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The Sustainable City XIV

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Fourteenth International Conference on Urban Regeneration and Sustainability

SUSTAINABLE CITY XIV

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Giorgio Passerini
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University of Rome 'La Sapienza', Italy

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Wessex Institute
Ashurst Lodge, Ashurst
Southampton SO40 7AA, UK

Editorial Board

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Editors

Giorgio Passerini
Marche Polytechnic University, Italy
Member of WIT Board of Directors

Stefano Ricci
University of Rome 'La Sapienza', Italy

WIT*PRESS* Southampton, Boston

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Giorgio Passerini
Marche Polytechnic University, Italy
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Stefano Ricci
University of Rome 'La Sapienza', Italy

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Preface

The present volume contains a selection of the papers presented at the 14th International Conference on Urban Regeneration and Sustainability (Sustainable City 2020) which was to take place in Rome, organised by the Wessex Institute of Technology and University of Rome 'La Sapienza' and was subsequently held online due to SARS-Covid pandemic.

Sustainable City 2020 follows a series of very successful meetings that started in Rio (2000), followed by Segovia (2002), Siena (2004), Tallinn (2006), Skiathos (2008), A Coruña (2010), Ancona (2012), Kuala Lumpur (2013), Siena (2014), Medellin (2015), Alicante (2016), Seville (2017) and Valencia (2019). Although this was the first online edition, the large number of delegates and the quality of papers and presentations testified the worldwide interest and the success of the conference series.

As for the previous ones, the meeting addresses the multidisciplinary components of urban planning, the challenges presented by the increasing size of the cities, the amount of resources required and the complexity of modern society. The variety of topics and experiences is one of the main reasons behind the success of the series, which attracts a substantial number of contributions, in particular case studies investigated by contributors with distinct backgrounds belonging to different countries.

Today, planning sustainable contemporary cities requires in-depth knowledge of urban systems' dynamics, of energy and matter exchange, and the implementation and maintenance of ordered structures directly or indirectly supplied and maintained by natural resources. Urban areas result in a series of environmental challenges varying from the consumption of natural resources and the subsequent generation of waste and pollution, contributing to the development of social and economic imbalances. As cities continue to grow all over the world, these problems tend to become more acute and require the development of new solutions. Largest cities are probably the most complex mechanisms to manage. They represent a fertile ground for architects, engineers, city planners, social and political scientists, and other professionals able to conceive new ideas and time them according to technological advances and human requirements.

As a final remark, we wish to highlight the new challenges triggered by the SARS-Covid2 pandemic. As a matter of fact, the pandemic will forever change the city as a whole, and that change must be carefully driven to avoid shocks and dead ends. The knowledge expressed, transmitted and discussed in all "Sustainable City" conferences will be crucial in shaping the post-pandemic cities of tomorrow. Also for this reason, the papers contained in this book, as well as those from previous conferences since 2000, have been archived in the eLibrary of the Wessex Institute (http://

www.witpress.com/elibrary) where they are permanently accessible to the international scientific community.

The Editors wish to acknowledge the authors, the members of the Scientific Committee, the Referees, the Institutional Partners, who supported the Conference, and Priscilla Cook, of the Conference Secretariat, who did an outstanding job of coordination together with the WIT Press staff, Isabelle Rham in particular.

Finally, the Editors, the Chairmen, the Members of Scientific Committee and of the Wessex Institute wish to remember the late Professor Carlos Brebbia, founder of Wessex Institute and of WIT Press, who foresaw and established this series of meetings.

The Editors, 2020

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SECTION 1
URBAN STRATEGIES

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ROLE OF MUNICIPALITIES IN THE URBAN PLANNING OF POST-OIL GULF CITIES: THE CASE OF DUBAI, UNITED ARAB EMIRATES

EMAN ASSI
American University of Ras Al Khaimah, United Arab Emirates

ABSTRACT

Dubai is a highly memorable place: The image in your mind matches up with a colorful history of a pearl diving, fishing, gold trading settlement. Since the beginning of the 20th century, trade was the driving force behind its wealth and success. With little or no resources, Dubai became the main center-port in the Persian Gulf, the busiest regional trading center. The first Dubai Plan was assigned to John Harris in 1960, by his highness Sheikh Rashid Bin Saeed Al Maktoum. This paper aims to assess how John Harris' developmental plans addressed the vision of his Highness to transfer Dubai into a modern, global city. In doing so, the author attempted to understand the process of transformation and its impact on the cultural and social changes of the city. More specifically, the author answers the following questions: What was the main focus of these plans? How were these plans implemented on the ground? What were the main challenges that faced John Harris and Dubai Municipality to achieve the goals set? The author researched documents and archives of Dubai Municipality, meeting minutes of the Municipality Council and *Dubai Monthly Journal*, which were very helpful in looking in depth at this period. The author concludes that urban development, when in a state involved with certain power, could be more influential at nation-building, in shaping the urban city landscape. Dubai's urbanization did not face conflicts between old and new, like other Arabic cities. For John Harris, the focus was on both the functional and aesthetic aspect, to integrate the conservation of historic buildings as part of a living process, in which good new buildings were encouraged.

Keywords: city planning, cultural heritage, Dubai, historic architecture, John Harris, Persian Gulf, United Arab Emirates, urban development, urban planning.

1 INTRODUCTION

Dubai Municipality, established in 1957, was not one of the earliest municipalities in the Persian Gulf [1]. The first one was the city of Manama Municipality in the Kingdom of Bahrain, established in 1919, followed by Kuwait City Municipality, established in 1930. Although Gulf municipalities share the same reason for their establishment, the organizational structure they adopted, the responsibilities they carried to address the newly emerging situation, they still differed in their effectiveness to address rapid changes, the level of decentralization given to the municipal council, and their programs and priorities. Within 25 years, Dubai Municipality succeeded in transferring Dubai from being a small fishing port to a modern global city, highly recognized on the world map. In 1975, Dubai was known as the jewel of the Middle East. Dubai's World Trade Centre building was the first skyscraper in the Middle East [2].

In 1960, Dubai underwent rapid physical and social changes. These changes were not generated only by oil revenue, but also expanding commerce and free trade. Dubai's population increased through immigration, to reach 445% within 15 years. According to Dubai statistics, the population had increased from 40,000 inhabitants in 1960 to 183,000 inhabitants in 1975 [3]. In the early 1960s, Dubai did not have much infrastructure, with few telephone lines, and lack of paved roads, utility networks and running water. The first house built of concrete blocks was constructed in 1956; as a large number of Dubai's inhabitants had lived in palm-frond (*barasti)* houses.

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The *barasti* quarters usually had a compound for extended families to be grouped together in clusters of related families [4]. The alleys were nowhere wide enough to let a car pass through. There was no need for wide spaces between houses since each house and compound was built to provide a maximum of privacy inside. Transport within the town was possibly only on donkey or camel until the beginning of the 1960s, when some roads were opened up by the municipality. Dubai had no cars in the early 20th century. Cars could be driven over the salt flats (*Sabkhah*) and along the beach at low tide, but had to be left well outside the built-up quarters of Dubai. Traffic between Dubai and Deira was largely accomplished by rowing boats (called *abra*); there were, and still are, a number of fixed landing points on either side of the creek. In the 1930s a taxi service operated in Dubai; and between Dubai and Deira, around the eastern end of the creek. Another service went between Dubai and Sharjah. Waste disposal management in Dubai at that time also was managed through the social and cultural system. Proper refuse disposal was not organized until sometime in the late 1950s, when Sheikh Rashid appointed some people to undertake this for all quarters of the city-state.

In 1939, His Highness (HH) Sheikh Saeed Bin Maktoum delegated a lot of the responsibility for domestic affairs of the City State of Dubai to his son, Rashid. Sheikh Rashid became ruler in 1958, so when funds become available to improve conditions in the sheikhdom, he initiated changes which had much in common with those proposed in 1938 [5].

The 1950s were a period of transition for Dubai Creek, starting when the silting of the creek especially at its mouth, which forced larger boats to instead use nearby ports like Sharjah. Dubai's Ruler's decision to launch the dredging of Khor Dubai likely became the key for the future development of the city. Sheikh Rashid himself (1958–1990) institutionalized his relationship with merchants through his *majlis* and the court, concentrating his efforts on trade [1].

2 SHIFTING FROM TRIBAL TO MUNICIPAL: THE GULF EXPERIENCE

Many Arab cities were left out of the international global discourse [6], according to the globalization definition by Saasen, with focus only on cities which are nodes in the network of globalization and considered places where the global economy is being coordinated and reproduced [7]. Castells' definition also similarly identified global cities to be places in which advanced services are produced and consumed. Dubai, as an evolving city, was also not considered within this definition [8]. For Shami, Arab cities are seen as a product of people with a complicated mechanism [9].

The focus of all Gulf States in the 20th century is to find ways to shift from governance from the tribal structure adopted for many years, to a municipal governance structure that will be capable of addressing new emerging issues [6]. Before, it was impossible for these countries to survive without the tribal structure. In most cases, the tribal structure started with families united to find water, food and other resources through collective efforts: They protect them and refuse to share them with others. The emphasis on the group excluded the rise of a strong leader. Accordingly, tribal leadership is often called, according to Halem, "the first among equals", suggesting that a collective leadership in which one among a number of leaders is recognized as the most authoritative [10]. The principal leader, or *sheikh*, in this case, must continue to consult with his lesser colleagues [11]. The big transformation in the Gulf in the beginning of the 20th century made it difficult for the tribal structure to continue to function. This was because of the new types of responsibilities that emerged. Each had to find its own way to distinguish itself from its neighbors, while confronting local challenges to the newfound wealth and potential power [9].

When the Municipality of Manama in Bahrain was established according to the law issued in 1920, it had limited responsibilities and a modest budget. The first budget was in 1920 with revenue of 604 dinar and expenditures of 604 dinar. The main aim of the eight appointed municipal council members was to serve the community in their daily life, through a new reform that covered the major parts of public life, such as justice, trade and customs [12]. Their responsibilities expanded to include other duties. Later, the Bahrain municipality became responsible for everything [13].

In Kuwait, the municipality was established in 1930. The main aim was to improve the conditions of health and the social conditions of the community, through an elected municipal council. The Municipal Council had the power to make decisions that would serve the community well [14]. Its responsibilities were expanded to cover the issues of health, tax collection and management of urban development. The first master plan was laid in 1951; it included many improvements [15]. Another decree was issued in 1954, to define the role and responsibilities, as well as its organizational structure, within a certain allocated budget. Later, in 1960, another decree was issued about the beautification of the city and food safety.

3 CREATION OF DUBAI MUNICIPALITY COUNCIL

In 1958, HH Sheikh Saeed Bin Maktoum died, and his son Rashid, who had been largely responsible for the government in Dubai, became the ruler. Soon after he became a ruler, Sheikh Rashid established a municipal council, which later became the basis for the municipal administration, for which task a qualified clerk was recruited from Sudan [16]. By 1961, the three sections of this municipality employed 40 staff members and 120 laborers, and had a budget of 300,000 Rupees, of which 40,000 Rupees were subsides and 260,000 Rupees were derived from tax revenues [17].

In the early establishment of Dubai Municipality, and in accordance with the traditional Arab desert style democracy, which grants the leader authority, his Highness the ruler directed and controlled all developments personally, with the help of informal committees and representatives of all interests concerned in each project. The municipality was responsible for engineering, licensing trades and business, public health, fire-fighting provisions and the work of the gardening department [18].

Establishment of Dubai Municipality can be seen as a step toward setting up a governmental institutional system and formal regulations in favor of trade development [19]. The Municipality was responsible for enforcing local orders and notices to regulate trade, improve conditions and provide opportunities to new developments in the trade business; which was reflected in the first set of local orders of the Dubai Municipality in 1961. The Municipality was concerned about controlling new construction. The local order #13 included regulations on new construction and existing buildings. It regulated the urban expansion of buildings and lands assigned to trade, and building notices and permits on the type and location of new construction.

The first decree issued was in 1957, defining a list of 23 members appointed to the council, most of whom were well-known merchants in Dubai, due to their wider knowledge on daily issues and their advice about future plans for Dubai. In its second meeting, the Dubai Municipal Council had taken 22 decisions: six decisions on how to increase revenue (building permits, movies, alcohol, parking), four decisions on relocating some uses, three decisions about upgrading health conditions such as regulation of sanitary inspection holes, firefighting cars; and three decisions for improving infrastructure: building roads, improving the lighting network, and a proposal for laws and regulations to control the rapid city transformation [20].

4 JOHN HARRIS PLANS

The necessity to have good infrastructure and plan further development of the town led to the engagement of a British firm architect and town planner, John Harris, who was involved in shaping Dubai city for 10 years, starting from his first master plan 1960, then updating his proposal in 1965 and a new one again in 1970. The reason for having several master plans in a short time was to enable the city to respond to the unexpected growth of the population, which was beyond the estimated future expansion.

In 1959, Dubai did not have much infrastructure [21]. John Harris' 1959 plan focused on improving infrastructure, health, educational housing, schools, and trade and commerce construction, to ensure that Dubai took its place as a modern, thriving city. His sketch map was the first map to fuse the present and past. The proposed road system was an extension of an already existing axis in the historic core around the creek, allowing for its integration with future development. John Harris' map was not a conventional approach to planning. It is more of a series of roads onto the desert, as one way of anticipating very rapid development. A development committee was formed at the municipality, to assist in realization of the plan. The committee included John Harris and the senior representative of Sir William Halcrow and Partners, who administered the town planning on behalf of the Municipality for four years. The main aim was to direct public services and control building development in accordance with Harris' proposed developmental framework [22].

John Harris' deep understanding of contextual conditions was reflected in how he reinterpreted the structure of the old city and achieved an urban continuity. His proposed plan for Dubai was mainly about extending the city into the desert. It did not erase the old town, but instead created a new order of orthogonal grids and roads, based on the existing scale of the old street pattern. Between 1960 and 1971, land reclamation and the deepening of the creek's channels proceeded, allowing coasters of up to 800 tons to use creek facilities. The dredging of the creek, mainly at its entrance, was a necessary condition to maintain the port and commercial activities that had existed throughout the past. The main purpose of the developmental plan prepared by John Harris in 1971 was to give suggestions to assist in guiding development during the next coming years. In this regard, John Harris noted:

> "His Highness Sheikh Rashid Bin Saeed Al Maktoum, ruler of Dubai, has great wisdom in promoting the planning of Dubai, and in ensuring that opportunities were readily available for the achievement of the planning aims. His farsighted [vision] has been abundantly justified by the results to date, and by the prosperous and secure promise of Dubai future" [23].

5 CHALLENGES

In his 1971 plan, John Harris attempted to identify key problems, and made recommendations concerning certain of them. For others, it was not possible to reach a conclusion without the benefit of surveys and research; so he suggested that some research and surveys should be undertaken. For John Harris, the physical character of Dubai possessed unique traditional and urban spatial qualities centered on the creek, that should be considered in any developmental plans for Dubai. He wrote:

> "The physical character of Dubai has been determined by a variety of factors: its setting on the creek; the relatively flat terrain; the compact intimacy of scale of the building with informal meandering walkways between, the relatively low roofline broken by the decorated square wind towers thrusting upward to catch each breath of air movement. From natural response to particular

> problems of climate and geographical consideration, there has emerged [a] rich and appropriate local vernacular of building form and details. This vernacular has an intrinsic value, an undeniable attraction, and unquestionable harmony: one of which are measurable, but all of which contribute to the fascination exerted by Dubai and its creek" [24].

On the other hand, the rapid development that happened in the 1960s had brought many benefits and vastly improved the quality of life; and the efforts being made in education, health, housing and schools, and in trade and commerce, ensured that Dubai took its place as a modern, thriving city; however, this rapid development could be dangerous where the increasing rate of growth and change would not allow time for new ideas and new building forms to be absorbed and integrated happily into what already existed. To achieve integration, demands between the conservation of the historic fabric and development should happen. John Harris stressed the need to have a degree of conservation, where the preservation of the best of the old buildings was part of a living process in which good new buildings was encouraged [24]. For that reason, he suggested implementing a survey of old buildings worthy of preservation, and/or restoration to ensure future development is based on a policy involving conservation.

Conservation, according to Harris, implies a resolution of conflicting activities, and this is seen to be essential if a good environment is to result. Convenience for vehicles must be offset against the protection of the environment from bad effects. Conservation demands an understanding of the various factors that merge together, and add interest and richness to the vernacular. These factors are difficult to identify, often impossible to isolate and cannot be qualified, yet they provide the key to the varying degrees of attraction offered by different cities, towns and villages. Observation of Old Dubai and Deira (still seen in the Bastakiya area) leads to an appreciation of certain factors that contribute to their appeal:

- The scale of buildings and the defined spaces between buildings relate readily to the scale of the human being.
- The tight grouping of buildings leads to sharp and welcome contrast between the natural and manmade environment.
- Unity is achieved by considerable variation within restricted limits, of: size, height, proportions and patterns.
- Monotony is avoided by considerable variation, within restricted limits, of: size, height, proportions and patterns.

The 1971 plan highlighted concerns related to specific issues to be tackled in the future:

- Land ownership: The shapes of the existing plots are often not related to road networks, and are very irregular; thus, there is a need to pursue a complete survey of all privately-owned land, to be recorded in the town map.
- Planning control and building regulation: It's important that many adopted regulations shall be readily understood. It's the Municipality's responsibility to keep the public informed, not only on the regulations, but also about the reasons justifying their adoption.
- Staff: There is a need to expand the municipality's capacity to have technical staff expert in planning, to enhance coordination and follow-up with new projects prepared by consultants.
- Coordination and phasing: If development is to proceed in an orderly and efficient manner, there should be phased coordination. Much of the information used will be

based on forecasts, these require constant appraisal to see how reality varies from forecast, so that adjustments may be made accordingly.

Recommendations suggested by John Harris that might have assisted in guiding the continuing development along reasonable lines would focus on improving the roads and transportation infrastructure, public services and economic structure; as well as the legislation and urban planning regulations. These were grouped as follows:

1. Road network, vehicle ferries, car parking provisions, harbor, public transportation.
2. Industry, tourism and hotels.
3. Housing, medical services, educational facilities, government and civic amenities, library, museums, sport facilities, open spaces; planning, fire service and postal services.
4. Special focus should be made on the height of buildings, Deira Gulf cornice and Sharjah road development.

6 CONCLUSIONS

One of the key players in shaping the physical urban environment of Dubai in the second half of the 20th century is Dubai Municipality. It has played a prominent part in the successful planning of Dubai. The ruler established a municipality, controlled by a council of leading merchants; with considerable freedom of action to assist in the development of Dubai. The Municipality prepares its budget, collects municipal taxes, and submits to the Ruler through the council chairman, with requests for subsidies for major municipal works.

John Harris addressed the most important issues in his developmental plans, which are: the direction of future expansion of the city and the street system. His plan was a reflection of why Sheikh Rashid selected him to carry out this mission. His understanding and awareness of the logic of the current context enabled him to integrate the historic core of Dubai, the most important driving force of the economy in Dubai, into the future growth of the city [25]. John Harris grappled with the limited resources, but still managed to understand the context. The new proposed developmental plan by John Harris was an attempt to respond to the challenges that were raised from continuous development and HH Sheikh Rashid's guidance through the Dubai Municipality, to consider several issues of influence in the future. He raised attention to the fact that developing Dubai should still be centered on the creek. The focus should be on both the functional and the aesthetic aspects, to achieve integration of conservation of the historic buildings as part of a living process, in which good new buildings are encouraged.

One final word: few countries have changed as rapidly in the course of one generation, as United Arab Emirates. The development of Dubai stands as an example that, given the right circumstances, it is possible for a community of merchants on the Persian Gulf's Trucial Coast to reach out beyond the resources of their own immediate environment.

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REVISITING THE URBAN DEFINITION FOR THE ISLAND OF MAURITIUS

BIBI NAJIAH KAUDEER & SANTARAM VENKANNAH
Department of Mechanical Engineering, Faculty of Engineering, University of Mauritius, Mauritius

ABSTRACT

Mauritius is a small island located in the south west of the Indian Ocean, about 900 km from the island of Madagascar. The island of Mauritius, being of volcanic origin, remained uninhabited until the 16th century and became colonised by the French and afterwards by the British. In 1968, the country gained its independence and had a population of about 600,000 inhabitants. Around 50 years later, the population size has doubled, however, despite a growing population Mauritius has seen a negative urban growth. Being limited in size and with an increasing population, a negative urban growth of the island seems to be inconsistent. Therefore, revisiting the urban definition used in Mauritius was important to counteract the threats posed by unsustainable urbanisation. The research took into account the population statistics of different areas of the island. It was observed that population size, density and quality of life is growing outside the limits of legally defined urban areas which means that rural areas are urbanising in Mauritius. Three villages were identified to be urban, namely Triolet, Goodlands and Saint Pierre. An additional four villages, namely Moka, New Grove, Mahebourg and Le Hochet were found to be at the fringe of urbanisation. Acknowledging the urbanisation of these areas is primordial for sustainable urbanisation as it allows for decentralisation of such areas, whereby, they can have their own administration and budget to tackle environmental and social issues.
Keywords: Mauritius, urbanisation.

1 INTRODUCTION

The urban population of the world has grown rapidly from 751 million in 1950 to 4.2 billion in 2018 [1]. Cities and towns have existed for 6000 years BC or more. The earliest recorded cities were developed for several reasons which included commercial, religious and political factors; however, the share of the urban population remained low fluctuating between 4% and 7% up to until 1850 [2]. After that period, the industrial revolution occurred which changed the shape of urbanisation, by creating favourable environment for urban growth through mass production and enhancement in transport and communication systems.

Apart from changes in the industry, the industrial revolution brought changes in technology, science, military science, education and others. This created a need for multiple functions in one place as compared to rural areas, where only skills for agriculture may have been required. These multi-needs led to high population densities and migration into urban areas, eventually leading to urban growth. Thus, by default, urban areas display concentrated human habitation areas and altered land use compared to rural areas, which is visible even from space.

In addition to a completely different landscape, urban areas are complex systems where the inhabitants have a unique relationship with economic and social activities [3], [4]. Urbanisation also has a huge impact on the environment and climate change, ranging from damages to the ecosystems, biodiversity, water sheds to emissions of greenhouse gases, if unsustainable urban growth occurs.

Urbanisation is becoming increasingly important as the urban areas become larger, numerous, more populated and more complex. Urbanisation without any doubt contributes to the improvement of the quality of life of the urban residents, and is one of the main reasons of global migration trends towards urban areas. Urban residents benefit from better

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infrastructure, higher salaries and improved productivity compared to rural residents [5]. Cities even contribute to reduce rural poverty by increasing the demand for labour, the demand for rural goods, migration and fund transfers to rural areas [6], [7].

However, if urbanisation is not planned carefully, it leads to unsustainable growth causing detrimental impacts on the environment and climate such as water pollution, air pollution, huge waste production, high energy consumption and emissions. Apart from impacts on the environment, Krass [8] identified social, political and economic risks and disadvantages, that urbanisation have in south east Asian cities. Mass unemployment, exploitation of labour, informal and illegal settlement on environmental sensitive land, wide disparities between the poor and the rich and imbalanced representation of the general public; are among the risks of unsustainable urbanisation.

Apart from these risks identified, urban areas are themselves faced with external vulnerabilities such as extreme weather events and sea level rise for coastal cities. Currently, Mauritius is already facing the impact of climate variability and extreme weather events. Average temperature across the island is rising at a rate of 1.5°C per decade and even higher rise in temperature has been observed in urban stations. Sea levels are rising at a rate of 2.1 mm/yr for the past 10 years at the coast of the main city of Port Louis. Extreme events such as flash floods in the month of February and March have increased, causing disruptions to socio-economical activities and even loss of lives [9]. The national authority for disaster management in Mauritius identified inadequate stormwater drainage in existing and developing regions, backfilling of wetlands and insufficient maintenance of water ways in densely populated areas [10].

2 URBAN DEFINITION

Urban area definition from one country to another vary around the world and to such an extent that if superimposed it would be misleading, for example in Turkey; an urban area is a place with a population of 20,000 inhabitants, while in Norway, it is only 200 people [11].

Administrative and legal boundaries are one of the most used definitions around the world to delimit urban areas from rural areas. These delimitations are often defined in the prevailing town and country planning laws as it is the case in Mauritius. These boundaries may be modified after a census and may also require changes in the laws. However, very often censuses are carried out after every 5–10 years and since not all censuses will require amendments to the administrative boundaries, these boundaries can stay static for several decades. Owning to the fact that urban areas are fast growing areas, administrative boundaries often overlook the dynamic nature of these areas and hence are not able to measure the real size of urban areas. China has recently adopted versatile and dynamic urban definitions where villages connected to city or town areas are also defined as urban [12]. Given China’s large share of world’s population, this definition has changed the scales of world’s urban and rural shares.

Population size is another common way of defining urban areas. However, the range of population size is also very wide spread starting from 200 inhabitants as in the case of Greenland; up to 50,000 inhabitants which is used in Japan [11]. These values are highly dependent on the overall country population. The population size criterion is similar to administrative boundary criteria as both are based on rigid and physical boundaries that delimitate a locality. Residential areas often grow in the surrounding urban areas, thus, these definitions may end up excluding numerous inhabitants who are functionally part of the city or town in terms of derivation of their livelihoods. Furthermore, population size criterion does not account for economic and social factors.

High population density is a major characteristic of urbanisation, nevertheless, population density is rarely used as a lone criterion to define urban areas, as shortage of resources can cause high population density in certain rural areas also, for example presence of water may cause a large number of people to settle down in a small rural area or even a densely populated refugee camp. Thus, population density is used in conjunction with other criteria, for example, Canada defines urban areas as places with 1000 or more inhabitants, having a population density of 400 or more per square kilometre [11]. In India, population density is used along with the main economic activity of the locality in defining urban areas [11].

Apart from population related factors, other parameters are also factored in the definition of urban areas, for example in Japan, economic activity is one of the criteria used such that if more than 60% of the population are engaged in manufacturing, trade or other urban type of business, the area becomes urban [11]. In certain countries, urbanisation is seen in the social dimension; where urban residents are more educated and well-off, which is evident as urban areas have more facilities. These particular characteristics of urban areas attract people to migrate towards them, especially in large developing countries such as China and India.

As the world becomes more urban, defining urban areas gain more attention both at international and national levels, perhaps because of the iconic moment of the shift from being "rural" to "urban". Although, urban scholars agree that "urban" means more than population size and/or density, the idea of relatively large, densely populated and well serviced infrastructure developments come to mind when urban areas are thought of.

Urbanisation is also closely related to the change in land use, and due to this characteristic can be remotely sensed using satellite data. One such tool is the CORINE (Coordination of Information on the Environment) Land Cover program, being used to map urbanisation in Europe. A study carried out in Poland using CORINE was able to identify urban sprawl [13]. Thus, remote sensing provides the ability to monitor urban and rural systems at various spatial and temporal scales, making remote sensing one of valuable tools in addressing issues related to sustainable development [14]. However, remote sensing requires high quality satellite imagery (low cloud cover), which was not readily available for Mauritius. In addition, due to the small size of the island, using a polygon of 25 ha to represent one type of land use may lead considerable generalisation. Furthermore, urbanisation in Mauritius is more driven by improvement of quality of life and urban density.

2.1 The Mauritian context

Mauritius is a small island located in the south west of the Indian Ocean, about 900km east of the island of Madagascar and currently house around 1.3 million inhabitants. Mauritius has seen its population size doubled in the past 50 years, and is one of the top 20 most densely populated countries in the world, which is foreseeable due to its limited size. However, since 2009, the urban population growth has been reported as negative value, which seems inconsistent with the increase in population. The urban population has decreased by 3% in the past 30 years. It seems that the urban areas are being depopulated; on the other hand, the population size is increasing. With limited land resources, it is obvious that the rise in population is being absorbed in rural areas, which means that urbanisation is occurring outside the legally defined urban areas. This type of accidental urbanisation is often unplanned and leads to unsustainable growth.

The island of Mauritius is divided into nine districts which house the urban and rural areas. As to date, five urban areas are legally recognised, namely the main administrative city of Port Louis, and four towns; Beau Bassin-Rose Hill, Vacoas-Phoenix, Curepipe, and Quatre

Figure 1: Urban areas in Mauritius.

Bornes. These urban areas are administered under their individual municipal council, while the villages council areas (VCAs) are administered by the District council in which they are situated. With the exception of Port Louis, the four towns are primarily located in the district of Plaine Wilhems. Fig. 1 shows the geographical location of urban areas in Mauritius.

Mauritius uses the administrative tool to define urban areas, that is legally defined boundaries for urban areas without due consideration of the dynamics of urbanisation. The legal tool for defining these boundaries is set in the Local Government Act 2011 [15]. These boundaries have remained almost the same since 1980, that is for nearly four decades, during which the population size has grown by 30% [16]. During the same period, urban population grew steadily, peaking in the years 2008–2009 and started to decline thereof [1].

The island of Mauritius is 1864 km^2 in size and has an overall population density of 623 inhabitants per km^2 per area of land [1]. The population density has been increasing, almost doubling since 1970 and is even higher than the world's most populous middle income countries such as India and Nigeria. Some of the urban areas such as Beau Bassin/Rose Hill in Mauritius are even more densely populated than the megacities such as Shanghai and Lagos where population density is 3,800 p/km^2 and 3,200 p/km^2 respectively [1]. The reason for the high population density is the limited amount of land resources available.

In addition to a shrinking urban population size, a decrease in the population density in urban areas has been observed between the two recent population censuses as shown in Table 1.

Table 1: Population density of urban areas for the last three censuses [16].

Urban area	Population density(p/km^2)		
	1990	2000	2011
City of Port Louis	3,108	3,265	2,959
Beau Bassin/Rose Hill	4,547	5,137	5,111
Quatre Bornes	3,303	3,164	3,207
Curepipe	3,068	3,339	2,946
Vacoas/Phoenix	1,890	1,856	1,947

The growing population size and density of the island depicts another picture which could mean urbanisation is occurring outside the legally defined urban boundaries, which need identification.

Identifying the urban areas early on will help with sustainable development through decentralisation. All the VCAs in a district share the same agenda and budget because they are being administered through District Councils. Little or no particular attention is given to the specificity of an area, for example, a coastal high density VCA will have the same share of budget as an inland VCA; despite the fact that the risks faced by a coastal VCA are higher. Administrative and financial decentralisation allows such areas to have more independence in local decision making. This type of decentralisation will help to focus on major issues in these areas such as urban flood which is more hazardous due to high population density. Decentralisation will also allow such areas to have their own facilities, reducing the demand for commuting for services and reducing the pressure on congested urban services.

Recently, Mauritius has launched a smart city development scheme with a view of developing self-sufficient sustainable cities which will improve the wellbeing of inhabitants [17]. These smart cities are being built on undeveloped land in rural areas. It becomes more important thus to recognise urbanising areas such that they can be integrated in those smart cities to ensure inclusive growth and eliminating any disparity between these regions.

At a national level, the formal recognition of urban and urbanising areas allows for enhanced land use and resource planning, improved monitoring of biodiversity and opportunities to drive investment and reduce poverty in such areas. This paper focuses on using demographic data to identify urban and urbanising areas other than the currently defined ones in Mauritius.

3 METHODOLOGY

3.1 Population size

As mentioned earlier, population size is the most used criteria for defining urban population in the world. In Mauritius, according to the most recent census of 2011, it was observed that all the five existing urban areas had more than 50,000 inhabitants. Data from the past four censuses show that all the legally defined urban areas had a population more than 20,000 inhabitants since 1983; while it is only in the year 2000 that the VCAs started to have more than 20,000 inhabitants as shown in Table 2.

Table 2: Number of inhabitants in urban and rural areas in Mauritius [16].

	Census year			
Range of inhabitants	1983	1990	2000	2011
Number of urban areas	5	5	5	5
100,000 or more inhabitants	1	1	3	3
50,000–99,999 inhabitants	1	4	2	2
20,000–49,999 inhabitants	3	–	–	–
Less than 20,000 inhabitants	–	–	–	–
Number of village council areas (VCAs)	93	124	124	124
20,000 or more inhabitants	–	–	1	2
10,000–19,999 inhabitants	9	9	13	17
5,000–9,999 inhabitants	24	29	34	33
3,000–4,999 inhabitants	23	29	25	27
2,000–2999 inhabitants	16	27	29	26
1,000–1,999 inhabitants	23	25	19	16
500–999 inhabitants	2	4	2	2
200–499 inhabitants	1	1	1	1
Less than 200 inhabitants	–	–	–	–

Based on the above data, it has been proposed that a population size of above 20,000 inhabitants should be a cut-off limit to categorise an area as urban. Although population size does not fully reflect the dynamics of urbanisation, owing to the small size of Mauritius, it is thought to be a good criterion, without exuberating urbanisation trends, as high population size will inevitably lead to a high population density.

3.2 Population density and quality of life

For VCAs that have a population size of less than 20,000 inhabitants, an additional criterion was proposed based on population density and quality of life; that is VCAs having a population size above 15,000 inhabitants, a population density of above 1000 p/km^2 and a Relative Development Index (RDI) of above 0.7945. The RDI is an index computed by the Central Statistics Office of Mauritius, mainly, for the ranking of administrative areas in terms of integrated development. The index itself is a composite of the following variables [16]: (1) Percentage of households having piped water, Percentage of households having electricity, (2) Percentage of households having flush toilet, (3) Percentage of households living in dwellings made of concrete, (4) Percentage of households having one or more rooms used for living purposes per person, (5) Percentage of households who own their dwelling, (6) Percentage of population aged 18 years and over having at least School Certificate or equivalent educational attainment, (7) Primary Enrolment Ratio, (8) Secondary Enrolment Ratio, (9) Literacy Rate of The Population Aged 12 Years and Over, (10) Employment Rate of The Population Aged 12 Years and Over, (11) Percentage of the employed population in occupational groups 1, 2 and 3 of the International Standard Classification of Occupations (ISCO), i.e. legislators, senior officials and managers; professionals; and technicians and associate professionals.

In order to choose the cut-off point between rural and urban, the average value of RDI displayed by the urban areas was calculated. The average value was found to be 0.7945 based on 2011 census data, thus, this value is taken as delimiting RDI value for urban and rural areas. Since urban areas are also associated with high population density, a value of 1,000 p/km^2 was also chosen to identify urban areas with population size above 15,000 inhabitants but less than 20,000 inhabitants.

3.3 Working definition of urban areas

A working definition has been proposed to identify urban areas, other than the legally defined one as follows:

"An urban area is:

1. A village council area with a population above 20,000 inhabitants or;
2. A village council area with a population above 15,000 inhabitants with a relative development index above or equal to the average relative development index of the existing urban areas and a population density above 1000 p/km^2".

The process for identification used in this paper is given in Fig. 2.

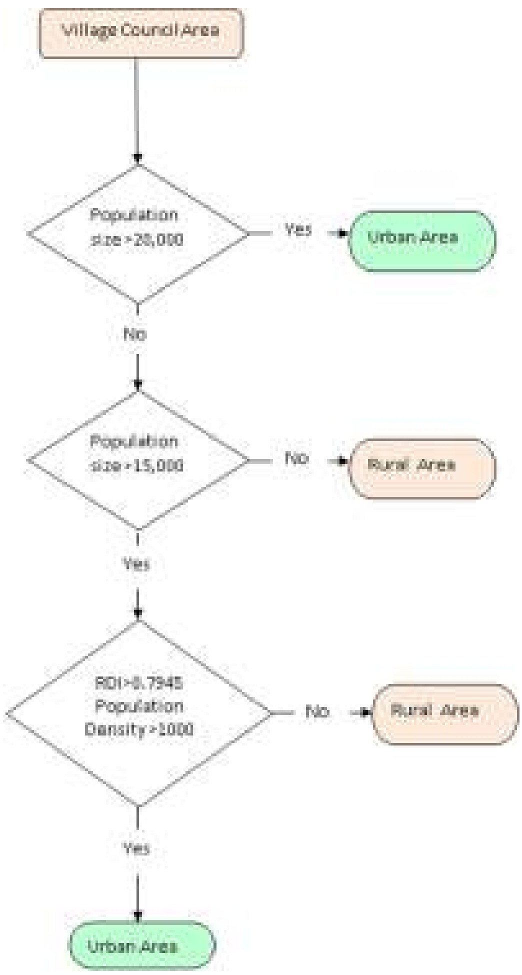

Figure 2: Proposed process for Identification of urban areas.

4 RESULTS

When the population size criterion of above 15,000 inhabitants was applied, eight VCAs were found to have more than 15,000 inhabitants, out of which two had more than 20,000 inhabitants as shown in Table 3. These two VCAs are namely Triolet and Goodlands, qualify to be urban based on the above 20,000 inhabitants criterion. These two villages are located in the north of the island.

Further screening was done for the remaining six VCAs based on the population density and RDI criteria to determine if they could qualify as urban. Only one VCA, namely St Pierre, was found to have an RDI above the urban areas average, that is, 0.7945 as shown in Table 4.

Table 3: VCAs with population size above 15,000 inhabitants [16].

SN	VCA	Population size/ inhabitants
1.	Triolet VCA	23,386
2.	Goodlands VCA	20,712
3.	Bel Air Riv. Sèche VCA	17,605
4.	St Pierre VCA	15,982
5.	Centre de Flacq VCA	15,791
6.	Bambous VCA	15,345
7.	Mahébourg VCA	15,176
8.	Le Hochet VCA	15,034

Table 4: RDI and population density of selected VCAs [16].

SN	VCA	RDI	Population density
1.	Bel Air Riv. Sèche VCA	0.7182	970.0
2.	**St Pierre VCA**	**0.8100**	**1,223.7**
3.	Centre de Flacq VCA	0.7743	779.0
4.	Bambous VCA	0.6545	702.9
5.	Mahébourg VCA	0.7661	6,775.0
6.	Le Hochet VCA	0.7650	2,778.9

It can be observed that two of the VCAs namely Mahebourg and Le Hochet have a very high population density but have a lower RDI than the set criterion, therefore, was not identified as urban. However, attention also should be given to such areas as they will surely become urban in the near future as the overall island RDI has been improving. Thus, it is expected that the RDI of such areas also will increase soon.

Having a closer look at the most developed VCAs in the island as shown in Table 5; it can be observed that New Grove and Moka should be considered as urbanising areas as they have a growing population size and density.

The 12 parameters used to calculate the RDI were also studied for these seven regions and compared with the most developed area of the island, that is, ward 2 of the Quatre Bornes Town which has an RDI value of 0.8925. Little difference was found in terms of services available in these areas, however, a noticeable difference was found in terms of education level and type of employment by inhabitants. Moka VCA had similar characteristics as Quatre Bornes Town with high level of infrastructure and large portion of inhabitants having

Table 5: Most developed VCAs of the island [16].

SN	Village	RDI	Population density (p/km^2)	Population size (inhabitants)
1.	Triolet VCA	0.8002	1,574.8	23,386
2.	St Pierre VCA	0.8100	1,223.7	15,982
3.	New Grove VCA	0.8030	1,895.1	10,518
4.	Moka VCA	0.8715	507.2	8,846
5.	Brisée Verdière VCA	0.8043	482.2	7,512
6.	Long Mountain VCA	0.8093	508.4	6,995

Table 6: Urban population based on census 2011 data.

Year	2011
Total inhabitants	1,196,383
Urban inhabitants (administrative boundary)	499,349
Triolet	23,386
Goodlands	20,712
St Pierre	15,982
Total urban	559,429
Percentage urban (based on administrative boundary)	42%
Percentage urban (based on population size)	47%

higher education and professional employments of around 50% compared to around 25% in the other areas. These two areas also had bigger houses.

From the above data, three VCAs have been identified as urban, namely, Triolet, Goodlands and St Pierre and an additional four urbanising areas have been identified namely Moka, New Grove, Mahebourg and Le Hochet. Finally, the urban population has been estimated to 47% instead of 42% (Table 6) when administrative and legal boundary criteria are applied. These data are evidence that urbanisation of rural areas is occurring in several parts of the island, hence, negating the perception of de-urbanisation in Mauritius.

If the above process is coupled with appropriate remote sensing tools (smaller polygons for training areas), mapping of urbanisation in Mauritius can be done in a real time scale that is as and when its occurring.

5 CONCLUSION

Mauritius is a small island with a growing population size and density, however, is showing a negative urban growth. This paper has reviewed the current urban definition used, and based on demographic data has proposed another working definition to identify other urban and urbanising areas. The proposed definition classifies an area as urban if the population size is above 20,000 inhabitants or if population size is less than 20,000 but above 15,000, and having a population density of above 1,000 p/km^2 together with an RDI above 0.7945. When the definition was applied, three VCAs were identified as urban, namely, Triolet, Goodlands and St Pierre and an additional four urbanising areas were identified namely Moka, New Grove, Mahebourg and Le Hochet. The additional urban areas would lead the urban population to increase to 47%. These data are evidence of urbanisation occurring in rural areas, thus particular attention should be given to these areas and future smart cities to ensure sustainable and inclusive development.

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MOVING TOWARDS SUSTAINABLE AGRICULTURAL LAND MANAGEMENT AND PRACTICES IN KOSOVO

FJOLLË CAKA
Institute for Environment and Health, South East European University, North Macedonia

ABSTRACT

Agriculture is one of the sectors contributing to large greenhouse gas emissions, thus impacting ecosystems vitality, public health and climate change. It is also a very climate-sensitive sector, which is expected to face many challenges (especially economic damages) due to climate change impacts, mainly in developing countries. Even though agriculture is considered a national priority for Kosovo's economic development, there are still many prevalent challenges, including agricultural land loss and management (due to urbanization and economic developments), agricultural land contamination and pollution, high dependency on irrigation, old farm buildings and equipment, lack of knowledge on contemporary production techniques, and incompliance with the EU standards. With current agricultural and food production practices being inefficient and resource-consuming, coupled with potential future climate change impacts in the country, it is crucial to move towards more climate-resilient and sustainable practices. As Kosovo integrates its development and climate adaptation considerations in policy and technical changes, it is crucial to strengthen the rural, peri-urban and urban linkages towards ensuring food security and increased communities resilience. While climate adaptation require a mixture of capital and behavioural changes, lack thereof may increase adverse impacts on food security, public health, poverty reduction and economic development. Sustainable agriculture and food production practices can contribute to improved livelihoods and local economic development, food security, poverty reduction, social inclusion, health and sustainable and climate-resilient city development. In this regard, this paper presents current issues in the agricultural sector (land management and food production practices) and suggests respective recommendations for policy and practice improvements (including protection of agricultural land and its sustainable management, expanded irrigation network, nutrients use and manure management, shift to more climate-resilient produce, promotion of urban agriculture, enhanced institutional support and incentives) towards communities' future sustainable and resilient development in Kosovo.

Keywords: sustainable agriculture, climate-resilient agriculture, urban agriculture, sustainable food production practices.

1 INTRODUCTION

Agriculture is very climate-sensitive sector [1]. Climate change can impact the amount of land that is farmed, how the farmland is used (e.g. for crops or livestock), type of crop or livestock species (or their respective mixes/breeds alterations), and whether to irrigate or not, depending on countries' specific latitudes [1], [2]. From 1960 to 2000, changes in temperature and CO_2 concentrations have caused a net global increase in agricultural GDP from 2% to 4%, followed by a 3% to 5% total change in agricultural production [1]. However, studies show that if temperature increases by 3°C, farmland losses begin to outweigh the gains [1]. In addition, even though irrigation choices depend on precipitation, temperature increase can also increase the amount of water needed, thus the costs [1]. To reduce potential costs and losses, farmers have to switch to more feasible (temperature and water stress resilient) crops or livestock species. For example, African and South American farmers are more likely to raise sheep and less likely to raise dairy and beef cattle in response to temperature increases [1]. Such changes may be costly on their own (if specific infrastructural arrangements or other interventions have to be done), but may also have adverse impacts on the farmers' revenues out of such products (e.g. if they have to grow crops or livestock that

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do not have a high demand on the market). In this regard, as climate changes, agrarian countries (especially developing ones in the low latitudes) are expected to experience large damages and losses [1], [2].

In addition, agriculture itself contributes to high environmental pressures and climate change impacts through soil degradation (erosion, compaction), energy consumption for on-farm operations, water stress from irrigation and other on-farm water, water pollution and salinization, greenhouse gas (GHG) emissions (from nutrients application, manure spreading and storage, animal housing and grazing), and biodiversity loss [3]. Global resource extraction and processing of materials, fuels and food accounts for around half of the total GHG emissions, and for more than 90% of biodiversity loss and water stress in the world [3]. According to Kosovo's GHG emissions inventory for the period of 2008–2013, agriculture sector emits 690 Gg CO_2 eq., which accounts for 7% of the total emissions [4]. Agricultural emissions mainly derive from livestock enteric fermentation (digestive processes) and from manure management (around 550 Gg CO_2 eq. per year), as well as from land fertilization and burning of biomass (around 150 Gg CO_2 eq. per year) [4].

Since agricultural practices have economic and environmental impacts in most of the countries around the world (including Kosovo), moving towards sustainable respective practices is crucial towards the achievement of Sustainable Development Goals (SDGs). Sustainable food and agriculture have great potential in addressing hunger, poverty and sustainability issues through the provision of affordable and nutritious food, strengthening of livelihoods, promotion of inclusive growth, revitalization of rural and urban landscapes, and improvement of environmental performance.

With agriculture being an important (but sensitive) economic sector in Kosovo, itself facing potential future adverse impacts from climate change [5], it is crucial to shift to more sustainable and climate-resilient agricultural policies and food production practices. In this regard, Kosovo has already started environmental and climate change mainstreaming in its agricultural policies, and respective sector strategies and action plans [5], [6]. Furthermore, it has also started applying land use and management policies towards agricultural land protection (from pollution, degradation, and loss/conversion to construction land) and improvement (thus increasing its productivity). However, challenges still remain, as current agriculture and food production/transportation practices in Kosovo remain resource-consuming and inefficient, contributing to loss of biodiversity, water scarcity, increased GHG emissions and pollution of air, water and soil [3], [7].

This paper analyses prevalent issues in agricultural sector in Kosovo, suggesting respective approaches and measures for embracing more sustainable and climate-resilient practices towards the country's decoupling of economic development from environmental degradation. It is based on literature review for identifying existing agricultural practices in Kosovo, their impact on economy, environment and climate change, and respective institutions' roles and responsibilities. Upon the identification of main issues and challenges, respective recommendations towards making the agricultural sector and food production practices more sustainable and climate-resilient are provided.

2 BACKGROUND

2.1 Agricultural activities, land use and products

Agriculture is an important and strategic economic activity for Kosovo as well, contributing to its gross domestic product (GDP) by 7% [8]. It represents income opportunities, especially for rural areas, as urban agriculture is not that prevalent. In 2018, there were 2,942 registered agri-businesses, with a total of 13,156 people employed in the sector (marking a 25.9% increase from the previous year) [8]. Agricultural activities comprised 6.4% of the country's total economic activities [8].

In 2018, Kosovo's total land used for agriculture was 418,582 ha, out of which 52.12% were meadows and pastures (including cooperatives), 45% arable land, 1.84% fruit plantations, 0.78% vineyards, 0.24% gardens, and 0.03% plant nurseries [8]. Most of the arable land (81.32%) is of high quality (1–4 land classes), lying on both the eastern and western plains of the country and along the river valleys [9]. Agricultural land in Kosovo is mainly cultivated for cereal grains (123,869 ha), vegetables (17,886 ha), fruits (7,992 ha), vineyards (3,272 ha) [8]. Around 160 ha of land are used for medical and aromatic plants cultivation, and 179,580 ha are certified for medical plants and wild fruits collection [6]. Main cultivated crops comprise cereal grains (65% wheat, 31% corn, and 4% oats, barley, rye and others), vegetables (20% potatoes, 17% peppers, 16% beans, 13% squash, 34% others), fruits (32% apples, 23% plums, 19% raspberries, 26% others), vineyards (75% wine grain, 25% table grain) [8]. Most raised cattle include beefs, goats and chickens [8]. In 2018, agricultural production from crops was 388 million Euros, whereas from livestock 272 million Euros [8].

However, current agricultural production capacities in Kosovo do not fulfil the country's needs, therefore, products' import remains still high [8]. Around 42.3% of agricultural products were imported from European Union (EU) countries (including Germany, Poland and Italy), 33.6% from Central European Free Trade Agreement (CEFTA) countries (including Serbia, Macedonia and Albania), and 24.1% from other countries [8].

2.2 Agricultural development and land management

Agricultural development and land management in Kosovo is regulated from laws and Administrative Instructions developed by the Ministry of Agriculture, Forestry and Rural Development (MAFRD), Ministry of Economy and Environment (MEE, previously Ministry of Environment and Spatial Planning – MESP) and other relevant institutions. Law No. 03/L-098 on Agriculture and Rural Development (and respective strategy an action plan) aims to develop the agriculture sector (especially in rural areas) in Kosovo, by supporting market competitiveness, land management, economic diversification, local communities development, food quality and sustainable production, in lieu with EU directives [7, p. 1]. Law No. 03/L-016 on Food controls food safety and its contents quality in all food chain levels, whereas Law No. 02/L-75 on Public Health safeguards human health through disease prevention (including food-borne diseases) [7].

Even though at initial stage, progress is also being made in organic agriculture, mainly in the legal aspect (Law No. 04/L-085 on Organic Agriculture corresponding with the EC regulations No. 834/2007 and No. 889/2008) and product certification (through two international certification bodies, one from Albania and one from Greece), following international practices mainly from Croatia, Slovenia, Romania, Bulgaria and Hungary [7]. However, certification costs are high, hence increasing the production cost. In this regard, most of the organic produce is oriented for export to the EU countries (like Austria, Germany and Switzerland) and other neighbouring (Serbia, Macedonia and Montenegro) countries [7].

The MAFRD has supported agricultural development through investments in physical assets of agricultural economies and products processing and trade, farms diversification and business development, and irrigation [8]. It has also supported farmers with agricultural inputs (sapling), agricultural loans and loan guarantees, agricultural sector insurance, and capacity building (awareness raising, trainings, counselling, local action groups, etc.) [7]. It has also been stimulating youth engagement in agricultural and other non-agricultural activities (such as agro-tourism) by setting age limits for farm owners when applying for investment subventions and grants, training and access to different information [7]. As a result, women and youth employment in agriculture (especially on organic agriculture collection points) is increasing [7].

Law No. 04/L-040 on Land Regulation mandates the Ministry of Agriculture, Forestry and Rural Development (MAFRD), Kosovo Cadastral Agency (KCA), municipalities and municipal cadastral offices as main responsible institutions for land use regulation [6]. Most (88%) of the agricultural land ownership in Kosovo is private and 12% public (owned by state enterprises and cooperatives, with farms ranging from 500 to 1,500 ha) [5]. Around 93% of agricultural households own farms smaller than 5 ha, with most of them ranging between 2 and 5 ha [7], [8]. Only 1.7% of the farms are of 10 ha or more [7]. This land fragmentation remains a challenge to feasible food production, collection and transportation processes.

3 MAIN ISSUES

Despite many measures undertaken by the local and central level institutions, land (soil) pollution and degradation trend in Kosovo is increasing, especially along the main local and regional streets [6]. Some of the identified main issues in agricultural sector in Kosovo include agricultural land loss to new constructions (due to expansion of urban areas, riverbed extractions, or other roadside developments), poor land management practices (land fragmentation and conversion and lack of comprehensive and functional system for land monitoring), poor agricultural production practices (incompliance with the EU standards due to the lack of knowledge or technologies), high land contamination (due to industrial facilities or complexes, garbage disposal and landfill sites in the proximity), old farm buildings and equipment, absence of manure storage facilities on livestock farms (which is stored in heaps outside barns, close to road drains and along river basins), lack of data, monitoring and management (of the use of pesticide and fertilizers in agricultural land, agricultural pollution's impact on surface water and health impacts), and high dependency on government subsidies and international donor funding [6], [7], [12].

From year 2000–2018, the total urban area in Kosovo has grown by 57% (a total of 6,000 ha), mainly to the cost of agricultural land [10] causing a decrease of the total land area used for agricultural purposes by 1.6% [10]. The arable land area is also very low (0.25 ha/person) as compared to that of EU countries (0.52 ha/person) [11]. Agricultural land loss to new (illegal) constructions and riverbed excavations causes reduced farmland and green space areas, damage to soil and water resources, industrial pollution, and landfills [5]–[7], [9], [12]. Furthermore, around 10,000 ha of agricultural land (along with around 9,000 residential objects and respective technical infrastructure and 50,000 inhabitants) are threatened from river floods [11].

Kosovo's institutions have already undertaken agricultural land protection measures and municipal inspectorates have started reporting illegal conversions from agricultural to non-agricultural land [7]. Efforts have been made in protection of agricultural land from illegal constructions (especially on qualitative agricultural land, categories 1–4 or other special zones) and supporting agricultural and rural development; therefore a slight increase of land used for agricultural purposes has been noted during the past years (2016–2018) [6], [8], [11].

Even though the transition from traditional family farms to commercial ones is ongoing, land fragmentation is still one of the main issues contributing in low work efficiency, thus causing high production costs [7]. On the other hand, besides private home gardens, urban agriculture or farming (including community gardens or other rooftop and vertical farms) is not that prevalent in Kosovo. Some initiatives for growing urban produce (including permaculture activities) have already started, but they remain in a very small scale. A slight increase of such activities has also been noted during the past several months shutdown due to the COVID-19 pandemic.

Furthermore, agricultural land is often used without any criteria or standards due to lack of knowledge on contemporary (production) practices and technologies, old farm buildings and equipment, and lack of inspection [7]. In this regard, land is often degraded beyond repair, which when coupled with soil pollution reduces the quality and quantity of agricultural products and cultures [6].

Usage of pesticides and fertilizers in agriculture contributes towards water pollution as well. Around 19,000 tons of nitrogen is produced from livestock each year, and with improper manure storage and management, much of it leaches into soil and local water bodies [12]. This poses a potential health risk since many rural villages depend on wells and local springs for potable water (due to the lack of access to piped drinking water) [12].

In addition, agriculture in Kosovo is highly dependent on irrigation, but only around 5% of the total arable land area is irrigated (compared to 20% in the EU) [11]. Considering Kosovo's water stress and potential water scarcity, increased irrigation remains an ongoing challenge.

The agricultural sector in Kosovo, despite being favorited and considered a national priority for the country's economic development, is still heavily reliant on agricultural loans (provided by many banks and micro-financial institutions) and international financing [7]. Efforts are also being made in compensating farmers from damages caused by low or high temperatures, and rainfall; however, insurance companies still lack expertise in assessing agricultural damages and hesitate in selling agricultural insurance policies (since the risk is systematic, causing huge potential losses) [7].

4 CONCLUSIONS AND RECOMMENDATIONS

Kosovo is rich with agricultural land, the majority of which is of high quality. However due to poor land management and agricultural and food production practices, agricultural land continues to be converted to construction land, is degraded beyond repair, and remains contaminated. As such, current agricultural production does not fulfil current population needs, therefore the country is heavily reliant on import. As population grows and demand for food will increase.

With agriculture being a very climate-sensitive sector (and highly dependent on irrigation), future projected temperature increases and precipitation changes in the region will add additional challenges to food security, livelihood opportunities and economic development in Kosovo, especially in rural areas. As such, there will be an increased need for greater agricultural yields, generated using less water, energy and space on land [13].

Climate adaptation requires a mixture of capital and behavioural changing [1]. Promising opportunities provided by climate change shall be used smartly, whereas potential damages should be avoided or reduced [1]. However, if no climate change adaptation measures are undertaken, Kosovo may face negative consequences for food security, public health, poverty reduction and economic development (mainly affecting agriculture, forestry and water resources) [5]. Furthermore, adaptation costs will rise exponentially, if there are no current successful mitigation efforts [5]. Therefore, incorporating climate change considerations in policy and technical changes, as well as increased capital and improved access in the agricultural sector and related food production practices in Kosovo is crucial [2].

In this regard, development policies and climate adaptation should be integrated into one cohesive program for a more progressive development of Kosovo; hence, a holistic and systemic approach towards strengthening the urban, peri-urban and rural agricultural linkages towards enhancing livelihoods and food security and resilience is needed.

Adequate agricultural development and land management policies, food production practices, and institutional and donor support can contribute in achieving Kosovo's potential for ensuring enough food supply for its current and estimated population growth [9]. Furthermore, consumption of local produce supports national economic growth and contributes towards reduced associated food transportation costs and GHG emissions. Hence, sustainable agriculture and food production practices should remain a strategic priority towards communities' sustainable and resilient development in Kosovo.

Table 1: Recommendations towards sustainable agriculture and food policies and practices.

Science-based and sustainable approach	• Investing in data collection, reporting and verification in agriculture sector [19]. • Supporting sustainable and healthy food policies and systems (according to the EU's Farm to Fork Strategy) [3]. • Integrating ecosystems and their services into decision-making towards preserving and restoring the natural capital (including agriculture, fisheries) [3]. • Undertaking studies on climate adaptation in agriculture (including what crops to grow, what animals to raise, what inputs to employ) based on the specific context [1]. • Sustainable land use planning (protecting agricultural land loss and degradation from urbanization and other infrastructural projects through concentrated and compact developments, as well as from river floods) [9], [11]. • Revising harvesting, planting and fire policies taking into account ecological changes due to climate change [1]. • Shifting to more sustainable and climate resilient/resistant crop products and livestock breeds (e.g. more resistant to water stress or salinity, temperature increase, parasites and diseases) [1], [3], [14].
Institutional support and incentives	• Provision of low-cost favorable locations for agricultural purposes [9]. • Investing in water sector infrastructure including dams (for storing early winter melt for valuable growing season irrigation), levees (for controlling flooding), and new irrigation canals [1], [9], [11]. • Promotion of sustainable practices in agriculture, such as precision agriculture, organic farming, agro-ecology, agro-forestry and stricter animal welfare standards [3]. • Supporting urban agriculture initiatives, including community gardens, green rooftops and facades [15], [16]. • Developing sustainable farming or food certification schemes (to encourage commitment in sustainable management and consumption) [3]. • Implementation of eco-schemes as rewarding measures on improved environmental and climate performance, e.g. for farmers managing and storing carbon in the soil, better management of nutrients for improved water quality and emissions reductions [3].

Table 1: Continued.

Sustainable practices (and technological advancements)	• Promotion of low impact development techniques (e.g. natural drainage by planting trees and deep-rooted crops and implementing crop rotation) [3]. • Using architectural innovation (bio domes, double-glazed roofs for retention of heat, light modular steel frames for rapid expansion and adaptation, LED lights) and tech-savvy farming techniques (zero carbon greenhouses, hydroponic systems, geothermal energy, controlled indoor environment) to improve the environmental performance of existing and new greenhouses (as the case of the Westland region in the Netherlands) and bio domes (in the Sustainable City, a net zero energy community in Dubai, UAE) [13], [20]. • Integrating renewable energy generation on-site (e.g. installation of solar thermal systems, photovoltaic panels, wind turbines, biomass boilers on farms or related buildings) [3]. • Adopting water saving technology, such as sprinklers and drip irrigation [1]. • Investing in insulation and cooling capacities of agriculture related facilities [1].
Management	• Sustainable farm management (including ecological buffer strips, landscape planning, energy and water efficiency, and development of biological corridors around and between farms [14], [18]. • Soil quality and nutrients use management. • Grass and grazing management (by reducing it during plant flowering periods) [14]. • Rainwater storage and usage management for irrigation or animal washing/watering [1], [14]. • Proper animal husbandry and manure management [14].
Monitoring	• Developing a comprehensive agricultural land inventory and monitoring program [6], [11]. • Reducing and monitoring the use, risk and environmental impact of chemical pesticides, fertilizers and antibiotics [3], [6]. • Using Life Cycle Assessment (LCA) or ecosystem service indicators (with appropriate metrics for monitoring, measuring and continuously improving farm environmental performance) [14].
Awareness raising	• Raising awareness in responsible production and consumption (e.g. selling products directly from farm shops or local farmer markets, co-operating with local food processors, hosting farm open days and guided public tours, allowing gleaning/harvesting leftover crops, supporting healthy diets and reduced food waste) [3], [12]. • Reducing the environmental impact of food processing and retail sectors (by lowering their carbon footprint in transport, storage, packaging and food waste).

Agricultural activities/practices that should become more sustainable include sustainable agricultural land use planning and management, soil quality and nutrients use management, crop planning and protection, grass and grazing management, animal husbandry, irrigation management, and manure management [14]. Even though agricultural development is crucial for the economic development of rural areas, urban areas can benefit from agricultural developments as well. Community gardens (developed in city parks, underutilized areas, rooftops or vertical spaces) in urban areas can contribute in increased access to affordable and nutritious food; local ecosystem, air quality and public health improvements; urban island effect reductions; healthy eating lifestyle awareness raising; and strengthened community ties and social cohesion [15], [16]. Furthermore, such gardens can also serve for storm-water management through rainwater harvesting and storage.

The European Commission (EC)'s Joint Research Centre (JRC) provides a lot of best environmental management practices, such as techniques, measures and actions that can be taken in sectors of agriculture and food processing towards their environmental performance improvements and impacts minimization [14], [17]. Additional recommendations on sustainable agriculture and food production systems are provided within the new European Green Deal (signed in 2019) and the EC's Sectoral Reference Document (SRD) in Agriculture (2018) [3], [14]. A summary of recommendations for moving towards sustainable agricultural land management and food production practices in Kosovo is provided in Table 1.

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SUSTAINABLE URBANIZATION IN PATAGONIA TO ADDRESS CLIMATE CHANGE AND COUNTRY NDCS: A CASE STUDY OF A MIXED COASTAL URBANIZATION PROJECT

DANIEL PEREZ[1], LAURA PEREZ[1], ADRIANA PEREZ[1] & JORGE ABRAMIAN[2]
[1]Refugio de los Lobos S.A., Argentina
[2]Civiltec, Argentina

ABSTRACT

The current energy matrix in Argentina is highly dependent on fossil sources, with a low contribution from renewable sources. Argentina adhered to the Paris agreements of 2015 for the reduction of CO_2 emissions. Therefore, the commitment to comply with the implementation of the NDC (National Determined Contributions) objectives mainly related to the generation of renewable energy and efficiency. This project aims at capacity building to support energy transitions towards low emissions and economic, ecological, resilient, and inclusive urbanizations. As the population grows, the quality of ecosystems and the urban environment correlates to public health, where the balance between demographics reduces pressure on the natural environment, creating and improving the conditions of sustainable urbanizations to provide greater protection of biodiversity and the natural environment. The project is a possible scalable model of sustainable urbanization development in arid coastal environments, addressing issues of land restauration, clean energy generation, reducing fossil fuel dependency, waste and water management, circular economies, and bioclimatic architecture for energy efficiency to combat climate change. A case study is presented as the first mixed eco-urbanization project in Patagonia, designed to minimize the impact on the environment and the living beings; combining rewilding of eroded coastal areas, for the creation of natural landscape reserve areas, and public areas, including an interpretation of scientific research and education centre; and other facilities. All these combined, promoting socialization and exchange, benefit the entire community. The multithemed project would be unprecedented in the region. It restores an area eroded for decades by quarries, landfills from human misuse, ordering a public-private space, generation of productive activities, direct investment, and employment. It enhances landscape conditions to support tourist resources and the beauties of the Patagonian region.

Keywords: sustainable urbanization, arid environments, eco-urbanization, mixed urbanization, Patagonia, urban planning, eroded coastal, energy transitions, dune, coastal restauration.

1 INTRODUCTION

Climate change as global effect imposes a systemic risk to economies, people, and communities. In the future, the consequences could be even worse, provided mitigation measures are not implemented [1]. Climate risk management problem in the finances of a country becomes an integral part of the solution for sustainable economic development [2].

Compliance to the climate goals of the Paris Agreement requires significant investments, where access to finance and investment programs are necessary for long-term recovery. The COVID 19 pandemic adds to this challenge and highlights the need for investments in green recovery to minimize climate risk, favouring energy transitions [3]. As well as to contribute to the development of mechanisms for the participation of the private sector in the formulation and implementation of climate policies with a focus on the implementation of country (NDCs) mitigation actions [4]. It promotes the exchange of experiences and good practices, joint learning, and collaboration to address common challenges, by developing strategies, projects, financing mechanisms, and technical advice.

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This project specifically addresses the following country NDCs:

- Energy: renewable energy and home distribution, energy efficiency;
- Ecological restoration in degraded environments;
- Mobility: urban planning to facilitate walking, cycling.

2 DEMOGRAPHIC GROWTH AND SUSTAINABLE DEVELOPMENT

Patagonia comprises vast territories of land. However, due to unplanned growth during decades, cities, and urban conglomerations resulted in highly concentrated areas with poor connectivity and public services. The nearby coastal city of Comodoro Rivadavia had its origins in oil exploitation. Since the early 1900, it has grown through oil camps to house workers from abroad who came seeking opportunities following rapid economic growth. For this reason, the city suffers of lack of long-term urban planning and grew in patches, resulting in disconnected highly dense neighbourhoods, often facing with their backs to the sea, beauties of natural landscapes [5].

In line with the objectives of the UN (sustainable cities) and the country NDCs towards the reduction of emissions, mitigating climate change, the use of energy through clean sources is selected. It promotes the use of residential renewable energies with possible subsequent reinjection into the electricity grid through the new law on the Promotion of Distributed Generation of Renewable Energy Integrated to the Public Electricity Grid [6].

From its inception and throughout the entire process, the urbanization project is designed to provide solutions to both urban planning and the ordering of public and private space, with access to public areas and the focus on linking with the community and improving services. It contemplates a low density of spaces for residences in a Patagonian environment and in a coastal environment, with the rewilding of native vegetation in the eroded coastal area (Fig. 1).

Figure 1: Image showing the future location of the project and eroded coastline at the end.

3 DESCRIPTION

Located on the east coast of Patagonia, at the parallel 45degS, in the province of Chubut, Argentina. The project was conceived under the concept of Mixed Urbanization based on sustainability, accessibility, and innovation, integrating spaces for housing, public area, and restored landscape reserves. The urban master planning is based on a landscape strategy incorporating the characteristics of geomorphology of the existing terrain and natural environment. It aims to improve the quality of life in an arid Patagonian context, the preservation of the ecosystem and the generation of renewable energy in common and residential areas. Commitment to preserve the characteristics of the environment is a priority for the project, preservation of the natural environment through the efficient use of energy, resources and waste management, bioclimatic architecture in favour energy savings. It applies concepts of ecological urbanization linked to sustainable, green, environmentally conscious bioclimatic architecture, designing for energy efficiency. It is proposed a public recreation area, guaranteeing free access to the beach, recreation areas, and facilities for scientific research related to Patagonian biodiversity, coastal studies, and environment education, among others. All in a natural, and orderly environment available to the entire community. At the same time, contained by an urban framework of private houses and private spaces where residents assume commitments such as the use of renewable energy, recycling of waste and the control of effluents, among others, respecting and enhancing the natural landscape. It aims to provide collective and inclusive solutions. To achieve this, a team of specialists in each discipline provides support and guidance to residential users.

3.1 Issues addressed

The project addresses the following local and regional issues:

- Population growth, concentration in large cities, high density
- Land and coastline affected by landfills and garbage dumps
- Lack of awareness on environmental, coastal erosion and energy issues
- Dune and coastal protection eroded by anthropogenic use and increasingly aggressive weather
- Regional housing shortages in a context of nature and sea
- Lack of potable water as a resource in this arid Patagonia region
- High dependence on fossil fuels for energy consumption
- Limitations and interruptions in the local electrical distribution network
- Irrational use of energies; cultural and low efficiency in constructions
- High dependency of fossil extraction, poor diversification of the local economy
- Inadequate policies to support green development
- Lack of awareness, government policies and support on sustainable development and measures to combat climate change.

4 RECREATING LANDSCAPE

In the year 1985 the founder of the project and owner of the land that hosts a colony of sea lions, due to the constant aggression by hunters to fauna, donated this part of the land with the purpose of conservation of the ecology, flora, fauna, and allowing tourist development converted in the Protected Natural Area Punta Marques, administered by the government of the province.

4.1 Dune and coastal regeneration

The adjacent coastal area of Belvedere beach suffered human misuse for decades and mitigation measures had to be taken to restore and preserve the coastal environment and ecosystem [7]. The sensitivity of these environments to erosion is high due to the poor structure of the soils predisposing them to wind and water erosion [8]. After researching and analyses, it was decided to invest in a coastal bioengineering solution. The objective of the project – never developed on a Patagonian beach – was to rebuild the sand dune that serves as a coastal protection system (Fig. 2). Once created, this system behaves dynamically changing according to the action of the wind and the sea. Reconstruction of sand dunes with compatible local sand was considered of high interest and a unique experience in the southeast Atlantic coastline of Argentina. As a contribution in recompositing a decayed ecosystem, preventing from being exposed to human behaviour, once reforested with native species for soil fixing, this area will be dedicated to landscape and coastal reserve for future preservation. With respect to vegetation, it is proposed to maintain the physiognomic-floristic attributes of the dominant plant communities [9]. The reconstruction of dunes provides a dual purpose:

1. Ensure availability of sand for a natural dynamic coastal process generated by the wind and sea actions
2. An extended section of the dune beach fill provides long term protection, extending the berm and dry beach to contribute with additional protection of the dune to further mitigating, and even mitigate climate change effects of rising sea levels (Fig. 3).

The immense value that sand dunes represent in terms of shoreline stability and coastal protection is widely recognized and many countries have undertaken projects to rebuild and preserve existing dunes. Through this effort, a technical solution is offered that combines natural landscape and environmental improvement, with the use of sand material from the same terrain source.

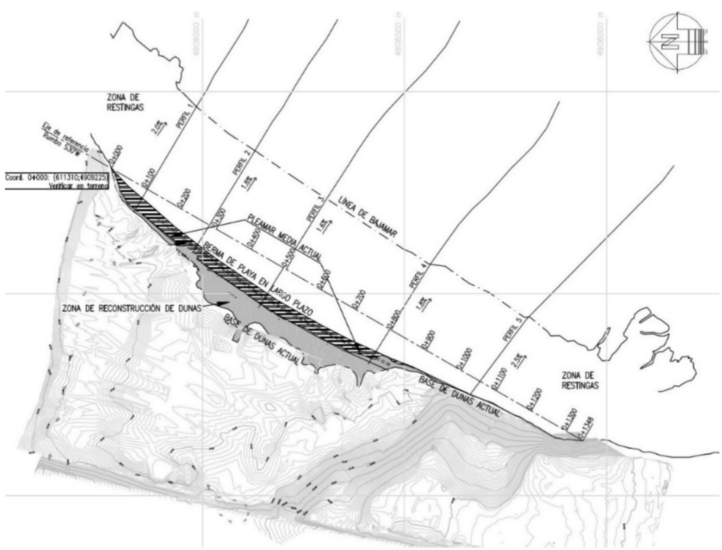

Figure 2: Simulated long term coastal profile, after the sand dunes system restauration.

Figure 3: Formed dry beach section recreated after partial restauration of sand dunes.

Figure 4: Terrain and coastal condition before restauration, evidencing severe erosion.

4.2 Terrain Geomorphology and Lagoon

The dune erosion and the lowering of ground levels were the effects of decades of sand mining for human recreational activities and landfills, in addition to the compaction of the soil by vehicles and human transit. The original line of coastal dunes was degraded and breached resulting in seawater flooding the lower areas during high tides (Fig. 4).

Several studies were conducted related to littoral transport, erosion, sedimentation, and the design of an artificial fill to recover the dune system and achieve stabilization of the currently deteriorated beach. The project solution approach includes the reconstruction of a line of dunes and the development of a shallow lagoon in an area of depressed topography (Fig. 5). The surface and shape of the lagoon was determined studying the existing lowest contour lines and applying criteria to minimize interventions, soil movements, and impacts to native species. The resulted lagoon shape is shown in Fig. 6, the contour lines and dimensions additionally allow recreational development of nautical activities independent of the sea.

Figure 5: Partial coastal/dune restoration and re-established height levelled coastal terrain.

Figure 6: Resulted lagoon contour profile from studying eroded low ground levels.

5 URBAN PLANNING – DENSITY AND CONNECTIVITY

The masterplan is designed respecting the geomorphology of the land – highly eroded as a result of decades of soil extraction by the quarry and land misuse by visitors. A low-density urbanization in Patagonia, promoting sustainable development and its concepts enhancing the natural landscape. It introduces a concept of urban life centred on people in relation to the environment. It promotes smart city/IoT and 24.7 connectivity technologies for the administration of public services, distributed energy generation, onsite treatment of sewage effluents. The model is transferable to public initiatives.

The urban plan design contemplates more than 60% of land dedicated to landscape reserve purpose and only 25% of the soil occupation coefficient (SOA) of each property terrain. Overall, combining these parameters, it represents only 10% of the total soil occupied by constructions, therefore preserving the natural aspect of the land. Additionally, the design of common buildings considers bioclimatic factors such as sun/position/latitude/wind and predominant nature elements, where isolation materials and renewable energy generates the conditions for living only with the necessary. Other strategies to achieve this purpose are green roofs (vegetation) in houses with flat roofs to mimics the effect of land. All this combined is unknown in the region.

The project is aligned with 15 of the 17 objectives of the ONU in sustainable development goals with a focus on objective 11 sustainable cities and communities; objectives 1, 3–15, 17.

With respect to mobility within the urbanization, the urban plan design favours mobility by walking and bicycle through dedicate pathways considering all necessary for life will be located within 10 min walk. In the future, in favour of energy transitions, dedicated parking areas with solar chargers will be provided for electric cars or scooters.

5.1 Project proposal summary

- Restauration of degraded coastal ecosystem.
- Recycling waste and circular economies with organizations that use materials to reinsert them as transformed materials into the economy, examples are plastic bricks, posts, decks.
- Clean energy, reduction of fossil fuels, renewable energy by solar panels, biodigester from organic waste.
- Employment: produces up to 1000 direct and indirect employees as the project progresses.
- Water scarcity in this arid region of eastern Patagonia will be addressed with different strategies including a desalinization plant.
- Sustainable bioclimatic houses for energy efficiency.
- Landscape and green reserves.
- Educational and sport centres.
- Research and interpretation center to promote ecologic tourism.
- Mobility, urban planning to motivate walk, cycle, and future solar power stations for electric vehicles.

6 LOCAL OWNERSHIP – BENEFICIARIES

The direct beneficiaries of the project are mainly two groups. The first are the new owners of parcels that share the vision of a lifestyle in complete integration with the nature with the conditions of dynamic sustainable urbanization. Other beneficiaries are visitors and vacationers who will enjoy access to the beach in proper conditions of hygiene, safety, and environmental balance in terms of a public good provided by the project, in contrast to its current deteriorating conditions. The indirect beneficiaries are the groups of the research and academic activities of the regional scientific community and environmental groups that will access the surrounding wild environment in conditions facilitated by currently non-existent infrastructure accessories. The scientific community will access a dedicated onsite scientific research facility for specialized research work, in contrast with today's practice where certain tests and studies on topics of algae, microalgae, bivalves and biodiversity are disseminated in different locations. Other beneficiaries are local organizations that use recycled materials, to reinsert transformed goods into the economy.

7 INNOVATION

The combined multipurpose nature of the project aims to improve the conditions of the surrounding environment. These include access to the beach with adequate conditions for its future preservation, and facilities for research, education, tourism, and sports activities. Some dedicated spaces converted into public goods including the transfer of ownership to the local government to ensure the public condition such as beach access roads, and dedicated parking areas – avoiding today's issue and impact of fuel/oil vehicle's contamination on the beach during low tides. With regards to energy generation, the possibility to reinject distributed generation of electric power into the grid is of interest of the local energy cooperative and treatment plant of sewage effluents with biodigesters, and smart city makes the sustainable condition of the urbanization's elements for the community take ownership and serves as a scalable and replicable case study. Technological innovation and adaptation in current times is an essential pillar [10]. Best practices, lessons learned, procedures, implementation are to be captured and shared with public and government to eventually support policies towards sustainable development as mitigation to climate change.

8 REPLICABILITY

This project can be partially or totally replicated as a model of sustainable development. It represents a way to address population growth through sustainable urban development, in areas whereby territory/land distribution regulation issued by local governments is compatible with urban use. Land that is on the outskirts of the main dense sector of cities, in contact with originally natural areas, that however are now damaged due to pressure from human presence and polluting activities. This is applicable when the use of land permits to be developed into urban areas, while still maintaining the connection with the nature and ecology of the place. It is particularly important in areas of vast territory of unused land, and populations concentrated in crowded cities. It aims not to densify an urban sector but to preserve the natural aspects of the land or restoring when it is damaged, improving the quality of land for use by the communities, either residential, recreational, education, scientific, or a combination. It accounts for sustainability concepts such as a specific urban plan design adapted to the geomorphology of the terrain and bioclimatic buildings with architecture adapted to the environment such as weather, sun, latitude, and elements of nature.

9 GENDER DIVERSIFICATION AND INCLUSION

Diversity and innovation for a new knowledge economy is an essential part of this project, as a better future cannot be built without equity and integration, or technology and innovation [10]. The inclusive condition of the project is materialized by converting access, use, and preservation of an area of the Patagonian coast – suffering a drastic process of degradation – creating the necessary conditions for life in a sustainable manner. It involves transferring key accessibility areas of the infrastructure to the local government, and joint programs for public environmental education. Currently, women's content is majority with a strong presence at each level of our organization from the board presidency, communication, engineering, architecture, design, biology, forestry, biochemistry, tourism. We promote empowerment and equal opportunities across our entire organization. Although women have achieved more and better spaces of representation in social, academic, and labour spheres, the plan is to work in this direction, by sponsoring activities to develop women groups. In addition, it is intended to work with marginalized groups in activities such as recycling, promoting small enterprises reinserting their produced goods – such as bricks, outdoor furniture from recycled plastics – into the local economy creating true circular economies cycles.

10 SHARING BEST PRACTICES

To Improve skills and knowledge transfer to the local community, a series of workshops on themes of sustainable urban development will be organized for the community participation, with invitees from specialists, academia, suppliers. Sessions on specialty themes in line with recommendations to accelerate the reduction of emissions on the following topics:

- Renewable energy generation: SolarPV/Eolic generation (net energy, residential distributed energy; guidance, access to finance programs, minimum generation for residential of 30% and more than 80% in common buildings).
- Bioclimatic buildings for thermal isolation.
- Green heating from geothermal energy.
- Recycling and circular economies.
- Biodigesters at urban scale for energy generation.
- Seawater desalinization.
- Mobility: strategies within the urbanization, design of walk/cycle paths, car solar power chargers.
- Smart cities: IoT technology, real time measurement, self-learning processes.
- Lessons and experiences shared through communication material, publications, academic papers in relevant events.

11 CONCLUSIONS

Although at a small scale, the sustainable mixed urban development project described – addressing issues such as restoration, clean energy generation reducing fossil fuel dependency, waste, and water management – could provide a positive impact for NDC implementation at country level. Its replication and scalability will represent the possibility of building capacity at a global scale approach. Therefore, the opportunity with a small contribution to produce a positive global impact. The project aims for capacity building to support energy transitions towards low emissions and economic, ecological, resilient, and inclusive recovery of communities.

It becomes critical to relate at country level climate risk management and investment/finance programs to tackle risk mitigation, as ignoring today's issues will exacerbate conditions for further deterioration of economies, and people's wellbeing.

COVID 19, has placed communities under stress, as evidenced by a correlation between urban environment and health. Therefore, the quality of ecosystems and the urban environment impacts hygiene, safety, public health. Ultimate balance between demographics reduces pressure on the natural environment improving conditions of sustainable urbanizations and greater protection of biodiversity.

Investment in the reconstruction of sand dunes restoring an ecological system is considered of high interest, unique on the Atlantic coast.

Future mechanisms of cooperation will be beneficial, ranging from funding to technical assistance, and participation in programs with all players from public governance to the private sector.

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SECTION 2
THE COMMUNITY AND THE CITY

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TEMPORARY TRANSFORMATIONS TO ACCESS AND EXPERIENCE SUSTAINABLE CITY PUBLIC SPACES

ANDREA BOERI, DANILA LONGO, SERENA ORLANDI, ROSSELLA ROVERSI & GIULIA TURCI
Department of Architecture, University of Bologna, Italy

ABSTRACT

The challenges of contemporary urban regeneration processes call for innovative and sustainable operating models and strategies. Cultural Heritage acknowledgement and valorisation, combined with participatory and engagement practices, can trigger reactivation and re-appropriation of underused urban spaces. Co-design, self-construction and participatory paths, through demonstrative and temporary actions, can generate new dynamics in the public space use, provide effective solutions to tackle climate change, improve outdoor microclimatic comfort conditions, and enhance Cultural Heritage accessibility and knowledge, fostering responsibility for the common good. The implementation of demonstrative interventions, co-created with local administrations, stakeholders and citizens, represents a viable and effective tool to test temporary experimental transformations and to monitor and evaluate their impacts, recalibrating the proposed strategies on a case-by-case basis. This integrated and innovative approach was experimented in the Bologna University area by the EU Horizon 2020 project ROCK – Regeneration and Optimisation of Cultural Heritage in creative and Knowledge cities (GA 730280) – through a series of pilot actions. ROCK experimentations are implemented in the historical city centres, enhancing public open space fruition and performative potentials, to generate new resilient processes in terms of environmental sustainability and social inclusion. The co-design and self-construction interventions on Piazza Rossini (focused on in this paper) represent short-term and reversible transformations with a long-term impressive and beyond expectations results.

Keywords: co-design, Cultural Heritage, temporary transformations, environmental sustainability, urban regeneration, integrated approach, unconventional uses, co-creation, conservation, ROCK project.

1 INTRODUCTION

The complex dynamics characterising urban regeneration processes in the contemporary city call for the experimentation of alternative, integrated and sustainable cultural and operative models for the urban and architectural project. The active role played by Cultural Heritage (CH) in sustainable development processes, in the promotion of cultural diversity and in the synergy of competences among all the involved public, institutional and private actors, is supported by the awareness of individual and collective participation in cultural life as a right, as stated by the Council of Europe Framework Convention on the Value of Cultural Heritage for the Society signed in Faro in 2005 [1].

This community commitment finds in co-planning, co-production, self-construction and co-management fundamental steps for experimental urban transformation processes so that being able to possibly achieve long-term results through temporary and pilot actions [2]–[4].

In this context, historic centres are intended as extraordinary laboratories where testing innovative CH-led strategies, capable to reactivate and transform the space of the city, unfolding and revealing unexpressed potential, experimenting unconventional uses and directly involving local communities and stakeholders [5], [6]. The acknowledgment of the positive value of the city as a heritage and common pool resource, according to a vision that combines conservation, enhancement and innovation actions, represents a key aspect of the proposed approach [7].

Several experimentations carried out by the Municipality of Bologna (IT) in the heart of the historic city centre, in collaboration with Fondazione Innovazione Urbana (FIU) – centre

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of analysis, communication, elaboration and co-production on urban transformations to face social, environmental and technological challenges – and the University of Bologna – Department of Architecture can contribute to clarify the above described approach, tapping into the creative potential of local users, especially students. These actions are conceived and realised by the ROCK project (Regeneration and Optimisation of Cultural Heritage in creative and Knowledge cities, G.A. 730280), funded in 2017 under the EU Horizon programme in the axis "Climate Action, Environment, Resource Efficiency and Raw Materials", "Greening the Economy", in response to the call "Cultural Heritage as a driver for sustainable growth" (Call ID: H2020-SC5-2016-2017). The project, whose ending will be in December 2020, is leaded by the Municipality of Bologna with scientific coordination of the University of Bologna and involves 10 European Cities and 32 partners [8].

ROCK interprets historic city centres as privileged living laboratories where new models of urban strategies and practices are tested to demonstrate how tangible and intangible CH can be a powerful engine of regeneration, sustainable development and economic growth for the whole city. ROCK provides new ways to access CH and to promote perception of shared heritage as collective property, fostering the usability of spaces to all and improving CH functions from a user perspective. The experimentation of regeneration actions focuses on public open spaces, whose use and performance value allows – through co-design processes – to improve both social inclusion and competitiveness of the city at international level [9].

One of the main actions implemented by the ROCK project is described by the present paper: it concerns experimental spatial and use configurations for Piazza Rossini, a public space in the middle of the University historical area, used for a long time as a parking lot and returned by ROCK to a community role.

2 INNOVATIVE STRATEGIES FOR URBAN REGENERATION

The project and process which involved Piazza Rossini, Bologna, are intended as an interesting storytelling opportunity to present possible CH-led urban regeneration strategies: an integrated approach that finds its main components in co-design, reinterpretation of historical memory, experimentation of greening solutions and opportunity of public space re-appropriation.

2.1 Participation: co-design process

The ROCK project applies Living Lab methodology [10] to the university area in order to experiment, observe and verify different actions and to improve accessibility to services and to CH. In Bologna, this model has been applied in U-Lab, an iterative process of research and action, which works on viable solutions based on community needs and on urban accessibility through the co-creation of shared services, both oriented towards changing behaviours and modifying space layout.

During the running of the ROCK project, a set of demonstration actions were carried out in the three Replicator cities (Bologna, Lisbon and Skopje), in order to test the replicability and effectiveness of the approach and of the related models successfully implemented in seven Role cities. As regards Piazza Rossini case study in Bologna, the preliminary considerations were born during the participatory laboratory "U-Lab" which took place on this specific area and attended by over 250 people. From an active comparison and exchange of ideas between the main involved stakeholders (institutions, associations, students, etc.), the need to restore a social dimension to the square emerged, paying particular attention to greening and lighting as design elements.

During the participatory phases some suggestions were collected and placed at the base of Piazza Rossini regeneration project: [the need to] create a "Light Plan" to ensure good visibility in the area, a fundamental element to increase the perception of safety, in particular for deaf people and to lead the public visitors towards new rest and stay areas; [the need to] provide places reserved for children with urban furniture suitable for playing and resting; [the need to] make the square more democratic, to serve everyone and not just cars or a few categories of people, rethinking its primary and secondary uses [11].

2.2 Greening: testing shared sustainable strategies and solutions

As will be explained later more in detail, the basic idea for the renovation of piazza Rossini is the transformation into a green area. The choice of the meadow as a temporary solution for urban regeneration fits in the European framework, which sees cities at the forefront of efforts to tackle climate change. Examples of similar approaches applied to historical spaces can be found in several temporary interventions. For instance, in 2017 Plaza Mayor in Madrid was covered by a giant meadow of natural grass that allowed citizens and tourists to sit down and enjoy the square from a new perspective, reflecting about how green can transform the way of living and using public spaces. The simple, but impressive, project was realized by the artist SpY in the context of “Cuatro Estaciones”, an urban art program run by the Madrid City Council to celebrate the Plaza 400th anniversary [12]. Likewise, in Italy some best practices of temporary greening – “Piazza Vecchia Fiorita”, Bergamo, 2014; “Un Altro Parco in Città”, Pistoia, 2019; “Il prato temporaneo in Piazza Grande”, Arezzo, 2019; “La città che foglia e fiora”, Design Week, Genoa – are arising the discussion on the dynamics of communities and places re-activation and are generating a debate around the theme of sustainability in historic city centres.

Heat waves phenomenon in European cities is increasingly frequent. As highlighted by “IdroMeteoClima Report” [13], in 2019 the urban areas in the Po Valley recorded up to 60 tropical nights (with a minimum temperature above 20°C) and 80 hot days (with a maximum temperature above 30°C). Future climatic scenarios, elaborated by Arpae Emilia-Romagna, show a probable average temperature increase in Bologna of two degree for the period 2021–2050 compared to 1961–1990, with the strongest anomalies that may occur during the summer period, leading to a consequent increase in heat waves [14]. The city of Bologna must therefore adapt to climate change and rising temperatures, with concrete actions that follow its extensive and integrated urban planning – Urban Environment Adaptation Plan (BlueAp), Action Plan for Sustainable Energy (PAES), Mayors Adapt initiative, new Urban General Plan (PUG) with its Resilience goal. This can be done both with demonstrative and symbolic actions aimed at changing users’ behaviour and with real “devices” that help to reduce temperatures in urban spaces. The meadow in Piazza Rossini responds to both objectives in a demonstrative way.

As was pointed out by the report “Rigenerare la città con la natura” [15] and by other Emilia-Romagna Region documents [16], [17], cities are encouraged to enhance the presence of urban greenery, due to its essential function of thermal regulation and resilience to climate change. In fact, a vegetative element, such as a lawn, leads to a reduction in the reflection of infrared rays at night, and it also allows a beneficial excursion between day and night [18]. Furthermore, some species of vegetation could have a mitigating effect on the presence of pollutants in the atmosphere, by capturing the particulate matter (PM_{10}, $PM_{2.5}$) thanks to the roughness of the leaf surfaces.

In order to test the efficiency of greening strategies implemented by the ROCK project in Piazza Scaravilli – a public space overlooking Via Zamboni and placed a few meters away from Piazza Rossini – the University of Bologna analysed in detail the effects of the intervention through simulations performed with ENVI-Met software [19] and through the data collection from the environmental sensors placed in the area by the Acciona company, a project partner. Simulations show significant temperature variations in view of “Malerbe” project, demonstrating how even a small greening intervention can significantly contribute to the heat island mitigation [20].

2.3 Opportunity: An active demonstration of re-appropriation of public space

The first temporary project for Piazza Rossini was successfully embraced by the citizens, with an average daily presence of over 30,000 visitors – monitored through 10 crowd analysis sensors with WiFi-GPS technology installed in the area – who did not just transit through the area but spent some time in the square. During the week of experimentation in September 2019, an increase in flows with an average of 27,000 daily and a peak in the day of around 36,000 visitors have been registered: the weekly inflows amounted to 200,000 visitors.

The installation was abundantly commented upon on social media, on blogs and on social networks. Furthermore, a large number of citizens, local associations and social entrepreneurial activities (e.g. Salvaiciclisti, Dynamo, Kilowatt), professional intermediaries (Ordine degli Architetti Bologna) and ad-hoc initiatives (Strade Aperte Bologna) enthusiastically endorsed the initiative as a first step towards a future vision and action for the city. The positive reaction came also from citizens, also supported by a spontaneous collection of signatures called “A meadow in Piazza Rossini”, showing how a reversible intervention, carried out in self-construction and in a few days, can trigger dynamics of re-activation of communities as well as places, raising awareness on climate change and generating a heated debate around the theme of sustainability of historic centres.

Emerging from the covid-19 pandemic, cities are embracing several strategies to grant wider and healthier public space, to create safe and attractive situations for visitors and to provide inclusive environments for the largest categories of citizens to retrieve the city public social dimension, compromised by the forced distancing. In this context “Strade Aperte” initiative, born in Bologna, in addition to supporting with a positive response the Piazza Rossini project, proposes city widespread interventions and temporary installations. The aim is to promote new forms and uses of public spaces, fostering the suburb’s enhancement through the reactivation of proximity spaces and creation of suitable streets for pedestrians and bicycles [21].

3 TEMPORARY AND PILOT TRANSFORMATIONS OF PUBLIC SPACE: PIAZZA ROSSINI PROJECT IN BOLOGNA

The experimentations on Piazza Rossini are part of a broader strategy of actions that systematically involved the main public spaces of the university district – as recalled by the name of the initiative, “The Five Squares” of the University Zone – developed in synergy with the programming of “Bologna Design Week” and “Researchers’ Night” in September 2019 (Fig. 1).

The Five Squares wanted to represent a proposal and an event dedicated to urban regeneration, optimization and accessibility of CH, incentive and promotion of public space care through the deployment of its potential and the testing of unconventional uses, according to an environmental sustainability perspective.

Piazza Giacomo Rossini is a public space of great historical and architectural value. The square is defined by many relevant buildings: the Basilica San Giacomo Maggiore, the former convent of Santa Cecilia, home of “Giovan Battista Martini” Music Conservatory, the late Renaissance front of Palazzo Magnani (currently used as a bank office) that preserves

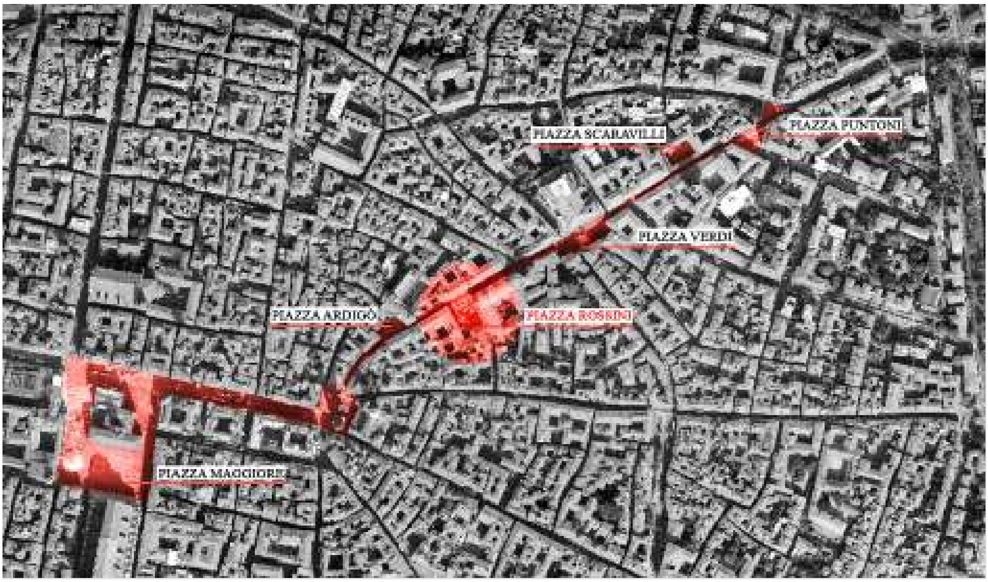

Figure 1: The U-Zone system of open public spaces involved in The Five Square workshop. The red circular spot points out Piazza Rossini, object of the temporary urban transformation projects. *(Source: ROCK Project, 2019 [8].)*

remarkable frescoes and an open-to-public picture gallery, Palazzina Lambertini, an example of eighteenth-century civil architecture and the sixteenth-century Palazzo Malvezzi, current headquarters of the "Metropolitan City" public body of Bologna.

The Square has always had the function of public parking area for cars and bicycles, preventing its use as an urban space for stopping, gathering and socialize: pedestrians could only circulate on the narrow sidewalk margin next to the road lane, while the presence of the parked vehicles in the middle of the area interfered with the view of the surrounding architectural scenario.

The temporary design actions provided in Piazza Rossini, implemented through two main and successive phases of transition, led to the permanent transformation path of the square into a new pedestrian and regenerated space for both citizens and city users. The unexpected perception of the square space proposed by the temporary-reuse project, in addition to the experimentation of new uses, offered the opportunity to rediscover and appreciate the details of the architecture overlooking the square and recall an historical reference. In fact, several historical documents – maps and views – represent Piazza Rossini area with a different pavement surface compared to other squares or roadways: detail of *Bononiensis ditio* in the Vatican "Sala Bologna", dating back to 1575, shows a green vegetable pavement for the buildings internal courtyards; similarly, the View of Piazza Rossini by F.B. Werner, dated to 1732, represent a cobblestone floor that defines the area of the ancient churchyard or cemetery of San Giacomo Maggiore Basilica, marking his different surface texture. The choice of the vegetable lawn was suggested by these archival documents, searched and deeply analysed by the students involved in the Five Square project.

