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Urban River Recovery Inspired by Nature-Based Solutions and Biophilic Design in Albufeira, Portugal

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Abstract: Mass urbanisation presents one of the most urgent challenges of the 21st century. The development of cities and the related increasing ground sealing are asking even more for the restoration of urban rivers, especially in the face of climate change and its consequences. This paper aims to demonstrate nature-inspired solutions in a recovery of a Southern European river that was canalised and transformed in culvert pipes. The river restoration project naturally tells the history of the city, creates a sense for the place, as well as unifying blue–green infrastructure in a symbolic way by offering areas for recreation. To improve well-being and city resilience in the long term, a regenerative sustainability approach based on biophilic design patterns was proposed. Such actions will provide greater health, social cohesion, and well-being for residents and simultaneously reduce the risks of climate change, such as heat island effect and flash floods, presenting the benefits of the transition to a regenerative economy and holistic thinking.

Keywords: built environment; urban design; regenerative design; sustainable development; river restoration; biophilic urbanism

1. Introduction

The global population is to reach almost 10 billion by 2050 according to revised projections [1]. Today, 54% of the world's population lives in urban areas, a proportion that is expected to increase to 66% by 2050 [2]. The underlying economic conditions and the need for growth, due to the growing population, have to include environmentally sustainable policies in order to address the problem in accordance with a healthy environment. Quality of city life and the attractiveness of cities are key parameters for success in the global competition for growth. In an effort to face the needs of our society we have to move from the idea of a circular economy towards a regenerative economy. While a circular economy is an attractive policy that aims to keep products at their highest utility through a positive developing cycle, a regenerative economy aims to create a stable and healthy system including not only green solutions but a humanistic and ecological values system that has to do with the rebirth of life itself [3].

The current system of conventional design, where we produce, consume, and create waste, placed us at the mercy of abrupt climate change and social and ecological collapse [4]. Regenerative systems, through their implicit design, do just the opposite. Regenerative economics is an economic system that works to regenerate capital assets providing goods and services that contribute to our well-being [5]. It is a principle of an ongoing self-renewal process, which built relationships and allows socio-ecological systems to constantly evolve.

Nature is regarded as vital for a fulfilled and healthy life and cities and urban planners are encouraged to advance Biophilic design: to bring more nature into the city, making it greener and

richer in nature [6]. It is unanimous that the relationship between green infrastructure and the urban environment is essential to increase well-being and population health. Therefore, as mentioned by Kellert [7], landscape design that reconnects the humankind with nature is essential to provide people with opportunities to live and work in healthy places with less stress and overall greater health and well-being.

As the world population continues to urbanise and the effects of global warming are predictable, a sustainable development that encourages our city's ecosystems rather than eliminating them is the most essential. Urbanisation causes a number of problems, such as the loss of green public space for recreation, increased surface runoff, and flooding hazards and thus, negatively affects people's well-being. Urban river restoration opportunities bring nature back to the cities and help to develop climate resilient cities [8]. Currently, the European Union is aiming to be a world leader in renaturing cities and researches projects of river restoration and nature-based solutions to promote climate resilience in urban areas [9].

Nature-based solutions reduce multiple risks, as well as contribute to climate change adaptation and mitigation. River restoration using nature-based solutions can help to reduce the risk of floods and heat waves, while improving the water quality and quantity. Green infrastructure provides numerous ecosystem services that positively affect people's lives [10]. The international literature provides a new evidence-based vision enabling cities to adapt, develop and reconnect with nature [10–12].

An objective of this paper was to demonstrate nature-inspired solutions for the recovery of the river of Albufeira in Southern Portugal, which was canalised and transformed in culvert pipes. The project proposal identifies actions to move towards a Biophilic City; ways to promote nature within the built environment; ways to improve well-being and city resilience in the long term; and also proposes a regenerative sustainability approach based on biophilic design. Such actions will reduce the risks of climate change, such as heat island effect and flash floods, and present the benefits of the transition to a regenerative economy and holistic thinking.

2. Theoretical Framework of the Study

2.1. *Biophilia and Biophilic Design*

Biophilia is humankind's inherited biological connection with nature. According to Browning [13], the constant existence of natural elements in our historical past, human intuition, and neural science shows that connections with nature are vital to providing a healthful and dynamic life as an urban species. Most of what we regard as normal nowadays is relatively recent, such as raising food on a large scale in the last 12,000 years, the invention of the city 6000 years ago and the mass production of goods and services since the 19th century. The long passed ages of humanity's direct contact with nature explains why crackling fires fascinate us, why a garden view can enhance our creativity, why animal companionship and strolling through a park have healing effects on mental and physical health [14].

