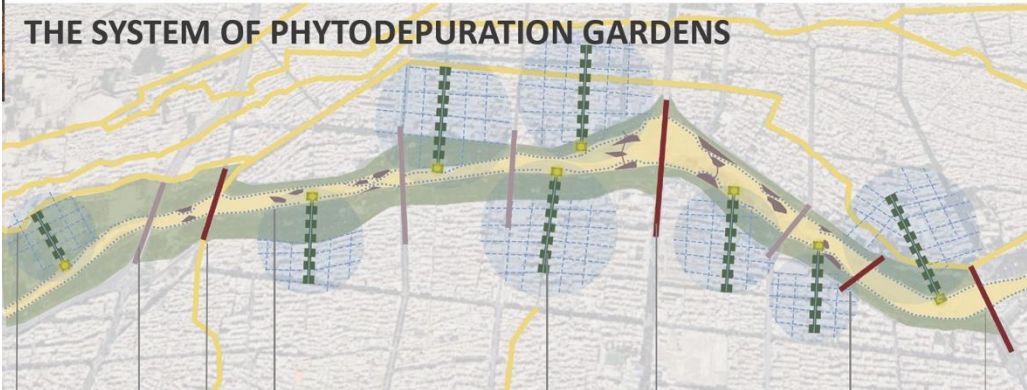


Fig 4c S. Azzam, A. Deghani, A. M. H. Khah, F. Ianiri, D. Mishra, S. A. Mousavi,

This may be a way to reinterpret in a contemporary key the complex relationship between the city of Isfahan and its waters. A relationship that, in the best Persian tradition, has developed in forms of close integration between technical infrastructure and public space. In fact, for centuries Iranian cities have presented a complex integration with water infrastructures, and in Isfahan the Kajou bridge, built under Shah Abbas I (c. 1650) is not only a link between the two banks of the river; it was conceived as a multifunctional building on three levels: it connects the two banks and integrates the public space with pavilions and resting places and acts as a dam: while on the downstream side, it connects to the river with a system of steps measuring the water level where it is possible to stop, the upstream side regulated the flow of water to irrigate the royal gardens or on certain particular occasions to flood a large section of the river (between *Choobi Bridge* and *Kajou Bridge*) where a water festival called *Ab pasan* or *Ab rizan* was held. Thus a flexible landscape was defined that could also accommodate the playful aspect.

### 3.3.3 *Phytodepuration gardens: towards a sustainable landscape*

Another hypothesis considered during the workshop was that of recovering the whitewater waste in certain portions of the building fabric and conveying it to phyto-purification gardens to be created in empty lots or lots occupied by ruined buildings (fig. 4c).

This can also be a way of reinventing the archetypal Persian garden. We thought of gardens enclosed by walls with small urban services and in the centre phyto-purification tanks. From here the purified water is channelled, depending on the slope of the land, to *Madi* or to the river.

This would define corridors of urban regeneration on the right and left banks of the *Zayanderud*, within a dense urban fabric currently lacking in greenery. This would create garden systems parallel to the historical urban axis of the *Chahar bagh*, garden systems mindful of the structural relationship between garden and city that characterised Isfahan's urban form.

## 4. Discussion and conclusion

The contribution highlights how waterless riverbeds can be strategic areas for urban planning and design in the face of climate and social changes and contemporary urban challenges.

The intention is to highlight the role that nature, landscape and public spaces play in the process of urban regeneration, with voids becoming a valuable resource, permeable soils capable of participating in the management of water resources and solving hydrogeological problems.

The students' projects are developed in different geographical areas, but with similar problems related to the degradation of the riverbed related to a loss of water, as well as the loss of the role and identity of the river and its historical relations with the context crossed.

To better understand what policies, tools, activities, and initiatives can be effectively deployed in urban contexts to counter and mitigate climate change and its short- and medium-term consequences (Farinella; Ronconi, 2008), some of the key points identified through the three workshop projects are outlined.

The elements, briefly summarized in the following points, can represent useful references for integrated urban design solutions, fostering an innovative relationship with water variability:

- 1 *the riverbed as a multi-level landscape architecture*, mending the different axes, layers, functions and areas of the city and capable of defining a new urban morphology.
- 2 *the riverbed as a green infrastructure*, with its ecological and social role, representing an effective reconnection of the city's natural and semi-natural spaces, supported by multi-level connections linked to soft mobility.
- 3 *the river as a blue infrastructure*, fostering white wastewater recycling, deriving from parts of the building fabric, into phytodepuration gardens, located in specially designated lots in strategic areas of the city.

4 *the riverbed as an innovative and inclusive public space*, integrating nature and culture, and reconfiguring the relationships between water, landscape and heritage with the support of contemporary urban art as a material and immaterial network.

The river is no longer seen exclusively as the bed that receives the waters, but a complex system of connected areas within a complex environment, with naturalistic contents and urban and landscape relationships. It can be configured as a sequence of functional layers, with different land uses that complete and integrate existing services, receiving the most interesting design inputs from the existent urban structures and polarities.

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