3.1 Green Please! The meadow you don't expect

"Green Please! The meadow you don't expect" is the name of the project of the first temporary redefinition of the square, as a result of a shared and participatory process. The project was conceived through a co-design and co-construction workshop that involved students of the Department of Architecture of the University of Bologna, coordinating with FIU. The project envisaged the partial occupation of the parking area, about 400 sqm, through the setting up of a vegetable meadow in rolls, which covered the surface corresponding to twenty parking spaces, eleven motorcycle parking and the relative manoeuvring area. Furthermore, in a decentralized position, an iconic "Maxxi Poppy" outdoor floor lighting fixture was positioned. Maxxi Poppy is designed and produced by Viabizzuno srl, a partner company of the ROCK project (Fig. 2). The construction system of the whole installation was designed to be self-built by the workshop unskilled participants, with limited economic resources. The self-construction set-up, carried out in about three days of work, was itself conceived as a performative event, actively demonstrating the re-appropriation of space and its possible and unconventional use.

(a) (b)

Figure 2: (a) Aerial views of the completed "Green Please!" set-up; (b) the Square with the Maxxi Poppy and, in the background, Palazzo Malvezzi. *(Source: ROCK Project, 2019 [8].)*

During the days of the "Bologna Design Week" (22–29 September 2019) and the Researchers' Night (27 September 2019), visitors had the opportunity to sit, gather and freely stop on the green carpet. Several activities, such as concerts, lectures and workshops, were organized on the meadow during the experimentation days, while other initiatives were born in a spontaneous way.

The project aimed both to experiment new uses in public spaces in the heart of the university area and to offer the opportunity to rediscover and appreciate the view and the details of the architectural treasures overlooking the square, not possible in the previous configuration. In response to the positive feedback obtained from citizenship and from the sharing of project aims and outcomes, the Municipality of Bologna established that the square will be no longer occupied by cars, starting a transition path that will transform definitively the square into pedestrian. The installation, designed and built to stay on site just for a week, was extended for additional ten days.

Following the necessary removal of the first set-up, the square remained off-limits to cars and the area was temporarily cordoned off to prevent access to vehicles. Another new temporary configuration became necessary, requiring the construction of a new transitional configuration of the expected duration of about a year, so to allow the Municipality to develop the project of the permanent configuration of the square.

3.2 Green Please 2.0! The green you don't expect

"Green Please 2.0! The green you don't expect. A project for piazza Rossini in transition" is the designed answer for the second temporary transition project, implemented and realized by the FIU during the 2020 summer, with the scientific collaboration of the Department of Architecture – University of Bologna and BAG Studio.

The new project is on the same line of the first one, in order to make citizens perceive that the design intentions are following a similar thematic trend. At the same time, the new square configuration represents a further development of the previous one, since its longer stay implies design and technological solutions of a higher level of complexity. The guide principles of the implemented solution are: absolute reversibility – given the expected period of stay – usability, adequate durability, ease of maintenance and subsequent restoration of the previous state of places. In addition, the project has educational, social and awareness purposes on ecological issues, environmental and common CH care.

The temporary urban installation is basically a new meadow, bounded by a wooden edge 15 cm high, which contains the soil substrate. A ramp makes it accessible for all, overcoming the small height difference (Fig. 3). The vegetable footboard is partially occupied by planters that house small ecosystem of plants, in line with other experimental actions of urban green injection within the historical university area developed by the ROCK project: the temporary installation "Malerbe" (Piazza Scaravilli, 2017–2019) [22] and the pocket garden "U-Garden" (Terrace of the Municipal Theatre in Piazza Verdi, summer 2019) [23] (Fig. 4).

Figure 3: Concept of the second temporary project "Green Please 2.0! the green you don't expect". *(Source: ROCK Project, 2020 [8].)*

(a)

(b)

Figure 4: (a) “Malerbe” temporary construction in Piazza Scaravilli, outcome of a co-design and co-construction workshop coordinated by the Department of Architecture, University of Bologna with Centro Antartide, that changes the parking area into a dynamic urban garden; (b) “U-Garden”, the project for the pocket garden realized on the terrace of the Municipal Theatre of Bologna in the summer of 2019, as part of the actions implemented by “The Five Square” workshop. *(Source: ROCK Project, 2019 [22], [23].)*

The surface occupied by the system of wooden tanks extends for about 30 sqm and contains shrubs, perennial herbaceous plants, aromatic herbs and ornamental grasses. These are all native plants, selected to ensure biodiversity, with different characteristics changing with seasons, to make the green area interesting all year round; trees of first size, about 3/4 meters high, have also been planted. During the night, two "Maxxi Poppy" (by Viabbizuno, ROCK-partner) light up the space.

Beyond the functional aspect, the planters are entrusted with the transmission of the messages they report written on the vertical sides, in white characters. The writings, sized in height to be legible by those passing by through Via Zamboni, explain in different languages the transience of the project and aim to communicate respect and responsibility towards the public place.

They convey the message that the installation does not correspond to the definitive asset of the square, clarifying the transitory nature of the intervention, which dictated conditions, expressive possibilities and available budget.

The installation was open to the public from the beginning of July 2020 and the Municipality of Bologna, in collaboration with FIU, promoted a series of open and cultural activities to be carried out on the lawn of Piazza Rossini – "Take care of U. Encounters and stories on the meadow" – as part of the summer activities of "Bologna Estate". Taking advantage of this rediscovered space, the initiative is fostering a sense of appropriation, responsibility and care for CH and common public spaces (Figs 5–7).

Figure 5: The "Green Please 2.0" project under construction, June 2020. *(Source: ROCK Project, 2020 [8].)*

Figure 6: The "Green Please 2.0" installation completed, June 2020. *(Source: ROCK Project, 2020 [8].)*

Figure 7: The "Green Please 2.0" project by night, July 2020. *(Source: ROCK Project, 2020 [8].)*

4 CONCLUSIONS

The co-designed greening interventions for Piazza Rossini are temporary and are characterized by an experimental nature: pilot experiences, which – although of limited duration in time – aim at achieving long-term impacts and results. The rediscovery and re-appropriation of this public space by citizens must correspond to the contextual construction of a sense of collective responsibility towards common CH.

The temporary solutions realized by the project will accompany city-users and citizens along the pedestrianization process of the square, proposing perceptions and uses in stark contrast to the previous car park consolidated function. Where there were only cars and where it was not even possible to safety walk, a lawn is allowing to stop and appreciate the precious architectures facing the square, promoting the educational function of the city public spaces and a more responsible behaviour towards both the natural and built environments.

The project – in addition to the spatial transformation of the public square and its changing perception – generated a heated debate among architects, urban planners, intellectuals, art historians, citizens and citizens' associations, on issues such as the compatibility between the character of the historical urban structure and the proposed greening intervention, the opportunity to respond to the need for relationships, sociability, and community spaces toward the risk of improper uses. A green lawn in the heart of the university area of Bologna could enable uses that could be considered "not appropriate" (wandering, sunbathing, making noise, etc.) to the historical and institutional context. However, how many "appropriate" uses could it generate? Even if the green presence is very limited in the area, the problems related to the "movida" seem to be so relevant to overshadow all other potential scenarios and benefits. The challenge focuses on the collective responsibility of the Piazza Rossini community and the projects aim is to emphasize the importance of taking care of common places, strengthening their sense of re-appropriation and raise awareness of pressing climate issues. The numerous reactions came from citizens at the first and second testing steps, showed how a reversible intervention, carried out in self-construction, with limited resources and in a few days, can trigger important community dynamics, raising awareness on climate change and generating a heated debate around the theme of sustainability of historic centres.

The experimentation will continue during the next year, waiting for the square to assume its final configuration: a period during which the city will have the opportunity to learn to respect, enhance and make grow, like a vegetable seedling, this rediscovered place, and find more pondered answers to the issues that the current installation has raised.

The temporary Piazza Rossini projects – as well as "Strade Aperte", "Malerbe", "U-Garden" or other greening initiative cited – fit in the general tendency to provide openness spaces, first for testing, then to review, correct and test again solutions for cities that are constantly changing and evolving, in the attempt to slow down the threat of climate and global changes with small local successful efforts [24]. They finally fit in a future vision for cities that are changing their times and rhythms (e.g. slow-fast city integration) enabled by a peculiar use of technologies as empowering devices, used to monitor local small-scale experiments and verify their effects for an greener envisaged future cities.

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HUMANIZING THE VERTICAL CITY: THREE STRATEGIES TO BRING THE GROUND LEVEL CLOSER TO THE CLOUDS

ADRIÁN MARTÍNEZ MUÑOZ
Department of History, Theory and Architectural Composition, University of Seville, Spain

ABSTRACT

The reflection on the contemporary vertical city seems to lack theoretical support that is capable of dealing with density, verticality and complexity following a model that puts the inhabitant in the center. Urban developments, mainly located in the Asian-Pacific cities, are driven by a rising real estate market that builds to speculate and not to inhabit. On the other hand, the planners, surpassed by the urgencies to which they are subjected, project environments that follow the principles of an Athens Charter, published almost 80 years ago. It is time to ask about alternatives capable of addressing the city as an organism of multiple layers and dimensions, which proposes to organize the city in height more freely, richly and more spontaneously. This paper will go over some projects, which are closer to vertical urban planning than to the building itself, which sought the radical multiplication of ground level, elevating the social and the relational away from ground level to find more human growth strategies. The actions analyzed in this text will be strategies such as the shelving of villas as an architectural structure, the location of semi-open spaces such as squares or parks distributed in height, or fragments of cities uprooted from the Earth's crust and elevated hundreds of meters. Otherwise, concepts such as community, social cohesion and urban fabric will disappear from our cities, losing the greatest value we have as a society: the collective.

Keywords: ground level, public space, vertical city, urban ground, megastructure, stacking.

1 INTRODUCTION

One of the earliest concepts of a vertical city was developed in 1922 by Le Corbusier, who proposed a plan where three million people would be housed in a specially designed "contemporary city". This notion of a vertical city was Le Corbusier's first systematic attempt to design an environment in which man, nature and machines could be reconciled. However, nearly 100 years later, the predominant residential building in the city today remains that of a vertically extrude tall tower. Cities continue to be filled with towers that don't address the fundamental conditions of liveability on several counts. First, at the urban scale, towers continue to be built as wall-like masses, one next to another, without the sensibility to relate to the surroundings or the street life below. Second, the apartments within these towers are often small, and interiorized, climate-controlled capsules, disconnected from the surrounding environment and with no access to outdoor spaces and amenities (Fig. 1).

The massive scale and high-density development have accelerated the shrinkage of the social life of the elderly and children, for example. The transformation of urban scale, making the city taller, bigger, and faster, increases the difficulty of social participation and segregates many people from their social context. With no place to socialize, more and more people are excluded from city life. This not only leads to great spatial changes but also destroys the memory and experience of the local residents, and destroy the organic fabric at a human scale formed over a much longer period of time.

The question remains relevant: can we design an urban environment of high intensity that is efficient, sustainable, and liveable, with the amenities, landscapes, and lifestyle choices that we enjoy on the ground? Architects must discover, and that is the aim of this paper, how

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Figure 1: Vertical city today: Beichen Jixianli District, Tianjin, China. *(Source: Google Earth.)*

to raise the conditions of urban life on the ground floor to heights in order to humanize the vertical city of the next decades.

2 METHODOLOGY

In order to provide new strategies to challenge the vertical city based in modern principles and achieve models which could generate a more human city, this paper establishes a methodology which consists on tracked back some conceptual developments and ideas, made mainly from the 1960s, whose main purpose was the theoretical idea of bringing the ground level in the air as a multiplication of the real ground level.

Firstly, a deep scan of the architecture history was done, looking particularly projects and case studies of previous design proposals produced by other architects who worked with the idea of introducing a fragment of urban space radically in heights, not just a terrace or a patio in a skyscraper. The projects were chosen from different cultures and times.

Secondly, after a selection of projects mainly from the 1960s to the present, they were classified in groups sharing the same project parameters and thought through similar actions. Three groups of strategies were defined: the shelving of villas, the endless modular repetition and the cities' fragments uprooted from the earth's crust.

Thirdly, critical analysis and comparison between the projects of the same "category" was done with the target of defining a new way to rethink the vertical city. New drawings were produced to help convey some of these ideas when the bibliography wasn't complete.

It is important to note that the research of this subject is being developed in the doctoral thesis ongoing of the author.

3 THE SHELVING OF VILLAS

Around 1909, the publication of a realistic-looking diagram (Fig. 2) in the October issue of the satirical magazine *Life*, contributed, from outside the design discipline, with an idea that has made us reflect the most on the possibility of living at higher altitudes with conditions similar to those of the ground level. The drawing, with a concept made possible by the invention of the elevator, showed a large 84-level steel frame that contained a piece of a garden city on each floor. A slim architectural support with replaceable villas, understood as an open and ever-changing structure.

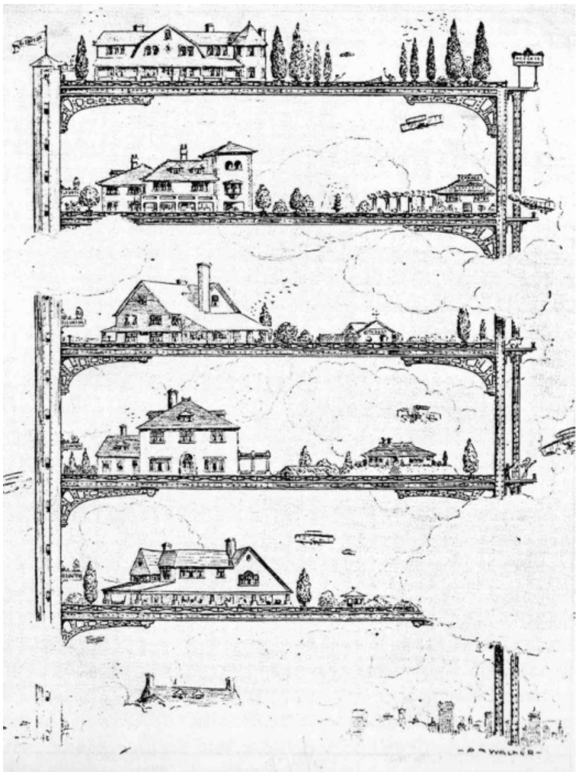


Figure 2: Theorem of 1909 [1].

While the framework of infrastructural dimensions remained untouchable, the cartoony *cottages* could be altered as in the city at the ground level. The robust columns, almost invisible due to the camouflage effect provided by the clouds, sheltered the elevators and stairs. Each “shelf” was separated approximately five storeys from the next, giving each landowner freedom to arrange their living volume within ample boundaries. The landscape that was reproduced on each level was idyllic, like that pertaining to life outside the city and in contact with nature. Everything in this drawing was graphed with the intention of bringing the virgin soil, until now on Earth, to the air. One perceives in this diagram the desire to enjoy the air, the light, and the views of the new vertical city that was beginning to make its way.

It was the Dutch architect Rem Koolhaas who brought this diagram to light, which he called Theorem of 1909 in his thesis *Delirious New York* in 1978. Possibly, Koolhaas already knew by then the concept of *supporting structur*e [2], coined by N.J. Habraken in *Des dragers en de mensen*, published in Utrecht in 1962. Habraken would be well acquainted with Project “A”, Fort l’Empereur in Algiers, by Le Corbusier in 1931. This project was, according to

Reyner Banham, the true precursor of the megastructure concept, due to its enormous length, and the differentiation between the permanent main structure and the dwellings, which were added according to the needs of the residents.

Beyond the iconographic power that the *Theorem of 1909* could provide, it was a true conceptual contribution to the world of architecture that could be branded as contemporary: the strategy of multiplying a plot of the city, preserving its free spaces, gardens and orchards, several meters above the ground, inside the urban fabric of the great metropolis. A new vertical city within the city that supports and feeds it. A great three-dimensional structure, of extraordinary complexity, with a porosity of empty spaces that would make our dense cities of today more human. Above all, one wonders when contemplating this image: Where is the ground level? Are there 84 ground levels? These questions motivate this essay to begin by referring to that visionary cartoon published in an American weekly magazine.

In 1981, the SITE group (Sculpture In The Environment), following the hypotheses of N.J. Habraken and drawing from the diagram Theorem of 1909, proposed a theoretical project for a habitable tower called *Highrise of Homes* (Fig. 3). James Wines, founder of the SITE team, described the project as a vertical community that could satisfy the personal desire to enjoy the cultural advantages of an urban center, without sacrificing the identity of the private house and the garden space associated with the suburbs. Wines continued with the proposal of a support structure of steel and concrete, U-shaped and 8 to 10 floors high in this case, where each level could be used to develop residential programs. Wines' research did not advance conceptually with respect to the drawing published in *Life* magazine, but he did develop an important body of graphic work around the idea, generating perspective, elevation and plan drawings. Sketches that tried with great picturesqueness to make that first provocation of 1909 a reality. Wines' prototype came to be considered for construction in a site in Battery Park City, in New York City, but it was never built.

Figure 3: James Wines' *Highrise of Homes,* 1981 [3].

Although the work *Highrise of Homes* returned to the idea of multiplying the ground level, it would be some time later when a proposal with substantial changes with respect to the 1909 drawing appeared. It was the project *Rustic Farms* (1977) by the Dutch MVRDV office for the town of Waddinxveen (Fig. 4). In this project, the literal image of a "bookshelf" that was loaded with smaller buildings disappeared, giving way to the stacking of platforms as elevated open floors. The large pillar-supports that contained the communication cores were no longer designed in such a way; instead large open surfaces were stacked on top of the built volumes, a leitmotif of the Dutch office. In a way, this project lacked the conceptual power of considering the built volumes as replaceable, since they were the ones supporting the large platforms. This research, however, addressed something that its predecessors failed to do: spatial recognition of the perimeter of habitable cells at two heights. The space surrounding the house was undefined, creating an uncertain field in which multiple agreements between the inhabitants could take place. While in the *Theorem of 1909* and in Wines' work the architectures placed in the great structure were designed contrasting in style with the support itself, in this project the houses had a higher level of abstraction, outlining them as prismatic volumes of two displaced levels. The relationship with the platform, which simulated the ground level, had two levels: one that reproduced life at ground level and the other corresponding with the fragment of the volume of the same dwelling lower floor. In the first case, the relationship with the elevated floor was proposed as one uses the existing ground level, that is, having it available for orchards, recreation areas, solariums, home extensions, etc. The other, a balcony-type space, corresponded to the lower floor and immediately had the following "ground level platform" above it.

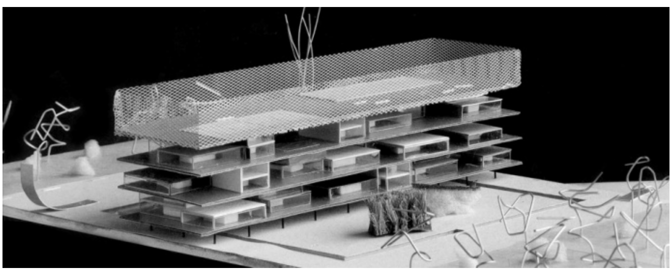


Figure 4: MVRDV, *Rustic Farms,* Waddinxveen, 1997 [4].

In August 2019, a brief note in *The Guardian* newspaper reported on the discovery of *Cosmo Park:* a neighborhood of 78 single-family homes located on the roof of a large shopping center in the city of Jakarta (Fig. 5). This complex, built ten years ago, was revealed thanks to photographs taken with a drone. As if it were the execution of the previously reviewed ideas, this intervention gathers a large part of the reflections on the multiplication of the ground level. Elevated ten floors and on a surface of 1.2 hectares corresponding to the roof of a shopping center, the new neighborhood is built with the same architecture as if it were located at the ground level. It does not seem to differ in any way from another located on the surface of the Earth. It is literally an exercise of reproduction of the city located a few meters below; a certain surreal urban bubble, where normal life develops at an abnormal altitude. Cosmo Park has become a sought-after luxury neighborhood for the wealthier classes due to its downtown location and great facilities, similar to those in a low-density neighborhood: from landscaped areas, private garages, community pools, sports courts, perfectly paved driveways, supermarkets and even a laundry. In this kind of futuristic dystopia there is a strange feeling of being up and down simultaneously. One lives in an environment identical to that of the street level, but on the horizon, one can see the city from

Figure 5: Cosmo Park, Jakarta [5].

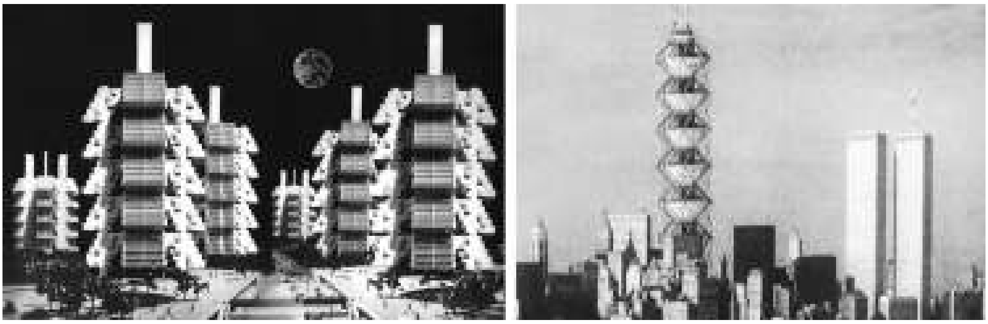
above. This oasis in the center of the noisy and dense megalopolis is a suburb in the heights with the same conditions as those at the ground level.

4 ENDLESS VERTICAL MODULAR REPETITION

Now, it would be feasible to outline a narrative that would branch into two pairs of projects with similar actions; each of them conceived in different architectural times and cultures, but which largely share reflections. These will be the second and the third strategy that this article attempts to cover. The first pair will be composed of *Tree-shaped Community* (1968) by the Japanese architect Kiyonori Kikutake and the project *The Coexistence Tower* (1984) by the Future Systems team. In these two unbuilt towers, the action of raising the elevation of the city by repeating a module with an urban plaza contained in a built mass, became the central theme, but not as voids available to be occupied as it happened in the first strategy, but as elevated urban pores that would make verticality more human and liveable.

It seems right to point out certain similarities between the *Tree-shaped Community* project (1968) and *The Coexistence Tower* (1984) (Fig. 6). Both, in an exercise of extreme simplification, built their proposals based on the repetition of a module that responded to the most human scale in the city. As if it were the sculpture *Column without end* (1938) by Constantin Brancusi, these two projects approached vertical construction through the strategy of stacking identical modules with a piece of urban space inside, as a public square or park, now hundreds of meters from the original ground (Fig. 7). As in Brancusi's sculpture, the two projects seem to have neither feet nor heads and aspire to continue growing to infinity.

Danish architect Jan Gehl, very critical of the construction of the vertical city [6], expressed in several writings the need to create a city with urban quality at eye level. This appreciation interests us because it associated public space to the ground level, and this to people as something indivisible, so that the activities and actions identified with the public



(a) (b)

Figure 6: (a) Kikutake, *Tree-shaped Community,* 1968 [7]; and (b) Future Systems, *The Coexistence Tower*, 1984 [8].

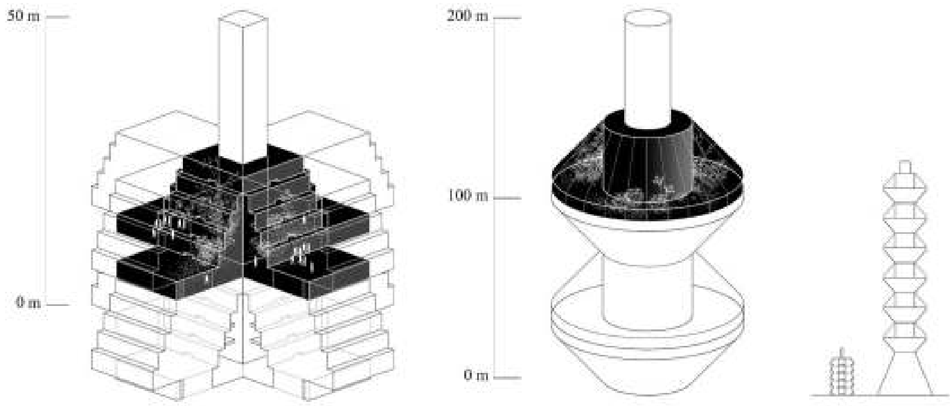
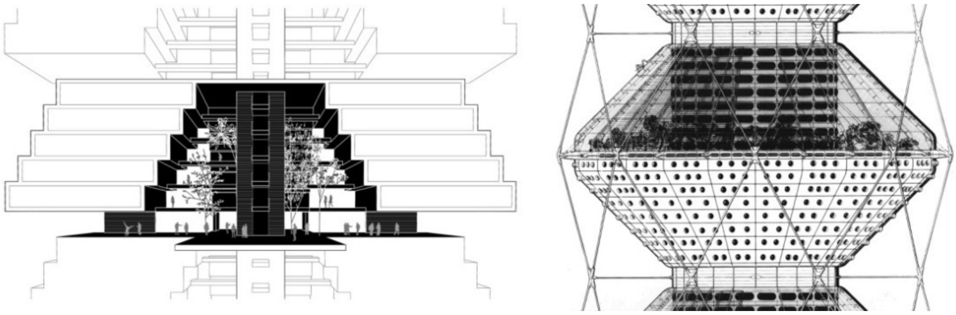


Figure 7: Identical modules stacked with a portion of urban ground inside. *(Source: Diagram by the author.)*

were developed: walking, standing, sitting, looking, conversing, speaking, listening and expressing oneself. In some way, this reflection indicates the need to establish elevated public urban floors so that life in the towers is fed by the urban conditions of the city. It seems that both the Kikutake project and the Future Systems project attempted to elevate that *urban quality to eye level* on levels equidistantly repeated across the stacked modules.

The *Tree-shaped Community* version from 1968 is clearly related to that idea, and in this case, motivated by the well-being of children in a residential tower. Kikutake organized its vertical community based on a five-storey module that enclosed a large atrium, like a public open space, crossed by the spine, which constituted the communication cores, and to which the access galleries to the houses overlooked (Fig. 8). The strategy was inspired by a report by Keiko Watanable that analyzed how children who lived above the fifth floor in tall buildings only watched and did not join other children who played in the park located in the city. The result was a tower where, apparently, there were no floors above the fifth. The location of that concave void open to *the horizon at eye level* caused the houses to be terraced



(a) (b)

Figure 8: (a) Three dimensional section of “ground floor” *Tree-shaped Community (Source: Diagram by the author)*; and (b) Detail of *The Coexistence Tower* [9].

creating clusters of five floors that gave great formal expression to the whole. The repetition of many of those towers created the illusion of a mega-forest in harmony with nature. This project contains two of the obsessions that Kikutake pursued in his work: the relationship with nature and the social relationships between people [7].

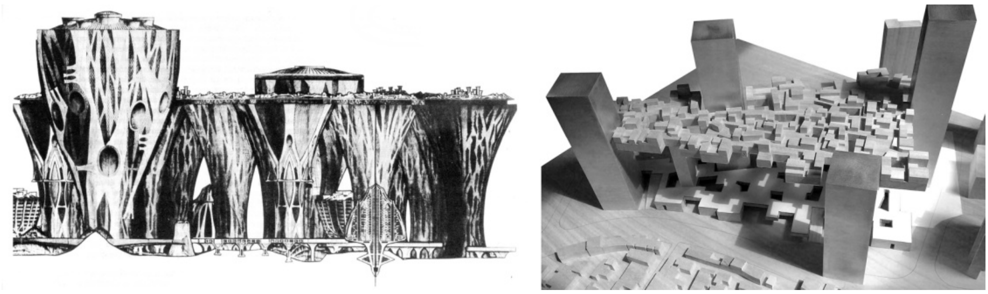
In the Kikutake project, the fragment of urban land multiplied every five levels had a cruciform plan, with each arm of the cross of approximately 15 m, and was threaded by the core that sheltered elevators and stairs. The void was surrounded by the houses that gradually closed the section until giving way to the next module. The children would invade that communal plaza, fixing their gazes on the open landscape, which would allow them to feel high up but with no obstacles in sight. The spatial configuration of this space, opened like gills in each corner of the cross, would allow one to feel covered and protected from the weather, creating a large public volume in which to carry out the activities mentioned by Gehl.

On the other hand, almost two decades later and from a different architectural background, Jan Kaplický and David Nixon, founding partners of the Future Systems studio, gained financial support from the Graham Foundation in Chicago to explore the limits of the skyscraper. The result was the prototype Project 112: *The Coexistence Tower* (1984): a structure developed in collaboration with Ove Arup that reached 150 levels in a mega-skyscraper that combined 672 apartments with 285,000 m^2 of offices and seven elevated parks [9].

The strategy, similar to that of the Kikutake Project, although on a much larger scale, was based on the repetition of a module consisting of an inverted cone trunk of eight floors of houses, plus a cylinder of eight other floors of offices on its major base. Such a volumetric arrangement created a circular crown available as a park or public square; the space that interests us. This circular strip of urban land, multiplied seven times, was a clear example of how to raise the ground level and introduce it into a vertical building (Fig. 7). The efficiency with which this public space was included in a typology designed a priori to densify, sheds light for those who today think about how to humanize the vertical city of the future without giving up building vertically. As in the *Tree-shaped Community* project, the elevated urban land had a volume of air that recreated an open-air city plaza (Fig. 8). If in the Kikutake project that air was largely covered by the homes themselves, in *The Coexistence Tower* it was a space with a clear exterior orientation. Another empty cone trunk shaped by a warp of post-tensioned cables enclosed the new seven ground levels.

5 CITIES' FRAGMENTS UPROOTED FROM THE EARTH'S CRUST

The third strategy, perhaps the most radical, that this paper tries to exemplify as multiplication and manipulation of the ground level is the one that, in an almost unnatural way, proposes to separate and elevate an imprecise fragment of earth with everything on it. *The Mesa City* project (1959) of the Italian architect Paolo Soleri and the project *The Lifted Village* (2011) (Fig. 9) of the Dutch team MVRDV could be paired within this strategy and establish a dialogue.



(a) (b)

Figure 9: (a) Paolo Soleri, *Mesa City,* 1959 [10]; and (b) MVRDV, *The Lifted Village,* 2011 [12].

Among the architects considered mega-structuralists, Paolo Soleri always occupied a position difficult to classify. His reflection on how the construction of the city transformed planet Earth left a legacy of anthropomorphic architectures that had a great impact on the culture and architectural thought of the late 1950s. Soleri insistently expressed in his projects the need to concentrate and densify the human settlements to free the surface of the globe from urban sprawl [10]. Far from academic discourse, the *Mesa City* project was the development of the romantic idea of building a city as an accumulation of muscle mass, of energy bulges with ventricular cavities that seemed to beat. A large amount of organic matter that seemed to hatch from the earth's crust and later solidify into compact, dense, three-dimensional figures. When appreciating the elevation drawings of *Mesa City*, it is not a glimpse of an architecture of cables, tubes or flat surfaces, but the natural expression of a city that has grown from the earth and uprooted hundreds of meters away. The project fed the fantasy of a unified city between natural geology and that manipulated by man in a perfect biological balance. An architecture like a human ecology [11].

Mesa City was designed for two million residents on approximately one hundred acres. A kind of neonature that was brought to life by the two-dimensional interaction of the different architectural organisms: dense towers in the vertical dimension and a large plateau or piece of city horizontally. All connected by a multilevel communications network that threaded the dense volumes of its arcologies. It is the trimming and elevation of a fragment of the earth's crust that we are interested in highlighting as an exemplary action of the third strategy on the multiplication of ground level. In *Mesa City* the dimension corresponding to the city or town on the large logs seemed the consequence of a horizontal cut at a certain height. The result was a base made up of sectioned circumferences, as if it were a cluster of bottles upside down. There the minor buildings of all kinds of programs were organized through a layout similar to that of the historic city, and the inhabitants moved in an environment that recreated the construction of society according to the Italian architect.

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On the other side of the mirror, *The Lifted Village* project, once again by the Dutch study MVRDV, was a contemporary case study whose way of proceeding is linked to that of Paolo Soleri, mainly with regard to the strategy of multiplying the ground level and certain visual and spatial relationships. Beyond these, they draw from different cultures and reflections, as it would happen in the previous case between Kikutake and Future Systems. *The Lifted Village* was the result of a competition for a prime location in the Chinese city of Shanghai in 2011. The 4.5-hectare site was in southern front of the center of Pudong, and extended towards the historic Bund, in the north. To the west of the site was the traditional YuYuan shopping area and the old town of Shanghai. The location of the project seems to offer us the keys that shaped the proposal of the Dutch team, boasting one of its maxims: the overlapping and mixing of typologies and programs. On the one hand, a group of skyscrapers responded to the dense and vertical financial district of Pudong, and on the other, a fragment of a historic city was cut out and raised 100 m from the ground, being hanged in the air by the group of towers.

The radicality with which the elevated "town" is captured in the images that accompany the project makes us reflect on the sensations and experiences that an inhabitant would live moving along that ground level, 100 m from the original land level. Undoubtedly, the fantastic provocation that this project implies leads us to reflect on its viability as an alternative architectural action to the city of towers inherited from the Modern Movement and the Athens Charter (1943). MVRDV anticipates the difficulties that this type of strategy would have: lack of sunlight under this elevated piece of city, finishing of the lower face of the rootless bark, structural complexity to support such mass in the air, and evacuation of the inhabitants in case of fire. For each one of them, they point out potential solutions: opening of large patios that introduce light into the lower city, a reflective photoluminescent system for the finishing of the inferior surface, large beams between the towers, and, finally, a structure in the form of branches between the "town" and "towers" serve as fire escape ladders, while providing secondary structural reinforcement. The latter was also intuited by Soleri in its large trunks-supports, with arms or branches that opened to cover a larger area of the supported city. Both in *Mesa City* and in *The Lifted Village*, what Jan Gehl demanded about urban quality at eye level is fulfilled, in these cases, in the elevated portion of the city.

6 RESULTS AND DISCUSSION

Through the comparison of the selected projects under similar conceptual actions, it has been discovered the following ideas of each strategy:

- Strategy 1. *The shelving of villas:* In spite of the concept is very theoretical, the present overpopulation has demonstrated this idea could be interesting to explore in order to reuse a series of marginal urban space, as the *Cosmo Park* case do. The flexibility offered by this concept would be promoted to change the capability of a tower considering that his purpose is to be adaptable to the necessity of the city. Also, the idea of situating a ground urban level ready to be altered with similar conditions to the real ground floor would be a great value to investors. Besides a new relationship between the structure and the built mass, creating a space without specific use and with a lot of possibilities.
- Strategy 2. *The endless vertical modular repetition:* The great inconvenience of living in a very high tower disconnected many meters from the ground of the city is challenged in the Kikutake and Future Systems projects. Both projects, the idea of building in height is used through the addition of a module of several floors with a fragment of urban land inside. This idea could be very interesting to make life in the towers more bearable, for example for children, because they will have the sensation of living close to an urban square or park.

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- Strategy 3. *Cities' fragments uprooted from the earth's crust: Mesa City* project (1959) by the Italian architect Paolo Soleri and *The Lifted Village* project (2011) by the Dutch team MVRDV reflected on how to uproot a fragment of the earth's crust and elevate it, almost as in science fiction. This provocative idea could contribute interesting possibilities to displace urban structures to the height. Here it would be a problem the evacuation of inhabitants because the fragment of land in the air is bigger than the other strategies. In the *Lifted Village's* project, we can see how this is one of the most fragile decision.

All projects commented would come to answer the investigations of the environmental psychologist Robert Gifford, a professor at the University of Vitoria in Canada. Gifford, in his article *The Consequences of Living in High-Rise Buildings* (2007), analyzed from various points of view the side effects of living in residential towers. The article began by asking: "Are residential towers good or bad for people?" [13]. The methodology used to carry out the report was based on personal interviews with the inhabitants and on direct observations through case studies, always with the focus on the search for difficulties related to living in vertical buildings. Among the most studied problems were fear, dissatisfaction, stress, behavioral changes, suicide, lack of social relationship, lack of solidarity and developmental problems in children.

In a fragment of the text, Gifford analyzed the behavior and development of children living in high-rise residential typologies with respect to those who do so close to the street level. The author's conclusion from the study speaks of a child growing up inside a tower suffering from misbehavior and continuous tantrums, in addition to disorders such as primary nocturnal enuresis. The activity that best stages this lack is play. A daily action that we usually carry out in streets and squares around us, but in these cases, families who live in towers do not feel safe by allowing their children to play on the street, separated vertically by hundreds of meters from their home. Therefore, children are pushed to grow inside the cell, using their time for play in solitary entertainments that not only impede their motor development, but also harm their future personality. Gifford, however, pointed out that these behaviours would improve if the residential towers had green and play areas similar to the city below.

In the light of the results, the strategies analyzed show different alternatives about how to raise the conditions of urban life on the ground floor to heights. If we establish a comparison between the projects commented and the modern urbanism of identical towers one next to another in an infinite grid, we will understand the profits for people's life, generating a city model more human.

Finally, several prototypes of residential megastructures are being built facing with this purpose in the city of Singapore. This city is a pioneer in this type of project, among which is The Pinnacle Duxton, built by ARC + RSP Architects in 2009 (Fig. 10). A vertical complex of 1,848 houses and 50 storeys high that dreams of literally bringing the street and the Plaza to the clouds, producing elevations of urban strata several meters from the Earth's mass to create a multi-ground zero city. A kind of spatial illusion built on the basis of two horizontal "trays" that cross the towers, which contain: gardens for children's games, areas for barbecues, solariums and areas equipped for gymnastics.

7 CONCLUSION

According to current United Nations (ONU) projections, by the year 2050 the world population will increase from 7.6 billion to 9.7 billion and close to 66% of this population will live in cities, declaring the age of the vertical city. So, what if it was not possible to reject the construction of the city vertically? [15].

Figure 10: ARC+RSP architects, *The Pinnacle Duxton,* Singapore, 2009 [14].

The three strategies mentioned above on the multiplication of a piece of city land can help start a new period of reflection on how we should face the construction of the vertical city of the future. While the cities today already face the phenomenon of verticalism, they do so based on simple modern planning according to the canons of ventilation, lighting and vegetation. The case studies discussed in this text could provide avenues to explore to transfer life in the ground of the city to the heights. It seems appropriate to return to some of those architectural actions that fostered the transfer of the most collective plan in the city, the ground level, closer to the clouds.

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UNIVERSITY CAMPUS AND STUDENTS' EMOTIONS: THE ROLE OF LANDSCAPE

LAMIS HANI, DINA MAMDOUH NASSAR & ALI BAKR
Architectural Engineering Department, Faculty of Engineering, Alexandria University, Egypt

ABSTRACT

In university campuses, interaction between the campus users and the physical environment takes place, where students are subjected to daily stress and mental fatigue, great concern must be given to university students for fostering a successful learning experience on campus. This research aims to study the effect of landscape elements within the university campus on students' emotions. This study is divided into two sections; the first is a review of the landscape elements and students' emotions on campus. The second is an analysis of the effects of landscape elements on students' emotions. The research conducted a questionnaire; the findings were illustrated in the form of a two-dimensional matrix between landscape elements and students' emotions. The results of this research have proven that student–landscape interaction on campus often affects students' emotions positively, however, depending on some emotional and landscape preferences, negative emotions might be experienced while viewing or using landscape elements.

Keywords: landscape, university campus, emotions, learning environment, academic performance.

1 INTRODUCTION

University campus is composed of roads, buildings, and spaces, forming a physical environment, just like the urban pattern, but with a smaller scale [1]. For some people, the landscape is considered as a complementary element that is used in the open spaces surrounding buildings and facilities, disregarding its great impact on the users' emotions leading to a change in their behaviour, attitude, and quality of life, as what was mentioned by Mitchell et al. [2] about the factors affecting the quality of life, and they are health, security, physical environment, personal development and community development [1].

Meyer and Turner [3] defined human emotions as complicated psychological states which take place psychologically, then they affect human behaviour, cognition, and feelings. Although students' emotions are originated with their personality and in their original environments, however, interaction with the physical environment, with all of its components, including landscape, plays an important role in affecting these emotions [4].

As illustrated by Dober [5] if the landscape experience is convenient, nice, functional, exciting, and safe, then the landscape is in good order [4]. The objective of this research is to foster students' positive emotions on campus by using the appropriate landscape elements that form a successful experience in the campus open spaces, leading to a development in students learning and academic performance and achievement.

To achieve the objective of the research, it followed inductive and deductive methodology starting from the literature review to the results section. The research is divided into two sections, the first section is a theoretical framework using a literature review that discusses and analyses students' emotions as a result of their interaction with landscape elements on campus, the second section is a two-phase section, where phase one was an analysis to different landscape scenes that was taken in the three case studies according to Kaplan's theory of landscape preferences for preferable environments, while in phase two a questionnaire was conducted to monitor the emotional states of students to the different landscape elements available in the scenes chosen in phase one. The results of the questionnaire were then represented in the form of a two-dimensional matrix between the

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landscape elements on campus and students' emotions resulting from the interaction with these landscape elements, the research is then continued by a discussion of the matrix results and findings, and a general conclusion.

2 LITERATURE REVIEW

2.1 Emotions and the physical environment in university campuses

Hockenbury and Hockenbury defined emotions as a complex psychological state [6]. Most theorists stated that basic emotions are natural, general, and obvious states, which develop to serve adaptive functions, all other emotions can be formed by combining any of the basic emotions. As Giacomoni discussed [7] Descartes suggested that the six basic emotions, which are joy, sadness, love, desire, hatred, and wonder, can be combined to form all other emotional states [8]. However, the most famous basic emotions list is called "the big six" by Ekman [9]. His list included happiness, sadness, fear, surprise, anger, and disgust. And then came another theorist, such as Pultchik, Ekman, and Levenson, who kept on adding to the list [10]. As an example for the lists of emotions is Pultchik's Wheel of Emotions, which is similar to the idea of the colour wheel, where combining two colours produces a third colour, in Pultchik's wheel also the combination of two emotions results in a third emotion [11]. The importance of emotions in students learning life is being taken into consideration lately in educational research. As Pekrun et al. [12] stated in 2010, emotions can be considered as an important part of the learning process, as they were found to be related to students' productivity, quality of learning, and well-being. In Harvard University, a department of counselling and mental health services was specified to manage students mental health and well-being, including the importance of students' emotions in their activities, they started multi-session workshops in 2019, for introducing new approaches for participants on handling their feelings and emotions [13].

Studies had proven that the urban space has several factors affecting peoples' emotions, among these factors is the landscape elements used in this space, where people live, grow, work, and perform. Although the human–landscape interaction has been studied in many ways, the emotional value of landscape elements has been neglected [14].

2.2 Landscape in university campus

Outdoor space, as said by Ashihara [15], is a building without a roof, where a connection between man and things takes place. The successful design of the urban space depends on the balance between some design standards regulating the human–space relationship [16].

There are two basic informational domains based on Kaplan and Wendt [17] contributions for landscape preferences in the most preferred environments (LEEP), these two domains are understanding and exploration. By combining these two domains, four distinctive patterns were generated. These patterns are complexity, which refers to the number of different elements in the scene, coherence, defined as providing a sense of order to the scene, by using patterns of brightness, size, and texture to drive attention to the scene, legibility, by easily understanding and remembering the place, and mystery, which is the ability of the scene to offer more, encouraging exploration. These four patterns have created a framework for landscape researches for creating the characteristics of the preferable environment [18].

As Law Olmsted [19] stated that the enjoyment of scenery employs the mind without fatigue and yet exercises it, tranquilizes it and yet enlivens it and thus, through the influence of the mind over the body gives the effect of refreshing rest and reinvigoration to the whole system. University campus is a reliable opportunity for promoting positivity for its users, affecting their behaviour. However, students in university campuses are usually subjected to a high level of stress, referring to a malfunction between the campus environment and the students' needs. Landscaping the outdoor spaces of university campuses is among the essential factors that affect the campus users, students specifically [20]. Humans can bond emotionally with the surrounding landscape. Thus, studying the relationship between landscape elements and students' emotions in the university campus can contribute to applying the optimum design for the landscape elements used on campus [21].

2.3 Linking landscape elements to students' emotions on campus

Landscape elements on campus vary between soft landscape elements and hard landscape elements. The most common landscape elements used in university campuses are: vegetation, water features, outdoor space furniture including seats and benches, bollards, trash cans, kiosks and public art, in addition to lighting elements, signage, circulation features including gates, edges, and paths, and finally parking utilities [22].

3 METHODS AND MATERIALS

3.1 Methods

The method used in this research is two-phased addressing the effect of landscape elements on university students' emotional states. Primary references were used in data collection weather by gathering information from universities' administration offices or by students' questionnaires. Phase one focused on landscape preferences (LEEP), as discussed by Kaplan, and their application on the three chosen case studies. In phase two, a questionnaire was used to monitor students' emotional responses to the selected landscape scenes from phase one.

The objective of phase one was to determine the optimum landscape scenes in the three universities that would evoke students' emotional responses to the questionnaire, while the objective of phase two was to analyse the emotional responses to the selected scenes to create a two-dimensional matrix correlating students' emotion on using the different landscape elements on campus which can be used by landscape architects to create a successful landscape experience on campus.

3.2 Materials

3.2.1 Study area

Three universities were chosen for the case study where questionnaires would be distributed, all of the three universities are in Alexandria so that the cultural factor would be constant, these three universities are Arab Academy for Science and Technology (AAST), Pharos University in Alexandria (PUA), and Faculty of Engineering Alexandria University (EAU).

The first university campus in the case studies is one of the oldest governmental campuses in Alexandria, it is the Faculty of Engineering campus (EAU). The total area of the campus is about 109,600 m^2, distributed as shown in Fig. 1. The second university campus in the case studies is Arab Academy for Science and Technology AAST. The total area of the campus is about 165,018 m^2, distributed as shown in Fig. 2. The third and last university in the case studies is Pharos University in Alexandria PUA. The total area of the campus is about 175,740 m^2, distributed as shown in Fig. 3.

Phase 1 was conducted to analyse landscape scenes in each of the chosen case studies, according to the landscape preferences for preferred environments (LEEP) Stated by Kaplan,

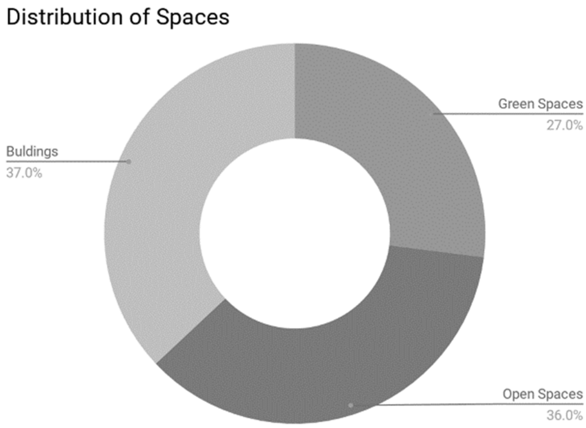

Figure 1: Distribution of spaces in Faculty of Engineering, Alexandria University, Egypt (EAU).

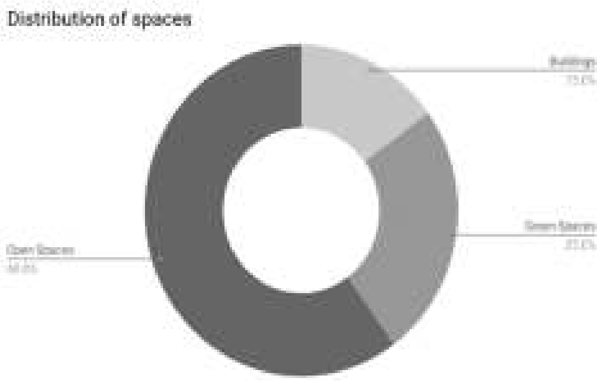

Figure 2: Distribution of spaces in Arab Academy for Science and Technology, Alexandria, Egypt (AAST).

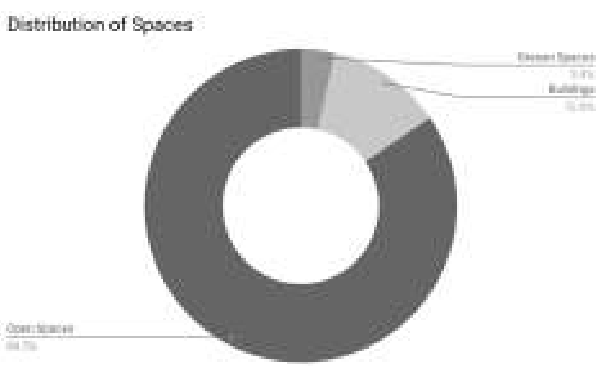

Figure 3: Distribution of spaces in Pharos University in Alexandria, Egypt (PUA).

which are Complexity, Coherence, Legibility, and Mystery. This was achieved by taking pictures of the different open spaces with different landscape elements in each campus, as shown in Figs 4–6 and comparing the different scenes as shown in Table 1.


(a)


(b)


(c)

Figure 4: Landscape scenes from Faculty of Engineering, Alexandria University (EAU).


(a)


(b)

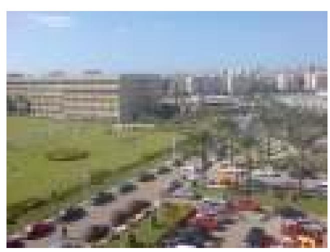
(c)

Figure 5: Landscape scenes from Arab Academy for Science and Technology (AAST).

(a) (b) (c)

Figure 6: Landscape scenes from Pharos University in Alexandria (PUA).

Table 1: Comparing the landscape scenes from the three universities, according to the landscape preferences for preferable environments by Kaplan.

LEEP	EAU			AAST			PUA		
Complexity	4(a)	4(b)	4(c)	5(a)	5(b)	5(c)	6(a)	6(b)	6(c)
	✓	✗	✓	✓	✓	✓	✗	✗	✗
Coherence	4(a)	4(b)	4(c)	5(a)	5(b)	5(c)	6(a)	6(b)	6(c)
	✓	✓	✓	✓	✓	✗	✗	✓	✓
Legibility	4(a)	4(b)	4(c)	5(a)	5(b)	5(c)	6(a)	6(b)	6(c)
	✓	✗	✓	✓	✓	✗	✗	✓	✓
Mystery	4(a)	4(b)	4(c)	5(a)	5(b)	5(c)	6(a)	6(b)	6(c)
	✓	✗	✗	✗	✓	✓	✓	✓	✗

According to the previous comparison in Table 1, the landscape scene with the most landscape preferences achieved in each campus was decided to be the scene sent for the students with the questionnaire.

From the Table 1, we can deduce that in the Faculty of Engineering, Alexandria University, the scene with the most implemented preferences is 4(a), where the four landscape preferences by Kaplan are implemented, while scene 5(b) is the one with the four preferences implemented in AAST, and scene 6(b) in PUA where three of the four preferences were implemented.

3.2.2 Data collection and questionnaires

Based on the literature review, campus landscape elements were listed and the different emotions students can feel during their campus landscape experience were discussed, accordingly, a questionnaire was conducted, where 65 students were asked to answer the 45 questions while viewing the scene from their campus that was chosen from the comparison in phase one. The questionnaires were sent online and filled by more than 65 students from the three chosen universities. The ages of the students who filled the questionnaire ranged from 21 to 25 years old, 70% of the students were females while the rest were males.

Students' engagement in decision making and their opinions are from the most important factors in the success of any institution. Every student was required to view the scene from his campus that was chosen in phase one according to Kaplan's landscape preferences, and then answer the questionnaire based on the scene he viewed. The questionnaire was divided into three sections; the first section was for gathering general information about the students, where the ages of students, genders, and which university campuses did they attend were questioned. The second section was the main part relating landscape elements to students' emotions, in this part students were asked about each landscape element, whether is it available in their campus or not, how they use it, the way it was designed, and its suitability for being usable, and lastly, at the end of each landscape element questions, a question about the emotion/s the students feel towards using or viewing this landscape element. The third section, and the last one, was about the students' opinions on the effect of their emotional states on their academic performance and achievements.

The results of the questionnaire were then represented into a two-dimensional matrix correlating students' emotions on using the different landscape elements on campus.

4 RESULTS

4.1 Students' questionnaires

The results of the students' questionnaire are represented in the Landscape and Emotions matrix, as the questionnaire results approve the validity of the results of the literature review studies of the emotions experienced on student–landscape interaction.

4.2 Analysis of questionnaire results

This matrix was based on the studies from the literature review section and the analysis of landscape elements and their benefits and uses on campus, and therefore their impact on students' emotions, and the validity of this matrix was checked by the results of students' questionnaires on their emotions during their campus landscape experience. The matrix shown in Table 2 was represented by symbols, where the ✓ symbol illustrates that from 40 to 100% of the participated students experienced the emotion while using the corresponding landscape element, the $\underline{✓}$ symbol represents the emotions of 10–40% of the participated students, while the empty cells represent 0–10% of the participated students experiencing the same emotion while using the corresponding landscape element.

5 DISCUSSION

The results of the questionnaire show that all the three components of emotions can be affected by landscape experience, although the subjective experience is the most affected component, as the personal factors interfere in human's reaction to viewing landscape

Table 2: Landscape elements and students' emotions matrix.

			Benefits and uses of landscape	Students' emotions									
				Positive emotions				Negative emotions					
				Pride	Happiness	Hope	Relief	Shame	Anger	Disgust	Fear	Anxiety	Boredom
Landscape elements	**Vegetation**	**Trees and shrubs**	Shading and cooling		✓		✓						
			Decrease noise		✓	✓	✓						
			Aesthetic quality	✓	✓	✓	✓						
			Space to study		✓	✓	✓						
			Space to rest		✓		✓						
			Space to socialize		✓								
		Grass	Smell of grass		✓		✓						
			Aesthetic value		✓								
			Rest or study		✓		✓			✓	✓	✓	
			Socialize		✓					✓	✓	✓	
		Flowers	Vision and smell		✓	✓							
			Excessive colours		✓	✓				✓		✓	
	Water features	**Static**	Reflective surfaces			✓	✓						
			Space to study		✓	✓	✓						✓
			Space to rest		✓	✓	✓						✓
		Dynamic	Dynamic effect		✓								
			Focal point	✓			✓						
			Space to study		✓	✓			✓			✓	
	Open space furniture	**Seats and benches**	Space to study		✓		✓			✓	✓		
			Space to rest		✓		✓			✓	✓		
			Space to socialize		✓		✓			✓	✓		
			Shaded		✓		✓			✓	✓		
		Trash cans	Human senses	✓			✓			✓			

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Table 2: Continued.

				Students' emotions									
				Positive emotions				Negative emotions					
			Benefits and uses of landscape	**Pride**	**Happiness**	**Hope**	**Relief**	**Shame**	**Anger**	**Disgust**	**Fear**	**Anxiety**	**Boredom**
Landscape elements	**Open space furniture cont.**	**Public art**	Aesthetic value	$\underline{\checkmark}$	✔					$\underline{\checkmark}$			
			Focal point		✔		✔						
		Kiosks	Informational		✔	✔	✔						
			Selling and showing		✔					$\underline{\checkmark}$	$\underline{\checkmark}$		
		Bollards	Control movement				$\underline{\checkmark}$		✔	$\underline{\checkmark}$	$\underline{\checkmark}$	✔	
	Lighting	**Cool white**	Studying		✔	✔	✔						
			Socializing		✔	✔	✔						
		Warm white	Studying									$\underline{\checkmark}$	
			Socializing										
		Different colours	Studying			$\underline{\checkmark}$			✔			✔	
			Socializing			✔			$\underline{\checkmark}$			$\underline{\checkmark}$	
			Aesthetic value		✔								
	Signage and banners		Easing navigation	✔	✔	✔	✔						
			Computerized	✔	✔	✔	✔	$\underline{\checkmark}$			$\underline{\checkmark}$	$\underline{\checkmark}$	
	Circulation	**Gate**	Campus character	✔		✔					$\underline{\checkmark}$	$\underline{\checkmark}$	
			Aesthetic value	✔	✔	$\underline{\checkmark}$					$\underline{\checkmark}$	$\underline{\checkmark}$	$\underline{\checkmark}$
		Edges	Tangible		$\underline{\checkmark}$		$\underline{\checkmark}$				$\underline{\checkmark}$	$\underline{\checkmark}$	$\underline{\checkmark}$
			Intangible		✔	✔	✔				$\underline{\checkmark}$	$\underline{\checkmark}$	
			Form shaded paths		✔		✔						
		Pedestrian and vehicular routes	Intersections								✔	✔	
			Shortcuts		✔	✔	✔						
			Aesthetic value							$\underline{\checkmark}$	$\underline{\checkmark}$	$\underline{\checkmark}$	
	Services	**Parking lots**	Accessibility		$\underline{\checkmark}$	$\underline{\checkmark}$	$\underline{\checkmark}$						
			Aesthetic value							✔	✔	✔	

Note: Empty cells = 0–10%; $\underline{\checkmark}$ = 10–40%; ✔ = 40–100%.

elements, as appeared in the questionnaire results, some students preferred different colors in trees or flowers, and others recommended using the shortcuts rather than walking in the passenger's walkways for easily reaching their destinations, but according to the majority of the students' answers, the psychological and the behavioral responses are also strongly affected due to the usage of landscape elements, as observed, when showed the landscape scenes in each campus, the landscape experience was often a positive emotions experience as long as the landscape elements are in the suitable locations and with the appropriate design standards and sufficiency. According to students' answers, landscape elements might also lead to negative emotions, this is mostly caused by the subjective experience of emotions where personal reasons take place, such as people who get scared of grass and they do not prefer sitting or walking on it, people who dislike shared seats and prefer sitting alone not in large groups, or people who hate specific colors in flowers. The psychological and behavioral responses also affect the negativity of experienced emotions during the landscape experience, as some of the landscape elements might cause anxiety or confusion such as dynamic water features near the studying area, other elements might cause the feeling of straining or suffocation such as solid edges surrounding the campus and the bollards that prevent from moving freely, lighting also might be a source of negative emotions when space is softly lit, whether, by natural or artificial light, it might give the feeling of relaxation which is not preferred for students on campus, it also might lead to boredom due to the excessed relaxing feeling.

6 CONCLUSION

In the educational sector, students' academic achievement was proven by research to be strongly affected by their emotions, which are influenced by several physical and mental factors. There is a strong relationship between emotion and environment, people might behave differently according to how space impacts their emotional response. While this area is being neglected in most of the previous research, the purpose of this study was to investigate the neglected human–landscape interaction from the psychological view. This study uses a qualitative analysis using a methodological and applicable framework of the emotional factor as a variable that is affected by the presence of landscape elements on campus to positively affect students' academic performance and enhance their academic achievements. Many variables could be considered when studying landscape effects on human emotions and psychological states, such as age and social, educational, and cultural backgrounds, however, this research focused on university campus students' emotions, whose ages and cultural backgrounds are mostly similar.

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SECTION 3
SUSTAINABLE ENERGY AND THE CITY

SUSTAINABILITY THROUGH ENERGY CONSERVATION BUILDING CODES: COMPARATIVE ANALYSIS OF GREEN BUILDING REGULATIONS IN THE MIDDLE EAST

EDWIN RODRIGUEZ-UBINAS[1], SARAH ALZAROUNI[1], NOURA ALHAMMADI[1], MOHAMED ALANTALI[1], FATMA BEHZAD[2] & SGOURIS SGOURIDIS[1]
[1]DEWA R&D Center, Dubai Electricity and Water Authority, UAE
[2]College of Engineering, American University of Sharjah, UAE

ABSTRACT

In the UAE, buildings consume more than 80% of the total electrical generation, where the cooling systems are responsible for approximately 70% of the buildings' peak electrical load. The government of Dubai initiated several efforts to improve building efficiency and move towards a more sustainable city. This paper benchmarks the different building codes in the UAE and the GCC, focusing on building envelopes, HVAC efficiency, and the application of renewable energy. Additionally, we compare requirements with the UAE early adopters of the Zero Energy Building concept. Despite having similar climate conditions and construction systems across the UAE, the green building regulations of Dubai, Abu Dhabi, and Ras Al Khaimah have different threshold requirements. For example, the maximum thermal transmittance (u-value) of the exterior walls in Dubai is 0.57, 0.32 in Abu Dhabi, and 0.48 W/m^{2}K in Ras al Khaimah. Constructed Nearly Zero Energy buildings have U-values that are substantially lower than the Dubai regulations, between 0.06 to 0.32 W/m^{2}K. We also found differences in other envelope requirements, the share of renewables, and COP values for air conditioning systems. The differences between the codes and between the early adopters nZEB help us to identify opportunities for improvement and standardization of these regulations and define a path toward wider nZEB adoption in the Emirates.

Keywords: sustainable cities, green buildings, zero energy buildings, energy consumption, building envelope, cooling systems, building code.

1 INTRODUCTION

Worldwide energy consumption and greenhouse gas emissions are rising due to urbanization, population growth, and economic development. Therefore, national and international organizations are implementing efforts to improve energy demand management, reduce energy waste, and transform the buildings into producers of clean energy. The 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (COP 21) and the 2015 Paris Agreement on climate change emphasizes the urgency to reduce the CO_2 emissions of the building sector [1]. Building regulations are one of the most efficacious and cost-effective policies to reduce greenhouse gas emissions from both new and existing buildings [2]. The transition to Nearly Zero Energy Buildings (nZEB) and Zero Energy Buildings (ZEB) is a necessary action to achieve climate-neutrality in the built environment. Near Zero Energy Buildings (nZEB) increase energy efficiency by an average of 74%, provide reliable performance and high owner satisfaction [3].

Building energy use intensity (EUI) decreased between 2000 to 2015 in the US, the European Union, China, and India. However, during this period, the building EUI in Arab countries experienced significant growth. In the Gulf Cooperation Council (GCC) countries, commercial buildings' average EUI doubled in this period, from 311 to 598 kWh/m^2, and the average EUI of the residential sector increased from 198 kWh/m^2 to 306 kWh/m^2 (Analysis of Optimal). Among the GCC countries, Kuwait was the first to introduce a building

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efficiency code and implementing its first Energy Conservation Code of Practice in 1983 that is regularly revised [4], [5]. The Kingdom of Saudi Arabia (KSA) started implementing an energy efficiency program in buildings in 2010. In 2018, the Saudi Building Code National Committee launched the Saudi energy conservation codes, SBC-601 and SBC 602, for residential and non-residential buildings [6]. Additionally, the Ministry of Housing of the KSA developed the Mostadam Rating System, aiming to contribute to the sustainability of residential units [7]. In 2018, the Kingdom of Bahrain launched its first energy conservation code, focusing on governmental entities and, in 2020, the Unified Guidebook of Building Permit Regulations, a building code with mandatory requirements for all the buildings in the kingdom. Qatar developed the Global Sustainability Assessment System (GSAS) in 2019. This was the first performance-based system in the Middle East and North Africa region and was developed for rating both green buildings and infrastructures [5], [7].

In the UAE, there is not a federal building energy code. However, three emirates have developed their green buildings regulations and their respective building rating systems. In 2008, Abu Dhabi established the Estidama Green Building Code and created the Pearl Building Rating [8]. In 2008, the Dubai government announced an energy conservation code for buildings as part of the Dubai Demand Side Management (DSM). The Dubai Electricity and Water Authority (DEWA) and the Dubai Municipality introduced the first version of the Green Building Regulations and Specifications in 2011. In the beginning, they were mandatory only for government buildings. In 2014, they became compulsory for all the Dubai buildings [9], [10]. Two years later, Dubai Municipality launched the Al Sa'fat Rating System to contribute even more to the sustainable built environment. Similarly, Ras Al Khaimah Municipality launched Barjeel, Ras Al Khaimah's Green Building Regulations, in 2018, to reduce 30% of the energy consumption of the buildings in this emirate [11].

Dubai is committed to the goal of becoming one of the most energy-efficient cities in the world. To reach this goal, the Dubai Supreme Council of Energy developed the Dubai Demand Side Management (DSM), with the support of several governmental [12]. Most DSM programs are related to the buildings sector, recognizing that buildings in Dubai consume more than 80% of total electricity output [13]. The DSM strategy includes continuous updates of buildings policies and regulations, building retrofitting, district cooling, equipment energy certification, and other initiatives aimed at increasing the efficiency of the buildings and lay the foundation for the transition to the nZEB. DEWA established the Distributed Renewable Resources Generation program that enables the development of nZEB in Dubai, and, in 2014, launched the Shams Dubai, a pioneering initiative in the GCC, designed to accelerate and facilitate the installation of photovoltaic in buildings. These frameworks have stimulated the development of several commercial and pilot projects inspired by nZEB concepts that demonstrate its benefits and viability [14], [15].

Our study supports the efforts of Dubai, other Emirates, and the GCC governments to increase the level of sustainability of their cities by identifying areas of potential improvement in building codes, benchmarking them against each other, and with actual building performance of nZEB early adopters.

2 METHODOLOGY

To assess building energy codes in context, we first quantify the current demand trend in the electrical energy consumption of buildings in Dubai. Then, we summarize the vision and main objectives of the Dubai GBR&S and compare it with the relevant regulations in other jurisdictions shown in Table 1. Using publicly available information, we compare GBR&S requirements with the corresponding building regulations and building rating systems in other GCC countries (the Kingdom of Saudi Arabia, the Kingdom of Bahrain, Qatar, and

Kuwait). Then, we compare GBR&S with the regulations of other Emirates (Abu Dhabi and Ras Al Khaimah) and with the early adopters of ZEB concepts. We focus our analysis on the elements that most affect the energy consumption in GCC buildings, their envelope, and cooling systems, in addition to the share of renewables, an essential requirement for the nZEB. As early adopters of nZEB Buildings in the UAE, we selected three residential projects: The Sustainable City (TSC) in Dubai, the Masdar Eco-villa in Abu Dhabi, and the Mohammad Bin Rashid Space Center (MBRSC) Autonomous House in Dubai. These three cases exceed the current UAE regulations, have energy use intensity (EUI) significantly lower than the typical UAE buildings, and show different levels of energy balance. We finalized our study identifying the potential areas of improvement of the current Dubai GBR&S.

Table 1: GCC building regulations that are part of this study.

Country/city	Regulation	Rating system	Most recent edition	Ref.
Dubai	Al Sa'fat	Sa'fa	2017	[16]
Abu Dhabi	Estidama	Pearl Rating System	2016	[8]
Ras Al Khaimah	Barjeel Green Building Regulation	-	2018	[17]
Kuwait	Energy Conservation Code of Practice	-	2014	[5]
Kingdom of Saudi Arabia	Saudi Green Building Code	Mostadam Rating System	2018	[7]
Kingdom of Bahrain	Unified Guidebook of Building Permit Regulations	-	2019	[18]
Qatar	Global Sustainability Assessment System	-	2019	[19]

3 BUILDINGS IN DUBAI AND GOVERNMENT RESPONSE

3.1 Buildings in Dubai: energy consumption and CO_2 emissions

Dubai is a cosmopolitan city undergoing massive urban growth and industrialization; therefore, electricity consumption within the Emirate has become a rising concern. Fig. 1 shows electricity demand by sectors in 2019. Buildings are responsible for 86.1% of all the city electricity consumption. Commercial buildings demanded 49.0% of electricity, the residential sector 29.0%, and the government buildings (mosques, police stations, offices, public hospitals, schools, etc.) 8.2%. Furthermore, Fig. 2 shows the electricity demand per number of commercial and residential customers. Over the past six years. There is no clear indication that commercial buildings' efficiency has increased. However, the average consumption per residential customer started to decrease from 2015 slightly [13], [20]–[24].

3.2 Dubai Demand Side Management (DSM)

Dubai is committed to the goal of becoming one of the most energy-efficient cities in the world. To reach this goal, in 2013, the Dubai Supreme Council of Energy developed the Dubai DSM as part of the Dubai Integrated Energy Strategy (DIES) 2030. DSM focuses on the design and management of programs and measures that have as objective to incentive and guide the end-users towards more efficient use of the energy. The DSM strategy 2030s objective is to reduce electricity and water consumption by 30%. Green building regulations, voluntary standards and labels, building retrofits, and tariffs are policy options available to

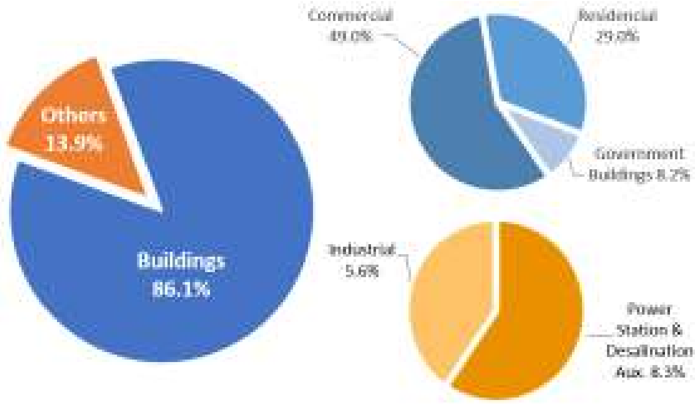

Figure 1: Dubai electricity demand by sectors, 2019. *(Source: Authors, using data from Dubai Electricity and Water Authority [13].)*

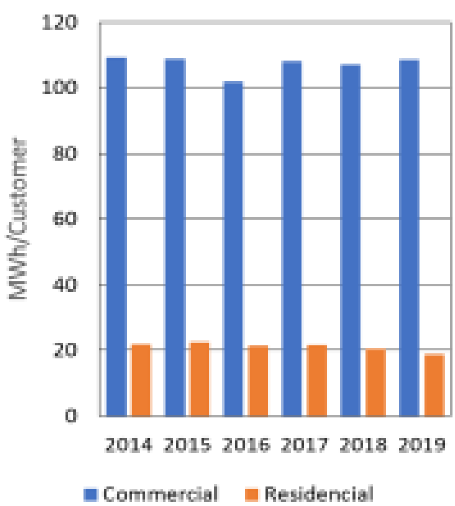

Figure 2: Dubai annual average electricity demanded by customers. *(Source: Authors, using data from [13], [20]–[24].)*

achieve these goals [12]. In 2013, DEWA established Etihad ESCO to develop a viable performance contracting market for energy service companies, centered on building retrofits, installation of PV in buildings, and increasing the penetration of district cooling.

The constant evolution of the Dubai buildings regulation is Dubai Municipality's contribution to the DSM strategy. As planned, the DSM is in the phase of scaling-up its impact and developing new initiatives, including the transition to nZEB [9], [12].

In Dubai, electricity rates follow a slab tariff approach that increases the rate with consumption (Table 2). While simple, this system is not fully exploiting the options provided by a more adaptive tariff system. Hence, the Dubai Supreme Council of Energy has included

Table 2: Dubai Electricity and Water Authority (DEWA) residential/commercial tariffs. *(Source: www.dewa.gov.ae/en/consumer/billing/slab-tariff.)*

Code	Consumption (kWh)/ month	Slab tariff (fils/kWh)	Slab tariff US cents/kWh	Remarks
G	0-2000	23	6.3	- Electricity fuel surcharge 6.5 fils/kWh (1.8 US cents/kWh) September 2020. - Currency conversion: 3.67 Dirhams = USD $1.
Y	2001-4000	28	7.6	
O	4001-6000	32	8.7	
R	6001 and above	38	10	

the program "Change of tariffs rates" as part of its DSM programs, which may signal the start of a positive transformation.

3.3 Dubai Green Building Regulations and building ratings

In 2010, Dubai Green Building Regulations and Specifications (GBR&S) was only mandatory for new government buildings, and in 2014 was enforced to all the buildings [9]. The GBR&S aim is to support Dubai's Strategic Plan, create a more sustainable urban environment, and extend the ability of this emirate's infrastructure to meet the needs of its future development. Dubai Municipality relaunched the buildings' regulations in 2017 as Al Sa'fat, Dubai Green Building Evaluation System. Al Sa'fat has 33 mandatory general requirements, many optional provisions whose compliance determinates the building ranting. Al Sa'fat rating system has five main categories; one of them is the "Resource Effectiveness – Energy". This category includes all the requirements for high energy-efficient buildings in Dubai, including requirements about the envelope, air conditioning, ventilation, and renewables in buildings Nearly ZEB [16], [25].

4 DUBAI AND THE GCC BUILDING REGULATIONS

4.1 GCC climate

The climate in GCC countries is very similar, with long and very hot summers, as shown in Fig. 3. They correspond to the Bwh (Hot Desert Climate) in the Köppen-Geiger climate classification and 1B (Very Hot-Dry Climate) in the International Energy Conservation Code (IECC), developed by the International Code Council (ICC) [26]. According to this code, all areas that surpass 5000 degree-days of the annual CDD10ºC belong to Zone 1 (see Fig. 4). And, the B correspond to Dry areas, locations meet the following criteria (annual precipitation in cm < 2.0 × (annual mean temperature in °C + 7). As a reference, we include the Cooling Degree Hours (CDH 26.7°C) in Fig. 5. As previously mentioned, cooling loads that utilize HVAC systems take the larger share of the electricity consumption within the GCC countries, all due to the challenging climatic conditions of the region. Therefore, it is essential to apply passive design strategies, use highly efficient equipment, and adequately operate the buildings to reduce the energy demand related to the cooling needs.

4.2 Building regulations in the GCC

GCC countries have instituted building codes and regulations to manage their electricity consumption and foster a more energy-efficient built environment. Kuwait took the lead in introducing a building efficiency code, publishing the first version of its Energy Conservation

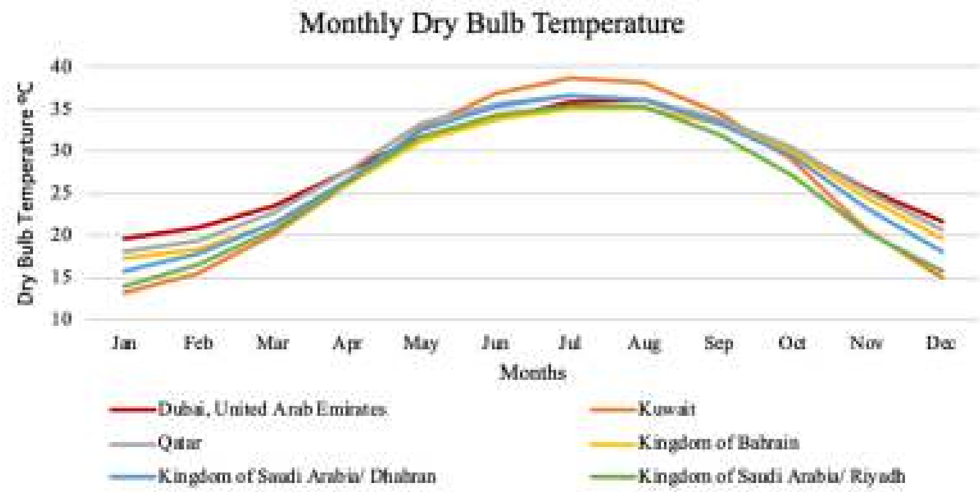

Figure 3: GCC countries' typical ambient temperature. *(Source: Authors.)*

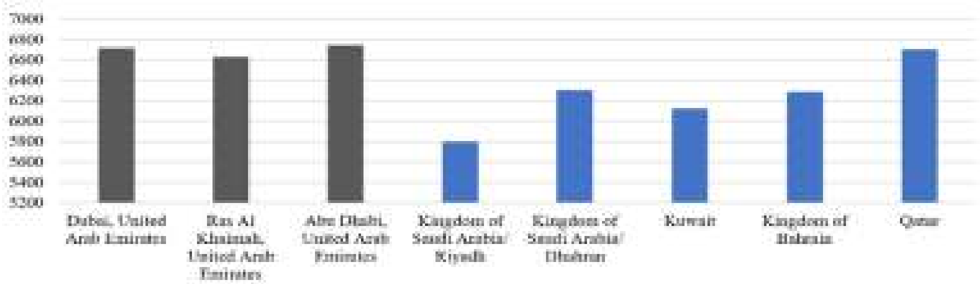

Figure 4: Climate of the GCC countries – Annual Cooling Degree Days (CDD) 10°C. *(Source: Authors.)*

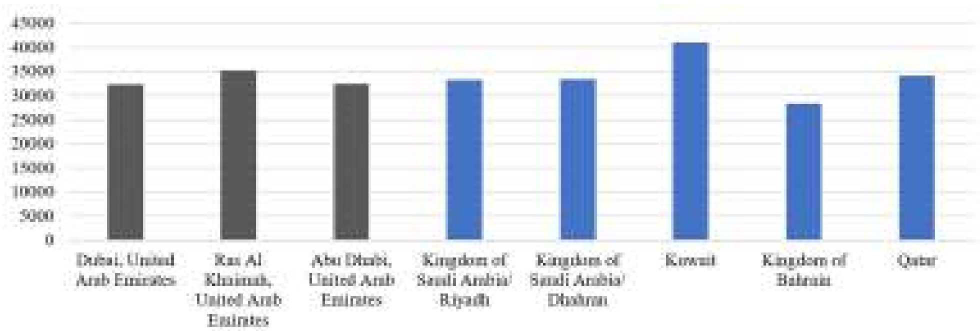

Figure 5: Climate of the GCC countries – Annual Cooling Degree Hours (CDH) 26.7°C. *(Source: Authors.)*

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Code of Practice in 1983. The code has since been revised in 2010, and more recently, in 2014. A study performed on a residential model in Kuwait found that buildings built according to the 1983 code can achieve up to 23% in energy savings when retrofitted according to the 2010 revision [27].

In 2010, the Kingdom of Saudi Arabia (KSA) launched an energy efficiency program called the Saudi Energy Efficiency Center through the Council of Ministers' resolution [28]. What followed was the enactment of the Saudi Building Code (SBC) 601 and 602 in 2017 aimed to regulate the energy performance of residential low-rise buildings and commercial high-rise buildings [29]. These codes had yearly released publications, with the latest edition released in 2019 [6]. This paper will draw comparison values from the 2019 SBC 602. Additionally, KSA devised the Sustainable Building Regulation in 2019 in line with its Vision 2030 of creating a pathway for future economic and developmental action. The building code created was coupled with the Mostadam Rating System, aimed to contribute to the sustainability of residential units [7]. A study carried out before the launch of the Saudi Green Building Code shows that it is possible to reach an energy savings of 45%, improving the thermal characteristics of the buildings' envelope [30].

Similarly, the Kingdom of Bahrain published its Unified Guidebook of Building Permit Regulations in 2019 through its building permit portal, Benayat [18]. It is of note that the focus of this regulation is not sustainability or energy efficiency. Its main objective is to implement in the kingdom the latest international construction standards and best practices. However, as later comparisons will show, Bahrain's guidelines are not very different from the energy efficiency-oriented codes set by other GCC countries, and the Bahrain Sustainable Energy Authority is working on the Green Building Code, and Labelling Program is under development [31].

Finally, Qatar has released the Global Sustainability Assessment System (GSAS) in 2007 through the Gulf Organization for Research and Development. The system has since had four editions released, with its latest version published in 2019. The GSAS is unique in the sense that it is the first performance-based system in the GCC and broader MENA region. Unlike the other regulations and codes in the GCC, GSAS does not rely on benchmark values for passive parameters within the building envelope. GSAS assesses the sustainability and efficiency of a building through a specific method of performance analysis, with the help of a custom devised simulation [19]. In that sense, the GSAS assures that the end goal of the building, energy efficiency, and sustainability, is indeed achieved as measured by its actual performance.

4.3 Comparison between Dubai and other GCC regulations

Table 3 compares the thermal transmittance (U-values) required by the regulations of the GCC countries. Since the climate of these countries is similar, the U-values should equal or very close. However, we found significant differences between the requirements of their building codes. In Dubai and Bahrain, there is one U-value for walls and another for the roofs. However, in Kuwait, the U-value depends on the type of construction. The thermal transmittance requirements different between light and heavy construction and between walls with exterior light or dark colors. The KSA has three climatic zones (main area, north, and mountain), and rightly, each of them has theirs on requirements. We utilized the requirements of the main area for the comparisons. Bahrain's regulation is the least restrictive, which can be explained by the fact that its regulation is not focused on energy efficiency. In general, Dubai's values fall in the mid-range of the countries that we compared. Finally, as mentioned, Qatar's regulations are based on performance and not on the properties for building elements.

Table 3: Comparison of opaque buildings' envelope requirements in the GCC.

Country	Regulation	Year	Average U-value (W/m^{2}K)				Ref.
			External walls	Roof	Floor	Basement walls	
Dubai	Al Sa'fat[a]	2014	0.57	0.30	-	[b]	[16]
Kuwait	Energy Conservation Code of Practice	2014	0.227–0.568[c]	0.155–0.397[c]	[d]	-	[5]
Kingdom of Saudi Arabia	Saudi Green Building Code	2019	0.34–0.45[e]	0.2–0.27[e]	-	-	[6]
Kingdom of Bahrain	Unified Guidebook of Building Permit Regulations	2019	0.75	0.6	-	-	[18]

[a]Individual Private Villas are exempt if 200 mm thermal blocks with a U-value of maximum 0.5 W/m^{2}K are used.
[b]The floors are in contact with the ground, the insulation should only be applied to 1 m in from the perimeter of the building.
[c]U-value of the external wall varies depending on the construction (very light to heavy construction) and wall color (light to dark exterior color).
[d]floors exposed to ambient conditions shall be treated as roofs, and partitions exposed to non-air-conditioned areas shall be treated as walls for U-values requirement.
[e]Dependent on the different zone classifications within the country.

Table 4: Comparison of the translucent envelope requirements in the GCC.

Emirate	Regulation	Year of mandate	Average U-value (W/m^{2}K)			SHGC	Ref.
			Glazed walls and windows		Skylights		
Dubai	Al Sa'fat	2014	≤ 40% 40%–60% ≥ 60%	2.1 1.9 1.9	1.9	~ 0.35[c] ~ 0.28 ~ 0.22	[16]
Kuwait	Energy Conservation Code of Practice	2014[d]	≤ 15% 15%–50% ≥ 50%	3.61 3.33 2.0	-	0.4 0.25 0.23	[5]
Kingdom of Saudi Arabia	Sustainable Building	2018	25%	2.67	4.26	0.35	[6]
Kingdom of Bahrain	Unified Guidebook of Building Permit Regulations	2019[d]	≤ 40% ≥ 40%	2.1 1.9	-	-	[18]

[a]The average U-value and the SHGC of the glazed walls and windows depends on the percentage of the total area of the external walls that let in light.
[b]SHGC will differ for walls and roofs depending on the average percentage of the area that allows light to pass. conditioned floor area.
[c]The SHGC was calculated by multiplying the Shading Coefficient with 0.87 [32].
[d]Year of the latest edition.

Table 4 compares the U-values of the Glazed walls, windows, and skylights as well as the Solar Heat Gain Coefficient (SHGC) of Dubai and the building codes of the GCC countries. The U-values for Dubai and Bahrain are almost equivalents, alternating between 2.1 and 1.9 W/m^{2}K for glaze walls and windows. And, in that case, Kuwait has a more relaxed threshold in place, allowing a U-value up to 3.61 W/m^{2}K for some cases. However, Kuwait requires the lowest SHGC value 0.25 for the most common sizes, 15% to 50% of glazing. And Dubai requires the lowest SHGC value for ample glazings, 0.22 for 60% glazed areas or larger.

5 DUBAI AND OTHER EMIRATES BUILDING REGULATIONS

5.1 Other building regulations in the UAE

The Abu Dhabi Urban Planning Council launched the Estidama – Green Buildings Regulations in 2008, and two years later, the Estidama Pearl Rating System [8]. This sustainable building rating system has four pillars environmental, economic, social, and cultural. The rating system has five levels. Buildings that comply with all the mandatory requirements get the level 1 Pear. Starting in September 2010, all new applicable buildings must meet the 1-Pearl, and all government-funded buildings must achieve a minimum 2-Pearl rating.

The Estidama includes documents for four rating options: Pearl Villa Rating System, Building Rating System, Pearl Community Rating System, and the Public Realm Rating System. And, similarly to the Al Sa'fat regulation, one of the seven Pearl Rating System is "Resourceful Energy". This category deal with the buildings' energy conservation, energy efficiency, and renewables, as well as with the improvement of social awareness, monitoring, and reporting [8].

The Ras Al Khaimah government launched the Barjeel – Green Building Regulations in 2018, under the RAK Energy Efficiency and Renewable Energy Strategy 2040, as part of its energy and water savings initiatives [11]. Barjeel regulates all new buildings in the Emirate of RAK, including the economic and free zones. Barjeel sets minimum requirements for different building types. The regulations target five main areas, two of which are related to energy use and harvesting: energy efficiency and renewable energy. During its first year, its compliance was voluntary. However, from January 2020, its requirements are mandatory for all new construction [11].

5.2 Comparison between Dubai and other emirates regulations

Table 5 shows the maximum thermal transmittance (U-value) for opaque envelopes of the different emirates' green building codes. The weather of the three emirates is very similar. However, their stringency levels vary. The newer regulations included new requirements and are generally more stringent. Barjeel's requirements for the roof are the same as the Al Sa'fat, but when it comes to the wall, it is more exigent. The current version of Estidama came approximately two years after Al Sa'fat and introduced more restricted requirements than Barjeel and Al Sa'fat. The cooling demand of the buildings that follow the current version of Estidama will be lower than the ones following other UAE regulations.

In Table 6, we compare the U-values and Solar Heat Gain Coefficients (SHGC) of the different emirates green building codes. Al Sa'fat requirements for glazed walls and window is more restrictive than both Estidama and Barjeel. However, there is no significant difference between them. Al Sa'fat mandates the U-values to be between 1.9 and 2.1 W/m^{2}K, and the other Emirates regulations require 2.2 W/m^{2}K. For skylights, Al Sa'fat and Barjeel establish a threshold of 1.9 and 1.8 W/m^{2}K, respectively, and Estidama is less restrictive as it requires 2.2 W/m^{2}K. Al Sa'fat relates the U-value of the glazed wall and windows to the window-to-

Table 5: Comparison of the opaque envelope requirements in the UAE.

Emirate	Regulation	Year of mandate	Average U-value (W/m^2K) External walls	Roof	Floor	Basement. walls	Ref.
Dubai	Al Sa'fat[a]	2014	0.57	0.30	-	[b]	[16]
Abu Dhabi	Estidama[c]	2016	0.32	0.14	0.15	0.28	[8]
Ras Al Khaimah	Barjeel	2020	0.48	0.30	-	-	[11]

[a]Individual Private Villas are exempt if 200 mm thermal blocks with a U-value of maximum 0.5 W/m^2K are used.
[b]The floors are in contact with the ground, the insulation should only be applied to 1 m in from the perimeter of the building.
[c]Glazed-elements with back insulated panels must be treated as walls (and therefore must meet the performance requirement for walls.

Table 6: Comparison of the translucent envelope requirements in the UAE.

Emirate	Regulation	Year of mandate	Average U-value (W/m^2K) Glazed walls and windows		Skylights	SHGC	Ref.
Dubai	Al Sa'fat	2014	≤ 40%	2.1	1.9	~ 0.35 [c]	[16]
			40–60%	1.9		~ 0.28	
			≥ 60%	1.9		~ 0.22	
Abu Dhabi	Estidama [d]	2016		2.2	2.2	0.30	[10]
Ras Al Khaimah	Barjeel	2020		2.2	1.8	0.30	[11]

[a]The average U-value and the SHGC of the glazed walls and windows depends on the percentage of the total area of the external walls that let in light.
[b]SHGC will differ for walls and roofs depending on the average percentage of the area that allows light to pass conditioned floor area.
[c]The SHGC was calculated by multiplying the Shading Coefficient with 0.87 [32].
[d]Glazing area must be less than 15% of the conditioned floor area.

wall ratio, while Estidama establishes that the glazing area must be less than 15% of the conditioned floor area.

Al Sa'fat establishes the minimum energy efficiency requirements of HVAC and other requirements as zones subdivisions and controls. As shown in Table 6, Estidama in Abu Dhabi, the air conditioning system must have a minimum coefficient of performance (COP) of 3.4. Al Sa'fat stipulates that the ventilation energy recovery systems must be provided in all new buildings where the need for treated outdoor air exceeds 1,000 l per second. In this case, these systems must handle at least 50% of the total exhausted air and should have at least 70% sensible load recovery efficiency (DGBC). Table 7 also shows the significant differences in terms of minimum COP for air-cooled air conditioners. Abu Dhabi's Estidama seems to be the most updated with the progress of AC system efficiency.

6 COMPARISON WITH UAE EARLY ADOPTERS OF THE NZEB CONCEPT

As early adopters of Nearly and Zero Energy Buildings in the UEA, we selected three residential projects: The Sustainable City in Dubai (a real estate success), the Masdar City Eco-villa in Abu Dhabi (demonstrate economic feasibility and availability of the necessary materials and equipment in the local market), and the Mohammad Bin Rashed Space Center Autonomous House in Dubai (prototype of the passive house concept and positive energy buildings).

Table 7: Air conditioning and energy recovery ventilation requirements in the UAE.

Emirate	Regulation	Year of mandate	Air conditioning	Ventilation	Ref.
			Minimum COP	Sensible load recovery efficiency	
Dubai	Al Sa'fat	2014	2.8[a]	70%	[16]
Abu Dhabi	Estidama	2016	3.4	–	[8]
Ras Al Khaimah	Barjeel	2020	2.37	70%	[11]

[a]COP requirement varies depending on the type of equipment.

6.1 Early adopters of the Nearly and Zero Energy Buildings in the UAE

The Sustainable City in Dubai serves as a comprehensive sustainable community comprised of 500 villas, 89 apartments, a mixed-use development, an urban farm, an equestrian club, and a school. TSC considers social, economic, and environmental sustainability. The villas' design utilizes both passive strategies and highly efficient systems, resulting in 65% lower Electricity Use Intensities (EUI) than similar villas in Dubai [9], [33]. The four-bedroom villas consuming about a 100 kWh/m^2 year and have a PV system able to generate 40% of their total energy demand.

Masdar City's Eco-Villa puts forward a residency equipped to the needs and expectations of the typical Emirati family in a highly energy-efficient structure. They constructed its walls using Insulated Concrete Forms (ICF), resulting in low thermal transmission opaque envelope. Having the goal to maintain the consumption below to 97 kWh/m^2 year, this house also includes high-efficiency equipment and energy management systems. Additionally, it has a PV system able to generates 102% of the house energy demand. On the other hand, 90% of the materials used within the construction of the project were locally sourced. That points out that the UAE market is ready to supply the necessary materials to the nZEB buildings [34].

MBRSC Autonomous House is an ambitious early adopter of ZEB, showcasing the strides that can be achieved within the path of energy efficiency. Standing at a two-floor office structure, passive elements such as the geometry alongside the orientation of the building helps reduce the primary energy consumption. A highly efficient air-cooled electric chiller efficiently delivers cooling loads to the building. Moreover, a PV field producing 40 kW in addition to a 48 kWh battery storage generates enough power to fulfill the demands of the building, enabling the building to produce more energy than it consumes, and granting it the title of a positive energy building [35].

As seen in Table 8, the early adopters prove to be highly efficient and cover all or a significant portion of its annual energy with renewable energy produced on-site.

Figure 6: Early adopters of the nZEB and ZEB in the UAE. (a) The Sustainable City – four-bedroom villa; (b) Masdar – Eco Villa; and (c) MBRSC Autonomous House. *(Source: Diamond Developers, MBR Space Center, and Masdar City.)*

Table 8: Minimum air conditioning and energy recovery ventilation requirements.

Early adopter	City	Area (m^2)	Consumption (kWh/m^2year)	PV installed (kWp)	Share of renewables (%)	Ref.
The Sustainable City	Dubai	433[a]	100[a]	9.8[a]	40[a]	[9], [33]
Masdar City – Eco Villa	Abu Dhabi	405	97	NIA[b]	102	[34]
MBRSC Autonomous House	Dubai	550	42[c]	40.0	187	[35]

[a]Information based on 2018 data of 4-bedroom villas, using a sample size of 53% (120 units).
[b]As per Masdar City documents, the villa has 89 PV panels with an output of 40,000 kWh year.
[c]Used as an office, without the typical use of the kitchen, laundry, and bathroom a house.

Table 9: Comparison between Dubai and ZEB early adopters' envelope regulations.

Emirate	Regulation/case study	Year of mandate	Average U-value (W/m^2K)				Ref.
			External walls	Roof	Floor	Basement. walls	
Dubai	Al Sa'fat[a]	2014	0.57	0.30	-	[b]	[16]
Dubai	The Sustainable City	2015[c]	0.32	0.20	1.3	-	[9], [33]
Dubai	Autonomous House (MBRSC)	2016[c]	0.063	0.061	0.7	-	[35]
Abu Dhabi	Eco-Villa (Masdar city)	2017[c]	0.16	-	-	-	[34]

[a]Individual Private Villas are exempt if 200 mm thermal blocks with a U-value of maximum 0.5 W/m^2K are used.
[b]The floors are in contact with the ground; the insulation should only be applied to one meter in from the perimeter of the building.
[c]Year of construction.

6.2 Comparison between Dubai regulations and the early adopters of the ZEB in the UAE

The U-values of the wall and roof, seen in Table 9, of the Sustainable City villas, exceed Al Sa'fat requirements, and are close to complying with the Estidama regulations. However, they were designed more than a year before. Having a successful real estate project developed with U-values lower than Al Sa'fat indicates that the market can accept more restricted requirements for the buildings' opaque envelope. The Autonomous House, on the other hand, has a U-value significantly lowers than the other early adopters and the regulations in the UAE. This fact shows that voluntary certifications for the buildings in the UAE can suggest values that drastically exceed the current energy conservation codes.

Similarly, as Table 10 shows that windows in The Sustainable City villas have a U-value that is much lower than that of Al Sa'fat. This fact also indicates that there is a margin to revise the current Dubai green buildings regulations. As anticipated, the Autonomous House proves to have the lowest U-value glazing of 0.7 W/m^2K. But reach these values are only possible using triple glazing, cavities filled with inert gasses, Low-E coatings, and very efficient frames.

Table 10: Comparison between the U-value of translucent building envelopes.

Emirate	Regulation/case study	Year	Average U-value (W/m^{2}K)			SHGC	Ref.
			Glazed walls and windows		Skylights		
Dubai	Al Sa'fat	2014	≤ 40% 40–60% ≥ 60%	2.1 1.9 1.9	1.9	~ 0.35[c] ~ 0.28 ~ 0.22	[16]
Dubai	The Sustainable City	2015[d]		1.3	-	-	[9], [33]
Dubai	Autonomous house (MBRSC)	2016[d]		0.7	-	0.29	[35]

[a]The average U-value and the SHGC of the glazed walls and windows depends on the percentage of the total area of the external walls that let in light.
[b]SHGC will differ for walls and roofs depending on the average percentage of the area that allows light to pass conditioned floor area.
[c]The SHGC was calculated by multiplying the Shading Coefficient with 0.87 [32].
[d]Year of construction.