The human evolution shows mankind evolving in an adaptive response to natural and not artificial or human created forces [15]. Additionally, Kellert and Calabrese [15] mention that the human body as well as its mind and senses developed in a bio-centric and not civil engineered world. Thus, a biophilic design deals with the relationship between nature and design of the built environment, while treating our surrounding environment with respect rather than domination. The biophilic design aims to utilise green infrastructure to improve people's health and well-being [16]. Therefore, a landscape design, which reconnects humankind with nature is essential to provide people with opportunities to live and work in healthy places with less stress and overall greater health and well-being. As global warming impacts well-being and the world population continues to urbanise, a sustainable development that restores urban ecosystems rather than eliminates them is crucial.

2.2. Development of Cities and the Metamorphosis of Their Rivers

Humans used to settle down close to riverbanks, where the soil is fertile and the source of food and possibility of transport are given. Over time this settlement has transformed the natural environment into the towns, cities, and ports we see today. In that way, the increasing migration to cities leads to an unsustainable evolution, where a development that meets the needs of the present generation without compromising the ability of the future generation to meet their own needs has declined [17].

As the settlement pressure in cities increases, green spaces have to make room for human settlements, the development for trade, industry, and infrastructure. Additionally, urban rivers have been heavily reduced to enable development, to carry waste, to supply drinking water, and facilitate transport. As mentioned by Prominski et al. [18], a city's first engineering constructions were designed to regulate rivers with the purpose to protect settlements from the destructive forces of floodwater. Nowadays, most urban rivers have been straightened and transformed into channels or underground culvert pipes.

Owing to the formulation and implementation of the EU Water Framework Directive [19], which aims to achieve good conditions in all European Water courses, an increasing amount of attention was directed towards urban rivers. This was not only about flood defence as a consequence of climate change, but the opportunities offered by rivers for recreational use becoming important as places for contemplation and rehabilitation. With considerable improvements in water quality through better wastewater treatment, rainwater management, and the establishment of water-purifying plants, urban rivers are no longer shunned as stinking backwater; according to Prominski et al. [18], it is the fairest face and the first impression visitors gain of a town.

In water management terms, predictions of climate change and isolated flood and low-flow emergencies have directed attention to the necessity of adapting urban river spaces. The prognosis of longer periods of drought, more frequent heavy downpours and rising sea levels has led to the critical examination of flood protection systems and of cities' water supply and wastewater systems. The 2007 EU Flood Risk Management Directive [20] committed member states to carry out precise evaluations of the dangers posed by flooding and to draw up management plans to improve flood protection. The resulting necessary mitigation works brought the need for change to the urban environment, both above and below ground. In parallel, the EU Water Framework Directive [19], prioritised ecological objectives, such as better water quality and watercourse structure, requiring the protection, enhancement, and restoration of all surface water bodies so that cities become more sustainable in a way that allows both current and future generations to meet their needs.

2.3. Urban River Restoration for City Resilience Enhancement

River restoration is an emergent activity in many countries because of the increasing awareness of environmental degradation [21]. In Europe, urban ecosystems have been degraded as a result of human activities. The development of cities and the related increasing ground sealing further require a restoration of urban rivers, especially in the face of climate change and its consequences. Hard surfaces prevent water from naturally draining through the soil, resulting in increased floods, erosion, pollution, and decreased habitat. Urbanisation affects a river in many ways including water quality, physical structure, and the ability to support wildlife. It also influences run-off from impervious surfaces such as roads, roofs, and water quantity because of the decreased flow and reduced groundwater levels through abstraction. These stresses make rivers less resilient to the effects of climate change, which would further have a negative effect on the cities' climate [22].

The simplest method to improve rivers is to return flows to a more natural state. Implementing a green-blue infrastructure, including sustainable urban drainage and green roofs, is a long-term approach to managing surface and groundwater by reducing the rate and volume of run-off [23]. In that way, river restoration directly improves the habitat, reduces the risk of flash floods, improves groundwater management, and decreases the urban heat island effect.

However, the consequences of catastrophic floods of the recent years, the need for more public green space for adaptation to climate change risks and the perception that we have to restore part of the damaged urban ecosystems have increasingly been called into question [24]. Urban regeneration is an opportunity to revitalise rivers and offers a variety of ecological, social, and economic benefits including an improved flood management using more natural processes, a reduced likelihood of negative impacts caused by climate change through increased ecosystem resilience, as well as a reconnection of people to the natural environment through better access to recreation and improved well-being [25].

The Cheonggyecheon river restoration project was an ambitious urban regeneration initiative that transformed the urban space of Seoul, Korea [26]. The river that had been buried under a highway in 1967 was recovered in 2002 by decommissioning the highway, excavating the new river channel and undertaking works for a linear park river corridor that decreased flood risk and created recreation opportunities [27]. The Madrid Rio Project was another urban regeneration project that transformed one of the most degraded and neglected zones of the city and became one of the most beautiful cultural areas. It connected green zones and historic gardens and recovered the use of the river [28].

2.4. Regenerative Design for the Degraded Urban Ecosystem

Restorative sustainability employs strategies in the city process of design that produce a positive impact on the natural environment, society, and human well-being, restoring socioecological systems to a healthy state [29]. Many European cities are frontrunners in the transition towards a low carbon, resource efficient, and green economy. Meanwhile, it is becoming clear that the built environment must go beyond this. It must have a net positive environmental benefit for the living world [30]. Creativity and innovation will build a new economic system to address urban growth problems in an entirely different direction. Regenerative design is an effort to build a green economy that restores the relationship between nature and people.

Key challenges for sustainable cities are to provide solutions to significantly increase cities' resource efficiency through actions addressing mobility, climate change, and environmental quality [31]. Such actions should bring profound economic, social and environmental impacts, resulting in a better quality of life (including health and social cohesion), jobs, and growth [32]. A range of design solutions can be adopted to improve aspects of urban design by reducing the heat island and other climate change effects [33]. The role of plants in mitigating and adapting the urban environment to climate change is mentioned in many studies about regenerative sustainability and resilient cities [34].

The regenerative design follows some principles by designing in an adaptable way without wasting extra materials, to restore, to reuse, to remanufacture, and finally to recycle. By using environmentally friendly adapted and reconstructed materials, we create a more regenerative built environment. Figure 1 presents the stages from conventional to regenerative design and consequently from conventional to regenerative economy. The main idea is to use holistic thinking instead of reductionist thinking, to move from technical systems development to living systems development, and from degenerating design to regenerative design to build into the landscape using patterns that connect nature and humans in a coevolving relationship [35].



Figure 1. The stages of development, from conventional to regenerative, showing that regeneration goes far beyond sustainability (adapted from References [36,37]).

The built environment is part of the climate change problem, thus, sustainability in green infrastructure has to be recognised as an adequate measure for current and future urban design. In this respect, regenerative urban systems have to address climate change; limited resources and social divide aiming not only to reduce but also to create positive impacts. Urban green infrastructure has to do with the improvement in energy, water, and carbon resources consumption, which will have positive effects on the place, health, and education. Thermal comfort and energy efficiency, net positive water, recycled or upcycled materials, a safe environment, good relationship with the place, positive feelings, and environmental justice are some of the positive effects of regenerative economy systems [38,39].

3. Materials and Methods

3.1. The Study Area

Albufeira is a small city in the southernmost Portuguese region of the Algarve. The municipality population in 2011 was 40,828, in an area of 140 km². A sea and sun tourist destination, Albufeira expands to more than 300,000 residents during summer. The climate is Mediterranean with hot and dry summers, an average temperature of 17.7 °C, 500 mm of precipitation (the highest month is January with 84 mm) and more than 300 sunny days. The Albufeira River crosses the old town and ends in Pescadores beach. This river creates frequent events of flash flooding because it was canalised and put underground in sewage pipes close to the old town, which according to studies of the regional hydrographic administration, were insufficient (>50 m³/s instead of 86–130 m³/s of expected runoff).

The river of Albufeira flows its natural course in a soft meander between low hills (Figure 2) ending in a small lagoon next of the beach in the Atlantic Ocean. Earlier the city was called Al-uhera by the Arabs when it was part of the Arab empire, which means that the coastal lagoon historically was a defining factor for the city. Before the tourism boom, Albufeira was a small fishing village with strong connections to the ocean and a fishery economy. Albufeira was a naturally built retention basin in the middle of the city, acting furthermore as a city harbour where the ecological water cycle managed heavy rain events by itself.