Table 11: Recap of best values found in the GCC building regulations and the early adopter of the nZEB in the UAE. For the units of the values, refer to the previous tables. *(Source: Authors, from [5], [8], [9], [11], [25], [31], [33]–[35].)*

	Dubai's regulation		Best regulation in the GCC			Nearly zero energy early adopter			Zero energy prototype (MBRSC)	
	Value	%	Value	%	Country/City	Value	%	Adopter	Value	%
Wall U-value	0.57	100	0.426[a]	134	Kuwait	0.16	356	Eco Villa	0.063	905
Roof U-value	0.3	100	0.199	151	Kuwait	0.2	150	TSC	0.061	492
Glazed walls and windows U-value	1.9[b]	100	1.9	100	Dubai and Bahrai28n	1.3	146	TSC	0.7	271
SHGC	0.28[c]	100	0.25[d]	100	Kuwait	-	-	-	0.29[e]	121
HVAC COP	2.8[f]	100	3.4	121	Abu Dhabi	3.9[g]	163	Eco Villa	-	-
Sensible load recovery efficiency	70%	100	70%	100	Dubai/RAK	-	-	-	-	-

[a]This value was selected based on the average U-value, specifically for medium construction, dark external color.
[b]Based on the U-value taken at the glass area percentage between 40% and 60%.
[c]Based on the SHGC taken at glass area percentage between 40% and 60%.
[d]Based on the SHGC taken at glass area percentage between 15% and 50%.
[e]The window glass area percentage is very low on the MBRSC prototype. Thus, it is compared to the Dubai Regulation's SHGC value of 0.35.
[f]COP requirement varies depending on the type of equipment.
[g]Two variable refrigerant flow cooling systems for this villa were studied [36].

7 OPPORTUNITIES FOR THE NEXT UPDATE OF THE DUBAI REGULATIONS

Table 11 shows the regulations set within Dubai and compares them to the most restrictive regulations found in the GCC as well as the early adopters present in the UAE. The values for the Al Sa'fat regulations in Dubai are listed, then the strictest regulation value and its subsequent percentage increase from the Al Sa'fat code as well as its belonging county. For the nZEB early adopters, the better performer between the Masdar Eco Villa and The Sustainable City was chosen based on their specific performance in each category.

Additionally, the MBRSC Autonomous House was selected to represent the Zero Energy Prototype, as shown in Table 11. The U-values of the wall and roof were both prevailed by the Kuwaiti regulations code, which had the lowest average for minimum U-value in their regulations. It is important to note that in other categories of construction, the Kuwaiti code could call for either a lesser or higher U-value benchmark for the building model; however, the average values were selected for the comparison in this table. As for the nZEB early adopters, the Eco Villa and TSC both prevailed in different compartments within the compared properties, showing their strides in energy efficiency. Finally, the comparison between the Dubai building code and the MBRSC Zero Energy Prototype sheds light on the extent of the performance of the prototype, with the U-value of the wall exceeding nine times the fraction of the upper threshold set by Al Sa'fat.

8 CONCLUSIONS

In the middle East, several governments are implementing policies to promote a more sustainable built environment. In the GCC countries, these efforts have become more intense over the last decade, with the launch of new or updated building codes and with the creation of Demand Side Management strategies. Essential actions for the transition to the zero net emissions and carbon neutrality.

In our study, we provided an overview of the GCC countries' regulations comparing them to each other and the actual building performance of early adopters of nZEB. The differences found between them are a valuable source of information for the revision of the current regulations and the progressive changes toward the nZEB buildings. In the case of Dubai, we found that the government has implemented a very complete Demand Side Management program that has the buildings, responsible for the 86% of the electricity consumption, as its focus. Some of the implemented actions to accelerate the transition to the city decarbonization are the revision of the electricity and water tariff, the building retrofits program (Etihad ESCO), the impulse of the district cooling, the distributed generation, the creation of the Shams Dubai program, and the development of the Dubai Green Buildings Regulations and Specifications. Regarding the regulations and the reduction of cooling energy demand, we have found the following opportunities:

- Thermal insulation requirements of the building opaque envelope. The required U-values can be more restrictive, in a conservative way, moving from the current 0.57 and 0.30 W/m^{2}K for walls and roofs to 0.42 and 0.20 W/m^{2}K as in the Kuwait regulation. Or being more demanding and establish a limit for the walls equal or close to 0.16, as in the Masdar City Eco Villa. The value for roof and walls of the MBRSC Autonomous House (0.06 W/m^{2}K) can be used for voluntary requirements and to provide recognition to outstanding buildings.
- The glazing thermal transmittance requirements. Similarly, the U-values of the glazing systems might conservatively change form 1.9 W/m^{2}K to 1.5 W/m^{2}K, surpassing the other GCC codes, or be lowered to 1.3 W/m^{2}K as in the villas of The Sustainable City. Values below 1.1 W/m^{2}K, as in the MBRSC house (0.7 W/m^{2}K), requires highly efficient triple glazing. Adequately designed buildings, in most cases, will not need these outstanding solutions to get adequate performance.
- The glazing solar heat gain coefficient (SHGC). Due to the high temperatures and solar radiation that characterizes the region, the SHGC value is also very relevant facto. The current Dubai regulation already has a low value (0.28) for 40–60% glazed area, surpassed only by Kuwait, with 0.25 for 15% to 50%.

- Coefficient of Performance (COP) of the air conditioning. The efficiency of the HVAC systems has noticeably increased in the last years, which offers an excellent opportunity to reduce the buildings' energy efficiency. The current COP requirement of the water chiller package varies depending on the type of equipment, starting from 2.8. However, the air conditioning system must have a minimum coefficient of performance (COP) of 3.4, as the Estidama Pearl system.

Our future works will include the energy-saving and the economic analysis of the potential regulations' changes, inferred by this comparative study. There are two other relevant aspects of the evolution of the current codes that require further research. One is the transition from prescriptive to mix regulations (prescriptive/performance), as have been already done by Qatar. And the other is to evaluate the benefits of different codes for non-residential and residential (including low rise buildings), as per the ASHRAE model. The Kingdom of Saudi Arabia used this model.

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GEOGRAPHICALLY WEIGHTED PRINCIPAL COMPONENTS ANALYSIS APPROACH TO EVALUATE ELECTRICITY CONSUMPTION BEHAVIOUR

NATHALIA TEJEDOR-FLORES[1,2,3], PURIFICACIÓN VICENTE-GALINDO[4]
& PURIFICACIÓN GALINDO-VILLARDÓN[4]
[1]Centro de Investigaciones Hidráulicas e Hidrotécnicas, Universidad Tecnológica de Panamá, Panama
[2]Sistema Nacional de Investigación, Panama
[3]Centro de Estudios Multidisciplinarios en Ciencias, Ingeniería y Tecnología-AIP, Panama
[4]Departamento de Estadística, Universidad de Salamanca, Spain

ABSTRACT

Electricity consumer behaviour is primarily based on individual decisions, which are often driven by external factors such as economic incentives, existing demographics, environmental variables, social norms, and infrastructure. This study aims to understand the amount of electricity used per hour dedicated in the household (HH) sectors and the paid sectors – including agriculture (AG), other productive sectors (PS) and the service and government sector (SG) – using Geographically Weighted Principal Components Analysis (GWPCA). In the literature, we found that a standard Principal Components Analysis (PCA) can be replaced with a GWPCA when we want to account for a certain spatial heterogeneity. To use the GWPCA to compare the results with a standard PCA, we took the data used in a previous investigation and applied both analyses in order to find a better way to understand the electricity consumer behaviour, using a multivariate analysis. The standard PCA reveals that the first three components collectively account for 73.66% of the variation in the data. Using GWPCA, we found a clear geographical variation in the percentage of total variance data, with higher percentages (90%–95%) located in the south-west and a small part of the north-east of the case of study used. Also, the electrical Energy Throughput in Paid Work (ET_{PW}), and the amount of energy used per hour dedicated to the Paid Work sector (EMR_{PW}), appears to play an important part in defining the local structure in the south-west (coastal region) and in the northern part of the case of study used, respectively. The comparison results suggest that GWPCA provides better fitness than the standard PCA model by considering spatial heterogeneity.

Keywords: Geographically Weighted Principal Components Analysis, multivariate analysis, sustainable development, electricity consumption.

1 INTRODUCTION

According to Bybee in 1991, environmental issues have expanded from local to global; they have evolved from minor to major, and they have extended from personal concerns to public policies. In this period, the concept of Sustainability appears as "the most necessary unifying central idea at this moment in human history" [1]. "A threatened future" is the title of the first chapter of *Our Common Future, Report of the World Commission on Environment and Development* and the first attempts to introduce the concept of sustainable development, defined as "development, which meets the needs of current generations without compromising the ability of future generations to meet their own needs" [2].

Daly in 1992, defines sustainable development in a biophysical perspective that distinguishes three fundamental aspects: (1) Renewable resources, indicating that the rate of use must not exceeds the rate of regeneration; (2) Pollution, the rate of waste generation must not exceed the assimilation capacity of the environment; and (3) Non-renewable resources, indicating the development of renewable substitutes for those resources [3]. Meanwhile, in 1995 Goodland, affirms that "sustainable development should integrate social, environmental, and economic sustainability and use these three to start to make development

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sustainable" [4]. There are different definitions of sustainable development, such as Berkes and Folke in 1998, in the book "Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience" present an integrated vision of the "human being in nature"[5], in this vision the ecosystems are integrated with human society.

At the beginning of this 21st century, a new scientific domain, Sustainability Science, started to develop with the explicit aim of facing the present situation of planetary emergency to make possible the transition to sustainable societies [6]. This new science, called "Sustainability Science" was first announced by 23 researchers from different areas of knowledge, in an article published in 2011, in the journal Science: "A new field of sustainability science is emerging that seeks to understand the fundamental character of interactions between nature and society" [7]. Sustainability science integrates different fields, for example, economy, the study of biodiversity, energy efficiency, and many others, which have in common human actions that affect nature.

The Water-Energy-Food Nexus has emerged as a useful concept to addresses interactions and feedback between human and natural systems. It focuses on the resource base, including both biophysical and socio-economic resources, on which we depend to achieve social, environmental and economic goals pertaining to water, energy and food [8]. To understand the electricity consumption of a country, using the Water-Energy-Food Nexus, the Food and Agriculture Organization of the United Nations (FAO) and other scientific research, propose to use the Multi-Scale Integrated Analysis of Societal and Ecosystem Metabolism (MuSIASEM) approach [9]–[14]. The MuSIASEM is an innovative approach to accounting that integrates quantitative information generated by distinct types of conventional models based on different dimensions and scales of analysis [15]. Using the MuSIASEM variables, the aims of this study is to understand the amount of electricity used per hour dedicated in the household (HH) sectors and the paid sectors, included agriculture (AG), other productive sectors (PS) and the service and government sector (SG), in this case, in a country, applying Geographically Weighted Principal Components Analysis (GWPCA), in order to account for a certain spatial heterogeneity. The text is divided into five main sections: Section 1 contains the introduction; Section 2 presents the theoretical foundations of the GWPCA; Section 3 the description of variables, database and methodology used; Section 4 contains the summary of key findings and Section 5 presents the conclusions of this study.

2 THEORETICAL FOUNDATIONS

Principal Components Analysis (PCA) is widely used in many contexts for reducing the dimensionality of multivariate data [16] but, according to Harris et al. in 2011 [17], standard PCA can be replaced with a geographically weighted PCA (GWPCA), when we want to account for a certain spatial heterogeneity.

2.1 Geographically Weighted Principal Components Analysis

GWPCA is an extension of the classical PCA, while PCA analysis can provide information regarding the global internal structure; it fails to consider that the covariance structure of the data can change spatially. In essence, GWPCA performs a local PCA analysis by considering a neighbourhood around each spatial feature [18].

2.1.1 From PCA to GWPCA

Given a data matrix X composed by n rows (individuals) and m columns (variables) with a matrix of covariances $\sum$. The trace of $\sum$ is the total variance in the data. If the columns in X are standardised with zero mean and unit variance, the values in $\sum$ will be those in the correlation matrix for X with its trace equivalent to the number of columns in X. A standard result in linear algebra states that:

$$LVL^T = R, \tag{1}$$

where V is a diagonal matrix of eigenvalues, L is a matrix of eigenvectors and the matrix R is symmetric and positive definite [17].

The principal components are found by post-multiplying the original data values X by L; the correlation matrix for XL is an identity matrix, Fig. 1.

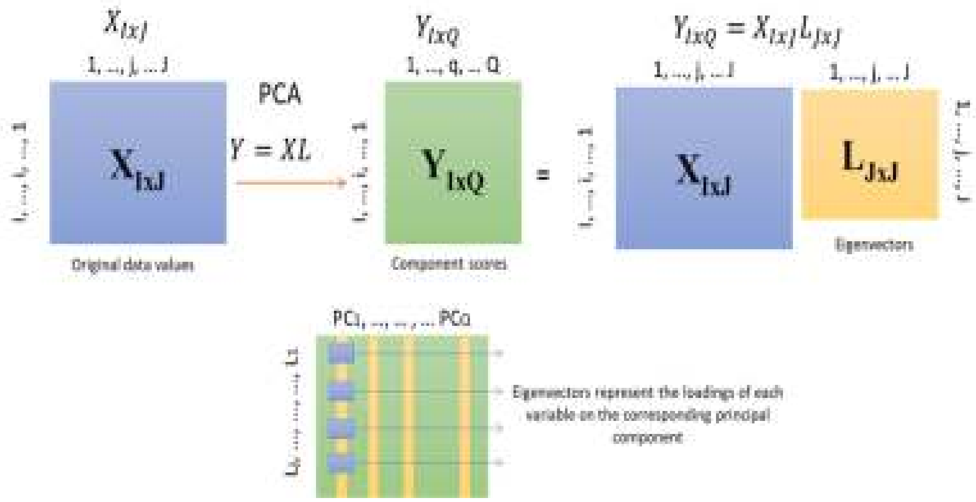


Figure 1: Principal Components Analysis.

In GWPCA, a vector of variables x_i has spatial location *i* is assumed to have a multivariate normal distribution with mean vector μ and variance–covariance matrix ∑ that is [17]:

$$x_i \sim N(\mu, \Sigma). \tag{2}$$

Furthermore, if spatial location i has coordinates (u, v), then PCA with local geographical effects involves regarding x_i as conditional on *u* and *v*, and making μ and ∑ functions of *u* and *v*; thus [17]:

$$x_i|(\mathrm{u}, \mathrm{v}) \sim N(\mu(u,v), \Sigma(u,v)). \tag{3}$$

As μ and ∑ are functions of *u* and *v*, this implies that each element of μ(*u*,*v*) and ∑(*u*,*v*) is also a function of *u* and *v*. To obtain the GW principal components, the decomposition of the GW variance–covariance matrix provides the GW eigenvalues and GW eigenvectors. The product of the *i*th row of the data matrix with the GW eigenvectors for the *i*th location provides the ith row of GW component scores. The GW variance–covariance matrix is [17]:

$$\Sigma(u,v) = X^T W(u,v) X, \tag{4}$$

where W(u, v) is a diagonal matrix of geographic weights that can be generated using kernel function presented in Table 1 [19].

Table 1: Six kernel functions [19].

Global Model	$w_{ij} = 1$	(5)
Gaussian	$w_{ij} = \exp\left(-\frac{1}{2}\left(\frac{d_{ij}}{h}\right)^2\right)$	(6)
Exponential	$w_{ij} = \exp\left(-\frac{\lvert d_{ij}\rvert}{h}\right)$	(7)
Box-car	$w_{ij} = \begin{cases} 1 & if\ \lvert d_{ij}\rvert < h, \\ 0 & otherwise \end{cases}$	(8)
Bi-square	$w_{ij} = \begin{cases} \left(1 - \left({d_{ij}}/{h}\right)^2\right)^2 & if\ \lvert d_{ij}\rvert < h, \\ 0 & otherwise \end{cases}$	(9)
Tri-cube	$w_{ij} = \begin{cases} \left(1 - \left({d_{ij}}/{h}\right)^3\right)^3 & if\ \lvert d_{ij}\rvert < h, \\ 0 & otherwise \end{cases}$	(10)

w_{ij} is the *j*th element of the diagonal of the matrix of geographical weights $W(u_i; v_i)$, and d_{ij} is the distance between observations *i* and *j*, and *b* is the bandwidth.

The GW principal components for the location (u_i, v_i) is given by (11):

$$LVL^T \mid (u_i, v_i) = \sum(u_i, v_i), \tag{11}$$

where $\sum(u_i, v_i)$ is the GW variance–covariance matrix for location (u_i, v_i).

3 METHODOLOGY

3.1 Case study

Ecuador, like most Latin American countries, does not have an extensive statistical culture. The dismantling of public planning during the 1980s and 1990s, plus the financial crises of the late 1990s, made the production of public statistics a low priority for the governments [20]. Others aspects which have caused serious social and environmental impacts and also, characterize the historical, economic and environmental development, not only from Ecuador but also from other Latin American countries, are deforestation, changes in land use, high rates of population growth, and the deterioration of tropical forests, causing important losses of biodiversity in this areas [9]. We used the unit of administrative and territorial division of Ecuador called a "canton". Cantons are the second-level subdivisions of Ecuador, below the provinces and they are formed by an urban centre, and its rural parishes. A total of 221 cantons were used in this study because with studies at this geographical level we can reach more detailed conclusions.

3.2 Description of variables

The database used includes 26 variables that measure characteristics of human societies in the 221 cantons of Ecuador. This database has been used in a previous study, related also with multivariate analysis, using BIPLOT Approach [21]. See Table 2 [22].

We used three main economic sectors (activity i): Agriculture, livestock and fishing sector (AG); Industrial sector (PS); and Service and Government sector (SG). The population and activity of economic sectors data were obtained from the statistics published by the National Institute of Statistics and Censuses of Ecuador Government, gross domestic product from the Central Bank of Ecuador and energy data from the Statistics of the Electric Sector of the Ecuador Government. See Table 3.

Table 2: Description of the MuSIASEM variables used [22].

Variable	Description	Unit
Total Energy Throughput (TET)	Total energy sources that are used for generating electricity in an economy in one year	Mega joules (MJ)
Total Human Activity (THA)	Total human time a society has available for conducting different activities	Hours (h)
Gross Domestic Product (GDP)	Added value generated by an economy in one year	US dollars ($)
Energy Throughput in activity i (ET_i)	Energy sources that are used for generating electricity in activity i, in one year	Mega joules (MJ)
Human Activity in activity i (HA_i)	Human time a society has allocated to activity i	Hours (h)
Added value generated by activity i (GDP_i)	Sum of the value added from the various economic sectors	US dollars ($)
Exosomatic Metabolic Rate, average of the society (EMR_{SA})	The amount of electricity per hour of human time for the whole society	MJ/h
Exosomatic Metabolic Rate for activity i (EMR_i)	The amount of electricity used per hour dedicated to each sector	MJ/h
Economic labour productivity for activity i (ELP_i)	Added value per hour of working time in activity i	$/h
Economic Energy Intensity (EEI)	Energy consumption in electricity per unit of added value	(MJ/$)

Table 3: Summary of the online sources used in the database.

Database	Source
Population	https://bit.ly/3hgCueB
Employment	https://bit.ly/31k0lUZ
GDP	https://bit.ly/34qEZYm
Energy	https://bit.ly/3hknexq

3.3 Data analysis

The database from the previous step was organized in an *I*x*J* data matrix, where rows *I* correspond to the 221 Cantons of Ecuador and columns *J* correspond to 26 variables. We used the Gwmodel R package, developed by Gollini et al. in 2015 [19], to apply the GWPCA in our database. The outputs of this analysis are mapped to provide a useful exploratory tool into the nature of the data spatial heterogeneity. The GWmodel R package includes functions for: GW summary statistics, GW principal components analysis, GW regression, and GW discriminant analysis; some of which are provided in basic and robust forms [19]. We added to the data matrix the geographic location (u_i, v_i) in WGS 84/UTM zone 18N coordinate system, of the 221 cantons and used a bi-square function to generated the diagonal matrix of geographic weights W(u, v), Fig. 2.

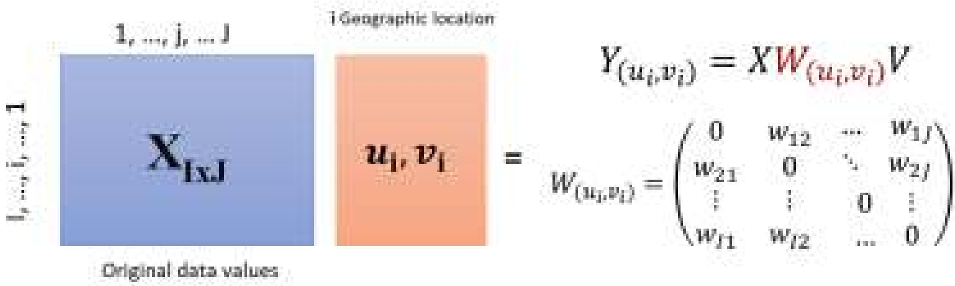


Figure 2: Geographically Weighted Principal Components Analysis.

4 RESULTS

4.1 Principal Components Analysis

We standardise the data and specify the global PCA with the covariance matrix, the same standardised data are also used in the GWPCA calibrations, which are similarly specified with covariance matrices. The effect of this standardization is to make each variable have equal importance in the subsequent analysis [19]. The standard PCA reveals that the first three components collectively account for 73.66% of the variation in the data. See Table 4.

Table 4: Variability % explained of global PCA.

Components	% of Variance	Cumulative %
1	54.93	54.93
2	10.41	65.34
3	8.32	73.66

In Table 5, component 1 appears to represent the Total Human Activity (THA) and Human Activity in Household (HAHH); component 2, the Economic Labour Productivity in Paid Work (ELPPW) and component 3, the Exosomatic Metabolic Rate in Household (EMRHH). These are whole-country statistics and interpretations [19], and they may not represent the local social structure of each Ecuador canton.

Table 5: Loadings of global PCA.

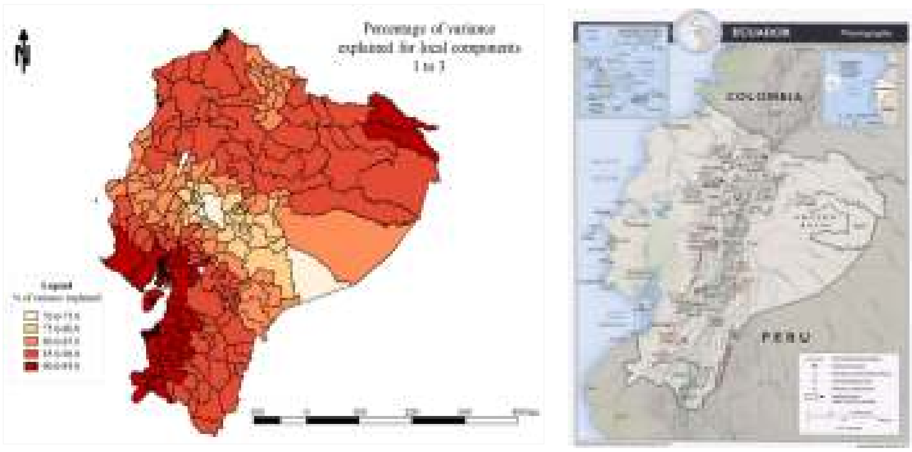
Variable	Comp.1	Comp.2	Comp.3
THA	-0.252	-0.059	0.020
HA_{AG}	-0.192	-0.061	0.023
HA_{PS}	-0.249	-0.062	0.025
HA_{SG}	-0.250	-0.062	0.023
HA_{PW}	-0.250	-0.063	0.024
HA_{HH}	-0.252	-0.058	0.020
TET	-0.244	0.030	-0.139
ET_{HH}	-0.199	0.043	-0.360
ET_{PW}	-0.245	0.018	0.012
ET_{SG}	-0.235	0.055	0.016
ET_{AG}	-0.238	-0.032	0.012
ET_{PS}	-0.238	-0.005	0.008
EMR_{SA}	-0.027	0.275	-0.559
EMR_{HH}	-0.014	0.139	-0.598
EMR_{SG}	-0.012	0.376	0.093
EMR_{AG}	-0.196	0.066	0.012
EMR_{PS}	-0.024	0.294	-0.029
EMR_{PW}	-0.038	0.474	0.042
GDP	-0.247	0.001	0.068
GDP_{SG}	-0.245	-0.065	0.024
GDP_{PS}	-0.224	0.100	0.136
GDP_{AG}	-0.168	0.067	0.016
ELP_{PW}	-0.021	0.412	0.262
ELP_{SG}	-0.049	0.046	0.033
ELP_{PS}	-0.012	0.370	0.264
ELP_{AG}	-0.036	0.278	0.007

4.2 Geographically Weighted Principal Components Analysis

A major challenge in GWPCA is in the estimation of the bandwidth [19]. For this study, we calibrated the GWPCA with a bi-square kernel using adaptive bandwidths whose sizes are chosen automatically and objectively via cross-validation [23]. The bi-square function is useful as it can provide an intermediate weighting between the box-car and the Gaussian functions [24].

For visualizing the output from GWPCA, we focused on: how data dimensionality varies spatially and how the original variables influence the components [19]. To visualize and interpret the results, we mapped the spatial distribution of the local percentage of variance explained and the first three principal components.

Fig. 3(a) shows the spatial distribution of the percentage of variance explained for the first three principal components. The fact that the variance changes throughout the study area also suggests the advantage of using GWPCA against standard PCA [26]. The percentage of variance explained for the first three local components in the GWPCA exceeds the percentage of variance explained for the first three components in the standard PCA (73.66%), in some cantons of Ecuador. There is a clear geographical variation in the results of the percentage of variance explained, with higher percentages (90%–95%) located in the south-west (coastal region) and a small part of the northeast (Amazon region), Fig. 3(b).The GWPCA offers the possibility of making not only a conjunct interpretation for all data but also as many analyses as there are data, according to their location [26].



(a) (b)

Figure 3: (a) Percentage of variance explained for the first three local components; and (b) Physiography map of Ecuador [25].

In Figs 4, 5, and 6 we can see the spatial distribution of the winning (highest absolute local loading in the corresponding component [17]) variables for the first three geographically weighted components. In Fig. 4, we can observe that the electrical Energy Throughput in Paid Work (ET_{PW}) and the amount of energy used per hour dedicated to the Paid Work sector (EMR_{PW}), appears to represent an important part in defining the local structure in the south-west (coastal region) and in the northern part of Ecuador, respectively. In the literature, we can found that the Exosomatic Metabolic Rate of the productive sector (EMR_{PW}) can be used as a proxy for the level of capitalization of the economy [27].

In the principal component 2, the energy sources that are used for generating electricity in the industrial sector (ET_{PS}) plays an important role in the north-east part of Ecuador (coastal region); and the variable Economic Labour Productivity per hour (ELP_{PW}) appears to be important in the north-western part of Ecuador (Amazon region). In the cantons located in the central part of Ecuador, the variable related to Economic Labour Productivity in the Services and Government sector (ELP_{SG}) is the one to appear important in this part of the country (see Fig. 5).

In component 3, the amount of electricity used per hour dedicated in the Agriculture sector (EMR_{AG}) is the winning variable in the north-east and the variable related with the amount of electricity used per hour in society (EMR_{SA}) is the winning variable in the north-west and part of the cantons located in the centre of Ecuador. In the cantons located in the southern part of Ecuador, the winning variable is the one related to the Gross Domestic Product generated by the Agriculture sector (GDP_{AG}). See Fig. 6.

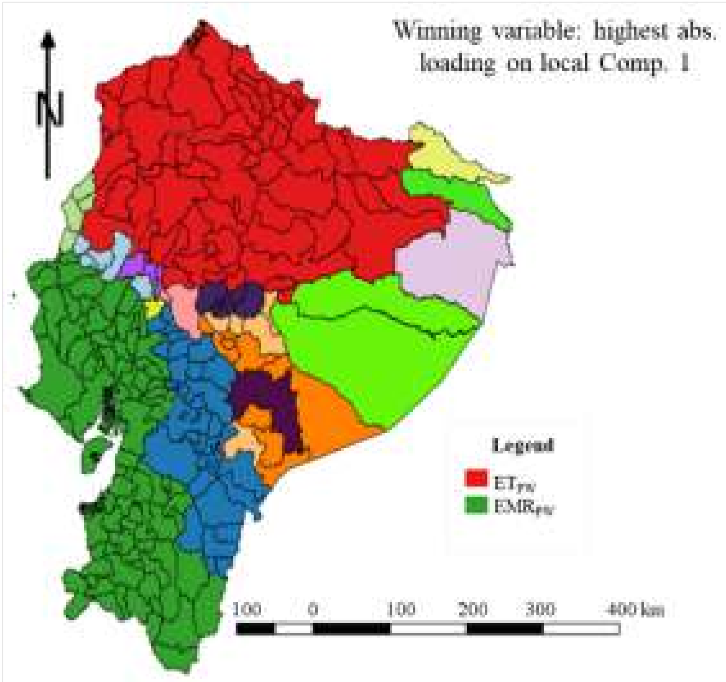


Figure 4: Winning variable on local component 1.

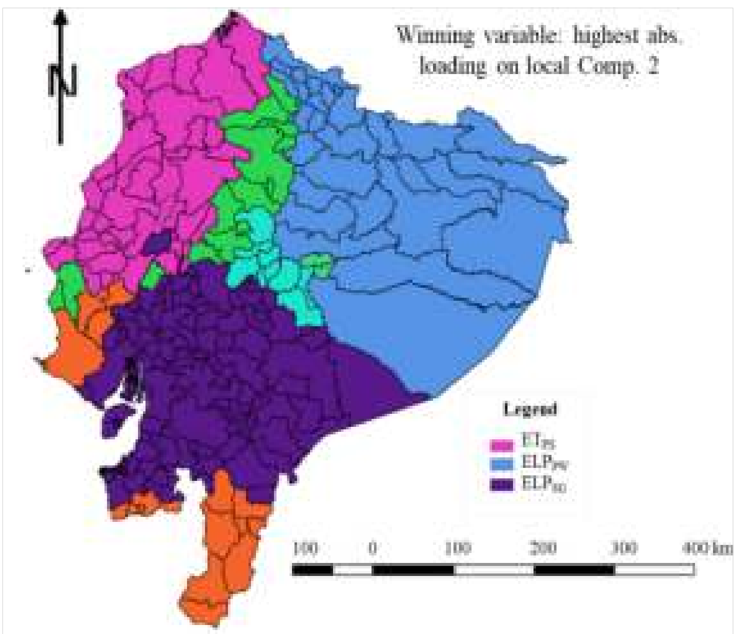


Figure 5: Winning variable on local component 2.

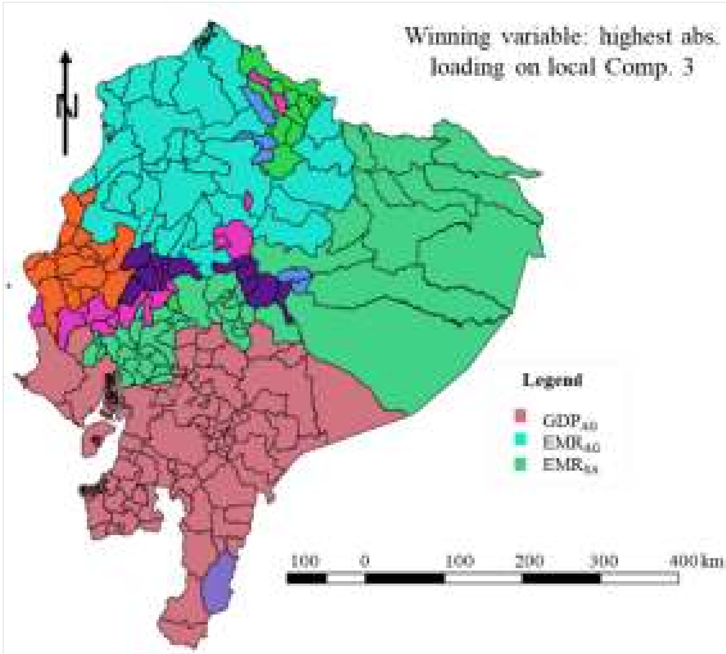


Figure 6: Winning variable on local component 3.

5 CONCLUSIONS

Concluding remarks:

1. In the bibliographic review, we found that similar investigations usually study large geographic units (for example countries, regions or provinces). This investigation at a smaller geographical level (cantons) provides more detailed results that facilitate the implementation of local improvement and development strategies in the country.
2. In this study we used the GWPCA, to account for a certain spatial heterogeneity of the database, and we found an optimal bandwidth using the Kernel Bi-square function.
3. The percentage of variance explained, using the GWPCA, for the first three local components exceeds the percentage of variance explained for the first three components in the standard PCA (73.66%), in some cantons of Ecuador. The higher percentages of variance explained (90%–95%) are located in the south-west (coastal region) and a small part of the northeast (Amazon region).
4. One of the advantages of using the GWPCA is to be able to visualize and interpret the factors that influence the analysis of sustainable development, focusing on how data dimensionality varies spatially, thus obtaining, a greater degree of detail and precision that can be used to support local decision making.

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SECTION 4
ARCHITECTURAL ISSUES

PASSIVE STRATEGIES FOR ENERGY-EFFICIENT BUILDING ENVELOPES FOR HOUSING DEVELOPMENTS IN HOT ARID CLIMATES

KARMINA D. REYES-BARAJAS, RAMONA A. ROMERO-MORENO, CRISTINA SOTELO-SALAS, ANÍBAL LUNA-LEÓN & GONZALO BOJÓRQUEZ-MORALES
Facultad de Arquitectura y Diseño, Universidad Autónoma de Baja California, México

ABSTRACT
Buildings and the construction sector are responsible for 36% of the final energy use as well as 39% of carbon emissions, while the residential sector accounted for 22% of total energy consumption and 17% of carbon emissions. Therefore, housing requires measures which reduce energy consumption and carbon emissions without affecting the living conditions of its occupants. In Mexico, the most commonly used construction systems in mass housing are concrete block walls and concrete slabs, these systems adversely affect comfort conditions and increase energy consumption especially in regions with a hot arid climate, such as Mexicali, in Mexico's northwest region. The objective is to determine the thermal behavior and energy performance of three environmental adaptation strategies applied in the building envelope: thermal insulation, thermal mass, and air cavity walls. A commercial prototype of mass housing was considered as a benchmark case, with concrete block walls and a concrete beam and expanded polystyrene composite roof. The building energy simulation was carried out with the Design Builder® software for the summer period, where building performance was evaluated with passive design strategies (simulation scenarios include variations in thickness and position of materials that make up the layers in the building components) against a benchmark case (without strategies), the corresponding thermal transmittance values (U-value) were also estimated. The results show differences in surface temperature, cooling demand and operative temperature inside the house; energy-saving potential is shown, which contributes to carbon emissions reduction and thus aids in climate change mitigation.
Keywords: passive strategies, energy efficient housing, mass-built houses, hot arid climate, demand of cooling and thermal comfort.

1 INTRODUCTION

Globally, buildings and the construction sector are responsible for 36% of global energy end use and 30% of carbon emissions [1]. While in Mexico the national total energy consumption, at the residential level, accounts for 17.1% [2], that is, more than half of global energy consumption.

These registered percentages are influenced by various factors, such as the climatic region and user's needs, that is, the type of lighting required in the home, the food preparation methods, the heating and cooling systems used to obtain a comfortable indoor climate, among other factors. Mexico's hot arid region (in the states of Baja California, Chihuahua, Coahuila, Nuevo León, Sonora, Sinaloa and Durango) is where high energy consumption is registered, due in large part to the aforementioned factors, however another influencing factor is the lack of use of insulation in the home, INEGI [3] shows that only 22.5% of the homes in this climatic region have wall insulation, while 89.6% of the homes have roof insulation. Cruz [4] states that even economic income, cultural customs, age of the inhabitants, as well as the amount and activity that each member of the family carries out have an effect on the generation of carbon emissions, and therefore, in the total energy consumption in the home.

Accordingly, one of the strategies to reduce high energy consumption and elevated temperatures inside the home is to minimize conductive heat flow, since it is the most

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appropriate measure if there is a significant difference in temperatures between the interior and exterior of the building, as indicated by La Roche [5]. He establishes that there are various techniques within this strategy, among them is thermal insulation and the inclusion of an air space or air cavity, both techniques are applicable to walls, roofs, and floors.

Authors like Barbosa and Ip [6] and Sotelo-Salas et al. [7], show that the technique of ventilated façades in hot arid climates have a considerable thermal impact on the interior environment of a building due to the natural ventilation that takes place in the air cavity, which flows through the building envelope and generates an adequate indoor air quality providing a comfortable thermal environment for the users [8], this translates to a reduced cooling load and energy demand. The depth of the air cavity can vary depending on the design and the thermal performance required.

Furthermore, as previously mentioned, a technique with considerable impact for heat gain reduction is insulation, since the appropriate thermal insulation in the building envelope in extreme climates allows significant savings in energy consumption, as stated by Friess and Rakhshan [9], they report up to 20% in energy savings and 55% in cooling demand in a desert climate. However, despite the fact that the hot arid climatic region has the highest percentage of some type of insulation implementation throughout the country, it also documents that 85.1% of homes do not have thermal insulation [3]. Another important aspect to consider is the low conductivity and high thermal resistance of the material to be used in the envelope, since heat flow is directly proportional to thermal conductivity, if a building material has 50% less conductivity than another, this reduces 50% of the heat flux in the envelope [5].

Considering the factors that influence elevated energy consumption, the climatic conditions of the city of Mexicali, which has registered maximum temperatures of 45°C and up to 54°C historically [10], and the lack of thermal efficiency in low income dwellings, this research focused on providing solutions for this widespread problem, through the study of thermal behaviour and energy performance of an existing housing prototype to determine its deficiencies, and subsequently, propose cooling strategies through an array of passive design measures applied directly to the building envelope.

Therefore, this research was carried out based on the parameters established in the Mexican standards for energy efficiency, while the evaluation of these climatic adaptation techniques were carried out with the Design Builder building energy simulation (BES) software, in which the climatic data of the city were entered, as well as the selected benchmark case and, subsequently, the cases were analyzed with the application of the various techniques, from which favorable results were obtained in the reduction of energy consumption and increase in thermal comfort.

2 METHODS

The research carried out is quantitative in nature since building energy simulations were conducted to evaluate the energy performance of the benchmark case as well as the performance of the applied bioclimatic adaptation techniques.

2.1 Study cases

A benchmark case (BC) was established from the existing housing prototype and its default envelope building materials, case studies were modified with the previously described climatic adaptation techniques.

2.1.1 Benchmark case

For the selection of the benchmark prototype, low income mass housing in Mexicali were identified. The selected prototype has 41.24 m^2 of construction area in a 120.05 m^2 lot. The main façade is south facing, the dwelling has two bedrooms, one bathroom, a living/dining room area and a kitchen (Fig. 1).

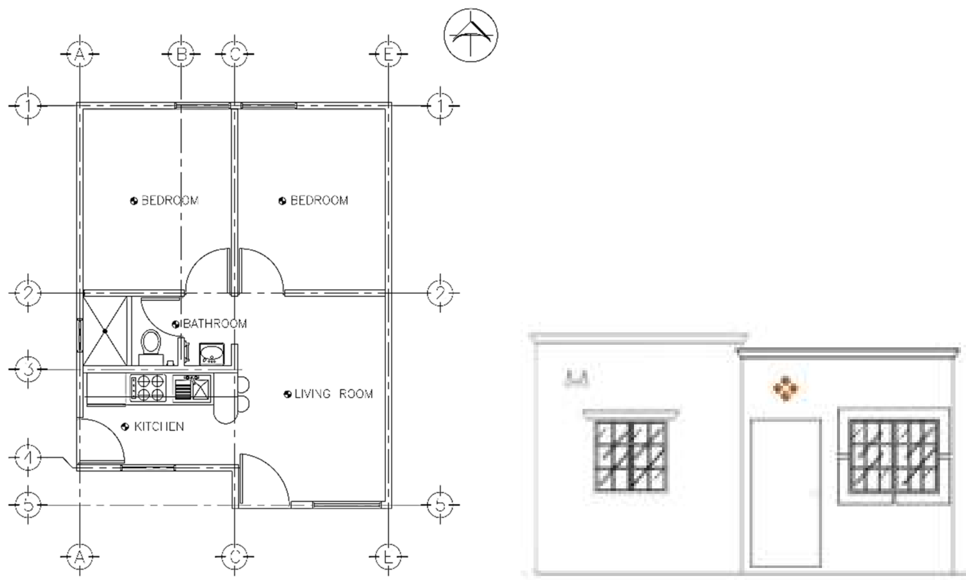

Figure 1: Benchmark case (BC). *(Source: Authors, from the housing prototype plans, 2011.)*

The constructive system of the benchmark case is predominant in the affordable housing market, it consists of concrete masonry unit blocks (CMU) of 0.12 m x 0.2 m x 0.4 m with hollow cores, cores are cast every 0.61 m with concrete f'c = 140 kg/cm^2. The roof is made of a composite concrete joist and vault which is 0.17 m thick, the concrete is f'c = 200 kg/cm^2 and with reinforcing steel bars (Ø0.0071 m); covered with fiberglass reinforcement mesh and two layers of plaster, finished with elastomeric paint. Table 1 shows the layout of the benchmark case and its south facing façade.

Table 1: Surface areas of the benchmark case envelope. *(Source: Authors, from the housing prototype construction plans, 2020.)*

Orientation	Surface area (m^2)			
	Walls	Windows	Doors	Total
North	15.47	2.20	–	17.67
South	14.02	2.38	1.85	18.25
East	22.04	N/A	–	22.04
West	20.25	0.37	1.78	22.40
Total	72.15	4.95	3.63	80.73
Roof				41.24

2.1.2 Modified benchmark case

The benchmark case was modified with the application of thermal insulation techniques (A) and the air cavity technique on the opaque ventilated façade (B), with thickness variations (Table 2). The evaluated cases in technique A were simulated with 0.0254 m (1”) of expanded polystyrene, while in technique B, in addition to the different thickness in the air cavity for the construction system of the ventilated façade, the inner wall is a plasterboard wall with a steel frame structure of 0.0762 m (3”) rectangular steel tube at every 0.6 m (vertically and horizontally), the interior face is a 0.0127 m plasterboard, the hollow interior of the wall is filled with fiberglass, the outside face is 0.0127 m fiber-cement board and grills were proposed to allow natural ventilation in the air cavity. Finally, technique C was simulated with the combination of techniques A and B.

Table 2: Case studies modified with passive design techniques. *(Source: Authors, 2020.)*

Name	Description
BC	Benchmark case
A	Benchmark case with expanded polystyrene insulation
A1	Benchmark case with 0.0254 insulation in south façade
A2	Benchmark case with 0.0254 insulation in west façade
A3	Benchmark case with 0.0254 insulation in north façade
A4	Benchmark case with 0.0254 insulation in east façade
B	Benchmark case with air cavity
B1	Benchmark case with 0.1 m air cavity
B2	Benchmark case with 0.15 m air cavity
B3	Benchmark case with 0.2 m air cavity
B4	Benchmark case with 0.25 m air cavity
B5	Benchmark case with 0.3 m air cavity
B6	Benchmark case with 0.35 m air cavity
C	Benchmark case with combined A and B
C1	Benchmark case with A1 and B6
C2	Benchmark case with A4 and B6

Table 3 shows the thermal transmittance values (U value) of the construction systems evaluated in the different case studies.

Table 3: Thermal transmittance of constructive systems. *(Source: Authors, from data obtained in Design Builder®, 2020.)*

	Constructive system	Valor “U” (W/m^2 °C)[1]
BC	Concrete masonry unit blocks, cast cores, 0.12 m	2.932
	Concrete joist and beam roof 0.17 m	0.860
A	Concrete masonry unit blocks, cast cores, 0.12 m with a layer of expanded polystyrene 0.0254 m (1”)	0.988
B	Fiber cement board wall 0.12 m, with fiberglass insulation	0.439

[1]U value obtained from Design Builder®.

For the simulated scenarios, in addition to the envelope constructive systems, the internal loads of the house were considered, such as the electrical appliances (televisions, refrigerator, coffee maker, microwave, chargers, laptop, gas burner, internet modem, hair dryer), air conditioning (HVAC), lighting (six bulbs) and the activities and of four users.

2.2 Building energy simulation setup

To achieve these results, as already mentioned, the Design Builder® version 5.4.0.021 software was used. The city of Mexicali is located at 32° 39' 54" N latitude, 115° 27' 21" W longitude and 4 m above sea level [10]. The weather file from the California climate zone CZ15RV2 was used, as well as the specifications of the construction systems that were used in the simulation scenarios, the benchmark case was also modeled with its corresponding thermal zones.

Simulations were evaluated in the summer period (May to October), this period is introduced in the simulation program, considering the effect of the internal loads mentioned above. Certain simulations were evaluated with natural ventilation, in order to show the impact that each technique had on comfort conditions inside the dwelling, and others were carried out considering air conditioning use.

Technique A was evaluated in each of the basic cardinal orientations while technique B was only evaluated in the critical orientation (obtained from the scenarios in technique A), and finally, technique C was analyzed by combining the critical orientation in the technique A and the most favorable scenario in technique B, in order to achieve a comparison of the three techniques to visualize the best option in energy savings and comfort conditions in the dwelling.

Therefore, the evaluation will obtain results of energy performance and comfort conditions based con cooling load (sensitive zone cooling), heat gains per wall surface area (kWh/m^2) and comfort based on the predicted mean vote (PMV) model. For the analysis of the data, especially those of thermal comfort, the data obtained by the BES software had to be entered into a spreadsheet [11], in order to present data on the scale established by the PMV model in the ISO 7730 standard [12] (Fig. 2).

COMFORT SCALE ISO-7730	
< -3	Very cold
-3 a -2	Cold
-2 a -1	Slightly cold
-1 a -0.5	Comfortable cold
-0.5 a 0.5	Comfort
0.5 - 1	Comfortable warm
1 a 2	Slightly warm
2 a 3	Hot
> 3	Very hot

Figure 2: Comfort scale. *(Source: Luna from ISO-7730, 2019.)*

3 RESULTS

The energy consumption results of each case study are presented, as well as the required cooling load and the thermal comfort performance.

3.1 Energy performance

The results of heat gains were presented only in walls, this because, as shown in Table 1, the walls represent more surface area than any other envelope component. Table 4 shows the results obtained in kWh from the simulations of technique A, there it can be observed that in the BC total gain through walls was close to 10,000 kWh and in addition, the critical case is A1, that is, if the insulation is implemented in this orientation it results in the minimum heat gain reduction compared to the other case studies.

Table 4: Results of the case studies in the summer period. *(Source: Authors, 2020.)*

Case study	Heat gains through wall (kWh)	m^2	Heat gains through wall (m^2)
BC	9,988.56	72.15	–
A1	8,716.27	14.02	621.52
A2	7,889.90	20.25	389.57
A3	8,908.25	15.47	575.84
A4	7,444.92	22.04	332.30

Table 5 shows the energy to be removed or sensible cooling of the thermal zone considering the external and internal loads of the benchmark case.

Table 5: Cooling load for selected case studies. *(Source: Authors, 2020.)*

Name	Cooling loads (kWh)
BC	–17,337.63
A1	–16,113.77
A2	–15,339.30
A3	–16,285.66
A4	–14,870.49

Table 6 shows the results that were obtained, both for heat gains and cooling loads, for technique B. It is observed that in heat gains per wall, with respect to BC, case B6 showed a slightly over than 2,000 kWh reduction, this was considered the best case scenario, while the B1 case showed the lowest energy reduction with 1,962 kWh. While the best case for cooling load reduction was B1 and the worst (or critical) case was B6. However when comparing the BC with the most favorable case, the difference is not as significant since only 1,330.53 kWh were saved.

Table 6: Results of case studies in the summer period. *(Source: Authors, 2020.)*

Name	Heat gains through wall (kWh)	Cooling loads (kWh)
B1	8,025.68	–16,007.1
B2	8,0001.74	–16,411.7
B3	7,977.8	–16,480.3
B4	7,956.3	–16,483.8
B5	7,934.36	–16,496.1
B6	7,911.76	–16,502.7

Table 7 shows the results of the evaluating technique C, it is shown that based on the results of BC with technique C2 it reduces more than 4,000 kWh of heat gains per wall, and 3,322 kWh less than the BC of cooling loads.

Table 7: Results of case studies in the summer period. *(Source: Authors, 2020.)*

Name	Heat gains through wall (kWh)	Cooling loads (kWh)
BC	9,988.56	–17,337.63
C1	7,927.10	–16,542.26
C2	5,371.79	–14,005.41

In Fig. 3 each evaluated technique is compared, and it is observed that the best option to reduce energy consumption in the dwelling is C2. Finally, Fig. 4 shows the results of heat gains per wall that were obtained from the evaluated case studies.

3.2 Thermal comfort performance

The evaluation of the benchmark case showed that the dwelling maintains 100% of the summer period in comfort conditions, this considering that most Mexicali dwellings keep air conditioning systems constantly activated (Table 8). However if only the use of natural ventilation is considered, this condition was implemented to better illustrate the effect of each technique, a 17.8% of hours in thermal comfort is obtained for the summer period for the BC. Technique A shows A2 and A4 as best cases with 23.4% of hours in thermal comfort, as shown in Table 9.

Table 10 shows the results of technique B, where the best case was B6 with 30.2% hours in thermal comfort, so it was concluded that technique B performs better than technique A because it provides more hours in thermal comfort.

Figure 3: Performance of technique C case studies. *(Source: Authors, 2020.)*

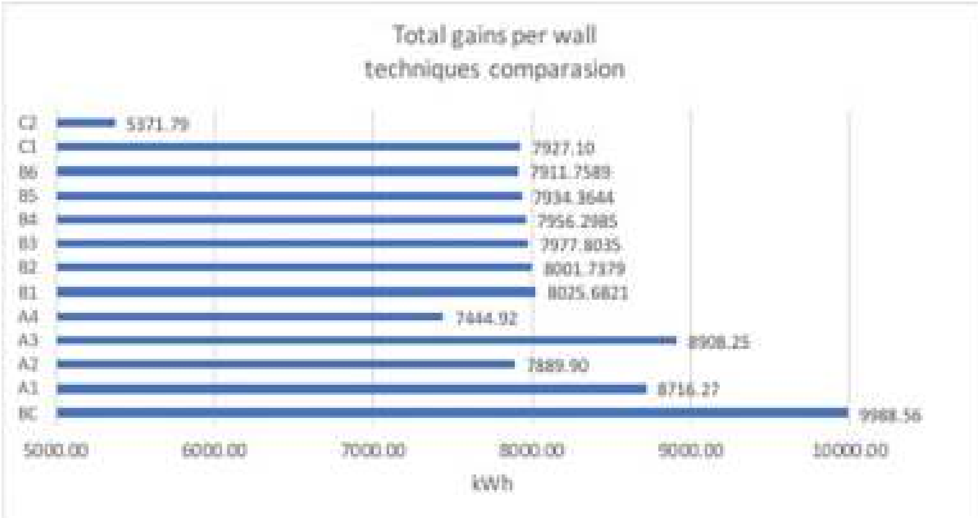

Figure 4: Energy performance of case studies. *(Source: Authors, 2020.)*

Table 8: BC thermal comfort. *(Source: Authors, 2020.)*

Case studies	Thermal comfort hours in summer	Thermal comfort (%)
BC with HVAC	4399	100
BC with natural ventilation	269	17.8

Table 9: Thermal comfort results of case studies. *(Source: Authors, 2020.)*

Name	Thermal comfort hours in summer	Thermal comfort (%)
BC	269	17.8
A1	360	22.5
A2	385	23.4
A3	358	22.3
A4	394	23.4

Table 10: Thermal comfort results of case studies. *(Source: Authors, 2020.)*

Name	Thermal comfort hours in summer	Thermal comfort (%)
B1	368	23.3
B2	350	22.6
B3	556	29.6
B4	565	29.9
B5	563	30
B6	575	30.2

Lastly, the results of technique C are shown in Table 11, these are the best options of all the techniques evaluated, with 30.5 to 31.4% of thermal comfort obtained for the summer period (Fig. 5).

Table 11: Thermal comfort results of case studies. *(Source: Authors, 2020).*

Name	Thermal comfort hours in summer	Thermal comfort (%)
BC	269	17.8
C1	572	30.5
C2	574	31.4

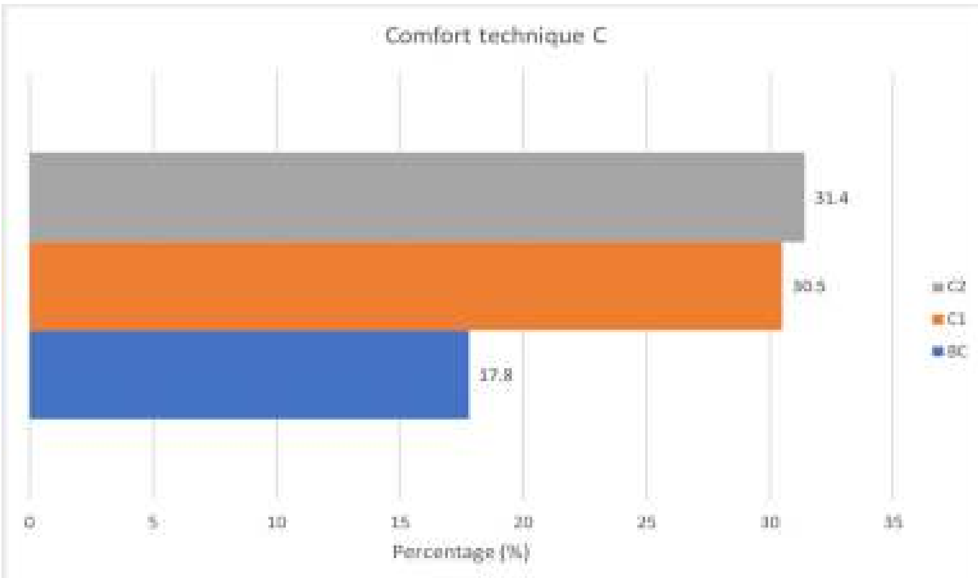

Figure 5: Thermal comfort of technique C case studies. *(Source: Authors, 2020.)*

Therefore, it was determined that to obtain greater thermal comfort conditions, the best option is to use technique A, since it provides higher percentages of comfort for the summer period (Fig. 6).

4 CONCLUSIONS

In the results presented, it is observed that the implementation of any of the evaluated techniques in the dwelling results in favorable performance, both in thermal comfort and for energy consumption reduction, however not all the passive design measures present significant differences with respect to the benchmark case, that is, in some cases there are minimum savings of just over 1,000 kWh in energy consumption and a difference of only 4.5% in thermal comfort in the worst-case scenario. The other case studies had similar results, that is, only in one of the output variables (cooling loads, wall gains or thermal comfort) had better results than in the other ones.

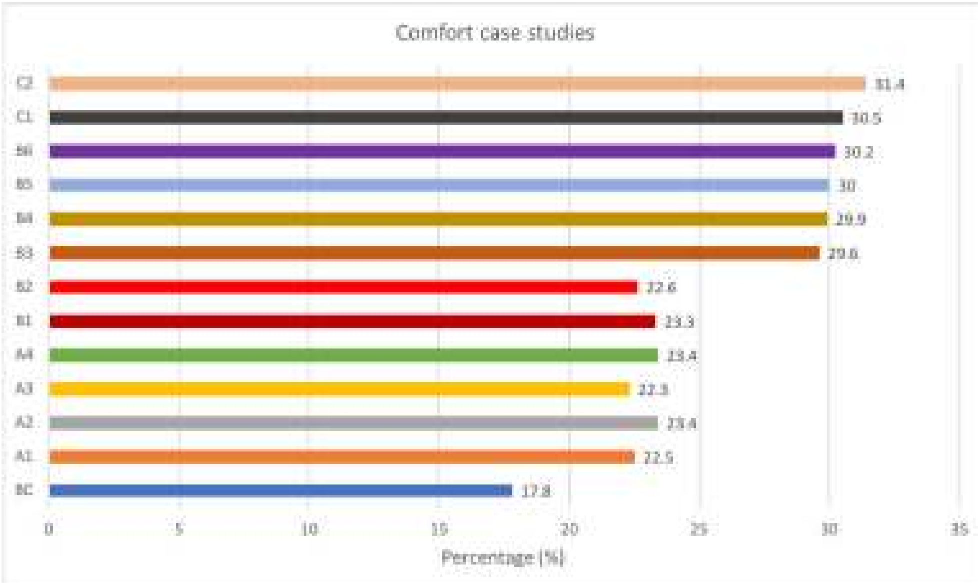

Figure 6: Thermal comfort performance in case studies. *(Source: Authors, 2020.)*

Such is the case of evaluations carried out with technique B, they all represent a minimum difference in gains per wall only between 1,900 and 2,055 kWh, in cooling loads just with 800 to 1,330 kWh and in thermal comfort the differences are 4.3% to 12% more comfort than in the benchmark case. Another favorable case was the A2, with more than 2,000 kWh less than in the benchmark case but only in cooling loads, however, in terms of thermal comfort is one of the least favorable cases.

Therefore, it was determined that the best option is to implement the C2 technique, because this case study presents better conditions in both thermal comfort and energy consumption, it is the combination of the air cavity with a thickness of 0.35 m and the thermal insulation applied to the east-facing wall, since this case reduced more than 4,000 kWh compared to the BC in wall heat gains and just over 3,000 kWh in the cooling load. It is also the best case to promote comfortable indoor conditions for the dwelling, as 31.4% of thermal comfort was achieved in the summer period with natural ventilation, that is, 13.6% more than in the BC. This clearly demonstrates that the implementation of bioclimatic adaptation techniques such as thermal insulation and opaque ventilated façades have a favorable impact in hot arid climates.

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IDENTIFYING THE EVOLUTION OF CITIES' ARCHITECTURAL CHARACTERS IN CONNECTION TO GLOBAL EVENTS OVER TIME

YOMNA YASSER FAHMY, DINA MAMDOUH NASSAR & ZEYAD TAREK ELSAYAD
Architectural Engineering Department, Faculty of Engineering, Alexandria University, Egypt

ABSTRACT

In the past decade, many of the world's aspects were subjected to a great change caused by many events that took place in various countries and yet affected almost the whole world, which is now explained by the term "globalization". That recent picture of the world is a result of many accumulated changes that had happened over a long period of time, which of course had an influence on people's lives. Architecture was deeply influenced by these changes as it represented them in its concepts and designs through consecutive eras as a witness to the different events that took place. However, sometimes the architectural changes were slight, but other times the changes were deeper which indicates how people's lives were affected back then, which eventually affected the architectural characters of many cities across the globe. This research connects the cycles of globalization with the architectural evolution and the changes in local architectural identities over time to detect the severity of the impact of globalization on the architectural products. Therefore, the study focuses on two main points: the impact of globalization forces on architecture, and the evolution of the architectural identity features in three cities with deep rooted history, which are Paris, Moscow and Cairo. The study analyzes architectural products from subsequent years, which were subjected to many world-changing global events in order to track the change and to detect the era in which architecture lost most of its unique identity in these cities. Eventually it was clear that the last phase of architectural development – which extends to the present time – had the most brutal impact on people, due to the openness that led to globalize cultures and standardize norms. Architects focused on the building's functions rather than the local identity, which eventually resulted in making the replicas of buildings around the world without a unique character for each place.

Keywords: architectural identity, architectural character, globalization, globalization forces.

1 INTRODUCTION

Over the course of history, architecture played an important role in manifesting the identities of cities; as each era had its unique architecture that represents the culture and ideologies of people, as well as their values and traditions. Moreover, architecture isn't only a witness of past risen and fallen civilizations, but also an evidence of their existence for the upcoming generations to analyze and learn from. In fact, any architectural identity of any place was formed over a long period of time by adding each generation's imprint of their evolved thoughts and ideas to the old inherited identity features of their ancestors, leading it to cope with their present culture and beliefs, which allowed architecture to gain its continuity over time.

The world has encountered many challenges through of history that changed many of its norms due to the openness and connections between distant countries that have grown stronger every day more that the day before. That openness and ability to connect countries politically, economically and even culturally was later referred to by the term "globalization" which had touched nearly every aspect of peoples' lives over time and forced other terms to appear in order to explain the changes happening in many fields. For instance, the term "global culture" describes the resemblance in people's ideas and preferences around the

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world which is caused by what is called "globalization forces" which were defined as the main dimensions of globalization. These dimensions are political, economic and cultural.

These changes affected people's lives and were manifested in their lifestyles and their architecture as a result. Therefore, the current features of architecture are a result of many phases of development. In the past, architecture represented the identity of the place it was located in, which allows the viewer to speculate the characteristics of the place through its architectural features. For instance, some design principles are used to match the culture of users, also, the building materials and façade and roof designs represent the climatic and geographical status of the place, which integrates the building in its environment and creates a bond between it and its users. The changes in architectural principles and values caused by globalization forces were sometimes viewed as an opportunity to thrive and other times as a way to obliterate the local character and identity. However, as many cities were subjected to these changes, each city evolved differently according to the level of technological development that reached it, while some cities maintained parts of their identity in the process. The research analyzes architectural identities of three megacities from different geographical locations; which are, Moscow, Paris and Cairo to track the levels of change over the cycles of globalization. As, Moscow and Paris were mostly in the center of global events, their architecture was more influenced and rapidly developing. On the other hand, Cairo as a third world city has encountered delay in technological development. That made its architecture change slowly while maintaining parts of its identity along the way.

2 ARCHITECTURAL CHARACTERISTICS DEFINING A CITY'S IDENTITY

A city's identity is produced from the characteristics of its societies, which represent the local culture of its inhabitants as well as the natural features of the city. Each era that passes by adds to the historical background of the city, which eventually contributes in shaping the city's unique identity. The city's built environment with its streets, squares and buildings represent the interaction between people and their surroundings, therefore, any change in the fabric of that built environment indicates a change in people's lives or even causes that change. However, if architecture is considered as a mirror to the social, political and economic status of the society, then analyzing architecture of anytime can help in understanding these circumstances of the time it was established in [1].

Despite that architecture has two main aspects; form and function, however, whenever people view any architectural product, the first thing that catches their attention is its form and visual details, which gains their approval or rejection. Therefore, visual perception is an essential aspect of architectural criticism, as people judge a building's form, materials and colors before getting to experience its function [2]. [2] According to Lynch, the environmental image consists of three main elements which are identity, structure and meaning and they always appear together. Image identity can be recognized if the object has distinctive elements that distinguish it among other objects, the structure represents connections between the objects, and structure must have a sentimental value and emotional meaning to the viewer [3].

3 THE IMPACT OF GLOBALIZATION ON SOCIETIES

The term "Globalization" was shaped in the second half of the 20th century. It was defined as the interaction between social relations linking distant societies together; that a local happening might occur as a result to an event in another society located miles away [4]. By time, globalization forces and their dominance over the world participated in creating a common global culture, similar identities and life styles and created a global network between near and distant societies. The rapid technological development kept spreading in

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the entire world making people stray away from their localized ideologies and consider them as old ideas that need changing, which undermined the old devotion of place and society. The transmission of ideas and values around the world extended social relations and created what is called "cultural globalization", which involves the formation of shared cultural identities represented in shared norms, and knowledge, which caused deep interactions between different cultures [5].

As a result to these changes caused by globalization, many societies got wealthy and developed after decades of poverty and ignorance. On the other hand, some societies were copying the cultures of developed ones and their architecture as well, which eventually caused their local identity to get lost in the process and them being left with a replica of a foreign identity they know nothing about but its superficial image. Architecture – as a witness to these events – kept representing these changes in people's culture and lifestyle through time till it reached its current status. However, many third world cities, especially the ones that have experienced rapid growth and development in the past two decades, were deeply affected by the contradicting forces of globalization and localization, therefore, they created a "co-existence" model which embraces the characteristics of modernization without neglecting the traditional features of the society. That model was essential to maintain their identity when globalization forces were affecting every aspect of people's lives which led them to a serious case of "identity loss" [6].

4 CLASSIFYING THE GLOBALIZATION CYCLES

The last global era is only a manifestation of the enormous global interaction that has been building up since the beginning of humanity. Each period of globalization had its own distinctive characteristics that surely affected the eras that came after. That's how the latest stage of globalization was formed, by developing global forces over a long period of time [1].

Researchers have divided the history of globalization into cycles, as many waves of change have hit the world over time. However, some researches divided them into five cycles, as the age of exploration in the 15th and 16th centuries wasn't counted as a cycle, but more of a preparation era, which starts it in the 19th century with Globalization 1.0 that ends by 1914, Globalization 2.0 begins in 1945 and lasts till 1989, Globalization 3.0 begins in 1989 and ends in 2008, and lastly Globalization 4.0 starts in 2008 and is still ongoing [7].

Thomas L. Friedman divided globalization history into three periods; Globalization 1.0 (1492–1800) which brought countries closer to each other by the trade routes, Globalization 2.0 (1800–2000) in which companies where affected the most, collaborations and trade between them were facilitated, and Globalization 3.0 (2000–present) which affected people's culture and lifestyle. As the world operates with people and for people, that last cycle had the most influences on the overall changes taking place around them [8].

Architecture was indeed affected by the globalization forces, as its features were changed as a response to the historical events, and to the social, economic, and technological developments. Therefore, the architectural cycles of change parallel to those of globalization, as they would represent the architectural analogy of the world's development. That architectural development would be divided into five cycles marking the main turning points in the history of architecture which helped in forming what is now called "contemporary architecture". The industrial revolution was one of the main turning points in the history of architecture, therefore, it marks the first substantial change in the architectural product. The time between 1918 and 1945 witnessed the two world wars which caused lots of destruction to the world followed by the need to rebuild and reconstruct. Also, the oil discovery in the Arabian Gulf area affected the entire world and had a great impact on architecture. And lastly the new technological developments of the 21st century contributed in introducing new design tools to architects which appeared in their designs.

To sum it up, the global architectural development cycles would be: (I) pre-industrial revolution (before 1840); (II) Post industrial revolution (1840–1914); (III) post world wars (1945–1970); (IV) post oil discovery in Arabian Gulf (1960–2000); and (V) from 2000 to present.

5 THE GLOBAL-ARCHITECTURAL CYCLES OF CHANGE

As architecture is deeply connected to the human life and is constantly representing the developing needs of the society, it has been essential for it to react to the ongoing changes in the world that are caused by the globalization forces. Many architectural similarities can be noticed between cities from east to west, in their old and new architecture. These similarities were caused by the trending architectural styles of each time that have been embraced by many architects in different spots of the world. By the early 20th century, architects started to develop their design techniques in order to cope with the developing technologies, industries, as well as social and political statuses, Therefore, the "international style" was born. However, about a century later, architecture was pressured to globalize, as architects were interested in studying other architects' works in various places in the world. The technological development allowed them to analyze their work in high quality pictures in magazines and journals, which gave them the opportunity to scan the world's architecture and share design concepts and try to imitate them with their different materials, such as, glass, aluminum, titanium. Whenever these materials weren't available in the place of construction, they were imported in order to complete the whole picture of the façade. Which explains how the globalization forces facilitated the appearance of glassy-metal facades in many cities around the world [9].

Many modern architects and planners in the past decades have neglected the human needs in the process of designing cities. They focused on making unique individual buildings rather than creating a complete balanced built environment with well-designed urban spaces. However, since the millennium, many people migrated from rural areas to the cities, which caused cities to grow bigger in size and will continue that growth for the upcoming years as well. In the 1900s only 10% of the world population lived in cities, while by the year 2007 that percentage increased to reach about 50% and experts expect it to keep increasing till it reaches 75% by the year 2050. That growth calls for these cities to make serious decisions regarding their planning options in order to focus on people's needs [10].

The global adoption of a universal style of architecture may have caused the architectural identities of many cities to be blurred or neglected in favor of creating remarkable buildings. However, the changes seen in building facades in present time are the product of a long time interaction with many globalization forces in many aspects of people's lives, which eventually reflected on their architecture. That change should have had a connection to the cultural background of people in different distant megacities such as, Moscow, Paris and Cairo. But, on the contrary, many similarities where spotted in the architectural products despite of the clear differences in culture and history of these Counties.

5.1 1st cycle: Pre-industrial revolution

When the Europeans discovered the Americas and Australia in the 15th century, knowledge was expanded across the globe, which is the initial simplified concept of globalization. That discovery had a great impact on the world's economic and political statuses, as these lands were dominated by the colonizers' culture and architecture and cross oceanic trade routes were created, which helped in transferring architectural trends and ideas from west to east [1]. Europe witnessed the rise of many architectural styles as a response to the changes in the economic, political and cultural aspects of that time. These styles eventually spread to various countries years after their emergence in their home countries. The early Romanesque, was followed by gothic, renaissance, baroque and rococo architecture between the years 1000 and 1800. Classicism in architecture emerged between the years 1750 and 1800 as well. These styles were presented by their clear features and concepts in the European architecture of that time, and they have also travelled to other foreign cultures dominated by European colonizers. Eventually many trends faded away and other movements rose to revive them. By that time Russia was reconstructing many of its buildings after the fire of 1812 that destroyed most of the wooden buildings of Moscow. Many of the Russian buildings were designed with the eclectic style, and some used the neo-classicism [11]. In the three chosen megacities, neo-classicism was used in the Bolshoi Theatre in Moscow (Fig. 1) and in Saint Vincent de Paul church in Paris (Fig. 2), where the resemblance in the façade appears in the colonnade and ornamentation. While Egypt at that time was under the dominance of the Ottoman Empire which influenced its architecture and focused on constructing mosques with multiples domes and vaults as well as schools, such as, Mohamed Ali's grand mosque [12] (Fig. 3).

Figure 1: The Bolshoi Theatre 1825 (Moscow, Russia) [17] [17].

Figure 2: Saint Vincent de Paul 1824 (Paris, France) [17][17].

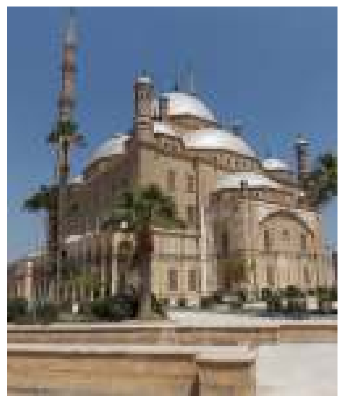

Figure 3: Mohamed Ali Mosque 1830 (Cairo, Egypt) [17][17].

5.2 2nd cycle: 1840–1914 (post-industrial revolution)

New manufacturing processes and techniques were introduced to the world after the industrial revolution, which led to using more machines than manpower in the manufacturing process, as well as using new materials like iron and chemicals and harnessing the power of water and steam in the production sector [13]. As a result to the development of new technologies, Architects starting using new materials such as iron and cement in architectural designs as structural materials and decorative elements as well.

In Paris, the Grand Palais (Fig. 4) was constructed using both steel framing structures and reinforced concrete with a glass vault providing natural lighting inside the building. However, in order to maintain the architectural identity of the building, the façade was designed following the beaux-arts style using stone and marble and decorating with French ornamentations. On the other hand, Moscow at that time wasn't influenced by the changes in the world until the collapse of the Soviet Union, so the architectural identity was bold in buildings. For example, the state historical museum in Moscow (Fig. 5) was designed based on a Russian version of the baroque style where it represented the identity with its red brick façade, towers, and arched small windows.

By that time, Egypt's architecture was changed by the British colonizers. However, Cairo as a cosmopolitan city has managed to keep some features of its identity despite of the change forced on its architecture. In 1869, the Egyptian khedive ordered to build Omar ElKhayam Palace (Fig. 6) to host guests during the opening of Suez Canal. The Palace was constructed using steel frames and reinforced concrete with interior artifacts imported from Paris and Germany. However, the Islamic identity appeared in the façade where ornamentation with Islamic patterns and arches where used (Fig. 7).

Figure 4: Grand Palais, Paris 1897–1900 [17].

Figure 5: State historical Museum 1872 [17].

Figure 6: Omar ElKhayam Palace, Cairo 1869 [15].

Figure 7: A detail in Omar ElKhayam palace showing the Islamic patterns and arches [16].

5.3 3rd cycle: After the World Wars (1945–1970)

The main highlight of this cycle was the vast spreading of technology and the huge development it has achieved that facilitated the transaction of knowledge, ideas and communication between people in different continents. This cycle witnessed the birth of the term “modern architecture”. However, modernism spreading in the west was a result to the need of reconstructing the damaged cities after World War II. Later on, the trade routes facilitated by globalization forces made it easier for these concepts to travel fast across the globe, and for western architects to put their imprint in eastern societies with these new modern concepts [1].

The UNESCO Heritage Center in Paris (Fig. 8) built in 1958 is an example of how globalization affected architecture, as it’s a combined product of three architects with different nationalities; French, Hungarian and Italian, who represented modern architecture in the building’s unusual tripod form and the plain facades with rectangular openings. Modernity was also present in Moscow’s architecture by that time, as the collapsing of the Soviet Union connected Russia with the rest of the world and allowed new ideologies into people’s lives. The Russian White House (Fig. 9) was designed in 1965 with modern principles represented in the monochromatic facades that lack any kind of ornamentation with glass windows repetition.

Figure 8: Headquarters of the UNESCO, Paris 1958 [17].

Figure 9: Russian White House, Moscow 1965 [17].

Egyptian modern architecture of that time was a bit close to those of Paris and Moscow. In 1951, King Farouk ordered the demolition of the British army houses in Tahir square and to build a building complex in its location to serve the citizens known as “AlTahrir Complex building” (Fig. 10). The building’s design focused on the function over its aesthetics as its facades are plain with now ornamentations or decorations, instead, its facades are busy with an array of rectangular openings. However, its master plan was created in a shape of an arc facing the Tahrir square to match the building’s shape with the surrounding urban design.

5.4 4th Cycle: 1960–2000 (after oil discovery in Arabian Gulf)

Many Arab countries have encountered some changes in the political, economic and cultural fields by the second half of the 20th century because of many reasons, such as, political independence, population growth, and most importantly; the oil discovery in the Arabian Gulf area which affected the entire world’s economy. The rapid financial growth after the oil production caused a major resuscitation in the building industry, as many Arabian Gulf cities were designed from scratch and went under construction shortly after this sudden wealth [6].

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As technology developed, high tech building style emerged in the late 1960s using lightweight materials and sheer surfaces with application of new technologies in the building. The building of Russian Academy of Science in Moscow (Fig. 11) was one of the unique buildings at the time because of its postmodern design and its twenty two story towers. Modern technology was embedded in the building's design as it is operated by modern systems. People gave it the name "golden brains" because of the golden decoration on the roof that refracts and reflects light in cloudy days.

Figure 10: AlTahrir complex building, Cairo 1951 [17].

Figure 11: Russian Academy of Science, Moscow 1973–1990 [17].

In Paris, the Opera Bastille building (Fig. 12) was built in 1989 with modern sound and light technologies to host a huge amount of users. Modern building technologies helped in making a remarkable building using reinforced concrete, glass, aluminum and marble. The building occupies a huge space with its curved form and transparent glass façades and no ornamentations were used to decorate it.

By that time, Egypt was still in the modern architecture era, as it fell behind in receiving modern technologies due to the difficulties of being third world country. The "Al Ahram" Building (Fig. 13) was constructed in 1986 as a headquarters to Al Ahram institution. The building follows modern architecture principles in building and façade design and materials, as it was constructed with reinforced concrete with some horizontal concrete shaders and rectangular openings with a large glass entrance for the building.

5.5 5th cycle: 2000–present (the 21st century)

By the beginning of the 21st century, people started to stray further from their local roots, which they considered "outdated" and started to copy western concepts and ideas as they became the standard for modernity, which was in return represented in their built environment and specifically in their architectural products as their desire to have more modern buildings increased as well [9].

Architecture of that cycle was driven by the countries' need to compete with each other to build the most iconic and tall building, which eventually caused local identity to get lost in the process making the cities look alike [14].

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Figure 12: The Opéra Bastille 1989 [19].

Figure 13: The Al Ahram Building 1968 [20].

In 2005 the CBX Tower (Fig. 14), a 142 m tall tower was built in Paris as an iconic building with a façade covered entirely with glass with absolutely no sign of any French traditional architectural identity feature. Another example of iconic buildings is the Oko Tower in Moscow (Fig. 15) which were marked as one of the tallest buildings in the world in 2015. The tower is a residential building that includes a hotel. Its façade is made of glass from bottom to roof without pointing to the Russian identity in any way.

On the other hand, Egypt was trying to catch the race of high rise buildings but in a slower pace. In 2003, Nile City Towers (Fig. 16) were constructed on the bank of the Nile as high rise 34 story building with 142 m tall. Despite the height of the building that resembles the height of the CBX Tower in Paris, it didn't follow the international trend of covering towers' facades with glass. Instead, marble and paint were used beside in the façade to balance the ratio between solids and voids. The local identity was represented in the colonnade at the top of the façade and the little golden domes on top of the towers that connects the building to its ottoman Islamic architecture roots.

Figure 14: CBX Tower, 2005 142 m tall [17].

Figure 15: Oko Towers, Moscow [17].

Figure 16: Nile City Towers, Egypt [18].

6 CONCLUSION

The research demonstrated that the identities of cities are formed not only by its distinctive climatic and geographical features, but by its people's culture as well. Architecture has always manifested the culture people interacting with it, and that's what created the differences in architectural identities between cities around the world. However, the architectural changes through the course of history can be positively seen as an opportunity for development as long as it responds to people's needs of that time.

Globalization cycles were classified by researches according to the major events that took place in the world causing a great impact on the entire world. However, the research classified them in accordance to the events that had the biggest impact on architecture and changed its features and principles in the world. That classification divided globalization cycles into five cycles; before the industrial revolution, after the industrial revolution, after the world wars, after the oil discovery in the Arabian Gulf, and the architecture of the 21st century. The research demonstrated the architecture of each cycle as the world kept changing over time, ideas were shared easily and new architectural concepts easily travelled around the world. However, as the architectural phases of change went by, some architectural styles were forced on societies regardless of their local identities and traditions.

The research analyzed architectural products from 3 megacities from different geographical locations; which are Paris, Moscow and Cairo. Paris and Moscow held on to their local identities until the 3rd cycle of architectural globalization, but the need to reconstruct cities after the damage caused by world wars was an opportunity for architects to represent new styles in buildings. Therefore, the local identities of both cities was gradually lost and faded from their architectural products until eventually the last cycle had the most brutal impact on their architecture. As countries competed in producing the most iconic buildings, their architectural products became more alike in the last cycle of architectural globalization. Therefore, the CBX tower in Paris and Oko Tower in Moscow share lots of architectural design concepts and show no sign of any identity feature.

On the other hand, Egypt's status as a third world country was actually a blessing. The world's developed technologies arrived to Egypt many years after their emergence in their home countries, which allowed Cairo's architecture to develop slowly and maintain parts of its local identity. Modern architectural concepts dominated building designs in Cairo while trying to put ornamentation and motifs to create a sense of belonging to the building. However, Cairo wasn't completely behind the world in architectural development, in fact,

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many high-rise buildings were constructed within the last cycle of globalization, but with a glimpse of its identity attached to it. That's what kept happening in Cairo for decades. As a cosmopolitan city, it manages to keep its identity against the waves of change while benefiting from the change and coping with the international development.

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EVALUATING THE LEGIBILITY OF COMPLEX BUILDINGS: A QUANTITATIVE MODEL FOR INDOOR WAYFINDING

SARAH H. AHMED[1,2], DINA S. TAHA[1] & ASMAA E. HASAN[1]
[1]Department of Architectural Engineering, Alexandria University, Egypt
[2]Architectural Engineering Department, Pharos University in Alexandria, Egypt

ABSTRACT

Wayfinding presents a significant aspect in architectural design since it is associated with the spatial organization and the legibility of indoor environments. It is believed that the physical characteristics of the indoor environment influence the performance of individuals in finding their way in complex settings. Navigation in such buildings can be a distressing process if the needed spatial information is not clearly presented to users; hence, it is important during the design phase to consider the factors that affect users' wayfinding performance. This paper examines these factors in indoor environments and focuses on the design variables that influence their legibility. Furthermore, it attempts to develop a quantitative evaluation model that assesses wayfinding in complex buildings in terms of their architectural design variables, through assigning weights of importance to these variables. For the purpose of implementing and testing the evaluation model, two case studies were conducted in shopping centers in Cairo, Egypt. The performance of users during the study was found to be consistent with the results of the evaluation model. This suggests that the assigned weights of the design variables were rather logical. These weights help in defining the design priorities for wayfinding: building configuration and its complexity are regarded as the first priority, followed by architectural differentiation, visual accessibility, and lastly, landmarks.

Keywords: architectural design, complex buildings, legibility, wayfinding performance.

1 INTRODUCTION

Physical environments have always been affecting individuals positively or negatively in both direct and indirect ways. A positive effect can be direct when the environment fulfills individuals' needs, on the other hand, it can be indirect, for instance, when environments create chances for desired social interactions [1]. As for the negative effects, the design of physical environments can directly cause discomfort which in some cases, may indirectly provoke unpleasant emotions as frustration or stress. One of the unfortunate experiences that negatively affect individuals is disorientation. The consequences of disorientation may range from being stressful or frustrating, as being late for an appointment, to being seriously dangerous as failing to find the emergency room in a hospital [2]. Being lost in a building was reported by several users as a frustrating experience since they fail to know their location nor locate their destination [2]. Such an unpleasant experience may result in the feeling of being trapped in a man-made maze [3].

Individuals usually face disorientation problems in environments or buildings that they perceive as complex. Buildings such as: museums, faculty campuses, convention centers, shopping centers, airports, and hospitals, are frequently referred to as complex. These buildings were found to challenge users' navigational abilities and test their spatial orientation which may result in navigational errors, stressful and frustrating conditions [2], [4]–[7].

Generally, the built environment has been referred to as complex in several occasions, for instance, Williams [8] defined it as: "The built environment, comprised of the physical structures and elements of man-made living, working, travelling and recreational environment, is a complex and multi layered system governed by a web of ecological, social, cultural,

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economic, and political relationships". This multi-layered system is believed to be composed of many interacting components that have the ability to generate a new quality of collective behavior through self-organization. These interacting components may be presented in the form of temporal, functional, and spatial structures [9], [10].

Indoor environments are one form of the built environment; therefore, it is valid to apply the definition of complex systems to indoor settings. Accordingly, a complex building may be defined as a large indoor environment with temporal, spatial, and functional variables.

In conclusion, a complex building is characterized by one or more of the following [5]:

(a) Being large in size, with a function that requires movement, or hosting a large number of people;
(b) Including multiple activities and different functions;
(c) Having a high density and a high level of diversity of occupancy and usage;
(d) Having multiple or fragmented ownership, management, or tenancy.

The study of the physical characteristics of indoor environments has been the focus of several researchers due to its proven impact on legibility, and hence, wayfinding [10], [11]. Individuals rely on environmental cues to orient themselves inside buildings and create an image of the setting [6], [12]. Therefore, in order to eliminate or reduce wayfinding problems, it is essential to understand the impact of the legibility of the physical environment and its elements [4]. In addition to, specifying all the physical environmental variables that contribute in easing spatial orientation and wayfinding of users [13]. Literature has mentioned multiple physical variables that affect legibility and indoor wayfinding. These include, but are not limited to the following: (1) plan configuration and complexity [10], [11], [14], (2) architectural differentiation [2], [12], [15], (3) landmarks [6], [14], [16], (4) visual accessibility [17]–[20], (5) circulation systems [3], [17], [21], (6) grouping of spaces [3], [21], (7) entrances [6], [21], and lastly (8) signs and maps [11], [22]–[24]. This research will focus on the architectural design variables that affect indoor wayfinding, while disregarding signs and maps, since they are graphic design variables and their existence does not overcome a poorly designed building [3].

2 RESEARCH AIM AND OBJECTIVES

The research aims to develop a quantitative evaluation model of the design characteristics of indoor physical environments as a means to enhance users' comprehension of complex buildings. This proves useful in facilitating the way-finding process and avoiding user's disorientation and frustrating experience. Within this aim, the objective of this research is to:

(a) Investigate the wayfinding cues perceived by users and their effectiveness,
(b) Formulate a quantitative evaluation model that assesses wayfinding in complex buildings in terms of their architectural design variables.
(c) Conclude the proper weights for the different variables.

Through the investigation of previous researches, it has been noticed that the evaluation of wayfinding in complex buildings is either qualitative for the whole building or quantitative for one or two architectural design variables [5], [19], [25].

This research attempts to examine thoroughly the relationships among all the variables and propose a weight for each one. Thus, create a quantitative model that allows an objective grading of buildings as a whole in relation to their architectural design variables. Furthermore, it will allow an objective comparison between two or more buildings regarding their legibility and ease of wayfinding.

3 METHODOLOGY AND RESEARCH METHODS

This research utilized a multi-method approach to collect and analyze data, which included: literature research, a structured questionnaire, and multi-criteria decision methods. The implementation of the multi-method approach required choosing a workflow to benefit from the outcome of each method (Fig. 1).

4 RESEARCH FRAMEWORK

This research developed a framework for the purpose of creating a quantitative evaluation model for wayfinding in complex buildings. The framework is based on weighing the importance of the architectural design variables, designing a questionnaire, and eventually, creating an objective evaluation model.

4.1 Weight of importance of architectural design variables

A thorough review of literature facilitated setting the importance of architectural design variables affecting wayfinding in complex buildings. Firstly, the research examined the frequency of occurrence of each variable in a total of twenty references that were published between 1975 to 2019. Secondly, the importance of each variable was inspected as a means of grouping the important ones mentioned in these references (Fig. 2).

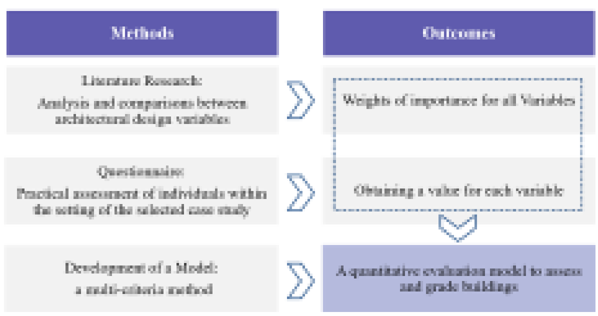

Figure 1: Workflow of main methods and their outcomes.

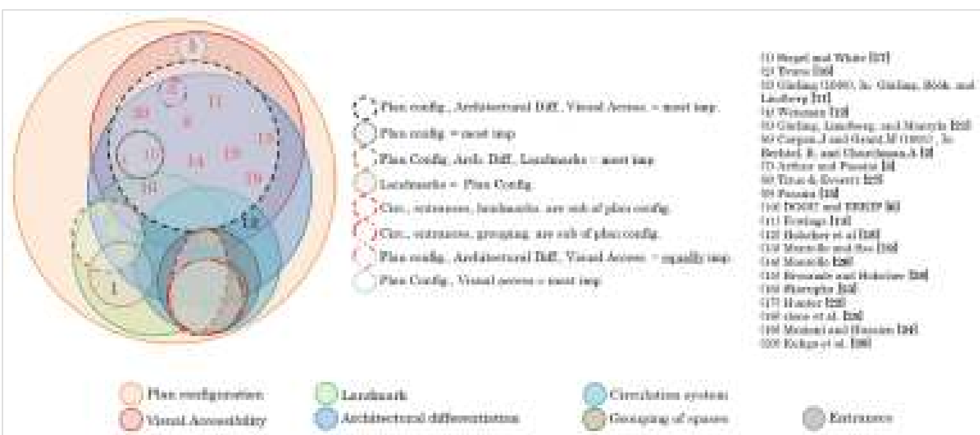

Figure 2: The occurrence and the importance of variables as mentioned in references.

Finally, an analytical method was employed to compare between the different opinions regarding the importance of specific variables. Each variable is analyzed as follows:

Ten of the reviewed references agreed that Plan Configuration, Architectural Differentiation, and Visual Accessibility are the three most important variables [10]–[12], [18], [19], [23]–[27]. While Garling et al. [20] suggested that Plan Configuration and Visual Accessibility are the most effective ones. Plan Configuration was mentioned in all twenty reviewed references: eleven of which considered it as one of the most effective variables, while two references [11], [27], addition to Haq and Girotto [28] considered it as the most important one. Hence, Plan Configuration may be considered as the first and the most effective variable.

Three references considered Architectural Differentiation as one of the three most affecting variables along with Plan Configuration and Landmarks [2], [14], [15]. In addition to, ten references that regarded it as one of the three most important variables with Plan Configuration and Visual Accessibility [10]–[12], [18], [19], [23]–[27]. Architectural Differentiation was mentioned in seventeen of the reviewed references: thirteen of which considered it one of the three most effective variables. Hence, Architectural Differentiation is suggested to be the second most effective variable.

Ten References agreed that Visual Accessibility is one of the three most important variables [10]–[12], [18], [19], [23]–[27], along with Garling et al. [20] who regarded it as one of two most effective variables. Visual Accessibility was mentioned in fourteen of the reviewed references: eleven of which considered it one of the most effective variables. Hence, Visual Accessibility may be considered the third most effective variable.

Dogu and Erkip [4] suggested that Entrances, Circulation System, Landmarks are part of Plan Configuration and Complexity, whereas Arthur and Passini [3] suggested that Entrances and Circulation System are part of Plan Configuration and Complexity. Furthermore, Hunter [21] suggested that Entrances, Circulation System, Landmarks, & Grouping of Spaces affect the legibility of Plan Configuration. Hölscher et al. [29] highlighted the importance of Circulation System as a wayfinding aid. Hence, Entrances and Circulation System may be considered as sub-variables to Plan Configuration and Complexity.

Arthur and Passini [3] and Hunter [21] suggested that Grouping of Spaces affect the legibility of plan layout and form. Hence, Grouping of Spaces may as well be considered a sub-variable to Plan Configuration and Complexity. Two references suggested that Landmarks variable is important for the legibility of Plan Configuration and wayfinding [6], [21], while another two references suggested that Landmarks are essential for wayfinding and even more important than Plan Configuration and its Complexity [15], [16]. Landmark variable was mentioned in six out of the twenty reviewed references: three of which considered it one of the important variables, while two regarded it as the most important variable. Hence, Landmarks may be considered the fourth most effective variable.

In summary, the results of the analysis suggest that plan configuration and complexity as the most important variable, followed in importance by architectural differentiation, visual accessibility, and lastly landmarks. Furthermore, plan configuration and complexity variable is proposed to include three sub-variables; entrances, circulation system, and grouping of spaces. This research will adopt these architectural variables as the criteria of the evaluation model. The normalized weight of importance of each variable is shown in Table 1.

4.2 Design of the questionnaire

A questionnaire of twenty-four questions was designed to gather data about wayfinding behavior of users, in addition to their perception and cognition of indoor environments. It

Table 1: Proposed relative weights of the criteria.

Plan config. and complexity			Architectural differentiation	Visual accessibility	Landmarks
Entrances	Circulation systems	Grouping of spaces			
0.40			0.30	0.20	0.10

aims to practically assess buildings according to the wayfinding performance of their users. The format of the questionnaire is a combination of close-ended questions, open-ended questions and wayfinding tasks. The final form of the questionnaire is the result of an analysis of previous studies, such as Weisman [11], Lawton [30], and Dogu and Erkip [4]; in addition to a thorough review of the theories concerned with the design features that aid wayfinding.

The questionnaire is composed of four sections: The first section focuses on demographic data and identifies the familiarity, frequency, and purpose of visit for the questionnaire's respondents. The second section is concerned with the sense of direction and orientation of users in buildings. The third section focuses on the architectural features of the indoor environment and their legibility. In this section, each question refers to a specific architectural design variable. The fourth section of the questionnaire investigate the cognitive and wayfinding abilities of users through guiding tasks, pointing tasks, and cognitive mapping.

The questionnaire is designed to be handed out to users of selected buildings for study. Firstly, the answers of each question within the questionnaire is given a rank as a means to quantify the answers of the respondents (Table 2). Secondly, the results of the questionnaire are to be processed through simple additive weighting method (SAW). In this research, each architectural design variable represents an aspect, the alternatives are the respondents, while the attributes are the questions corresponding to the selected variable (Fig. 3). The value of each variable is determined by dividing the sum of values of the attributes with the number of respondents [31].

4.3 Design of the evaluation model

In order to objectively assess buildings according to all the architectural design variables and to grade buildings in comparison to each other, an AHP method was adopted. This method is based on hierarchically structuring the components of the problem, in addition to assigning numerical values to all the variables and factors that are taken into consideration. Applying AHP method requires setting a goal or objective, determining the criteria for evaluation, and finally choosing the alternatives [32], [33]. In this research, the objective is evaluating complex buildings in terms of wayfinding, while the criteria adopted is the list of the architectural design variables affecting indoor wayfinding. And at the third level, the

Table 2: Example of the weighted questionnaire answers.

Question no.	Questionnaire answer	Rank	Normalized weight
10	Very accurate	4	1
	Almost accurate	3	0.75
	Not entirely	2	0.5
	Not at all	1	0.25

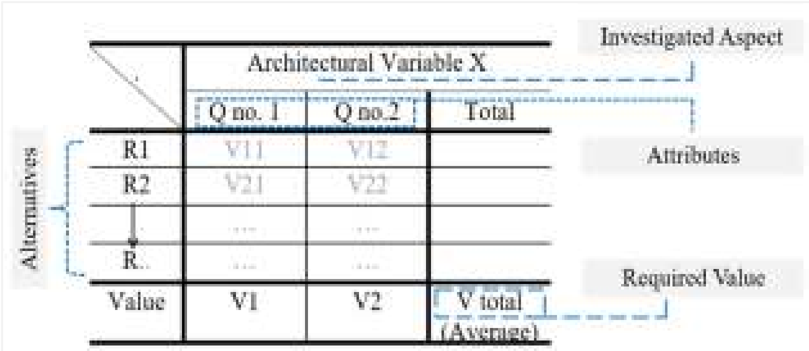

Figure 3: A simplified diagram of the applied SAW model.

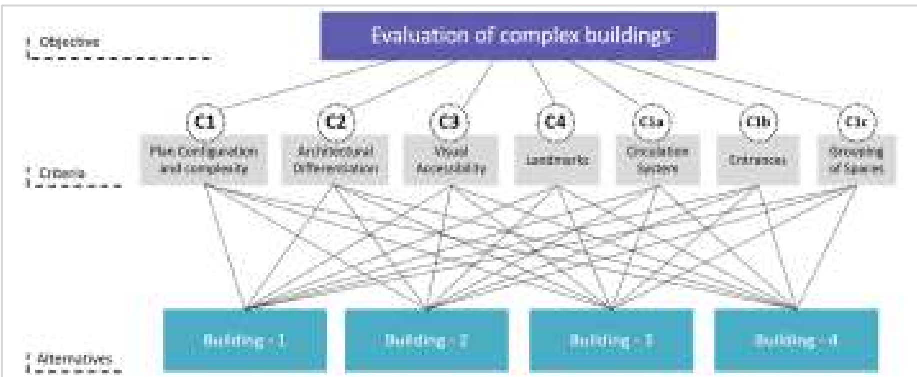

Figure 4: Hierarchal structure of the AHP evaluation model.

alternatives are the selected buildings for evaluation (Fig. 4). The model is designed to assess each building separately according to the list of criteria, in addition to comparing multiple buildings to each other and grade them.