As urbanisation increased in Albufeira due to high demand from tourism, the lagoon was replaced by the new city centre, which is completely impermeable to water and does not reflect the sense of the place, supporting flash floods rather than preventing them. Rebuilding the natural river ecosystem running through the city will give Albufeira its individual sense back as well as protecting the city from flood hazards due to a biophilic urban design.



Figure 2. A representation of the medieval times city of Albufeira and a recent photo from the flash flood (obtained from the RTP TV channel during the news of 1 November 2015), showing that the buried river found its natural way to the Atlantic Ocean.

3.2. Analysing the Study Area by the Science of Strolling

The new proposal for Albufeira River recovery has to meet the main objectives, such as the creating of a sense of place, a biophilic alternative facing flood protection, and improving well-being, as well as socio-economic advantages of nature-based solutions.

The study area was analysed by the science of strolling, which is a method in the field of aesthetics and cultural studies with the aim of becoming conscious of the conditions of perception of the environment and enhancement of environmental perception itself. According to Burckhardt [40], the critical analysis of contemporary planning practices, through the perspective of a walker at the study area, can be characterised by four different zones each marked by their surrounding elements with conflicts as well as potentials arising out of the site-specific atmosphere of the surroundings as shown in Table 1. Figure 3 illustrates the four zones of the study area following the science of strolling.

Table 1. The conflicts and potentials of the study area.

Zones	Conflict	Potential
Zone 1: Backyard silence	Unshaded plain park area without identifying the character, no integration of the river and the bordering camping area	Extending the atmosphere of the densely planted camping area with its community gardens by integrating the river as a connecting element and thus, creating a cooling comfort as well as a backyard feeling for recreation
Zone 2: Sub-urban laughter	Lined up landscape elements (residential—areapark—road) without any interaction and the disappearing of the river from view	Making the residential area interact with the park due to the creation of a joyful public area with the river integration as the main attraction as well as providing a sound and visual barrier for the bordering road linking both sides by a pedestrian underpass
Zone 3: Nature chirping	Busy road separating the municipal green belt and negatively influencing the recreational nature experience the character of the area	Connecting the green belt by implementing a green bridge for animal migration as well as extending the forest atmosphere of the surrounding mountains by the creation of urban woods and wetlands, providing a retention basin tangible in all states of flood levels
Zone 4: Urban sounds	Heat island effect strengthened by the absence of the river and a climate adapted infrastructure, as well as the lack of a historical sense of the place	Recreating the sense of place as well as linking public urban spaces by following the symbolic waterline acting at the same time as a part of the city’s blue and green infrastructure



Figure 3. The four zones of the study area following the science of strolling: Area 1—backyard silence (A); Area 2—sub-urban laughter (B); Area 3—nature chirping (C); Area 4—urban sounds (D).

The strolling process is an alternative to the reductionist thinking and technocratic centrally planned economy. It is based on traditional methods in cultural studies as well as experimental practices like taking reflective walks and aesthetic interventions [40].

4. Results

4.1. The Concept of the Project

The concept of the Albufeira project for urban river recovery was inspired by nature-based solutions and biophilic design. It was inspired by previous research on biophilic design, the development of cities and their rivers as well as nature-based solutions for city resilience enhancement and the analysis of the study area using the strolling method. The river recovery was conceived as a continuous green corridor along the restored river evolving all the way down from the camping area north of Albufeira until the river mouth in the Atlantic Ocean.

Making the city resilient to climate change and its consequences, linking the bordering residential areas, activating city dweller and visitor interest to the history of the place, and the provisioning of areas for recreation were positive byproducts of the river restoration using high standards in the socioeconomic competition of the touristic hotspots in the Algarve region. Turning the fear of the river's destructive force into an atmospheric enjoyment, tangible by strolling along the symbolic waterline, strengthens the connection of humankind and the river ecosystem; improving quality of life and environmental stewardship. The outcome was the creation of a new linear park for Albufeira that is ecologically sound, aesthetically satisfying, and economically rewarding. The project connects residents and tourists with nature and the spirit of the place providing them with outdoor recreation opportunities in a multifunctional space that enhances city resilience (Figure 4).



Figure 4. The concept of Albufeira's green corridor linear park.