The numeric values of each component in the model are obtained through the structured questionnaire and the previous analytic review of literature. The weight of the criteria was proposed in Table 1. While the value of each alternative in relation to the criteria is designated to be obtained from the questionnaire and quantified through SAW method. These values will then be processed using Super Decisions software which implements the AHP method. A simplified form of the input data on the software is shown in Fig. 5.

5 EXPERIMENT AND RESULTS

During this research, the investigation of wayfinding in complex buildings required selecting a building of two characteristics; first, a public building that would allow unconditional access to a diversity of users. Second, the existence and the variability of important aspects as familiarity, purpose of visit, and frequency of visit. These two characteristics are present in shopping centers; therefore, they are selected to be the focus of this research. The nature of shopping centers as an indoor-retail setting, places users in a complex environment where

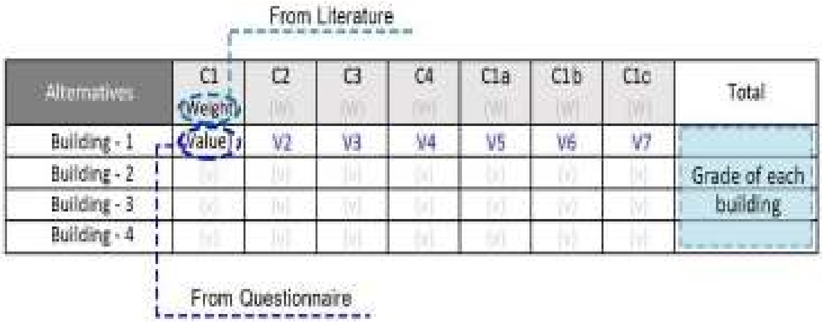

Figure 5: A simplified from of the AHP model.

they unintentionally perform several cognitive and wayfinding tasks [34]. Two shopping centers in Egypt are selected for study; Mall of Arabia (MoA) and Mall of Egypt (MoE).

5.1 Description of case studies

The first selected shopping center is MoA which is located on 26th July road in 6th October city. The two-storey building is designed around two inner courts with a gross building area (GBA) of 205,169 sq. meters. MoA was established in two phases; the first phase included a loop layout enclosing a large court with a fountain. The second phase was an expansion of a U-shaped layout that created another court named “The Park”. The first phase represents the ground floor, while the second phase represents the underground floor and it is double the height of the first floor. The underground and the ground floors have two common atriums including the vertical circulation systems

The second shopping center is MoE, which is located on El-Wahat regional road in 6th October city. The building is of two stories and of a typical layout with a gross building area (GBA) of 226,222 sq. meters. MoA is designed on a rectangular layout with an open plaza at one side and a large atrium in its center named “The Valley”. The building has a total of fifteen entry points; the main entrance accessed from the plaza, along with six entrances on the ground floor, and the other eight entrances on the first floor. The two floors are connected with several vertical circulation elements close to the entrances, in addition to escalators placed along the corridors.

5.2 Implementation

The questionnaire was handed out to a total of fifty respondents selected randomly. In MoA, twenty-five respondents were chosen at the atrium adjacent to entrance no.4 and no.5 (Fig. 6). While in MoE, another twenty-five respondents were chosen at a spot adjacent to the node between entrance no. E5 and “The Valley” (Fig. 6).

In both cases, and for all participants, the answers of section three of the questionnaire (concerning architectural features of the indoor environment) were weighted and quantified through SAW method in order to obtain the total value of each architectural variable. Tables 3 and 4 portray the feedback of each of the questionnaire’s respondents on the different architectural variables in both case studies. For example, visual accessibility variable is investigated through questions no.12 and no.14. In case of respondent no.1 (R1), question

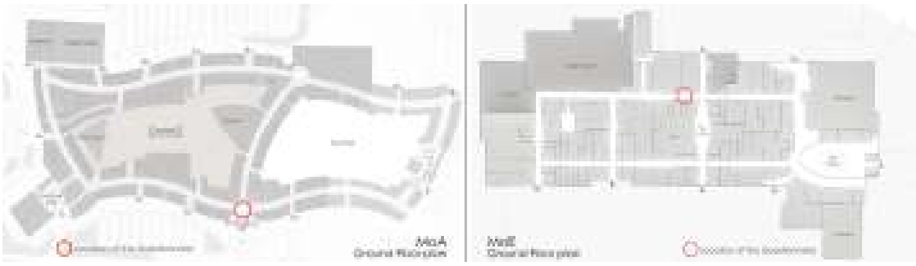

Figure 6: Location of the questionnaire on the ground floor plans of MoA and MoE. *(Source: Mall of Arabia [35], Mall of Egypt [36], edited by researcher.)*

Table 3: The weighted values of architectural variables for respondents at MoA.

Mall of Arabia – MoA							
	C1	C2	C3	C4	C1a	C1b	C1c
	Plan config and complexity	Architectural differentiation	Visual accessibility	Landmarks	Circulation systems	Entrances	Grouping of spaces
	Q-22, Q-11	Q-11, Q-16	Q-12, Q-14	Q-18	Q-17, Q-20	Q-13	Q-15
R1	0.375	0.175	0.625	0.060	0.750	0.500	0.250
R2	0.250	0.175	0.375	0.060	0.625	0.250	0.500
R3	0.750	0.175	0.750	0.250	0.750	0.750	0.250
R4	0.625	0.175	0.625	0.250	0.750	0.750	0.500
R5	0.750	0.300	0.625	0.250	0.750	0.750	0.250
R6	0.375	0.300	0.500	0.060	0.500	0.500	0.500
R7	0.625	0.300	0.625	0.250	0.500	0.500	0.500
R8	0.750	0.300	0.750	0.250	0.750	0.750	0.500
R9	0.625	0.300	0.625	0.250	0.750	0.750	0.500
R10	0.250	0.175	0.375	0.060	0.500	0.250	0.500
R11	0.750	0.175	0.750	0.250	0.750	0.750	0.750
R12	0.750	0.300	0.625	0.250	0.750	0.750	0.500
R13	0.375	0.300	0.500	0.060	0.500	0.500	0.500
R14	0.375	0.300	0.500	0.060	0.500	0.500	0.750
R15	0.625	0.300	0.625	0.250	0.750	0.750	0.500
R16	0.375	0.175	0.625	0.060	0.750	0.500	0.250
R17	0.250	0.175	0.375	0.060	0.625	0.250	0.750
R18	0.625	0.175	0.625	0.250	0.750	0.750	0.500
R19	0.375	0.175	0.625	0.060	0.750	0.500	0.750
R20	0.625	0.300	0.625	0.250	0.750	0.750	0.250
R21	0.250	0.175	0.375	0.060	0.625	0.250	0.750
R22	0.625	0.175	0.625	0.250	0.750	0.750	0.500
R23	0.375	0.300	0.500	0.060	0.500	0.500	0.750
R24	0.750	0.300	0.625	0.250	0.750	0.750	0.750
R25	0.750	0.175	0.750	0.250	0.750	0.750	0.590
Value	0.530	0.235	0.585	0.166	0.675	0.590	0.750

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Table 4: The weighted values of architectural variables for respondents at MoE.

Mall of Egypt – MoE							
	C1	C2	C3	C4	C1a	C1b	C1c
	Plan config and complexity	Architectural differentiation	Visual accessibility	Landmarks	Circulation systems	Entrances	Grouping of spaces
	Q-22, Q-11	Q-11, Q-16	Q-12, Q-14	Q-18	Q-17, Q-20	Q-13	Q-15
R26	0.500	0.300	0.750	0.250	0.750	0.750	0.500
R27	0.250	0.300	0.750	0.250	1.000	1.000	0.250
R28	0.500	0.300	0.875	1.000	0.875	1.000	0.250
R29	0.375	0.175	0.750	0.250	0.750	0.750	0.250
R30	0.500	0.750	0.750	1.000	0.750	0.750	0.250
R31	0.500	0.175	0.875	0.250	0.750	1.000	0.250
R32	0.500	0.175	0.750	0.250	0.750	0.750	0.750
R33	0.250	0.175	0.750	0.060	0.750	0.750	0.250
R34	0.750	0.300	0.875	0.250	0.875	0.750	0.500
R35	0.375	0.175	0.750	0.250	0.750	0.750	0.250
R36	0.625	0.300	0.875	0.250	1.000	1.000	0.500
R37	0.625	0.175	0.750	0.250	0.750	0.750	0.250
R38	0.625	0.300	0.750	1.000	0.750	0.750	0.500
R39	0.500	0.300	0.750	0.250	0.750	0.750	0.250
R40	0.625	0.300	0.875	0.060	1.000	0.750	0.500
R41	0.625	0.300	0.875	0.250	1.000	0.750	0.750
R42	0.250	0.175	0.750	0.060	0.750	0.750	0.500
R43	0.750	0.300	0.750	0.250	0.875	0.750	0.500
R44	0.750	0.300	0.750	0.060	1.000	0.750	0.750
R45	0.500	0.300	0.750	0.060	0.750	0.750	0.250
R46	0.500	0.875	0.750	0.250	0.750	0.750	0.750
R47	0.750	0.300	0.750	0.250	0.875	0.750	0.500
R48	0.625	0.300	0.750	1.000	0.750	0.750	0.500
R49	0.500	0.300	0.750	0.250	0.750	0.750	0.250
R50	0.625	0.300	0.875	0.250	1.000	0.750	0.750
Value	0.535	0.306	0.785	0.408	0.830	0.790	0.440

no.12 was answered as "hard" which corresponds to a weighted value of 0.5. While question no.14 was answered as "almost easy" which corresponds to a weighted value of 0.75. Therefore, the weighted value of visual accessibility variable for R1 is the average of both values, which is equal to 0.625. The exact method is applied for respondents R1 to R25 and the average sum of their values is calculated to obtain a total weighted value of visual accessibility variable in MoA which is equal 0.585. In the same manner, the rest of the architectural variables are calculated for both case studies.

The results of the previous method are utilized as the input data for the AHP evaluation model. For each case study, the value of each variable is multiplied by its relative weight

(Table 1) and the added to other variables. For example, the calculations of MoA are as follows:

C1 Plan config. and complexity (C1a, C1b, C1c):	(Avg. 0.530,0.675,0.590,0.750) x 0.4
	+
C2 Architectural Differentiation:	(0.235) x 0.3
	+
C3 Visual Accessibility:	(0.585) x 0.2
	+
C4 Landmarks:	(0.166) x 0.1
	0.4314

The Super Decisions software implements the previous method of calculation, in addition to comparing between different case studies and prioritizing them. The input data of MoA (Table 3) and MoE (Table 4) is inserted in the model, along with the suggested weight of variables in Table 1. The evaluation model calculates the total value of both shopping centers in respect of all the architectural variables, in addition to ranking them in relation to each other. Table 5 represents the final form and results of the evaluation model.

Table 5: The results of the evaluation model as produced by Super Decisions software.

Alternatives	Priorities	Totals	Architectural differentiation	Landmarks	Plan configuration	Visual accessibility
			0.3	0.1	0.4	0.2
MoA	0.4380	0.4314	0.235000	0.166000	0.568330	0.585000
MoE	0.5620	0.5536	0.306000	0.408000	0.660000	0.785000

6 FINDINGS AND DISCUSSION

The results of the evaluation model show that the calculated total value of MoA is 0.4314, while, MoE is 0.5536 (Table 5). These results suggest that MoE is better than MoA in respect to the architectural variables affecting wayfinding. In order to check the validation of these results, they are compared with the performance of respondents in the last section of the questionnaire. In MoA, only 28% of the respondents succeeded in giving directions while 64% of MoE respondents were able to give directions successfully. During the task of locating an unseen goal 4% of MoA respondents were able to complete the task, on the other hand, 64% completed the task successfully in MoE. Lastly, when asked to locate themselves on a map, only 16% of MoA respondents succeeded, while 56% of the respondent at MoE located themselves correctly. These percentages show that the wayfinding and cognitive performance of users in MoE is significantly higher than users of MoA. Moreover, the respondents of both shopping centers reported their need for a printed map to assist them in finding their way, with a 64% in MoA and 44% in MoE. However, when asked about their wayfinding experience, 48% of MoA respondents reported facing difficulties every time they visit the building, while only 16% faced the same issue in MoE. These findings support the final results of the evaluation model.

Furthermore, disorientation and wayfinding difficulties experienced in MoA can be linked to the spatial properties and the design of the building. Through the results of the questionnaire, it can be deduced which architectural variables had a negative effect on wayfinding in each case. For instance, when comparing the calculated value of entrances variable in both MoA and MoE, the value of MoA is remarkably lower than the latter. The entrances of MoA were of a great number which may lead to confusion and uncertainty.

Moreover, the layout of the building does not strengthen the existence of these entrances, an issue that led to the placement of large digits on the exterior of each entrance and large signs in the interior. On the other hand, the main entrance of MoE has a strong identity and the other entrances are placed on a grid which facilitates finding their location. Both shopping centers scored low values of architectural differentiation. The analysis of the two buildings shows that, apart from the different ceiling designs, there is no clear distinctiveness or differentiation. Furthermore, almost none of the respondents reported noticing the differentiation of the ceilings. The lack of landmarks in MoA affected the wayfinding performance of its users and it is reflected on its calculated value. When asked, the respondents did not recall perceiving any landmarks in the buildings and they failed to select any elements that they could utilize as a landmark. Instead, some of them utilized one of the two atriums or a shop overlooking them as a landmark. In the case of MoE, users were able to perceive designed landmarks as the water element located in "The Valley". Some users relied on information desks as physical cues, while others reported relying on an anchor entertainment zone. Generally, MoE offers more elements and zones that can be regarded as landmarks, therefore its concluded landmark value is higher than MoA. Similarly, the value of visual accessibility in MoE was found to be higher than MoA. Such difference may be explained by the existence of the large atrium in the center and the corridors of the first and second floor which overlook the ground floor creating a visual connection between floors. Generally, evidence suggests that MoE eases wayfinding when compared to MoA and such suggestion is consistent with the results of the proposed evaluations model.

7 CONCLUSION

This research proposed a quantitative model to evaluate complex buildings in general and shopping centers in particular in respect to wayfinding. The consistency between the recorded performance of users and the results of the evaluation model, suggests that the weighted values of the architectural variables are rather logical. These weights help in defining the design priorities for wayfinding. Building configuration and its complexity are regarded as the first priority when designing buildings for wayfinding, followed by architectural differentiation, visual accessibility, and lastly, landmarks. Generally, the suggested evaluation model can provide an objective judgement when assessing wayfinding in complex buildings. The model develops a grade for buildings, in addition to providing a quantitative comparison between two or more buildings in respect to their spatial characteristics and physical elements. This model can be employed to assess and enhance existing buildings for better wayfinding. Furthermore, it can provide an insight into the effectiveness of each architectural design variable from the perspective of users. Such an insight can be employed in the early planning of complex buildings as a means to optimize their design for wayfinding.

Future research should aim to conduct the designed questionnaire and implement the evaluation model on a larger sample of users of shopping centers. Furthermore, it is recommended to apply the framework of this research on different typologies of complex buildings in order to investigate the validity of the evaluation model and the proposed weights of the architectural variables on a wider scale.

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SUSTAINABLE CITY GEOMETRIES: SACRED GEOMETRY OF RITUAL SPACE, ARCHITECTURE AND CITY LANDSCAPE IN KANDY, SRI LANKA

WASANA DE SILVA[1] & NISAL AMARAKOON[2]
[1]University of Moratuwa, Sri Lanka
[2]Oxford Brookes University, UK

ABSTRACT

Esala perahera rituals, performing in Kandy, Sri Lanka re-establish spatial relationships between people, temples, the city, villages, river, valley and the mountains through walking and dramatic performances, evoke spiritual atmosphere. Analysing these revealed sustainable city concepts and mathematical geometrical patterns. However, there is a boundary, where cannot be researched beyond to understand the deeper dimensions of the sacred geometries, without geometrical and mathematical analysis. This research examines the geometries of the spatial relationships established by ritual space in Kandy, and its relevance to the city landscape and architecture, to understand sustainable city and sacred geometries. Ritual space created through performing *Esala perahera* for 15 continuous days is analysed for the purpose, in order to explain sacred dimensions and depth of the place, beyond the boundaries of architectural and landscape analyses. The method of study is by a geometrical analysis of ritual space, architectural elements and the city landscape, exploring geometry in two, three and higher dimensions; to understand the sacred geometries and geographies. It examines the higher dimensions of the centre, axis, and the circular motion and discusses sustainable city geometries. The geometrical analysis is done by utilizing architectural and landscape analytical diagrams developed in a previous study, employing a phenomenological, anthropological, ethnographical research approach. This study reveals further insights of the place; people, social/cultural/religious system, architecture, topographical location, the city and spiritual dimension of the space; where this place cannot be easily understood in isolation, by employing either research approach. Geometrical analysis is useful to further understand the phenomenological, anthropological, ethnographical perspective of the place and strengthened the conclusions of previous studies. Geometries of Kandy reveal the spiritual dimensions, unfolding physical and non-physical side of the place, and traditional city that sustains between these two, continuing sacred geographies, establishing sustainable city geometries, in contrast to new developments.

Keywords: sustainable city geometry, spatial relationships, ritual space, sacred geometry, sacred geography, Esala perahera*, sacred heritage sites, place.*

1 INTRODUCTION

Kandy is the last kingdom (1596–1815 CE) of Sri Lanka; however, some of its traditional understanding of the place still continues, in the form of rituals, festivals, and religious cultural concepts. The ritual space, established through fifteen continuous performing of *Esala perahera* annually, re-enacts the place, giving rebirth to the place [1]. Geometric formation of centre, line, circle, circumambulation and axis as important spatial dimensions, revealed through these performances, manifest the space and city landscape as sacred, establishing geometrical and mathematical relationships in the space and time. The role of the body is central in these dynamics of place. Analysing these revealed sustainable city concepts and mathematical geometrical patterns; however, mathematical geometrical realization of the space needed to be further examined. How do these important spatial dimensions reveal spiritual dimensions, and unfold the place spatially and temporarily,

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realizing sacred geometry, harmoniously and proportionately? If these cosmic understanding of the place, city and landscape, could be further explained through mathematical geometrical realization, it would possibly reveal a different avenue to understand sustainable city geometries, which is a needful topic, however, rarely discussed today.

This research argues that, the space produced by rituals establishes sacred geometry, affirming the role of the body as the central tool of recognizing divine reality, weaving space through geometrical and mathematical relationships, between physical and non-physical realms of the place, referring to sacred geometry; manifests the city landscape and architecture. The research examines one, two, three and higher dimensions of centre, line, circle, circumambulation and axis; and its relevance to sacred geometry and the place concept. It discusses the earliest mathematician–philosophers' ideas, that are holistic and more related to sacred geometry, to reveal how sacred dimensions and geometry harmoniously and proportionately manifest in space and time. Furthermore, the research examines the contextual concepts of sacred geometries of the place, and analyses the geometries of the spatial relationships established by ritual space, employing *Esala perahera* in Kandy, and its relevance to the city landscape and architecture, to understand the sustainable city and sacred geometries.

2 GEOMETRICAL MATHEMATICAL REALITY OF THE WORLD AND PLACE

Geometry is the branch of mathematics that deals with the deduction of the properties, measurement, and relationships of points, lines, angles, and figures in space; from their defining conditions, by means of certain assumed properties of space. Life is interwoven with geometric forms, such as the angles of atomic bonds in the molecules, the spherical shape of the cell that itself develops with a geometric progression from one to two, to four, to eight cells and beyond, the helical spirals of DNA, and the lattice patterns of crystals [2]; angles of planetary attraction and the spherical movements between earth, sun, moon and other planets, and with cosmic relationships. Mathematical reality of the divine beauty, usually seen in scared art and architecture, contains universal patterns of designs, following sacred geometry.

2.1 Sacred geometry

Sacred geometry is the place where mind and matter, the spiritual and the physical, the manifest and unmanifest, the bound and boundless meet. When understanding the universe, geometric proportions control the order of patterns in mathematical ratios, which are important elements in sacred geometry [3]. Sacred Geometry opens out the oneness of the world, underlying all forms and dimensions to the unity, the sacred origin of all things; while at the same time, flourishes the vivid nature of the world, through harmoniously and proportionately established geometrical relationships. Plato (circa 427–347 BCE) describes the geometric creation of the world in his book *Timaeus* [4]. On geometry, he writes in his *Republic* [5], "[Geometry is]... persuaded for the sake of the knowledge of what eternally exists, and not of what comes for a moment into existence, and then perishes,... [it] must draw the soul towards truth and give the finishing touch to the philosophic spirit". Hence, geometry as the unchanging reality of the changing world, reflects in the world, nature, man, and in all good arts and architectural works, as Plato describes: the best bond between earth and sky (heaven), the geometric proportion, which is sacred. Sacred geometry by means of proportions, and harmonious relationships, establishes the links between the human world with the divine world.

2.2 Plato's Lambda: A world phenomenon

Plato (*Timaeus*) explained, the soul, the intermediate existence, between the unchanging essence of the universe and the changing existence of the physical universe itself, has been divided into harmoniously proportional subdivisions and formed into a long strip, by the Creator. The strip was then marked off into intervals [2]. The obtained seven integers; 1,2,3,4,8,9, and 27 are composed of the monad, source of all numbers, the first even and first odd, and their squares and cubes, which represent the dimensions of zero, one, two and three. These numbers are arranged in the geometric progression by 2 and the geometric progression by 3, and Plato arranged them into a universal model (Fig. 1).

Monad				1			Point	0D
First even and odd			2		3		Line	1D
Squares		4				9	Plane	2D
Cubes	8					27	Solid	3D

Figure 1: Plato's Lambda. (D = dimension).

This is called Plato's Lambda, because it is shaped like the Greek letter λ. In reality Plato's Lambda represents four dimensions, where all dimensions originate from the point, the zero dimension; an important world phenomenon. The four dimensions are described in Geometry as follows:

Point – A point has no size, width, length of depth; therefore, zero dimension.
Line – A line is defined as a set of points with no thickness; thus, one dimension.
Plane – A plane is two-dimensional, which has length and width.
Solid – A solid is three-dimensional, which has length, width and depth.

Plato shows the above discussed proportions in Pythagorean ("Music of Spheres") music system, as the multiplication of 2 and of 3, which gives all the numbers by successive multiplication by fifths (3/2). Plato uses an arithmetic mean and harmonic mean to number musical octaves, fourths and fifths. This order of mathematical geometrical proportions in the space and time, unifying physical (earth) and the non-physical domains (heaven), establishes a holistic mathematical model of a place, a mini cosmos. The phenomenon of place [6], [7], is widely discussed in architecture [8], [9], landscape research [10], philosophical psychology [11] and phenomenological geography [12]; to explain the inseparable experience of people with their context: the buildings, architecture, cities and landscape.

Plato's idea of *lambda* explains a universal concept, where each dimension is reciprocally relating to the next dimension. All these dimensions, diverging from or converging to the point, establish a holistic place spatially and temporally, between the physical and non-physical regions; the dynamics of place that represents unity and multiplicity. In the Sri Lankan–Indian context, the cosmic dance (Fig. 2) of the dance of Shiva [13] and the Hindu gopuram (Fig. 3) are ideal examples that symbolize "dynamics of place" and "unity and multiplicity", respectively, where myth evokes the sacred geometry, the reality of the place and the world. Therefore, *lambda* describes the holistic reality of the world of the divine experience/higher dimension, which is not possible to understand, if only each dimension is focused separately. However, mathematics is considered as forms in four groups, dating back to the Pythagoreans [2]. The *Quadrivium*; Arithmetic (number), Geometry (as number in space), Music (or Harmony as number in time) and Astronomy (or Cosmology as number in time and space), as Plato points out, were as means for studying, the highest kind of knowledge: Wisdom.

Figure 2: Cosmic dance.

Figure 3: Gopuram.

2.3 Order of nature: Unity and multiplicity

Musical ratios have a close relationship with art and architecture, and the order of nature; those ratios that are pleasing to the ear would also be pleasing to the eye, mind and for the place. Furthermore, some systems of proportions, in mathematical geometrical agreement, illustrate sacred geometry, which has been recognized, as good, beauty and truth in traditional art, architecture and in nature.

Fibonacci sequence
The Fibonacci sequence is a sequence starting from 0 and 1, then formed adding the previous two numbers, to find the next number in the sequence:

0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144....

Golden ratio
Also called golden proportion, golden mean, divine ratio, divine proportion, sacred cut; found in nature: plants, flowers, shells, planets and galaxies. The golden ratio is evident in sacred architecture and arts throughout the history; golden ratio is designated by the Greek letter ϕ

$$\phi = \frac{1+\sqrt{5}}{2}.$$

The significance of the golden ratio is found by dividing each number by the previous number of the Fibonacci sequence, which gives: 1/1 = 1, 2/1 = 2, 3/2 = 1.5, and so on, up to 144/89 = 1.6179….Then the resulting sequence is:

1, 2, 1.5, 1.666..., 1.6, 1.625, 1.615…, 1.619…, 1.6176…, 1.6181…, 1.6179….

It can be seen that it’s converging to the golden ratio. It symbolizes the regeneration and progression and extension from Unity [2], its relationship to birth, the zero dimension, the point. The golden ratio is exhibited in many forms, which have been recognized as sacred geometries, evident in traditional art and architecture.

Great pyramid
By taking the slant height and half base length of the great pyramid of Giza, its significance to the golden ratio can be calculated (Fig. 4). Dividing slant height s by half base gives, 186.369 ÷ 115.182 = 1.61804. Then, adding both the slant height and half base and dividing by the largest number (which, in this case, is the slant height) gives, (186.369 + 115.182)/186.369 = 1.61803; which differs from the golden ratio ϕ (1.618033) by only one unit in the fifth decimal place.

Spirals
Most commonly in nature, plants display the Fibonacci numbers. Sunflower seeds, pinecones, pineapples show spirals of successive Fibonacci numbers. Snail shells and the spiral of waves are also significant to the Fibonacci numbers. The Fibonacci spiral reveals the origin, the birth and mathematical geometrical relationship of the physical world to the origin (Figs 5 and 6).

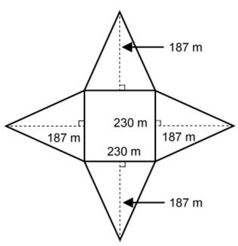

Figure 4: Proportions of the great pyramid.

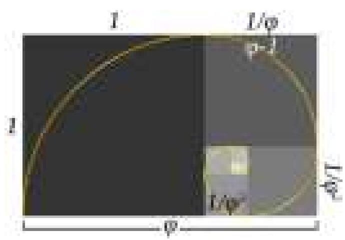

Figure 5: Fibonacci spiral, the sizes of squares are made corresponding to the Fibonacci sequence.

Figure 6: Golden triangles inscribed in a logarithmic spiral.

Circles
Circles are almost evident in creating sacred proportions, and as the base for projection of sacred geometries, for example, the golden ratio in the pentagon and pentagram (Fig. 7). Human body proportions consist of the golden ratio and circles (Fig. 8).

3 GEOMETRY OF THE RITUAL SPACE AND CONTEXTUAL CONCEPTS

How people experience the sacred geometry and geography, through embodied performing, and contextual concepts reveals more insights about the sacred geometry of the place.

3.1 Geometrical archetype

The above illustrated, geometries and proportions manifest the divine beauty, the nature of order and birth, a dynamic spatial temporal concept. Reality, as Plato stated, consisted of archetypal Ideas, or pure essences, of which the visible world is only a reflection. Sacred

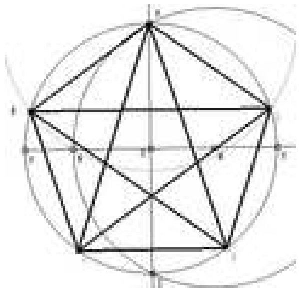

Figure 7: Pentagon and pentagram.

Figure 8: Body proportions, dance of Shiva.

geometry and mathematical proportions remind the "divine reality", which cannot be perceived by senses alone [4], De Silva [1] proposes that rituals evoke bodily understanding of the world and place, through embodied performing [14]. The place could be explained as unfolded mathematical geometrical proportions in space and time, originated from the zero dimension and flourishing to one, two, three and the cosmic level, and vice versa; where buildings, architecture, villages, cities and landscapes at different scales reflect the same universal understanding, relating to higher dimensions, to zero dimensions, the geometrical archetype.

3.2 Contextual concepts: Sacred geometry and geography

How sacred geometry is utilized in this region, is evident in pilgrim journeys to holy centres, parading in the city, and the circumambulation of cities, temples, sacred trees, sacred objects and geographic regions; a cosmological, mythical understanding of the place and geography, by means of the bodily performing. The central role of the body as the mediator of the "sacred geometry" between the earth and the divine domain, is evident in all these. The geometries of distinctive geographies, and topographies evoke myth, and are honoured by pilgrimages throughout human history; a universal phenomenon, which belongs to human experience of sanctity of place [15], the cosmic understanding of human being [16]. The pilgrim journey establishes a line, a sacred axis uniting the holy centre/point with the mundane dimension. Circumambulation establishes the circle, and unifying with centre and axis of the place, that reminds archetypal geometry, the holistic concept of the place. Sinha [17] relates the archetypal idea to sacred geographies; landscape of mountains, hills, trees and water; and explains how these evoke the mind toward the sacred geometries of centre, axis/path, and the transcending experience between physical and non-physical realms.

Mandala, is a geometrical mathematical diagram (Figs 9 and 10), common in the Indian–Sri Lankan context, utilized in placing buildings, temples, palaces, cities. The centre of these geometrical forms is recognized as most spiritual, where Brahma the creator of the world resides, and the two dimensional mandala can project as a pyramid of three dimensional, where the axis passes the centre uniting with the origin of the place. Pilgrim mandala [18] worships specific geographic region, and continuous repeating of circuits enhances the sacred geographies of the Mandala, as the evidence of the human component/body in mediating the sacred geometry between earth and heaven. These contextual understandings highlight the centre/point, axis and circumambulation, the unity and multiplicity of the place, and its

Figure 9: Brahma, at the centre.

Figure 10: Tibetan Buddhist mandala.

relevance to rituals and myth. Life is interwoven with geometric relationships, mathematical proportions of divine order. According to the *Manasara*, a 10th century CE text of Hindu architecture, the layout of the Hindu city is based on the “Cosmic cross”, the cardinal points of which are from the universe. Thus, the whole city is a celestial city, a cosmogram [18]. Also, cosmic cross marks the point, the unity and the birth of the place; important phenomenon related to sacred geometry and sacred dimensions.

4 SACRED GEOMETRY AND SACRED GEOGRAPHY, KANDY

How *Esala perahera* rituals establish sacred geometry and sacred geography, can be explained by mathematical–phenomenological and ethnographical analysis.

4.1 *Esala perahera* rituals in Kandy

Esala perahera festivals, one of the major rituals performed annually in Kandy during July/August, celebrate intact relationship of people with the place, temples, old city and landscape. These celebrations are more than cultural displays [1], signify the role of the body and dynamics of the place. These rituals are performing through fifteen continuous days, ending on full moon *poya* day, as evidence of the cosmic relationship. Table 1 illustrates the details of events and the significant aspect of performing. The last kingdom of Sri Lanka, Kandy was taken under British power in 1815 CE. Some old city streets during 1815 CE (Fig. 11) do not exist today; but *Esala perahera*, parades only along the old streets of the city.

4.2 Analysis: Place emerges through establishing rituals

The first five ritual events mark geometries of point, line and circle during the first four days, performed at the four main temples: Natha, Vishnu, Kataragama and Pattini (Fig. 12).

Numbers in space and time comply with the order of Fibonacci series (Table 2); birth of the place from point or zero dimension and emerging to the next dimensions. In the ritual place the point is marked by the religious/cultural event called “*kapa situweema*” (planting a pole): the historical origin goes back to ancient times, interpreted as the birth of the Vishnu, the guardian of the place/world, a main god in the divine triad of Hinduism, an important world phenomenon. Hence, the geometries formed by the first five events of inner parades and *kumbal perahera*, re-enact the place, unfolding the holistic dimensions of the place, as in the world phenomenon of Lambda.

Table 1: *Esala perahera*, Kandy: Time, space and method of performing.

Ritual	Time intervals	Methods of performing	Significant aspect
Kapa situweema	Once a year Two days	Parades, rituals, music, offerings. Cutting the tree, planting *Kapa*.	Marking a centre and axis
Inner parade	Four consecutive days	Small procession, music, offerings, and rituals.	Marking a place/encircling
Outer parade *Kumbal perahera* and *Randoli perahera*	Ten days at night	Long procession parades clockwise along the old streets, walking, dancing, acrobatics, singing.	Circumambulation the city and valley
Diya kapeema	From full moon midnight till dawn	Walking, dancing, playing, bathing, music, offering food.	The city is connected with water.
Day parade	From midday till evening	Walking, dancing, playing music, acrobatics.	Revisiting the place.

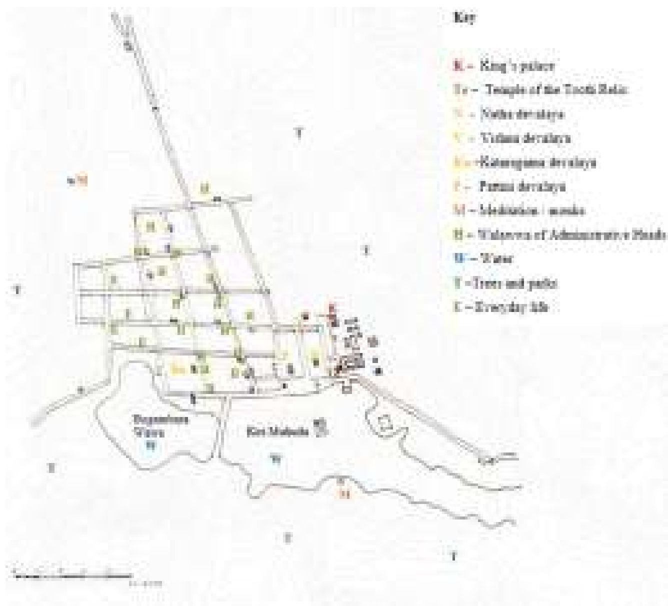

Figure 11: Kandy 1815 CE plan.

The evidence of the golden ratio is examined in these parades, by calculating distances of circumambulation (Fig. 13 and Table 3).

Let distance $a > b$. Then, find a/b and $(a + b)/b$. If a/b and $(a + b)/b$ are equal to 1.618 the proportion has the golden ratio.

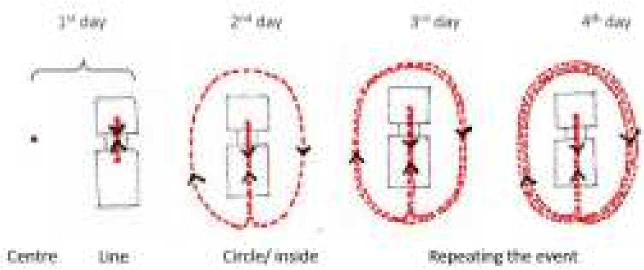

Figure 12: First five events.

Table 2: One temple: Inner rituals and *Kumbal perahera.*

Day	Geometry	Numbers in the space	Numbers in the time	Dimensions – space factor
1	Point	01	00 Continues/static	Zero
1	Line	01	01	One
2	Circle	01	01	Two
3	Circle	02	02	Two
4	Circle	03	03	Two
5–9	Circumambulation	05	05	Three

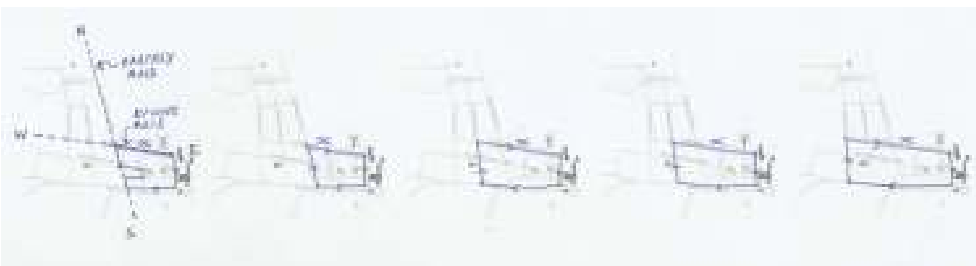

Figure 13: Circumambulation, days 5–9 *Kumbal perahera.*

Table 3: *Kumbal perahera*.

Day (2012)	Length of axis (x)	Length of rest of circumambulation (y)	y/x 2012	$(x + y)/y$ 2012	y/x (from 2020 results)	$(x + y)/y$ (2020 results)
5	554.74 m	1089.21 m	1.96	1.51	2.67	1.37
6	312.91 m	657.55 m	2.10	1.48	2.10	1.48
7	444.24 m	795.65 m	1.79	1.56	1.85	1.54
8	444.24 m	820.62 m	1.85	1.54	1.85	1.54
9	554.74 m	956.53 m	1.72	1.60	1.72	1.60

The research compares the data from 2012 with the data from 2020, and in both 2012 and 2020, results converge towards the golden ratio. The slight deviation of results from the golden ratio is apparent, as the Kandyan kingdom lost its independence in 1815 CE: British power dominated over the land and the system, and made significant changes. Furthermore, the place is open to substantial changes, due to contemporary developments and globalization, despite temple priests who believe the traditional performing continues without changes to the original version happening during the king's period. The research checked for the evidence of the golden ratio, in *Randoli perahara*, 2020 (Fig. 14 and Table 4).

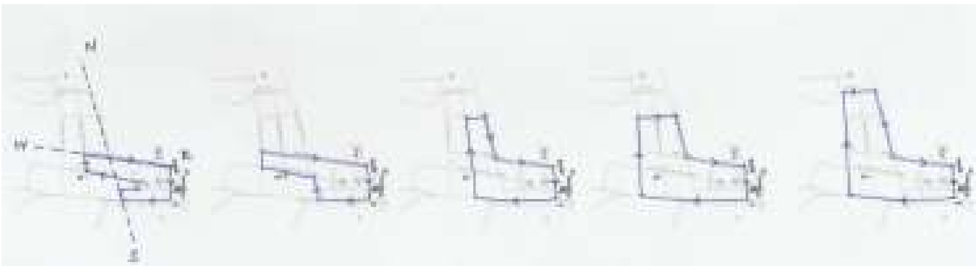

Figure 14: Circumambulation, days 10–14 *Randoli perahera.*

Table 4: *Randoli perahera.*

Day	Length of divine and earthly axis (x)	Length of rest of circumambulation (y)	y/x	$(x+y)/y$
10	570.05 m	846.61 m	1.49	1.67
11	605.6 m	859.58 m	1.42	1.70
12	556.43 m	1131.29 m	2.03	1.49
13	556.43 m	1336.86 m	2.40	1.41
14	698.21 m	1436.34 m	2.06	1.49

These results show that, inner rituals are more spiritual and closed to sacred geometries, than outer parades. Temple priests believe the same. Repeated patterns of circumambulation of parades in a clockwise movement do highlight the temple square (Fig. 15), as the most sacred. The spiral movement of parades could be related to the golden spiral (Fig. 16) which represents the same temple square, as the sacred origin. Furthermore, historical evidences prove the origin of Kandy was in the same place, associated with the story of a Brahmin (sage), who resided at this place, having transcendental experience. The sacred geometry of Kandy city is primarily guided by sacred geography, the topography of the place, and the formation of the triangular-shaped valley by the three surrounding mountains [19] (Fig. 17).

5 SUSTAINABLE CITY GEOMETRIES

5.1 Architecture and landscape of the traditional city

Architecture, urban landscape and the social cultural system of the traditional city, manifest the agreement, with the sacred geometry and the sacred geography (Table 5). In this geometrical model of the city, the dimensions of centre and axis are more sacred, while the city landscape, topography and geography, exist at the bottom level, uniting with the rest of

Figure 15: Spiral movement.

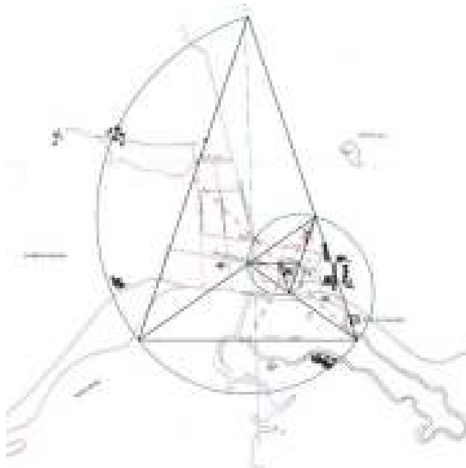

Figure 16: Fibonacci spiral.

Figure 17: Kandy city is in a triangular-shaped valley enclosed by three mountains.

other levels or dimensions and the origin/unity. The traditional city is the result of all the dimensions being organized in the same order of nature, divulge unity and multiplicity in the place; signify that, the worldly dimensions sustain with the sacred dimensions. All the physical components establish a link, by means of sacred geometry, to unity. Sacred physical elements; mountains, water and trees or forest are interwoven in the city landscape, responding to the triangular-shaped valley and the volume of the valley, the pyramid. The resulting city is in unity of harmony, following the order of sacred geometries, establishes sustainable city geometries. Continuous rituals establish sacred geometry spatially and temporarily, strengthen the place attachment, with its origin, the sacred dimensions. The city landscape and architecture manifest this understanding, reserving space for the human component, for walking and experience the city landscape and re-enacting sacred geometries.

Table 5: Sacred geometry in different dimensions and scales.

Sacred geometry	Architecture/city/topography/rituals	Number
Centre/point	Natha temple square (origin of the place)	1
	Inter-section of two primary axis	1
	Total crosses in 1815 plan	16
	Valley (converging effect)	1
	Planting Kapa at 4 temples	4
Line/axis	NS principal axis – Earthly axis	1
	EW principal axis – Divine street	1
	Divine street	2
	Taking sacred insignia to the door step	4
Circle/ circumambulation/ circuits	Dome above the Natha temple	1
	Ruins – (area utilized for the consecration rituals)	1
	Circumambulation the city	10
Square	Temple square	1
	Total squares in the city grid (1815)	21
Octagon	Pattirippuwa	1
Rectangle	Temple of the tooth relic	1
	Pavilion to perform music rituals in temples and temple of the tooth relic	5
Triangle	City form (including buildings, water, fields)	1
	Entrances in temple square make a triangle valley	1
Conical shape	Stupa	2
	gopuram	2
Pyramid	Volume of the valley – including city and the topography/geography	1

5.2 Concluding discussion: Sustainable city geometries and issues today

Today, except for the 15 evenings, when rituals take place once a year, the streets are overcrowded and dominated by cars and other vehicles, exhausting the bodily understanding of the place. The divine agreement between the place, architecture, people, with the unity, is disturbed, and guided by contemporary developments. What could be missing today is, as we are learnt to perceive, each dimension as a separate entity, and our city planning regulations, policies, and design aspects focused only at the bottom level of the place, where only the three dimensional buildings, streets and city landscape exist physically; we don’t realize how these sustain with the sacred origin of the place, the unity.

6 CONCLUSION

This research disclosed that performing *Esala perahera* establishes sacred geometries, re-enacting the place spatially and temporally, revealing holistic dimensions and dynamics of place, signify the birth of the place; affirming Plato’s idea of Lambda. All the dimensions of the traditional city Kandy, are holistically inter-related, following the order of nature; unity and multiplicity, and systems of proportions. The city landscape manifests the agreement between sacred geometry and geography. Three dimensional components; buildings, streets, landscape of the city has the co-relationships with other dimensions, sustaining the worldly dimensions with the origin, the unity. The resulting city establishes sustainable city geometries, while continuous rituals re-establish the place; weaving the place by means of sacred geometry, empowering the body–place attachment with the origin. In conclusion, this research approach has opened more insight, to understand sustainable city geometries.

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SECTION 5
SUSTAINABLE REGENERATION AND LIVEABLE PUBLIC SPACES (SPECIAL SESSION ORGANISED BY M. SEPE)

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URBAN TOOLS AND GOOD PRACTICES: REALIZING SUSTAINABLE PUBLIC SPACES

MARICHELA SEPE
ISMed National Research Council – DIARC University of Naples Federico II, Italy

ABSTRACT

The research – titled *Public Spaces. From Principles to Practice* – illustrated in this paper was carried out by the author in the framework of the Urban Maestro New Governance Strategies for Urban Design Horizon 2020 research project and the INU Community Public Space, the latter coordinated by the author. The Urban Maestro Project – coordinated by the UCL and in partnership with UN-Habitat – "looks at the ways European cities are being designed and financed, focusing on innovative ways of generating and implementing urban spatial quality". Among the objective, the project compares experiences in Europe to international practices. Accordingly, the author, as a member of the Advisory and Support Group, shared the good Italian practices in the public space field. The Community Public Space has the objective to collect best practices of public space in Italy, starting from the Charter of Public Space, which was adopted during the second Biennial of Public Space held in Rome in 2015 and updated during the 2019 Biennial. The Charter is composed by 50 principles that are a sort of guidelines for liveable and sustainable public spaces. In order to comprehend the relationship between theory and practice and verify the validity of the Charter after 10 years of its creation, about 30 case studies were collected. The cases are all Italian and quite recent, except two – Piazza del Campo in Siena and Piazza Chanoux in Aosta – which, although hold, are always contemporary in their uses. The general framework which emerges shows different design, planning, cultural, geographical, social and financial factors that can determine the quality of a public space. Starting from these premises, the methodology and main results of this research will be illustrated. Emblematic case studies with particular attention to sustainability will complete the paper.
Keywords: urban design, sustainability, public spaces, best practices, urban regeneration.

1 INTRODUCTION

Public spaces are places which are designed to be used by the public and realized with public funds. The typology of the public spaces in the last years changed, welcoming new functions, materials, urban furniture, trying to meet the always widening needs of people, including: differentiated lanes for sport, walking and cycling, wireless and QR codes to have information of many kinds, games for all ages and abilities and specific design for the protection by flood and other environmental events [1]–[11]. Nonetheless, the public space does not always give an added value to the area or to an urban regeneration project; accordingly, a Charter of Public Space was carried out and adopted in the framework of the second Biennial of Public Space of Rome [12].

The present research – titled "Public Spaces. From principles to practice" – was carried out by the author in the framework of the "Urban Maestro. New Governance Strategies for Urban Design" Horizon 2020 research project and the INU Community Public Space, the latter coordinated by the author.

The Urban Maestro Project – coordinated by the UCL and in partnership with UN-Habitat "looks at the ways European cities are being designed and financed, focusing on innovative ways of generating and implementing urban spatial quality". Among the objective, the project has the comparison of the experiences in Europe to international practices. Accordingly, the author, as a member of the Advisory and Support Group, shared the good Italian practices in the public space field.

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The Community Public Space of the Italian Institute of Urban Planning (INU) has the objective to collect best practices of public space in Italy, starting from the Charter of Public Space which, as aforementioned, was adopted during the second Biennial of Public Space held in Rome in 2013 and updated during the 2019 Biennial. The Charter is composed by 50 principles that are a sort of guidelines for liveable and sustainable public space. In order to comprehend the relationship between theory and practice and verify the validity of the Charter after 10 years of its creation, about 30 case emblematic studies were collected. The public spaces were chosen in basis on seven categories, including waterfronts, squares, gardens, parks, transportation open-air hubs, nature paths and projects on large scale. The cases are quite recent except two – Piazza del Campo in Siena and Piazza Chanoux in Aosta – which, although hold, are always contemporary in their uses [13].

Starting from this premises, the paper will show in the second section the methodology used for the collection of information. The original method is called QPS-D@taC – Quality Public Space D@ta Collection. Section 3 will report the main principles of the Charter and Section 4 will show four case studies which are particular emblematic with respect to their sustainability achieved in different ways. Finally, Section 5 draws the observation and conclusion. All the case studies are related to one or more principles of the Charter. The general framework which emerges shows different design, planning, cultural, geographical, social and financial factors that can determine the quality of a public space.

2 THE METHODOLOGY

The public spaces which were chosen are based on seven categories, including waterfronts, squares, gardens, parks, transportation open-air hubs, nature paths and projects on large scale. The description of the chosen spaces – carried out using the QPS-D@taC – Quality Public Space D@ta Collection method – is realized through a database, constructed collecting the information, images and planimetries useful both in the phase of design and realization of a public space, and in the management phase. Information relative to the success of the space and its presence – where there is – on the social networks are also inserted.

The element 1 to collect is the year of realization. The element 2 is the planimetry or a drawn of the project that make understandable the shape and/or the position of the public space with respect to the surrounding territory.

The element 3 is the city where the space is located and its address. The element 4 is the measure of the surface that covers the area. This data has the function to make comprehending, together with its localization, the "urban weight" of that specific space in the context. It is a physical data but allows to comprehend the wideness of the project intervention.

The element 5 consists in the institutions which are involved. This data is useful to comprehend if and what public entities are involved in the process of realization of the space and if the private sector is involved. The presence of public entities makes clearer the will of the administrations to realize a space that is public and is for the public and, in that case, in what phase of the construction the private sector contributes (namely, in the executive project or in its management). The funds (element 6) is another useful data and is connected to the previous one because it needs to indicate the whole amount, both the public and private ones – where used – of them used to realize the public space. The presence of an urban or urban planning project (element 7) which is the general framework for the realization of the public space makes comprehending both the used planning tool and the wideness of the operation, namely if the public space is part of a greater project of regeneration, or if it is a project which only concerns the public space in object.

The element 8 consists in the policies which are carried out for the specific public space, but, as the previous data, in the case in which the space has been realized in the framework of a wider project of regeneration, may concerns a wider area.

The element 9 is the kind of uses. This is an information that serves to frame what are the potential activities that are thought for the specific public space and what are those that have been really carried out. This data gives the information also as regards to the success of the project (element 10). The presence of many activities allows the use by people of different ages and then a greater possibility of attendance and satisfaction. The images (element 11) that are collected give the visual illustration of what is described in the database, while the data concerning the factors (element 12) which testify the success of the case study offer a diversified frame of the modality of use, attendance, cultural events and presence on the social networks. In particular, the data concerning the presence on the social networks, although not exhaustive, because the presence of that public space as a background of a picture does not guarantee that the space is agreeable and of success, offers in any case – within a wider framework of information – a news on the typology and quantity of users and on their perception (trough the kind of hashtags, number of followers and likes, or numbers and kinds of comments).

Finally, the database contains the main bibliographical and website references (elements 13–14) and constitute the sources from which information on the public space were collected. This information is collected together with those provided by the technicians and professionals who worked in different way in the realization of the cases in object [13].

3 THE CHARTER

The Charter of Public Space aims at serving all those who believe in the city and in its extraordinary ability for hospitality, solidarity, conviviality and sharing; in its inimitable virtue in encouraging social interaction, encounter, togetherness, freedom and democracy; and in its calling for giving life to these values through public space. At the same time, cities show the worsening of economic, social, ethnic, cultural and generational inequalities. Public space must be the place where citizenship rights are guaranteed, and differences are respected and appreciated [12]. In the following, the main principles are reported.

The charter is based on a wide and inclusive concept of citizenship that goes beyond its legal definition. All in their capacity, as users, are "citizens" and have the same rights and duties with regard to the public space.

I. Definition of Public Space

6. Public spaces are all places publicly owned or of public use, accessible and enjoyable by all for free and without a profit motive. Each public space has its own spatial, historic, environmental, social and economic features.

7. Public spaces are a key element of individual and social well-being, the places of a community's collective life, expressions of the diversity of their common natural and cultural richness and a foundation of their identity, as expressed by the European Landscape Convention. The community recognizes itself in its public places and pursues the improvement of their spatial quality.

8. Public spaces consist of open environments (e.g. streets, sidewalks, squares, gardens, parks) and in sheltered spaces created without a profit motive and for everyone's enjoyment (e.g. public libraries, museums). Both when they possess a clear identity, can be defined as "places". The objective is that all public spaces should become "places".

10. Public spaces, whenever safeguards of natural or historical value allow, must be made accessible without barriers to the motorial, sensorially and intellectively handicapped.

12. Conversely, public spaces which are not yet accessible and/or usable must be considered as “potential public spaces”, and therefore as a precious resource for the strengthening and renovation of the existing system of public space, and thus of urban quality as a whole.

II. Typologies of public space

13. Public spaces can be distinguished in: a) spaces that have an exclusive or prevalent functional character; b) spaces that presuppose or favour individual uses; c) spaces that, by mix of functions, form, meanings and by connecting the built with the non-built, have the prevalent role of aggregation and social condensation. In the web of these latter functions is the essence of the city.

14. Public spaces:

a) Are the physical web and support for the movement and the stationing of people and means of transport, from which the vitality of the city depends;

c) Offer precious opportunities for recreation, physical exercise and regeneration for all (parks, gardens, public sports facilities);

f) Promote conviviality, encounter, and freedom of expression;

g) Are an integral and meaningful part of the urban architecture and landscape, with a determinant role in the overall image of the city.

15. For the above characteristics, they represent the principal resource available to public administration on which to build integrated policies and to a broad range of urban planning, of morphological and functional upgrading of the urban fabric and of social and economic regeneration.

III. Creation of public space

16. Every public space should be designed with full consideration for diversity.

18. It is advisable for decisions regarding the creation, the management and the enjoyment of public space to be subjected to clear and transparent participatory processes with all interested stakeholders. Such processes, be they institutionalized, regulated or spontaneous, are to be regarded as a right of urban residents and not as unilateral initiatives of government.

19. It is vital to regard urban public spaces as a continuous, articulated and integrated system, to be developed from the scale of neighbourhoods relationships to vast environmental spaces, to facilitate the diffusion of its enjoyment within the whole community and to raise urban quality.

23. Eliminating and/or overcoming the physical barriers that impede or limit access to certain categories of users is therefore a priority goal to pursue both in the design of new public spaces and in the adaptation of existing ones.

25. Design must pay full attention to maintenance and management costs by using simple solutions and materials that are durable, simple, easily replaceable and climatically adequate.

27. The role of urban public spaces for environmental regulation (drainage, microclimate…), the environmental protection of ecologically valuable areas (river banks, wetlands, biodiversity) and the reduction of urban environmental risks must be taken into account both in the design and management phases.

28. In areas destroyed by catastrophic events public spaces must be the starting point of the reconstruction process.

29. The creation, improvement and management of public spaces can provide an opportunity for new job creation and private investment, also in harmony with the provisions of the European Landscape Convention.

30. Interdisciplinary and participatory approaches to public-space design are an exciting opportunity for planners, landscape professionals, architects, technicians and designers to express fully their social roles.

VI. Enjoyment of public spaces

43. All citizens, regardless of their role, are users of public space. All of them have the right to access and enjoy it in complete freedom, within the rules of civic coexistence. In cities ever more complex and diverse, this requires democratic processes, dialogue and regard for diversity.

45. The enjoyment of public space involves rights and duties. The right to enjoy adequate public spaces involves the duty to contribute to this goal through freely chosen modalities that can vary from the mere adoption of responsible individual or collective behaviours to involvement in initiatives of active citizenry.

46. The enjoyment of public spaces is a fundamental ingredient for determining and applying indicators of their quality, to be employed throughout the entire creation-management-enjoyment cycle.

48. Events and interventions defined as temporary, included the so-called "urban public art", particularly if linked to an overall strategy, are a form of enjoyment of public space that can become a "good practice" to confer meaning and urban quality to "waiting spaces" rapidly, at low cost and with a strong involvement of the community.

49. The enjoyment of public space is intimately linked to its civil, respectful and responsible use. The quality of public-space enjoyment is therefore tied not only to the availability, quality, mutability, adaptability and maintenance level of public spaces, but also to the behaviour of individual citizens.

50. The good use of public spaces is closely linked to their mutability and adaptability in relation to the changing needs of citizens.

4 CASE STUDIES

The research identified emblematic public spaces including waterfronts (such as Matteotti waterfront in Pescara, the Old Port in Genova, the Natural Park on the waterfront in San Benedetto del Tronto, the Foro Italico in Palermo), squares (such as Piazza Matteotti in Catanzaro, Piazza Goldoni in Trieste, Piazza dei Libri in Catania, Piazzetta Mediterraneo, in Palermo, Piazza del Campo in Siena, Piazza Chanoux, in Aosta, Nuova Monteluce, in Perugia, and Corso Nazionale and Piazza Monumento, in Termoli), gardens (such as Sensory garden in Rupicole park in Rome and the Public Garden in San Donà di Piave), parks (such as Parco Portello in Milano, Cavalieri di Vittorio Veneto in Torino, Children Park in Lecce, Music Park in Cagliari), transportation open-air hubs (such as New Civic Centre in Scandicci, Enrico Berlinguer Square, Toledo Station in Napoli and Railway Station in Padova), nature paths (such as RespiArt, Pampeago, in Val di Fiemme, Dosso di San Rocco in Trento, Art-nature path in Val di Sella and Bicycle Lane along the Nera river in Narni) and two project on larger scale (Gardentopia Gardens in Matera and Open Lab Project in Bologna. Of these, the public spaces that are chosen as case studies are: the Waterfront Natural Park in San Benedetto del Tronto, Sensory garden in Rupicole park in Rome, the nature paths of RespiArt, in Val di Fiemme, and the bicycle lane along the Nera river, particularly emblematic for the sustainability [13]–[17].

As regards the Waterfront Natural Park in San Benedetto del Tronto, it is located in the Marche, Central Italy. The park, of about 2,700 m^2, was realized in 2007. The Institution which has involved is the San Benedetto del Tronto Municipality as well as the used funds were municipal. Detailed plan of public initiative for hotel accommodation and related concessions was carried out in order to realize the waterfront.

The main policies which were activated include: the free concession of private spaces for public use, the creation of an urban space for children and the creation of a space with a naturalistic-environmental matrix.

Many uses have been designed, including walk, run, bicycle, observation and stop. The cycle path that runs along the promenade crosses ten theme gardens and relax areas furnished with seats and both visual and olfactory points of observation. In particular, the Country Garden – with small dunes and an agricultural cart from the Marche region under an arch – reconstructs a typical rural area of the Piceno countryside; the Children's Garden is used for educational games and amusements for children; the Health Garden has medicinal plants which are used for their curative properties; the Citrus Garden, with trees of the Citrus family and a Calamondino, the Mediterranean Garden, with typical essences of the Mediterranean scrub, the palm garden, with 25 species of palms and a bright turf, the Arid Garden with succulents and cacti, the Wet Garden, with a freshwater lake, a bridge and a small waterfall, the Rose Garden, with 27 varieties of roses ("including La Sevillana", which has the characteristic of flourishing several times) have specific aesthetic and ornamental properties and activate the different perceptions. The gardens also serve as access to the bathing establishments and at various times of the year cultural and social events are there organized.

The fruition is of different types. The thematic gardens are all equipped with information guides, tactile maps and plates for each species of plants, which support its didactic function, and are also usable by the blind.

The elements that testify the success of the public space include: the insertion in the network of blogs for opinions on the gardens of the Marche region; the Organization of periodic visits to the theme gardens during the summer period; and the organization of events of different kinds during the year. As a further element that testify the success of this space, although there is no presence of it in the social networks, many web sites contain information about this waterfront and its activities.

Among the gardens, the Sensory garden at the Rupicole Park in Rome is particular interesting. The garden was realized in 2012 in a surface of 4,000 m^2. The property is public and the Institution that is involved in the creation of the space is "Roma Capitale" – Department of Social Services and Health Promotion. The Institutions involved in the management of the garden include: the Department of Social Policies of the Municipality of Rome and the Botanical Garden of Tor Vergata with some researchers and teachers, who carried out activities with the disabled (gardening courses and more); Cospexa social cooperative: Project 96, the Center for Social Integration, Obiettivo Uomo, Iskra, Virtus Italia and the Istituto Sant'Antonio.

The funds for the construction of the space are also public and were given by the Lazio Region – Rome Capital Program, and the funds for the management were given by the Municipality of Rome, Botanical Garden.

The urban planning tool of reference is the 2008 General Regulatory Plan (Italian acronym PRG) Public green and local public services, while the urban project was carried out by the Botanical garden in collaboration with a private studio of architecture (mtstudio). The urban policies and types of use are many. The garden is used two days a week by a nearby association of disabled. Gardening courses are organized, and participants can obtain a certificate. In this way, the garden is kept in order through the courses, without great expenses for the public administration. The goal is to create a space for all residents of the neighbourhood, where recreational activities, socialization, job placement and rehabilitation can also be carried out, such as gardening training courses for people with different forms of disabilities. Other uses include: workshops in green areas for children, teenagers and disabled adults; horticultural therapy and aromatherapy; the management and arrangement of the garden by guests of the accommodation community; integration between the guests of the housing community, the residents of the neighbourhood (children, adults and the elderly) and the institutions of the area.

As regards the fruition, the garden is fully usable from all points of view. There is also a particular sensorial path, which, thanks to the help of a handrail and tactile paving for the blind, allows easy access for the visually impaired.

The parking areas, located along the routes, are of great importance for the elderly, as well as for the people with motor and sensory disability.

With respect to the elements that testify the success of the case study, for the first time, an interaction has taken place between the various social cooperatives that have taken part in the activities planned on the proposal of Cospexa. The Horticultural therapy is a rehabilitative method for discomfort and disability. It consists of encouraging, preparing and supporting the subject in the care and management of greenery, in the cultivation of flowers, vegetables and other plants.

The project includes an age group between 20 and 50 years old, between mentally and physically disabled people, who have attitudes for this type of work. The maximum number of patients is 50. The public administration of Rome was also awarded, and the project won the "Simonetta Bastelli" award in 2013.

As regards the social media, the garden is present on twitter with 703 likes and on Facebook with 2,463 likes.

With respect to the nature path, RespiArt, Pampeago in Val di Fiemme (Sudtirol) was carried out in 2011 in a 3 km route. The property consists of a small public part (the Municipality of Tesero) and in a large private part (the Magnifica Comunità di Fiemme). The project born from a project by the journalist and art curator Beatrice Calamari and the artist Marco Nones. The institutions involved in the project management include Val di Fiemme Tourism Board and Trentino Marketing which help to promote the park. The historic body of the "Magnifica Comunità di Fiemme" (which has managed the forests of the Val di Fiemme since 1111) donates wood for the creation of the works, and the hotels in the Val di Fiemme host the artists. The funds for the construction and the management of the space are constituted by private contributions. The urban planning tools of reference is constituted by the 2010 variant to the General Regulatory Plan of the Municipality of Tesero and other plans for specific areas including the high integrity area E108, the pasture areas E107, and the skiable areas and ski lift systems, D208.

The policies which were activated consist in the concession of spaces for cultural and social events. RespirArt invites visitors to relax in the ever-changing nature, allowing to rediscover the sense of *wonder*, taking the *new* as an unrepeatable opportunity. Atmospheric agents do not damage the works, but complete them, shaping them and changing their colours.

The uses concern the walk and the stop, as well as guided visits to discover nature, art and typical food, and wine products. Outdoor concerts are held in the park at the Latemar theatre, which organizes a large theatrical season. Among the elements that testify the success of the space, RespirArt collaborates assiduously with Italian and foreign artists and cultural associations. The new projects mean that the park becomes not only an artistic, but also a social and cultural centre of reference, such as the case of the "RespirArt Day", an itinerant party with artists, which has reached the tenth edition.

The entrance to the RespirArt park is completely free. During the winter, the park can only be visited with skis, as it is crossed by the Agnello slope of the Ski Centre Latemar. Being a high-altitude park in the Unesco Dolomites, it has not been violated by asphalting, earth movements or other impactful interventions. It runs on mountain paths with small, slightly steep sections. Therefore, it is not possible to access with wheelchairs.

As regards the social networks, the park is present on Instagram with 917 followers and 1,389 likes, Facebook with 1,124 followers and 1,118 likes, and on YouTube there is a presentation video on the Visitfiemme channel.

The last case study of public space is the Bike path along the Nera river and the greenways of the Nera gorges which was realized in 2016 in Narni, in a surface of 11 km.

The Institution which was involved is the Municipality of Narni and the funds come from the "Cycle path along the Nera river" (Narni – Nera Montoro – Oasis of San Liberato) – POR FESR 2007-2013 – AXIS II – Activity b2, and the Project for the enhancement of the banks of the Nera and the greenways of the Nera gorges – POR FESR 2007-2013 – AXIS II – Activity b1.

As regards the urban project, Narni municipal administration implemented the program. The interventions that led to the creation of the Greenways along the Gorges of the Black River were designed by a team of various professionals.

The policies which were carried out are many. The intervention is configured within a complex program of enhancement of the gorges of the Nera river, aimed at: activating an economic process of sustainable development and requalification of the environmental landscape heritage; consolidating a territorial offer qualified in cultural and environmental terms; and stimulating local development and its insertion in the large regional tourist circuits. The goal was to develop a strategic line for the creation of greenways routes and demonstrate how these can be a tool for enhancing the territory and its resources and representing a potential means for alternative mobility for daily movements, recreational activities and tourism.

With respect to the type of use, the project is based on the environmental redevelopment of the area of the Nera River, where the infrastructures and services are concentrated, and runs longitudinally, taking advantage of the waterway and the complex system of paths that develop along the two sides. Along this system, significant polarities are articulated in settlement terms. Furthermore, along the slopes, a series of specific elements of attraction lead the visitor to areas and artefacts of historical, archaeological and landscape interest, villages, abbeys, natural sources, ancient industrial settlements. The park consists of an integrated system of spaces, places of community life and its collective memory and paths for cycle and pedestrian mobility capable of responding to the growing demand for meeting and non-systematic mobility, including tourism and hospitality. It is a space that, promoting the meeting and conviviality as well as offering opportunities for recreation and exercise, has a prevalent role of social aggregation.

Among the elements that testify the success of the path, in 2017 there was a presence of up to 500–600 people passing through. With the creation of a *Temporary Purpose Association* (which deals with animation, provision of services, ordinary maintenance and promotion of the tourist itineraries of the Gorges with the spirit of enhancing the cultural, food and wine, music and sports activities of the area) which manages this area, a further increasing in visitors and passing people is expected. With respect to the social network, Gole Del Nera is on Facebook with 3,071 followers and on Instagram with 1,001 followers.

5 OBSERVATION AND CONCLUSION

The paper has illustrated a research carried out in the framework of the Urban Maestro Horizon 2020 project and the INU Community Public Space. The research has as an object to collect best practices of public space in Italy, starting from the Charter of Public Space which was adopted during the second Biennial of Public Space, held in Rome in 2013, and updated during the 2019 Biennial and, contemporaneously, to verify its current validity.

The method which was used for the case studies is the QPS-D@taC – Quality Public Space D@ta Collection one. The general framework which emerged shows different design, planning, cultural, geographical, social and financial factors that can determine the quality and sustainability of a public space.

The cases concern waterfronts (in Pescara, Genova, San Benedetto del Tronto and Palermo), squares (in Catanzaro, Trieste, Catania, Palermo, Siena, Aosta, Perugia, and Termoli), gardens (in Rome and San Donà di Piave), parks (in Milano, Torino, Lecce, Cagliari, transportation open-air hubs (in Scandicci, Napoli and Padova), nature paths (in Trento, Val di Sella and Nera river) and projects on larger scale (in Matera and in Bologna. Of these, the public spaces that are chosen as case studies include: the Waterfront Natural Park in San Benedetto del Tronto, the Sensory garden in Rupicole park in Rome, the nature paths of RespiArt, in Val di Fiemme, and the Bicycle lane along the Nera river.

The case studies which were chosen for this paper are particularly focused on the social, economic and environmental sustainability. Furthermore, in all the public spaces, many of the principle of the Charter of Public Space are followed. In particular, the first – namely "Public spaces are all places publicly owned or of public use, accessible and enjoyable by all for free and without a profit motive. Each public space has its own spatial, historic, environmental, social and economic features" – 13, 14 and 15 are always followed.

The aims of the study are in this way carried out. In the first case, that of the Natural Park on the Waterfront in San Benedetto del Tronto, the main policies and uses include: the free concession of private spaces for public use; the creation of an urban space for children and the creation of a space with a naturalistic-environmental matrix; the garden to be used for educational games and amusements for children; and the Health Garden with medicinal plants. The Park is easily accessible and is used in all the seasons representing an important place of socialization and its social, economic and environmental sustainability.

In the second case, the Sensory garden at the Rupicole Park in Rome, spaces for all residents of the neighbourhood are carried out, with recreational activities, socialization, job placement and rehabilitation, such as gardening training courses for people with different forms of disabilities, workshops in green areas for children, teenagers and disabled adults; horticultural therapy and aromatherapy; the management and arrangement of the garden by guests of the accommodation community; integration between the guests of the housing community, the residents of the neighbourhood (children, adults and the elderly) and the institutions in the area. The workshop has also the function to contribute to the management of the garden with a small contribute by the Administration. Also in this space, the sustainability in its threefold meaning is respected.

As regards the nature path, RespiArt, Pampeago in Val di Fiemme, the policies which were activated consist in the concession of spaces for cultural and social events while the uses concern the walk and the stop, as well as guided visits to discover nature, art and typical food and wine products. Being a high-altitude park in the Unesco Dolomites, it has not been violated by asphalting, earth movements or other impactful interventions.

The last case was the Cycle path along the Nera river which promoted policies to activate an economic process of sustainable development and requalification of the environmental landscape heritage in order to consolidate a territorial offer qualified in cultural and environmental terms and to stimulate local development and its insertion in the large regional tourist circuits. Also, these two last case studies are projects which take in particular account the sustainability.

The public spaces are mainly realized with public funds, in the framework of wider urban planning tools, and have all activated urban policies that allow an overall and sustainable success.

Finally, the research has now a new goal. Due to the current pandemic event, public spaces were not used for months. Indeed, a new challenge is occurring for the sanitary emergency [18], requiring – as a future step of the study – an update of the methodology and case studies. The flexibility of the method which was used for the collection of the data allows that some factors can be added to the database aimed at verifying how the social and physical distance will be carried out in the public spaces and how, for effect of this distance, the use of the places will change. Furthermore, new data to collect could arise from the updated onsite inspections, including new ways to use the spaces and new equipment and urban furniture which will probably change movements, paces and fruitions.

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GREEN AND BLUE INFRASTRUCTURES AS THE STRUCTURE OF A BIOREGION: THE CASE OF THE PONTINA BIOREGION

ALBERTO BUDONI[1] & LIANA RICCI[2]
[1]La Sapienza University of Rome, Italy
[2]University College Dublin, Ireland

ABSTRACT
European Commission (2013) defined Green and Blue infrastructures as a strategically planned network of natural and semi-natural areas designed and managed to provide a wide range of ecosystem services. They constitute an important reference for building effective approaches to urban and regional planning if integrated in the bioregional vision. A vision that starting from Berg's founding contribution has developed in various countries and in Italy through the territorialist school of Magnaghi. The idea of bioregion is based on the co-evolutionary relationship between humans and nature which requires transdisciplinary research work. This work can refer to two key concepts: structural invariant and accessibility. The first considers natural elements and anthropic "sediments" that characterise the landscape by combining nature and culture. The second concerns the way in which human beings move and use, interact and enjoy living in a space. The fruition of the physical space, the ecological and mobility networks together with the analysis of the security perception, affordability, and beauty/wellbeing for the human beings can be understood within the green and blue infrastructures system as the structure of a bioregion. In particular, the water represents a natural resource where the nature-human interaction needs to be particularly well managed to ensure sustainable and inclusive blue and green infrastructures. The competitive uses of water and the over exploitation of water sources led to substantial negative environmental and social impacts (e.g. water shortage and seawater intrusion, flood risk, water pollution). The paper discusses the case study of the Pontine bioregion which includes all these aspects. In the Municipality of Latina, located at the centre of the Pontine bioregion, a project co-funded by the EU (Upper project-Urban Innovative Actions) aims to define a bioregional structure based on the integration of ecological networks, mobility networks and new forms of public–private partnership.
Keywords: infrastructures, bioregion, heritage, structural invariants, commons, social-contracts.

1 INTRODUCTION

In the EU, green Infrastructure strategy, the Green Infrastructure (GI) is defined as "a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services. It incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas. On land, GI is present in rural and urban settings" [1]. In a recent review on the implementation of the EU GI strategy, it is stated that the Natura 2000 network is the "backbone" of the GI, together with "natural and semi-natural spaces outside Natura 2000, such as parks, private gardens, hedges, vegetated buffer strips along rivers or structure-rich agricultural landscapes with certain features and practices, and artificial features such as green roofs, green walls, or eco-bridges and fish ladders" [2]. The same review highlights that although GI are promoted in the EU Urban and Regional Policy and several Member States established national ecological networks GI are still limited at EU level. The review concludes that GI are mainly implemented at a small scale, neglecting their potential economic and social benefits [2]. This conclusion is reflected the activities undertaken by the Member States [3] which are interesting and innovative but are mainly

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complementary to other more consolidated sectors and intervention policies (e.g. energy policies), demonstrating a "fragmented" and local application of the green infrastructure concept, and giving little attention to the complexity and the large scale relevance (regional, national and transboundary nature) of the ecological networks. From the experience of the Green Crown of Turin (Corona Verde di Torino) which worked on the regional scale it emerges that in the collective imagination the green infrastructure refer to parks and natural conservation, without grasping their environmental restoration function, morphology, offer of integrated services but also of local development [4]. The paper discusses the application of the bioregional theoretical framework for an integrated and multi-level deployment of Green and Blue Infrastructures (G&BI). It first provides a review of the structural invariant concept in the bioregional vision and after explores the potential of social contracts for G&B Infrastructure planning and design focusing on water infrastructures. In Sections 4 and 5 the paper analyses case studies from the Upper project to characterise how the bioregional approach experimentation can emerge and evolve into the integration of ecological networks, mobility networks and new forms of public-private partnerships. The paper concludes that to achieve an effective and sustainable distribution of G&BI the combination of the bioregional vision with social contract strategies is most promising to build and effective integrated territorial approach.

2 STRUCTURAL INVARIANTS OF A BIOREGION

2.1 The bioregional vision

The bioregional vision as we know it, has its cultural roots in Europe and the United States USA in the second half of the nineteenth century, but the first definition of bioregion was formulated by Berg and Darsmann [5] in the late 1970s. This definition focuses on an integrated vision of natural features and of how communities have historically interpreted their relations with the environment rather than on ecological determinism, "In declaring that it will be reinhabitants rather than scientists who define 'home place', bioregionalism was cut forever from the tether of a more sterile biogeography" [6]. Two essential environmental and social issues emerge: the disconnection between humans and natural environment; the search for constructive strategies to link the protection of social networks and economic conditions with the pragmatic use [7] of planning tools or environmental interventions [8]. Furthermore, three main currents of thought can be highlighted [9]: the ecocentric founded on a deep ecological morality and an environmental philosophy that promotes interspecific equity, rejecting the dichotomous view of human beings and nature; the scientific-managerial based on the control and manipulation of the non-human environment, it replaces the local knowledge with external logic aiming at conservation of sensitive areas in favour of economic growth; the socio-environmental that highlights the contradictions of the dominant modes of production, re-evaluating the local knowledge and the ethics of the places. Only the latter is adequate to protect biodiversity and addressing individual and collective social and environmental justice issues.

2.2 Bioregional citizenship

In this perspective the bioregional citizenship concept enable to "sees beyond a physically defined bioregion, recognises the emotional ties people feel beyond their immediate living space, and includes environmental justice as a useful concept to advance the bioregionalist agenda" [9].

This concept is particularly appropriate to face the new phase of urban regionalization or the new regionalism [10]. It is no longer enough to interpret the condition of the contemporary spatial development with the idea of a metropolis that grows progressively incorporating the small centres. The urban expansion is no more based only on contiguity or commuting to and from a metropolitan centre. New settlements are generally composed by widespread residential or microproductive urbanization of agricultural areas (sprawl), where tertiary functions as shopping malls or high added value services are located. This dynamic is produced by what Soja [11] calls synechism, that is a system polycentric settlements of the urban region that works as an entity that includes the metropolitan city and it not only under his influence. In Italy, the bioregionalist approach has been recently integrated into urban and regional planning, putting emphasis on the ability of the bioregion to self-sustaining through a new coevolutionary relationship between inhabitants-producers and the territory; a relationship that is based on shared and community-based heritage values and commons [12]. This approach acknowledges that contemporary urbanization process concerns the whole urban region including cities and towns. From the denser urban fabrics of the metropolitan areas to the discontinuous rural settlements on remote inner areas, a plural and multicentric vision contribute to rebuild the urbanity through new synergic rural-urban relationships [12].

The bioregional perspective is a promising conceptual framework addressing the fragmentation in the implementation of G&BI projects and plan as well as of their integration into the planning process. It also provides an analytical framework of the new urban regionalism starting from some reference points:

- the physiographic structures and the characters left by settlements evolution are the heritage that provides or will provide retro-innovation elements for alternative transformation dynamics rather than passive determinants of the settlement organization;
- the ability of the inhabitants to recognize the both physical and immaterial territorial heritage, is the main factor of regional performance and the key catalyst for increasing global and local interaction.

2.3 The concept of structural invariant

From the two previous considerations two lines of research emerge. The first considers natural elements and anthropic "sediments" that characterise the landscape by combining nature and culture. These "sediments" are often recognized as heritage to be protected and preserved and each country determines how to do it. In Italy, heritage protection and conservation have a remarkable tradition and in the last three decades a significant innovation has taken place in landscape and urban planning.

The concept of structural invariant has become a point of reference which, mainly from the Tuscany region, has spread to the other Italian regions.

By structural invariants the law of the Tuscany Region means the specific characteristics, the generative principles and the rules that ensure the protection and reproduction of identified territorial heritage components. Characters, principles and rules concern: a) the morphotypological and landscape aspects of the territorial heritage; b) the relationships between the constituent elements of the territorial heritage; c) the generative, utilization, maintenance and transformation rules of the territorial heritage which ensure its persistence. The identification of structural invariants concerns the whole territory, including its derelict parts (Art.5 of the Regional Law n.65/2014). The protection of these elements significantly contributes to shape the territory but it is not sufficient to achieve positive results; the relationships between the territory itself and the invariants are neglected, leading to the loss of its structural values and to its transformation into a “museum object”.

The second line of research concerns the way in which human beings move, use, interact and enjoy living in a space. It is necessary to investigate the living environments not only through sociological and ethnographic analysis but also through the study of population mobility which in Italy is highly connected the definition of labour market areas (e.g. the Made in Italy industrial districts) [13] as the main references for the delimitation of a bioregion. More than a new administrative district, this delimitation is recognising the boundaries of a living environment that contribute to build a bioregional citizenship and territorial heritage. This recognition tends to be limited to accessibility networks, spaces of production, and service or functions. Although leisure and recreational services may be located in protected natural areas they exclude large portion of the bioregion leaving marginalized and abandoned spaces to polluting and illegal uses damaging the “sediments” of the territorial heritage and its relationships with the context. G&BI are a suitable tool re-establishing the links between context and “sediments” if there are not considered as a mere replacement of grey infrastructure. Nature Based Solutions (NBS) become effective building blocks of G&BI, if their technologies integrate environmental efficiency, and culture to rediscover environment, landscape, and paying attention to their systemic relationships G&BI become the structure of a bioregion affecting both the physical structure and the collective image.

3 EXPLORING SOCIAL-CONTRATCS FOR GREEN AND BLUE INFRASTRUCTURES

3.1 G&BI approach and the role of the water resource

The emphasis on green and blue connections at regional scale is frequently linked to ecological networks end related ecosystem services. Networks and particularly green corridors are considered with multiple functions such as climate change adaptation, water management and drainage, biodiversity conservation carbon sequestration, leisure and recreational space. Despite its regional accent G&BI approach promotes focus on natural processes, on connectivity and multifunctionality, and involves collaboration across disciplines. It shifts the attention of planning from single functions such as drainage, leisure conservation neglecting the natural processes, to synergizing of knowledges, integrating ecosystems services [14], [15], and ecological network language and theory. Integrating the (bio-)physical dimensions with the on socio-cultural, institutional, and political conditions lead also to identify a series of barriers for G&BI uptake such as the lack of economic and social evaluation and the lack of integration with other urban (or spatial) dimensions. If some authors argue that economic value with its benefits and appropriate finance methods should be introduced to develop credible business projects for informed decision-making of local authority [16], others maintain that economic evaluation of ecosystem services and G&BI impacts lead to the commodification of fundamental non-renewable resources undermining their sustainability and equity dimension [17]. The adoption of a bioregional “scale” and approach can contribute to overcome this dichotomy linking the ecological dimension to the local economic dimension. In addition, given the complexity and the conflicts among socio-cultural, bio-physical, economic, institutional and political actors the bioregional vision can be an affective framework for decision-making and projects/initiatives development and implementation, providing a shared territorial platform and sets of values based on the local economic, environmental, socio-cultural and political context.

In the urban region the water represents a natural resource where the nature-human interaction needs to be particularly well managed to ensure a sustainable and inclusive blue and green infrastructure (e.g. flood risk, water shortage, water pollution). In response to resource constraints, growing populations, and climate change, different approaches for urban water sustainability have been developed with focus decentralization, integration, resource efficiency, affordability, participation, or restoring natural systems [18].

The privatisation of water services and infrastructure is acknowledged to be having a major impact on the governance of water and on its physical and social impacts, leading to exploitation, and the exclusion of social and ecological interests in urban water decision-making [19], [20].

3.2 A new governance through social-contracts

The transition towards new governance regime and the reorganisation of the agency behind the reconfiguration of the urban infrastructure has been barely considered in the planning and design of G&BI. If attention has been given to the adaptation of infrastructure and services to privatisation or liberalisation and partially to the reconfiguration of the triad provider, regulator and user, the range of actors and technologies working in-between this triad as “intermediaries” is neglected [21]. Integrating this in the bioregional vision helps to understand how changes in one set of actors, activities process has implications elsewhere in water sector for instance. The reconfiguration of the water infrastructure dependent on perceptions, values and cognitions and is often associated to normative notions to describe desirability of transformation. Actors shapes the infrastructure system through agency and governance, and the type of political-, value- and power-based processes. The transformation processes rebalance rights and responsibilities between the different actors; an infrastructure system mediating the relationship between resources, providers and users/co-providers [22] is also distributing rights and responsibilities, is based on and is shaping the dynamic interaction between actors, building a system of rules and social networks. Those interactions can be translated into a “social contract” such as a plan which can constrain or limit public authority and power and protect citizens rights, according to specific assumptions on rights and responsibilities. In addition, a “social contract” allows to experiment with new forms of commons management [23]. The River Contracts are the result of national and European environmental regulatory frameworks. The river contracts were introduced in France and Italy in the early ’90s in response to specific environmental and water management issues defined during the 1992 Rio Summit. The introduction of different types of land pacts or contracts is meant to integrate the complexity of the natural environmental and of the actors involved in their management and governance and improve community participation. River Contracts are voluntary tools grouping different actors and stakeholders in a legal entity for a sustainable management of water resources along a water basin. They are strategic and negotiated planning documents, aiming to promote the enhancement of river environment e.g. safeguarding from flood risk contexts, and the involving a wide of local, regional or national institution and stakeholders across different scales and sectors.

In Sections 4 and 5 is illustrated the case study of the Pontina bioregion. In particular, Section 4 discusses how the local authority drafted the Upper project, highlighting the problems that are emerging to overcome the traditional grey infrastructure approach. Section 5 investigates how the coastal and river contracts introduced in the Pontina region can demonstrate their potentials and shortcoming as a planning tool for promoting and integrated bioregional approach for G&BI.

4 DEVELOPING THE UPPER PROJECT IN THE PONTINA BIOREGION

4.1 Objectives and risks of the Upper project

The case study of the Pontine bioregion allows to apply theoretical reflections above through various research experiences and including the Upper project. It's project co-funded by the EU Urban Innovative Actions, an initiative promoting pilot projects for sustainable urban development. The Municipality of Latina is the promoter of the project that is ongoing (it will end in August 2022) and the authors of this paper are member of the project working group of Sapienza University and external expert on environmental planning and water infrastructure in coastal settlements. The Upper project has as primary objective the construction of 3 productive parks for the production of plants and the definition of advanced Nature Based Solutions (NBS) to be applied on 8 pilot sites. Upper is a complex and innovative project that develops on three integrated intervention lines: that of environmental requalification and innovation of green technologies implicit in the NBS concept; the economic one aimed at promoting both the formation of startup companies dedicated to NBS and the development of a market in the Green Public Procurement of NBS making the town of Latina become a reference for the other municipal administrations of the bioregion; the social one linked to the insertion into the world of work of disadvantaged inhabitants through training courses on the care of plants and the experimentation of new models of Public Private Partnership (PPP) concerning not only the companies that will manage the three productive parks but also the citizens who they may be involved in the management of the testing areas after their renovation. The test sites and productive parks are located in different types of areas, almost all within the urban centre but with different characteristics not only for the type of soil, more or less rich in vegetation or completely waterproofed, but above all for the context. In particular (see Fig. 1): a) green areas equipped for recreation (n.2); b) green areas making up the central place of a square (n.5); c) degraded green areas in undefined public spaces (n.3–4); d) degraded areas on the edge of urban fabrics (n.6); e) areas bordering urban areas with significant levels of naturalness (n.9); f) areas adjacent to water courses with or without hydraulic risks (n.1–8–10); g) areas for car parks with or without trees (n.2–7). The social contexts of the areas are also different from one another, ranging from areas with affluent populations to areas with most vulnerable citizens because they are migrants or belong to the Roma ethnic group. This physical and social variety of the areas allows different types of applications which, if they give good results, can be used in many other cities, at regional and national but also European level.

The integration between the three areas of intervention is has been showing some problematic issues and is likely to have a negative impact on implementation times and on the quality of the entire project. The renovation of the areas is managed by Latina Municipality through public contracts which are quite complex and whit uncertainties and possible bureaucratic hitches due also to the anti-corruption rules. This situation undermines the innovation potentials of the projects with a prevailing traditional approach. The new green infrastructure are considered as grey infrastructure in the design, restricting citizens' participation and social learning process. The other problematic node is the difficulty of creating start-up companies in a new market and in a complex regulatory and bureaucratic. Both issues need a broad definition of NBS and a transdisciplinary multisectoral approach including extensive information and dissemination activities closely connected to the areas of experimentation.

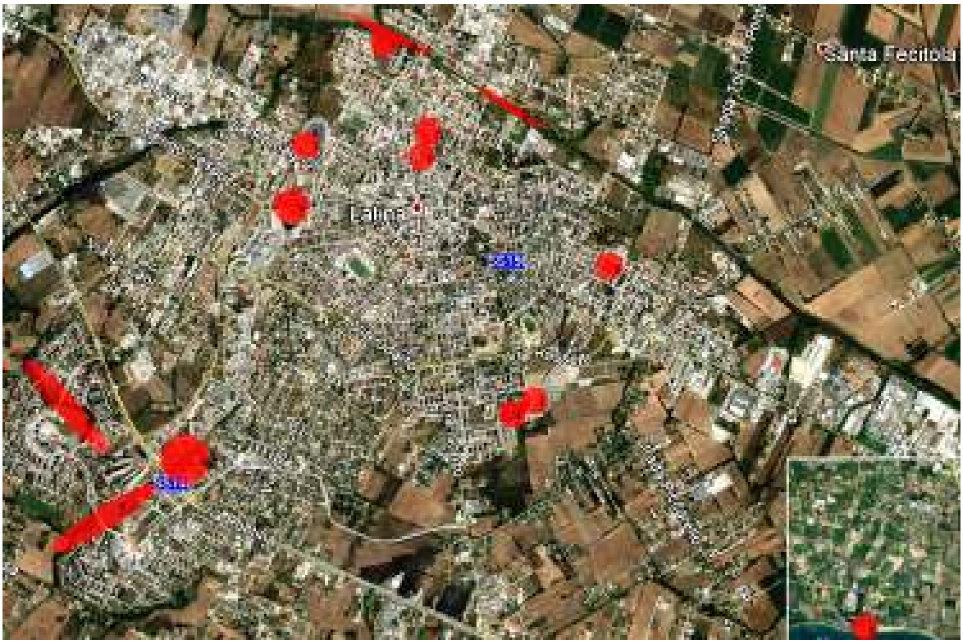

Figure 1: The areas of the Upper project. *(Source: Comune di Latina [24].)*

4.2 NBS as systemic "connectors" of the Pontine bioregion

The bioregional vision is fundamental to address these issues. First, a design of "truly green" areas, with NBS not limited to technological solutions without relations with the context, cannot be separated from the entire abiotic system and imbalances induced by anthropic pressures; from the core areas (sources of biodiversity) which must be linked to areas with poor naturalistic value but strategic to build an ecological network. In the case of the Pontine bioregion and the territory of the Municipality of Latina these aspects are really important. The integral reclamation has profoundly altered the ecosystems, reducing forest cover, replacing most of the hydrographic network with artificial water bodies, canals and water pumping systems. The foundation of Latina (formerly Littoria) in 1932, as well as the other "new" towns of Sabaudia and Pontinia, was not envisaged in the initial planning of land reclamation. The plan was supposed to include only the hydraulic works and the division into farms, as well as the assignment of land and housing to settlers who would have access only to services for rural life in nearby rural villages. The success obtained in giving a new structure to the territory led to the formation of towns that were meant to exemplify the Fascist ideal of the rural town. The rural town shouldn't be "contaminated" by urban growth and far from the railways that could have facilitate development. However, Latina was soon an anomalous with the role of provincial capital acquired in 1934 and its tertiary endowment. After WW2, the Agro Pontino became one of the hubs of a new industrial development thrust promoted by the Cassa per il Mezzogiorno (the national fund for development of Southern Italy). Although the number of inhabitants has grown significantly (Latina is now the second largest city in Lazio, with over 125,000 residents), the crisis of the Pontine manufacturing industries and the abolition of the Cassa per il Mezzogiorno have diverted economic growth towards the tertiary sector and the transformation of agriculture towards more profitable segments such as fruits and vegetables. On the other hand, building expansion has grown. Along with the construction of shopping centres and tertiary functions integrated with residential housing, sprawl settlements have developed. In addition to consuming land and compromising agricultural uses, sprawl modifies the landscape and the identity of the territory. The city of Latina has therefore become the most important centres of the homonymous Province and of the Pontine bioregion constituted (see Fig. 2) by the Pontine plain, by the western side of the Lepini mountains, by the Amaseno valley. All these morphological elements are closely connected by the hydrographic network and the groundwater in the diversity of the geological conformation: limestone that of the mountain area, marsh that of the plain, dune that of the coastal belt. The bioregion, with the other cities of Terracina, Sabaudia, Cisterna di Latina, San Felice Circeo and the centres of the Lepini mountains is the main living environment for about 300,000 inhabitants who, from the analyses on mobility, also maintain significant relationships with Rome and with the contiguous areas to the bioregion (transition zone of the bioregion). Like Latina, the entire plain the bioregion is affected by urban sprawl, industrial pressures and intensive agriculture activities compromising the eco-systems.

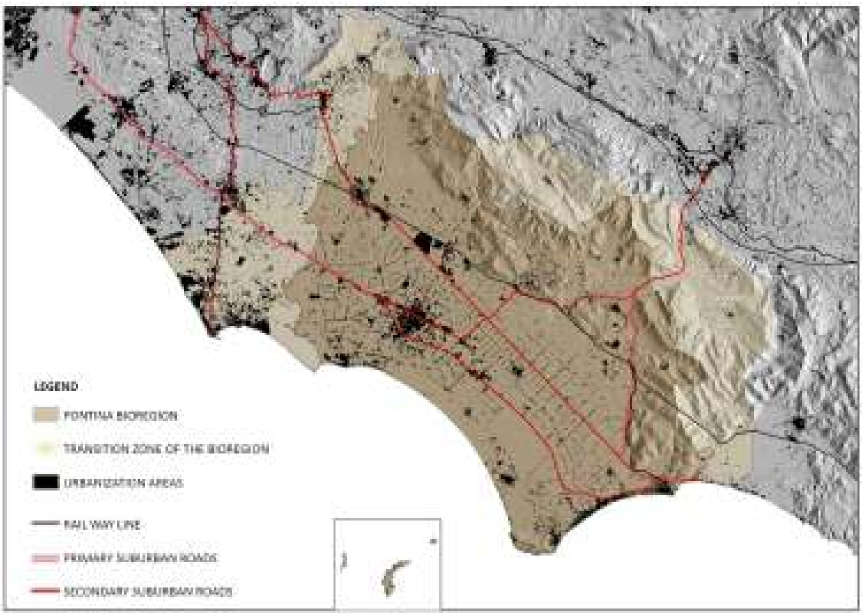

Figure 2: The Pontina bioregion. (*Source: Bodoni et al., 2018 [25].)*

5 INTEGRATING WATER INFRASTRUCTURES AND COMMONS THROUGH SOCIAL CONTRACTS

5.1 Water infrastructures at the centre of the relationship between nature and culture in the Pontine bioregion

Water infrastructure are particularly relevant to the history and future development of the Pontina region, ability to continue residing, farming and conducting other economic and social activities, depends on a complex pumping and drainage system that affected by urban expansion and environmental change. The attempt to drain the marshes in the Pontina Plain date back to the Roman Empire (or earlier). Extensive land reclamation work was performed periodically and the "integral land reclamation" (bonifica integrale), including not only the hydraulic sector but also the human and health sector, was conducted between 1926 and 1939. The result was a complex system of channels and water pumps collecting and driving the water from the mountains to the sea trough the coastal plain. Drainage, defensive and irrigation works, together with roads construction land and mountain improvement, changed the bio-physical nature and the land governance of the area creating a very sensitive environment. The vulnerability of the Pontina plain is currently exacerbated by progressive artificialisation of the natural environment, soil sealing and urban expansion. The intensification of human activities which took place in the first decades of the twentieth century, progressively moved from agriculture to coastal tourism and to the development of industrial settlements. This increased the exploitation of the groundwater resource, as little attention was given both to the anthropogenic impact on water resources and land reclamation water infrastructure and on the connection and interdependencies between green and natural areas and urban and rural settlements. The privatisation of water services, competitive uses of water and the over exploitation of water sources led to substantial negative environmental and social impacts (e.g. water shortage and seawater intrusion). Hence there is a need to reconcile interactions between nature and human society and but also to understand the implications of the socio-technical changes.

5.2 The social contracts of the Upper project

A bioregional vision is considered particularly effective in a context where the water cycle and the equilibrium between fresh water coming from the Lepini mountains and the sea water is considered as one sensitive environment and complex socio-technical system.

In the Upper project the adoption of a bioregional "scale" and approach aims to integrates ecological dimension to the local economic dimension engaging local enterprises with the re-connection, both at the city and regional scale, of the green and blue features/elements of the Pontina Region. The project has the ambition to both promote local economic development and rediscovery the cultural and historical value of the 8 selected pilot sites building join initiatives and synergies between socio-cultural, bio-physical, economic, institutional, and political actors. The Upper project focus on derelict green areas and try to reconnect them to the urban environment at the local and bioregional scale.

Three out of eight sites selected for the testing and demonstration of NBSs are conceived to effectively link blue and green infrastructure as they are beside an important artificial water body, the Canale Acque medie, a reclamation channel (area 8), a residual natural water body the Fosso Paoloni (area 9) and on low laying an areas (p.p. 3) surrounded by water streams and at the side of the Oasis Life Rewetland, the site of an phytodepuration experimental project realised by the Province administration during the implementation of the Rewetland Life+ project. The three sites are experimental sites where innovative NBSs will be tested, the latter includes also one of the productive parks for the plants selections and productions and the definition of advanced NBSs. The NBSs Strategy builds on previous collaborative governance process and on water and Greens infrastructures networks implemented by Latina Province both in statutory planning (Water Monitoring project, and the Provincial Territorial Coordination Plan 2003) and in innovative projects co-funded by the EU such as the Life+ Rewetland project (2010–2014) [26] and the Life Greenchange project [27] started in 2018. These Life projects together with the Interreg Med Coasting project led to the formulation of River Contracts (CdF) and a Coast Contract started between 2016 and 2019 with the aim of activating a multilevel territorial governance process through the involvement of public and private actors such as the Province of Latina, the Municipalities, the XIII Mountain Community of the Lepini and Ausoni Mountains, the Land Reclamation Consortium of the Agro Pontino, the trade associations as well as the sports, environmental and cultural associations [28].

A large group of stakeholders directly involved in the realization of the project will include: Labsus Association, Isimpact Association, Association Magma, Lazio Innova spa, the networks “Latina 2032” and Coordination Vialibera, as well as the neighbourhood associations “Porta Nord-Campo Boario” and “Parco degli Elleni”. Labsus Association, specialized in participatory and citizenship governance, will take part in the Co-design seminars applying its extensive experience in collaborative paths and local social contract which can integrate and expand the above-mentioned experience. The project will also establish of a broad stakeholder steering group to contribute to the progress and monitoring of the project.

The integrated governance system implemented through the cooperation between the River and Coast Contracts and the Upper pilot projects participated design and implementation, is an opportunity to involve all public and private subjects interested in the management and use of the resource at local level, in order to promote a cross-sectoral and multi-scale approach and active participation of the actors, to strengthen collaboration between Municipalities and other public bodies and private stakeholders in the planning, design and management of G&BI such as river basins, shorelines, woodlands etc.

6 CONCLUSIONS

The G&BI deployment is limited by small scale, fragmented interventions, and integrated approaches paying attention to the economic and social benefits and to the commons green and blues resource pools, is little explored. The bioregional approach and the social contracts represent an opportunity for integrating the multiple dimensions of G&BI into urban and regional planning.

Particularly, the structural invariant concepts translate in increasing the awareness, ownership and relevance of green and blue natural resources and infrastructure (e.g. rivers or shorelines) as commons. The social contracts on the other side enable shared decisions and promote processes where residents and other relevant stakeholders become the key actors in the design and management of G&BI and commons. This clearly emerge in the Upper project where the demonstration sites are areas where residents and enterprises actively engage in decision-making, actions and management. This will ensure long-term the sustainability of the initiatives avoiding that the areas are abandoned after the realisation of the EU project.

The bioregional framework and the social contracts strategy are little explored and leave open a series of questions such as: how to deal with the power relations and conflicts between the different actors and stakeholder involved in the social contract; how to meet the need for environmental and economic resilience in a fast changing environment exposed to environmental, economic, health crisis or disruptive changes; how to adopt a flexible and transformative approach to cope with high uncertainty and avoiding losses; how better orient public-private partnership to work for the commons, e.g. how move towards green public procurement and corporate social responsibility for supporting G&BI. The Upper project gives the opportunity to experiment various forms of social contract keeping in mind the structural invariants of the bioregion to explore the problematic issues mentioned above. However, a bioregional vision must be maintained to scale up and connect local initiatives, coordinating between the local social contracts and creating a link with the bioregional citizenship.

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PUBLIC SPACES FOR SUSTAINABILITY OF CONTEMPORARY METROPOLISES: PROJECT THEMES AND RECURRING CHARACTERS FOR THE QUALITY OF DESIGN

GIUSEPPE CALDAROLA
Department of Architecture and Arts, IUAV University of Venice, Italy

ABSTRACT

The present study records recurrent guidelines through different case studies of architectural and urban design projects, considered as "models" of different ways for managing the existing urban conditions due to generate new urban qualities. Innovative public spaces, new urban functions, formal/informal hybrid forms of living/using the city (or its parts) can be considered as "common" design topics of various interventions. Resetting urban fabrics, redesigning places, recharging their characters and values can be considered as starting points, shared tools of different regeneration projects, with strong strategical values and figurative features, especially in European and extra-European contexts: a "common ground" by which several contemporary metropolises are undertaking innovative policies and design features to rethink their existing conditions. In several cases – even with situational differences – enhancing the system of public spaces becomes an opportunity to improve their liveability. The "Laboratori Metropolitani" program of the IUAV University of Venice focuses on some contemporary metropolises, defines case studies, and allows the combination of research features and project actions due to recognizing and evaluating recurrent themes in these transformation dynamics. Different cities – such as Sao Paulo, Dar es Salaam, Seoul, New York, Santiago de Chile, Hong Kong, Mexico City and Moscow – have undertaken recent actions of urban regeneration. Recurrent ways of interventions are emerging, mostly public initiatives: virtuous processes of urban regeneration descend with significant effects in terms of urban quality. More complex urban regeneration policies can be appreciated, with positive effects on the same places and the surrounding areas, also consolidating and enhancing the specific identity matrices; different projects, supported by public policies and favored by different practices, follow the general principle/aimed output of qualification/implementation of the public realm (in its different forms). The interventions on the public spaces seem to be the main opportunity to create lasting condition of urban sustainability and inclusiveness, to generate liveable places.

Keywords: public space, collective realm, regeneration projects, urban design, quality of design.

1 INTRODUCTION

Several new processes of urbanization (or better, of re-urbanization) are overpassing contemporary metropolises, especially in extra-national contexts (European and more over extra-European): cities are expanding their dimensions; at the same time and more frequently, entire internal parts are under transformation (Jacobs [1]). Working in between the existing urban fabrics, high impact interventions are rethinking and redesigning the built city "per parts": new policies and new design processes are developed and activated due to transform places, change their character, increase their value (Aymonino et al. [2]).

In particular conditions of urban complexity – as imageable in the biggest world contemporary metropolises – various plans and programs are under activation. Various interventions have recurring characters: common design topics can be identified and can be reconducted under the public spaces system formation, renovation and development issues. Contemporary metropolises are trying to systematize the internal public spaces capacities to trigger positive transformation dynamics on larger portions of their urban fabrics. Managing

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the system of existing public spaces and increasing themselves, with their different levels of variations and integrations with the rest of the built city, seem to be a common denominator and, likewise, the main vehicle for transforming and implementing urban qualities, living qualities (Gehl [3], [4]).

2 CONTEMPORARY METROPOLISES AND RECURRING DESIGN TOPICS: TRANSFORMING CITIES, MANAGING COMPLEXITY

Some of the principal contemporary metropolises – different from each other and, as well as, in equally different contexts – have undertaken alternative actions of urban regeneration, both supported or triggered by innovative public policies and/or more spontaneous practices. In the same contexts, a lot of different projects can be checked as directly descending from the same policies and practices. Several projects deal with spaces of different natures, conditions and configurations. These cities have undertaken urban renovation projects which follow the more general principle/objective of qualification-implementation of the public space; they pass through gradual densification and redevelopment processes of more or less central areas, characterized by conditions of abandonment or degraded and affected by physical and social marginalization phenomena (Koolhaas [5]). For all these areas, alternative strategic actions are experimenting possible new urban condition scenarios and new life cycles assessments: through these, cities become a primarily relevant experimental laboratory (Caldarola [6]). The observation of the subsequent transformation dynamics that are affecting some of the world's major metropolises and megacities becomes a useful tool to set comparative views and analysis.

Specific dimensional parameters – as size, variety of transformations, strong physical–spatial and social inequalities – in some of the worldwide metropolises return not (at least not directly) comparable conditions with the largest part of the European cities: first differences can be recognized through the actual numbers of inhabitants and tendential population growth data, as well as, through the density data. The internal complexity conditions make almost impossible to imagine the formation of general plans and instruments capable of fully controlling and managing the whole transformations as a whole as well to form systemic projects, favoring designs made "per parts" (Caldarola [6]).

In these cities, principal questions concern old and new areas of expansion, new infrastructures and services which allow metropolitan territories, already in overcrowding of population, to reach new urban controlled volumetric densities and fluxus scenarios (Berghauser Pont and Haupt [7]). Investigating contemporary metropolises cases also allows to deal and measure with recurring conditions – even with differences by specific contextual conditions – which have already required the experimentation of innovative tools, capable of facilitating conceptions, promotions, managements and controls of the transformations.

Even in different geographical contexts and in equally different numerical–dimensional conditions and data – both from the increasing quantities of inhabitants to urban densities, spatial qualities and equipment of services and infrastructures – a sort of "common ground" seems possible to outline trough the different recent transformation processes. Various expansion processes, such as (and above all) those on internal still urbanized areas, concern dimensionally comparable surfaces; establish recurring calibres of interventions, types of interventions, types of spaces and functions (Sim [8]).

Alternative possible ways of implementing urban transformations, places for regeneration projects concentration, types of projects to be developed, actions to be undertaken, scenarios of new urbanity to be pursued are already under redefinition. In metropolitan contexts, have already emerged conditions of a sort of public action "surrendering" in the urban transformations management and control. Likewise, a sort of "rediscovery" and reactivation in the same public action is recognizable through promoting urban projects (their role becomes newly central): they become a new possible way to recover the effectiveness of promotion, control and government of transformations (Caldarola [9]).

Experimenting alternative strategic actions, urban projects are entrusted by the task of imagining new life cycles for more or less large parts of the cities, also for those parts not directly affected by the transformations but indirectly modified by them in their own characters, uses and possible users. By this newly central dimension, the urban project in itself is becoming the opportunity for new cycles of public actions and is allowing cities to become a laboratory where dealing with "unconventional" interferences between different and constantly evolving disciplinary areas.

In the same contexts, urban projects are proposed following several plans and programs, also conveying design competitions; new urban projects concern spaces of different natures and configurations; even if with different contextual variations, they descend from the more general principle/objective of qualification-implementation of the public space; they pass through imagining new life cycles for service infrastructures and promoting gradual and modulated processes of densification and redevelopment of more or less central areas of the cities, characterized by conditions of abandonment or degradation and/or affected by physical and social marginalization phenomena (Koolhaas [5]).

Through different projects and also through reconciling aspects related to the temporary nature of the interventions or to the experimental nature and to the communicative value of the same, the urban public spaces provision can be modified and expanded. Local problems are solved (often on a not larger scale than the neighborhood one), acting on the urban environment and developing various public policies. In particular, new public spaces are also generated by new involvements of citizens during the entire design processes, by increased usages of temporary and low-cost interventions (recurring to them especially in initial and preliminary stages of transformations). Small-scale interventions are increasing their numbers: they allow to trig virtuous regeneration dynamics on areas with greater surfaces than those directly under transformation and to support effective long-term results (such as numerous practices commonly indicated as situational or tactical ones) (Lyndon and Garcia [10], Paans and Pasel [11]).

The research of the IUAV University of Venice, made by the "Laboratori Metropolitani" program, analyzes some contemporary metropolises and allows to combine research and project actions due to record recurring transformations dynamics. A complex set of actions is emerging, mostly public and spontaneous ones, from which virtuous processes of urban regeneration descend. To deal with this topic, the research records the general guidelines of plans and programs and the projects they descend; the didactic programs – especially, the ones of the seminar "Laboratori Metropolitani" – try to accompany the same institutional actions with free design proposals, settled with the contribution of students in architecture. The analysis and design exercises allow to outline recurring methodological conditions and common actions between different urban contexts, also through the recovery and the innovation of integrated, multidisciplinary and multisectoral approaches in a multi-scalar vision, identified a useful tool for approaching specific urban conditions.

By comparing the results of the case analyses, has emerged the idea that the future structure of cities interested by strong demographic and economic expansions must start from a new look "from within", precisely from those "central peripheries" that represent the more problematic and alive part of the urban fabrics. Density, as a merely numerical or percentage data, seems no longer an insurmountable logistical problem: it becomes the starting point of unexpressed qualitative potentials if enrolled in reversing bad uses and consequent malfunctions of the involved quantities (Uytenhaak [12]). Precisely the unresolved or malfunctioning internal urban areas, due to their positions, visibilities, quantities of transits and connective potentials, have the ability to trigger virtuous processes, to expand models and meanings beyond their real dimensions, to produce exportable conditions, with appropriate measures and variations, on larger parts of the metropolitan areas.

3 REARMING PUBLIC SPACES, REDEFINING PUBLIC REALM

The project themes, on which the main internal transformations of contemporary metropolises are established, concern abandoned or partially dismissed areas, with lacks or their original functions or characterized by under-utilization or spontaneous high-density levels, often narrowed between infrastructural bundles and with incongruous scalar presences compared to pre-existing urban fabrics and road networks. They deal with those spaces commonly defined as “Neglected spaces”, “Lost spaces”, “24 hour spaces”, “Invaded spaces”, “exclusionary spaces”, “Consumption spaces”, “Privatized spaces”, just to mention some possible categorizations traceable in various studies and research (Koolhaas [5]). Their recycle and reuse projects, undertaken as a possibility of new uses and lives chapters, are superimposing a sort of “lingua franca” in urban planning and urban design, also investing the architectural design projects (Marini and Corbellini [13]). Recent policies and projects take into increasingly account the reorganization of the sense of the possible ways of using the areas, especially conforming the public spaces, set as the backbone of new spatial and social configurations in contemporary cities.

These general ideas emerged working on the metropolises cases analyzed by the “Laboratori Metropolitani” program: São Paulo, Dar es Salaam, Seoul, New York, Santiago de Chile, Hong Kong and Mexico City, Moscow and Nanjing can be used as cases of cities (rapidly become metropolises or megalopolises in more or less recent times) interested by rapid dynamics of transformation, apparently different from each other but equally comparable, with common and recurring conditions of urban growth and transformations of internal areas, with high values of demographic increase and with significant modulation/remodulation of the existing fabrics and of the settled functions.

In these cities, new public policies of urban regeneration are under activation with top-down approaches; new spontaneous practices of appropriation (or reappropriation) and reuse of different places are emerging by bottom-up approaches and initiatives; huge renovation areas have been still transformed or are going to be identified as “resources”, “starting point” for more complex developments; this, especially for achieving the more general objective of making the cities in themselves more liveable and sustainable.

These cities are re-compounding and recollect, in all design processes, the ways of living and using places issues or are exploring alternative possibilities to establishing different conditions trough alternative scenarios developments (Schenk [14]). Cities are reflecting on the spaces under transformation in themselves, on their specific conditions as on dimensional terms, characteristics and constitutional elements. Cities are working on the existing buildings, on more or less extended portions of the urban fabrics, trying to identify and avoid (or, at least, minimize) the impacts of all those elements that can act as barriers, limits, precincts: this, to generate new urban conditions of continuity and connection in those places, actually characterized by discontinuity, physical and social marginalization, improper uses, etc (Berghauser Pont and Haupt [7]).

Recurring topics can be identified through different projects, commonly indicated as good practices. Dealing with the establishment of new densities – which usually are modulated and allowed to support the transformation costs – cities are forming new plazas, boulevards and green areas due to increase the quantities of places for staying, for gathering (Gehl and Svarre [15]). These kind of interventions are settled to change the character of places, only addictable as transitional ones. Cities are forming a revitalized network of streets and covered and open air passages due make more recognizable their capability of being places suitable for the open air living (Colville-Andersen [16], Sadik-Kahn and Solomonow [17]). Cities are managing the public transport and are improving the cycle and pedestrian accessibility to their inner areas. For all the regeneration areas, a new integrated program of materials an urban furniture is defined to enhance their recognisability. Cities are making themselves "greener"; are texting alternative ways to generate 24 hour spaces or to obtain a maximized extension of the using times due to avoid risks connected to low using levels (mixed uses for mixed users, also increasing the role of young population).

The compresence of these topics and their specific uses, allows the creation of liveable and suitable places and, as the same, act as an indicator of the quality of design. These topics – with alternative specific weights per each design process – follow the general objective of rearming the urban public spaces system, of enhancing its own capability in giving specific characters and identities to the place which belong and to the city in itself (or, at least, to a significant part of it) (Stipa [18]).

4 A BRIEF REVIEW ON CASE STUDIES: PROJECTS FOR CITIES "FULL OF SPACE"

Gradual densification dynamics are interesting the city of São Paulo. Entire parts of its urban fabric are under transformation by several different kinds of interventions: especially at the neighborhood scale, the city is redesigning existing grids, road networks and plots by replacing existing buildings, in-filling services, varying densities, creating or managing the existing open air spaces quantities. Common topic of this interventions is to experiment possible changes in users and uses of the same public spaces under transformation and their possible functions. The overall image of these transforming places and their original vocations are changed; new urban population groups are installed. These dynamics of transformations do not respond to general planning but to partial logics, more often induced by the real estate market, determining the creation of friction areas, residual spaces and process waste. Along their borders, informal settlements are forming or reforming with unequal socio-economic conditions in occupying and neighboring the same urban sectors. Extremely different housing models are placing in direct comparison, alternating seamlessly throughout the territory. Physical proximity and social distance generate a mapping of heterogeneous isolated fences within the same urban sectors, held together only by the infrastructural networks, of which the transformation and/or adaptation to the new residential pressure is not often expected.

Dar es Salaam is registering rapid expansion of urbanized territories with population growth data that foresee the doubling of the current 4,000,000 inhabitants (registered) over a decade. Settlement pressure, as a consequence of short-range migratory flows, feeds the informal settlements sectors increasing, characterized by low quality housing, lack of infrastructure and diffuse self-construction. Recent public policies aimed to realize minimal services to reach a general improved (as possible) conditions of quality living in informal settlements: these policies have produced poorly structuring results, at least not systemic or capable of generating a new overall image of the places.

Interventions limited on individual lots or urban blocks can be checked, not deriving from a general planning program but resulting and depending from economic interest of the real estate market or of the private investments. As general results of this condition, several different areas of friction and residuals spaces are emerging and the image of a city without "architecture" is superimposing: the one of a city, composed by heterogeneous fabrics, belonging to the different phases of urban growth and alternatively attributable to "planned" interventions or self-construction. Through a new general urban plan (2012), the city is responding to settlement pressure, to the demand for areas for residential and non-residential settlements, to the necessary improvement of living conditions in informal settlements. The new Masterplan provides the redesign of core areas superimposing a grid of spatial units, in which urban questions would be solved at a neighborhood scale, and the formation of five new satellite cities. Contemporarily, the plan promotes the containment of the expansion of built-up areas by the activation of modulated densification processes or reassessments of portions of the existing urban fabrics.

Existing infrastructure networks, public transport systems, neighborhood services are under transformation and reorganization; new urban micro-centralities and areas of protection and enhancement of naturalistic and environmental emergencies are under creation; landscape protection and specific measures to prevent hydrogeological instability on flooding areas are under promotion, also with the introduction of forms of urban agriculture. For specific conditions of urbanity and complexity, Dar Es Salaam becomes a laboratory for experimenting alternative life cycles for the public spaces aimed at implementing the quality of living (Bartolone and Caldarola [19]).

Seoul returns dynamics of rapid population growth with strong settlement pressure, spatially defined by expansion and regeneration areas, introduction of new modulated densities. Through several urban regeneration interventions, significant central parts of the city had already been re-established by the creation of new public services and equipment as well as by the more general requalification and implementation of public spaces systems, also accompanied by the transformation of the urban infrastructures. Plans and programs had already guided public actions and private initiatives – these one, especially supported by a series of interventions promoted by the principal industrial corporations – and have supported high-density residential constructions interventions. The masterplan for Cheonggyecheon area could be considered as an emblematic case of urban regeneration: the regeneration of that central part of the city started from the transformation of the existing infrastructures and aimed at the formation of a new city center by enhancing the public spaces systems.

The public urban regeneration program had led to the reopening of the stream, the canal that had been covered to build up an urban highway after the war. The dismantling intervention of the urban highway, the reopening of the canal and the formation of the new linear public spaces for a total extension of 10.9 km was carried out in 2005. Starting from this construction, various neighboring areas has flourished with intensive building interventions by substitutions of the existing fabrics. Despite the extensive transformations already occurred – conveyed by the formation of the new linear public space – the Seoul municipality is trying to preserve some historical or modern buildings along the stream, as the Sewon Sangaa one: their preservation criteria are under definition and are submitted to the more general addresses of the debate on the formation of the new public spaces system along the stream and surrounding areas.

The Sewon Sangaa is a 1 km long building, located along the fire zone of the Japanese occupation period. It is a “manifesto” building with its specific architectural facies. It exemplifies recurring urbanization conditions, recognizable in several parts of the inner areas of the city, affected by significant urbanization or re-urbanization processes at the beginning of the second half of the 20th century. Those areas show recurring characteristics of juxtaposition and compresence of different functions within the same urban blocks or within the same building. Close to the Sewon Sangaa building there is an informal settlement, functionally dense and with main productive vocation: settled activities ranging from the electronic components to paper mills and ironworks sectors, with very high productivity indices such as to make the eight informal urban blocks (of which the building constitutes the central spine) a sort of "perfect machine" and almost unchangeable Here the real estate pressure would like the demolition of the macro-scale building that constitutes the backbone of the surrounding informal settlement to create a public park with mixed-use towers (mainly tertiary), forming a new downtown. A first masterplan was made on private initiative, against which efforts were being made to define various strategic actions of public initiative, aimed at the conservation of the building (considered as an "heritage" building, a "manifesto" of the Korean economic boom), re-functionalising it and intervening punctually by infilling micro-scalar public equipment.

In New York, following new public policies (supported by the transportation and construction departments of the municipality), are allowing several interventions of urban regeneration: through these, the municipality aims to regenerate the existing city and to contain the more recent expansionary trends. A systematic series of interventions have affected the island of Manhattan, starting with the redevelopment of its riverfront following the dismantling of the port system along the entire perimeter with the formation of new urban parks and the location of new public facilities. Alongside these interventions, the redevelopment of existing public spaces and the reorganization of the road networks have started: main results of these policies can be easily recognizable through the interventions that have lead the reassessment of Times Square, transformed into a pedestrian areas starting from a space traffic dominated, and all along the Broadway 7 miles route.

Directly descending from these previous formal interventions, a systematic program of public and private interventions is interesting areas with main residential vocations in the neighborhoods of Queens, Brooklyn and the Bronx. Here, alongside interventions aimed at redesigning roadway reinforcement – made under the general principle of encouraging pedestrian uses of urban spaces and reorganizing the streetscape components – the formation of public micro-spaces, the networking of pedestrian paths and public spaces and the implementation of themselves are undertaken, also with compensation systems due to promote and encourage private initiatives (i.e., the BIDs programs) in the creation of neighborhood services and equipment.

The interventions carried out along Roosevelt Avenue, integrated with the formation of new neighborhood micro-equipment and public supports for private initiatives, make the areas of Queens a representative case of more general methods of interventions on urban public spaces and on the possibility of amplifying their uses and users also improving the integration of semi-public, semi-private and private areas.

The municipality of Santiago de Chile has recently implemented new urban regeneration policies. Among the numerous interventions that generated the modulation/remodulation of existing densities, particular attention has been given to the implementation of the urban public space system: both existing and newly formed ones whose program has been carefully examined by the municipality since from the start of the ideation of the transformation and in every phase of the approval procedures. Through international design competitions, the municipality intended to promote the drafting of masterplans that had significant effects in terms of the regeneration of the spaces inside the consolidated city.

The competition for the Alameda Avenue is one of one of the effective instruments descending from the new public policies, also and above all for the central role of the areas included in the design proposals. The Alameda is the road axis that crosses the entire city on the east–west direction, really close to the original terrain of the Rio Mapocho, the river that was buried to make space for the creation of an urban highway and recently affected by the reopening and by conspicuous interventions of building speculation along its course. Alongside the Alameda, the municipality is promoting systematic actions aimed at the formation of sequences of ringed public spaces, also and above all starting from the infrastructural reorganization.

Mexico City shows complex and alternative urban conditions, comparable to the other cases in terms of quantities and qualities of numbers of inhabitants, population, areas under transformation, public policies and private initiatives with more or less significative effects on the urban fabrics. Particularly significant of the ongoing debate on the transformability of the city, on urban regeneration topics, on buildings and urban transformations in progress is what is now under construction along the extension of the Ferrocarril de Cuernavaca. This is the area of a local the railway track, partially dismissed and characterized by low levels of usage, that crosses eleven neighborhoods, significantly different in terms of social composition and conditions of urbanity. Along the railway road a linear park (the "Bosque urbano Ferrocarril de Cuernavaca" project, made under public promotion by the Gaeta-Springall Office) is reopening to the city an infrastructural space, till now privatized and affected by spontaneous and uncontrolled different uses by the citizens. Mixing design processes with direct participative programs for the population, the formation of the linear public space Bosque Urbano FLCC, alongside the infrastructure, is becoming the principal occasion to develop a urban quality project in Mexico city.

5 TOWARD NEW URBAN CONDITIONS: THE "COLLECTIVE SPACE" CHANCE

In all the case studies, urban policies and design actions highlight recurring conditioned in terms of transforming surfaces dimensions, specific characteristics, varied design "calibers" grafted onto them, types of the descending interventions. Always central are the topic of qualifying and implementing the system of urban public spaces; forming "networks" of spaces through the implementation of connective systems between green areas, traffic calmed areas and pedestrian ones and between different public transport systems. Equally central are the needs of multidisciplinary and interdisciplinary approaches to urban issues, for new possible integrations and interactions between specialized knowledges (White [20]). Transforming the role and character of urban infrastructures becomes an opportunity to redevelop parts of the cities in which they fall; new centralities can be generated working on unresolved urban passages, poised between abandonments and improper uses, characterized by "exclusionary" conditions, inaccessible and detached from their closest contexts or characterized by low levels of integration. In each metropolitan case, new public spaces derive from new ways of dealing with the relationships between cities and their infrastructures, city centers and their peripheries, formal areas and informal ones, planned and self-constructed areas, vertical and horizontal dimensions, fences or borders and margins.

In all these addressed cases, specific analyses have been conducted on areas included among infrastructural bundles for checking modalities by which these modulated relationships could become occasions of increased urban quality and for establishing higher integration conditions with the external fabrics and with the surrounding buildings (i.e., the dismissed or characterized by conditions of underutilization railway tracks of São Paulo and Mexico City); on the systems of spaces more or less directly connected with road axes for which alternate scenarios of configurations of networks of public spaces are imagined (i.e., the Alameda Avenue of Santiago de Chile or the Roosevelt Avenue of New York); on more or less significant parts of urban fabrics characterized by absence or scarce supply of public services and equipment (i.e., the Sewon Sangaa area of Seoul, the residential areas of Queens along Roosevelt Avenue in New York or the informal and planned settlements of Dar es Salaam); on relationships between macro scalar presences and inconsistencies in different urban fabrics for which different configurations are hypothesized (i.e., the Sewon Sangaa of

Seoul and the neighboring fabric); on the new settlements and the methods of generating quality of living, also and above all, according to criteria of containment of soil consumption and of self-sufficiency and sustainability.

The case studies show different possibilities to generate new urban public spaces systems starting from the renovation of the existing ones or from the creation of new, often “unconventional”, ones that can flourish alongside, amongst, within or in-between the consolidated urban fabrics.

The creation of a new public space becomes an “occasion” to improve urban quality, to make cities (or significant parts of them) more liveable and sustainable, only if the specific conditions settled by the projects pass through a complete evaluation of the possible outcomes on the enhanced public realm. Proper the appertaining of the newly generated system of public spaces to the public realm – this last, as in its own more general accepting of “Place for people” – becomes immediately recognizable if it clearly shows its specific conditions of being accessible and inviting, lively and diverse, healthy and prosperous, attractive, safe and secure (and this, joining both the physical and spatial settings and the perceptive components) (Gehl [3]).

These features seem to be the core issues of the quality of design, to be considered, declined and compounded to enhance projects values.

Successfully places outcome from not just realizing a public space but compounding itself as an enhanced part of the public realm; successfully projects flourish considering each intervention of urban regeneration as a chance to improve the collective space, the indicator of the health status of the urban public realm (Sennett [21]).

Qualities of design could emerge if the increasing the public spaces system topic maintain a central role in whole design processes. They could reach full values if the same design processes are informed on: multidisciplinary approaches, to allow the possibilities of retraining specialistic or sectorial projects in the main topic of the development of the quality of the “public” city; new densities, to increase different possible uses and users; mixed uses and social values completion, to form places for staying with rebalanced conditions of transition between public and private realms; networking, to overcome the condition of a public realm made per punctual spaces, not connected, and to favourite interconnected systems of public spaces and public services; permeability, to reset exclusionary condition; calibres of interventions, to generate significative impacts overcoming the specific perimeters and dimensions of the transforming areas and to reopen the project areas to their context; balanced condition of low design and high impacts features and of low costs and high tech components, to reopen the areas to the possibilities of generating unconventional and unexpected uses, retain attractiveness, environmental liveability, reversibility and successive completions of the interventions.

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POSTER FOR THE SOFT CITY

VITTORIA CRISOSTOMI
Dipartimento Architettura, Università Roma 3, Italy

ABSTRACT
Climate change and its effects call for concrete concern about how cities should reorganize themselves. Cities today are already vastly different from what we have learned in the manuals for lifestyles, production, and ways of living. Urban planning must revise its foundations according to the options of reduced emissions, renewable energy, circular economy and zero land consumption. It will therefore have to take a different method of mixing up the addendums of policies for cities. Instead of a complete theoretical treatment, it is necessary to grasp the faint signals scattered in the organization of the city, consolidating in new paradigms that are defined and simultaneously experienced. The experiment could concern the formation of a new profile for the city of Rome, in view of the election of the new Mayor in 2021, whose points could define a "Poster for the Soft City" in which the elements of planning are revisited in the light of new values and applied to the true city of today. The protection of the environment must be practiced with projects accompanying the needs of nature and the morphology of the places. The size of the public works is strictly in line with needs and the projects commensurate with them. Network engineering models for mobility are reviewed as an urban service to people, attentive to user behavior. The green areas which were once given up as standard, never equipped and abandoned, become the system of green networks and soft mobility rebuilding where possible the ecological continuity, according to a new landscape that keeps the original morphology together with the necessary new transformations. Entrepreneurs will also have to change and become administrators of the existing annuity, inventors and recipients of additional marginal annuity based on the improvement of settlement quality, committing themselves to management quotas and improvement of the surrounding public space.
Keywords: urban policies, new city planning, systemic approach, urban development, well-being city, soft city, annuity.

1 URBAN INNOVATION IS AN EMERGENCY

It is clear that the epochal climate change, the events that follow, partly catastrophic, and in part slowly enveloping, are highlighted in these days by the recurrence of cyclical epidemics and pandemics.

In parallel, although they continue to replicate in a fake presence, uninterrupted and reassuring, the rules that govern the organization of cities have also changed profoundly, the result of structural changes that have crossed all functions, all social groups and all rules of aggregation.

The cities worked and transformed up to now are the extreme result of a theory which has in the center the work of the man and the transformations brought to the biosphere, considered interventions and improvement always and however salvific, in a process of continuous growth called progress [1].

The limitations of this process had already been highlighted in the early 1970s by the theories and experiences of McHarg. He had recalled the knowledge of the ecological cycles and their causal connections that form an organized system. That is basis of the plan according to the rules of nature and defining the anthropogenic uses and the intensity of the possible transformations [2].

This line of thought called "ecological planning" has rebounded for some time in the world of urban studies also in Italy [3]–[6].

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However, in the 1980s the core of the discipline was the pursuit of flexibility of plans and the uninterrupted push towards expansion, despite the growing awareness of the necessary respect for ecological cycles and landscapes [7]. Therefore the cultural thrust of ecological planning has been diverted towards the normative aspects of the discipline. Non-systemic supporting tools allowed elementary and simplified representations of complex problems, which could be matched by equally elementary solutions.

Despite everything, catastrophes and disruptions generated by the force of nature continue, disasters that are generated by thoughtless human transformations stratified over time, new unstoppable cycles of transformation of cities. The lack of utility and effectiveness of such simplifiers and automatic systems is apparent. These systems do not enter in the processes and reduce the actions of defense and protection in elementary connections stimulus.

2 A CHANGE OF METHOD IS ESSENTIAL

Therefore, it is not just a question of adapting to a new climate, of restoring degraded situations, of futuristic technological projects. Instead, we need a structural revision of the sense that cities have taken, of the new organizational rules of their vitality, of the reasons that establish their evolution [8]. In this context, it would be good to immediately worry about how cities should accompany new patterns of consumption, new ways of producing and trading, new ways of asking for mobility and relationships, new ways of asking for welfare and new ways of farming. There is a lack of real awareness of the new ways of evolving the city, already much more than what we have learned about in manuals, starting with borders. Even more different with the current Covid 19.

New forms of diagnosis of ongoing processes in cities must be matched by appropriate urban and planning discipline that is not satisfactorily reflected in traditional tools and practices. Moreover, we cannot wait for solutions resulting from global rebalances and policies; instead, the consequences are imminent and already clear. What is needed to make the measures of reconstitution and defense close and real is to immediately build a new profile of discipline that takes on a different way of mixing the addendums of policies for cities. Together with the organization of the city we must keep in mind the main options of a new system with reduced emissions, renewable energy, circular economy and zero land consumption [9].

However, you cannot expect all these new processes to be organized and packaged somewhere, structured in a system and disseminated and practiced. Instead, it is necessary to grasp the small faint signals scattered in the organization of the city, in the stratifications of its history and in the roots of social issues. Trying to consolidate, for parts even non-systematic ones, in new paradigms that are defined and tested at the same time, before and instead of a complete theoretical treatment. Moreover, it is necessary to seek, with the usual method of trial and error, the real opportunities for experimentation [10].

An experiment may involve restarting and forming a new profile for the city of Rome, today waiting for a change in urban policy that could be redefined during the elections of the new Mayor in 2021.

The problems that always remain are those that are well-known but still unresolved, common to all metropolitan cities, each with a coloring linked to specific territorial and institutional conditions. Inefficient mobility, poor quality of general settlement, inequalities, faded development profile, interrupted works, these being still present show that they cannot be compensated with the answers given so far.

The two traditional routes are clearly not appropriate. The construction of prospects for development and growth through the armament of large projects and major works, often interrupted, whose lack of positive repercussions were measured. Or the list by axes or sectoral guidelines of things to do, mixing local-scale topics with urban-scale performance, wasting intelligence and money on disconnected and ineffective actions.

The solution does not lie in disciplinary instruments or technologies. It is clear that we must exert a change of vision on the nature of the city and not only on the instruments, a change of conduct of actions and not only of the review of the regulatory system. The paradigms of a re-founded urbanism become understandable and close to reality if they are based on a redefinition and reinterpretation of complex relationships that cross the problems of all time, on a correct integrated and innovative use of what there is [11].

The pillars of this necessary new way of representing problems are already written in the history of policies for cities since the late 1990s. Until the early 1990s, policies were geared to growth, and town planning was geared to orderly development of inhabited areas. After the neoliberal attempts and the obvious recession, the limits of linear growth and sectoral planning practices have become evident. Those attempts have become insufficient both to guide globalized development and to contain local conflicts. Policies will have to regulate the pursuit of profit and economic development even without physical growth, which will exalt the functional assets and the basic activities of the cities with which they enter into international competition. They will also have to regulate the containment of the selective effects of development and disparities, which will feed the search for redistributive and equitable forms of wealth. The two aspects come together producing a generalized demand for well-being and quality of settlement. For both, urban planning, in the form of the city, will have to recompose profits and work, environmental quality and social cohesion. In short, economic well-being and quality of life [12].

At this point discipline must assume the entire city is a single complex system, to ensure performance for all citizens of ~~a~~ overlaid and always conflicting reality. Interests, behavior, social groups, cultures, needs, are strongly integrated and, even if they can be typified, require differentiated policies and specific design treatments [13].

A new method will have to propose a vision of competitiveness, sustainability and closeness to needs. One must experience a city equal to the existing one, but “other than itself” whose points could define a “soft city poster”. It will not only be the smart one permeated by new organizational technologies [14], not yet the augmented one to be fully devised in a vision of the future [15], but some first concrete seeds of practice, within the immediate reach of the available tools, for a city re-founded on commensurate projects.

In the first trials, the construction of well-being can begin by the search and identification of the necessary performances. Every sustainable intervention in the city means that it is in balance with the forms of the territory, with what it produces, with those who live in it, with those who use it and how it evolves. The city must become a resilient welcoming and productive place, with a solid basic economy, not based on tourism bite and escape nor on the all-encompassing presence of the Vatican.

Vision and realism are composed relying on the feeble and dispersed vectors of possible innovation already underway. A new policy for the city must be founded, played entirely on the level of value, on the new way of being a city and on the specific way of enhancing its essence.

3 A SOFT CITY POSTER

Here is a possible list of old problems to look at, and then solve, with new eyes. Here is a possible “Manifesto for the soft city” according to three main dimensions: environmental dimension, settlement dimension, economic dimension.

3.1 From undeveloped islands to continuous systems

It is necessary to abandon the defense of the environment as a stiffening to any transformation and the protection of existing through inhibitory constraints. The projects must follow the reasons of the nature and morphology of the places, where to recompose and allow the present life cycles and awareness of the limits. There is an evident determinism, of the limits of the possible transformations for those who know how to read the rules of the places and match them with the needs of men.

This concretely means that the problem of the inhospitable green areas is actually that of the unperceived open spaces and this must be addressed by the reading of the primary form of city's soil, attributing meaning to all free spaces. The free areas between the built-up areas, green areas yielded in urban conventions never equipped and left abandoned, areas waiting for destinies in the interstices between neighborhoods, wrecks of intermittent waterways, areas unbuildable for intrinsic characteristics, these have to be reinserted in the continuous system of nature and its rules, that has housed the built-up areas and is often hidden from it. What is needed is the reconnection of a unitary configuration that infiltrates the built up areas, in which the parts assume a current sense. What we are going to need is a proper use of the outcrops of a continuous system, an enhancement of the green porosity made visible and accessible to citizens as soon as they leave their homes, just like the sidewalk. We need to move in a design of green networks and soft mobility reconstructing ecological continuity where it is possible, now fundamental post Covid 19.

The city that is already there must be inserted in a new understandable landscape, which holds together the original landscape brought back into everyday life, the existing city and the necessary transformations.

3.2 From additions to rearticulating of the settlement system

Urban growth with the simple rules of occupation of the soil according to successive additions is not a simple problem of market, in fact, it is a rigid method, more and more out of the cycle of life of the city. In concrete terms it means that the life cycle and the needs of the citizens must be accompanied with forms of technological reviews of the building and densification for the optimization of the public equipment. Forms of integration between built-up city districts must be found, filling the porosity of low density that does not use the city thoroughly according to the margins offered by nature [16].

It is necessary to soften the construction offer for new demographic forms and new types of families such as individuals, the elderly, students and young couples. The same applies to new forms of production, which can often be identified as infiltration of new functions with little space consumption [17].

It is necessary to soften the production of public works, governing its impact dimensions and positive repercussions proportionate to the problem. From large-scale new projects to projects that are tailored to needs, with projects tailored to them in techniques, costs and maintenance modes [18].

From stiffened traffic in the construction of the network engineering model to a very unlikely Fordist city, it is necessary to shape mobility as a service to people and think of relationships as value-creating city functions. From offering standard transport services to offering accessibility to urban benefits by local systems. It is not necessary to connect nodes of the network, but places of the people. It involves care of the connections and order of the networks, attention to the fluidity of the entire cycle of journey between local and urban and adequate response to the utility function of the user [19].

3.3 From absolute annuity to optimization of market factors

The system of traditional enterprises of serial building production has accumulated enough unsold produce to begin to consider a system change. From administrators of the existing annuity and its rigid organized and systematic maintenance, to inventors and receivers of additional marginal annuity based on the improvement of the settlement quality. Additional externalities can be captured not only by the overhauling and completing the building stock, but also committing to maintenance quotas management and improvement of the surrounding public space. It has been shown that the re-entry of these externalities can increase the value of the sold produce by at least 5% [20]. In this case, it is clear that the public operator will also have to soften the imperative style towards a proactive and negotiating profile accompanying the process [21].

It should be noted that growth is damaged by inequalities. Welfare services will have to take care of the local social profile on the part of citizens. Will have soften the responses by offering more articulated local ways of living, revisiting the existing public spaces in the neighborhood that support everyday life [22].

4 PROSPECTS FOR DEVELOPMENT

These criteria and values of the soft, well-being city must also be applied to development. In order to be alive and constantly changing and in order to have an international role, Rome must not limit itself to offering quality of life to the settled population and an efficient functioning. It must have precise prospects of growth and development in the sectors repeatedly mentioned which, together with the functions of Capital, constitute the economic basis. These must be accompanied by plans for structural changes for adaptation and its new profile.

We cannot deny the presence of real estate developers and the necessary operations to be carried out to innovate the image of the political functions of Capital and Finance present in Rome. We cannot deny that tourism, related to the demand for leisure time and cultural enjoyment, has an important future, even if the paradigms by which it is practiced are to be reviewed completely. It is established that the film and audiovisual industry is in full revival in Italy and it is necessary to strengthen the innovative forms with which it faces the international market. Quietly, with widespread localizations and peripherals of small businesses, Rome is becoming a hub of technology and start-up experimentation, which needs to be given the right business image and a package of services and appropriate infrastructure. Universities and the system of connected research, although solid, need a strengthening of image and important places of self-representation.

Then the guide in the choice of the most important transformations will have to be to select among the projects, widely existing, and the most useful for the development of the driving activities. They will be subjected to the revision according to the new method of the city with the best settlement quality, of the city ductile and looked with a new system of values, of a “soft city” able to hold together many factors in balance.

The criterion of the soft city has a center and two connected processes: that of the settlement quality of integrated neighborhoods and the flow of daily life, and that of urban projects for the new development of the city. They are two networks of relationships of interests of aspirations of behaviors that support each other and connect in some special places.

This construction of soft urban planning for Rome seems indispensable to refund the cohesion of the city on a value of substance: values are not abstract but guide actions and have concrete economic and social fallout. Only in this way does it seems possible for urban planning to undertake a shared review of the profile of the city and, starting from the principle of identification and respect for the primary urban form, outline its programmatic features and the future.

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MOBILITY FOR HEALTH: DESIGNING OPEN PARKS TO ENCOURAGE PHYSICAL ACTIVITY

CHLOE KADI & ANDREAS SAVVIDES
University of Cyprus, Cyprus

ABSTRACT

The objective of this study is to investigate how the planning and design of open parks within neighbourhoods and communities can promote physical activity in order to enhance the health of the local population. An extensive literature review was conducted for studies regarding the relationship between health and physical activity and on the park characteristics that can promote physical activity among people. The findings of the literature review were then compared and analysed in order to identify the main characteristics of urban parks that can promote physical activity and enhance public health. In order to find out how the characteristics identified in the literature were applied in real life, an analysis of three existing parks in three different countries was conducted. The parks, apart from their geographical location, also vary in size and layout. The parks were chosen because they are urban open parks and they include facilities for physical activity.

Keywords: health, public health, well-being, physical activity, leisure-time physical activity, urban planning, active living behaviour, open parks.

1 INTRODUCTION

How can the planning and design of open parks within neighbourhoods and communities promote physical activity in order to enhance the health of the people?

The aim is to investigate the parameters that should be taken in account in the planning and design of open parks within neighbourhoods/communities in order to enhance and ameliorate the quality of life of people in the community. Due to time and scope limitations, the current research investigates the features and characteristics that a park must provide in order to encourage physical activity for its users.

1.1 Rationale

Studies have shown that physical activity (PA) can reduce the probability of earlier mortality by decreasing such diseases as heart disease, diabetes, high blood pressure, cancer, depression, anxiety, and obesity while building up the body and ensuring the health of human bone structure, skeletal joints and muscular disposition [1], [2].

Unfortunately, PA levels have declined over recent decades, with a shift towards sedentary lifestyle [3]. Today, physical inactivity and unhealthy diet are second only to tobacco as the main causes of premature death [4]. Reversing this trend could confer considerable population health benefits [3].

Literature indicates two main factors for the shift of people towards sedentary lifestyle: The personal factors related mainly to gender, race, age, ethnicity, socioeconomic status and religion and need a behavioural change and factors arising from the urban design of neighbourhoods/communities and cities [1]–[3]. Targeted education programs can affect behavioural change of the individuals. At the same time, there must be changes and interventions at the neighbourhood scale of the community to make it easier for people to be physically active. Such interventions include, among others, design that promotes active transport, designing neighbourhoods so as to include a mixture of facilities with related

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infrastructure for a multitude of activities for exercise and leisure, such as outdoor exercise equipment and play areas connected by various park trails [1].

Research into this topic indicates that approaches utilizing evidence-based tools to inform decisions and plans at the architectural and urban design scale can also make a positive contribution to the inclusion of physical activities for health [4]. Such strategies as those prescribed by proponents of Active Design – that is designing urban spaces in such a way so as to promote an active lifestyle improve not only the physical condition of city dwellers, but also the physical qualities and maintenance of open spaces in the cities, such as parks, as the more frequent interactions of city dwellers with these facilities, leads to a demand for higher quality environments.

Such measures are those that alter people's decisions about how to handle everyday trips for work of access to services and amenities by having them decide against the use of mechanical means of transport and choose to take their bicycle or to walk to their destination or to choose to climb a stair rather than taking the elevator and this advice is proposed for people of all ages, regardless of gender and accounting for various conditions of physical mobility, as long as appropriate infrastructural support is provided [4].

In fact, due to sedentary jobs and lifestyle and the increasing dependence on motorised transport, the opportunity for a more active lifestyle, both for the purpose of everyday errands as well as for purposes of leisure, has to be sought at every opportunity and to always present a viable and healthier alternative [1], [4].

Whether engaging green or more recently green and blue infrastructures – that take into account the aquatic parameter of planning for green spaces and parks – these amenities need to find physical correspondence to major corridors of mobility, commercial and civic centres and nodes of education and culture [5].

Due to time and scope limitations, the current research investigates the features and characteristics that a park in a neighbourhood must provide in order to encourage physical activity for its users.

Local parks, offer the opportunity for physical activity at low or no cost [1]. Yet, it is recognised that park environmental characteristics such as features, access, condition, aesthetics, safety and policies are most related to physical activity [1].

Study objectives:

- Investigate whether physical activity can positively influence public health.
- Investigate how urban design can encourage physical activity and promote an active lifestyle for people with specific focus on public/communal spaces and open parks.
- Investigate the core benefits of parks to park users.
- Identify the park characteristics that encourage people to visit parks and promote physical activity.

The key questions to be answered:

- What is the definition of "Health" and "Public health"?
- Does physical activity positively influence health?
- How can urban design and built environment encourage physical activity?
- What are the benefits of open parks on peoples' health?
- What are the main characteristics of park design and layout which can promote physical activity and public health? Investigate how urban design can encourage

2 LITERATURE REVIEW

According to the World Health Organization [6], health is “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity”. Public Health is defined as “the science and art of promoting and protecting health and well-being, preventing ill-health and prolonging life through the organized efforts of society” [7].

2.1 Physical activity and health

Physical Activity (PA) and health related to the design and building of parks are directly linked to economic performance and economic indicators that on one show property values increasing with closer proximity to these green spaces but also poverty levels decreasing, resulting in more resilient and socially cohesive communities across many cultures and mentalities [8]. The constant goal of such international bodies is to make people and especially city dwellers who may perhaps lead more sedentary lives to institute lifestyle changes by adopting pastimes directly associated with the presence and close proximity of parks to work and home [5] that improve the quality of life and may even extent its span [7] as a result of improved health.

WHO’s PA strategy for the European Region for the period 2016–2025 targets specifically prevalent type of sedentary lifestyles mentioned above with the aim of achieving real change through a decrease of indicators associated with medical conditions – not including communicable diseases – that are directly attributed to lact of physical activity. These kinds of ailments – that is non-communicable diseases (NCDs) – are some of the main causes of death in Europe [5].

In the USA alone, an estimated 200,000 to 300,000 deaths are attributed to a distinct lack of physical activity [2]. Action on the top seven risk factors, namely: high blood pressure, high cholesterol, high blood glucose, excess weight, physical inactivity, tobacco smoking, and alcohol abuse – cause a reduction in disability-adjusted life-years (DALYs) lost by nearly 60% in the WHO European Region and 45% in high-income European countries [8].

WHO defines PA as an important foundation of health throughout life. Apart from its known health benefits regarding NCDs, it also has positive effects on mental health by reducing stress reactions, such as anxiety and depression and by possibly delaying the effects of Alzheimer’s disease and other forms of dementia. Furthermore, PA is fundamental to achieving energy balance and weight control [5]. Among older people, PA helps to maintain health, agility and functional independence and to enhance social participation. It may also help in balance and stability and in assisting in chronic disease rehabilitation, becoming a critical component of a healthy life [5].

Physical activity can be effective at all phases of chronic disease management, from primordial prevention (prevention of risk factors) through treatment and rehabilitation. The prevention of chronic diseases results to the improvement of quality of life and the reduction of health care costs [9]. Recommended guidelines for physical activity encompass four components: frequency, time or duration, type and intensity of physical activity [1].

There are different forms, kinds and levels of intensity of PA. These include fundamental movement skills, active play, leisure activities, such as walking, dancing, hiking and biking, sports and structured exercise [5]. Sallis et al. [9] classifies physical activity into four domains of life that describe how people spend their time: leisure/recreation/exercise, occupation/school, transportation, and household. The four domains are relevant to and driven by different built environment features and policies.

WHO [5] recommends that adults and older people undertake at least 150 minutes of moderate-intensity aerobic physical activity each week. Children and young people should accumulate at least 60 minutes of moderate to vigorous-intensity physical activity every day. However, it is recognised that a small amount of PA is better than none [5].

Moderate-intensity aerobic physical activity is equivalent to brisk walk. Vigorous-intensity physical activity is exemplified by jogging [10]. To promote and maintain good health and physical independence, adults will benefit from performing activities that maintain or increase muscular strength and endurance for a minimum of two days each week. (It is recommended that 8–10 exercises be performed on two or more non-consecutive days each week using the major muscle groups). To maximize strength development, climbing stairs is appropriate, among other activities [10].

2.2 The effect of the built environment on physical activity and public health

Built environments are all places built or designed by humans, including buildings, grounds around buildings, community facilities, transportation infrastructure, parks and trails [9]. According to Troped [11] the built environment includes the man-made surroundings that provide settings that may be used or appropriated or accessed for purposes of engaging in physical activity, such as neighbourhoods, streets, public transportation systems, commercial centres, schools, parks, trails and other outdoor recreational spaces. The design of the built environment can have a crucial and positive influence on improving public health [4].

Characteristics of built environments, including the transportation systems, have been related to rates of chronic disease, mental health and risk factors [9], [12]. The degree of accessibility designed in the built environment can also encourage persons with disabilities to be physically active and to be socially integrated into their community [12]. Physical activity can be fostered by designing spaces and streets that encourage walking, cycling, and other forms of active transportation [4] and by creating facilities such as trails, swimming pools, parks, courts, greenways, soccer fields, picnic areas, open spaces and playgrounds [1], [9] that allow people to engage in leisurely activities that satisfy the PA requirement.

Research on the relationship between the built environment and health has largely focused on housing, transportation, and neighbourhood characteristics [13].

Pate et al. [14] indicates that the environment often presents important barriers to participation in physical activity, including a lack of bicycle trails and walking paths away from traffic, inclement weather, and unsafe neighbourhoods. Other studies have consistently shown an association between a deteriorated physical environment and higher rates of crime, making neighbourhoods less safe for walking and in some cases resulting in greater social isolation [13].

The implications and significance of built environment to promote physical activity and public health are evident throughout the literature. The scope of this study has been limited to the effects of park design to physical activity alone. For completeness, a brief summary of the role of the built environment on public health and of other elements of the built environment that can promote physical activity can be found below.

3 PARKS AND PUBLIC HEALTH

Local parks are close-to-home facilities and services available at low or no cost. According to studies [15], local parks and organized recreation programs and facilities are appreciated by people and their communities are a result of extracting specific benefits. These benefits can take many different forms including,

- Personal benefits, which are pertinent to an individual's health and physiological and mental wellbeing, such as finding a good balance between active and sedentary past times that may be addressed by exercise one hand and relaxation and leisure in the context of natural environments on the other.

- Environmental benefits, which look at the health of entire eco systems and look to find balance in nature between the flora and fauna and the human presence.
- Social benefits, which look not at the individual but rather as the collective and enhance community resilience and acceptance by providing places for the community to cohabit and interact and is characterized by diverse locales for a diverse community.
- Economic benefits, which look at reciprocal and multiplying effects that may be realized from closeness to the park facilities but also from complementary uses that may enhance commercial activities as venues of exchange that add value to the broader area, like availability, bringing business activity to community, influence on property values
- Cultural benefits, which look at parks as not only venues for relaxation, leisure or physical activity but also as spaces for education and for the production of culture by hosting a diverse range of activities that transform them to outdoor classrooms.

Local parks are also critical in preserving the natural resources for communities, protecting open space and connecting children to nature. They also contribute to improving the overall health and wellness of the community by promoting social equity [15] by acting as social levellers through the programs that may be offered that are universally accessible and that appeal and bring together very diverse groups of people activity.

Moreover, the National Recreation and Park Association [16] includes to the above benefits, those that play a key role in the physical development of youths and young adults and to their mental development and physical wellbeing as well. They can achieve these by hosting organized activities that develop social skills through interactive and collaborative activities in nature, that teach them how to analyse and resolve challenges individually and collectively with a view to becoming more responsible and informed citizens of their community. In Fig. 1, the lower section of the model demonstrates the factors that influence the frequency of use and non-use of a park with associated benefits.

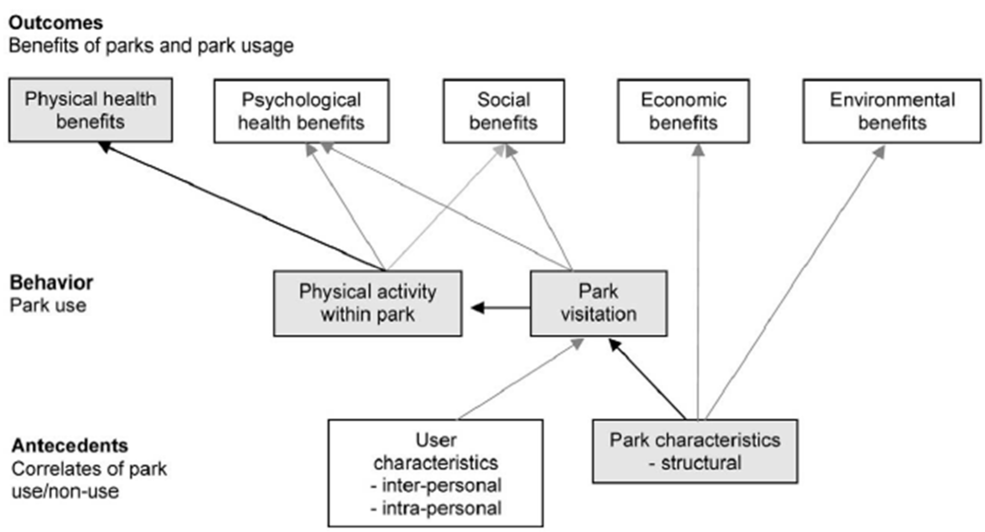

Figure 1: Relationship between park and physical activity [1].

3.1 Physical health benefits

Parks that are conveniently located are associated with physical activity from which are derived health benefits that are related to enjoying the cinematographic sensation of engaging natural scenery while engaging in a more active lifestyle [1], [13] encompassing activities in beautiful natural settings that elevate the human spirit.

3.2 Psychological health benefits

As mentioned above, the human spirit may be uplifted at the same time that one benefits from physical activity if this happens in a natural setting conducive to the amelioration of the human psyche, emotions and mental stability. Even the simple act of looking out a window as such places as community parks may be an uplifting experience. Other studies found that park users were in a better mood and reported lower levels of anxiety, stress and sadness after visiting parks [1]. In such settings that allow the individual to "get their mind of things" by engaging them both physically and emotionally has led to the reduction of depressive feelings or even to the betterment of an individual personal outlook towards a more positive approach to life's challenges [1], [5], [13].

3.3 Social benefits

Community pride may also be enhanced by the presence of well-kept parks especially in cases where the creation and maintenance of said parks turns out to be a collective activity that allows people to share this common asset through participatory and collaborative efforts. Social cohesion is strengthened by the taking place of common social activities and the setting of common social goals and in seeing them through by turning into settings where healthy behaviour (such as physical activity) is modelled [1] and where crime, aggression and violence are inhibited and social interaction among individuals promoted [1], [3], [15].

3.4 Economic benefits

Several studies pointed out that proximity to a park or reservoir – that is green and blue infrastructures, whether natural or manmade – has been shown to have a positive correlation to the real estate value of adjacent properties [1], [15].

3.5 Environmental benefits

The amassed environmental benefits that may be attributed to the increased presence of trees in parks has also been shown to combat the negative consequences of emission, such as those from automobile exhaust fumes in urban areas, by reducing air pollution and by providing shading and cooling [1], [15] and shaping the microclimate.

4 PARK CHARACTERISTICS AND RELATIONSHIP TO PHYSICAL ACTIVITY

With industrialization in the 19th century many of these nations and cities saw the first large scale appearance of organized open spaces and parks – some of them themed – with a view to providing open air spaces for congregations and common events thereby providing a healthier outlook from the severely dense and crammed conditions that prevailed at their work places and their places of habitation. These new spaces provided a proximity to nature and the natural, the trees were seen as filtering the polluted air and the healthier, cleaner surroundings were seen as countering what was perceived as the moral decay that characterized inner cities [17].

The role of parks continues to be as important today and not only for the reasons that brought them about in the past. In more recent times parks are also seen as places of leisure and recreation and learning, lending themselves to a variety of activities such as sports and markets and leisure and outdoors concerts and a variety of other cultural and commercial activities that appeal to a diverse community regardless of age, gender, condition of personal mobility or ethnic backgrounds as stated by Healthy People 2020 and the Institute of Medicine and cited accordingly by Sallis [9] and Bedimo-Rung [1].

It is therefore important for parks to have an inherent flexibility in the types of activity they may host and to cater to both the body and the soul, so to speak, by addressing the negative effects on human physiology and human psychology that may result from stressful situations experienced by city dwellers and to have also a calming effect on the community. These behaviours need to be examined and translated into reciprocal physical planning and design strategies for parks so as to become part of guidelines and bylaws governing urban design and community development initiatives by municipalities and communities [1]. In fact there are significant variations in park and outdoor recreation behaviours based on a number of demographic or social characteristics such as age, gender, race/ethnicity, socioeconomic status physical, cognitive or sensory ability and residential location [1], [3], [17], [18], but in this case they are not the focus of the current study. What is more pertinent are the environmental characteristics, which according to Bedimo-Rung [1], are comprised of six conceptual areas that operate through four geographic areas to encourage physical activity within parks, as demonstrated in Fig. 2.

5 CONCLUDING THOUGHTS

There is a vast amount of research studying the role of urban design towards a more sedentary lifestyle, which is associated with lower levels of physical activity. It is also widely recognised that increasing the levels of physical activity to 30 minutes a day may positively influence the health of people, especially in relation to non-communicable diseases (physical and mental) associated with insufficient activity levels, which are identified as a major reason for premature deaths. Research on the connections between the built environment and health has largely focused on housing, transportation, and neighbourhood characteristics. The current study was focused on the main characteristics of park design and layout which can promote physical activity and public health.

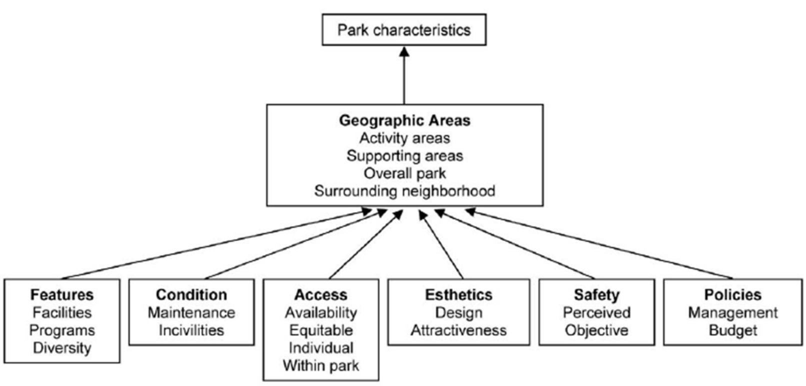

Figure 2: Environmental classification of park attributes [1].

The investigation has also verified what holds true for many a public infrastructure that is that people may be reluctant to visit a park if its maintenance and that of all related park facilities and equipment is poor or when concerns regarding crime and safety within the park, arise. Applying measures that ensure safety and good condition in open parks is essential for park users. The size of the park was also mentioned in the literature as an important factor for attracting people. The design of trails connecting smaller parks with limited features within a city may also encourage people to visit parks for more physical activity.

A number of environmental characteristics of open parks which can promote more physical activity have been identified in the literature and spelled out in the recommendations. Well-designed open parks in close distance to homes, which are easily accessible, offer a range of activities and supporting areas for all ages and provide an overall appealing environment. They provide city dwellers with options that offer them essential physical, mental and social benefits, in general, as well as more specific benefits for youth and young adults, as spelled out in the preceding text. Moreover, if one now considers the stress that has been placed on communities as a result of the COVID-19 restrictions regarding social distancing, parks may provide a flexible and evocative setting for many cultural and leisure but also commercial and even business-related activities that may occur outdoors.

Well-designed open parks are important community resources. Future research may focus on further environmental characteristics for open parks located in countries with hot climates. The association between physical activity levels in these countries and the specific park characteristics mentioned in the current study could be investigated and analysed.

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ATHENS WATERFRONT DEVELOPMENT: THE PUBLIC SPACE AS A MEANS FOR SUSTAINABLE REGENERATION

ELENI SPANOGIANNI & YIOTA THEODORA
Department of Urban and Regional Planning, School of Architecture, N.T.U.A., Greece

ABSTRACT

Waterfront management is a crucial issue in spatial planning of coastal and port cities, with interest in it intensifying. In the current critical time of a multifaceted crisis in Greece – a country with a strongly coastal/insular-based character – the challenge of a comprehensive confrontation of this subject becomes even stronger, mainly due to climate change and local identity. Recognizing that this special category of space is characterized by complexity, the article seeks to contribute to the ongoing debate, emphasizing the need to change the way we face waterfront development and utilize its dynamics.The purpose of this research is the designation of a multidimensional methodological approach which seeks to investigate the capability of public space to assume a role as a unifying element for the reassurance of the city-sea relationship. The Athenian coastal zone is defined as a pilot field of investigation, focusing from the Faliron Bay to the Hellinikon area. The article states its interest on this highly urbanized area, where a concentration of hyper-local infrastructures and functions is confirmed. The objective is to investigate the question as to whether the public space can act as a means for the reinforcement of the urban coastal front, the assurance of its spatial continuity and its attribution to citizens' everyday life. It aims at re-opening the discussion through supporting the need for the creation of a coastal sustainable strategy integrated into an overall urban policy with emphasis on new structures of governance and the reassurance of the city-sea relationship with the public space acting as a catalyst. In this rationale, attention is given, inter alia, to the systematic study of the proposed planning practices referring to the pilot area, mapping its spatio-functional transformations as well as structuring a new indicator-based assessment system ready to contribute to the evaluation and measurement of possible future changes and dynamics.

Keywords: coastal/port cities, waterfront development, spatial policies and urban regeneration, spatial and environmental planning, livable cities and smart sustainability, public space, climate change and resilience.

1 INTRODUCTION

The management of the natural environment is a subject of special criticality in terms of spatial development and design. Especially during the last 15 years, where in conditions of climate change and search of new forms of smart development in terms of sustainability, resilience and competitiveness, the protection and exploitation of the elements of nature remain firmly at the center of scientific research. An objective that especially in coastal and port cities acquires unique interest due to the coexistence of multiple (often incompatible) uses. In these fragile loci, where the pressures in the natural and structured environment are intense, the recovery of urban coastal front and the assurance of the city-water connection are emerging as major planning challenges [1], [2]. A trend, that raises a number of issues related to the management of the coastal area and its organic integration into the urban fabric. In the process of retrieving the coastal front, public space is projected as the key. The question, thus, arises: whether, and under what conditions, spatial planning could contribute to the optimal utilization of public space as a developmental factor in general, but also as a unifying element in the scale of the city. The article seeks to contribute to this question through the investigation of: whether and under what conditions the development

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options/planning practices could contribute to the constitution of a livable urban coastal front, ready to function as an organic part of the city. An issue, which has not ceased to concern at the level of official state policies, but also at the scientific level [3], [4], returns dynamically to the current situation of the recent pandemic and in fact in conditions of a multifaceted crisis. The data is constantly changing, clearly highlighting new needs and priorities. This fact makes the reconsideration of the research and planning methodology of the coastal urban front more necessary than ever. The interest focuses on Greece at a time, when efforts are underway towards the modernization and strengthening of the country's position at the international scene through the determination of new forms and dynamics of the coastal space, as well. To this direction, the need for the redefinition of the planning of public space is projected more and more based on protection, resilience, security and health, as well as social justice. More specifically, the research which is presented at this stage (i.e. from the Faliron Bay to Hellinikon area) [5] is part of a broader investigation having as a place of reference the entire coastal urban area of the Metropolitan Region of Athens [6].

The article is organized into three thematic sections (Sections 2, 3 and 4) in an inseparable correlation among them (Fig. 1). The first section opens the topic through the presentation of public space as a means for urban regeneration. The second one (with a more practical character) highlights issues which have been arisen through the pilot research, while the third one (associating the general problematic with the findings from Athens) proceeds to the formulation of thoughts/suggestions that could help in the formation of an overall policy for urban coastal areas. Emphasis is placed on the importance of organizing new governance structures and on the optimal utilization of natural and cultural heritage [5]–[9].

Figure 1: Basic thematic sections of research. *(Source: Own processing.)*

1.1 The methodological approach

The complexity of the coastal area poses particular difficulties that emphasize the need for special planning and therefore for the existence of an appropriate flexible methodology of research, assessment, imaging and ongoing surveillance. Contemporary experience and practice have highlighted on the one hand the importance of simultaneous observation of the urban coastal front as an organic part of the city, and on the other hand on the basis of monitoring the individual spatial parts, that make it up, and its interconnections with other areas of the city and beyond [2], [4]. In this rationale, the current debate about waterfront development and its importance in coastal cities' competitiveness and quality are being presented through the relevant literature. At the same time, in Greece the following are being investigated: (a) the current institutional framework for the coastal area and the environmental and spatial planning (e.g. implemented and proposed plans for the study area and more broadly, development policies, investment policy, etc.) and (b) the participants (key actors) in the planning process and their role. It is in the field wherea systematic recording, grouping and typing of the individual areas of the examined area is attempted based on specific environmental, spatial, and socio-economic criteria. Indicatively, crucial issues are approached which are related namely to the: (a) administrative structure, b) conditions of access and networking, (c) coastline features (landscapes/seascapes), (d) existence/quality of natural and cultural elements, (e) land uses and infrastructures, and (f) socio-economic characteristics of the Municipalities to which the investigated coastal areas belong. The main aim is: (a) the comprehension of the current situation and its dynamic development over time (1940–present), and (b) the identification of the implications of developmental and planning choices (or of their absence) on the natural and structured environment. The observation of the spatial-functional transformations and their effects takes place in important time-lapse sections, starting in 1940 and focusing on the last 20 years. During this period of 80 years, emphasis is placed on the designation of the factors that have functioned supportively or deterrently for the *spatial continuity* of Athens coastal front and the reassurance of its organic integration into the city.The main methodological tool for the observation and the evaluation was the processing of the aerial photographs of the area in the time periods/stations: 1940, 1962 and 1988 (Fig. 2). The cartographic depiction was followed by its correlation with quantitative and qualitative data, in order to draw conclusions about the character of the area and the role of the public space in it and beyond. In this regard, the interest has been focused on cartographic backgrounds and aerial photographs at various scales of 2019, in order to construct an overall database for the study area (i.e. Subsection A: the Faliron Bay: Municipalities of Moshato – Tavros, Kallithea and Palaio Faliro) (Figs 3 and 4).This area is, in the next phase, divided into four spatial subsections due to the differences among them regarding the: (a) existing conditions of access and networking and (b) features and elements of the *route* concerning nature and culture, the activities and infrastructure developed along the urban coastal front (or expected to develop), the quality of public space, the relationship with water as well as experiential actions to mention some. These differences make the distinction of the investigated area necessary for its optimal observation and the evaluation of the interconnections and correlations between its spatial parts (Fig. 4). At the same time, they constitute the criteria from which quantitative/qualitative indicators can emerge of spatial character (such as: geomorphology, structured-unstructured relationship, land uses, accessibility-networking), but also of socio-economic character (e.g. demographics, population density, etc.). Their determination is the subject of a following phase. The correlation and utilization of the cartographic material and the data from the field research in the present phase focus on the investigation of the existence of public spaces on the coastal front and the assessment of their quality and their spatial continuity (Figs 5 and 6).

1.2 The Faliron Bay as a place of reference

In the context of the problematic for the development of the coastal urban front, in Greece, a country with a strongly coastal/insular-based character, there are still open issues of its development, management and planning, which cause various problems in practice. Greece is a unique case of research as the total length of its coastline exceeding 15,000 km, ranking the country 11th in the world. Country's intense coastal/insular character raises issues of unique interest as far as the development, management and planning of its coastal and port cities [2], [9]. Main reasons, inter alia, the fragmentary legislation for the coastal area and the planning of urban areas combined with the involvement of many actors, without always clear responsibilities and the absence of a suitable coordinator [4], [5]. Athens is obviously an interesting case, as it is a highly populated coastal city with exceptional history and unique natural beauty where three important ports operate (Piraeus, Rafina, Lavrio). The coastal character of Athens brings out critical issues related to waterfront management and development, the relationship between the city and the sea, the spatial continuity of coastal areas and their organic integration into everyday life. Issues that, despite the important efforts made so far, remain unsolved. As mentioned above, special attention is given on the coastal zone from the Faliron Bay to the Hellenic Metropolitan Park. The specific area administratively belongs to five Municipalities (Moschato-Tavros, Kallithea, PalaioFaliron, Alimos and Hellinikon-Argyroupoli) (Fig. 3). It is an extremely dynamic coastal urban front characterized by: (a) a high concentration of infrastructures and functionsof supralocal importance, (b) intense densities, and (c) significant supra-local connections (i.e. road axes, transport systems). In this area dynamically organized spatial sections functioning as main sacs of tourist uses and recreation coexist with residential areas, as well as areas characterized by environmental degradation and quality problems. In such contradictory conditions, an intense investment interest dominates. Something which provokes various reactions, often tensions at the local community level. Indubitably the structure and the special features of Athens waterfront introduce management and development dilemmas. Hence, multiple planning challenges emerge at all different geographical levels [4], [8]–[9].

The special interest about Subsection A (the Faliron Bay: Municipalities of Moschato-Tavros, Kallithea and Palaio Faliro) was not random. This is an area defined by two natural boundaries of special importance for Athens, which are also administrative boundaries. Specifically, from the west the Kifissos river (its estuary is located inthe Faliron Bay) and from the east the Pikrodafni Stream (Fig. 4). The area, due to its special features and the intense interest, which gathers especially in the recent mainly 10 years, constitutes a key reference point and one of the most central exits of the city towards the sea. The already planned in progress large-scale interventions in the area of the Faliron Bay – related to city's "openness" to the sea – give to the specific area an additional (even stronger) dynamic. Its proposed distinction into four spatial subsections under the coastal road (Posidonos) raises a variety of issues in the exploration of typologies of public space and its qualities, through a logic of comparative view but also of a simultaneous approach of the wider space, where these areas belong to. More specifically the subsections are: (a) Subsection A1: part of the Faliron Bay/Municipality of Moshato-Tavros, (b) Subsection A2: part of the Faliron Bay/Municipality of Kallithea, (c) Subsection A3: Faliro Delta and Marina Floisvou/Municipality of Palaio Faliro, and (d) Subsection A4: Beaches of Palaio Faliro/Municipality of Palaio Faliro) (Fig. 4).

2 THE PUBLIC SPACE AS A MEANS FOR URBAN REGENERATION

In the context of globalization, spatial networking organization and climate change, coastal and port cities are gaining particular interest in the countries' development policies. The challenge and bet at the planning level are the organization of the public space in such a way, that it functions as a unifying element in the redefinition of the city-water relationship. An objective which especially in port cities presents additional interest, since the evolution of the production model and the changes in the organization and operation of modern ports require additional space, strengthening the tendency of their relocation away from the urban fabric – trend which allows the release of old port infrastructures. Thus, gaps arise, raising the issue of their reuse through their re-planning with the public space and the placement of tourism, leisure and culture facilities as the keys. Particularly in the case of port cities, the interest for urban coastal front is inextricably linked to the peculiarities of their economy, their strategic position, new technologies, but also to the incompatibilities found in the uses and the quality of the space at a local scale [2], [10]–[13]. In these fragile locales, the city-water relationship is redefined and projected as a comparative advantage. The main difficulty lies with the management of the plans that concern the port and those, that refer to the city. Thus, the recovery of the coastal front in port cities, as well as in coastal ones in general, is a dominant issue, as they are called upon to find the balance between global competitiveness and local sustainability and identity [13], [14]. In this rationale, where the public space is projected as a catalyst for the development and a means for the reconnection of the city with the water, its species and its typologies gain additional research interest. Of equal interest are parameters which, directly or indirectly, affect the use of the public space and the degree of appropriation, such as: (a) its ownership status, (b) who is (are) the actor(s) responsible for its management, and (c) who are the participants in the planning process (public and private sector, citizens). The above raise issues related to: whether and to what extent public spaces on the coast are "open" and under what conditions [2], [4], [7].Thus, the following are of major concern: (a) to whom public spaces are addressing to and what they offer, (b) how safe they are and to what extent they contribute to the quality of the urban environment [13], [15].

The international practice and experience have to show interesting examples implemented so far, through which the criticality of public space in the rebirth of coastal cities and port cities is projected, highlighting at the same time the importance of the active citizens' participation in their planning process, but also the criticality that the composition of the participants may have (public and private sector bodies, investors, citizens) [2], [4], [14]. Indicative reference is made for the case of Stockholm and Baltimore, two cities that have developed a particularly positive relationship with water through long-term strategic actions based on innovative governance structures and the establishment of cooperative relations with citizens [16]–[18]. In the case of Stockholm (Green Capital 2010) emphasis was placed on three axes: (a) the adaptation to climate change (e.g. technical infrastructure, water level, green, ecological materials, sustainable energy sources), (b) the reassurance of the accessibility and the sustainable urban mobility (unimpeded movement of pedestrians and bicycles, public transport, development of public spaces by the water, etc.) and (c) the defense of the complexity of uses and the location of infrastructure of supra-local importance. Equally interesting is the case of Baltimore, as is among the most successful examples of the renovation of former port facilities and their return to the city. The key is the establishment of public-private partnership through the creation of a single management and planning body (*Baltimore Waterfront Development*), as well as the development of actions for the public awareness on issues of protection and use of local identity. In both cases the public space is the key and the basic planning idea has to do with the reassurance of the spatial continuity and interconnection of its individual sections via routes with stop-motion networks along the water, while aiming at a connection with the historic areas of the cities and their neighborhoods.

Observing the international practice regarding the management of the coastal urban front, it appears that, regardless of the scale of the cities, common developmental and planning issues are emerging. Main principles of planned projects are, among others, the protection and management of history and natural and cultural heritage, the reassurance of access and sustainable mobility, the multifunctionality, the security and the formation of sustainable healthy public spaces. Experience has shown that the variety and spatial continuity of the activities in a public space constitute major principles for the formation of vibrant and creative waterfronts [10], [15], [19]. Parallel to the above, ensuring a variety of public spaces (i.e. scale, form, etc.), where security and image exchange are ensured, can play a crucial role in the pedestrian's choice to walk [20], [21]. Therefore, the variety of qualities and the spatial continuity of the coastal urban front enhance the development of experiential activities by the water and shape conditions of euphoria and creative search.

3 FALIRON BAY – ATHENS MEETS THE SEA

The interest for the *opening* of the city to the sea is special in Athens. Various efforts have been made towards this direction. One of the most recent and much-discussed is the case of the Faliron Bay, which is part of the new narrative, which is formed in recent years for the coastal zone; that of the *Athenian Riviera* and the unified planning of the area, which raises new dilemmas and challenges. This area has at times starred in development visions of which little have been realized. In modern times, the vision of its exploitation and, by extension, of the *opening* of Athens towards the Saronic Sea front, comes to the fore again through areas of recreation, culture, sports and tourism, and more specifically, through the recent completion of the construction of the *Stavros Niarchos Foundation Cultural Center*, which is a catalyst project for the initiation of the procedures for the redefinition of the Athens' relationship with the coastal front. The aforementioned pursuit is a developmental practical application of the directions of the New Regulatory Plan of Athens-Attiki (Law 4277/2014), the text of which uses the choice of the subheading *Athens – Mediterranean Coastal Metropolis* in order to make its coastal area a key comparative advantage. Indicatively it is mentioned that the seafront axis of the city from the Faliron Bay to Vouliagmeni is defined as development axis of metropolitan radiation, among which the *M*etropolitan Pole of the Hellenic Agios Kosmas and the Pole of the Faliron Bay are defined as poles of international and national range.

In order to approach this "new" *opening* of the city to the sea, the reading of the area takes place at different spatial levels. Initially, the observation of the area is realised through a broader rationale of understanding the space (from the Faliron Bay to Hellinikon) through its transformations since 1940 (Section 3.1.) (Fig. 2) and then emphasis is given to the pilot area Subsection A (Fig 3), which is part of the wider area, in order to discover the public space, which exists under the road on a comparative basis (Section 3.2.). More specifically, the approach of its qualities, its differences and its spatial continuities and discontinuities takes place both along the coastline and in relation to the city, so that in the last section of this section some first interesting findings and some open questions emerge through all this interaction (Section 3.3.).

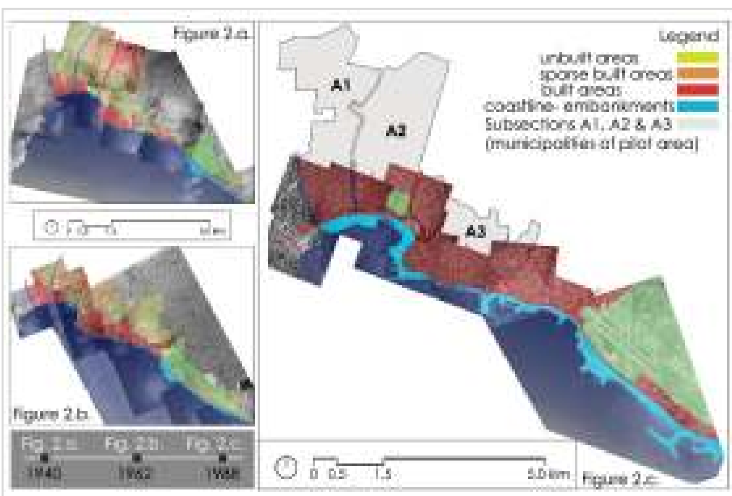

Figure 2: The Space-functional transformations of the broader area. (a) 1940; (b) 1962; and (c) 1988. *(Source: Aerial photographs, own processing.)*

3.1 From the Faliron Bay to Hellinikon: Space-functional transformations and dynamics after 1940

The complexity of the area from the Faliron Bay to Hellinikon (Fig. 3) is of particular interest in terms of its spatial-functional transformations and its dynamics, which are considered worth approaching. At this stage, as shown in Fig. 2, the successive changes in the density of the urban fabric of the city are highlighted in parallel view with the successive changes in the geomorphology of the coastal front (due to embankments, marine constructions, etc.) and accessibility conditions (due to the construction of new infrastructure as well as transport projects).

More specifically, during the first post-war period, the capital kept a "distance" from the beach, while the urban front was formed in an inconsistent narrow strip, parallel to the coast, at a depth of a few building blocks (Fig. 2(a)). Then, the 1970s is considered a crucial decade for the coastal zone of the Saronic Gulf, because it was then, that a series of spatial interventions began, most importantly the large technical embankments (in the Faliron Bay, Marina Floisvou, Marina Alimou and Marina of Agios Kosmas in Hellinikon), while the process of urbanization, that had begun in the previous decade, expands within the urban fabric (Fig. 2(b) and (c)). Then, during the 1980s, road construction works began, mainly related to the creation of the elevated Poseidon Avenue in the area of the Faliron Bay, a time when the generalization and expansion of the use of private cars and the strengthening of the role of the Airport of Hellinikon as a transportation hub contributed to the beach gaining a different interest. It is also characteristic, that in the next decade the first uses of culture-sports-recreation will begin to be located in specific places along the entire length of the study area, with the result that the area will receive large tourist and commercial development cargoes, intention which eventually manifests in the following years.

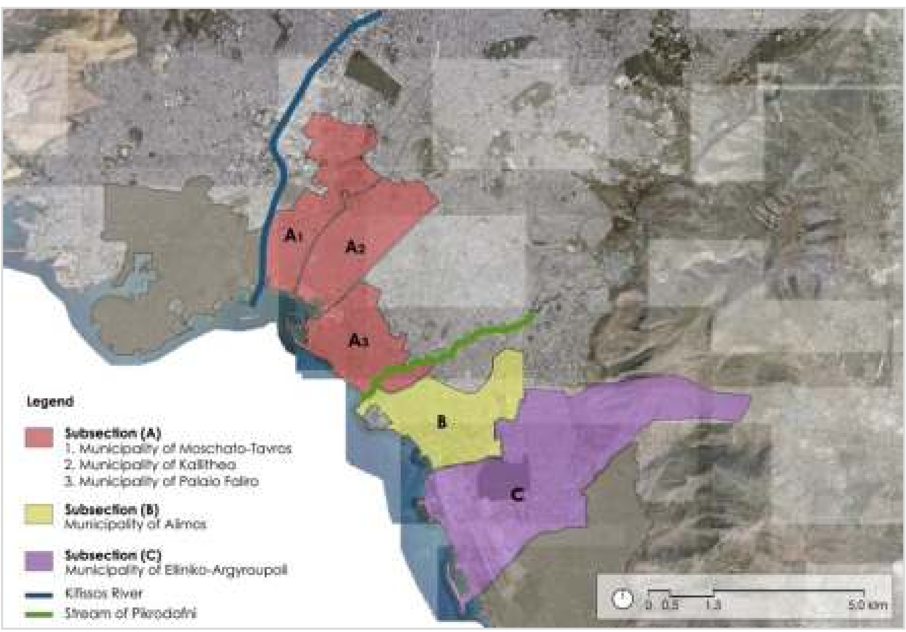

Figure 3: The geographic location of the coastline of the study area. *(Source: Google Earth, own processing.)*

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3.2 Investigating the different qualities of public space under the coastal road Posidonos

The place of reference Subsection A (Section 1.2.) presents a special complexity and diversity not only in terms of the existence or non-existence of spatial continuity between the four individual spatial units of the zone below the road, which compose it (Fig. 4), but also in terms of the relations, that develop, with the urban coastal front and consequently with the hinterland.

More specifically, for the investigation of the public space below the coastal road emphasis was given both on the cartographic material and on the quantitative approach of some indicators (as analyzed in Section 1.1.), concerning the: (1) total area ofeach subsection in 2019, (2) division of the total area of each subsection in the four basic categories (indoor buildings, outdoor facilities, open spaces and infrastructure) and (3) analytical approach of the category of open spaces in the current situation. Based on the above, the following table (Fig. 5) presenting these quantitative dimensions was created, which are of major interest for the approach of the public space at the present research effort. A first noteworthy remark is that all four areas (A1, A2, A3 and A4) are characterized by adequacy in open spaces, which show significant differences in their character and qualities. Open Spaces' division into natural landscaping, parks and routes for pedestrians and cyclists and unused areas gives a better picture of public space' quality of each subsection, resulting in some important findings. More specifically, with regard to Subsection 1, the – important for the city – free spaces within it remain unused in their entirety, a situation which is expected to be settled through the upcoming operations in the Faliron Bay. It is noted that these interventions also include Subsection 2, so they are expected to reverse the picture of the unused areas of this subsection as well, while in terms of the percentage occupied by open areas in the total area of each subsection, Subsections 1 and 3 present a corresponding image (54% and 52%, respectively).

Figure 4: The distinction of the pilot area into four subsections under the coastal road. *(Source: Google Earth, own processing.)*

		Part of Faliron Bay (Municipality of Moschato-Tavros)	Part of Faliron Bay (Municipality of Kallithea)	Faliro Delta & Marina Floisvou (Municipality of Palaio Faliro)	Beaches of Palaio Faliro (Municipality of Palaio Faliro)
		Subsection 1	Subsection 2	Subsection 3	Subsection 4
Total Area (sq.m)		327.340	329.050	517.800	85.360
Division of the total area of each subsection in 4 Basic Categories	Indoor Buildings	0 0,00%	18.800 6,00%	33.710 6,00%	1.400 2,00%
	Outdoor Facilities	0 0,00%	13.800 4,00%	50.790 10,00%	2.000 2,00%
	Open Spaces	267.290 82,00%	176.650 54,00%	267.590 52,00%	67.060 79,00%
	Infrastructure	60.050 18,00%	119.800 36,00%	165.710 32,00%	14.900 17,00%
Division of "Open Spaces" of each subsection in 3 Basic Subcategories	Natural Landscaping	0 0,00%	0 0,00%	0 0,00%	49.260 73,00%
	Parks / Routes for pedestrians & cyclists	0 0,00%	109.300 62,00%	259.240 97,00%	17.800 27,00%
	Unused Areas	267.290 100,00%	8.350 38,00%	517.800 3,00%	0 0,00%

Figure 5: Comparative approach for the 4 Subsections of the pilot area below the coastal road with quantitative criteria. *(Source: Own processing.)*

Regarding Subsection 3, the existence of parks and routes for pedestrians and cyclists is remarkable (97% of its free spaces). A fact, which suggests that the social role of the public space functions and, also, highlights an attractive space for the citizens, with properly designed sections in terms of qualities of public space, and consequently a *livable* part of the city. Finally, with regard to Subsection 4, the fact that most of its area is dominated by natural landscaping (73% of its free space) is of particular interest, a remark that is very important for the protection of the natural coastline, which in the other three subsections – due to the construction of marinas and embankments – has been dramatically altered.

3.3 Findings from the field research and open questions

In order to approach the first findings, which emerge from the field research of the selected pilot area, it is advisable to combine the above quantitative approach with the qualitative approach, which was followed in a previous research stage for the whole study area (from the Faliron Bay to Hellinikon), so that the up to now field research can be enriched with the new quantitative data, correlated with them and re-examined. More specifically, through the double reading of the proposed grid diagram (vertically and horizontally) (Fig. 6), a first reading of the public space and its qualities has been made, while at the same time both the positive and negative elements of the individual spatial units and the correlations between them were highlighted, with the aim of identifying the spatial discontinuities, that interrupt a unified route by the water.

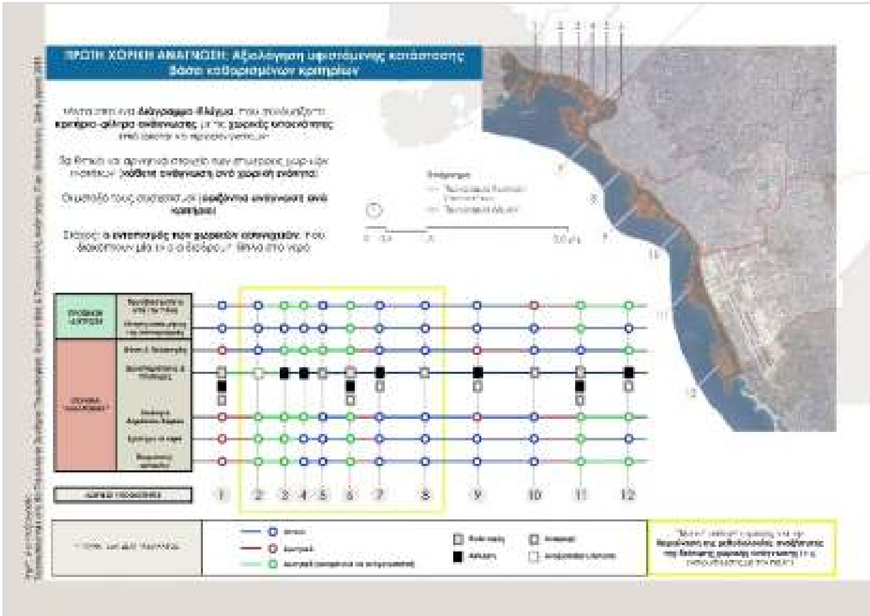

Figure 6: Qualitative approach of the pilot area with emphasis on the axes: (a) access-networking; and (b) land uses-activities. *(Source: Own processing in Greek.)*

More specifically, with regard to the first axis of *access-networking*, the operation of the coastal road as a barrier between the city and the coastal area along the largest part of the study area is considered particularly problematic. This picture is particularly strong in Subsection 1 (sub-area 2 of Fig. 6), while a similar picture appears in Subsection 2 (sub-areas 3, 4 and 5 of Fig. 6), where *Esplanade* is recognized as a positive design movement, which is an above-ground route of unification of the city, and specifically of the *Stavros Niarchos Foundation Cultural Center* (artificial point public space with a supra-local character above the coastal road) with the sea. Via the forthcoming interventions in the Faliron Bay these issues are expected to be solved, as the reassurance of the operational and physical continuity along the coastal zone is pursued, as well asthe strengthening of the city-sea relationship. Regarding Subsection 3 (sub-areas 6 and 7 of Fig. 6), although some obstacles are identified in the form of railings in the area of Faliro Delta and in its transitional zone of its connection with the spatial unit of Marina Floisvou – which arise due to ownership status – access from the city is considered satisfactory. Finally, in Subsection 4 (sub-area 8 of Fig. 6), the best access conditions to the coastal area are identified, as the flat pedestrian crossings allow the direct contact of the inhabitants with the water element, while in this part of the coastal zone the picture is also positive regarding on the unimpeded movement of pedestrians along the coastline.

At the level of land uses, those that are identified (tourism, commerce, culture, sports, education and recreation) appear to be compatible with the applicable legislation. It is noteworthy, that these uses are of interest in the present approach not so much regarding the ownership status of the land or building in which they are developed, but regarding the public access, as it is argued that issues that create spatial discontinuities due to the ownership status may be addressed through the arrangement and proper handling of uses. This desired spatial continuity seems to be broken by the existence of large unused areas and significant building stock in Subsection 1 (sub-area 2 of Fig. 6) in Faliron Bay, elements that, if used properly through the forthcoming interventions, can make a positive contribution to the confrontation of the lack of cohesion along the coastal front and have multiple benefits for the city. At this point it is advisable to formulate a concern about whether, and to what extents, more uses for the maritime space could be developed, so that this part of the coastal zone really functions as a privileged space between land and sea, an issue that can be approached at a later stage of research through a different methodology.

Closing the present section, it is noted that the proposed methodology for reading space through a quantitative and qualitative approach is part of a broader effort to formulate a methodological framework for the study area both to assess the current situation and to develop scenarios for the implementation of different policies. The aim of the research on the pilot area is not the simple aggregation of information but the apprehension of the complexity of the place of reference and the importance of the simultaneous display of spatial-functional data, the direct contact with the field and the designation of an innovative methodology of a multidisciplinary evaluation of the information. The further pursuit of this research effort is, via the identification of problems and the comparative advantages, to examine both the prospects of the exploitation of the study area and the optimal method of approaching an overall view of the urban coastal front of the *Metropolitan Region of Athens*.

4 WATERFRONT DEVELOPMENT NEEDS A COMPREHENSIVE POLICY

Through this route, multiple issues are highlighted for further investigation, both related to the management and planning of the special category of the urban coastal front and the emergence of public space as a catalyst for the reassurance of the city-sea relationship. In the international community, the ever-increasing interest of cities for the element of *water* is undeniable, seeking to highlight the conscious shift in its management as a means for changing the image of places. In this direction, the public space and the utilization of the local cultural heritage play a key role [22]. It is estimated that the public space is treated as a development factor for the image of the city; a finding that was approached briefly through the reference to the implemented design practices of international experience (Section 2). In Greece, although some important steps have been made to address the issues of interest, there are still some open issues. The aim of this effort is the contribution to the discussion through the communication of the first findings of a broader research, which having the *Metropolitan Region of Athens* as a spatial field of reference, investigates issues of accessibility, regulation of the individual spatial units of the urban coastal front and the relations between them, planning and implementation mechanisms, arrangement of land uses along the coastline, management of the natural and cultural environment, addressing impacts from climate change but also issues related to the management of natural disasters (such as the rise of the sea level) to name a few [4], [7], [8], [23].

It is argued that the reassurance of a successful development of the urban coastal front demands the creation of a coastal sustainable strategy integrated into an overall urban policy with the public space acting as a catalyst. The main challenge of planning at this level is the development of an organized network of public spaces on the urban coastal front by giving special emphasis to the following axes: (a) improvement of the accessibility from the city and special concern for the possibility of the existence of sustainable mobility along the coastline, (b) reconstruction of the land and sea divisions through a balanced development between economic pursuits and environmental parameters and c) functional and aesthetic upgrade of the coastal zone and reassurance of its vitality [2], [6]. At the same time, the observance of participatory procedures in the design process are considered to be of major importance, as well as the re-examination of new governance structures at the metropolitan level, which will be able to support the unified management of the coasts aiming at the better organization of the actions, the coordination of all stakeholders and the improvement of the effectiveness and monitoring of the application [4], [18], [24]. By highlighting the multiplicity and complexity of the relationships and interrelationships between them, this research effort leads to new research questions both about ways to manage and design the urban coastal front, as well as for the further search of the role of public space as a mechanism for strengthening the coastal front and ensuring its spatial continuity.