4.2. Recreation for City Dwellers and Visitors Due to a Biophilic Design

As already asserted in 1877 by John Muir, the people receive from nature far more than what they seek. Biophilic design reduces stress, improves cognitive function and creativity, improves our well-being, and provides healing for both city dwellers and visitors [13]. Adapted from Browning et al. [13], Table 2 illustrates the patterns of biophilic design and its functions in supporting stress reduction, cognitive performance, emotion, and mood enhancement as well as the human body in general. These patterns were used to provide recreation areas by walking through the new environment evolved by the restoration of the Albufeira River and the enhancement of its accompanying linear park.

Strolling through area 1, people experience the intimate, familiar, and calm backyard atmosphere given by the bordering camping area, which is enhanced by the implementation of fruit meadows, raingardens, and constructed wetlands containing water purifying plants that provide a better water quality along the reintegrated river (Figure 5a). Providing sports areas and meeting points along a curved pathway creates a slow and joyful movement through space inviting strollers to explore the environment. Due to the connection with nature and its natural river ecosystem, the presence of water as well as biomorphic forms of the pathway, the meeting areas and the shape of the river, this area enjoys all the advantages for recreation as shown in Table 2.

Table 2. The patterns of a biophilic design and their functions in supporting stress reduction, cognitive performance, emotion, mood and preference (adapted from Reference [13]).

Patterns	Stress Reduction	Cognitive Performance	Emotion, Mood and Preference
Visual connection with nature. A view to elements of nature, living systems, and natural processes	Lowered blood pressure and heart rate	Improved mental engagement/attentiveness	Positively impacted attitude and overall happiness
Non-visual connection with nature. Auditory, haptic, olfactory, or gustatory stimuli that create a deliberate reference to nature	Reduced systolic blood pressure and stress hormones	Positively impacted on cognitive performance	Perceived improvements in mental health and tranquillity
Thermal and airflow variability. Subtle changes in air temperature, relative humidity, airflow that mimic natural environments	Positively impacted comfort, well-being and productivity	Positively impacted concentration	Improved perception of temporal and spatial pleasure
Presence of water. A condition that enhances the experience of a place through seeing, hearing or touching of water	Reduced stress, increased feelings of tranquility,	Improved concentration and memory restoration	Observed preferences and positive emotional responses
Connection with natural systems. Awareness of natural processes, seasonal changes, characteristic of a healthy ecosystem		Enhanced perception and psychological responsiveness	Enhanced positive health responses; shifted perception of the environment
Biomorphic forms and patterns. Symbolic references to contoured, patterned, textured or numerical arrangements that persist in nature	Lower heart rate and blood pressure		Observed view preference
Material connection with nature. Material and elements from nature that create a sense of place	Decreased diastolic blood pressure	Improved creative performance	Improved comfort
Complexity and order. Rich sensory information that adheres to a spatial hierarchy similar to those encountered in nature	Positive perceptual and physiological stress responses	Improved concentration, attention	Observed view preference
Prospect. An unimpeded view over a distance for surveillance and planning	Reduced stress	Reduced fatigue	Improved comfort and perceived safety
Refuge. A place for withdrawal from environmental conditions in which the individual is protected from behind and overhead	Reduced stress	Perception of safety	Improved comfort and perceived safety
Mystery. The promise of more information achieved through partially obscured views that tempt to travel deeper into the environment		Improved creative performance	Induced strong pleasure response

By enhancing the connection of the residential area and the bordering park, bringing the river above ground, implementing playgrounds and thus, creating a sub-urban atmosphere in area 2, one can be active and interact with neighbours and city visitors and at the same time find relaxation enjoying the green lawns provided with seating steps facing the river. Well-being and greater health can be experienced in a friendly atmosphere by creating complexity and order due to plant selection variety and different pedestrian flows created by the movement through the space (fast or slow) and the path hierarchy (narrow and wide) (Figure 5b). A mysterious and peaceful atmosphere can be experienced in the nature chirping atmosphere. Urban forests and wetlands pick up the surrounding atmosphere of the densely planted mountains making visitors explore the landscape in all flood levels due to a pedestrian footbridge reaching into the retention area where water can be stored in case of occurring flash floods. As the Albufeira beach does not allow city visitors to bring their dogs, a dog park was built in this area offering dog lagoons containing naturally cleaned water by the close-by urban wetlands. The promise of more information achieved through partially obscured views due to the implementation of the forests and the hidden movement through the space, entice the individual to travel deeper into the environment and gain recreation before entering the rushing city area.