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SECTION 6
URBAN CONSERVATION AND REGENERATION

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PRESERVATION OF COMPANY TOWNS IN MEXICO

ALEJANDRO ACOSTA COLLAZO
Department of Architecture, Autonomous University of Aguascalientes, Mexico

ABSTRACT

A company town used to be a community that included services like work and housing, but also stores. The main buildings of a company town were the enterprise buildings, but for several reasons the whole built complex – including houses – are considered as a company town. The first company town in Mexico was La Constancia Mexicana in the state of Puebla, but there were some other company towns spread out in the whole country. In this paper, some company towns situated in different states of Mexico (Oaxaca, Tlaxcala, Puebla, Jalisco and Aguascalientes) were chosen for this study. Several preservation problems were detected, for example, the city of Aguascalientes continues to grow on the western side of it; hence, changing its historic sites. So, it is important to improve historic preservation, but also pursuing prosperity around cultural sites. The newest social housing projects and private developments nearby San Ignacio company town become a problem for the future of the building; therefore, cultural sustainability becomes a priority. A preservation option that some governments have a tendency to apply is the conversion of the historic buildings to museums, but not all the cases have to do with this practice. It is through a study of the taxonomic classification of architectural characteristics of company towns in Mexico that interpretive centres can help demonstrate the importance of their conservation and regeneration. Also, they can play a part in raising historical awareness. The paper can contribute to improve social and cultural issues of a city or a state. Besides, the final results could help city planning to advance in sustainability of architectural heritage sites. Preservation of company towns in Mexico can be instrumental in developing cultural identity. Also, recognition of significant historical facts of industrial heritage can help to stop the loss of several iconic buildings.

Keywords: company towns, historic preservation, sustainability, cultural identity.

1 INTRODUCTION

The objectives of this paper include analysing architectural characteristics of company towns, in order to understand the way they functioned and they solved spatial conditions. Also, the main zones of each selected company town will be compared to find out about production processes and their relationship with architecture.

The communities (small cities) named company towns were based on factories that were established in the whole world during industrial revolution. Mining towns are a good example of these circumstances and also prime movers. Marais et al. [1] argue: As mining intensified after the industrial revolution of the eighteenth century, mining companies all over the world began to build and manage towns for their employees. In providing housing, infrastructure and services, these towns performed a social function. They created new communities and became distinctive features of the landscape.

In 1902, Ebenezer Howard wrote down a book, related to ideal design standards for cities, communities and factories: *Garden Cities of Tomorrow*, published in London by Swan Sonnenschein and Co. Ltd. But the first edition was named as *To-morrow: A peaceful Path to Real Reform,* published in 1998. Howard was worried about how cities were growing rapidly and mentioned them as great cities. Also, he questioned himself about the happiness of people and searched for new urbanism methods to make the country more attractive than a town. Industrial revolution caused people a preference to live in a city, rather than in the countryside.

Howard assumed a town and the country could be considered as magnets. In fact, people preferred sometimes to live in a city because location of services and places to work, but in

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the ending of the 19th century there was a lack of houses for workers. So, Howard suggested a third magnet: Town–country, where good qualities of each one could be put together to promote better ways of living for societies. Howard visualised a Town–country magnet with beauty of nature, social opportunities, fields and parks with easy access, low rents, high wages, low rates, plenty to do, low prices, no sweating, field for enterprise, flow of capital, pure air and water, good drainage, bright homes and gardens, no smoke, no slums, freedom and cooperation. Yuan et al. [2] argue a survey of studies on Garden Cities over the past 100 years suggests that Howard's theory has only been considered qualitatively.

Somehow company towns took ideas from Howard's principles. Companies could offer opportunities for workers on a specific location, and of course, company towns could be situated in the countryside and offered reduced rents for workers, considering location advantages. This means the factory and housing for workers were situated at the same place or very close to each other.

In some way or another, company towns provided their employees sanitary conditions. Usually a company town was situated close to rivers or ponds to assure water supply to produce energy and the cleaning of equipment installed in the factory. But also the running water was for inhabitants. Besides, in some company towns a pond or a lake was created for leisure activities.

Also, another capitalist who developed social ideas to improve working conditions was Robert Owen. He bought the New Lanark mill and encouraged better conditions than merely profit-making ones and the countryside was an ideal place to get them. An interesting situation was that he promoted education for his workers.

In some of the cases mentioned on this paper a small school was founded near the factory. Besides, an important contribution of Owen was the foundation of New Harmony's experimental community in Indiana in 1825. Afterwards, several working communities in the United Sates followed Owenism.

In Mexico, the first company town: La Constancia Mexicana settled in Puebla in 1835 and it didn't close until 1991. Also San Ignacio in Aguascalientes was a historical company that was built in 1861. Nevertheless, the architectural floor plans looked like the ones from company towns in Europe or from the United States of America. This situation depended also on the owner's culture and their nationality. San Ignacio company town is a good example of it. The first owner: Pierre Cornú came from France and designed his factory with architectural styles accordingly, even though an original *Plan d'un batiment* hasn't been found. Such company town took ideas from Howard's garden city and community concepts from Robert Owen. Obviously, in most of the company towns mentioned on this paper there were also significant historic infrastructures surrounding the factories.

2 METHODOLOGY

The methodology used throughout the writing of this paper started selecting a sample of typical company towns in Mexico: La Soledad Vista Hermosa in Oaxaca, La Trinidad in Tlaxcala, La María in Puebla, La Constancia Mexicana in Puebla, Río Grande El Salto in Jalisco and San Ignacio in Aguascalientes. Afterwards, drawings were made in floor plans using Computer Aided Design (CAD) systems, in this process the drawings were made using an urban scale to be able to compare them; in addition, the "area" tool of the CAD system was useful to determine specific surfaces of the companies.

Furthermore, the main structures of the company towns, drawn in CAD systems, were extruded as volumes in order to compare them. So as to obtain more accurate results, a research was done to find historic drawings of the company towns selected, and also historic information obtained from company archives. After getting the correct sizes of each factory

– including heights, a taxonomic classification was made, based on overall similarities of the companies, also using colours on extruded volumes (original spatial use class and types of buildings), dimensions and square meters. The methodology included revising historical documents frequently to find certainty about the areas and correct zones.

The methodology used in this paper can be considered as qualitative, because historical research of architecture was practiced and also a researcher's interpretation was used. Groat and Wang [3] say the strategy of qualitative research is one of first-hand encounters with a specific and defined context. It involves gaining an understanding of how people in real-world situations "make sense" of their environment and themselves; and it depends on, rather than rejects, the researcher's interpretation of the collected data.

The method searches assets and limitations of the six company towns reviewed on this paper, but evaluation was restricted to taxonomic analysis, in order to comprehend spatial relationship of main zones built in each factory. Nevertheless, there are some other factors like geographic location and the relation to their historical context that were also considered by the author of this document.

This paper can also help to promote interpretive centres in Mexico where people can learn significant appreciations for historical company towns. Also institutions can help assemble valuable information and archives to keep business activity of company towns.

3 HOUSING FOR WORKERS AND INDUSTRIAL HERITAGE

During the 19th century and the beginning of the 20th century, several factories preferred to build houses for workers nearby the companies in Mexico. This is the case of textile factories, construction companies, railroad companies, mining companies, etc. Even though textile companies were very common in Mexico, also there used to be very interesting factories of some other architectural typologies and styles.

Paternalism was part of the way of living in company towns. The design of company towns included behaviours expressing attitudes of dominance; particularly in the way housing for workers was designed, for example in La Constancia Mexicana and San Ignacio. So, houses for workers were situated very close to work places (large factories) for practical reasons. The distance from home to work was insignificant, but also the company towns used to have stores, so workers didn't have to leave the place to buy provisions. However, sometimes workers couldn't afford to pay their basic needs and most of them were drowning in debt with the owners of the company towns. This situation was somehow used as a way to rule the workers and also their private lives.

There used to be a social balance in company towns – with no wealthy residents, but big houses were destined to the owners of the company or for the administrators. In fact, it can be observed that in most of the company towns analysed in this paper the houses of the owners can easily be identified; nevertheless, there used to be open spaces and squares with gardens where people could socialize with anyone. Shojae et al. [4] mention in establishing a deep mental and internal connection between the individual and the environment, it creates a sense of satisfaction and identity in him and increases the dynamism and vitality of the squares and the formation of social interactions in the residents. This was the case of San Ignacio company town.

Not all company towns in Mexico were to develop cities. In fact, some of the cases mentioned in this paper preferred to situate in isolated places with no densely-housed regions, but close to rivers, lakes or areas endowed with natural resources to ensure return of investments. Also, several company towns helped improved railway tracks and developed efficient infrastructure to communicate with cities and a nationwide network. The national

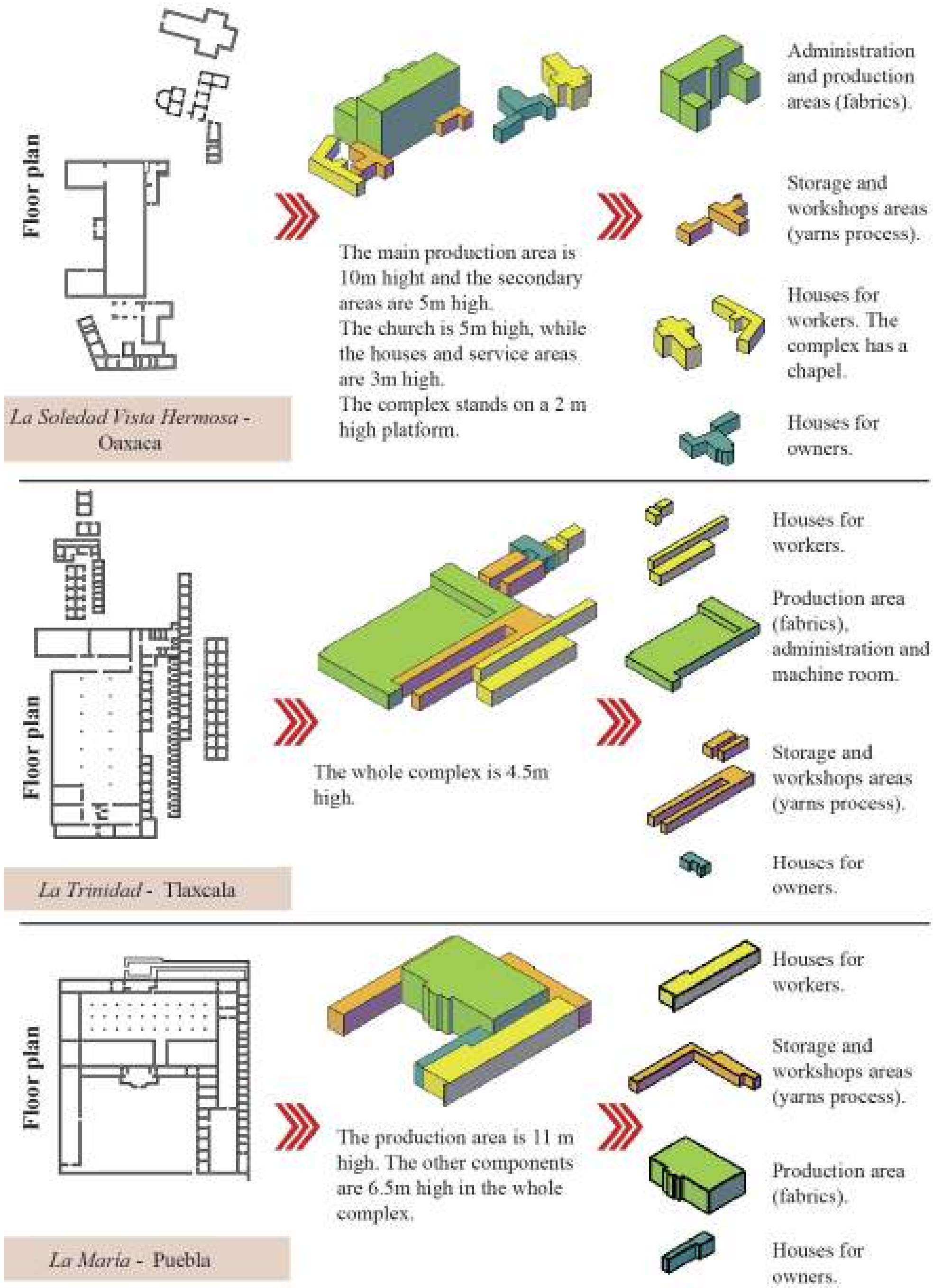

Figure 1: Sample of company towns in Oaxaca, Tlaxcala and Puebla. *(Source: Drawing made by Alejandro Acosta Collazo and Adriana Guadalupe Martín del Campo Cervantes, September 2020.)*

government also promoted fair practices of manufacturers and supported connections among factories. Nowadays, land speculation has affected some company towns, for example San Ignacio. This situation has also happened lately in Europe. Camerin [5] argues: in Barcelona, the destruction of the traditional working-class neighbourhood, which evolved based on industrial and railway activities, served to make way for speculative re-development lead by financial and real-estate capital, plus private's interest retreated from community-oriented planning initiatives.

Company towns could be considered nowadays as industrial heritage. But preservation of industrial facilities is not easy, although gradually city planning includes this type of heritage for preservation. However, landscape and city image become more complex. Sepe [6] mentions the contemporary city is the locus not only of complexity but also of simultaneity and instability, which give rise to situations of mutation and transitoriness. These are often predominantly motivated by economic gain, to the detriment of place identity which becomes increasingly compromised or unrecognizable.

Identity can also be formed by people's perception and it includes the images of a city and its architecture; thus, preservation of historic architecture can reinforce social identity. But a problem is the way societies learn to preserve iconic buildings and places. Hence, Architecture school don't teach too much about historic preservation. Wells [7] says one issue is that preservation is difficult to incorporate into architectural studios that often treat context as tangential to design and avoid the complexity of building reuse, instead favouring the theoretically pure area of new construction and design.

4 RESULTS

The comparison of the company towns selected for the writing of this paper shows common areas among them. Figs 1 and 2 illustrate a study of the taxonomic classification of architectural and urban characteristics of iconic textile company towns in Mexico. Administration and production areas always were the best built architectural spaces with special emphasis in the main access of the company. Very frequently, people can't imagine how beautiful some industrial heritage buildings are. In some cases, there were magnificent porticos built in stone, for example the main portico of San Ignacio was built of fine stonework white, with Gothic reminiscences on the main porch.

The design of housing for workers always was peculiar in company towns. In fact, company towns were small towns with some comfort pretentions for workers. The place used to have a small chapel, occasionally a school and the houses for workers were conveniently located neighbouring the factory. The best achieved designs, in terms of landscape architecture, were *La Constancia Mexicana, La María* and *San Ignacio* factories; thus the main façades of the buildings were those with remarkable views of the production and administration areas; but also, surrounded by the houses of workers. 4 m width x 8 m depth was the average size of the houses for workers.

In San Ignacio company town, the review of historical records demonstrated there were 40 houses with 30.81 m^2 apiece. Also, there used to be 65 small houses with 14.40 m^2 each one. It can be observed in Fig. 2 a reconstruction of housing for workers in San Ignacio Floor plan. In addition, four houses – occupied by administrators – had a surface of 50 m^2 each one. Furthermore, three big houses were built with 155 m^2 apiece, destined to owners and their families.

Even though houses for workers were kind of small, the total height of 4.5 m made them look bigger than what they really were. In fact, during the Viceroyalties in Mexico, especially during the 17th and 19th centuries, houses for workers were designed with enough room for

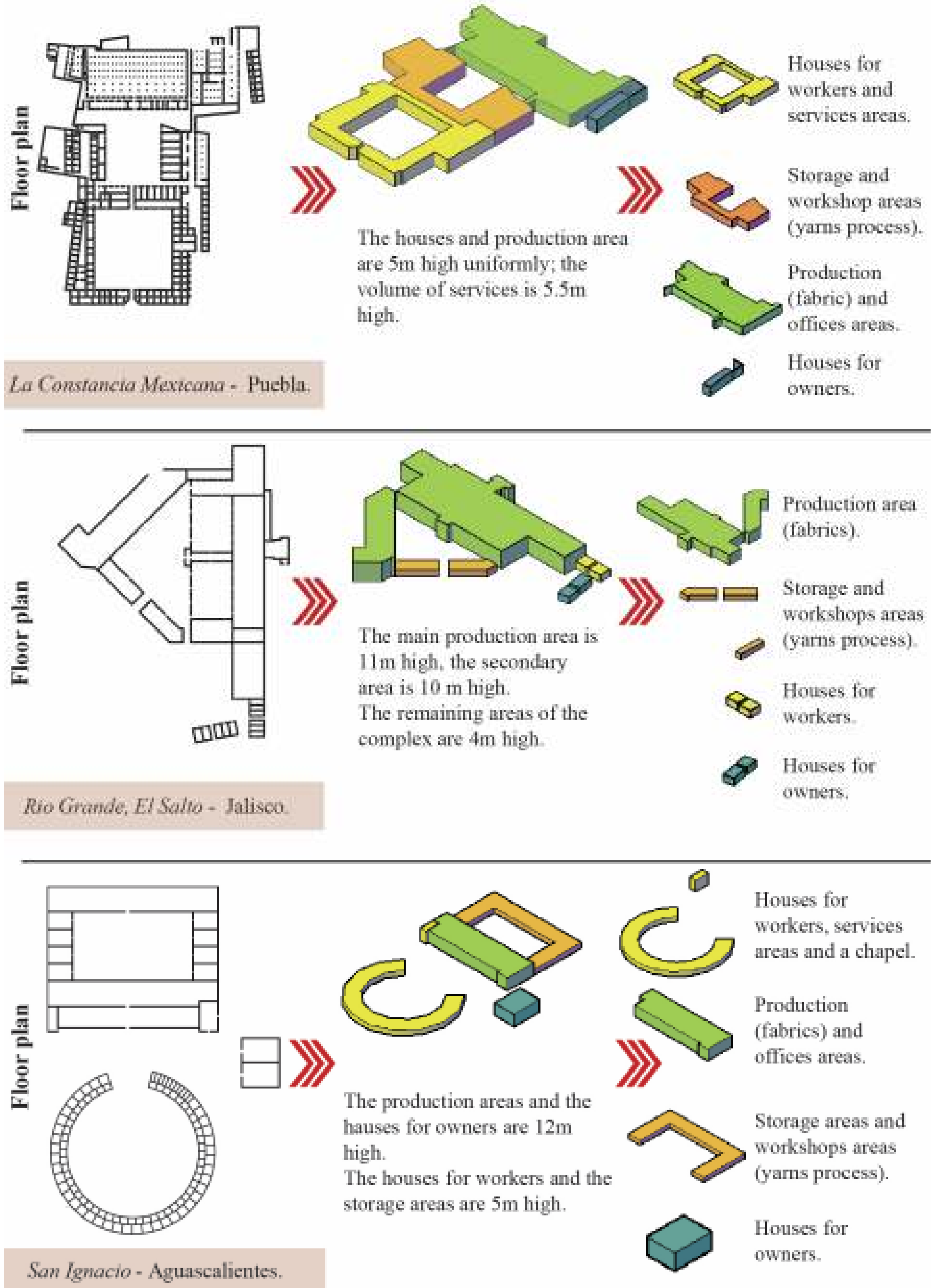

Figure 2: Sample of company towns in Puebla, Jalisco and Aguascalientes. *(Source: Drawing made by Alejandro Acosta Collazo and Adriana Guadalupe Martín del Campo Cervantes, September 2020.)*

a family composed of two or four people. The houses were made of stone or bricks, but some of them were also made of sun-dried bricks (adobes).

During the Industrial Revolution phase, rows of houses for workers became a usual panorama in company towns. This is the case of several factories mentioned in this paper: La Soledad, La Trinidad and La María. But also, in two cases: La Constancia Mexicana and San Ignacio, lines of houses making a main square in the centre were built. The square became a garden accessible to the workers and owners of company towns – and occasionally visitors were allowed to access to the estate property. For example, in San Ignacio company town there used to be a small lake beside the houses for workers and also the main garden, where some visitors, employees and the owners practiced leisure activities on weekends. This was a nice side of the company town facilities.

The improvements on the company towns sporadically included schools for workers; but chapels were very common buildings during the rise of the Mexican haciendas. Even though the sizes of the chapels were small, in some cases the interior decorations were remarkable. Some extraordinary baroque style chapels can be found in Mexican haciendas. Also, company towns had designers built fine altars inside the chapels.

Description of spatial distribution of industrial heritage buildings should be included in restoration projects and interpretive museum so people can understand the original designs of the buildings. But there's still a lot to do about it, Mundo et al. [8] mention post-occupancy evaluation (POE) studies of historic buildings with a new use could provide crucial information to the improvement of the building operation and satisfaction of staff and visitors. The latter will reduce staff discomfort and absenteeism while increasing their motivation to work. On the other hand, happy visitors will encourage others to visit the gallery and other converted historic buildings, which will contribute to the preservation of architectural heritage.

Storage and workshops structures were built in all the analysed cases mentioned in this paper, but they were located in diverse places of the company towns. They mainly supported the production of fabrics. Workshops included yarn process and the machines used to make fibres. In La Soledad company town, storage and workshops were kind of disseminated, but always near the administration and production areas. In the case of La Trinidad company town the storage and workshops buildings were situated beside the production area (fabrics), but lined up in orderly rows. In the case of La María company town, storage and workshops facilities were situated with the design of the main building accordingly – also lined up in rows.

La Constancia Mexicana is a good example of a European company town design variation. In such a case, the storage and workshop areas used to be situated among the houses for workers and the production buildings. This location and lay outs enhanced the manufacture of yarn and fabrics. This historical building is now being restored and an interpretive museum is getting ready to be opened to public soon. Also, there used to be a mill powered by water pressure in the factory, so the restoration works include a reconstruction of the mill. By the way, it was common to find mills in company towns that generated electricity, but in most of the cases mentioned in this paper the machines were stolen or sold out when the factories closed.

San Ignacio company town was the most magnificent industrial building located in the countryside of Aguascalientes City. Even though, most of the buildings analysed in this paper are Spanish style, in San Ignacio there used to be a French provincial style with mansard roof building. Pierre Cornú was the owner of this company and French influence was evident in the whole building design. Also, there used to be a mill powered by water pressure, but no pieces of it were found. In fact, nowadays the whole historic building is at risk of falling down. In addition, the city of Aguascalientes continues to grow on its western side and the newest social housing projects and private developments nearby have become a problem for the preservation of such historic building.

It can be observed taxonomic classification and typology in architecture enabled a better comparison among the most important and common components of a company town. This method also demonstrated a better understanding of how the constructors solved the original designs in accordance with the geographic locations.

5 CONCLUSIONS

Researching company towns still have a lot to accomplish in order to discover basic principles of their design and a theory based on architectural knowledge. Historical information of company towns can help instil and support best practices in preservation of industrial heritage. Also, recovering discussions about quotidian life in company towns can help interpretive centres to make people understand historical perspectives. This comprises interviews with former workers, historical videos of the factories or architectural spatial comparisons, as shown in this paper. Also, multimedia devices can be very helpful in interpretive museums.

The manufacturers didn’t make a lot of mistakes in the design of the original company towns mentioned in this paper. In fact, architecture in every factory depended on the geographic location, climate and the latest technology advancements. In addition, it can be observed in Fig. 3, that the largest buildings of the company towns were destined to production areas. In fact, in the case of Río Grande, El Salto – Jalisco, it occupied 92% of the whole company. Although in San Ignacio, there used to be a balance between the dimensions of the production (30%) and the workshop buildings (29%).

The biggest company town was Río Grande with a built area of 32,000 m^2, however La Constancia Mexicana (9,826 m^2) and San Ignacio (9,168 m^2) company towns had similar built areas. Also, the built zones destined to houses for workers were from 16% to 34% of the total built areas in each case, but not in Río Grande.

The adaptive reuse projects in preservation of company towns are important, but they ought to respect the original structures and aesthetics of the historic buildings. If administrators of such recovered buildings have to charge the entrance to visitors, the fee depends on the quality of services they offer, Moreno-Mendoza et al. [9] report there are differences between if the users understand that it is necessary to invest more or not in heritage, if they enjoy museums in books or TV, or if it is necessary to charge more expensive entry to offer improvements. It also follows that the visitor does not mind paying if their degree of satisfaction meets the expectations he had regarding the visit to the museum.

Depending on the cultural understandings of visitors, historic buildings can be perceived as part of the reuse projects. Thus, showing people, in designated specific rooms, how the company towns used to function – including its components, as presented in this paper – can allow site visitors to better understand the values of a company town.

Even though not all the abandoned industrial sites require to be restored; hence, the governments and researchers can select which buildings and places should be recovered. For example, Heaphy and Wiig [10] argue that former industrial areas, docks and warehouses, railroad embankments, car parks, and low-cost older residential blocks and houses are being replaced with high-end office spaces, higher density, opulent apartment blocks, and the corresponding amenities for a more lucrative demographic.

Also, if governments promote restoration and reuse of historic company towns, they also promote a circular economy. Foster [11] says all cultural heritage buildings and their adaptive

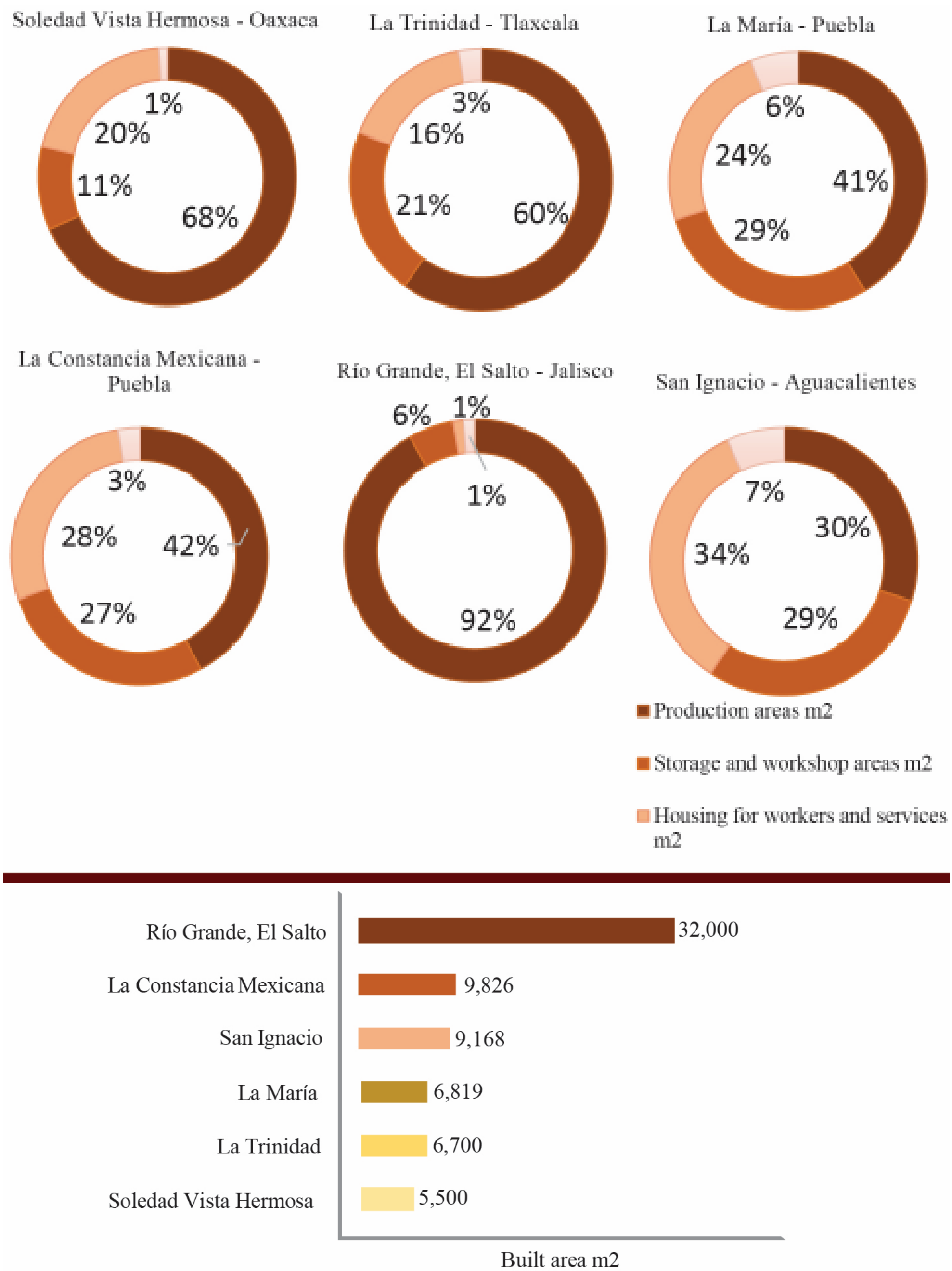

Figure 3: Comparison of company towns in Mexico. *(Source: Drawing made by Alejandro Acosta Collazo and Adriana Guadalupe Martín del Campo Cervantes, September 2020.)*

reuses are unique, place-based and community-based, meaning that a universal solution is impossible. This challenge may be obvious; nevertheless, it is significant. A consequence is that the strategies serve conflicting goals.

Finally, Calderón et al. [12] argue the tourism potential of a region requires, in the first place, an evaluation of its capabilities. So, it's convenient to think about the location of company towns to be restored and all their peculiarities, in order to adjust the adaptive reuses to what tourists expect to learn by visiting such historical places. In addition, preservation of company towns in Mexico can also be instrumental in developing cultural identity.

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EFFECTS OF TOURISM-LED URBAN REGENERATION ON THE HISTORICAL PART OF TEHRAN, IRAN

MAJID MANSOUR REZAEI[1], ALI MOHAMMAD SAADATI[2] & HELYA SEHAT[3]
[1]Urban and Tourism Study Group, Shanbeh Shahr, Tehran, Iran
[2]Mayor of the historical region of Tehran (region12), Iran
[3]University of Tehran, Iran

ABSTRACT

Over the last half-century, the role of tourism all over the world has increased remarkably in cities creating serious competition between cities in attracting more regional, national, and international tourists. Tehran has been the capital of Iran for over 200 years, however its relationship with urban tourism is new and young, with an attractive and audible narrative. For the very reason of this newly created dialogue, Tehran has been chosen to be studied through the lens of three eras: Qajar, Pahlavi, and Islamic Republic. Each era shows a monarchy, which shaped the capital based on a particular set of views, demands, and ideologies. Like most capital cities, Tehran had to change or even mutate at the demand of the different monarchies, and no wonder the city had lost many layers of its heritage and attractions through the urban changes. A major part of the urban changes has taken place in the last century. However, over the last 15 years, urban tourism has developed rapidly in Tehran. This means that tourism-led urban regeneration has successfully reshaped the cityscape, stimulated the renovation of many attractions and neighborhoods especially in the historic part of Tehran. The purpose of this article is to study and analyze urban tourism and its effects in Tehran over the last 15 years. Also, focusing on the historical part of Tehran, the role of urban tourism in regenerating the historical part of Tehran was investigated. The article is prepared for practical purposes. The research method is descriptive-analytical. Since the authors are the leading activists in the field of urban tourism in Tehran, the research is based on observations, conversations, and surveys done in four months (May–August 2020). Ultimately, the article presents the most important programs and projects necessary for the reform and development of urban tourism in the historical part of Tehran.

Keywords: tourism-led, urban regeneration, historical part, Tehran.

1 INTRODUCTION

In 1786, the Qajars empowered in Iran and introduced Tehran as the capital of the Qajar dynasty, but where was Tehran? A small and somehow, an infamous village located in the north part of the Central Plateau, which was noticed by Shah Tahmasb (the second Safavi king) for military and political purposes 232 years before its capitalization and raised great walls around Tehran.

Qajars chose Tehran as the capital when it was still a city surrounded by its old walls with an area of 4 km^2 and a population of fewer than 15,000 people. The capitalization of Tehran drawn attention to the city, causing the development and the creation of new urban spaces, and the development of urban services and equipment. Famous architects and artists were invited to Tehran to build a new capital from all over the country. However, the main development of the capital dates back to the fourth Qajar king Nasser al-Din Shah Qajar. A king who ruled for nearly 50 years and was the first Iranian king to visit Europe at the official invitations.

Nasser al-Din Shah's travels to Europe often coincided with world exhibitions in Vienna, Paris, London, and Brussels. Before these travels, the Isfahan school was the main primary model of Tehran's development. It is a school of Islamic philosophy in arts, also Iranian architecture and urban design that the most prominent examples of which are in the city of Isfahan. However, the result of these travels was extensive changes in all fields especially

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architecture and urban design. From this period on, a new chapter in the architecture of Tehran has begun, and the architects formed a style called Tehran's style by combining the Isfahan school and the European historical styles.

In 1878, as the population of Tehran increased to 150,000 people (approximately 10 times the population of the city), Nasser al-Din Shah commanded to devise a development plan for Tehran. The operators of his command were the professors and students of Dar al-Fonun School (the first high school based on European education), under the management of "Monsieur Bohler". Due to Bohler's efforts, the form of the new plan of Tehran was an octagon based on Renaissance and Baroque patterns, surrounded by ditches with 12 gates, the increase in the area from 4 km^2 to 19 km^2, and the formation of new public spaces, streets, and markets had changed the cityscape. This area of Tehran forms the old fabric of the city today, which has the values of architecture and urban design as well as being the occurrence place of the most important political and social events of Iranian history. The historic fabric has been the most valuable part of Tehran for decades despite serious changes and widespread destruction.

With the extinction of the Qajar dynasty in 1925 and the empowerment of the Pahlavi dynasty, once again they chose Tehran as the capital. The Pahlavi dynasty tried to erase the remnants of the Qajar dynasty from the city as much as possible, as well as the development of Tehran. During this period, they destroyed the city gates, filled the ditches, changed some of the city's squares, and destroyed several important buildings and sites.

The city of Tehran was expanded to the north, the new residence of the king, and the model of the city of Tehran was undergoing serious changes and from a classic city to a modern one based on motorized transportation. By the return of Iranian architects educated in European schools of architecture and urban design such as the Bauhaus (German art school) and the École des Beaux-Arts, and the government's official invitation of European architects and engineers to cooperate, Tehran quickly moved away from classical patterns and a new Tehran based on modern architectural and urban design patterns was born.

The people Tehran went along with the spirit of modernization. While the development of Tehran and the construction of new neighborhoods with facilities and infrastructures had occurred, some residents of the old part of the city had moved to new parts of the city since the formation of new and attractive cinemas, restaurants, cafes, and public spaces in the newly established parts of the city. The old parts of the city became relatively outdated and boring for some groups of citizens. Moreover, the new parts of the city were places for individual and social behaviors, which were not possible in the old part of the city due to the social structure. Gradually, the area of Tehran increased from 19 km^2 to 500 km^2, and its population increased from 250,000 to 4,530,000 people within the 5 decades of the Pahlavi dynasty (1925–1979). The old fabric of the city, as a remnant of the former monarchy, received less attention and development. In other words, the development cycle of the capital led to form a new identity for itself.

There was a revolution in Iran and Tehran was the center of the revolution in 1979. The Pahlavi dynasty gave away to the Islamic Republic. Once again, the new government chose Tehran as the capital of the country. Although there were discussions in the early years of the revolution about relocating the capital, they weren't surefire due to administrative and financial problems. The Islamic Republic tried to change Tehran based on its ideological view and began to erase the symbols of the Pahlavi monarchy. Once again, a new government eliminated a layer from Tehran and omitted a part of the memory of the city and its people.

The old district of Tehran was still not noticed by city managers in the post-revolutionary period, and the development of Tehran was being pursued outside its old district. During this period, the powerful market lobby, which was one of the main influences of the revolution, was able to take advantage of the inefficiency of urban management in favor of its economic interests and demands. These districts had valuable neighborhoods, streets, squares, buildings, and spaces that were changed one after another by markets and economic exploitations.

For example, Lalehzar Street, located in the north of the old part of Tehran, was the first street in Tehran designed based on modern European patterns. An attractive street with cinemas, theatres, modern shops, and cafes, which once many intellectuals, writers, poets, journalists, and other artists had come to visit. The powerful forces of the market completely attacked and intervened in this street. The first hotel in Tehran, located in this street, became a warehouse and center for electrical production. Cinemas were closed, some of them changed into passages, and others changed into warehouses. This trend also took place in the old neighborhoods of Tehran, and many of Tehran's old houses with valuable architectural features were turned into warehouses and production workshops.

The historical district of Tehran (Fig. 1), despite the existence of a few historical sites that were accessible to the public, was not recognized as a tourism destination due to problems such as traffic, masculine environment, lack of suitable tourism spaces, insecurity, and lack of support services and facilities. The community and domestic tourists did not consider tourism and other shortcomings. Even foreign tourists who looked at Iran's heritage values with a different perspective have been visiting a common route in Iran for decades. They took a flight to Tehran and went to the south of the country to visit Kashan, Isfahan, Shiraz, and Kerman, and then they return to their own country. For decades, Tehran was not only not seen but also not even introduced. Therefore, the historical district of Tehran should be considered an urban museum that shows signs of Iranian society's efforts to transform from a classical to a modern one.

The first decade of the 21st century is an important era in the social and cultural development of Iranian society in the post-revolutionary period. The development of cultural spaces and the growth of civil society led to a discourse in the public sphere of Tehran. Making documentaries, holding meetings with architects and urban planners, sociologists,

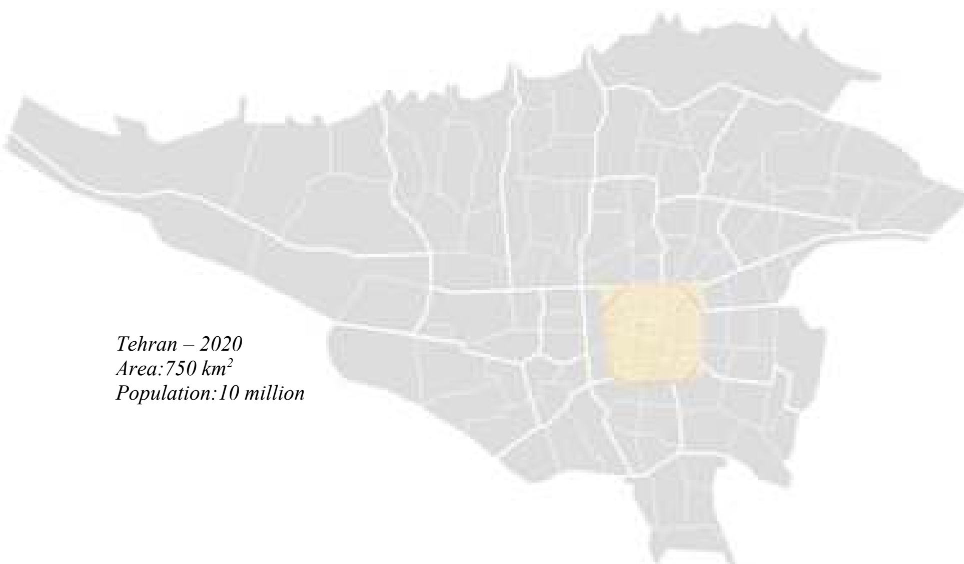

Figure 1: Location of the historical district of Tehran.

and artists, created an arena to investigate for a range of enthusiasts. Gradually, public magazines and newspapers prepared special letters about reading Tehran. The municipality of the old part of Tehran built several metro stations in the old part of Tehran and began limited measurements to implement action plans in the old part of Tehran. Several educated and interested young people started to tour in Tehran to show the hidden values in the old context of Tehran. Progressively, the private sector built a few restaurants, and cafes and the process of regeneration of the historical district of Tehran began.

2 TOURISM AND URBAN TOURISM

The concept of tourism is a complex and dynamic one. From the primary definitions of tourism that was offered in the first decade of the twentieth century until recent definitions it has been changing, so it is not easy to define it straightforwardly. From Guyer Feulner's point of view [1]: tourism is a unique phenomenon at modern times which is dependent on people's increasing need for a change and relaxation, their wish to recognize the beauties of nature, and the belief that nature gives happiness to human. At that time tourism was meant by going to nature. After the Second World War, an affiliation between the definition of tourism and "nature" has decreased, and "places" as a destination much Were noticed, for example, Cohen [2] mentioned that: tourism means visiting a "place" for leisure activities, like a holiday, entertainment, visiting family and friends, sports, resting, and recreation. According to Cohen [2], these places could be anywhere and were not limited to nature. Also, today based on tourist concepts are published by the United Nations World Tourism Organization (UNWTO). Modern tourism encompasses a growing number of new destinations, which are different from an old destination like natural, historical, beach sites and museum. In this regard and according to the European Commission [3], interest in local cultures and urban destination is growing, due to improving levels of education and economic welfare of common people, the desire to try different tastes, familiarize with different cultures, and shop, and because "Sea-Sand-Sun" tourism has considerably lost its popularity [4]. Tourism in cities became important. Tourism previously has developed in historical cities and capitals of states and then began to flourish in other cities by growing up. But in fact, what is urban tourism?

Researchers agree that urban tourism is a complex phenomenon consisting of a variety of tourism activities such as relaxation and entertainment in the city, recreational shopping, participating special arrangements and business meetings, art galleries, concerts, festivals, visiting some attractive places like exhibitions, demonstrations, shows, and museums, visiting kith and kin and relatives [5] but The actual attractions in urban tourism consist of human-generated attractiveness as well as the activities which are based on historical and cultural attractiveness. According to the UNWTO, Urban Tourism is "a type of tourism activity which takes place in an urban space with its inherent attributes characterized by non-agricultural-based economy such as administration, manufacturing, trade, and services and by being nodal points of transport. Urban/city destinations offer a broad and heterogeneous range of cultural, architectural, technological, social, and natural experiences and products for leisure and business".

The European Commission [3], defines urban tourism as "the set of tourist resources or activities located in towns and cities and offered to visitors from elsewhere". According to Law [6], Urban Tourism distinguishes between primary and additional elements of a city's tourism resources (Fig. 2).

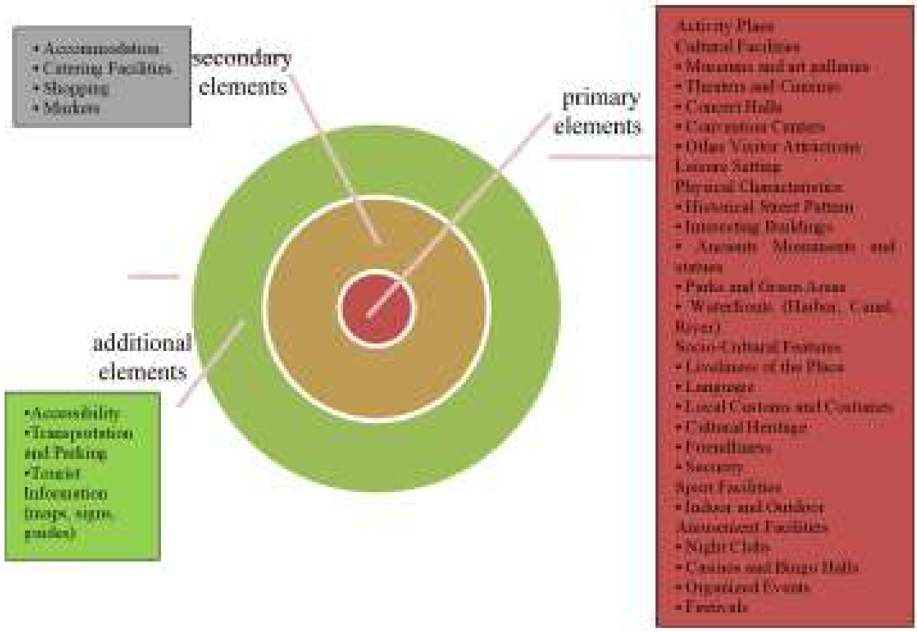

Figure 2: Urban tourism's resources.

3 URBAN REGENERATION

Urban regeneration can be traced back to the mid-19th century, to the urban development programs of Baron Haussmann in Paris [7]. But the theoretical definition of this concept dates back to the 1960s in policy programs addressing social deprivation in inner-city areas [8]. Urban regeneration was first formalized in the USA in the 1960s when relocation of marine activities triggered the total abandonment of large territories, which have become harbor derelict lands. Municipalities have often reassigned these empty urban lands to central business types of activities as Boston, Baltimore, and New Orleans. In the 1980s, a second phase was launched, on the London Docklands, and then in Barcelona. Urban regeneration led to the complete transformation of empty lands, through the reconstruction of multi-activity "bits of the city". Later, in the 1990s, urban regeneration was launched in many urban areas, often densely populated, functionally heterogeneous, but facing many urban malfunctions [9]. In a general definition, urban regeneration can be described as follows: "A comprehensive and integrated vision and action which leads to the resolution of urban problems and which seeks to bring about a lasting improvement in the economic, physical, social and environmental condition" [10]. However, although urban regeneration is often regarded as a comprehensive, holistic discipline, encompassing all the aspects mentioned, in practice it is rarely, if ever, truly comprehensive. It should be noted that it is different from urban renewal, urban rehabilitation, and urban (re)development. Urban regeneration, in essence, intends to change the nature of a place by involving the public, private and community and voluntary sectors working together toward a clear single aim: to improve the quality of life for all [11]. Fig. 3 indicates the variety of themes and topics involved in urban regeneration and the multiplicity of interrelated outputs such as Neighborhood strategies, Training and education, Physical improvements, Economic development, and Environmental action.

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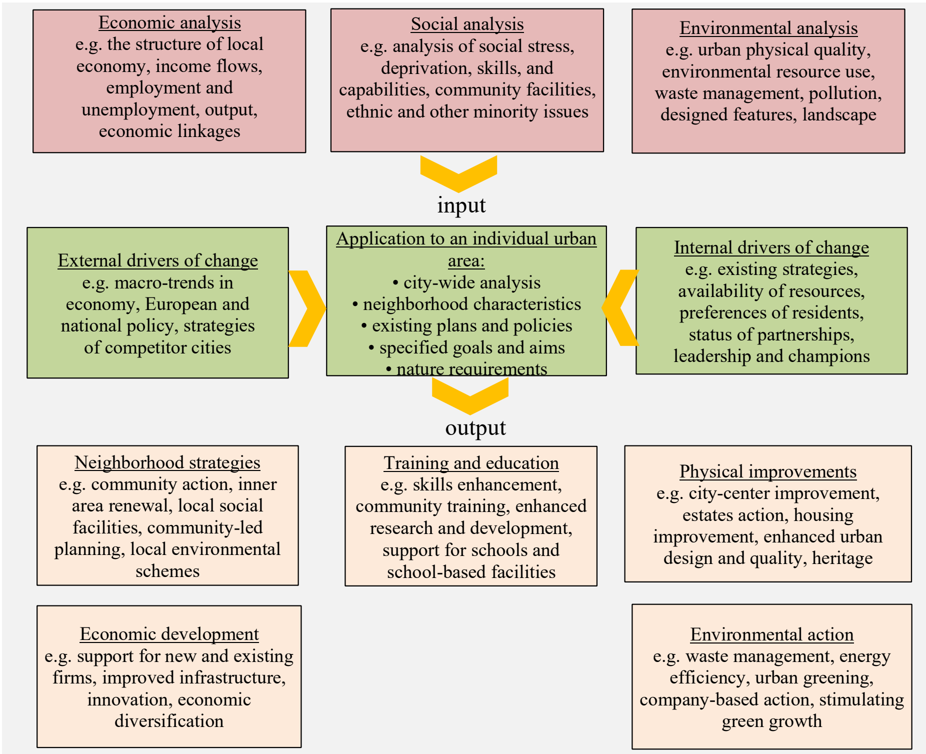

Figure 3: The urban regeneration process. *(Source: Roberts, 2000 [10].)*

4 URBAN TOURISM-LED URBAN REGENERATION

Recently, tourism and urban regeneration gained importance as two activities related to each other. As Swarbrooke [12] observes: "Tourism-based urban regeneration has become a major phenomenon in the past two decades". A lot of researchers highlight the close relationship between tourism and urban regeneration [12]–[14].

Tourism and urban regeneration are two activities that have risen in importance in the last two decades. Tourism is used as an urban regenerative tool as it is perceived to offer several benefits for towns and cities. from academic literature obviously that There is a well-explored connection between urban tourism and urban regeneration, with physical changes in a location (often through flagship developments) being used to boost its competitiveness in attracting businesses and investment and tourism strategies. Law [15] concedes that tourism can assist with physical, economic, and social regeneration, arguing that tourism investment benefits the local community as it involves the development of facilities, activities, the physical environment, and infrastructure. Smart leaders as well as residents who know the potential impacts of tourism can take advantage of this relationship [16].

In recent years, tourism has become one of the main motivations for urban regeneration, particularly in the inner-city areas. Similarly, Swarbrooke and Horner [17] argues that while tourists stimulate the development of services and facilities (e.g. shops, theatres, and infrastructure), these amenities can also be enjoyed by residents. Furthermore, he argues that urban tourism can potentially lead to inward investment from business people who decide to invest in other sectors in the city or relocate their business there. The growth of urban tourism in communities that have been badly affected by urban decline can also enhance local pride as residents will feel more positive about their town or city if it is perceived to be a worthwhile place to visit [17]. Tourism can be used to find new uses for derelict buildings and can improve the city's environment. Furthermore, as the restoration of old buildings involves a significant change in purpose (e.g. tourism), infrastructure and transport facilities are also often improved [18]. Zukin [19] highlights the mass appeal of the rehabilitation of heritage buildings for residential usage and tourism development schemes. While the restoration of heritage buildings can attract people back to the city to live, the rehabilitation of buildings for tourism, such as visitor attractions or accommodation, can also attract visitors. Craig-Smith and Fagence [18], argue that expenditure on cultural activity and heritage conservation ultimately pays for itself because of its appeal and use by tourists. Indeed, Craig-Smith and Fagence [18] argue that where possible, historic buildings should be rehabilitated because people are attracted to such buildings as they can relate to the history and historical structures. Tourism is valuable for the restoration, refurbishment, and revitalization of buildings in urban areas. Heritage buildings are commonly rehabilitated for accommodation, commercial storage, retailing, entertainment, and cultural purposes [19].

Tourism can be used to find new uses for derelict buildings and can improve the city's environment. Furthermore, as the restoration of old buildings involves a significant change in purpose (e.g. tourism), infrastructure and transport facilities are also often improved [18].

5 RESEARCH DESIGN AND APPROACH

In the first part, based on field observations and in-depth conversations of writers with managers of urban development and tourism in the historical district of Tehran, an attempt was made to answer this basic question:

Has the historical part of Tehran been able to create the necessary elements to become a tourism area? And what are its shortcomings?

In the second part, based on the literature reviewed in the field of urban regeneration, we identified and analyzed the effects of urban tourism on regeneration, focusing on its physical dimension, from the perspective of urban design.

Information presented in this article is the result of observations, conversations, and surveys done in 4 months (May–August 2020).

6 THE CASE OF TEHRAN – HISTORICAL DISTRICT

The historical region of Tehran has faced serious economic and social problems for decades due to transformation, high-level migration, crime, the decay of buildings, public spaces and infrastructure systems, and environmental damage, plus the expansion of Tehran and the creation of new neighborhoods and the relocation of old residents to these areas. A significant number of Afghan war migrants have settled in the historical part of Tehran and residents who do not have any attachments to the area and its values. On the other hand, this area includes historical buildings belonging to the post-Renaissance period, which are production workshops and warehouses due to their proximity to the commercial area and the main urban services.

The case study is Tehran's historical part called Naseri's Tehran is a clear example of the opportunity of tourism for regeneration, where urban regeneration has recently taken place for the needs of tourism. Tehran's historical part after a long time that had faced a crisis and has been regaining a new identity for its role in the culture and social system. The historical part has also changed in social terms. It is becoming even more multicultural, which many citizens and tourists want to visit and explore. Today many young people rediscovering their origins and its true greatness with a feeling of pride. To regenerate its territory and economy, Naseri's Tehran has adopted a coherent tourism policy.

The case study provides evidence to find a compromise between tradition and innovation, between the idea of tourism as a source of identity and social capital, and the culture as an important economic resource for the historical district of cities.

6.1 Part one: Observation of urban tourism resources

Although there in the historical part of Tehran has been some tourist attractions for a long time, such as several museums and several palaces, these spaces and places were not very popular for tourists. Tourists who visited these spaces and places had nothing to do with the historical part and quickly left this area. The beginning of the 21st century was a special period for the historical fabric of Tehran. For the first time, the Municipality closed two street bazaars to cars in this area and carried out urban design projects in the street. The private sector, citizens, and space users welcomed the projects. The Municipality facilitated access to the area by the creation of several metro stations, and the area saw a greater presence of women gradually. The private sector gradually realized the emerging need. The need was growing due to the presence of the new audience in the area. The audience came to the area due to the absolute advantage of the region in offering cheaper goods due to the presence of the grand bazaar of Tehran. The outer edges of Tehran Bazaar, located in the central part of Tehran's historic fabric, gradually changed from general-purpose stores to retail stores and support services for everyday urban life. Also, around 2009, independent groups and individuals organized creative tours in the historical context of Tehran. The private sector gradually realized the emerging need. The need was growing due to the presence of the new audience in the area. The audience came to the area due to the absolute advantage of the region in offering cheaper goods due to the presence of the grand bazaar of Tehran. The outer edges of Tehran Bazaar, located in the central part of Tehran's historic fabric, gradually changed from general-purpose stores to retail stores and support services for everyday urban life. Also, around 2009, independent groups and individuals organized creative tours in the historical context of Tehran. Now you can see new events every day. Tourism information spaces hold various meetings about tourism potentials in this district. Various sectors exploited these potentials with plenary cooperation, now. according to Law [6], urban tourism distinguishes between primary, secondary, and additional elements of urban tourism resources. These elements are observed and recognized by the authors as the activities in developing tourism. from Our observations showed the secondary elements such as accommodation and shopping as well as additional elements such as transportation and tourist information services have developed, but most developments have happened in the primary elements such as historical characteristics of buildings, streetscapes, and neighborhoods, by the emphasis on the local character. Fig. 4 was analyzed and categorized based on urban tourism resources provided by Law in the area.

6.2 Part two: The observation of physical regeneration

The important interventions that have taken place in the district have a straightway correlation with tourism. Tourism-led regeneration relying on the potential of the historical part of Tehran has been creating socio-cultural and economic value at the local scale so far. As a result of all these interventions, the historical heart of the city has begun to beat again. According to the authors' observations, repair, renovation, and revitalization of historic monuments and public spaces, with or without land-use change, have played a crucial role in urban tourism development, so most tourists tend to visit these spaces.

Figure 4: Urban tourism resources created during the last 2 decades in the historical district of Tehran.

The process of urban regeneration in the historical part has caused the regeneration of many areas and buildings both economically and socially with the help of urban tourism. For example, the development of tourism and its effects in recent years have led to the Preservation and revitalization of many old buildings, also the relocation of disturbing and incompatible jobs and activities in some parts of the district. These two projects are mentioned as the evidence for this claim, the "Oudlajan Bazaar" project is the result of transforming a plastic-selling into a handicraft bazaar, and the "Hajiha Passage" Project is also the result of transforming warehouse performance and incompatible activities into a reception, restaurant, and gallery space.

Although many regeneration schemes had relied on significant municipality funding for key infrastructure and tourism facilities, the recent private sector investments in tourism support services have helped the process of regeneration significantly in the historical part of Tehran.

In this regard, the municipality has been able to provide appropriate and attractive options for investors and activists in the field of tourism. By identifying, updating, and completing the database of valuable buildings in the area for the revitalization of historical buildings owned by the municipality, and encouraging the private sector to provide incentives for owners to preserve and revitalize the valuable buildings.

From Peter Roberts's point of view, the variety of themes and topics involved in urban regeneration and the multiplicity of interrelated outputs. This article focused on the physical dimension and showed how most of the interventions relied on the creation of flagship buildings and urban spaces to change the perception of a place. Fig. 5 shows the distribution and diversity of the physical dimensions of urban regeneration to create tourism projects in

Figure 5: Physical dimensions of urban regeneration during the last two decades in the historical district of Tehran: 43 building restorations, 22 street-environment improvements, and 18 urban street designs.

the district. Although the distribution of these projects is not the same, in addition to improving the physical and urban landscape, these projects have been able to help improve the social and economic dimensions of its areas and neighborhoods.

7 CONCLUSION

The primary aim of urban regeneration is to address the complex dynamics of urban areas and their difficulties. Tourism should be introduced as an essential element in urban regeneration. Developing tourism can achieve Neighborhood strategies, Training, and education, Physical improvements, Economic development, Environmental action.

The identification of challenges and opportunities for the city to achieve urban regeneration based on urban tourism can shed light on the nature of policy-making and executive measurements. In the historical part of Tehran, due to the unfavorable quality of space and also the significant destruction of old buildings and structures, the main focus was on the improvement of the spatial qualities, production of the place, revitalization, and regeneration of the buildings based on tourism.

Increasing tourism services and facilities helped to regenerate the historical district, due to Tehran's emphasis on developing urban tourism and the increase in the number of visitors and investment opportunities. Now that the flow of tourism has developed to a considerable extent in the area, it is necessary to consider and plan other sectors of the urban regeneration process.

Tourism-led regeneration in the historical area of Tehran should be supported not only by place-making but also by the socio-economical and cultural conditions of residents of the area should be improved. The historical district of Tehran, with its tangible and intangible cultural heritage, has the potential of being a cultural-tourism center. Improvements should be made to improve the social relations and the increase of quality of life as an outcome to get residents involved in the decision-making process. City management has adopted measurements to boost social networks and improve public knowledge, such as holding gatherings with artists, citizens, and private sector investors to learn about the socio-economical benefits of tourism. furthermore, the municipality needs to prepare a comprehensive plan that supports specific tourism plans and emphasizes the area's cultural and historical values.

The following actions can accelerate the development of tourism and urban regeneration:

- Networking and connection of tourism centers and destinations
- Support the private sector in investing in tourism and restoration of historical monuments
- Establishment of tourism information centers
- Improving security in some parts of the region, especially for women and children
- Improving lighting in some sections and streets
- Utilization of digital services to introduce tourism attractions
- Planning and development of branding and marketing of places
- Installation of signboards for places and tourism routes.

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SECTION 7
HEALTH ISSUES

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ADVANCING E-HEALTH IN SAUDI ARABIA: CALLING FOR SMART VILLAGE INITIATIVES

HASSAN TAIBAH[1], SUDHA ARLIKATTI[2] & BILL DELGROSSO[2]
[1]King Abdulaziz University, Jeddah, Saudi Arabia
[2]Rabdan Academy, Abu Dhabi, United Arab Emirates

ABSTRACT

The Kingdom of Saudi Arabia (KSA) presents a unique case study for examining e-health initiatives as it is a country that has transformed itself from a predominantly rural population to an urban, developed one, within a short span of 65 years following the discovery of large oil reserves. This paper examines the tenets of the KSA's eHealth Program, the progress made, and the gaps identified in meeting the needs of KSA's rural populations. It begins with a brief review of e-health efforts in rural and urban settings around the world, followed by a concept map created from the *Atlas of eHealth Country Profiles* by the World Health Organization, to identify strengths and weaknesses across eight themes, within the participating countries. This is followed by a description of the KSA case study; and an analysis of advancements made and challenges faced, including e-health foundations, legal frameworks, electronic health records adoption, mobile health data access and social media use. Finally, we make suggestions regarding enhancement of rural health coverage through the creation of Smart Village initiatives in dispersed Saudi villages.

Keywords: e-health, eHealth Program, health communication, information technology, public health, rural populations, Saudi Arabia, Smart Village, World Health Organization.

1 INTRODUCTION

The World Health Organization (WHO), in a bid to ensure universal health coverage, is a proponent of e-health strategies. WHO defines e-health as "the use of digital information electronically transmitted, stored, or obtained, in support of healthcare, both at local and distance level" [1]. It uses an information and communication technology (ICT) infrastructure, health-related information and ICT users as the three elements of a system that collectively support easy access to and sharing of real-time and stored healthcare information and services; for clinical, academic and managerial purposes [2].

In the context of receiving healthcare, rural populations are often faced with inequitable health quality and accessibility issues; due to a lack of trained doctors, clinicians and infrastructure. This intensifies the burden of disease management and medical expenses [3]. Furthermore, complications arise from patients' inability to travel long distances [4], as specialized health care facilities are only available in distant urban centers. Rural residents may also face financial, social or cultural restrictions; and geographical barriers, making them less adept at accessing healthcare [5]. Thus, there is a need to design smart e-health village enterprises aimed at addressing the urban–rural divide, by making resources available remotely, in order to empower local self-governance that supports universal health coverage.

The term "Smart Village" includes the use of technology for development, enhancement of overall health and welfare, and to aid public education, interaction and engagement [6]. Malche and Maheshwary [7] also reinforced the value of information technology for providing better access to services, including smart healthcare as part of Smart Village initiatives. However, it is important that such technologies supplement existing care and gradually move towards substituting different care services; based on individuals' characteristics, environment and preferences [4], to counter scepticism and low adoption.

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This paper uses a case study approach and describes the context in the Kingdom of Saudi Arabia (KSA) and its eHealth Program, as well as progress to date. It proposes that in advancing e-health adoption in the country, attention should be directed to the needs of the KSA rural populations, as well. This country's case study is unique, because KSA has transformed itself from a predominantly rural population to an urban one, a developing nation to a developed one, within a short span of 65 years, following the discovery of large oil reserves. The United Nations (UN) Human Development Index (HDI) places Saudi Arabia in the "very high" category for human development, as it ranks 39th out of 189 countries [8]. Still, 17% of the KSA population remains rural, receiving scant attention at the national level for health care planning and program deliverables. This gap needs to be addressed, as over 2,000 villages are dispersed over a vast land area of 2.15 million km^2 [9], making it difficult to provide timely, equitable, high-quality healthcare through traditional means.

The lack of clinicians to manage the increase in chronic diseases, such as diabetes, hypertension and heart diseases [10]; and contagious diseases, like Zika, MERS-Corona. and the Novel Corona Virus 2019 (COVID19), poses additional challenges.

This paper begins with a brief review of e-health efforts in rural and urban settings around the world, followed by a concept map created from the *Atlas of eHealth Country Profiles* by the WHO, to identify any strengths and weaknesses, across eight themes, in participating countries. This is followed by a description of the KSA case study; and an analysis of the advancements made, challenges faced and discussions of possible future strategies to reduce the urban–rural divide in adopting e-health. The paper concludes with suggestions for future research, including investments in creating Smart Village initiatives.

2 LITERATURE REVIEW

2.1 International efforts in e-health adoption in both rural and urban areas

A review of both rural and urban contexts around the world suggests that there are barriers to advancing e-health, depending on country-specific e-health policies, the availability of resources, funding, etc. E-health ICT applications are often viewed as instruments that help minimize the differences in providing healthcare services between rural and urban areas.

Ruxwana et al. [11] found that the factors influencing the adoption of e-health in the rural Eastern Cape provinces of South Africa included: inadequate infrastructure, services and resources; compounded by lower literacy rates, compared to other parts of the country. Additionally, public health authorities faced challenges from a lack of standardization and integration, poor technological resources, and a lack of ICT adoption or skills. They concluded that a successful implementation of e-health services requires three levels of resource commitments, namely: access to ICTs, access to supporting communication infrastructure and an IT-friendly national policy framework. They suggested that authorities adopt supportive policies that can ensure that rural populations acquire the necessary ICT-related skills.

In the case of rural India, an e-health initiative helped reduce infant mortality rates. Venkatesh et al. [12] noted the high infant mortality rates in rural India, with over 50 deaths for every 1,000 live births, which was due to the low quality of healthcare services. They believed that ICT could serve as a tool for health-related information gathering, especially for dissemination to pregnant women and mothers. They were able to demonstrate that by using e-health kiosks for health information dissemination, infant mortality rates could be reduced by a significant percentage; however, they acknowledge the need to continue using pre-existing social networks and word of mouth information-sharing in geographically remote areas, with low computer literacy rates and high illiteracy.

Martinez et al. [13] also found that successful implementation of e-health in rural India was more difficult than in urban areas, due to the high cost of ICT infrastructure and low literacy rates. Nevertheless, they advocated for e-health as a means of obtaining effective healthcare, because of its power to virtually connect patients in remote areas with competent healthcare providers; however, they emphasized that authorities must consider the local needs, norms, and cultural, educational and societal factors of the targeted population, while creating a national healthcare program targeting rural areas.

Gajanayake et al. [14] examined large and small countries in the European Union (EU), noting that they had either implemented or started implementing e-health programs, to ensure universal health coverage for their populations. Although most were successful in reaching their goals, the larger countries with diverse populations like England, France and Germany, were faced with challenges due to demographic complexities. The authors used global cases to evaluate and provide recommendations for future e-health initiatives. They conclude that well-articulated plans and preparations do not necessarily guarantee success. Variables like the changing socio-political climate, social interactions, national policies and the nature of funding could affect successful outcomes. They suggested that e-health programs be based on learned experiences of self and others, relating to both successful and failed initiatives.

The United Kingdom (UK) started its e-health program in 2002, under the National Health Services (NHS), for diagnosis, information sharing, telemedicine, managing appointments online, electronic prescriptions, and providing Summary Care Records (SCRs) to both patients and healthcare providers [15]. Gajanayake et al. [14] found that initially, the program was fraught with problems. The information-gathering system was not consistent with how clinicians collect patient information and led to low rates of adoption. Furthermore, the public awareness and education campaigns about it were inadequate and resulted in a very expensive, underutilized program. Subsequently, the SCR system was modified to align with the needs of the doctors and clinicians and the e-health education campaigns were improved, so that the public became aware of the myriad benefits of participating in e-health programs. Today, the UK SCR system is used by 98% of its healthcare practitioners [16] and is heralded as a success story.

Khan et al. [17] studied Australia's My Health Record (MyHR), a fully digitized healthcare program, by examining the design of the overall system, its performance, and successes and failure points; and found that healthcare providers were slow to adopt the system, as they failed to recognize the personal benefits of the MyHR system to providers. The usability of the system for multiple users, including doctors, pharmacists, insurance providers etc., had not been highlighted enough during program implementation. Furthermore, the awareness campaigns were not well thought out and did not reach enough healthcare providers and users, which led to a high resistance to change from the traditional methods to this new system. The authors also noted that the MyHR system raised issues about the morality of accessed data for secondary use/research and uncertainty related to the legal framework within which MyHR was operating.

The above country-specific studies, although limited, are useful in expanding our understanding of the various challenges faced in rural and urban contexts. These include: a large uneducated population with low computer literacy; the digital divide in rural versus urban settings, due to lack of a robust ICT infrastructure and training program; lack of buy-in from the public and associated healthcare providers; poorly designed educational campaigns that failed to communicate the value of e-health strategies for the greater good; sociocultural and financial challenges; and limiting national policies or inadequate legal frameworks for data sharing and privacy protection. This is further elucidated under the eight themes used by the WHO for monitoring e-health initiatives in participating countries in Table 1.

Table 1: E-health strategies across eight themes. Achievements (Yes) and challenges (No) for three countries.

Country	**United Kingdom**	**Australia**	**South Africa**
Population in millions	63	23	53
Internet users (% population)	87	82	41
ICT Development Index rank	8th	11th	84th
1. E-health foundations			
National universal health coverage policy or strategy;	Yes	Yes	Yes
National e-health policy or strategy;	Yes	Yes	No
Government supports internet sites in multiple languages	Yes	Yes	No
2. Legal frameworks for e-health			
Protects the privacy of individuals' health-related data held in electronic format in an EHR;	Yes	Yes	No
Allows individuals electronic access to their own health-related data when held in an EHR	Yes	Yes	No
3. Telehealth programs			
Teleradiology, telepsychiatry	Local	National	No
4. Electronic Health Records (EHR)			
National EHR system and legislation governing the use;	Yes	Yes	No
ICT-assisted functions like billing	Yes	Yes	No
5. Use of e-learning in health sciences			
Health sciences students pre-service;	Yes	Yes	N/A
Health professional in-service	Yes	Yes	N/A
6. M-health (health access through mobile phone)			
Toll-free emergency;	National	National	–
Management of disasters and emergencies	National	–	–
7. Social media			
National policy or strategy on the use of social media by government organizations	Yes	Yes	No
8. Big data			
Governing the use of big data in the health sector;	Yes	No	No
Governing the use of big data by private companies	Yes	Yes	No

2.2 A conceptual framework for monitoring e-health initiatives

In 2015, the third Global Survey on e-health helped the creation of very informative *Atlas of eHealth Country Profiles* [1], with data from 125 member countries (note that KSA did not participate in this survey). Data are grouped under eight themes shown in Fig. 1.

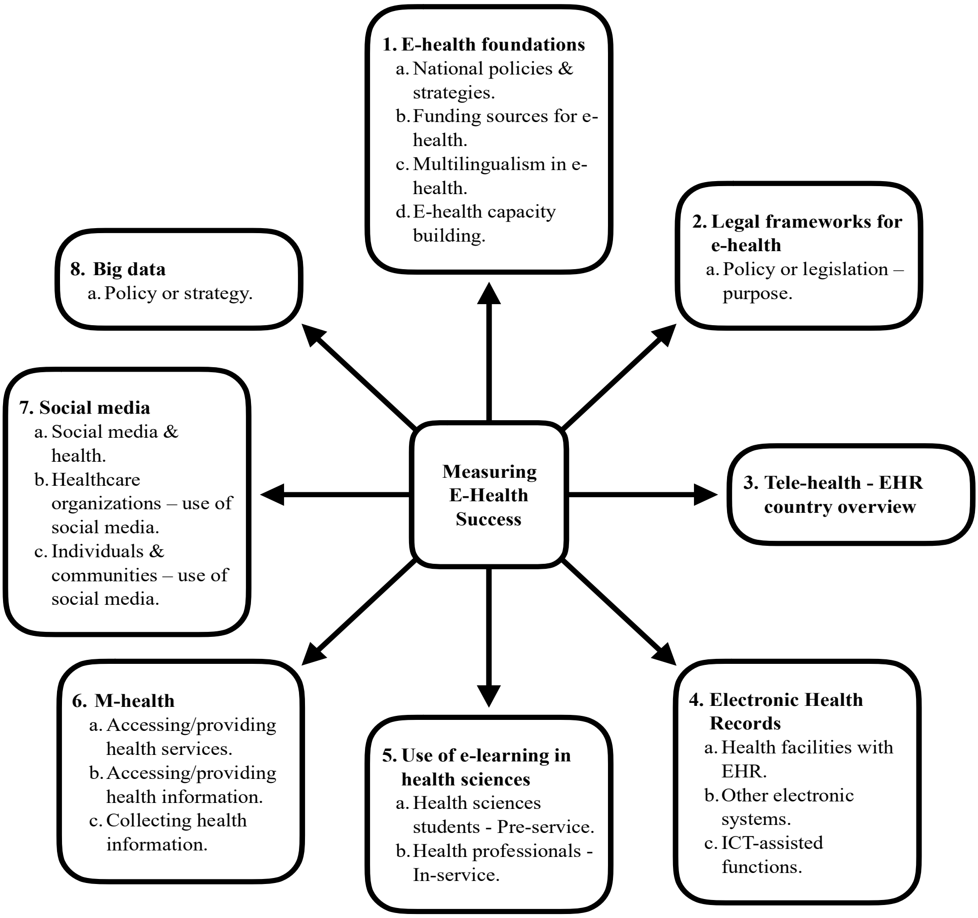

Figure 1: Conceptual framework based on WHO's highlighted themes. *(Source: Adapted from the* Atlas of eHealth Country Profiles*, WHO [1].)* Notes: E-health = electronic health, her = Electronic Health Records, ICT = information communication technology, M-health = mobile phone health.

The *Atlas* [1] reports on the unique progress made by the participating countries under each theme and is useful as a conceptual framework, to outline key areas of focus for our case study of the KSA. This conceptual framework is used to scan and present a truncated list of initiatives for the three countries discussed in the literature review. It serves to demonstrate the efficacy in using it for our case study analysis, in the subsequent section.

3 CASE STUDY

3.1 The context: Kingdom of Saudi Arabia

The KSA, with a land area of 2,149,690 km^2 (about 830,000 mi^2), is the largest country in the Middle East by land mass and the 14th largest in the world. A majority of the country is characterized by having a desert climate, with extreme heat during the day averaging at 45°C (113°F) to a sudden drop in temperature at night. Some regions, like the northern historic city of Al Turaif, also experience extreme climatic variations (with lows of –12°C/10.4°F, to highs of 54°C/129.2°F) [18], [19].

The roots of the country can be traced back through a long and vivid history, as both an ancient trading center and the birthplace of Islam in the early 7th century. The Saudis are religious, traditional and family-oriented, with a majority of citizens having Bedouin descent (a nomadic Arab of the desert), who herded domestic animals: mainly sheep, goats and camels [20]. After the urbanization of the country in the early 1970s, more than 95% of the Bedouins settled in villages or urban areas, moving away from traditional tribal lifestyles [21] to a more service-oriented livelihood.

Shortly after the establishment of the modern state in 1932 by King Abdulaziz Al-Saud, vast amounts of oil reserves were discovered, which led to the kingdom's transformation into a rich, developed, geopolitically influential country [22]. The World Bank characterizes the KSA as a high-income economy with a very high Human Development Index (HDI) of 0.853 [30]. This positions the KSA as 39th out of the 189 countries and territories of the world. The KSA increased its HDI points by 22.1% from 1997 to 2017, due to significant progress in the economic, education and healthcare sectors. This has raised life expectancy from birth, expected years of schooling, and the gross national income per capita [23], which are key indicators for measuring human development.

Saudi Arabia's population transformed from being 74.1% rural in 1955 to being an 82.1% urbanized population by 2019 [24], [25]. The number of cities increased from 58 in 1936 to 285 in 2015; and the KSA is expected to reach a 97.6% rate of urbanization by 2030. This urban population is predominantly settled in the five major cities of Riyadh, Jeddah, Makkah, Madina and Dammam [24]. The KSA holds a predominant position in the Arab world, as it is home to the holy cities of Makkah and Madina (Mecca and Medina), and is the global custodian of two of the most revered Islamic mosques. Every year, over 1.85 million international visitors from over 140 countries travel to the KSA to perform the Hajj pilgrimage or the Umrah [26], [27]. This requires the country's health care sector to be ever vigilant, and capable of providing affordable healthcare services to religious tourists or pilgrims, without disruptions to the domestic operations and services to its citizens and to expatriate workers.

The subject of offering e-health was heavily debated in the country during the 2000s, when scholars studying the healthcare system in the KSA found it to be lacking due to a shortage of funds, inexperienced staff, an inadequate number of facilities and increasing demand for free services. Despite a huge expenditure of SR 4 billion (Saudi Rials worth about US$ 1.1 billion) from 2008 to 2011 for various ad hoc e-health programs, the quality of healthcare delivery was found to be unsatisfactory, due to poor coordination among healthcare service providers. This highlights a need to launch a comprehensive national healthcare system [28], enabled with ICTs.

The seeds for developing a universal e-health strategy were introduced in 2002: A recommended expansion of tele-health usage and improvements to the Electronic Health Records (EHR) systems, as well as the establishment of the health informatics society, colleges and research centers [29]. In 2004, the King Saud Bin Abdul Aziz University for Health Sciences (KSAU-HS) was established; and in 2005, the Saudi Association for Health Informatics (SAHI). Subsequently, several e-health conferences were organized between 2006 to 2010, to raise e-health awareness in the country and to bring in experts from around the world. These activities led to launching of the Electronic Health Center of Research Excellence (E-CoRE), to conduct e-health research that helps enhance quality and reduce costs [29].

3.2 E-health evolution in the KSA and analysis of advancements

Although the KSA did not participate in the 2015 third Global eHealth Survey by the WHO, we found merit in using the eight themes used therein to analyze the advancements that have been made in e-health and outline any key areas of focus for the KSA (Fig. 1). It also will serve as a guide for future research and policy-making, possibly focused on Smart e-health Village enterprises.

3.2.1 Theme 1: E-health foundations

In the KSA, our e-health foundations pertain to national policies and strategies, funding sources for e-health enterprises, multilingualism in e-health, and capacity-building initiatives. In 2011, the Saudi Ministry of Health (MOH) launched a national e-health program, and it continues to earmark millions in funding to ensure that the program reaches world-class standards. The aim is to offer digitally equipped universal health coverage to all KSA residents, through government and private sector healthcare providers, to enhance efficiency, transparency and equity [30]. This will improve access to limitless data and promote cost savings [31], [32], by reducing the volume of revisits to healthcare clinicians. There are plans to continue to promote the use of multiple e-tools, including internet sites, SMS texting, telephone and digital information [33]–[35], to enhance e-health adoption; however, Saudi national policies and strategies for universal health appear to fall short of addressing the unique needs of rural populations, multilingual expatriate and religious tourist populations, and diversification of funding for e-health initiatives. Currently, funding is provided only by the government sector (MOH), which is clearly inadequate and unsustainable, as demand for health services multiplies. Investments by private or commercial, and non-profit health care sectors should be pursued, targeting rural needs. Furthermore, over 30% of the KSA expatriate population (10.7 million) [43], and thousands of international religious tourists, do not speak Arabic nor English. This underscores the need for national policies and legal frameworks for multilingualism in e-health.

The government should also support internet sites carrying health data in multiple languages, similar to the US Centers for Disease Control and Prevention (CDC). Also, there is an urgent need to build workforce capacity of ICT-trained staff, including physicians, clinicians, and ICT specialists, for healthcare enterprises [40]. This can be done by instituting a national training and recruitment strategy and encouraging rural youth to join the health sector enterprise as a career choice, through additional scholarships.

3.2.2 Theme 2: Legal frameworks for e-health

Legal frameworks for our eHealth Program pertain to policy or legislation, tele-health, EHRs, health facilities with EHR and ICT-assisted functions. In KSA, current legal frameworks are limited to patient privacy and information accessibility [44]. The present-day digital environment is complex, and the legal frameworks governing the sharing of health

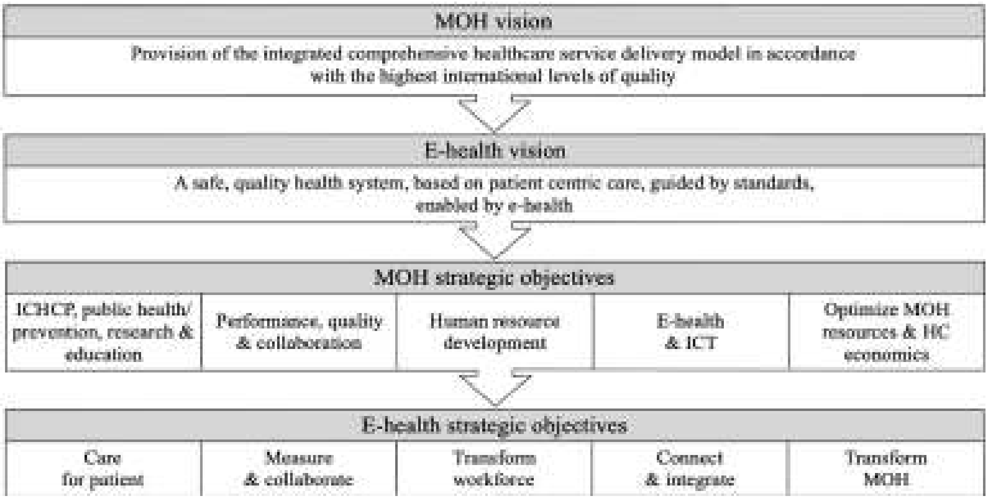

Figure 2: MOH strategic objectives focused on e-health and ICT [9, p. 270]. Notes: HC = healthcare, ICHCP = Integrated and Comprehensive Healthcare Plan, ICT = information communication technology, MOH = Saudi Ministry of Health.

information with professionals and researchers in other health organizations both within KSA and internationally need to be expanded upon (Fig. 2).

3.2.3 Theme 3: Tele-health EHR

Of all the common tele-health programs, only tele-radiology and remote patient monitoring have received mention at the national level, in the Saudi Health Information Exchange (HIE) platform [33]. With regard to remote patient monitoring, encouraging smart cities to adopt adjoining or nearby villages may offer solutions to facilitate remote patient monitoring and create hubs and sub-hubs of monitoring stations, so as to replicate and transfer the implementation of high-quality services to rural areas [45].

3.2.4 Theme 4: Electronic Health Records (EHRs)

EHRs include health care facilities that have adopted EHR and ICT enabled functions. Although there is a nationally governed interoperable Electronic Health Record (iEHR) system in the KSA, designed to offer unified, simple, user friendly and patient-centric services to help hospitals and emergency care units, most of its functions continue to be under-utilized [41]. Constantly updating the e-health system with advanced technologies is costly. Furthermore, having a growing aging population with a higher percentage with chronic diseases [36] is a challenge. The adoption and efficacy of the iEHR system can be increased by improving the integration with smaller primary health care facilities and offering incentives such as discounts to providers and patients, or even making it mandatory, as has been done in other developed nations (e.g. UK).

Research in health promotion and communication have consistently highlighted how "planned, persuasive messaging and communication campaigns can change awareness and health behaviors within populations" [37, p. 39]. Although the MOH focuses on chronic diseases like hypertension, diabetes, obesity and recent contagious diseases and viruses like MERS-Corona, Zika and Ebola viruses, it also raises awareness to lesser-known diseases like cholera, meningitis, yellow fever, Rift Valley fever, and dengue fever [33]. The MOH initiated a nationwide health awareness initiative campaign in 2016, using printed materials, fixed and mobile public displays, electronic message screens; and basic health care supplies like filter masks, hand sanitizer and umbrellas. They used text messages, cell phone banners, social media messaging, public service announcements (radio and TV), and flyers at special events including the *Your Health in Hajj and Umrah* booklets. These efforts are commendable and will continue to highlight the importance of e-health strategies and adoption of iEHR.

3.2.5 Theme 5: Use of e-learning in health sciences

Use of e-learning in health sciences pertains to pre-service students registered in health science degree-granting institutions and in-service health professionals. In this regard, the Saudi Association for Health Information (SAHI) uses e-learning to benefit health sciences students to access online training, which is convenient for rural practitioners [46]; however, little information is available on how local health entities are facilitating e-learning techniques for training their own employees. Investments should be made to ensure that in-service health professionals are offered continuing credits for training, to update their ICT skills to ensure computer literacy, which is the backbone of KSA e-health enterprises.

3.2.6 Theme 6: M-health

M-health pertains to accessing or providing health services and collecting, accessing and providing health information using one's mobile phone. Success with M-health is growing in KSA since the mobile penetration rate and internet users have reached about 100% in 2018, according to the General Authority for Statistics (GASTAT), while the total number of mobile phone users has reached 99.16% [18], [47]. According to the *Arab News* [48], the MOH introduced a toll-free health call center to provide medical counselling, internal referrals, and health-related information to the whole Saudi population. It was designed to increase awareness about infectious diseases, toxins and medicines. The center also collects complaints and suggestions from public and private health facilities; and evaluates, displays and updates statistics on the current level of delivered services.

3.2.7 Theme 7: Social media

The Social Media theme includes the use of social media channels for communicating health information by healthcare organizations, individuals and communities. In KSA, social media platforms, mainly Twitter and Rich Site Summary (RSS), are frequently used by national officials and ministries [49]. Moreover, via this platform, most health services are utilized by patients and care providers [33], [50]. The MOH governs this new communication tool by putting forward a specific national social media strategy on its official website [33]. The MOH has also engaged various stakeholders to manage resistance to e-health adoption and to guarantee effective implementation [9], [33]. In an attempt to transform the Saudi healthcare system through the National Transformation Program (NTP) 2020 and Vision 2030, the MOH started more than 40 health initiatives, including persuasive health communication messaging and e-health. Its vision is "a safe, quality health system, based on patient centric care, guided by standards, enabled by e-health" [9, p. 4].

In 2018, the MOH introduced "Seha", a mobile app used to deliver 1.4 million virtual health consultations in that year alone, which resulted in reduced doctor wait times and human-related errors. The ministry also created the "Mawid" app, to book patient appointments; as well as the medical staff-focused "Ashanak" and "Mawared" apps. Services manage registration, diagnoses and follow-ups [33]. This allows accessing of patient's information with ease and provides services remotely [38]. These digital capabilities are part of the MOH's framework (Fig. 2). The rate of use and challenges needs to be monitored and measured through future research initiatives.

3.2.8 Theme 8: Big data

The big data theme pertains to the policy or strategy for collecting and managing large volumes of data collected by the integration of various digital resources. There is not sufficient information openly available in this regard in KSA, but must include rural and urban needs utilization of big data technologies.

4 DISCUSSION AND CONCLUSIONS

This paper presents the evolution of e-health strategy in the KSA, using WHO's eight themes for examining advancements made in e-health adoption in countries. We acknowledge that others have also studied various aspects of e-health adoption in KSA but were rather ad hoc; a more systematic review was needed.

For example, Jamal et al. [39] focused on Saudi patients' health information-seeking behaviour, as well as the quality of online sources and patient usage. These results indicate that the internet provides valuable health information that positively impacting healthcare outcomes. The authors conclude that patients who search for health-related information online are more aware and take preventive measures to enhance their quality of life than others. Patients considered online sources as secondary to physicians and television announcements.

Alsulame et al. [40] investigated KSA's e-health system from the perspective of nine senior health information professionals, in 2013. Their findings suggest that e-health adoption varied among participants and their organizations. Challenges also stem from organizational and cultural reasons, end-user's perspectives of risks, and lack of qualified personnel to use the e-health system. Study participants recommended an independent national e-health entity that provides a central plan for implementing the initiative.

El Mahalli [41] focused on physicians' use of Saudi electronic health records (EHR) by conducting a cross-sectional study with 555 physicians from three public hospitals in the Eastern Province of the country. Services scrutinized included data back-up/ICT disaster recovery, pharmacy orders, customer contact and accessing health records. Their results show that most e-health functions are under-utilized, due to system hang-up, computer crash, power failure and excessive data entry.

These studies and ours lead us to conclude that if the KSA wants to make advancements in universal health coverage and reach an enviable position in e-health adoption compared to other developed nations of the world, it needs to focus its attention and investments on reducing the gaps between the urban and rural populations. The challenges and solutions to advancing e-health reaching into the 17% rural communities are listed in Table 2.

Furthermore, the MOH and researchers in the field of public administration, healthcare, medicine and social sciences could use the *Atlas of eHealth Country Profiles* by the WHO to guide information-gathering for future research in rural contexts, to reduce the divide. The country may also consider conducting a self-evaluation across all eight themes and participate in the survey in the future. Investments in the implementation of Smart eHealth Village enterprises should receive precedence. Local health officials facilitating forums and workshops about the use of this program can increase the successful implementation, as they are the authentic "known" local providers.

Table 2: Challenges and solutions for increasing e-health strategies in rural communities. ICT: information communication technology, MOH: Saudi Arabia's Ministry of Health, TV: television.

Challenges amplified in rural communities	Solutions
1. Care of patient • People still prefer physicians and the TV as methods to receive health-related information; the Internet is only a secondary source [39]. • Most of the e-health functions were under-utilized [41]. • Patients unaware of the importance of e-health initiatives and how to access it [5], [9]. • Poor accessibility to healthcare services and facilities continues [3], [28].	• Need patient care orientation • Change messaging and communication to rural-centric • Invest in rural ICT infrastructure
2. Measure and collaborate • Shortage of services expressed by patients, due to high demand for free services [28]. • Poor coordination among healthcare service providers [28].	• Encourage cross-training and coordination
3. Transform workforce • There is continued lack of healthcare funding [28]. • There is continued lack of qualified personnel in the e-health systems [40].	• Focus on better workforce orientation through training and ICT literacy
4. Connect and integrate • Recurring system hang ups, computer crashes, power failures and long data entry times [41].	• Ensure ICT standardization
5. Transform MOH • Large geographical area with numerous rural villages [42] need new policies. • Planning needs to be more developed, based on individual characteristics [5], i.e. culture-centric policies and efforts. • Steady long-term funds must be allocated for national e-health applications [5].	• Introduce rural-centric legal frameworks and policies • Disburse rural healthcare funds over a longer term and monitor progress

In conclusion, the MOH e-health initiatives can overcome limitations in our traditional healthcare systems with additional efforts by a coalition of KSA government, and private and non-profit sector stakeholders. This must be designed based on the nation's population, healthcare needs, economy and national legal frameworks.

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RELATIONSHIP BETWEEN URBAN ECOSYSTEM SERVICES AND HUMAN HEALTH RISKS: SYSTEMATIC REVIEW

GABRIELE ZABELSKYTE & IRINA MATIJOSAITIENE
Institute of Environmental Engineering, Kaunas University of Technology, Lithuania

ABSTRACT

Due to urbanization, there is a high demand for research in urban ecosystems linkage to human health risks. By 2050, around 70% of the world's population will live in urban areas with the rising challenges of urban space, facilities, and services as well as increasing risks of safety, quality of life, health care, etc. Therefore, there is a great need to analyze the urban ecosystem as an urban planning tool to mitigate human health risks. The main objective of this research is to identify the most and the least investigated urban ecosystems linked to human well-being. The systematic review method is used to analyze the existing literature on ecosystem services' impact on human health risks. Google Scholar, Science Direct, Scopus, and other targeted databases are used for the defined keywords, such as urban ecosystem services and human health, urban ecosystem services and human mental health, etc. Moreover, this paper uses the chronological order and "Word and Word Combination Frequency" method for identified relevant publications. In total, there are 2,498 records analyzed as matching the searched keywords. After the reduction of duplicates, screening, and full article analysis, 107 articles were left for further analysis. The results show that interest in the topic is increasing. Some ecosystem services' linkage to human health risks is more analyzed than others. The majority of analysis is done from a single urban ecosystem perspective (e.g., green infrastructure, water supply), therefore some challenges are defined, such as the lack of research. The majority of previous investigations focus on the urban ecosystem's impact on physical illness. Although the attention towards mental health risks and urban ecosystems is increasing, there are still some gaps because of expensive and long-lasting research.
Keywords: urban ecosystem services, human health risks, systematic literature review.

1 INTRODUCTION

In the last century, the urbanization process increased rapidly: in the 1950s, just less than a third of the population of the world lived in urban areas and projecting that by 2050s, there will live around 68% of the world's population [1]. The tendency of the annual growth of people who live in urban areas has social and economic advantages [2], but there are some significant challenges, such as the threat of public health security, quality of life [2]–[4]. Moreover, annual population growth harms the urban environment: infrastructure, urban ecosystems, and other elements of the city. Therefore, there is a need to focus on the relationship between urban ecosystem services (UES) and human health.

The concept of an urban ecosystem (UE) has been analyzed since the end of the 20th century. In general terms, the urban ecosystem describes how natural ecosystems interact with urban areas [5], [6]. Urban ecosystems are the composition of natural and artificial elements, which collaboration has an impact not only on the natural environment but for the social-economic factors, human behavior, institutions [6]. UE can be described as one ecosystem, or to be compiled from unique ecosystems such as wetland, urban parks, urban forests, lakes, and others [6]. Urban ecosystems have their functions in the city, which are described as urban ecosystem services.

The attention of the urban ecosystem services is increasing due to urbanization. Rapid urban population growth leads the city to face significant challenges, such as assurance to a healthy and safe environment. Urban ecosystem services defined as the benefit that society

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receives from the ecosystem function [7]. Moreover, links between the urban ecosystem, their services create a network not only trade-offs in between the services, but also with humans and their well-being [8], [9]. Millennium Ecosystem Assessment [10] describes the relationship between UES and human well-being, which includes human health [11]. Urban ecosystem services are divided into four categories: supporting, provisioning, regulating, and cultural, which are related to human health [10], [12] (Fig. 1).

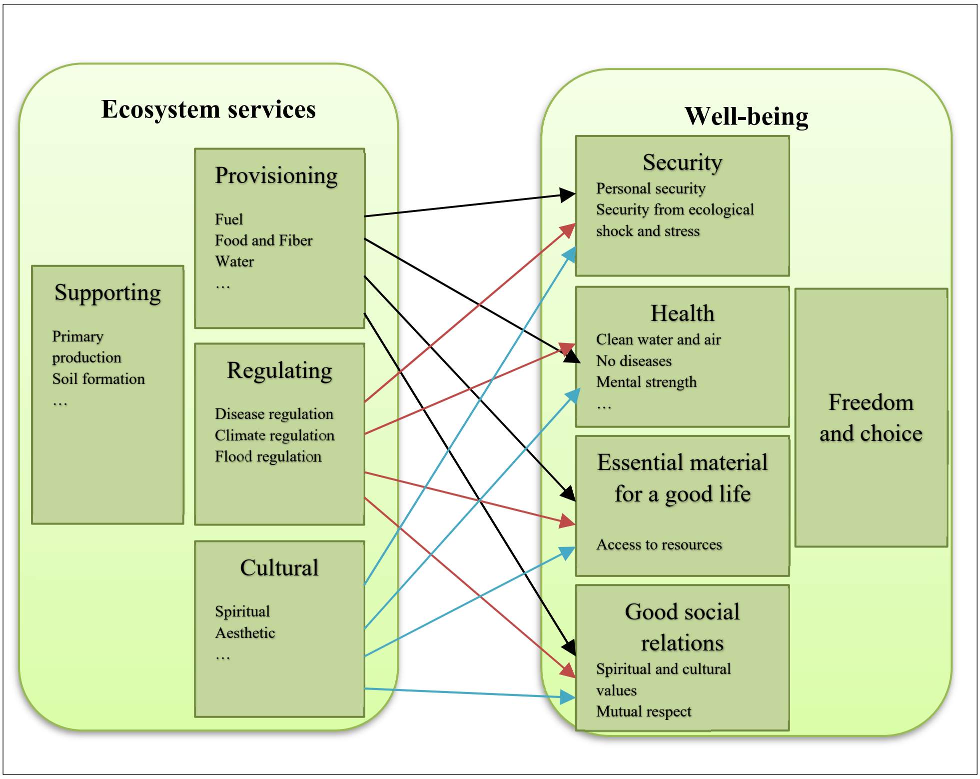

Figure 1: The connection between ecosystem services and well-being [10], [20].

Supporting ecosystem services are described as: "Ecosystem services that are necessary for the production of all other ecosystem services" [13]. Supporting ecosystem services provides water cycling, nutrient cycling, biomass production, atmospheric oxygen production, soil formation and retention, and other services, which are important to the city and its society [14]. Moreover, this group of services is a base for other ecosystem services.

Provisioning services supply to ecosystems, materials (fiber, food, water, and others) that are necessary for the production for all the ecosystem services [9], [15]. Since the city usually is highly populated, there is less space for provisioning services, but one of the usually applicable practices are urban gardens [16]. Urban gardens or school gardens provide some food for locals, for example, vegetables and fruits, but most of it is grown in rural or peri-urban areas. Nonetheless, the increasing areas of the urban gardens can supply locals, which have more benefits not only for ensuring basic materials but also it improves social and environmental aspects.

Regulating services is defined as the benefit acquired from the regulation of environmental conditions, such as water purification, climate regulation [17]. Regulating ecosystem services (RES) are important for the environment and human health. RES are both related to physical and psychological health. Air quality directly related to inhaling health problems, such as cardiovascular and respiratory diseases, chronic diseases, and others [18]–[20]. Nonetheless, green spaces of the city are capable of improving air quality, although there is still an important challenge, such as designing an urban green area since different flora have different characteristics. Regulating ecosystem services plays a crucial role in improving the quality of life.