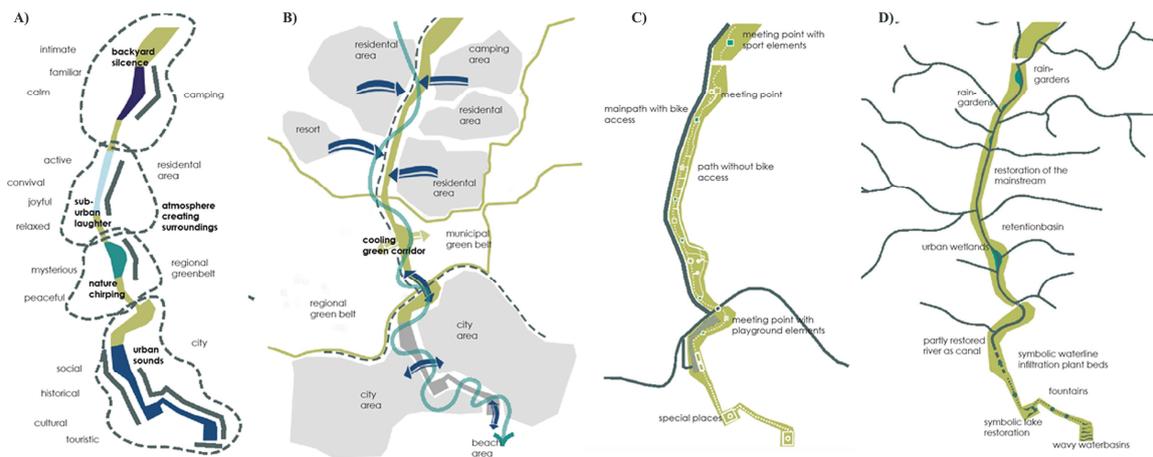


Figure 5. The representation of the atmosphere (A); green inking corridor (B); public spaces and path network (C); river restoration and the presence of water (D) in the four zones as defined by the strolling method.

One reaches zone 4 by walking through a pedestrian underpass designed as a wide and light tunnel where humankind experiences the non-visual connection with audible nature by the played sound of the water to avoid fear while passing it (Figure 5c). By experiencing the urban sounds, one finds out that the shape of the river changes, as the water is now running through a channel. The further humankind gets to the city centre, the more the river turns into a symbolic waterline represented as infiltration and evaporation beds, fountains, and water basins leading the way to the ocean where the river once used to run its natural course. As the functions of urban areas are spread wide, this zone can be roughly subdivided into three parts starting with the new mobility centre offering a bike and car park, as well as a local bus station and a green-roofed parking deck, letting the street end at this point. The multi-functional use of this area offers space for events as well as green fingers reaching into the city area providing a cooling comfort. By reducing the heat island effect, a blue and green infrastructure reaches all the way from the mobility centre along the symbolic waterline to the beach area where the river once found its mouth in the Atlantic Ocean (Figure 5d).

4.3. Creating a Sense of Place

Designed as a shaded cooling area, water basins are wave-shaped, symbolising the strong connection to the ocean Albufeira had as a small fishing village. As the conflict-potential is the highest in the urban sound area, this zone containing the city centre of Albufeira requires a more detailed proposal linking the following three dimensions: atmosphere, function, and space (Figure 6).

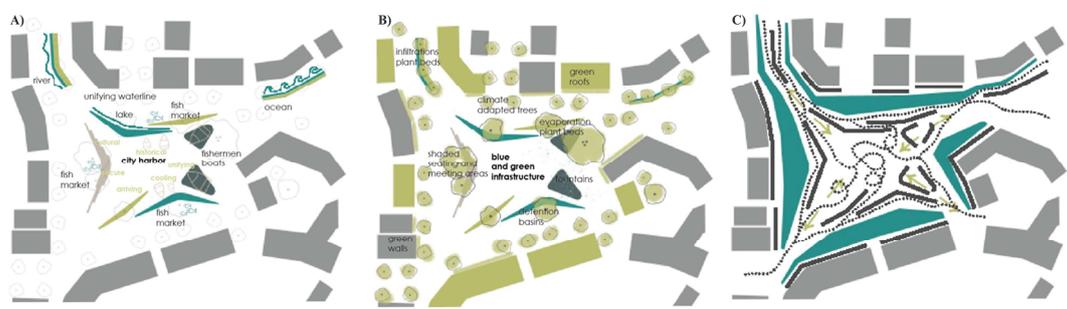


Figure 6. The three dimensions (atmosphere (A), function (B), space (C)), linked in the city centre creating a sense of place and bounding elements to tell the story of Albufeira’s history and reminding people of the name of the city in Arabic, Al uhera (the lagoon by the sea), in a symbolic way.

As described by Weidinger [41], what identifies a place is the character of the location made out of its space (spatial borders, structure, visual axes), function (cooling, entertaining, recreating) as well as its atmosphere. Known as a small fishing village, the fishing economy of Albufeira was always of high importance for the city. The naturally built lake in the middle of the old town centre was acting as a small harbour, where fishermen used to sell their day's catch. As shown in Figure 6, the space bounding elements tell the story of Albufeira's history, creating a sense for the place as well as unifying all bodies of surface water once represented in the city in a symbolic way. Turning people's fear of water into a "safe harbour" due to the pleasant presence of water creates a sense of the place offering areas for recreation.

The city centre should be multifunctional and enhance resilience to climate change and its consequences. In that aspect, creating a blue and green infrastructure for the city, as illustrated in Figure 6, reducing the heat island effect as well as providing temporary storage for occurring heavy rain events was the main objective of this area, together with the entertaining and recreating functions.

In Figure 6 the surrounding buildings of the city centre can be seen (mainly restaurants and tourism-related shops), which characterise this urban public space, and narrow streets that connected the inside function of the building with its outside area, interacting with the new design and building functional borders. Those borders, furthermore, create visual axes, a movement through the space as well as a public space network providing easy orientation for visitors (Figure 7, bottom-left). The new design for Albufeira's city centre brings the three dimensions together, as well as creating recreation areas. Moreover, due to a range of different biophilic design patterns, such as the presence of water and a comfortable thermal and airflow variability, a place that will provide recreation to residents and visitors of the city and be remembered can be created.

Regenerative design accepts and promotes 'place' as the primary starting point for design and connecting people back to the spirit of place in a way that they vitalised by it and become intrinsically motivated to care for it [40]. Genius Loci is the spirit, character, or atmosphere of a place or an entire town [42]. It is made out of its history and understanding of people creating an identity for the place [43]. Knowing a city's history is necessary to understand their contemporary shape and thus, realising why extreme events like flood hazards arrive from time to time.



Figure 7. The urban river recovery inspired by nature-based solutions and biophilic design in Albufeira, Portugal. Perspectives from the four zones derived from the scrolling method and the city centre symbolic lagoon.

4.4. Nature-Based Solutions

Nature-based solutions to increase the well-being and city resilience to climate change were also applied at selected locations in the new linear park of Albufeira (Figure 7). At the northern part of zone 1 (backyard silence), a constructed wetland will purify the water before it enters the linear park and the following raingardens and meadows will contribute to decreasing the runoff from the nearby avenue. Trees and shrubs along the avenue will offer privacy screening, acting as a sound and visual barrier (zone 2). Permeable paving options will be used for the paths along the park, while glowing stones will absorb solar energy during the day and release it at night at the cycle path, as in the Van Gogh-Roosegaarde route in Eindhoven [44]. For soil permeability and runoff reduction in the parking areas, permeable pavements may be used for a grass grid so the water could infiltrate and decrease the risk of flooding [45]. Retention basins and urban wetlands are proposed for zone 3 (urban chirping).

The region of the Algarve is a privileged place to reuse the solar energy, for that reason, solar benches and solar lights are some examples of the utilisation of sustainability techniques in the park. For zone 4 (urban sounds), green walls are proposed, which may decrease the visual and noise impact, and green rooftops on buildings may provide multiple ecosystem services such as thermal comfort, energy efficiency, retention of stormwater, and the provision of habitats. Nature-based solutions may bring more diverse natural features and processes into the urban area through locally adapted and resource efficient interventions [46].

Regenerative projects aim to reconnect the city and nature, improving quality of life and environmental stewardship [47]. A recycled landscape, which provides different multipurpose uses, is attractive and viable [48]. A good example of a landscape reclamation project was Park-Tranção, realised in Portugal at the Lisbon River [49]. This derelict industrial area was ecologically degraded, with high soil, water, and air contamination problems. The restoration of the 'place' offered a good public space for the well-being of citizens and also a healthy relationship between city and river.