Cultural ecosystem services are defined as a non-material benefit for the society through aesthetic, spiritual, religious experience, peoples' social benefit, and others [10], [15], [21], [22]. Nonetheless, to increase the positive impact on human health, it is very important to ensure the experience that is provided to humans during the visit of green areas in the city [23]. For example, a well-designed park, with some playgrounds for children, benches for elder society creates pleasure and nice feeling, but if the park has a poor condition, dark/unlighted areas, with no engaging activities, it arises unsafety feeling, which might harm health [24]–[27]. As well, there is another important condition, such as the proximity to the green or blue area. In a poor neighborhood, the areas are less maintained. Consequently, it might have a different impact rather than in a better neighborhood. Consequently, cultural urban ecosystem services are important for human health and well-being.

According to Jackson et al. [28], the ecosystem services that are most relevant to human health can be broadly categorized: air filtration; biodiversity conservation; climate stabilization; habitat maintenance; natural hazard mitigation; food, fuel and fiber production; water filtration; water regulation; and the provision of aesthetic environments and recreational opportunities. Therefore, researches focus on urban ecosystems as a tool to mitigate human health risks.

This paper aims to get deeper insights into the relationship between urban ecosystems and human health. A systematic literature review explains the importance of the topic by showing increasing attention every year, and word frequency technique reveals which word combinations are used the most.

2 METHODOLOGY

The research conducts a systematic analysis based on literature review strikethrough based analysis. The search has no limitations according to the date of publication, but only English language papers are included in the analysis. Moreover, extracted records are imported and organized in a reference tool Mendeley. Health and urban term combinations are compiled and applied for the records tracking (Table 1). Defined terms were searched in total in five search engines: PubMed, Science Direct, Web of Science, Google Scholar, and Scopus. The systematic review included papers in the journals, conferences papers, which are not duplicated with the journal papers, excluding books. Moreover, after the screening part, literature reviews are eliminated from the analysis.

2.1 Google Scholar

Google Scholar search engine was utilized by using a loop system: all health terms are combined with at least one of urban terms (Table 1). Moreover, the first 60 non-duplicated papers from the combined search terms were screened and included in further literature analysis. In total, there were 364 papers included, which are related to the topic.

Table 1: Defined keywords for a systematic literature review.

Urban terms	Health terms
Urban ecosystems	Human health
Urban ecosystem services	Public health
Urban planning	Mental health
Green spaces	Illness
Green infrastructure	Mental disorders
Urban parks	Well being
Waste management	
Water management	
Energy system	

2.2 PubMed

PubMed search tool is using a similar searching technique to Google Scholar. The importance of this search engine is that this database is more related to medical science. The defined terms are used with the limitation of the title and abstract. In total, there were 1,307 papers extracted, that were found with the combined keywords.

2.3 Web of Science (WoB), Scopus, and Science Direct (SD)

Web of Science, Scopus, and Science Direct search engines have similar instructions on managing the tool. There are some minor differences, such as the acronyms for a title, abstract (WoB = TI, Scopus = Title), the difference in using missing value sign (WoB = "*", Scopus "?"). Moreover, terms in SD have to be written with quotation marks. As in PubMed database, defined terms are also are searched only in the title and abstract For example, one of the strings in WoB is conducted: TI= ((Urban ecosystems OR Urban ecosystem services OR Urban Green space*) AND (Public health OR Human Health OR Mental Health)). Other terms are used in the same way constructed string. From the WoB search engine, 382 records are extracted, 672 from Scopus and 408 from SD.

For the systematic review, Mendeley was used to identify duplicates (Fig. 2). Firstly, in total, there were 64 records excluded as duplicates. Secondly, the screening part was conducted. In this part, the records were removed based on the relevance to the topic: if the title and abstract were not related to defined terms, the article was excluded for further analysis. In this part, 2,037 records did not meet the requirements and were removed. At least, full papers were analyzed to define if the record is relevant to the research. In the last part of the systematic review, 290 records were excluded as not relevant, as well as theoretical approaches and books.

2.4 Word frequency methodology

Word frequency technique has been performed by using the Qualitative Data Analysis Software NVivo 12 – QSR International. All the selected 107 articles are imported into the software, and with the function "Word frequency", analysis is conducted. The parameters for the function are: (i) to find 100 the most used words in papers that were selected; (ii) only five or more letter words have to be included in the analysis (to avoid dates, personal pronouns); and (iii) grouping with stemmed words.

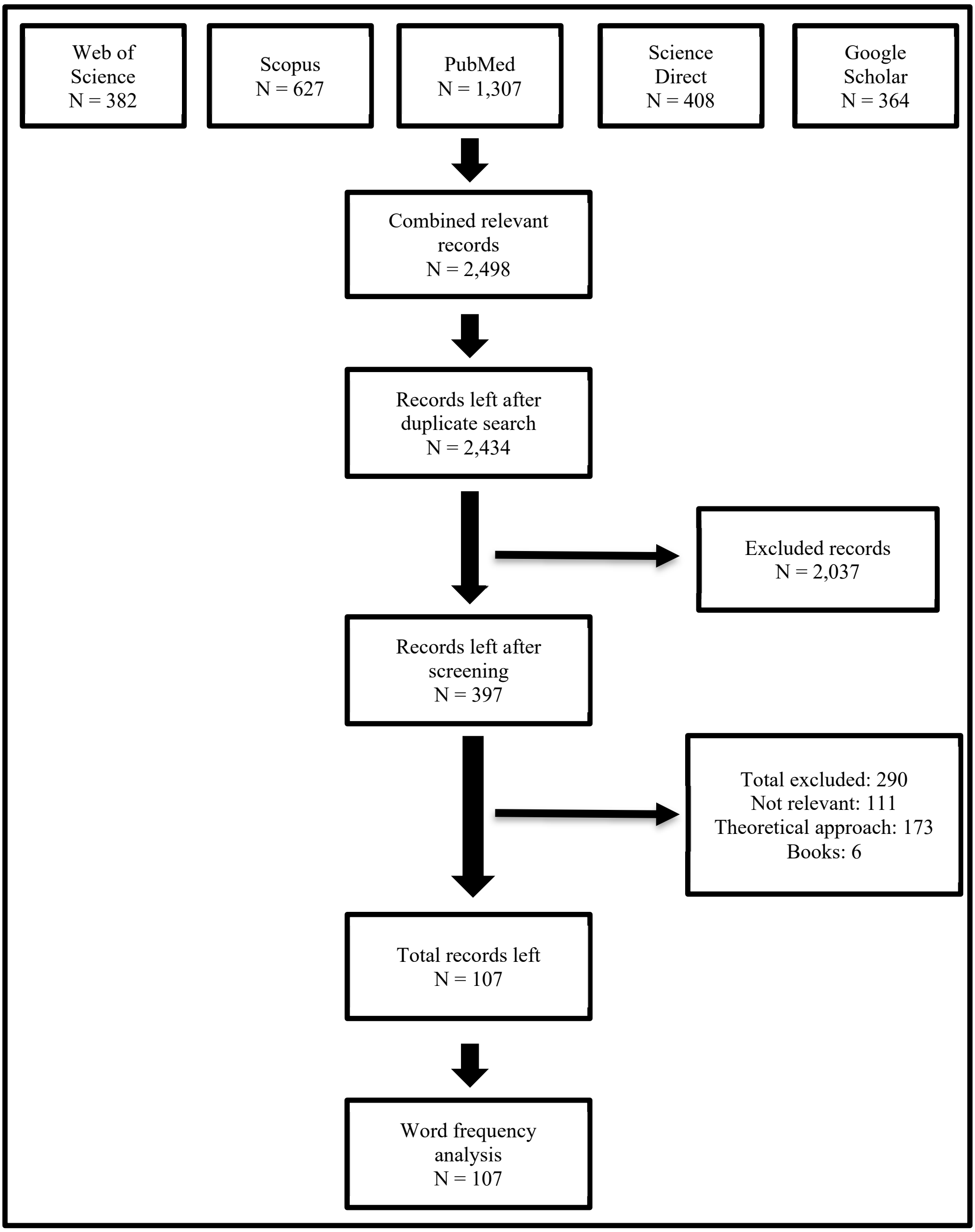

Figure 2: Systematic literature review scheme.

3 RESULTS

After the systematic review analysis, 107 papers have been selected as eligible. Nonetheless, only experimental records are included in the analysis, the number of publications (Fig. 3)

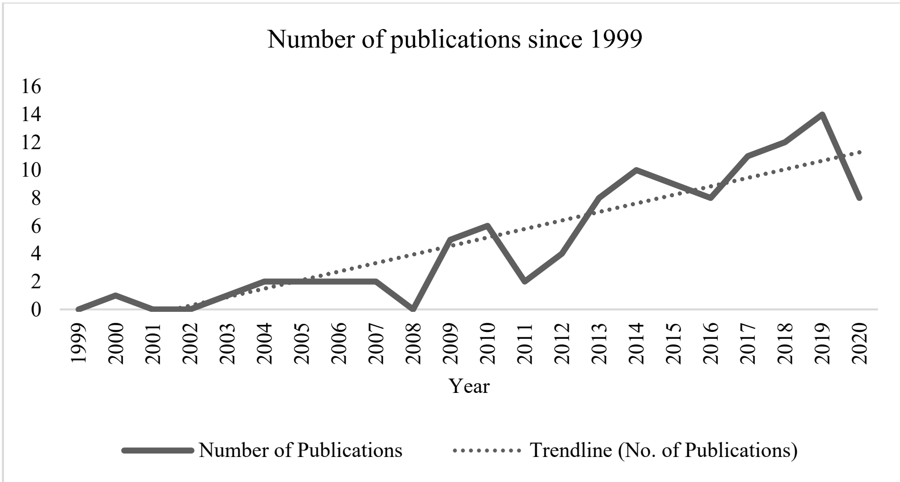

Figure 3: Chronologic publication analysis in the data range 1999–2020.

reveals, that the attention of the topic is increasing. Moreover, the figure shows a decline of publications in 2020 since the analysis has been performed until the 2020 of May.

3.1 Word frequency analysis

The results of the word frequency analysis demonstrate that the term greenness (3,199 times) is used the most frequently with the health term (Fig. 4). Other frequently used terms are space’ (2,785 times), urban (2,104 times), studying (1,880 times), environments (1,420 times), and activity (1,228 times). The cloud clarifies the strongest relationship between human health terms and urban ecosystem services terms.

Figure 4: Word frequency cloud.

3.2 Summary of methods is used to measure the impact on human health.

The summary of methods that are used in the selected records is divided into three main parts: (i) health risks evaluation methods and data gathering; (ii) urban ecosystems evaluation methods and data gathering; and (iii) statistical analysis methods, to evaluate the relationship between two objects (Table 2). The summary is concluded from 35 randomly chosen experiments. Methods analysis and summary show the most often used methodologies in urban ecosystem services evaluation and monitoring.

Table 2: Summary of health, urban ecosystem services, and statistical methods.

Health measurements	
Parameter	**Method**
Mental and physical health	Questionnaire (usually Likert scale)
Mental and physical health	Statistics from a public health institution
Physical health	Hormones, blood tests
Urban ecosystem services measurements	
Green spaces	Normalized difference vegetation index – NDVI
Air quality	• Measures of air quality/pollution from responsible institutions • Modeling tools for pollution distribution
Water quality	• Ex-situ and in-situ techniques • Flame photometric method for dissolved particles • UV-visible spectrometer for dissolved particles
Soil quality	• pH, organic matter, electrical conductivity, particle sizes, texture • Nir Spectrometer evaluating soil properties
Noise level	• Modeling noise level using SoundPLAN, which is an environmental noise modeling software • SiRENE (short and long term effects of transportation noise exposure) determines total transportation noise from the road
Statistical tools	
Anova	Durbin test
Single and multiple regression	Wu–Hausman F test
Logistic regression	Bivariate correlation test
Principal components analysis	Chi-square test

4 CONCLUSIONS

Urban ecosystem services and human health relationship is an important topic since the rapid urbanization raises new challenges. The research shows that every year the topic is getting more attention, but still, there is a high demand for improvements. Moreover, word frequency cloud shows, which aspects are investigated the most and which are investigated less. After reading and analyzing full papers, some differences are explicated. Urban green areas have a higher impact on aging generations' health, rather than younger. As well the significant impact on human health (both physical and mental) has a distance from residents' house and green space – the closer park or green area is to the housing, the better results according to the health. Mainly, it has significant results related to the stress level, anxiety.

Moreover, the frequency of visiting parks and time spent in the green area has an impact on human well-being [29], [30]. Hence, there are some negative aspects, which cause urban green infrastructure – the level of crimes, insecurity. The Tzoulas et al. study [31] shows that number of crimes is increasing with the increasing number of green infrastructure, which causes fear and insecurity level. Moreover, the unsafety in the city is related to other socioeconomic factors as well, such as age, neighborhood, and cultural background [32]. Although, the physical health evaluation is related to residents' movements, as well as with the environments' quality, such as water, soil, and air pollution, noise level. Mostly, the researchers conduct physico-chemical evaluation methods, assess their risk values, and compare with the World Health Organization (WHO) defined limited values. Noise pollution influences human well-being: it decreases the quality of sleep, causes increasing stress level, which causes other health factors, such as increased blood pressure, concentration problems, and others [33]. Nonetheless, the interest in urban ecosystems as a possible tool to mitigate health is increasing. Still, there is more research needed.

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BOTTOM-UP VERSUS TOP-DOWN HANDS-ON OPTIONS FOR MEASURING GHG AND POLLUTANTS IN SMART CITIES

SANDRINE QUÉRÉ & ANNIE LEVASSEUR
Department of Construction Engineering, École de Technologie Supérieure, Canada

ABSTRACT
Urbanized areas account for more than 70% of the carbon dioxide equivalent emissions. Their current greenhouse gas (GHG) emission is based on a bottom-up approach that adds the different sources of emissions (activity data multiplied by emission factors). Those current estimated inventories, based on statistics, are expensive and take months for data collection. Moreover, they raised scepticism for municipal decision-makers who are not certain how to understand and use them in urban policies planning support. Indeed, cities are lacking reliable, accessible information of a high standard on which to base GHG emission reduction decisions. To help smart cities measure and lower their emissions, another approach is currently under investigation: the top-down approach, based on real GHG measurements. In this paper, we present the current and potential hands-on options for measuring GHG: network of sensors, network of sensors coupled with atmospheric inversion modelling, and the laser beam system. We conclude by making recommendations for municipal decision makers to help them take ownership of in order to tackle climate change issues.
Keywords: city GHG emission inventory, sensors network, laser beam, air quality, smart city, empowering citizens.

1 INTRODUCTION

Cities account for more than 70% of energy-related global greenhouse gas (GHG) emissions [1]. Major cities in the world joined several initiatives such as the C40 Cities Climate Leadership Group and 100 Resilient Cities and took major commitments to lower their emissions. So far, cities GHG emission inventories are estimations obtained through a theoretical calculation. Those current inventories have incomplete and uncertain data. Moreover, they are of question of utility for mitigation decisions. Recently, a new trend appeared for smart cities to directly measure their GHG emissions to help them test and validate the impacts of their policy and urban decisions. In this paper, we discuss the different options tested by smart cities with their advantages and limitations.

In the past, cities have followed different protocols to establish their inventories, and recently, there is a tendency to use the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) [2] and the NAZCA platform [3]. The GPC inventory is an estimate of carbon dioxide (CO_2) emissions with all the other GHG converted into CO_2 equivalent (CO_2e). It is obtained through a theoretical calculation based on many assumptions that adds the different sources of emissions (activity data multiplied by emission factors).

2 NEED OF MEASUREMENT DATA

Traditional inventories have incomplete and uncertain data. For example, there is a lack of accurate statistics for the total amount of fuel used within cities [4]. And the uncertainty even builds up when extended to areas. For example, in 2010, estimates of GHG emissions in the Greater Toronto Area were available with the EDGAR [5] and FFDAS [6] inventories which provided a total of anthropogenic CO_2 emissions of 1.42×10^8 and 6.04×10^7 tonnes, respectively.

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Those current inventories are expensive and take months for data collection. Moreover, they raise scepticism for municipal decision-makers who are not certain how to understand and use them in urban policies planning support. Indeed, cities are lacking reliable, accessible information of a high standard on which to base GHG emission reduction decisions. In brief, they need real GHG measurements to provide clarity, transparency and accountability which is called the top-down approach.

To help smart cities measure and lower their emissions, different options have been chosen. It is beyond the scope of this paper to talk about the use of satellites or aircraft measures as we focus only on hands-on options that could be used directly and easily by municipal leaders, once a pilot project would have been demonstrated conjointly with universities. The first option that we present is the implementation of sensors network. The second one combines sensors network with atmospheric inverse modelling. The third one uses the laser beam technology.

3 NETWORK OF SENSORS

Several cities have already implemented GHG and pollutant sensors. Here, we describe the projects implemented in the cities of Oakland, London, and Trondheim.

3.1 Beacon Berkeley project

The University of California at Berkeley installed a network of 50 low-cost sensors to measure GHG and pollutants (CO_2, CO, NO, NO_2, O_3, PM). The sensors were spread over a 70 km^2 grid at approximately 2 km from each other. This pilot project aimed at helping the city of Oakland to validate the effectiveness of carbon-reduction strategies. According to R. Cohen, Beacon Berkeley project leader, “Real time observations will enable rapid verification of the effectiveness of policy and compliance with treaties and other agreements and commitments”. The major outcome of that project remained educational outreach on climate science as most of the sensors were displayed atop of schools [7].

3.2 London network

The city of London took a big step in 2018 to improve its air quality thanks to his mayor Sadiq Aman Khan. 100 fixed sensors have been installed on lampposts and buildings in the worst polluted areas and two Google street cars are driving across the city. The fixed sensors measure GHGs and pollutants (CO, O_3, NO_2, PM).

The Google street cars driving on the streets of London are equipped with sensors that already mapped the city of San Francisco with a 30 m resolution. The sensors were provided by the company Aclima which measured NO_2, NO and black carbon. In September 2018, Google and Aclima announced planning the measurement of CO and CO_2, O_3 and particles PM. The data are available to the public via Google BigQuery. According to Google, the data should help city decision makers to take the best mitigation measures. Aclima received a new funding of $24 million for this project.

In addition to that fixed and mobile network orchestrated by the city of London, mayor Khan’s objective was to raise citizen awareness. To that end, the city of London published a guide available to anyone wanting to monitor air quality. This guide describes the different sensors that are available to be bought on the market, how to collect the data, understand them and send them back to the city [8]. Mayor Khan believes that empowering Londoners with devices that provide them with a capacity of directly measuring what they are breathing is very important.

An example of the pollutant sensors that could be chosen by the Londoners are the PurpleAir sensors because the system is already connected to internet [9]. The PurpleAir sensors, developed in North America, are already used by the younger citizens, tech-savvy residents and parents concerned with air quality around schools. Those sensors give the real time and week average data for particles $PM_{1.0}$ (<1 µm), $PM_{2.5}$ (<2.5 µm) and PM_{10} (<10 µm). As an example, as shown in Fig. 1, are the $PM_{2.5}$ data for the Montreal area on 9th September 2020. The data for Fabreville Laval provides an index of 4 which indicates that air quality is considered satisfactory, and air pollution poses little or no risk. The data for downtown Montreal provides indexes of 63 and 64, which show that air quality is acceptable; however, if they are exposed for 24 hours, there may be a moderate health concern for people who are unusually sensitive to air pollution.

3.3 Trondheim network

Scandinavian cities, Trondheim in Norway and Vejle in Denmark, have chosen to test GHG and pollutant sensors within the Carbon Track and Trace (CTT) project [10]. CTT couples low-cost, open-source sensors to an Internet of Thing (IoT) platform. The main goal was to provide cities with a real-time GHG measurement capacity in order to directly measure the impacts of their policy and urban decisions. The second objective was to implement a semi-autonomous system for city GHG emission inventories.

That project started through the launch of a 24-hour climathon in 2016. After two years of project, the main outcome for the city of Trondheim was the possibility of discussing urban planning issues and see, for example, how pollution level would affect their decision making. They were also able to choose the location of air quality sensors according to new data sets such as road networks and the density of buildings.

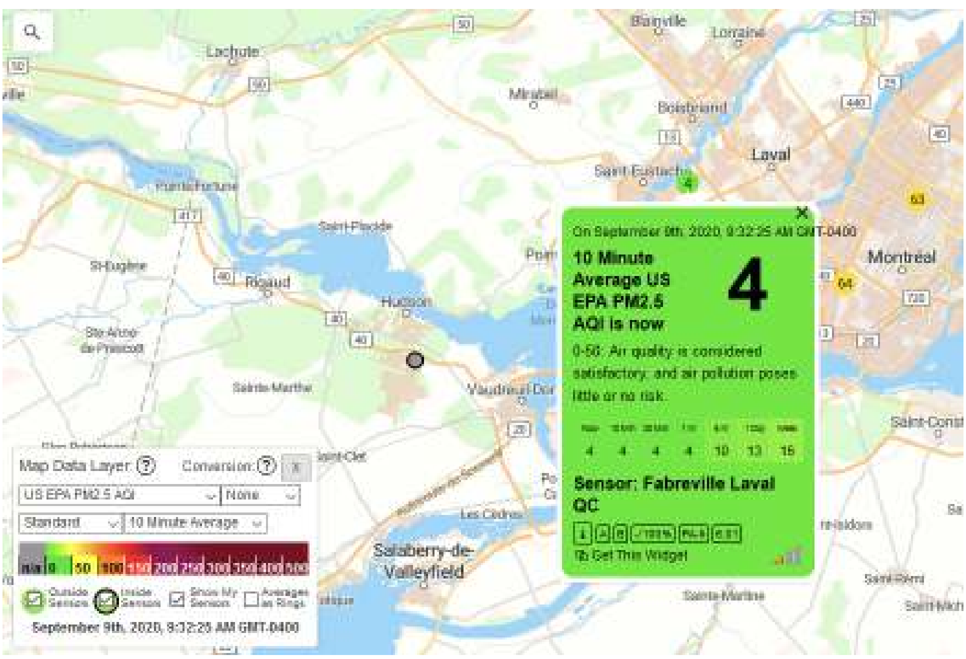

Figure 1: Air quality measurements for particles $PM_{2.5}$ with PurpleAir Sensors.

The main conclusion of their 2018 paper was that "Integration into decision support systems is a far goal". They understood that trying to link a CO_2 concentration curve with a traffic jam factor is much more complicated than a simple correlation as other elements account. CO_2 dynamics has to be properly modelled to identify its anthropogenic sources of emissions (ground transportation, residence, industry). They concluded their paper by stating that they would in their future work also include wind speed, temperature, weather conditions and seasonal patterns.

3.4 Main limitation of the sensors network

In brief, the main disadvantage of this method is the limited representativeness of total urban emissions and the impossibility of identifying the sources of emissions. Each site is influenced by both local and remote sources and no modelling is performed to identify the different sources.

4 SENSORS NETWORK COMBINED WITH ATMOSPHERIC INVERSE MODELLING

The second option smart cities have chosen to measure and lower their GHG emissions is to combine GHG sensor networks with atmospheric inverse modelling coupled with meteorological and chemical transport models. The main objectives of this methodology called CarboCount City were to estimate city GHG emission inventories independently from the traditional inventories, to decrease the current inventory uncertainties and also to identify the sources of emissions by using inverse atmospheric modelling. This method has already been implemented in test-bed cities, for example in Paris [11], [12] and Indianapolis [13], [14].

4.1 Atmospheric inverse modelling methodology

Emissions from the current GHG inventory are inputs for the combined meteorological and chemical transport model. The outputs provide estimates of CO_2 concentrations that are compared to the observations given by the sensors. The difference (estimates-observations) is used by an inversion technique that uses probabilistic tools to give the emissions of an updated inventory that would reduce this difference.

4.2 INFLUX project

In Indianapolis, the INFLUX project (Indianapolis Flux Experiment) main objective was to provide additional constraints for the compilation of inventories as well as elements of control (verification) of budgets obtained with conventional inventories. The INFLUX project showed the ability to estimate urban GHG emission inventory from three sources: a previous GHG inventory, airborne and tower-based measurements coupled with atmospheric inversion modelling.

Nevertheless, the results show some differences across methods that still have to be resolved. As the INFLUX project includes aircraft data and that research is still underway to resolve discrepancies, the model is not a hands-on system for cities [14].

4.3 Paris network

In 2015, the city of Paris received a lot of spotlight by hosting the COP21, the 21st Conference of the Parties of the United Nations Framework Convention on Climate Change (UNFCCC).

For the CarboCount City project implemented in Paris, only three expansive stations surrounding the city were used in the inverse modelling. They were located around the city, on buildings between 4–9 m above ground level [12].

The study used gradients between upwind and downwind concentrations because they are the best source of urban concentration data for inversion purposes. The most robust data for this study used only afternoon concentration gradients to avoid biases in the vertical mixing during nighttime, morning and evenings when chemical transport models cannot represent correctly the planetary boundary layer which is the lowest layer of the atmosphere that collects CO_2 emissions from cities [15]. A second condition was to sort the CO_2 gradients between pairs of stations along the wind direction. A third condition imposed a threshold on wind speeds (larger than 3 m/s) as chemical transport models have difficulties on modelling the lower speeds.

All in all, those conditions explained why 92% of the total hourly observations were removed. The main outcome of this paper was that the inverted CO_2 concentration emissions followed the monthly mean heating curve for the center of Paris [11].

4.4 Other studies based on the Paris network

Another study based on the Paris network and using observing system simulation experiments (OSSES) demonstrated the value of dense network in decreasing the uncertainty of the current inventories and in quantifying emissions for different sources of activity [16]. For example, the conventional AIRPARIF 2008 inventory based on a 1 km resolution is assigned a 20% 1 σ uncertainty in the monthly estimate of the total emissions from Île de France [17]. By simulating a network of 10 stations, the OSSES experiment estimated a monthly 1 σ uncertainty around 11%, which means a 42% uncertainty reduction. By simulating higher number of sensors, they demonstrated that the total and sectorial uncertainties were decreasing when the number of sensors was increasing.

Other studies have used observations of carbon isotopes and co-emitted pollutants to better quantify the sources of emissions [18], [19].

4.5 Main limitation of the atmospheric inverse modelling

Atmospheric inversion modelling aims at determining GHG flux in and out of the atmosphere. The sensor networks are ideally located around the city to compile urban inventories and not inside. According to reference [11], the inversion method still needs improvements to reach a satisfactory agreement between the measured concentrations and estimations. Even if studies on paper show that uncertainties decrease with the number of expansive stations, from a practical point of view, a network of low-cost sensors at a resolution of 100 m would need to be implemented to try to get an idea of the anthropogenic emissions. This second network would also increase dramatically the cost of those experiment. Designing an observing network suitable for urban policies needs to gain in maturity before being implemented [20].

5 LASER BEAM TECHNOLOGY

In order to overcome the gaps from the inverse atmospheric method, a new technology was tested in Paris for COP21. That technology, called Greenhouse gas Laser Imaging Tomography Experiment (GreenLITE), is based on a laser absorption spectroscopy system. Its main advantage is to measure 2-D spatial CO_2 concentrations [21].

5.1 Pilot project in Paris

This ground-based system was deployed over Paris for one year between November 2015 and November 2016 and utilized two laser transceivers and fifteen receivers covering ~25 km^2. The system provided the city of Paris with a yearlong of 24/7 real-time measurements capability. GreenLITE demonstrated its capacity of mapping CO_2 urban concentrations with a resolution of ~200 m. The near real-time measurement of CO_2 concentrations provides a first-order estimate of local changes in CO_2 flux, but cannot provide absolute flux values.

The measurements as well as atmospheric data (temperature, pressure, humidity, wind speed and direction) were displayed on a web interface. Initial assessments of the measurement against in situ instrumentation and modeled values showed very good agreement.

GreenLITE succeeded in mapping diurnal cycles linked to anthropogenic activity. For example, the laser beam technology was able to show the alternate traffic circulation policy implemented by the city of Paris to reduce CO_2 emissions during pollution peak days, as well as differences in weekday versus weekend diurnal cycles.

This technology provides spatially averaged measurements which may benefit atmospheric inversion modelling as the uncertainties obtained with GreenLITE are lower than those obtained with sensors [22] (personal communication with Jeremy Dobler).

GreenLITE demonstrated a similar system capability for methane. This methodology seems therefore to be promising in helping cities to evaluate their mitigation measures.

5.2 Main limitation of the laser beam technology

This technology measures the total CO_2 concentration along path observations between transceivers and receivers and cannot identify the different anthropogenic sources (ground transportation, industry, residence). Nevertheless, the CO_2 concentration map measures local carbon footprints and allows to know where the sources are located.

6 CHOOSING THE BEST OPTION

In order to choose the best system adapted to the city, stakeholders have firstly to identify their needs and objectives, as well as the mitigation measures that could be validated thanks to hands-on measurement GHG system.

As the perfect option able to identify different anthropogenic sources does not seem to exist yet, the development of innovative techniques to use new data sources is necessary. Those techniques might help to reconciliate the bottom-up and top-down approaches.

The implementation of a support process for municipal decision makers will help to take appropriate urban mitigation decisions, which could be, for example, validating the restriction of traffic on certain roads and see where the circulation adjustments happen, measuring GHG emissions for specific events, monitoring pollution at road interchanges or near industrial centers.

By enrolling their citizens as London did, cities empower them in being informed and taking action. Citizens can use their new knowledge in pollution to improve the air quality for their neighborhood, around the schools, around their workplaces and for their displacements.

7 CONCLUSIONS

Choosing the best measurement system for a city means identifying the needs and objectives, as well as evaluating the project feasibility and limitations. Some cities like London and Trondheim have chosen to record some trends and are now faced by the limited information given by the collected data. What do they mean and how to use them?

Other cities like Indianapolis or Paris have implemented GHG sensors coupled with a 3D sophisticated atmospheric inversion model. This method is able to provide additional constraints for the compilation of inventories. Stations placed at strategic locations determine the urban concentration data in the direction of the wind. A second network of low-cost sensors has to be implemented to measure the high-resolution urban flux and the anthropogenic emissions. No city has yet tried to implement a coherent and complete set of stations and low-cost sensors. The ultimate objective of estimating city GHG inventories independently from the traditional inventories remains a far goal. This inversion method is an open area of research and the path is still long before a high-density sensor network could test and validate municipal emission reduction measures.

A third option that we discussed is the laser beam technology that provides cities with a capacity to map CO_2 concentrations in real-time with a resolution of ~200 m. This system has already demonstrated its ability in validating urban mitigation measures and seems to be promising in regard to their effectiveness of policy implementation in both health and environmental scopes.

Our main recommendations concern the reconciliation of the bottom-up and top-down approaches, the development of innovative techniques to use new data sources and the implementation of a support process for decision makers so that they can take appropriate urban mitigation decisions and reach their GHG emission reduction targets.

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ANALYSIS OF FACTORS INFLUENCING BATHING CONDITIONS ON BEACHES IN NITERÓI, BRAZIL

EMILLY VIEIRA BRAGA COELHO PINTO, FERNANDO GUIMARÃES VICENTE, FLAVIO SILVA DE SANTANA, ANNA CAROLINA D'AVILA, RAQUEL LIMA OLIVEIRA & PAULO VITOR RIBEIRO MARQUES DA SILVA
Estácio de Sá University, Brazil

ABSTRACT

Nowadays, Niteroi is considered the city with the best conditions of basic sanitation in the State of Rio de Janeiro. Despite that, Niteroi constantly lives with its beaches being classified, regarding the conditions of bathing, as unfit for recreation of primary contact, even after the implantation of the submarine emissary of Icarai, which assesses the disposition of the sewage collected from eight districts of the city. Thus, the objective of this work is to analyze the evolution of bathing conditions of the beaches of Niteroi, close to the submarine emissary of Icarai, and to identify the main factors that influence these conditions. For that, the following was performed: (i) a qualitative study of Guanabara Bay conditions; (ii) the effects of the disposal of the sanitary effluents by the submarine emissary; (iii) a statistical analysis of the bulletins of the beaches studied; and (iv) a correlation between the rainfall index and the bathing conditions. Through the studies carried out, it was verified that the sanitary sewage arrangement carried out by the submarine emissary minimally impacts the bathing conditions of the nearby beaches. On the other hand, due to the streamflow of the Guanabara Bay, the pollution irregularly disposed of by other cities around the Bay is responsible for bringing to the shore of the Niteroi beaches contaminants that directly interfere with the beaches' bathing conditions. It is important to note that Guanabara Bay receives the drainage of 55 rivers, of which t50 are considered completely polluted by sewage. Another factor that impacts the bathing conditions of beaches is the pluviometric precipitation index of the locality that, because of the high levels of seasonal precipitation, surpass the capacity of collection and treatment of the sewage treatment stations, causing the overflow of this sewage to the ocean.

Keywords: bathing conditions, sewage, submarine emissary, sanitation.

1 INTRODUCTION

According to the National Sanitation Information System [1], in a survey published in 2017, 52.4% of the Brazilian population has access to sewage collection and, from this percentage, only 46% of sewage is treated [2].

Despite these disastrous data on basic sanitation, the city of Niteroi, in the state of Rio de Janeiro, has been gaining prominence, according to an award granted by the Brazilian Association of Sanitary and Environmental Engineering [3], which in 2018, after evaluation of almost 250 cities of Brazil, awarded Niteroi as the best city in Rio de Janeiro and one of the best in the country in actions related to the universalization of basic sanitation. However, even being considered one of the cities that has made the most progress towards the universalization of basic sanitation, Niteroi coexists with the beaches of its coast classified, mostly, as unsuitable for bathing.

The pollution that hits the beaches affects the quality of its waters and has a significant impact on local tourist activities and the quality of life of its residents. Thus, contaminated water needs to be treated as a vehicle of disease, harmful to marine fauna and flora, and harmful to the local economy [4].

In order to reduce the impact on beach bathing and water diseases, an assessment of the individual and set consequences of sewage discharges is required [5], [6].

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Thus, the present work aims to analyze the evolution of the bathing conditions of the beaches of Niteroi, near to the submarine emissary of Icarai, as well as the occurrence of waterborne disease transmission, and to identify the factors that interfere with the bathing conditions of the beaches of Niteroi.

2 WATER DISEASES

In general, regions suffering from lack of treated water and sewage systems tend to have higher rates of infectious diseases, which are transmitted due to contamination of rivers, lakes, streams, and even the sea by human and animal waste. However, this contamination can also occur through untreated sewage discharges, carried out by clandestine connections to the rainwater network [7], [8].

Among the main water diseases are gastroenteritis, cholera, typhoid fever, and hepatitis A. The following figures show the number of deaths (Fig. 1), the number of hospitalizations (Fig. 2), and the expenses incurred with hospitalizations (Fig. 3) caused by water diseases in the city of Niteroi.

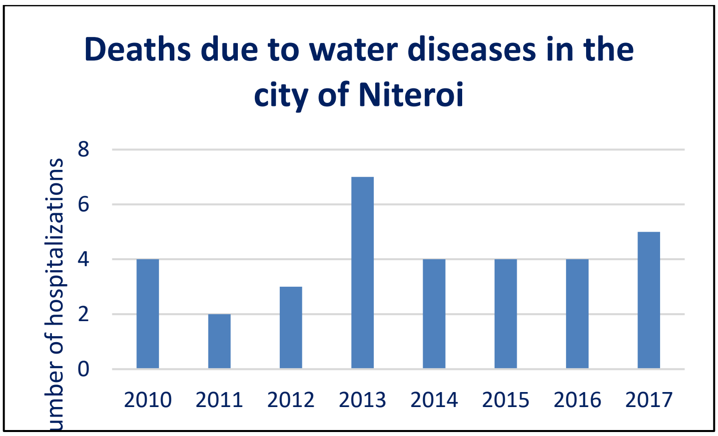

Figure 1: Deaths due to water diseases between 2010 and 2017 in Niteroi [9].

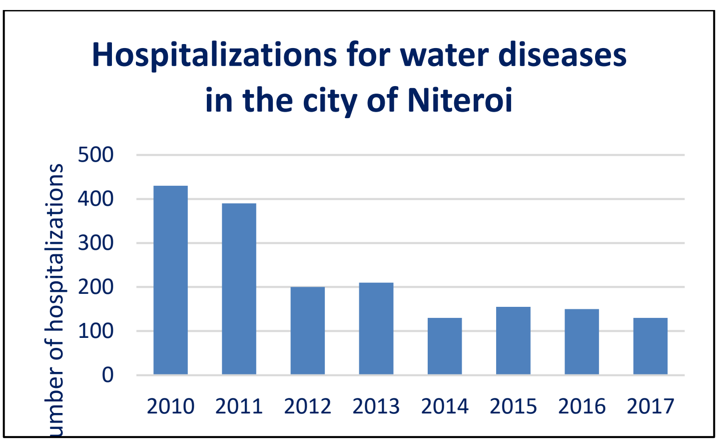

Figure 2: Hospitalizations for water diseases in Niteroi between 2010 and 2017 [9].

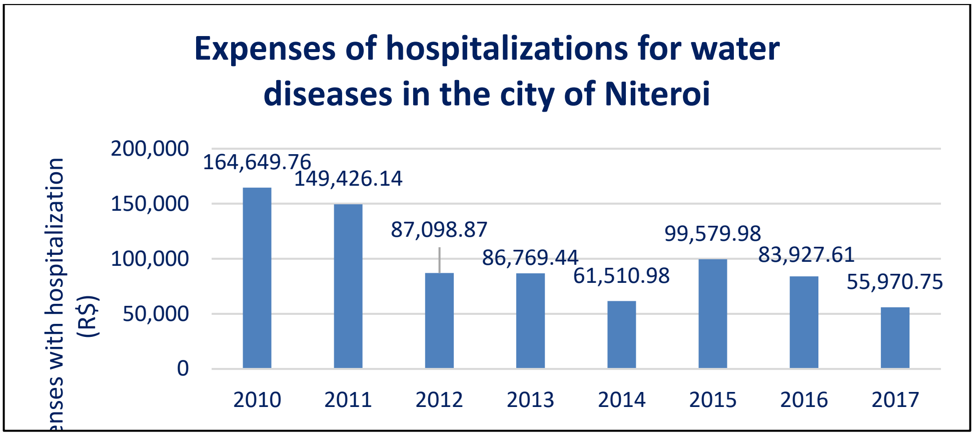

Figure 3: Expenses of hospitalizations for water diseases in Niteroi between 2010 and 2017 [9].

Table 1: Modelling scenarios.

Scenarios	Considerations
1	Clear sky summer
2	Fully cloudy sky summer
3	Clear sky winter

3 SUBMARINE EMISSARY

Knowing the movement of the effluent plume from a submarine emissary is extremely important because, from the concentrations of the contaminants present in it, it is possible to determine the areas that are most impacted by such releases [10]. According to Feitosa [11] and Ratti et al. [12], faecal coliform bacteria are considered a reference when it comes to contaminants. It is acceptable when values are below 1000 Fecal coliforms per 100 ml [13].

Feitosa [11] modeled the evolution of the contaminant plume from the Icarai, Ipanema, and Barra da Tijuca submarine emissaries, considering three distinct scenarios (Table 1).

For all three scenarios, Feitosa [11] used a 14-day simulation period, regarding the radiation levels of January (summer) and June (winter). In the first and third scenarios, clear sky summer and clear sky winter, a maximum cloud cover of 5% were considered, and in the second scenario, fully cloudy sky summer, 100% cloud cover was considered.

In all the scenarios mentioned, it is considered that water column density is homogeneous. Thus, during all simulations, the effluent plume will be superficial. In this sense, we can say that the solar radiation that acts on the plume occurs exclusively, according to the hourly and nebulous cover variations.

The results showed that the first scenario (Fig. 4), clear sky summer, was the one with the best bacterial decay condition. Due to the low presence of clouds, there was a higher incidence of solar radiation in the effluent plume and, consequently, higher and faster bacterial decay.

In the second scenario (Fig. 5), fully cloudy sky summer, there was low bacterial decay. This is due to the low amount of solar radiation reaching the plume, which makes the decay process slower and less effective.

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The third scenario (Fig. 6), clear sky winter, presented better results than the fully cloudy sky summer scenario, regarding bacterial decay, since clouds prevent the incidence of solar radiation, thus impairing the velocity of bacterial decay. When compared to the first scenario, clear sky summer, it presented lower decay speeds, which is to be expected, since, in summer, the incidence of solar radiation is higher than in winter.

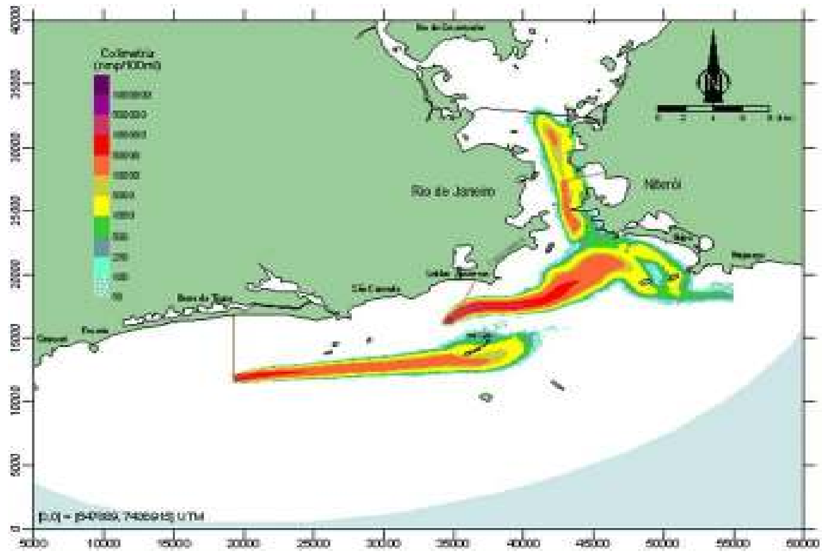

Figure 4: Fecal coliform concentrations in coastal waters under clear-sky summer conditions [11].

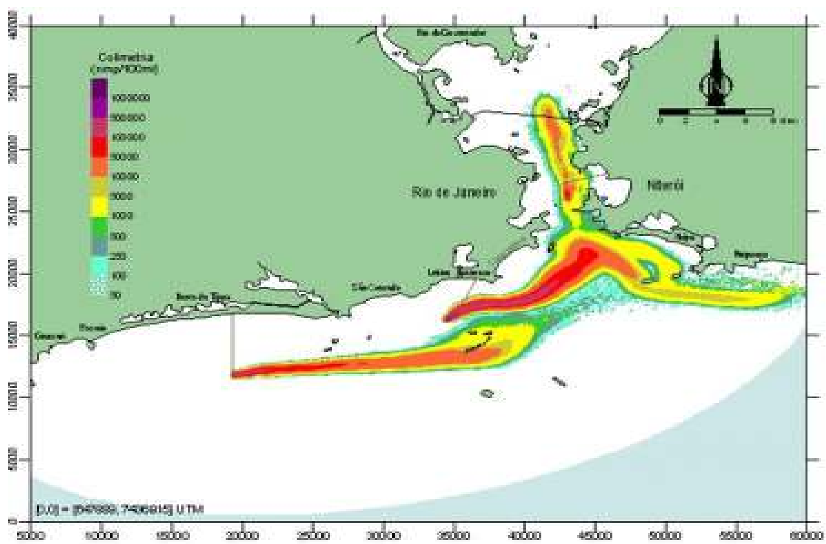

Figure 5: Fecal coliform concentrations in coastal waters under fully cloudy-sky summer conditions [11].

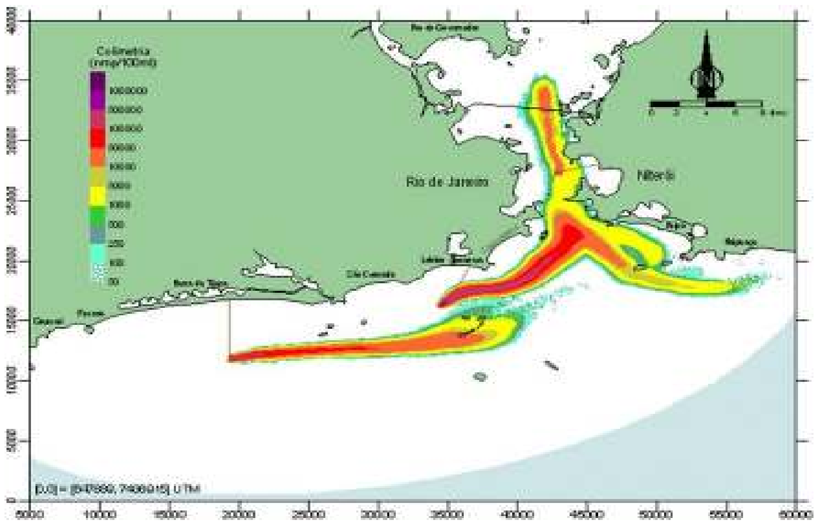

Figure 6: Fecal coliform concentrations in coastal waters under clear-sky winter conditions [11].

Given that Guanabara Bay has a long history of poor environmental care [5], effluent discharge from the submarine emissary is not the only source of pollution from Guanabara Bay [11], because according to Mesquita [14], Guanabara Bay receives the discharge of 50 rivers, of which 50 are considered completely polluted by sewage.

It is also essential to consider that the beaches located within Guanabara Bay already had their bathing conditions compromised due to the difficulty of the place to renew its water due to its brief section of water exchange with the ocean [5], [15].

The results show that the emissaries under study do not significantly imply in the water quality of the beaches, being indicated that such contamination occurs due to their connection with systems of rivers and channels that discharge their polluted waters in the coast and Guanabara Bay [11].

4 BATHING CONDITIONS OF STUDY REGION BEACHES

Bathing conditions data for the period from 2007 to 2019, provided by the Hydrometeorological and Water Quality Information Management (GeIHQ) – INEA-RJ, were analyzed between 2007 and 2013, samples were collected at only one monitoring point per beach and once a week.

Since 2014, the number of beach monitoring points increased, considering the length of each beach, and the collection periodicity was twice a week.

The monitoring points arranged along the beaches can be seen in Fig. 7 and Table 2. The samples are collected at an average depth of 1 m, as it is the zone area of the bathers, and conducted for analysis in the own laboratory of the State Environmental Institute of Rio de Janeiro (INEA), where the faecal and temperature indicator levels of each sample are checked.

From the results of these analyses, the beaches are classified according to the standards established in CONAMA Resolution No. 274/2000 [13], thus generating the weekly bathing bulletins published by INEA, classifying the beaches as PROPER or IMPROPER for swimming [16].

Figure 7: Location of sampling points in the Niteroi region. *(Source: Adapted from INEA [16].)*

Table 2: Monitoring points.

Beaches	Monitoring points
Boa Viagem	BV 01
Flechas	FC 00; FC 01
Icarai	IC 00; IC 01; IC 02; IC 03
São Francisco	SF 00; SF 01; SF 02
Charitas	CH 00; CH 01; CH 02

5 RESULTS AND DISCUSSION

5.1 Bathing conditions

A statistical analysis based on the data obtained was performed, and the evolution of the percentage of IMPROPER assessments of the beaches within the study area was traced between 2007 and 2013, as can be observed in Table 3, and between 2014 and 2019 according to Table 4.

From 2007 to 2010, excluding the beaches of São Francisco and Charitas that remained IMPROPER throughout the study period, the beaches of the study region maintained their beaches predominantly classified as PROPER by reaching a maximum IMPROPER percentage of 46%, observed at Boa Viagem beach in 2008.

However, in 2011 there was a rapid growth of IMPROPER conditions on the beaches of the study region, where the minimum of IMPROPER ratings was 77% on Boa Viagem beach. These terrible conditions remained until 2013, where 100% of the analyses performed on the samples of the beach of San Francisco indicated that it was IMPROPER for a primary contact.

Table 3: Evolution of the bathing conditions between 2007 and 2013.

Improper rating percentage							
Beaches	2007	2008	2009	2010	2011	2012	2013
Boa Viagem	17%	46%	23%	26%	98%	62%	69%
Flechas	31%	38%	38%	32%	77%	69%	85%
Icarai	23%	29%	38%	40%	88%	85%	94%
São Francisco	56%	96%	94%	82%	100%	100%	100%
Charitas	54%	88%	100%	90%	100%	100%	90%

Table 4: Evolution of the bathing conditions between 2014 and 2019.

Improper rating percentage							
Beaches	Point	2014	2015	2016	2017	2018	2019
Boa Viagem	BV 01	59%	75%	38%	34%	29%	59%
Flechas	FC 00	41%	36%	44%	23%	34%	56%
	FC 01	55%	52%	44%	30%	39%	63%
Icarai	IC 00	46%	41%	57%	35%	44%	78%
	IC 01	68%	61%	63%	46%	61%	70%
	IC 02	15%	25%	36%	23%	32%	52%
	IC 03	63%	51%	74%	53%	54%	96%
São Francisco	SF 00	98%	95%	94%	84%	96%	89%
	SF 01	88%	83%	89%	60%	73%	89%
	SF 02	80%	85%	81%	52%	62%	78%
Charitas	CH 00	65%	55%	61%	42%	49%	81%
	CH 01	40%	48%	58%	25%	52%	48%
	CH 02	68%	69%	68%	50%	40%	78%

From 2014 to 2018, excluding São Francisco beach, there was a gradual decrease of IMPROPER evaluations on the beaches of the study region. In 2019, the bathing conditions classified as IMPROPER returned to a significant increase and reached higher percentages. This is mainly because samples were analyzed only between January and April, which corresponds to the period with the highest rainfall of the year in the region under study.

5.2 Pluviometric index versus bathing conditions

Through the analysis of the obtained data was performed a correlation of the rainfall index of the city of Niteroi with the bathing conditions of its beaches. To establish such correlation (Fig. 8), it was used the average rainfall of the city of Niteroi [17] and the monthly average of "IMPROPER" assessments of Icarai beach, between 2014 and 2018.

Thus, the influence of rainfall on beach bathing conditions can be verified, since predominantly the beaching conditions of Icarai beach worsened as the average rainfall increased and, in the same way, the bathing conditions improved as the average rainfall decreased over the months of the year.

This is due to the increased volume of water that is added to the sewage system and, consequently, capitated by the sewage treatment plants, which are unable to properly this effluent stream, thus occurring their overflow to nature [18].

Fig. 9 shows the correlation between Enterococcus levels found in samples collected from Icarai beach (IC 01), on days when precipitation occurred within 48 hours before sampling. It should be noted that precipitation data were obtained from the National Institute of Meteorology (INMET) website.

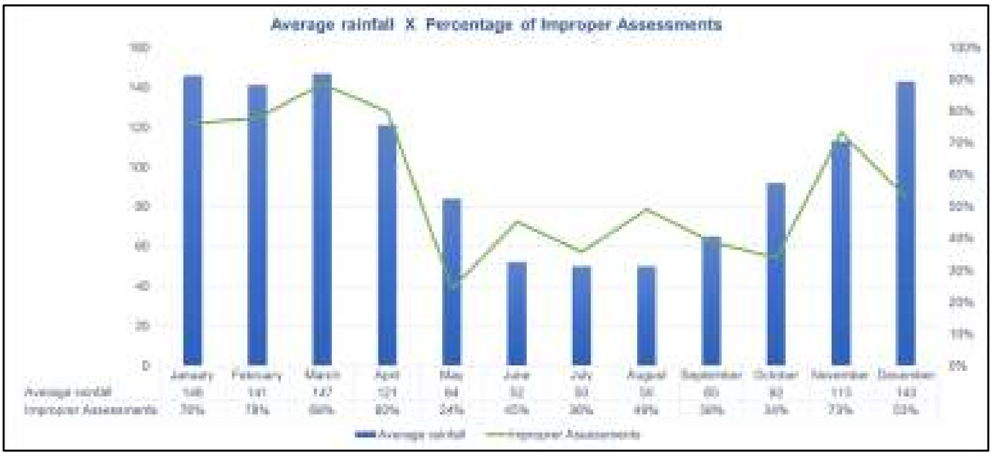

Figure 8: Correlation of Niteroi average rainfall with the percentage of IMPROPER assessments at sampling point IC 01.

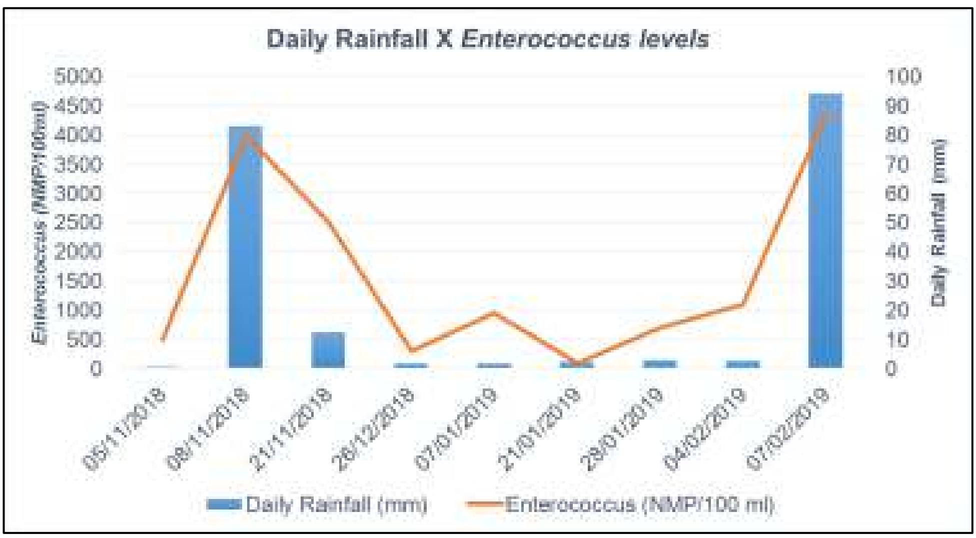

Figure 9: Correlation of daily rainfall with Enterococcus Levels in samples analyzed within 48 hours after precipitation at sampling point IC 01 between November 2018 and February 2019.

6 RESULTS AND DISCUSSION

From the studies that make up this academic research, it was verified the existence of factors capable of influencing the conditions of bathing, that during the last 12 years did not show significant improvement despite the constant improvement and expansion of the sanitation system of Niteroi, as well as the implementation of the Icarai submarine outfall.

It is essential to highlight that the high pollution index found in Guanabara Bay may be the main factor influencing the bathing conditions of Niteroi beaches, which through the flow of currents and tides, leads pollution to the edge of the city of Niteroi. It is also noteworthy that the clandestine connections between rainwater and sewage networks play a very harmful role, especially in precipitation conditions, given that the increased flow leads to the overflow of effluents in the sewage catchment networks and, consequently, the flow of this into nature without any kind of treatment.

Thus, it was verified the existence of measures capable of reversing the current situation of Guanabara Bay and, consequently, improving the water quality of Niteroi beaches. It turns out that most, if not all, sanitation plans have been neglected and paralyzed by successive governments, which is why bathing conditions have been worsening considerably year after year.

Therefore, the conclusion of the Guanabara Bay Depollution Program is considered as a perspective capable of improving the bathing conditions of the beaches of Niteroi, so that there is an evolution of the local ecosystem as a whole, thus avoiding the distribution of pollution between Niteroi and the other cities bathed by Guanabara Bay.

Equally necessary is the massive investment in environmental education both in schools and in communities surrounding Guanabara Bay, as well as the implementation of more intense public policies and social programs to raise awareness of the impacts caused by inadequate waste disposal (garbage and Sewer).

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SECTION 8
INTELLIGENT ENVIRONMENT

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HERITAGE-LED ONTOLOGIES: DIGITAL PLATFORM FOR SUPPORTING THE REGENERATION OF CULTURAL AND HISTORICAL SITES

BEATRICE TURILLAZZI[1], GIOVANNI LEONI[1], JACOPO GASPARI[1], ERNESTO IADANZA[2], MARINELLA MY[3], MARTINA MASSARI[1], SAVERIA O. M. BOULANGER[1] & AMIR DJALALI[1]
[1]Department of Architecture, University of Bologna, Italy
[2]Inception Srl, Italy
[3]Corvallis SpA, Italy

ABSTRACT
The increasing application of digital technologies to cultural heritage (CH) is wide and well documented, including a variety of tools such as digital archives, online guides and HBIM repositories. Several vocabularies and ontologies were designed to order heritage data and make CH more accessible and exploitable. However, these tools have often focused on a particular dimension of CH producing high value in separate sectors (e.g. access to conservation of historic buildings and data valorisation for restoration of heritage assets) but lacking ways for adapting or replicating the model to urban complex systems. Moreover, many studies and tools show large effort in cataloguing and archiving, but less in providing tools for designing and managing. The ROCK platform, developed within the Horizon 2020 (H2020) funded project ROCK (GA 730280), addresses the need for a management and intervention-oriented interoperable tool, aimed at storing, visualizing, elaborating and linking data on cultural heritage. The use of already existing ontologies was not sufficient for developing a tool to deal with the complexity of urban systems and heterogeneous data sources. Instead, a participative methodology was set in place for the development of a context-based semantic framework to define the needs and requirements of heritage-led regeneration actions.
Keywords: semantic platforms, cultural heritage integrated management, sustainable development, heritage-led regeneration, living lab.

1 INTRODUCTION

In a context of great global changes, increasing urbanization and technological advancements, historical cities and cultural heritage (CH), have been put forward since early 1990s as fundamental tools for sustainable and inclusive growth and development provided through urban regeneration processes [1]–[3]. CH-led urban regeneration processes assume heritage and its contextual characteristics as both repositories and engines of socio-economic development [4]–[6]. CH's "inherited legacies" [7] are assumed as unlimited source of knowledge and information to build a conscious design and planning for the present and future European built environment [8], a "heritage approach to growth" [9]. This information must be returned and made available in a clear manner to all actors who can put in place knowledge and skills to strengthen its value, and to those who can benefit from it. The necessity for making this data available for future uses demands new applications to facilitate information access through three-dimensional databases, without compromising the quality and amount of information captured in the survey [10] is one of the core concept of ROCK project, funded under the umbrella of Horizon 2020 programme (GA 730280).

Stemming from these premises, increasing accessibility to information in CH-led regeneration processes leads to:

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- a recognition and classification of cultural heritage assets, in order to increase the understanding of its meanings and layers;
- promoting the involvement of various stakeholders, actors, formal or informal institutions carrying out independent agendas that need to be coordinated; and
- enabling informed decisions for the management and control of heritage maintenance and conservation interventions.

Addressing the issue of accessibility of CH provides a new perspective for considering it as a driver for the construction of more conscious urban regeneration processes, which intertwine development and economic growth with its conservation and enhancement.

Accessibility to CH and its inherent knowledge is increasingly extended by the possibilities provided by new technologies and tools developed over the years. Digital guides, augmented reality, online archives [11], [12] and digital platforms, management dashboards and monitoring sensors [13]–[16] are just few examples of the multitude of tools that are nowadays available for managing and designing interventions on CH.

In this perspective, technologies and new digital media are increasingly adopted for promoting CH accessibility, collecting local material and immaterial data and gathering transnational knowledge, oriented to users, cultural operators and policy makers at once. A new set of technologies have made it possible not only to store historicised data, but also to dynamically monitor processes involving CH and to generate new data whose origin is diversified and fragmented. They can provide new opportunities for the "creation of new spaces, not only for consumption of heritage but also for its critical reflection" [17].

The Declaration "Cooperation on advancing digitization of cultural heritage" signed by Member States during the Digital Day 2019, has strengthened the commitment by the European Council, the European Parliament and the European Commission in promoting digital technologies to record, document and preserve Europe's CH and its accessibility to European citizens. Moreover, the Declaration states "The Union also needs to ensure that its digitised cultural content and related applications are available, where appropriate, on European platforms, in line with our values" [17, p. 2]. Furthermore, during the "Symposium Horizons for Heritage Research – Towards a Cluster on Cultural Heritage" of March 2019, the European Year of Cultural Heritage Team leader Dorothea Nigge highlighted the need to mobilise knowledge and research as a way to support advanced digitisation and foster actions for the future participation and access to CH.

In this scenario, scholars, researchers, professionals, curators as well as city users – residents, tourists, workers – have growing possibilities to interact with information and knowledge about different CH assets, to exchange experiences, to enrich data and contents through platforms and social media. This approach, together with the interpretation of heritage as an engine of urban regeneration, has produced a series of in-depth studies on common languages for the representation and accessibility of CH, by developing a series of ontologies providing specialized and non-specialized information and visualization of data locally. However, these studies have often been focused on a particular dimension of CH (e.g. access to conservation of historic buildings, data valorisation for restoration of heritage assets), producing high value in separate sectors but lacking opportunity to adapt the model to urban complex systems. In fact, since a historical urban system is subject to complex dynamics, it seems necessary to provide a comprehensive method to trace and return the evolution of the heritage-driven regeneration system and propose solutions for future development. The objective of this article is to report a systemic and multidimensional methodology developed within Horizon 2020 ROCK project. In order to define the background framework, a preliminary review of existing studies and projects on CH ontologies is provided.

2 HERITAGE ONTOLOGIES: A REVIEW

A constellation of tools and technological techniques are emerging to address complexity in CH regeneration by organising the existing information and data into new ontologies for CH access, as requested by the Digital Cultural heritage NETwork [3]. In computer science, ontologies are ways to explicitly specify some concepts. An ontology is therefore a common denomination and formal definition of the properties and interrelations of characteristics that exist for a particular domain [18]. The ontology presents, in a machine-readable form, the semantic relations among things, to represent the reality in terms of computer data. The variables that define a certain system are recognised and organised establishing relations between them, building a shared language. The complexity of sources, methods, disciplines and large amounts of data emerges as a key issue to define a standard ontology. Many studies have addressed this challenge, specifically in the CH domain, in the attempt to "associate complementary information from various dedicated systems" [19], integrating schemes, organising people, assets and places.

These experiences have been placing high emphasis in defining an interoperable system, able to integrate, address and exchange [18], [19] information among technicians, professionals, policy makers, scholars, but also end users [21], investors and city-makers. In the European context, this led to the design and implementation of digital data interoperable platforms to:

- promote interaction, exchange and cooperation between European public administrations;
- deliver European public services across national borders and sectors; and
- create tools able to ensure interoperability between legal instruments, business processes, information exchanges and components.

The interoperability issue fits one of the challenges of EU Digital Single Market, about digitizing European CH, making it accessible online and preserving it for future generations. Some examples of these attempts can be taken as a reference to highlight the lessons learned and the gaps still to be filled.

The INCEPTION (Inclusive Cultural Heritage in Europe through 3D Semantic Modelling) project offers an example of how to turn the architectural space as the foundation to create a protocol for optimizing the 3D documentation of CH [22]–[24]. Its platform addresses the spatial nature of CH, standardising the survey, storage and retrieval of data of the physical consistency of heritage building and sites. This was made possible through the development of a semantic ontology dedicated to CH buildings, together with a data model for cataloguing information (also referring to the Art and Architecture thesaurus developed by the Getty Research Institute). These semantic attributes are integrated with hierarchically-organised and mutually-aggregated 3D digital geometric models [25], [26] aiming to adapt the fruition of each building component to different user needs. This methodology is specifically based on geometric physical data to avoid fragmented information acquired by different sources and to facilitate data access and use.

The approach proposed by Acierno et al. [27] is an ontology-based model highlighting a synergic approach for the management of complex information related to the conservation of CH. In this model the authors pursue a twofold aim, to semantically capture and represent the conservation processes of CH and to put forward a model to exchange such information. What appears interesting is the domains in which the ontologies are modelled, which include the “actor” domain describing the people “concerned with the existence of the building” [27]. The model structures both direct and indirect knowledge and embeds also information emerging from stakeholders and users interested in the artefacts, even though it eventually focuses only on matters of conservation and restoration.

Kioussi et al. [28] work, aims to fill the existing gap on the lack of data on quality of materials and structures to be used as a background for decision-making in the selection of refurbishment strategies. This approach is oriented to develop criteria and methodologies to create a system for integrated documentation [28]. The scholars consider indicative parameters of data documentation, implementing national, European and international regulations to develop a common pan-European methodology governed by the existing European standards and codes [28]. The methodology proposes a quality control system based on three levels: (a) monitoring and inspection; (b) intervention; and (c) diagnosis.

Each level includes a set of data that cover aspects from functionality to interventions compatibility. The output of the methodology allows to move from the integrated documentation protocol to the parametrisation of the state of conservation [28] of each building based on the knowledge acquired on the asset during its lifetime. The application of the methodology provides the criteria and parameters that enable the selection in conservation problems and help to prioritize the monuments’ needs, therefore producing an European CH identity card [29].

The aforementioned examples show that a great amount of data is nowadays produced by different sources, using IT technologies, social media, urban monitoring tools, environmental sensing, and the surveying activities carried on by public administrations and private corporations. In this framework, the issues of availability, accessibility, and transparency of information are the key elements for any inclusive, sustainable and informed CH fruition and CH-led urban regeneration process.

3 CH, ONTOLOGIES AND COMPLEX URBAN SYSTEMS

These studies are undoubtedly of considerable interest in addressing the issue of accessibility and interoperability of data and information on CH. However, most of them are referred to individual buildings or to limited sites, often adopting a mono-dimensional methodological approach which refers to separate and sectoral indicators. This can’t be fully transferred to large processes of urban regeneration in historical context whose layered and complex nature [9] require more comprehensive and cross-disciplinary approaches especially when intertwined with sustainable development [30].

Despite the growing efforts spent to boost the fruition and dissemination of CH, what emerges is a lack of studies and tools addressing the organisation of information and data for the management and deployment of CH-led regeneration, especially at urban scale. Many studies deal with cataloguing and archiving but less with providing tools for designing and managing. At the same time, they mostly focus on the “reconstruction of possible pasts” [19], overlooking the identification of hypothesis for future development. A series of gaps are highlighted both in the instruments, their characteristics and their performances concerning the accessibility of information on CH and its management in a wider urban perspective.

- Data and information on CH are growing in number, refining and diversifying, going to characterize heritage with intangible elements or linked to technical information on the genesis of the product or good itself. The great diversity of data available necessarily refers to different sources, fragmented databases, heterogeneous storage, access modes and languages that are often not comparable.

- The ownership of the data is managed by different subjects or bodies, institutional or otherwise, a segmented constellation in which the actors involved are focused on their internal processes and struggle to interact with each other.
- The available tools and procedures are not able to cope with the complexity deriving from the not standardised information that CH has been accumulating and storing. They are unable to return a model that can recognise, describe, evaluate and replicate the vast amount of data surrounding CH both technical and qualitative, with an urban horizon.

What is evident is a lack of a shared vision for the collection, aggregation and process of data on complex dynamic systems such as the historic urban space, together with the narration and sharing of information on heritage monuments, buildings and entire sites at the urban scale. Historical urban space is in fact conceived as a whole, a collective system of spaces supporting all kind of relationships and connectivity at different levels. In order to enable urban regeneration processes and historical sites enhancements, CH should be conceived as a system of common objects, spaces and practices. Digital tools can help in the construction of such a model, allowing the mapping of formal and informal knowledge, practices, ideas and subjects, creating a collective regeneration resource for the city.

The ROCK (Regeneration and Optimisation of Cultural heritage in creative and Knowledge cities) H2020 project aims to tackle the aforementioned issues by granting the possibility to achieve interoperable models able to enrich the interdisciplinary knowledge of European cultural identity.

In the attempt to respond to these gaps, the ROCK project proposes an "enabling platform" [31], [32] for the knowledge, management, monitoring, redevelopment and enhancement of CH.

4 ROCK'S CH-LED REGENERATION APPROACH

The ROCK project aims to support the transformation of historic city centres afflicted by physical decay, social conflicts and poor life quality into Creative and Sustainable Districts through shared generation of new sustainable environmental, social, economic processes. ROCK develops three integrated management plans for three test-bed sites in the cities of Bologna, Lisbon and Skopje, aggregating shared principles, local strategies with site-specific CH-led regeneration tactics. ROCK provides new ways to access CH and to promote transparency and perception of collective property (as shared heritage), fostering the accessibility to spaces for all, improving the functions of CH from a user perspective, defining key policy issues, integrating the emerging spatial, temporal and virtual structures to support cohesion and develop a sense of belonging to a place [12].

ROCK promises to offer a possibility of thematic and systematic access to CH-related data, its constraints and limitations as well as possibilities for new uses. Much of the information provided by ROCK derives and is shared by the intersectoral actors involved during the research activities. These elements are held together by a digital infrastructure, an interoperable platform based on the model of management dashboards typical of many smart city interfaces. With respect to the latter, ROCK intends to put together both the aggregated data and the elements that emerge from participatory processes related to the regeneration of CH, in a decision support tool not only meant to be informative or managerial, but allowing the observation and the evaluation of a new approach to the regeneration of CH in European historical centres.

The ROCK platform operates on the relational aspects of CH recognition, production and management, providing procedures to design, monitor and evaluate CH-led urban regeneration processes that includes and intertwines not only measurable data, but also information emerging from field observations, interviews, ethnographic research and participatory activities.

The platform defines a protocol, a common vocabulary, that allows a transition from a segmented approach – in which the actors involved are focused on their internal processes and the collected data are fragmented – to a circular one, where a digital ecosystem reconnects all actors involved in the CH-driven regeneration process, enabling the exchange of information through the development of a conceptual grid made of historical data, empirical evidences and results from dynamic monitoring, to observe and validate the process.

The following section clarifies the methodological approach used by ROCK to identify the most useful datasets and interrelations to generate its ontology for CH-led regeneration.

4.1 Methodology

The ROCK data platform is the tool through which a series of datasets are compared, visualised and interpreted through the development of a monitoring logic based on the needs emerged within Bologna's replicator site. What characterizes ROCK's approach is that the definition of the evaluation framework of the actions, and therefore the identification of the relevant datasets to be collected, was co-designed through the establishment of a dedicated panel, based on the model of the living lab. The local community was involved not only in order to collect information and knowledge about the site or to probe the needs and desires of the community for the regeneration of the area, but also in the definition of the main issues to address and look for in the definition and evaluation of the actions related to the regeneration process. The Bologna living lab – U-Lab, coordinated and facilitated by the local urban agency Fondazione Innovazione Urbana – saw the participation of representatives from several institutions, cultural producers, SMEs and citizen's association involved in the cultural life of the test-bed site, namely the University district [33].

U-Lab participants were firstly asked to react over the proposed definitions of "sustainability", "accessibility" and "collaboration for new cultural productions". In a second phase, the participants were asked to discuss these topics in the context of four selected locations in the university area. In this way, the laboratory produced three contextual definitions of the three topics (scenarios) and their various dimensions and articulations, also in relation to the actual locations, as well as the requirements to be met with the implementation of the regeneration actions.

The work of U-Lab produced a first shared vocabulary, a situated "ontology" (albeit not yet formalised into a digital tool) of urban regeneration for the Bologna University district, in relation to the principles of the ROCK project. This provides a contextual vocabulary where the definition of the scenarios may differ from the conventional understanding. For instance, sustainability was more perceived in terms of care of public spaces rather than within its environmental implications (waste, CO_2 emission reduction, etc.). Similarly, accessibility was approached not simply in reducing or removing physical barriers, but as the necessity to create an inclusive environment which is able to welcome any kind of people or subjects. The issue of collaboration, finally, was framed in the sense of widening the offer of cultural events by the promotion of small cultural producers, as well as acting on the audience to widen and differentiate the public, also to attract different visitors to the University area.

These concepts were then translated into a series of requirements and indicators defined for each scenario, to which the various datasets were correlated, including the specific demonstration activities carried on in the test-bed site during the ROCK Project [34]. The datasets included in the ROCK platform can be grouped in the following main typologies:

- datasets already available from public institutions or private companies, such as points of interest, museum and theatres attendance, data from free-floating bike sharing services, etc;
- datasets regarding ROCK's activities, collected through databases specifically developed for the ROCK project (such as the ROCK Atlas and ROCKME, with data compiled by ROCK partners);
- datasets coming from real-time sensors tested within the ROCK project (temperature, humidity, noise, pollution, wind, flows and video neuroanalytics); and
- datasets related to specific analyses and activities, including mapping events, sentiment analyses related to rock actions, surveys, ethnographic researches etc.

The ROCK interoperable platform allows data to be gathered, processed and compared facilitating communication and relationships between different information sources.

4.2 The ROCK Platform

The ROCK platform aims at providing data and insights on CH and urban regeneration for the use of policy makers, researchers, cultural producers and businesses, as well as providing insights and information for the general public and civil society (Fig. 1).

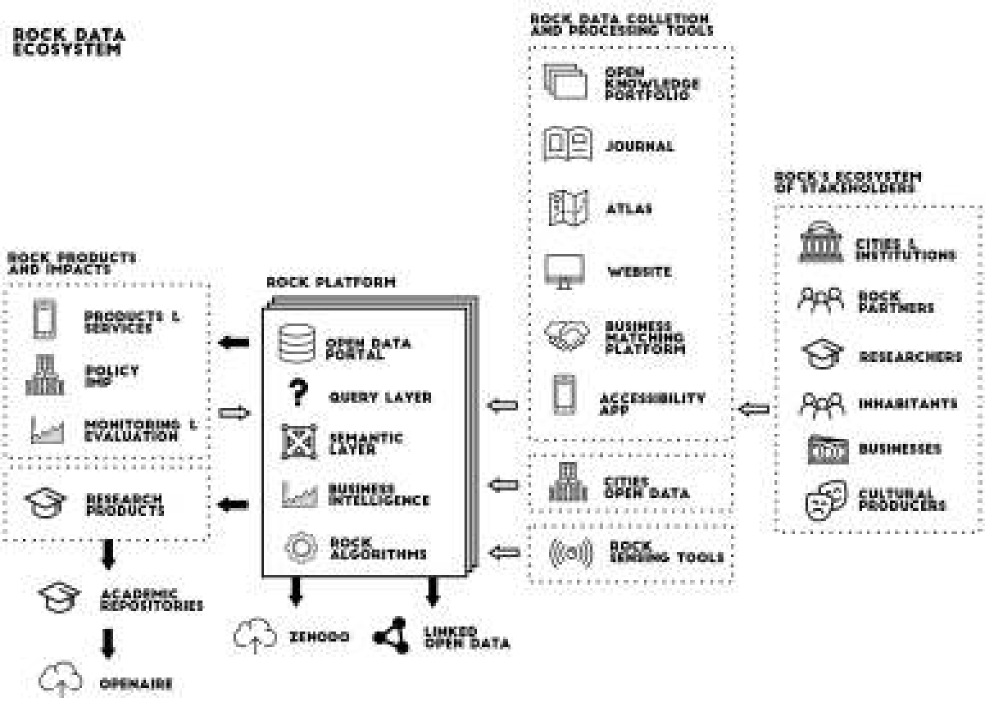

Figure 1: The ROCK tools' ecosystem.

The Platform is constituted by different layers specialized in performing specific functions (Fig. 2), interconnected with each other: the Query Layer, the Open Data Portal Layer, the Semantic Layer, the Business Intelligence Layer, the Big Data Layer.

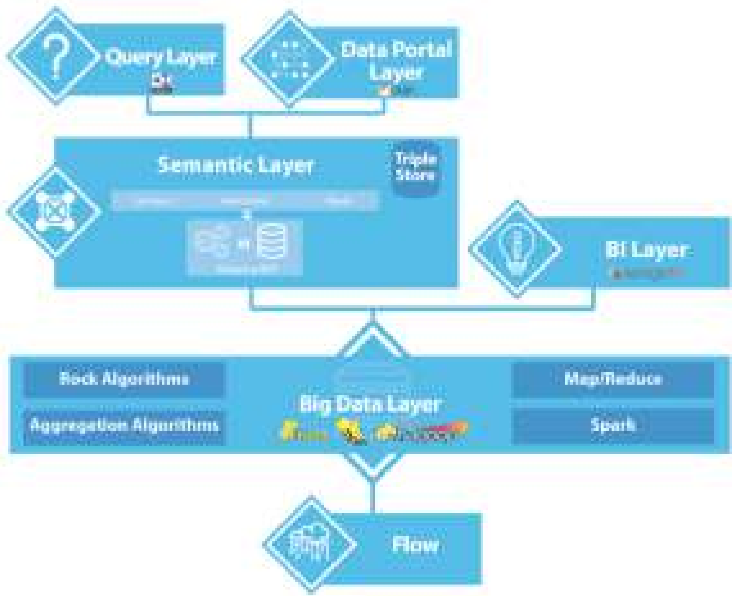

Figure 2: Platform layers.

The Open Data portal layer, based on CKAN, allows the storage and retrieval of data sets. Data are either uploaded directly by ROCK partners and stakeholders, or pulled through APIs (Application Programme Interfaces).

Data are then processed in the Semantic Layer, through a shared vocabulary and a knowledge based designed on existing standard ontologies for CH (e.g. the Getty Institute Art and Architecture Thesaurus, Link Geo Data Ontology, Dbpedia Ontology), tourism and points of interest, smart city sensors (e.g. SSN, Semantic Sensors Network Ontology). The use of semantic metadata allows not only to interoperate between heterogeneous data within the platform itself, but to link of related existing open data on CH.

The Query Layer allows the query of the semantic database using a SPARQL endpoint. Both spatial and classical alphanumeric information can be expressed according to the model. The platform stores exemplary queries to allow the retrieval of data from users who are not familiar with SPARQL syntax. The Big Data layer contains the tools for processing the data provided, and it allows data aggregation, the calculation of KPIs, and the creation of different scenario to test and evaluate urban regeneration actions.

Finally, the Business Intelligence Layer consists in the definition of reports and dashboards (Fig. 3) for the interactive presentation and analytics on the available data from the different implemented tools of the project. The Business Intelligence Layer allows citizens, business players as well as public functionaries to have an immediate access to data, to gain insights on urban trends and create reports for presentation.

5 CONCLUSIONS

ROCK addresses the lack of a comprehensive approach to CH regeneration projects at urban scale, shifting the attention from individual objects, to the city as a multi-dimensional, spatiotemporal continuum produced by institutional and individual actions. The attention to

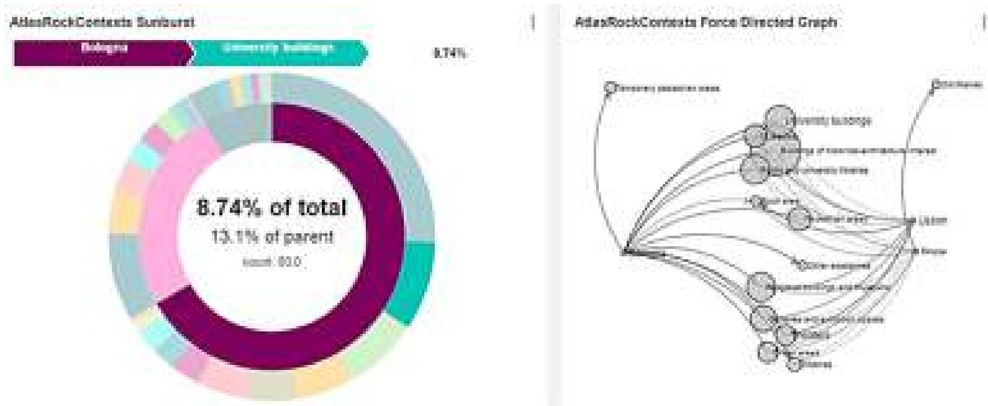

Figure 3: Example from the ROCK interoperable Platform's Business Intelligence Layer's possible visualisations.

heritage both at building and urban scale, allows the adoption of regeneration measures including new technologies, processes, new services and products to create new ways of recognizing, mapping appropriating CH while preventing socio-environmental decay and improving safety perception. The goal is to widen CH access and recognition, through a knowledge-based management to improve citizens' consciousness of CH as a common good that everybody can properly experience and must take care of. The scope is not simply to deliver intervention on the most representative CH elements, but to support and feed the creation of a sense of belonging where citizens become active actors of transformation, expressing their needs, expectations, visions to continue the evolution process within the city.

This is possible only providing a comprehensive and consistent picture of the available resources (material and immaterial ones), of the trends and possible synergies, of the institutional initiatives and network. This is the reason why the platform is so relevant in the project, providing a shared digital environment where all the involved subjects can contribute and at the same time can be informed of the progresses.

This approach requires the development of a common framework for the collection and reflection upon heterogeneous data, as well as the definition of qualitative and quantitative assessment methods to monitor and evaluate the impact of policies and actions in order to address architectural and urban design to inform urban policies. In the case of the ROCK project, this was made through an original use of the Living Lab paradigm, which involved citizens and stakeholders at different levels to co-design not only the actions to be undertaken, but also the tools to evaluate them in the framework of a common actions strategy. The results were necessarily linked to a specific environment and a cultural setting, influenced by local knowledge, languages, issues as well as the specific availability of resources. The use of the semantic approach allows the ROCK platform to be a scalable tool, capable of integrating information from various sources, including other CH-related projects and new applications and services, being the platform accessible from external sources at the same time.

The proposed methodology is highly replicable in very different contexts and at different scales, as the other replicator cities are demonstrating within ROCK project, and it also provided an original conceptual understanding of sustainability, accessibility and collaboration, to engender further researches and design interventions in other contexts.

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CRITICAL APPROACH OF DIGITAL FOOTPRINTS TO STUDY SPATIAL PRACTICES OF URBAN TOURIST AREAS: A CASE STUDY OF INSTAGRAM DATA IN BIARRITZ, FRANCE

MÉLANIE MONDO[1], MATTHIEU NOUCHER[2], GRÉGOIRE LE CAMPION[2],
LUC VACHER[1] & DIDIER VYE[1]
[1]Littoral Environnement et Sociétés (LIENSs), CNRS/La Rochelle University, France
[2]CNRS/Bordeaux Montaigne University, France

ABSTRACT
The rise of digital footprints has created a number of promises and expectations for the study of territorial dynamics, particularly those of tourist cities. These footprints would make the observation of visitors' spatial practices possible and make up for the lack of information on these practices at an urban scale. Thus, many studies use data from social networks to study the touristic space at different geographical scales. These studies provide several types of visualisations based on this data, thus making it possible to represent and show a supposedly new touristic space–time – from the heat map to the dashboard, the digital footprints are displayed as processed, aggregated, calculated and smoothed. All these transformations – resulting from algorithmic black boxes that do not allow a precise understanding of the methodologies (often complex and approximate) – are often not very transparent. Consequently, the technicality and opacity of this data make necessary the development of critical approaches that allow the deconstruction of these new mapping registers. Based on data collected on a widely used social network, Instagram, we wish to question digital footprints as a potential tool to observe tourist practices, by going back through the data genealogy, from the map to the footprint. Our approach consists of going back to the initial data and their associated metadata, in order to explore two fundamental dimensions, conditions pre-requisite for more complex explorations: time and space. Therefore, we collected a corpus of metadata from photographs published on Instagram between 2016 and 2018 in Biarritz, France, which we analyse following these two axes. Through this exploratory study, we will demonstrate that this data, though very rich, presents a certain number of limits, whether in terms of access to the data itself or its spatiotemporal precision.
Keywords: digital footprints, spatial practice, tourist city, critical data studies.

1 INTRODUCTION

In the spring of 2020, in the midst of the Covid-19 pandemic, a debate is raging over the geolocation of mobile phones and their potential role in optimising management of this crisis. Although the technology is by no means new, its application does however lie at the centre of controversy with some seeing it as an essential device for monitoring and controlling the spread of the virus while others denounce a freedom-destroying technology that opens the door to widespread individual surveillance [1]. In fact, an Italian research firm studied lockdown breaches on the basis of Instagram stories [2], in other words, the collections of content on user profiles, put online for a period of 24 hours and normally intended to showcase spontaneous moments, so more or less in real time.

The pandemic has made it possible to highlight the debates but also the promising prospects concerning the use of digital footprints. Their profusion is tending to promote the idea that once gathered, they would be able to meet the need for monitoring of territorial dynamics [3], [4]. In the field of tourism, these footprints would make it possible, in particular, to observe the spatial practices of visitors, so making up for a lack of information, especially within urban spaces [5]. In the context of sustainable cities, this information is

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important as it enables better management of tourist flows, and thus their impact on their direct environment.

Based on this prospect, we wanted to study the effective potential of digital footprints for the study of tourist dynamics in the city and, more especially, the supposed contribution of footprints from social media. On the basis of digital footprints, what can we say about tourist space–time in the city, in other words, the spatial and temporal dynamics associated with tourism in a city?

To answer this question, we suggest looking at basic data before it is mapped. In fact, although occasional entities, digital footprints are regularly represented after being processed, calculated, aggregated and smoothed by multiple geovisualisations including heatmaps and are becoming the new standard. The often complex and sometimes approximate methodologies associated with these mapping processing operations are rarely explained. Consequently, the technicality and the opacity of this data require the development of critical approaches that make it possible to deconstruct these new mapping. Our research is inspired by critical data studies that decipher the challenges of the digital revolution by deconstructing web infrastructures and data [6]. Thus, we propose starting from data collected on Instagram, a social medium that is widely used, particularly in the context of tourism practices, by going back up through the genealogy of the data: maps offering visualisations of social media data with footprints actually submitted by users.

To this end, we are interested in the data as it is left by the users and indexed by the platform: dot maps that locate photos, tags entered by users and metadata associated by the system at the time of online submission. Our objective is to start from these basic features to assess their effective potential in the study of an urban tourist space–time. Firstly, we analyse the challenges and value of the use of digital footprints, particularly those from social media, in order to study two essential dimensions of tourism: time (travel, visitor numbers, etc.) and space (places visited, photographed). In a second step, we detail our methodology associating exploration of data platforms and observations of field practices from the case study of Biarritz, a seaside resort in the southwest of France. The third part presents the results of the data analysis to assess the strengths and limitations of these footprints in order to understand the spatio-temporal dimension of the spatial practices of the tourist space. We will conclude by highlighting the discrepancies between the technological prospects and the actual potential of the available data.

2 DIGITAL FOOTPRINTS FOR THE STUDY OF TOURIST PRACTICES

The profusion of digital footprints has fed into numerous works on the geographic study of tourism practices (Section 2.1). We propose to work within the field of critical data studies in order to examine the actual potential of this type of data in studying the spatial dynamics of the tourist city (Section 2.2).

2.1 Digital footprints, the new "holy grail" of tourism studies?

Digital technology explores the functioning of social sciences in terms of their methods, paradigms and theoretical orientations as well as their purposes [7]. Geography does not escape these transformations, digital technology having become, in the space of a few years, the purpose, subject and means of study. Over the past decade, a great deal of research has focused on the geoweb – the aggregate of space technology and georeferenced information organised and transmitted over the Internet and accessible through the space media – and has concentrated on the development of Volunteered Geographic Information (VGI) [8]. With this expression, Goodchild translates the technical and organisational recompositions that have shaken up the production of geographic data in recent years with the development of the Internet and what he terms “citizen sensors”. The individual is now at the heart of data production through the exponential use of connected objects. Digital footprints have therefore multiplied in recent years and are increasingly used in research in the field of geography [9].

The quantity but, above all, the nature of the geolocated data now available has undergone a profound change, compared to data traditionally obtained from official statistics. In the field of tourism, these unprecedented sources come on top off the numerous field surveys to study tourist numbers, tourist satisfaction or even tallying of admissions at paid sites. The emergence of VGI, particularly from social media like Instagram, Flickr or Twitter, the contents of which are strongly linked to leisure activities, opens up dizzying prospects for the geolocated measurement of tourism practices. In fact, countless statistical footprints are now associated with our digital practices, which are themselves intertwined with our tourist activities: searches run on web browsers to book a hotel, online sharing of our photos or videos, requests on applications to find sites or optimise our trips, online reservations for excursions, online rental of bikes, etc. As Tovar [10] points out: “it is therefore now possible to perceive, measure and quantify the reality of our lives as never before, and most notably the geographic dimension”. Digital communications publicise an increasing part of our leisure practices and so produce masses of decentralised data of unprecedented abundance.

In the context of this study, we have chosen to focus on footprints from social media. Social media data provides access to more spontaneous information than conventional surveys, since the information collected is not dependent on a set of questions that could obscure certain practices. In fact, this “geo-crowdsourcing data” [11] has a volume, a precision and a semantic abundance such that research projects calling on this data are numerous for studying the city and the geographical practices of tourism [5], [12]. It makes it possible to map tourist mobility [13], [14], the spatial practices of tourists [15]–[17], to explore new forms of representation of tourist movements [17]–[20], or even identify attractive places [21]–[23]. It therefore seems possible to use this data to offer an alternative visualisation of the space–time of a tourist city.

2.2 Going beyond the “black box” effect to assess the advantages and limits of digital footprints

Although the heuristic potential of the footprints is effective, the multiplication of geovisualisations making it possible to represent the spatial practices resulting from digital footprints has also given rise to some reservations [24]. To date, critical approaches to big data mainly focused on the methodological biases associated with data processing but also on the social, political and ethical issues of these systems or on the remaining information deficiencies [25]–[27].

In fact, these critics make the observation that the mapping of footprints is rarely accompanied by the raw data on which the analyses are based. The results are often presented in the form of geovisualisation which has a tendency to conceal the basic data. In fact, (geo)visualisation occupies a central place in this research: for Girardin et al. “mapping and visualization are critical first steps to interpreting and explaining digital footprints” [14]. Beaude [28] also emphasises that “the main issue surrounding digital footprints is one of visibility”. Part of the research effort is now focused on making aesthetically pleasing representations, in the form of heatmaps (Fig. 1).

Figure 1: Heatmap of aggregated tweets in real time [43].

These representations show smoothed data, suggesting an impression of continuity of the mapped phenomena. The footprint, which is generally marked spatially in the form of a dot made up of the geographical coordinates of the content disseminated (texts, tags, photos, videos), becomes linear or even zonal, under the effect of these geovisualisations. These maps highlight areas with high visitor numbers or so-called hotspots whose precise definition is rarely discussed. Thanks to digital tools, it has also become easy to create dynamic maps, revealing the trend for the territory according to a temporal parameter. Aggregation, interpolation and extrapolation methods are at the heart of the techniques used here.

Although meticulous and popular, these maps raise questions in terms of research methodology and reproducibility [24]. Indeed, given the lack of transparency of the algorithms, it is difficult to escape a kind of "black box" effect: the processing operations performed on the data when loading on the platform, the increasingly difficult and limited access to the data, the poor documentation concerning this available information are all issues and barriers to take into account.

In order to assess the potential of digital footprints to improve understanding of the space–time of tourism in the city, we therefore propose deploying a critical study of one of these algorithmic black boxes. By drawing inspiration from critical data studies, we seek to move away from "ready-made" technoscientific promises and maps and immerse ourselves in data infrastructures to assess the strengths and limits of these new corpora. By relying, in particular, on the advances of mapping and critical GIS, critical data studies aim to reposition at the centre of scientific debates a renewed critical approach to data, from its collection through to its processing and then its use [29]. By focusing more specifically on the profusion of geovisualisations that arise from big data, they question the methodological biases potentially linked to the processing and spatialisation of data (sometimes summary, incomplete or approximate) and their effects in terms of socio-spatial inequalities or the construction of territorial fantasies.

It is in this spirit that we are conducting this empirical study. By analysing the raw data available within a social medium used by tourism players, we seek to assess its strengths and limitations in order to study the spatial practices of the urban tourist space. To that end, it strikes us as essential to decipher the digital footprint as close as possible to its creation, upstream of the maps which publicise them. The originality of our approach lies in our decision not to limit ourselves to a deconstruction of the finished products (maps and other geovisualisations), but instead to follow the trail back to the sources: the data – photos and tags entered by the user – and metadata – information automatically associated with the data by the system – in order to analyse its effective potential for studying tourist cities.

To do so, we examine the available data according to the two dimensions of time and space. Over time, we seek to question what the data tells us about the temporal variations in the visitor numbers at places. Through geographic information, we seek to question what the data tells us about the visibility of places used, frequented, photographed and shared.

3 STUDYING THE TOURISM SPACE–TIME VIA INSTAGRAM: FROM GEOTAG TO DATA RETRIEVAL

3.1 Instagram: at the heart of tourist practices

Long before the advent of digital technology, it was shown that photography was at the heart of the "tourist gaze" [30]: whether it is that of tourists and their desire to keep a momentum of their trip or to be photographed in attractive places, or that of economic players who want to showcase their territories through the promotion of a tourism "product" [31]. Photography therefore contributes to the profusion of material images in the field of tourism. These images therefore have a high performative value [32], [33] and since "The images are there to make the world peaceful, secure, welcoming and easy to understand" [34], the iconography has aimed to be positive and aesthetic while helping to make places desirable since tourism first began. Facilitated by a growing storage capacity, digitisation contributes to "compulsive photo taking" [32]. Social media allow for easy sharing of holiday images on a large scale. The mass of data posted on photo-sharing platforms makes it possible to capture recurrences in the subjects of these images.

Instagram is a social medium allowing everyone to produce, share and tag photographs, videos and images in large numbers. Created in 2010 and bought by Facebook in 2012, the platform continues to see its number of users grow. On a global scale, the medium has more than one billion active users every month in 2020, including 18 million in France [35]. Praised and criticised in equal measure, Instagram has become essential, especially in the tourism sector. In fact, the site contributes to the high visibility of tourist places [36]. The fact that it is free and user friendly thanks to the smartphone application makes it a tool for an *a priori* instantaneous dissemination of billions of photographs that can potentially be seen by millions of people. In addition, for socio-economic tourism players, the platform is a communication and marketing tool for tourists, whether actual or potential. Although, extremely popular with young people, especially 15–35 year olds, the use of Instagram is not limited to the dissemination of holiday snaps. This diversity of user profiles and associated practices is to be borne in mind in the results that we will present and will require a subsequent study. However, while not all Instagram users are tourists, we start from the assumption that in a seaside city with a strong tourist dimension, many use it to record their spatial practices.

3.2 Biarritz, a seaside city with a strong tourist dimension

Studying digital footprints on Instagram makes it possible to explore their potential for studying the temporal variation of visitor numbers and the visibility of places. To this end, we have decided to focus on the city of Biarritz. Located on the Basque coast in the southwest of France, it has been a centre of seaside tourism since the 19th century and has gained in international influence, largely thanks to the practice of surfing, of which it is the European centre [37].

Large-scale bathing practices induce seasonal visits. According to the official website of the city of Biarritz [38], the census by the INSEE (French national statistics bureau) revealed a winter population of 25,404 inhabitants in 2017 for an estimated summer population of 110,000 inhabitants. Although the city is marked by a strong seasonality, there are certain major events all year round, like an international surfing competition held in May on the city's main beach (Grande Plage).

This makes Biarritz an ideal case study for examining the uneven visibility of tourist places through a social medium such as Instagram. Indeed, the city is organised around emblematic places located around the Grande Plage such as the Casino Barrière, the Grand Hôtel, the Rocher de la Vierge or the Biarritz lighthouse. All of these places thus participate in the tourist imaginary of the city. It will then be interesting to compare the visibility of the places shared on Instagram compared to this fantasy.

We therefore make the assumption that the seasons, the events or the emblematic places constitute the space–time of a tourist city such as Biarritz and so should be visible through Instagram data.

3.3 Return to the source: Instagram data retrieval

In 2020, Instagram allows you to retrieve your own data as a network user. An API (Application Programming Interface) permits access to a data flow proposed by an application or a website. It is a commonly used method for accessing data from web platforms. The closing of APIs to the general public or restricted access thereto is an increasingly common phenomenon in social media, meaning that new methods of data collection need to be found. The proposed API makes it possible either to retrieve your own data, or to retrieve the 20 most recent posts by ten users. In order to conduct a Biarritz-wide study, it was necessary to use a third-party application.