One of the regenerative economy targets is to minimise the use of nonrenewable natural resources [50]. Therefore, in order to ameliorate the quality of city life and make cities attractive, flexible building materials, which last and adapt, and upcycling strategies are solutions for sustainable urban design [51]. One of the most important resources in water and regenerative design should recycle and purify all urban water by introducing new innovative technologies. Cities should increase green infrastructure and decrease sealed areas preventing the functioning of the water cycle [46]. Energy is another sector where long-term potentials and regenerative actions are required for sustainable development [52]. Solar and wind renewable energy can be used to decrease the CO₂ emissions and prevent the consequences of global warming from greenhouse gas emissions, meeting the emissions goal. Moreover, increasing urban green infrastructure has efficient results in reducing carbon emissions and many benefits for everyone, especially to economically vulnerable groups of people [53].

5. Conclusions and Recommendations

This paper presented a case of biophilic urbanism using the project of the Albufeira city river restoration. The project was inspired by nature-based solutions and by implementing a green and blue rather than a grey infrastructure to reduce the risks of climate change, such as heat island effect and flash floods, while simultaneously providing greater health and well-being for urban residents and visitors. The new urban design for Albufeira reflects humanity's innate need for nature and meets the needs of the following generations in a long-term sustainable solution that provides retention basins for water storage after torrential rains as well as a green and blue infrastructure, allowing the water to run its natural cycle. Due to the construction of wetlands and raingardens, the water quality will be improved and will enter the ocean clean. Adjacent to the supply of ecosystem services, a range of environmental, socio-cultural, ecological, and economic advantages were a result of the new design. The cooling green corridor brings fresh air to the city and thus, reduces the heat island effect making the city more energy efficient. City-cooling places all along the symbolic waterline, close to public spaces in the urban sounds area, create high-quality places for city residents and visitors. By establishing the blue-green infrastructure, the city will be cooled down, providing a great advantage in the socio-economic competition of the touristic hot spots in the region.

Another great advantage of the project was the creation of a historical sense of individuality, bringing back the identity of a place that will be memorised and associated with Albufeira and its fishing history. The project created a sense of place by recovering the buried river, reconnecting citizens with nature and the history of the place. Strolling along the symbolic waterline, the connection of people with the river ecosystem was strengthened and the fear of the river's destructive force tangibly turned into an atmosphere for enjoyment. The outcome was the creation of a linear park for Albufeira that was ecologically sound, aesthetically satisfying, economically rewarding, and where the relationship between people and nature was of love and respect rather than domination.

A civil engineering alternative proposal that was examined by the municipality of Albufeira pretended to solve the frequently occurring flash flood problems by constructing a tunnel to increase the drainage capacity and circumvent the city. This grey infrastructure solution, which might be technically correct, rapid, and with minimum environmental impact, does not bring any other socioeconomic advantage for the town and its population. The green and blue infrastructure provides multiple socio-cultural benefits and ecosystem services. Furthermore, it might be less cost-intensive and bring long-term benefits that will enhance city resilience to climate change and improve human health and well-being. The alternative project coming from civil engineering reductionist thinking has a short-term focus at the expense of long-term effects, while holistic thinking approaches river recovery as part of the long-term city planning for climate change adaptation in the implementation of nature-based solutions in a biophilic design project. This was seen as an opportunity to improve well-being and increase city resilience instead of providing solutions for flood risk.

Currently, there is no available data for the comparative assessment of the civil engineering and biophilic proposals and a quantitative framework of key performance indicators will be a task for future research. In order to provide evidence of the advantages of the solutions compared to alternative options needs monitoring for a long period since the benefits and services provided by the urban green infrastructure do not take place immediately after the completion of the project. Additionally we need to develop cost-benefit methodologies to assess the impact of the deployed solutions in as quantifiable a way as possible and considering all benefits (such as carbon sequestration, mitigation of heat island effects, natural cooling and heating, recreation, mitigation of soil sealing effects, enhanced soil, flood prevention, enhancement of biodiversity and natural capital, human well-being and health, reduction of noise and air pollution, improvement of water quality, and others [46]).

Taking account of scarce financial resources available to local governments and the lack of data to support the long-term benefits, it is necessary to find new approaches for financing this kind of project. Taking into consideration the uncertainties on cost, risks, and benefits, governments should promote biophilic urbanism and nature-based solutions by regulations and lower taxation, so as to make them attractive to citizens and companies, boosting the whole economy. More research is needed on biophilic urban planning approaches for different size cities, located in various climatic zones, with diverse ethnic compositions, income, quality of urban life etc.

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