We used a dedicated open-source software program, Instaloader (available on https://instaloader.github.io/), developed with the Python programming language, which allows public posts to be downloaded from Instagram using a keyword (hashtag), a place (geotag) or a profile (user). Data is retrieved in three formats: the post's image (.jpg), the legend (caption) in .txt format, and the post's metadata (.json).

Our data was therefore filtered using the names of geotags associated with Biarritz. On Instagram, this marking is done by the user who names the place in question, without entering geographic coordinates. The place is chosen by the user but can be suggested by the application if the geolocation is activated or according to the user's most recent inputs. Adding a geotag to your post increases its visibility on the platform. The list of geotags used is selected by an algorithm specific to Instagram. Not having access to the selection criteria of the algorithm, it is not possible to affirm that this list groups together all the geotags of Biarritz, nor to be sure of the geographical selection criteria. In addition, we have decided to limit our data collection in time between 2016 and 2018. In fact, in 2016, Instagram scrapped a way of geographically tagging its posts by only offering textual input [39]. In addition, the collection of data from the corpus having taken place in spring 2019, that year is not considered in order to work on full years.

The algorithm proposes a list of 1,000 geotags, reduced to 803 for the period studied. However, these geotags have different spatial granularities: from the Basque Country to the Rocher de la Vierge, passing through the Bayonne–Anglet–Biarritz conurbation or Biarritz.

These geotags may contain input errors. Since our geotags are not associated with precise geographic information, geocoding must be done. For this purpose, we use the tool made available by a French government structure for data sharing (Etalab) to geocode the majority of the database. Finally, the few missing geotags are georeferenced manually.

Our database contains 539,935 posts, including 223,850 geolocated before analysis. The documentation made available by Instagram does not detail all of this data. The description of the variables (Table 1) is the result of our research. Table 1 summarises this reverse engineering that has become essential in the absence of documentation.

Table 1: Metadata associated with Instagram photographs.

Variable name	**Description**	**Example**
Id_geo	Identifier added by us corresponding to the file in which the data was downloaded	Bardumarchede -biarritz.json
Geotag	Name of the geotag associated with the retrieved photograph	Bar du Marché
Node_id	Unique post identifier	1417400626828 247741
Is_video	True/False: this lets you know if the post is a video rather than a still image	False
Shortcode	Shortened post identifier code, appears to be used in the URL	BOrnlxCg4K9
Comments_disabled	True/False regarding the opening of comments on the post	False
Taken_at_timestamp	Timestamp (universal format for sharing date and time) corresponding to the placing on line of the post	1483187343
Video_view_count	Number of video views if it concerns a video	
Thumbnail_resources	Information about the miniature of the photograph	
Owner_id	Unique identifier of the account having posted	444619463
Width/height dimensions	Dimension of the photograph	350 × 350
Edge_liked_by_count	Number of “likes” on the post	231
Edge_media_to_comment_count	Number of comments on the post	4
Edge_media_preview_like_count	No information on the meaning of this indicator	231
Edge_media_to_caption	Caption of the post	#biarritz #croquette #nouvelan

The rapid modification of the data access rules (with the restrictions linked to the closing of the API), and the absence of documentation, make it difficult to use this data and reproduce a research process. The rapid development of the technological choices made by these proprietary platforms is one of the key factors to take into consideration ahead of any research. Nevertheless, the availability of an open source program making it possible to circumvent these obstructions, made it possible to constitute our database. The objective is now to explore them in order to better understand the tourist space–time of Biarritz between 2016 and 2018.

4 QUESTIONING THE SPACE–TIME OF THE TOURIST CITY OF BIARRITZ

We will firstly question the temporal marking of variations in visitor numbers (Section 4.1) before questioning the meaning of geotags and what they tell us about the visibility of places in the tourist city (Section 4.2). We start by recalling the supposed contributions of the digital footprints before opening their black box in order to clarify their interpretation limits but also the new opportunities they seem to offer.

4.1 Examining the temporal variations of visitor numbers in Biarritz from the digital footprints

4.1.1 Supposed contributions

What do the digital footprints tell us about the temporal variation of visitor numbers in Biarritz? Biarritz is a city marked by a strong seasonality and by major events attracting a large population. We therefore make the assumption that these expected peaks in visitor numbers are found in our exploration.

In fact, the abundance of digital data gives rise to hopes of observing a "city 24/7" [40]. Thus, with the digital footprints, it would be possible to have access to the finest temporal coverage in order to see the visitor numbers in the places vary. Instagram makes it possible to share your photographs in real time, at the very moment of taking them. In an urban tourist space, this would permit, by aggregation, visualisation of the temporal variations of the number of tourists visiting the city according to different granularities, namely interannual, seasonal, weekly and daily. It would therefore be possible to visualise the "urban pulsations", "expression of intersecting time frames which make up urban rhythms" [41] allowing the attractiveness of different parts of the city over time to be shown.

By associating temporal information with geotag information, it becomes possible to study temporal variation on two scales: that of the city on the one hand and that of the tourist sites on the other. In doing so, it is possible to distinguish similarities or differences in the number of visits to these places.

4.1.2 Exploring metadata

To study the temporal variations of Biarritz's visitor numbers through Instagram data, ideally access is needed to the temporal information of the photographs taken. This datum can be stored in EXIF (Exchangeable Image File) data, associated with the image. Automatically recorded by the device, they correspond to a set of data relating to each digital photograph and presented in a standardised format. However, for privacy reasons, this data is deleted when the photo is loaded onto the platform and is therefore not accessible when the data is downloaded. However, the metadata associated with each post provides timestamp type information which corresponds to the time of posting [17].

For each of our explorations, we will compare two geographic scales: Biarritz in general (with the whole corpus), and four well-known places in the city, namely the Rocher de la Vierge, symbol of the coastline, the Casino Barrière, emblematic of the city's tourist practice, the Grande Plage, an exceptional site for surfing, and the Biarritz Aquarium, whose visits theoretically depend less on the season and weather.

The exploration of the monthly variation (Fig. 2) confirms the importance of the seasonality of the tourist city with an increase in the number of posts from May to August, which is the expected peak, and its gradual decline through until autumn. The low season appears between January and March. Thus, on the scale of Biarritz, this study seems to validate the hypothesis that the number of posts on Instagram is a reliable indicator of the seasonality of the seaside tourist city. On the scale of the different places, we can see a similar trend but with specificities: the Grande Plage has two peaks: May (World Longboard Surfing Championships) and August. The Casino Barrière, is generally little present on the social medium in comparison with the other sites, has a fairly uniform visibility throughout the year but soars in December, probably due to the Christmas and New Year celebrations. The Aquarium and the Rocher de la Vierge have a visibility curve similar to that of the city with a peak in August.

We conclude this exploration by looking at the daily variations and the hours of posting on the Instagram site (Fig. 3). A general peak occurs in late afternoon around 5–6 p.m. The curve is quite similar for each place studied, even though we were expecting longer lulls at

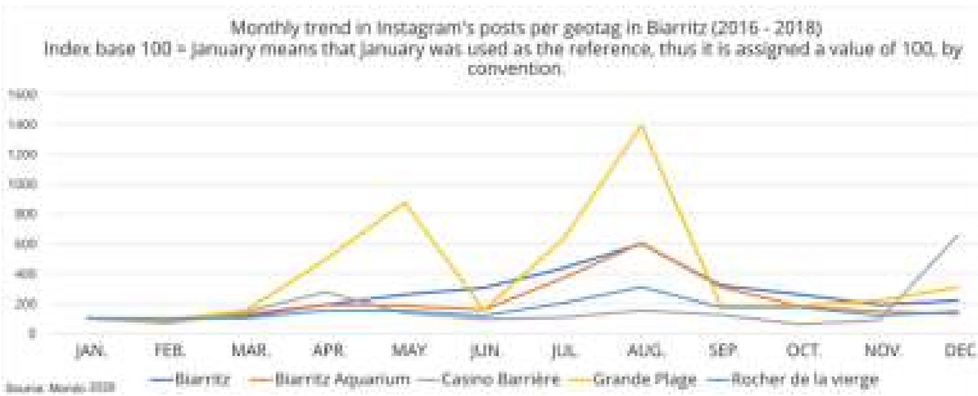

Figure 2: Monthly trend in Instagram's posts per geotag in Biarritz (2016–2018) (index 100 = January). *(Source: Author, 2020.)*

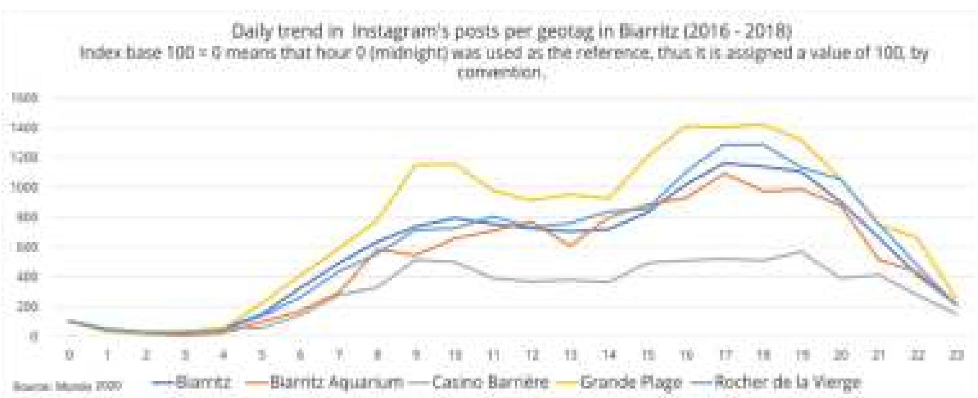

Figure 3: Daily trend in Instagram's posts per geotag in Biarritz (2016–2018) (index 100 = 0 h). *(Source: Author, 2020.)*

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the casino and the aquarium for example, which are not open-air sites and whose access opportunities are therefore restricted to opening times. Thus, the casino closes in the morning from 4 a.m. to 9 a.m., which is absolutely not evident on the curve. The aquarium has a first posting peak from 8 a.m., but there are also many posts made at 10 p.m., despite it being closed. These sites, located in the very centre of Biarritz, near the beaches, are therefore on the circuit of other activities and can be visited and/or photographed on several occasions. The photographs posted can be taken inside the buildings during the visits but also outside and therefore sometimes outside opening hours.

4.1.3 Limits and new research opportunities

Analysis of metadata on a fine time scale reveals a possible lag between the moment when the photograph is taken by the user and the moment when it is posted on the platform. Obviously, the photo may have been posted at the time it was taken, but it may also have been posted at a time when tourists are freer or when they take a break from walking around the city. But the uses can also be more calculated, and it is not uncommon to wait for an auspicious moment, in relation to the target audience, to post an image since the post will have varying degrees of visibility depending on the time of posting.

Some users can also choose to only post their photographs at the end of their stay, as we used to do traditionally with our photo albums. In any case, other than by examining the practices of the users concerned, it is not possible to identify the link between the exact moment the photograph was taken and the moment of its posting. The prospect of demonstrating the daily rhythm of the tourist city through Instagram data thus seems limited since the time studied does not necessarily correspond to the time spent on site.

However, an observation on other time and place scales is interesting since we can highlight the seasonal variations of the tourist city but also the specific characteristics of certain places within this city. The monthly observation also makes it possible to highlight peaks of interest for certain places corresponding to events.

4.2 Observing the visibility of tourist places through digital footprints

4.2.1 Supposed contributions

What does the data tell us about the visibility of places in the tourist city on Instagram? The visibility of a place or a practice feeds into and consolidates the tourist imaginary, yet it is no longer dependent solely on travel guides or institutions but is now fed into by each individual. The development of social media, their instantaneous nature and the fact that everyone can share their photos and opinions online have made it possible to multiply sources and reflect on the definition of the imaginary. By allowing individuals to represent a "place as an understandable tourist destination" [42], the tourist imaginary contributes to the attractiveness of the places.

The footprints left on Instagram must therefore allow us to identify the highlights of this tourist collective imagination of Biarritz: centred on the coast, and its emblematic sites such as the Rocher de la Vierge, the beaches, the Lighthouse or the Casino. These footprints will make it possible to outline, through their aggregation, envelopes of spatial practices of the tourist city. Since the footprints are also the fruit of diverse and varied profiles, we expect to see new places of visibility appear, embodying possible new hubs of attraction in the city.

4.2.2 Exploring metadata

We saw in the previous part that EXIF data was not available among the data retrieved on Instagram. In fact, the geolocation coordinates of where the photo was taken are also unavailable. The geographic tag of the image shared on social media then takes the form of a geotag, in other words, a place declared by the user from a predefined list or through manual entry. The hashtags associated with the images (such as #biarritz, #Pays Basque, #restaurant) can sometimes reveal other geographic information but their automatic detection is more complex.

The study and mapping of geotags in our corpus shows an uneven distribution of posts (Fig. 4). The maximum is 46,880 posts for the "Côte des Basques" geotag, followed by the "Rocher de la Vierge" (11,251) and the "Biarritz lighthouse" (8,830). Thus, there are no surprises when it comes to the most represented places. But we also find unexpected places such as a night club (Duplex Club Biarritz), or restaurants (Etxola Bibi or Le Surfing). Therefore, although we can identify many emblematic places, it is also possible to witness the appearance of other types of places that are more urban and not specifically touristy but that are nonetheless specific to the most common practices on Instagram: restaurants, bars and other places of social interaction. This visibility can largely be explained by the way photographs are shared on Instagram: we tag what is "instagrammable", we photograph what can be tagged and we share what will give the account visibility.

Outside the visible places, whether they are expected or not, we can focus on the white of the map. There are the expected invisible features, outside the centre. These concern neighbourhoods that are *a priori* more residential and less attractive, without any particularly remarkable places. But certain characteristic places are rendered invisible by this map, like the golf course near the Biarritz lighthouse: no footprint emerges from our database, whereas it is an extensive area, visited by many people. This invisibility can be explained by a possible

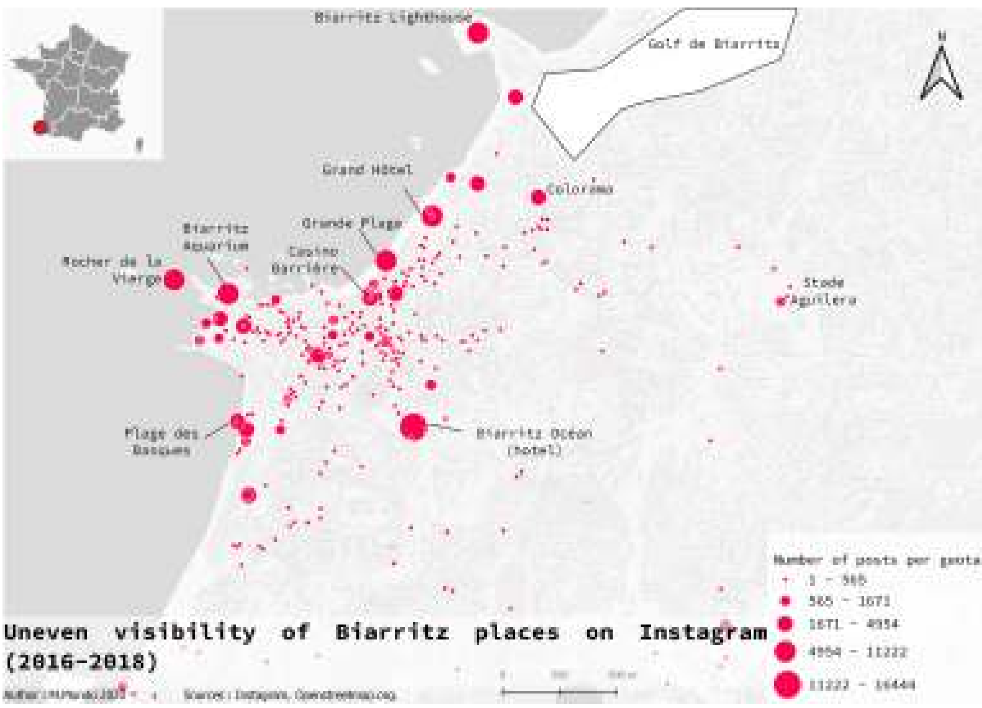

Figure 4: Uneven visibility of Biarritz places on Instagram (2016–2018). *(Source: Author, 2020.)*

divergence between the profile of users of the place and that of Instagram users, or because the Instagram algorithm did not incorporate it into places in Biarritz.

4.2.3 Limits and new research opportunities

Other places have surprising visibility, such as “Biarritz Océan” which stands on the outskirts of the city centre. This example is particularly illustrative of the limits of the automatic geolocation of geotags. Biarritz Océan is a hotel residence, but it is also the name given to the complex comprising the Aquarium and the Cité de l’Océan in Biarritz. However, the Cité de l’Océan museum is barely visible on this map. It is therefore possible that the two geotags with similar names were confused at the time of geocoding. In addition, during a stay in the field in May 2019, we noticed the presence in a disused garage of works of street art that were presented during the annual Colorama festival. We therefore sought to locate it in order to compare its official location in relation to our field exploration, but the two do not correspond. Indeed, certain geotags are linked to events (exhibitions, festival) more than to specific and unique places, all the more so when these events are temporary. Thus, the locations may not correspond from one year to the next and the year and the geotag would have to be made to coincide in order to have more precise information. So, even if the geotag corresponds to the identity of the place photographed, it does not necessarily correspond to its actual location.

The difficultly in distinguishing between frequented, visited and photographed places is also one of the original features of the Instagram approach in that points of interest are located by looking at the object staged, and not by strictly locating the object photographed. Although this limits an initial form of geographic analysis of these places it also allows us to examine the visibility and attractiveness of places differently.

5 CONCLUSION

Coming under critical data studies, this research shows that there is a divergence between the assumed contributions and the actual contributions of the digital footprints, particularly for understanding the space–time of the tourist city. Indeed, retrieving data from social media does not really constitute an alternative to the conventional collection of data to track visitor numbers in the tourist city over time. The data is complex to process and interpret, even if it gives rise to abundant public dissemination in the form of heatmaps that are difficult to interpret and to opaque methodologies. Even by following the trail back to the source of the data, these digital footprints are less calibrated than those collected during specific surveys conducted directly with visitors. They are also less precise than observation in the field, especially when it comes to defining the daily time frames of visitor numbers at places.

However, this divergence offers other perspectives for research into the tourist city. These digital footprints make it possible to highlight unprecedented time frames of tourist practice such as the moments devoted to sharing photographs on social media. In addition, data from Instagram shapes a more complex tourist imaginary by increasing the visibility of more banal or less expected places, whose only recognition comes from social media. Conversely, by default, they allow mapping of parts of the tourist city that do not appear on a social medium dedicated to sharing photographs.

It is however essential to go further in the exploration of this database. To learn more about tourism practices, a categorisation of Instagram users should be proposed, making it possible to distinguish a group of individuals termed “tourists”. By associating the question of the individual with that of time and space, it will then be possible to approach tourism in these three constitutive dimensions and so see how, on the basis of the study of journeys outside everyday space, the tourist city participates in the recreation of individuals.

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SMARTPHONE-BASED SENSING: LIFESTYLE AND MOBILITY DATA INTERPRETATION BY SMART CITIES

LADISLAVA FIALKA SOBKOVÁ, ŠIMON JIRÁČEK & MICHAL ČERTICKÝ
Czech Technical University, Czech Republic

ABSTRACT

The increasing demand for data and smart solutions is one of the fastest growing sectors of human activity. In recent decades smartphones and mobile phones have become a significant and stable source of data. Architects and urban planners have used them in various cases to identify urban patterns. This paper focuses on data gathered by fitness tracker applications which collect information about the movement of their users. The applications record the trajectory of the movement and detect the mode of transport. They require some basic information about the user (age, weight, height and sex) to calculate their caloric consumption. The data from activity tracking smartphone applications create a data lake that can be transformed into a new data source for the designing of healthier and more liveable cities. Combining the data layers and analysing them further could reveal properties and qualities of life in a given location that would not be apparent without processing these data. By analysing the data, we can observe the current state as well as tendencies in human behaviour over longer periods of time. Through the observation and comparison of physical activity in different urban contexts (topography, size of settlement, density of population, density of infrastructure, quality of public spaces, location, etc.), we can develop new alternatives and better knowledge of the influence the above-mentioned factors have on the life in cities. This paper describes data layer combinations that bring novel insights into the connection of physical activity and urban contexts by using data mining technology based on smartphone applications. The theoretical framework can be subsequently applied to various data sets with certain properties.

Keywords: city sensing, data mining, smartphone, physical activity, fitness tracker, strategy, smart city, interpretation.

1 INTRODUCTION

The cities of today are continuously producing large amounts of data [1]. The data can be gained automatically by many different sensors [2], which are a part of the public space and its facilities, or the data can be produced by the users of the city – its inhabitants [3]. 63% of the population in the Czech Republic have a smartphone. Among young people in the age of 16–24 years, the share is 95% [4]. An average user of a smartphone has 80 apps installed on their phone and uses almost 40 of them each month [5].

The movement of people is like the blood circulating in the veins of a city – a better knowledge of their mobility is crucial for various branches of human activities. The habits of the inhabitants of a city and their connection with various influence factors could be revealed also by analysing data gained by smartphone applications. This paper focuses on the data collected and transmitted by lifestyle-monitoring or activity tracking applications.

Currently there is also an increasing number of applications tracking the users' mobility to help in the fight against the Covid-19 pandemic [6], [7], which are based on the users' voluntary consent to share their geolocation data in time. In the Czech Republic, 14.9% of the population share their personal time and geo-tagged data in the Mapy.cz application [8], [9]. This application is a part of the governmental project Smart Quarantine aimed to assess risky contacts with persons who have tested positively for Covid-19 [9], [10].

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2 METHODOLOGY

The goal of the research is the description of different methodologies to use smartphone data. The research comprised three main phases:

- Specification of data sources and data categories;
- A literature review;
- Defining a novel use of the data obtained from fitness applications.

First, we identified the classes of data that users of these fitness and lifestyle applications provide through their smartphones. We used a data set from applications that provide information about the user's caloric expenditure as a basis. Subsequently, we identified alternative types of applications that collect the same data classes but provide users with a different benefit.

A research of English-language scientific literature was performed primarily by searching Web of Science, Google Scholar and ResearchGate. The search was limited to items published between 1975 and June 2020 and the keywords included "smartphone", "fitness", "lifestyle", "physical activity", "walkability", "mobility", "biking", "urban", "city". We searched the results for articles related to the topic of this study. We selected studies that could be repeated or conducted by using smartphone application data.

The bibliographies of the selected articles were examined for further relevant articles. Links found on websites where these articles were published were also searched for pertinent information.

Based on the literature review, thematically specific categories of data use in the urban sphere were created. Furthermore, the necessary input data for these individual categories were determined.

Data from fitness applications can be used also in other ways that have not yet been described in literature or implemented by using conventionally obtained data. A description of these innovative approaches to the data set, their importance and benefits is included in Section 4.

3 STATE OF THE ART

3.1 Data sources

In applications that monitor the user's movement patterns, the user usually has to select the activity manually, or the application uses the acceleration data obtained from a gyroscope and an accelerometer [11]. The application analyses the data gained from these sensors and identifies the type and mode of movement based on the shape of the acceleration curve. Applications with access to the location of the device can obtain more precise data by comparing the movement trajectory in time with the trajectories of public transport in space and time [12]. Geolocation data may be obtained through GPS or network-based location sensing technology, which drains the battery less [13].

Data gathered by the applications can be stored in databases. In each country, the collection, storage and use of such data is regulated by the respective national legislation [14], [15].

3.1.1 Fitness trackers

Fitness tracking applications and pedometers (Google Fit, Endomondo, Moves, MiFit, etc.) are primarily used to obtain information about the user's daily movement pattern, sports performance and calorie consumption. To find out their calorie consumption, the user has to enter certain basic factors influencing their metabolism, i.e. their age, weight, height and sex (see Fig. 1). The application software uses the above-mentioned methods to identify the type of movement (see Fig. 2). It can use geolocation data as additional information. Fitness tracking applications installed on smartphones can be often linked with further wearable devices which provide additional, more precise information on the user's activity, e.g. fitness bands, smartwatches, smart clothing with wearable technologies, etc. [16].

3.1.2 Mobility monitoring applications

Mobility monitoring applications provide the user with feedback on their transport behaviour, i.e. the choice of route and mode of transport. The CO2GO application, developed by MIT, suggested alternative routes and modes of transport in real time to reduce the user's carbon footprint while keeping a similar travel time [17]. UN Carbon Footprint Calculator, Carbon footprint and CO_2 tracker and other applications are based on a similar principle.

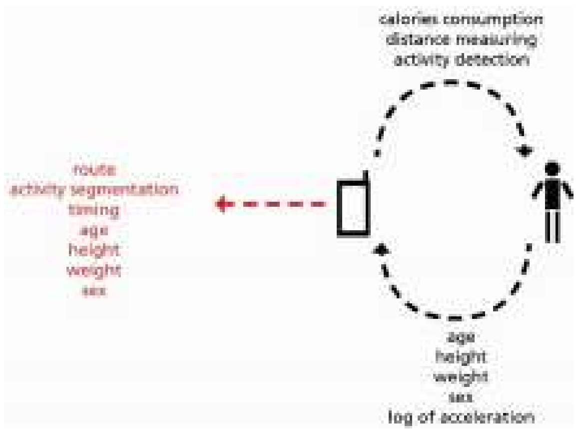

Figure 1: Scheme of the data-flow.

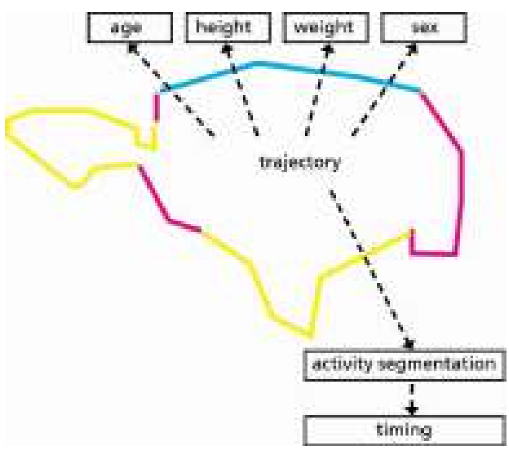

Figure 2: Scheme of the segmentation of trajectory.

3.1.3 Healthcare applications

Tracking and activity monitoring applications are also often used in healthcare, in particular by patients with cardiovascular diseases. In combination with up-to-date information from the patient's wearable monitoring devices, such applications can be used to develop tailor-made motivation programmes for the patient. As the devices monitor the user's pulse and location as well, they can be crucial in providing the patient with quick help in case of health problems [18]. Movement tracking can also increase the safety of patients with neurological diseases (such as Alzheimer's), especially when they become disoriented or get lost [19].

Smartphone apps are also used for the purposes of epidemiological measures, such as the above-mentioned Smart Quarantine project in the Czech Republic [10].

3.2 Data utilization

3.2.1 Tracking tool for urban research

Mobile applications are a new research tool. They can collect data more efficiently and with more precise temporal information than traditional questionnaires. Using a smartphone is a regular daily activity and thus does not disturb the users (respondents) in any way [20]. Smartphones collect data in a passive manner and create low-burden protocols over a long period of time [21]. This advantage has been used for example in a study of urban vitality conditions conducted in Barcelona [22], which utilized the Moves© application to aggregate data on the mode and trajectory of the participants' movement [23]. The data obtained were used to compare the activity of pedestrians in pedestrian activity spaces and in residential buffers.

The INTERACT study monitored the physical activity of its participants in four Canadian cities; the data were aggregated using the Ethica© application which was developed specifically for the purposes of scientific research studies [24]. When designing a study, the researchers can select which activities and sensor-based data will be monitored. The participants can join the study by downloading the application and signing in through a registration link. The data from the participants' application are available for analysis in real time [25]. The INTERACT study aims at collecting a database of 100 TB data which will be made available for analysis also to other research teams [24].

3.2.2 Evaluation of urban interventions

The World Health Organization/Europe has released the Health Economic Assessment Tool (HEAT) which is designed to assess the economic impacts of urban interventions that cause changes in the transport behaviour of people [26]. The HEAT method calculates the economic value of the health effects arising from cycling and walking. It compares the participants' condition before and after the project. Data from smartphone-based fitness trackers and mobility monitoring applications [20] can be used for assessment, if they are obtained from the respective area in sufficient density. However, the input data will have to be adjusted before use to make up for the difference between the actual numbers of persons cycling/walking through the respective area according to traffic surveys and the number of the application users passing through the area.

3.2.3 Property value and walkability correlation

Based on an analysis of public space and the knowledge of how it is used, locations with economic potential can be identified. A subsequent change in the arrangement of the public space and facilitation of the way it is used can have a demonstrable effect on the value of properties in the given area. This qualitative aspect is then demonstrated by a different price in comparison with properties in other similar locations with similar conditions.

In 2019, TC Group examined the relation between rent rates and the intensity of walking movement in a number of streets in European cities [27]. Calculated on the basis of the respective rents, the passing of one pedestrian in front of a commercial unit in the Gran Via street in Madrid cost 3.93 Eurocents, the passing of one pedestrian in the Serrano street cost 10.62 Eurocents, while the average rent was similar in both streets. In the latter case, thus, a shop owner has to pay twice as much for one potential customer to pass along their shop.

A careful choice of the location based on information about the movement in the given street, neighbourhood or whole town can thus optimize the operation costs of a commercial unit. The permeability of traffic in a street can by itself influence the rent rates of premises on the ground floor by 10% to 30% [28]. However, the perspective could be turned around and the available data could be used to point out the potential of individual areas to increase the value of these areas through adequate interventions in their arrangement.

The permeability of public space, i.e. the fluency with which the area can be passed through, is another factor contributing to a difference in the value of a property [29]. Local improvements can be achieved by increasing the number of possible crossings along the most natural route and by adjusting the number and setting of traffic lights to increase the inclusive fluency for pedestrians to the disadvantage of cars. Increasing the walking permeability by 10% can increase the value of a property by 1–9% [30]. Already the definition of a street network is a crucial influence on the economic aspect in question [31].

4 SMART CITY: USING DATA FROM MOBILE APPLICATIONS

Data from smartphone applications can be used as a data source for long-term monitoring of physical activity (PA). In relation to municipal and urban spaces, PA can be monitored and analysed in various contexts.

Every application aggregates and produces only such data that serve the purpose of the given application. Table 1 shows which data are usually collected by the applications listed in 2.1. The overview of categories and groups of collected data provided in Table 1 is arranged to facilitate their interpretation and thus to help understand and improve the living conditions in built-up areas. The proposed analyses aim at expanding our knowledge of urban environments and enabling studies that will serve as a solid basis for the designs created by urban planners and for the decision making of municipalities.

4.1 Walkable distance research

Walkable distance is defined as a referential value or normative value of the greatest distance people are willing to walk from a residential house to facilities providing essential services or to public transport stations [32]. This value should be adjusted in time, as it is influenced by the readiness of the residents to reach their destination without using any other mode of transport than walking. Long-term tendencies can be observed in the PA data obtained from smartphone applications whose users replace the role of respondents in traditional questionnaires.

In terms of walkable distance, various factors can have an influence on the user's decisions about daily mobility. Potential influence factors include:

- Total commuting time;
- Carpooling possibilities;
- Time loss in case of alternative means of transport (bike, walking, public transport);

Table 1: Table of database and data employment.

Usage of the data	Gender	Age	Height	Weight	GPS Coordinates	Mode	Additional information
Walking distance and commuting	**x**	**x**	**x**	**x**	**x**	**x**	
Total commuting time	x	x			x	x	
Possibility of carpooling	x	x			x	x	
Time loss	x	x			x	x	Public transport timetable
Cost reduction	x	x			x	x	Cost of fuel + public transport
Advantage in the field of PA	x	x			x	x	
A comparison of the spatial dependence of BMI	**x**	**x**	**x**	**x**	**x**	**x**	
In different age groups		x	x	x	x	x	
Influence of gender	x		x	x	x	x	
Overview in time	x	x	x	x	x	x	Timeframe
Physical activity (PA) research	**x**	**x**	**x**	**x**	**x**	**x**	
Dependency PA/sex and age	x	x			x	x	
Dependency PA/sex and BMI	x		x	x	x	x	
Dependency PA/age and BMI		x	x	x	x	x	
PA: overview in time	x	x	x	x	x	x	Timeframe
Research of influence of topography at PA	**x**	**x**	**x**	**x**	**x**	**x**	
BMI in different topographies			x	x	x	x	
Biking in different topographies	x	x			x	x	Plan of bicycle paths
Walking in different topographies	x	x			x	x	Plan of pedestrian paths
Research influence of character of settlement at PA	**x**	**x**	**x**	**x**	**x**	**x**	
Influence of density/quality of infrastructure	x	x	x	x	x	x	Plan of infrastructure
Influence of green infrastructure	x	x	x	x	x	x	Plan of green infrastructure
Influence of public transport infrastructure	x	x	x	x	x	x	Plan of public transport
Influence of security landscaping	x	x	x	x	x	x	Plan + report of measures
Research of walkability of public space at PA	**x**	**x**			**x**	**x**	Using Walkability Index influence factors
Economic assessment	**x**	**x**			**x**	**x**	Overcount of the input data
Economic assesment for cycling	x	x			x	x	Using HEAT
Economic assesment for walking	x	x			x	x	Using HEAT
Economic assesment for carbon emissions production	x	x			x	x	Level of air pollution
Property value and walkability correlation					x	x	Cost of property value

- Cost reduction in case of alternative means of transport;
- Increased physical activity required for alternative modes of transport.

4.2 A comparison of the spatial dependence of body mass index (BMI)

BMI is a measure for indicating nutritional status in adults [33]. It is defined as:

$$\mathrm{BMI} = \frac{weight\,[kg]}{height^{2}\,[\mathrm{m}]}. \tag{1}$$

Various studies have proven a connection between neighbourhood supportiveness for physical activity and BMI [34], [35]. There are also case studies that have examined the spatial dependence of BMI in certain localities [36]. We propose to use data from smartphone applications as source data for examining the influence of urban factors on BMI. Previous research has shown multiple interrelationships when examining BMI spatial dependence (social, individual and environmental – which are necessary to distinguish). This paper focuses on environmental factors because they can be influenced by changes in the development of public space, land use and transportation [37]. However, environmental factors can be also linked to gender or age groups which evince a higher rate of BMI relation to locality.

4.3 Physical activity research

The readiness to rely on one's own physical activity (such as cycling or walking) as a means of transport is essential in any city. Cycling has become an integral part of the identity of cities such as Copenhagen and Berlin. The acceptance of physical activity is not permanent, it changes in time: the motion patterns of inhabitants will differ in winter and in summer as well as under exceptional conditions (such as the Covid-19 epidemic or restricted operation of public transport). Regular physical activity does not only affect the individual by contributing to the prevention of diseases of affluence and by supporting mental well-being [38], [39], it also affects the liveliness and the economy of cities. It is therefore in the interest of municipal administrations to regard the physical activity of the users of public spaces as a relevant issue and to use is as a basis when introducing new measures (pedestrianisation, creating a barrier-free environment and installing street furniture in public spaces, promoting the construction of bike paths).

Databases containing the data categories indicated in Table 1 can provide data to examine the influence of sex, age [40] and BMI on ordinary daily physical activity of the population.

4.4 Research on the influence of topography on PA

In connection with the introduction of measures aimed at supporting cycling as a means of transport in Prague, one dissenting and unsubstantiated argument was mentioned in many discussions: Prague's topography (moderately undulating terrain) is not favourable for the development of cycling, the investment in this direction is therefore pointless [41]. However, with the advent of electromobility, this argument is losing ground. Moreover, there have been no studies in culturally comparable cities which would provide real data from different topographies and confirm or refute the aforementioned statement.

Data from smartphone applications listed in 2.1 seem to be a suitable basis to examine the hypothesis that hilly areas have a lower share of bicycle traffic and to establish a relation between cycling and local topography. When analysing such data (same as when analysing the influence of topography on walking), it is necessary to consider the fact that topography is one of the influence factors. Further major influence factors are the density, quality and safety of bike paths in the given area [42], [43].

When assessing the influence of topography on walking and BMI, it is necessary to account for the social and individual aspects mentioned in 3.2. Walking is also linked to other environmental influence factors that are defined in many studies as the area's walkability index [44], [45].

4.5 Research on the influence of the size and character of a settlement on PA

Data from the mobile applications listed in 2.1 can be used to measure the influence of lifestyle on the physical activity in various types of settlements and to verify the results in time. An interesting way of using such data could be to compare the physical activity in times of the Covid-19 pandemic in settlements that are different in size and whose population is currently affected by the virus to a different extent.

The individual settlements can be sorted by the type and character of the buildings (historical vs. industrial buildings), their density, number of inhabitants as well as the quality and density of the services and facilities available, which also includes accessibility and elements of green infrastructure.

4.6 Research on the influence of walkability of public space on PA

The walkability index [44], [45] can be combined with the data from databases including the categories listed in Table 1 to assess a given locality and to examine the relation between the walkability index and the physical activity in the area.

As the data are collected over a long period of time, it is possible to observe and measure the relation between the walkability index and the mobility behaviour of the users of public spaces in the given locality before and after the locality has been adjusted. Observing the relation between the individual variables can be used to update or localise the formulas for the calculation of the walkability index.

4.7 Economic assessment

The HEAT methodology, developed by the World Health Organization/Europe, uses the input data to calculate the economic impact of the health effects caused by a change in the way public and other spaces are used [26]. Where data from traffic surveys are not available or accessible, data from the applications mentioned in 2.1 can be used when recalculated in an appropriate manner to determine an approximate impact of past investments.

The pedestrianisation of streets does not bring benefits only in the field of public health. It is also proven that pedestrianisation of public spaces in city centres also has a positive economic effect [46]. After an examination of the relation between the rent rates and the intensity of the use of public spaces in the given locality, it will be possible to assess the effects of the adjustment of the public space on the income from properties adjacent to the respective public spaces in the given locality. Data from smartphone applications listed in 2.1 can be used to calculate the economic effects of investments in public space from the point of view of the owners of adjacent properties.

5 DISCUSSION

5.1 Data properties

Unlike data from mobile network providers (which, however, lack the precision based on GPS), data obtained from smartphone applications will probably not cover the whole population. Their density, i.e. the number of users in population, depends on how widely spread the given application is among smartphone users. The number of users also changes in time and can be influenced by marketing measures and specific features of the application. Moreover, GPS coverage is not fully guaranteed, as it is weaker for example inside of buildings. Battery draining when GPS is on remains a complication [13], which is why a part of the users turns off this functionality manually and by doing so decreases the precision of movement tracking.

5.2 Data accuracy

Individual applications demonstrate different levels of accuracy. For research purposes, it is ideal to obtain raw data, which are more flexible for use and analysis. When it is not possible to obtain raw data, inaccurate data should be marked or deleted from the data set completely [20].

Smartphone application data represent only a particular segment of the population. Fitness and activity tracking applications are used only by persons who take an active interest in their health and who therefore wish to monitor their daily physical activity. Users of the applications listed in 2.1.2 are concerned about the ecological impact of their own mobility behaviour on the environment. Applications mentioned under 2.1.3 are used by individuals with specific health problems.

Such specific qualities of the users have to be taken into consideration at all times. Based on further research, the data can be calibrated for a specific sample of the population.

5.3 Data utilization

The data utilization has to be adjusted according to how many users have installed the given application. Some applications will probably not provide an adequate sample of the population for all types of research projects (e.g. due to an insufficient number of users in a given locality) [47].

The data can be approached as follows:

- Application users are viewed as passive respondents of a survey.
- The data can be calibrated by expanding them on the total number of inhabitants, e.g. to use them as a replacement for a traffic survey (which, however, can be done only if the density of users in the given locality is high enough).
- Source data for further modelling – the research data set will be created as a result of a model (traffic modelling, agent-based models, activity-based models). In this case, the data can replace traffic survey logs.

5.4 Access to data

Mobile application databases are not a publicly available source of data. Access to such data can be granted by individual application users (only their own data processed by the application are provided) or by the publisher and operator of the given application (data processed by the application as well as raw data are provided).

Access to databases containing private data of the users – where geolocation and health data definitely have to be regarded as private data – is regulated in each country by the respective national legislation. From an ethical point of view, the application users should give their consent to the purpose for which the data are provided and this purpose should be precisely defined by the publisher of the application.

6 CONCLUSION

The paper brings an overview of how data obtained from smartphone fitness applications can be used for urban purposes and shows how the described research methods can be easily repeated or revised in different places, conditions or over a defined period of time. Fitness and activity tracking applications installed on smartphones collect data about the users' mobility and the modes of transport they choose. At the same time, they aggregate information on the users' weight, height, age and gender, which is necessary for the calculation of their calorie consumption. Such data allow us to find answers to questions regarding mobility habits of a large sample of the population without the need to actively address respondents.

Datasets obtained from these applications can be used to conduct research on commuting, walkable distances and the factors influencing them. Moreover, they can be used to compare spatial dependence and BMI and to examine regular daily physical activities in individual groups of the population. They can also serve as a basis for researching the influence of topography and of the settlement characteristics on the daily activities of the inhabitants.

In case of sufficient density of the data, they can be calibrated and used to research the walkability of urban spaces as well as the interrelation of the individual variables of walkability indexes and the physical activity in specific localities. Such adjusted data can also be utilized to assess the economic impacts of regular daily physical activity in urban environments. Research can be conducted also on the basis of data from mobility models. Such models integrate data from mobile applications, which thereby replace traffic survey logs.

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SECTION 9
PLANNING FOR RISK AND NATURAL HAZARDS

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RECONSTRUCTION STRATEGIES FOR SWMM-BASED CAMPUS LANDSCAPE STORMWATER MANAGEMENT

ZEXIN LEI, JUNJIE LUO & LEI CAO
Department of Landscape Architecture, School of Architecture, Tianjin University, China

ABSTRACT
Applying green stormwater infrastructure (GSI) to Tianjin University campus landscaping can not only reduce the negative impact of water runoff, but also improve the landscape environment for students. The campus also faces the risk of flooding, like other parts of the city of Tianjin, China. Different GSI layouts may be able to change the effective impervious area (EIA) without changing the total impervious area. Therefore, a reasonable GSI layout is critical for the efficiency of rainwater and flood management. Taking the Youth Lake area of Tianjin University as our research object, we set three scenarios separately, based on the storm water management model (SWMM), so the EIA area decreases thanks to an optimized GSI layout. Runoff and concentration models of scenarios under different rainstorm return periods were established by combining geographic information system with SWMM. Based on runoff analyses, peak discharge, peak times and the hydrological response of various drainage outlets in the diverse scenarios, we found that runoff can be reduced over 20% by only using GSI of 10 cm depth sunken green space and permeable pavement. If linear measurement of GSI such as a planting ditch, blind pipe and drainage pipe continue to be used to connect the impervious area with surrounding green space, the hydrological response will be further weakened, especially when the linear GSI is not placed parallel to the runoff direction. The same results as found by other studies leads us to conclude that following rainstorm events, upgrading weakens GSI control ability, even though GSI layout optimization was completed. We proved the key optimization strategy for GSI layout is intervention regarding runoff direction. Although campus needs a large concentrated hardened area to meet needs of students' daily activities; selection of GSI suitable for shape and location, especially using linear measures, can reduce EIA, accelerating the runoff attenuation process and reducing the campus flood risk.
Keywords: campus landscape reconstruction, green stormwater infrastructure (GSI), layout optimization, effective impervious area (EIA), hydrological response, storm water management model (SWMM).

1 INTRODUCTION

In China, stormwater management technology is known as "sponge city" construction. Some universities have taken the lead in using green stormwater infrastructure (GSI) to cope with drainage problems and improve the quality of their landscape environment [1]–[5]. By simulating natural hydrological processes, GSI can improve the water permeability and rainwater storage capacity of catchment areas, and increase the attenuation process for rainwater runoff. That is helpful to reduce the discharge and delay the flood peak. The renovation of campus landscapes provides an opportunity for GSI application, which can then provide reference for the development of cities and regions, in terms of making environmental policies [6], [7].

A variety of methods have been used in campus landscape design, guided by stormwater management, including the innovation and installation of new water storage areas [8]; the designing of the green roof, green wall, rain garden and other ecological landscaping [9]; and the selection and application of drought and waterlog-tolerant plants [10]. Those are effective ways to solve campus rainwater issues. The application of GSI to these campus landscapes mainly focuses on the type, quantification, materials and landscape morphology; as they

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directly affect runoff infiltration capacity. Yet application of GSI still lacks more detailed consideration on how to arrange and apply it properly.

Runoff and confluence in part of the impervious areas can result in flooding pressure [11]. But such a problem can be eliminated by improving the connectivity of impervious underlying surfaces, and reducing the number and areas of EIA [12]. In addition, campus landscape design needs to take both functions and ecological protection into consideration [13], to provide a better environment for students. The application of GSI and its optimized layout can improve ecological resilience to a certain extent, while at the same time, solve the rain and flood problems. With the deepening of our research, we need more accurate quantitative models to guide the practice of landscape design [14]. During campus rainwater management, it is necessary to complete a system simulation and special evaluation of rainfall, runoff, site infiltration capacity, water storage capacity [15] and water quality change [4], so that the measure's effect can be predicted. Previous studies show that EIA can explain the green space system layout for urban stormwater control [16]. Besides, the storm water management model (SWMM) is also an excellent model software for urban stormwater layout simulation with Low Impact Development (LID) [17], [18]. Although the dimension of the campus area is relatively smaller than an urban area, it could be more accurate to simulate the details of site drainage and cope with the rain and flood issues purposefully, by combining the Geographic Information System (GIS) with SWMM [19]–[22].

In order to get the GSI layout strategy to improve stormwater management efficiency by controlling the runoff path and reducing EIA, we performed this study. Under the same land use status, three scenarios with EIA reduced in turn were run in SWMM. By comparing the results of the hydrological response, the efficiency of stormwater management in the three scenarios was judged, and the optimization strategy for GSI was obtained.

2 STUDY AREA

The past decades saw the reconstruction of the old campus of Tianjin University. A large number of ponds on the campus were filled in and the ground was hardened. There are only four large ponds left, built into artificial lakes: Jingye Lake, Aiwan Lake, Youyi Lake and Youth Lake, the largest and deepest. The drainage outlets of the first three lakes are connected in series, and this water could finally discharge into Youth Lake. The outlet for Youth Lake is directly connected with the municipal drainage network [10]. In this way, the drainage of campus during flood season is guaranteed.

Along with elevation data, the current drainage network and roads data supported by GIS, the relatively independent and complete catchment area with Youth Lake at the center is delineated as our research area (Fig. 1(a)). This area is located in the north of the campus, having an area of about 21 hectares. The area's green rate is only about 17%, where green space is relatively scattered. The western and northern sections of the area are dormitory areas, while the southeast part is close to the teaching and research area. The whole area is frequently used and crowded. As the main area for student activities, a large area of centralized hard ground is required. Therefore, the Youth Lake area has the largest number of waterlogging spots throughout the campus in the flood season, which urgently need landscape renovation to ensure functionality of the site and improve site drainage.

3 DATA AND METHODS

To accurately obtain the production and concentration zoning of the study area, computer-assisted drafting (CAD) terrain data and rainwater pipe network information of Tianjin University were used as data sources. Through Watered Tool and Thiessen Method in

Figure 1: (a) Plan of Youth Lake area within the old campus of Tianjin University; (b)–(e) Identification of sub-catchments of our study area by GIS.

ArcGIS, combined with building location and elevation data, the water separation effect of buildings on the actual terrain was restored (Fig. 1(b)). Then we simulated runoff and confluence (Fig. 1(c)). Finally, the boundary of the sub-catchment area was modified by green space and water body (Fig. 1(d)), and the whole research area was divided into 59 sub-catchment areas (Fig. 1(e)), with geometric properties added.

3.1 SWMM settings

Based on the site confluence situation found by multiple field explorations in different quarters, combined with the existing underground network data, the GIS data information for the sub-catchment area was imported into SWMM. A generalized model of the whole Youth Lake area was formed, made up of 59 sub-catchment areas, 34 nodes and six rainwater outlets, connected with 34 pipe sections, respectively (Fig. 2). Due to differences between the design flood level of Youth Lake and the ground elevation of the campus, and because the waters can be connected to the municipal pipe network, our model does not consider the existence of rainstorm overflow or backflow of the external pipe network into the lake.

We needed, for SWMM runoff simulation, a large number of input parameters: Most of the parameters used to define the characteristics of the surface and rainwater drainage network can be imported into SWMM in the form of a TXT file from GIS data; other parameters referring to the SWMM model were entered manually from existing research on SWMM modeling in Tianjin city [23], [24]. The Horton formula was used for infiltration calculation and the flow volume was calculated by dynamic wave method.

3.2 Design for rainfall

According to "Tianjin sponge city construction technical guidelines" [25], the Chicago rainstorm type is used in the design of rainstorm type. Considering our campus environment,

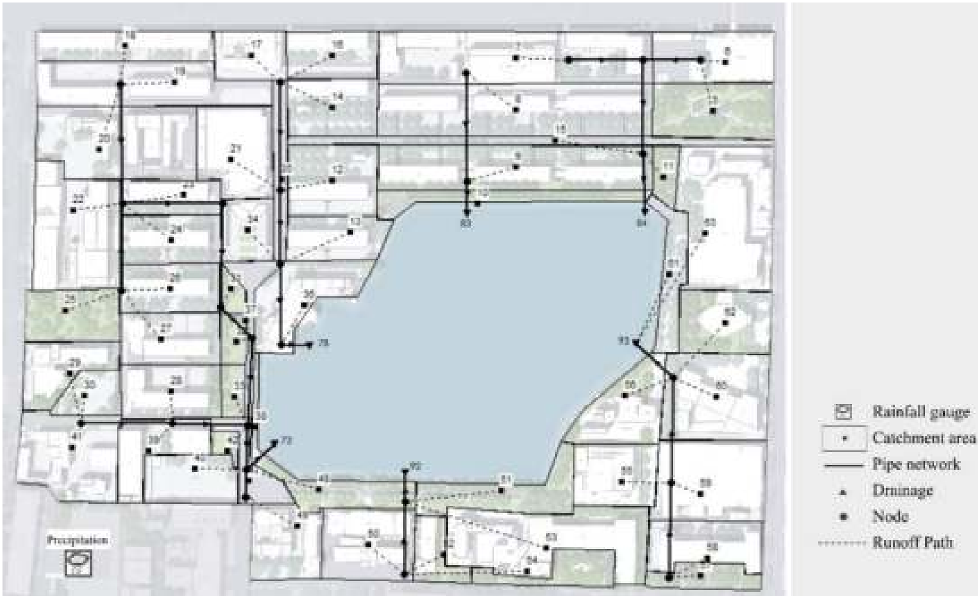

Figure 2: Generalized model of production and concentration in our study area.

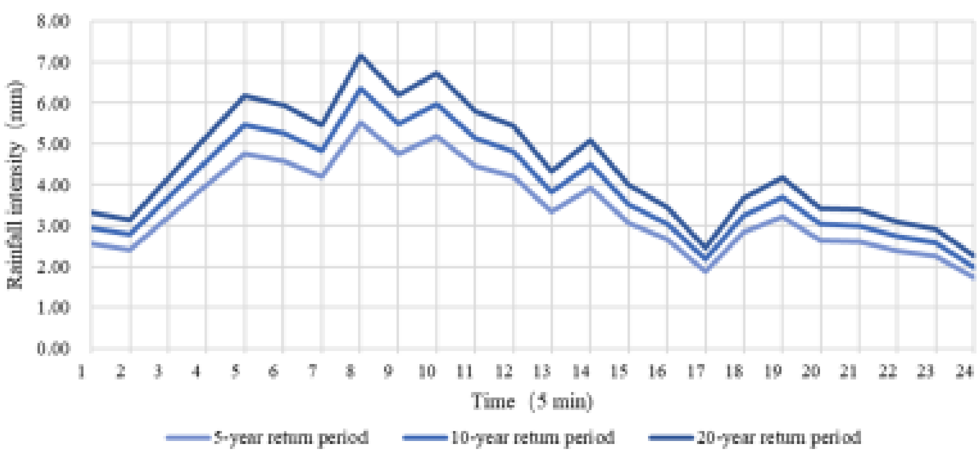

Figure 3: Design of 2-hour rainstorm within different return periods.

especially the living area, requires a higher level of rain and flood safety, so test rainfall was designed as follows: rainfall duration is for two hours and the return periods were 5, 10 and 20 years, respectively. Based on the above input parameters, the design of rainfall patterns with different return periods were obtained (Fig. 3).

3.3 Scenario scheme

The common GSI measures, such as sunken green space, permeable pavement, biological retention facilities and grass planting ditches were selected to design three scenarios of runoff pathways. The current situation of land used in the study area was basically unchanged, to ensure adequate transportation and activity space for students. Situation descriptions:

S1. Current situation (Table 1, S1).

S2. GSI transformation scenario (Table 1, S2).

Adhering to the principle of not affecting the study area's functions, all the green spaces, including the roadside tree pool were changed into sinking green space with a 10 cm depth [26]. Biological retention facilities were added to the main, centralized, green lands. Besides, some centralized hard pavement sites were set up with permeable pavement. Accordingly, we added a LID control unit in the sub-catchment area of our SWMM model, and specific parameters referring to the recommended value in the SWMM model manual. In order to compare with S3, all GSI facilities (including biological detention facilities, tree pools, permeable pavement) in this scenario simulation were not provided with drainage pipes or blind pipes, so the connectivity of impervious areas was not changed. In other words, the GSI transformation in this S2 scenario has reduced the TIA proportion of the study object to a certain extent, but has not effectively reduced the proportion of EIA.

S3. EIA reduction scenarios (Table 1, S3).

On the basis of S2, structures such as planting ditches and blind pipes were added, to ensure that most of runoff from the impervious area can be introduced into the nearby green spaces or permeable areas. EIA is reduced in this way. Corresponding to the SWMM, on the one hand, the routing method was changed from "OUTLET" to "PERVIOUS" and the parameters of underground channels in LID were set. On the other hand, the confluence directions of some parts of the catchment area were adjusted appropriately, and the runoff was drained into adjacent green space, and then discharged into the rainwater pipe network.

Table 1: Summary of statistics of relevant landscape features of our three study scenarios (S1, S2, and S3).

Landscape features	S1	S2	S3
Total impervious area (TIA)	65.32%	55.03%	54.06%
Effective impervious area (EIA)	60.57%	44.88%	32.97%
Green rate (including water body)	33.43%	34.76%	35.73%
Water body	18.07%	18.07%	18.07%
Sunken green space	0	13.26%	13.26%
Biological detention facilities	0	2.39%	2.39%
Grass planting ditch	0	1.13%	1.60%
Permeable pavement	1.25%	10.21%	10.21%

Accurate identification and direct measurement of EIA are complex [12]; however, thanks to the small scale of our study area, the attributes of each sub-catchment area in the SWMM model can be used to calculate the related landscape characteristics statistics of the three design scenarios. Table 1 compared with S1, the TIA of S2 and S3 as basically unchanged, but shows that EIA decreases in turn. And while the overall green space rate remained unchanged, the proportion of GSI increases. This means that the application of GSI did not transform the overall spatial pattern of the study area.

4 RESULTS AND DISCUSSION

4.1 Analysis of simulation results

Based on SWMM, the hydrological response of three scenarios can be comprehensively evaluated from total runoff, total discharge and the change process of discharge at each outlet.

4.1.1 Total runoff in the study area

In the same rainstorm event, the surface runoff characteristics showed that S1 total runoff and outflow were the maximum values of the three scenarios (Table 2). Compared with S1 and S2, it is easy to find that the total runoff reduction exceeded one-fifth when the green space was sunken and the centralized hardened area was replaced by permeable pavement under the premise of basically land use being unchanged. Results of S2 and S3 showed that runoff can be guided by planting ditches, blind pipes, drainage pipes or other linear forms, which can reduce the connection of the impervious area, and the flow can thus be further reduced. With the decrease of EIA, the rainfall and flood pressure of the site will be relieved.

Table 2: Production and exchange flow of different scenarios in different return periods.

	Runoff depth (mm)			Percentage of runoff reduction (%)			Outflow (mm)		
	P = 5	P = 10	P = 20	P = 5	P = 10	P = 20	P = 5	P = 10	P = 20
S1	80.265	92.644	105.04	–	–	–	13.033	15.038	17.051
S2	59.422	70.218	81.029	25.97	24.21	22.86	9.718	11.483	13.216
S3	49.934	61.052	72.658	37.79	34.10	30.83	8.171	10.019	11.921

P = return period in years, S = scenarios same as in Table 1.

In addition, upgrading of rainstorm events weakens the control ability of S2 and S3 as GSI optimal projects. It means the effects of stormwater regulation by GSI or LID is limited by increasing rainfall, which is consistent with existing research results [20], [27].

4.1.2 Total discharge into Youth Lake

As an independent catchment area, runoff flows into Youth Lake directly or through the drainage outlet. Therefore, variation of the flood peak of Youth Lake can directly reflect the total discharge of the area. As seen in Table 3, the greater the rainfall, the higher the peak value and the earlier the peak time, the greater the runoff pressure on the pipeline and the surface; however, GSI can provide more space for runoff infiltration and storage. The reduction of EIA area increases retention time of rainwater in GSI, which is beneficial to reduce rain flood pressure of Youth Lake and reduce the flood risk of dormitory living areas.

Table 3: Drainage and acceptance of lake at different scenarios in different return periods.

	Flow peak (CMS)			Time of flood emergence			Peak duration (min)		
	P = 5	P = 10	P = 20	P = 5	P = 10	P = 20	P = 5	P = 10	P = 20
S1	1.39	2.31	2.56	1 h 35 min	55 min	1 h	–	–	–
S2	1.13	1.62	1.94	1 h 40 min	1 h 5 min	1 h 5 min	5	10	5
S3	1.09	1.43	1.76	1 h 45 min	1 h 15 min	1 h 15 min	10	20	10

Table 3 shows that peak duration reaches the maximum value in the 10-year return period rainfall events, while the duration of 5-year and 20-year return periods are the same. More efforts are needed to explore whether this phenomenon means that there is some nonlinear relationship between the rainstorm and the attenuation rate of storm water storage capacity.

4.1.3 Flow process change at drain

According to the SWMM simulation results, the discharge flow process lines of each drainage outlet (Fig. 4) were plotted, and the change trend could be divided into three situations (S1, S2 and S3):

1. The peak values of S1, S2 and S3 decreased in turn, and the peak current time did not change significantly (Fig. 4(a)).
2. The peak values of S1, S2 and S3 did not change much, but the peak current time moved back obviously (Fig. 4(b)).
3. The peak values of S2 and S3 decreased, but the overall hydrological response of S3 was weaker than S2 (Fig. 4(c)).

The different drainage outlet discharge performances were closely related to the relationship between GSI layout and runoff path. According to the SWMM, there were six sub-drainage zones, and the number of drainage outlets in Fig. 2 represent the drainage zone. The variation of three different flow processes studied can be further explained by sorting out the topological relationship of the neutron catchment area in each drainage area (Fig. 5).

1. There are a large number of fragmented green patches in drainage zones 73, 84 and 93. The site runoff and peak flow can be improved upon by adding GSI facilities. Due to the limited area of green space, proper use of grass planting ditches and blind pipes to connect the impervious areas with green spaces can reduce peak discharge, but has little influence on peak current time.
2. Drainage zones 83 and 92 are adjacent to the north and south bank of Youth Lake. Most EIAs in these two drainage areas are converted into ineffective impervious areas by a series of lakeside greenbelts, perpendicular to the runoff direction. After the runoff enters the belt greenbelt vertically, the volume of greenbelt depression, the vegetation and sandstone soil can regulate rainwater and delay the runoff flow into the drainage outlet, as well as the peak current time. Because all EIA in drainage zone 92 is converted, it reveals a better effect on peak reduction than zone 83.
3. In drainage section 78, the road runs through the entire section. As a typical EIA, the road guides rainwater into the drainage outlet 78, along the site elevation and drainage network. In addition, the green rate in this area is low, and it could be reduced to some extent by adding GSI facilities appropriately along the road direction. But during the process of S3 setting, the rainwater runoff was adjusted, and the surrounding runoff was introduced into both sides of the road green space and downward square. As a result, in the case of a heavy rainstorm, S3 would instead cause more peak flow than S2.

4.2 Layout method of GSI guided by runoff path optimization

In different rainstorm return periods, runoff path simulation and hydrological response results of different scenarios were analyzed from three aspects: total runoff, total discharge and flow process change of six outlets. As the most common GSI measure, sunken green spaces and permeable pavement are very effective in reducing the stormwater pressure of our study site, dominated by impervious areas. The impervious area could be connected with the pervious

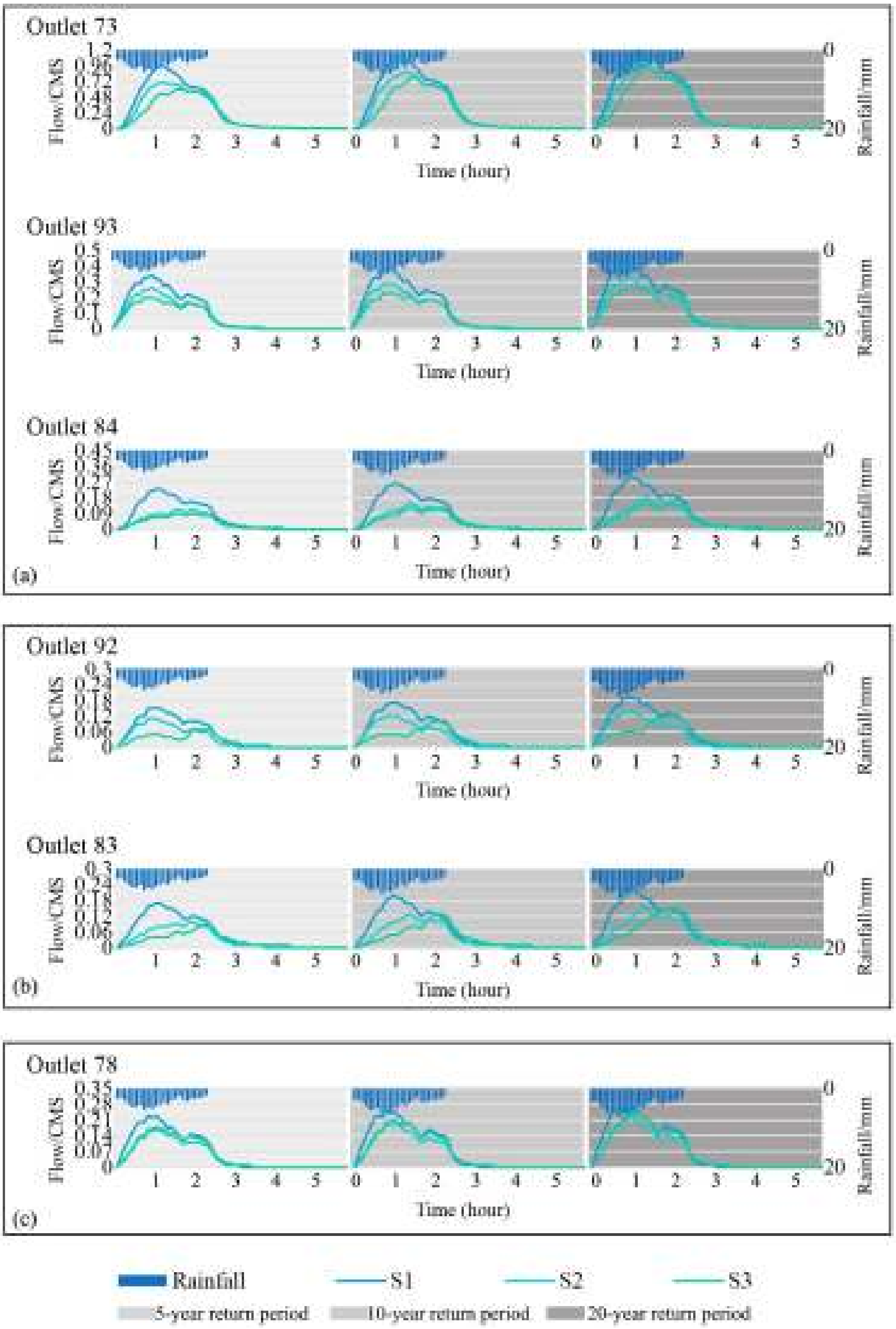

Figure 4: Line charts of discharge change process at drain outlets.

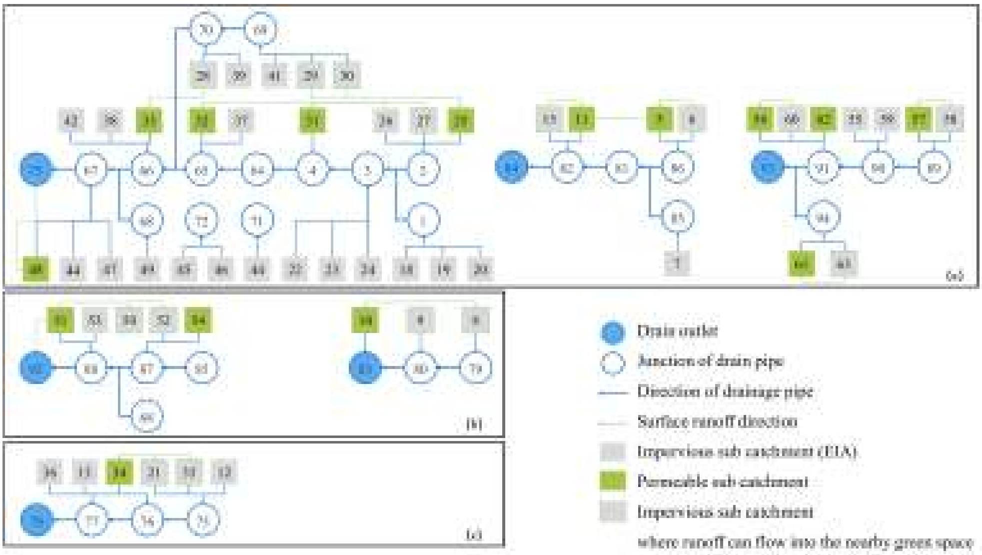

Figure 5: Site drainage area and topological relation of sub catchment area. EIA: effective impervious area.

area by drainage structures such as grass planting ditches, open channels, blind pipes, etc. This method can further reduce the site rainwater pressure in most campus areas; however, for some areas, such as roads, these methods are difficult to have make a positive impact. Therefore, the selection and layout of GSI must consider its relationship to the direction of runoff. For planar and dotted GSI measures such as sunken green lands, biological retention pools, rainwater gardens and seepage wells, their placement can effectively reduce environmental assessment and reduce the rainwater peak, if runoff can be cut off or blocked.

In addition, sufficient GSI measures can provide more flood storage space for the site, which has the obvious effect of delaying peak time; however, linear GSI measures, such as straw ditches and blind pipes, will have different effects on EIA conversion. On the one hand, linear measures can directly connect adjacent areas and improve drainage problems in impervious areas; but on the other hand, linear measures may increase the flood pressure across or at the end of runoff transport. Especially for impermeable linear areas, such as roads with large flow and high flow, barriers with adjacent impermeable areas should be increased to reduce inflow of peripheral runoff. Simply relying on sinking pools on both sides of the road to solve the problem of short-term rainwater accumulation on the road may, on the contrary, bring greater risk of waterlogging to the road, due to the height difference problem.

5 CONCLUSIONS

Most of the student activity areas on campus are hard paved. The traditional hardened site has a big problem with flooding. Also, it is urgent to update the landscape environment, for student use. Reducing EIA through optimizing the GSI layout is an effective measure to ensure rainwater and flood control under the demand of site use. In this paper, by means of multi-scene simulation in SWMM, we analyzed the relationship between the control site runoff path and that of our GSI layout, in a bid to control the EIA area and enhance the efficiency of site rainwater management. At the same time, the combination of GIS and

SWMM provided a method for scientific and quantitative evaluation of the site's hydrological response.

However, we should also recognize some limitations. Firstly, the topographic changes and sub-catchment areas in different campus environment areas are complicated. SWMM parameters with higher accuracy need more future field research. Also, our study uses rainstorm events to simulate site rainstorm and flood, but it fails to consider the sensitivity of GSI under different rainfall conditions. In order to better explore the rainwater response resulting from the reduction of GSI and EIA, we note that groundwater level changes, evaporation and utilization efficiency of the current pipeline network are not included in the simulation process; however, because the rainfall time and pipe network system of the three scenarios were identical, the green area settings have had little change. The validity of the research results can be guaranteed by controlling variables.

This study proposed a green infrastructure layout strategy to optimize the water runoff path and reduce the effective impervious area for the activities space, in the impervious area on campus, to reduce the risk of site flooding. That could help provide some plans for stormwater management in an urban hard activities area with complex functions such as our campus, through the method of model coupling and use of the grey–green combination in future research.

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VISUAL SIMULATION METHOD OF RUNOFF IN LANDSCAPE SPACE BASED ON UAV TILT PHOTOGRAPHY

JUNJIE LUO, ZEXIN LEI & LEI CAO
Department of Landscape Architecture, Tianjin University, China

ABSTRACT

Stormwater management caused by site runoff changes has become the focus of current landscape spatial planning. High precision terrain data is conducive to accurate simulation and scientific analysis of runoff. With the popularity of UAV, UAV has been widely used in landscape space planning. This study takes Fangmazhou Park in Hunan Province of China as an example and uses UAV tilt photography to make centimeter-level high-precision 3D models. Based on the Rhino-Grasshopper platform, the real-time rainfall data and the 3D model of the site are parameterized in order to obtain the real-time runoff simulation data and realize the simulation and analysis of the rainwater flow direction, flow rate and inundation range in landscape space. As the basis of landscape space rainstorm waterlogging risk management, this method provides more accurate and effective analysis for landscape spatial planning and performance evaluation.

Keywords: UAV, tilt photography, 3D live modeling, parameterization, visualization.

1 INTRODUCTION

With the gradual popularization of consumer grade unmanned aerial vehicle (UAV), UAV has been widely used in urban observation [1], power grid inspection [2], agricultural monitoring [3], and other fields. Although UAV related technology has been gradually applied in the design and practice of landscape architecture, most of the application research only stays at the basic aerial photography level, and less applied to the aerial survey with greater potential [4]. Compared with aerial photography, UAV aerial survey is more complex, including the acquisition of spatial data such as digital elevation model (DEM), digital orthophoto model (DOM), digital surface model (DSM) [5]–[7], multi type sensor measurement to obtain plant growth status [8], tilt photogrammetry to obtain 3D scene model, etc. Among them, oblique photography modeling as the current research hotspot of aerial survey [9], research in the field of landscape architecture includes landscape spatial analysis [10], landscape visual experience [11], landscape spatial mapping [12] and so on.

At present, the visualization research of landscape spatial runoff generation and concentration simulation using UAV oblique photography 3D modeling is still in its infancy. Liu Bin et al. carried out large-scale rainfall and flood risk assessment with the submerged depth as the key index through 3D modeling of oblique photography and spatial analysis function of GIS [13]; Wang Wei et al., taking Ziyunyunchuang special town in Nanjing, China as an example, collected the digital terrain of the study area with UAV and carried out hydrological analysis of inundated area with GIS. The relevant research can get the catchment area of the study area, and can be used as the basis for flood prevention landscape design [14]. However, the urban surface hydrological analysis methods based on GIS are mostly suitable for urban scale rainwater collection simulation and calculation, and are not suitable for high precision building scale [15] and small-scale landscape space. In this context, the Rhino-Grasshopper parametric platform with strong expansibility can not only simulate the wind environment and light environment of buildings and landscape space [16], but also carry out visual simulation and analysis of runoff in landscape space by loading

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high-precision 3D real scene model of UAV tilt photogrammetry. The platform can not only break through the limitation of spatial scale, but also simulate the runoff generation situation more vividly, integrate the landscape spatial runoff simulation process more intuitively, and realize the visualization and quantitative analysis of simulation results.

This study takes the visual simulation of rainwater runoff as the breakthrough point, and takes the landscape space of small and medium-sized as the research scope. Taking Fangmazhou Park in Hunan Province of China as a case study, this paper introduces the steps of 3D modeling with geographic information based on UAV tilt photogrammetry technology, and introduces the runoff visualization simulation analysis method of real scene model by using Rhino-Grasshopper parametric platform. This research method can be used as the basis of risk management of rainstorm waterlogging in landscape space, and the simulation results can be used for the optimization design of landscape space, and provide new ideas for the optimization of landscape space layout.

2 RESEARCH AREA AND RESEARCH METHOD

2.1 Research area

The study area is located in the old city group (111°6'27″E, 29°25'24″N) south of Cili County, Zhangjiajie City, Hunan Province, China. It is an important tourist city in the middle and lower reaches of the Yangtze River. With the development of urbanization, the flood disaster in Zhangjiajie is becoming more and more serious. The rainstorm in Zhangjiajie mainly occurs from June to August. Due to the short duration and high intensity of rainstorm, it is easy to cause ponding or runoff in some parts of the city to submerge the low-lying areas and form flood disasters.

The study area is located in Section B of Lishui scenic belt and the intersection of Lishui and loushui, which is an important urban waterfront leisure landscape space. The belt Waterfront Park formed in this section is about 500 m long with a total area of about 5.8 ha. Fitness square, children’s paradise, hydrophilic platform and other leisure activities are designed in the park to show the city’s brand image, highlight the cultural connotation and enrich the leisure and cultural life of citizens (Fig. 1). Because the study area is located at the confluence of rivers, the view is wide, the spatial scale is pleasant, the tourists are concentrated and the use frequency is high, but it is faced with certain rain flood threat and site rainwater management difficulty. There are many similar urban landscape spaces at home and abroad, so this study has a certain universality.

2.2 The method of making oblique photographic model and visual simulation of runoff

2.2.1 3D modeling of UAV oblique photography

Tilt photography 3D modeling is an aerial survey method to solve the 3D real scene model of the object and environment through multiple (usually thousands) continuous photos [17], which is a new data acquisition technology based on visual measurement in recent years. It can not only reflect the texture information of the object and the environment, but also generate the high-precision 3D model with spatial geographic information. Due to the advantages of flexibility, reliability, high precision and low cost, this technology has been widely used in land survey, construction survey, planning and design.

Figure 1: Aerial image of the research area (A is an aerial orthophoto image, B, C, D, and E are aerial images).

Figure 2: 3D modeling results (part). (a) Point cloud data; (b) Tin white model; (c) Tin mesh model; and (d) 3D real scene model.

The Mavic series and Phantom series UAVs developed by DJI Innovation Technology Co., Ltd. provide excellent flight platforms for obtaining geospatial information. In this study, DJI Mavic 2 professional UAV is selected as the data acquisition platform. Its single endurance time is about 30 minutes, and it is equipped with Hasselblad 1 inch CMOS, viewing angle of 77°, equivalent focal length of 28 mm, and effective pixel of 20 million. Because the research area is located in the open river bank, often accompanied by fast wind speed, the ability of this series of UAVs to effectively resist the wind speed of level 6 provides an effective guarantee for aerial survey. UAV can obtain DOM, DEM and DSM data of the research site by aerial mapping, and 3D real scene model can be constructed by oblique photography. The specific method and operation process are as follows:

1. Space aerial surveying. Select cloudy days or sun altitude angles greater than 30° for spatial aerial surveying to reduce the impact of shadows on the aerial model. On the premise that the airworthiness standards are met and flight safety is guaranteed, such as wind speed less than 6 levels, sufficient lighting, low radio interference, etc., the flight altitude is set to 40 m to obtain richer site information at the lowest possible flight altitude. A total of 58 airborne zones are set up in the aerial survey, with an overlap rate of 80%. Because Mavic 2 Pro is equipped with a single-lens camera, the tilt angle of the cloud platform is adjusted to 30° and 90° during aerial surveying, and cross-overlay flight mode is used for image data acquisition to ensure no data omission during the acquisition process, which reduces the impact of consumer-grade UAV single-lens and shorter flight duration. Through 5 batches, a total of 135 minutes and a 17.2 km air survey, 1624 aerial image data with POS data covering 5.8 ha were obtained.
2. Aerial triangulation. Import aerial imagery with POS data into the Context Capture Center Master (Smart3D) software. Elevation data and plane position of encrypted points are obtained by controlling point encryption and professional data operations on aerial imagery. In this process, only some control points need to be set artificially, and the software will automatically complete the aerial triangulation.
3. 3D modeling. After obtaining the aerial triangulation results from the professional data operation of Context Capture Center Master software, the site model is divided into 10 tiles to generate high-density 3D point clouds. The mesh surface is constructed by 3D point cloud, and the texture information is automatically mapped by the image. Finally, the results of 3D realistic model with clear texture are generated (Fig. 2).

4. Model export. The Context Capture Center Master software supports exporting OBJ wavefront format, Collada DAE, ESRI i3s scene database and other data formats. This study chooses OBJ wavefront format data format type to match Rhino-Grasshopper parameterization platform for data processing.

2.2.2 Visual simulation method of runoff

Due to the acceleration of urbanization process in recent years, the flood problem caused by the continuous improvement of urban ground hardness ratio has become increasingly prominent, which has become the research focus of landscape planning and design at home and abroad. Scientific visual simulation and analysis of elevation, slope and runoff of urban public space or landscape space can provide accurate and effective data support for rain flood assessment and optimization. Fluid path simulation algorithms based on runoff path simulation can be divided into particle system method and physical model method. Physical model methods are often used for complex fluid calculations because of their large computation and workload. In contrast, the particle system algorithm defines the volume of the object through the particle primitives, which is less computational and therefore more suitable for wind environment simulation and storm runoff simulation of urban landscape.

In this study, we use the Rhino-Grasshopper platform to establish a landscape spatial runoff simulation model based on particle system method. We simulate and analyze the three-dimensional real scene model built by UAV tilt photography (Fig. 3).

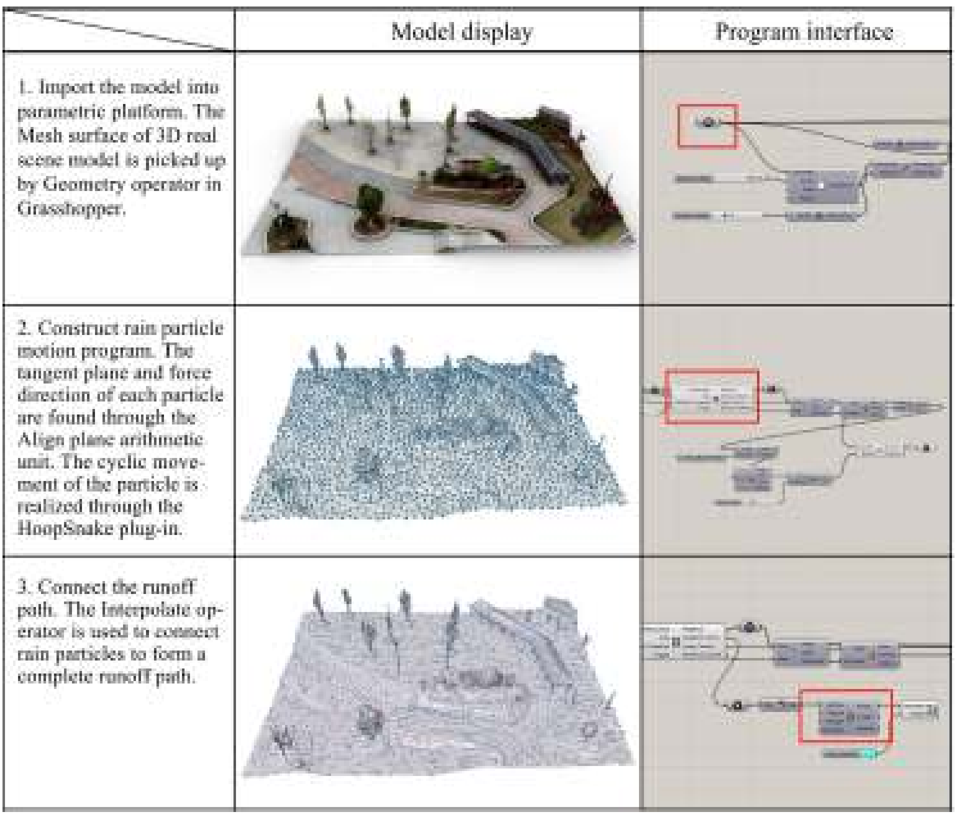

Figure 3: Process and method of visual simulation analysis of runoff.

Its internal logic can be described as follows: simulating the distribution of rainwater features by setting randomly distributed particles on the mesh surface of a three-dimensional real-world model; simulating the flow of rainwater on the surface by the motion path formed by the force state of particles. The particles released on the mesh surface are affected by gravity and surface supporting force. The trajectories change with the direction of resultant force and move to the lowest point of the surface. The continuous trajectory of all particles on the mesh surface is the runoff path of rainwater. The key to realizing simulation with parameterized platform is the accurate acquisition of the real-world model and its effective connection with the simulation program, which is generally divided into the following steps:

1. Import the model into the parameterized platform. First, the mesh model of UAV tilt photography is imported into Rhino in OBJ format, and the mesh surface of the model is picked up by Geometry in Grasshopper.
2. Construct the rainwater particle movement program. Rainwater simulated particles are constructed using operators such as Populate Geometry and Project Point, and the Align plane operator is used to find the facet on which each particle is located. Rotate the section along the Z-axis to find the steepest aspect of the section. The direction of the steepest downhill on the section is the direction of the force on the particle. The HoopSnake plug-in is used to perform the cyclic movement of the particle on the steepest slope of the cut surface.
3. Connect runoff paths. The Interpolate operator is used to connect rainwater particles from the HoopSnake cycle plug-in operation to form a complete runoff path. A color display is used to set the runoff path to blue for subsequent analysis of the overall situation.

3 VISUAL SIMULATION OF RUNOFF IN LANDSCAPE SPACE

3.1 Visual display of terrain

Terrain analysis is the basis of landscape spatial runoff research. The parameterized platform based on Rhino-Grasshopper can visualize and display the results of 3D modeling of oblique photography. According to the terrain elevation data, the overall terrain is determined, and the height difference between the highest and lowest points of the site is visually understood by displaying different elevation colors. The visual display and analysis logic is as follows:

1. Pick up the Mesh model obtained by UAV tilt photography, read the elevation point data on the model, and obtain the coordinates of all elevation points;
2. the elevation values are displayed in order from small to large, showing different elevation values from colder to warmer gradation ribbons.
3. mapping the gradient color band representing different elevation values to the site Mesh model, so as to match the model color and the numerical value.

The terrain of the study site shows the feature that the closer to the river surface, the lower the height (Fig. 4). Based on Grasshopper's logical construction process, the terrain model of the park is imported into the logical process, and the elevation analysis map is generated, and the visual model of the site terrain is established.

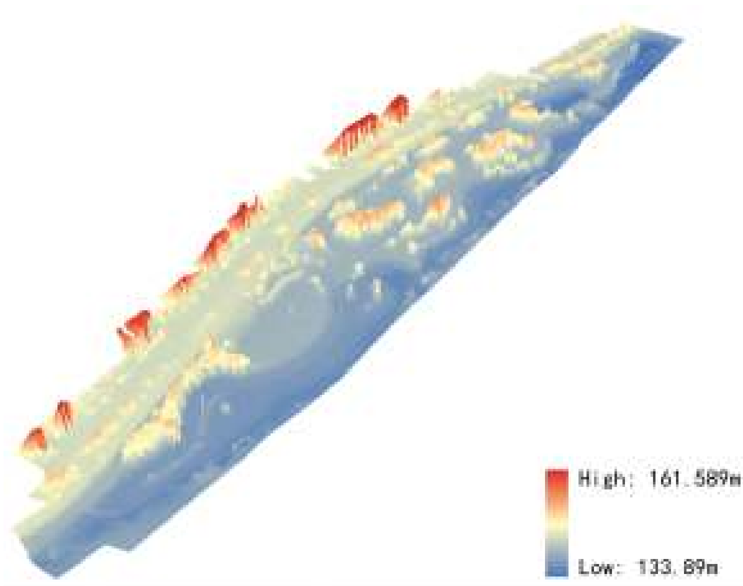

Figure 4: Visual display of terrain.

3.2 Visual display of rainfall

Rainfall is the main source of waterlogging disasters, and rainfall is the main driving variable in risk assessment. Obtaining effective meteorological data, analyzing them and visualizing them are very important for preventing and controlling waterlogging disasters. Conduit plug-in based on Rhino-Grasshopper parameterized platform enables custom data visualization and head up display, as well as real-time association with data acquisition.

This study collects real-time precipitation data from local meteorological websites in Zhangjiajie city, uses Conduit plug-in to associate real-time meteorological data with the model on Rhino-Grasshopper parameterized platform, and displays information such as precipitation every six hours and average monthly precipitation throughout the year in the Rhino display interface as a column chart.

According to Fig. 5, the monthly average precipitation in the study area is normal distribution. The highest monthly rainfall is June, with a value of 230 mm. The minimum month is January, with a value of 30 mm. The precipitation in every six hours shows the single day precipitation in the study area on May 29, 2020, and is simulated in real time through the Rhino-Grasshopper parameterization platform. Compared with the traditional precipitation model, a direct linkage relationship between meteorological data obtained from real-time monitoring and site model is established, which provides accurate data for real-time and actual monitoring of stormwater situation.

3.3 Visual simulation of runoff

Based on the above 3D visualization model of the park, we can use the Rhino-Grasshopper parameterization platform to load the model and associate with the local real-time rainfall data to achieve the visual simulation of the rainwater path in the landscape space. The key to

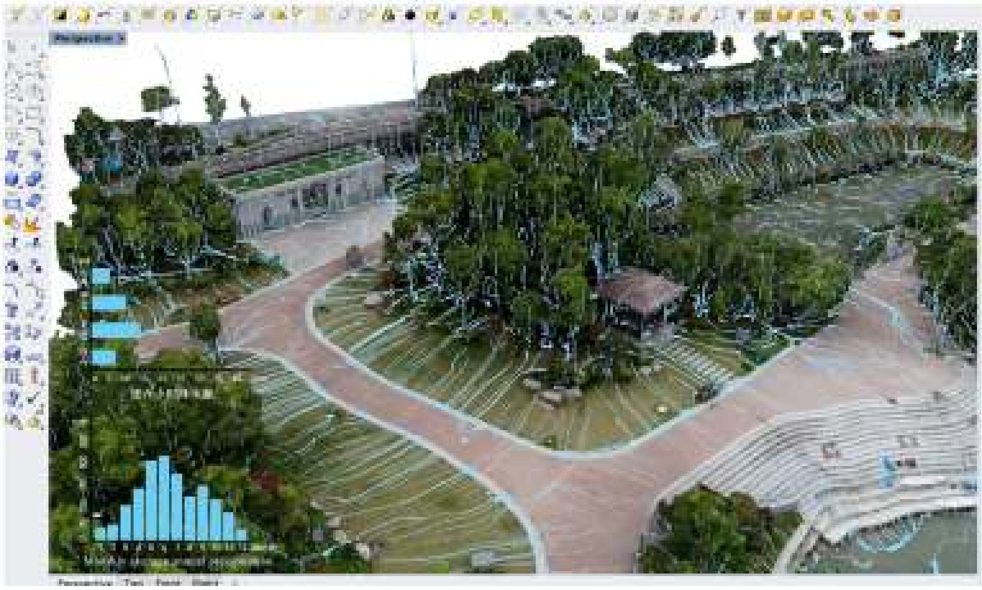

Figure 5: Visual display of rainfall.

the simulation program is to use HoopSnake plug-in to calculate the movement of rainwater particles on the steepest slope of the section. 5000, 10000 and 30000 rain particles were set up on the Mesh terrain surface of the 3D real model respectively, simulating the runoff condition under three different rainfall conditions including light rain, moderate rain and heavy rain. The Amplitude operator in the calculation program can calculate the step length of rain particle movement, which reflects the accuracy of runoff simulation. In this study, the single moving distance of rainwater particles is set to 2 cm and the number of cycles is 200 times. The aim is to achieve the high accuracy of visual simulation of the path by reducing the single moving distance of rainwater particles. Through the connection with real-time meteorological data, we can realize the automatic simulation display and dynamic analysis of the 3D scene model of the site. The high compatibility of Rhino-Grasshopper parameterized platform can realize the cooperation of multi software platforms including GIS. This research divides the catchment area by the hydrological analysis module of Spatial Analysis tool in GIS, and imports the data of sub-catchment area into Rhino-Grasshopper parameterization platform, which can realize seamless switch of visual simulation of rainwater runoff between single catchment area and the overall site model. Through the visual analysis and simulation of the site runoff under three different rainfall conditions of light rain, moderate rain and heavy rain (Fig. 6), the runoff direction and flow data in different areas of the site can be clearly obtained, and the height of the site can be combined with the elevation analysis, so that the location of the flood point can be further obtained.

4 RESULTS AND DISCUSSION

With the rapid development of urbanization in China and the increasing frequency of extreme weather disasters, urban flood problems become more and more serious [18]. Visual simulation and effective analysis of runoff in landscape space mainly consisting of urban

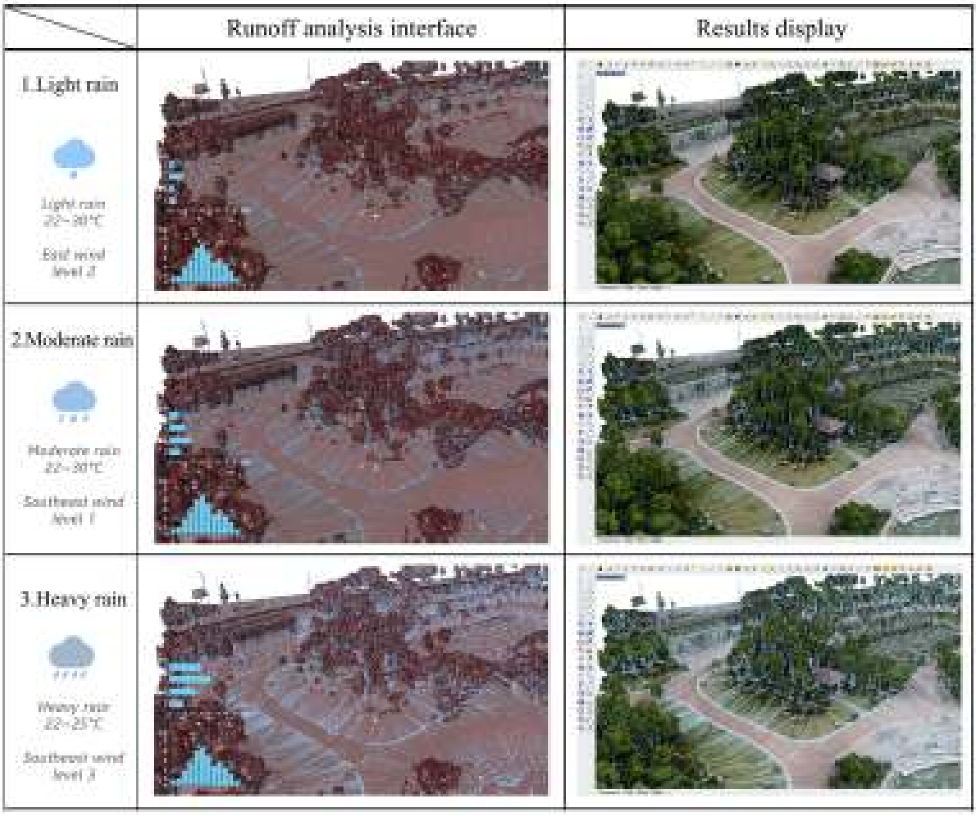

Figure 6: Visual simulation of site runoff under different rainfall conditions.

parks have also become a hot and difficult point in landscape planning and design. UAV tilt photography is a new data acquisition technology which has gradually absorbed the latest achievements in the field of vision measurement [19], It not only can truly reflect the surface morphology, obtain high-precision texture information, but also can generate a real three-dimensional surface model through advanced positioning and modeling technology. In this study, starting from a large number of problems of landscape space runoff which need to be solved urgently in China at present, a centimeter-level high-precision three-dimensional model is made using UAV measurement data, and the motion model of rainwater particles is established by Rhino-Grasshopper parametric platform to realize the visual simulation of landscape space runoff. By linking real-time meteorological data, the 3D model of the scene can be automatically displayed in real time, and the dynamic analysis of flow direction, flow rate and submergence point can be realized. Taking Fangmazhou Park in Zhangjiajie City, Hunan Province as an example, the visual simulation analysis of runoff based on 3D real-world model can intuitively see the runoff in the study area. This method can be used for complex landscape spatial runoff simulation and prediction analysis. As a basis for risk management of rainstorm waterlogging in landscape space, it provides experience for landscape spatial planning and performance evaluation after completion.

As UAV is widely used in landscape architecture planning and design, its high portability and timeliness will help practitioners obtain high-quality digital basic data such as DEM, DOM, DSM and 3D real-world model in the research area efficiently and quickly [20], and get rid of the time-consuming and laborious traditional terrestrial surveying or the low resolution of traditional satellite data. The UAV is equipped with a light tilt photogrammetry system which enables fast multi-angle image acquisition at 30–200 m low altitude in the city. One UAV can collect multi-view images of a city within a few days at several square kilometers. As a cutting-edge design tool and technology, parameterization brings about a change in design methods for landscape architecture planning and design, and also gives more scientific significance [21]. Through the combination of UAV aerial survey data and Rhino-Grasshopper parameterization platform, the centimeter-level super resolution data obtained from UAV aerial survey is applied to the study of terrain analysis, line of sight analysis and runoff analysis, providing more accurate data support for related research. UAV tilt photography 3D modeling, as the newly developed aerial survey technology, provides the technology and basic data support for the transformation of traditional gardens to digital gardens and intelligent gardens through the centimeter-level high-precision 3D model generated by them. It also greatly promotes the development and construction of smart city. With the continuous progress of new infrastructure construction such as 5G network and data center in China [22], and the continuous development of Internet of things and big data analysis, new technologies of digitalization, information and intelligence will surely promote the development of landscape architecture.

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Urban Agriculture and City Sustainability II

Edited by: ***S. MAMBRETTI****, Polytechnic of Milan, Italy and* ***J.L. MIRALLES I GARCIA****, Polytechnic University of Valencia, Spain*

As urban populations continue to increase it is essential to consider ways of reducing their impact in terms of the use of natural resources, waste production and climate change.

The increasing number of people in cities requires new strategies to supply the necessary food with limited provision of land and decreasing resources. This will become more challenging unless innovative solutions for growing and distributing food in urban environments are considered.

The scale of modern food production has created and exacerbated many vulnerabilities and the feeding of cities is now infinitely more complex. As such, the food system cannot be considered secure, ethical or sustainable.

In the last few years, there has been a rapid expansion in initiatives and projects exploring innovative methods and processes for sustainable food production. The majority of these projects are focused on providing alternative models that shift the power back from the global food system to communities and farmers improving social cohesion, health and wellbeing. It is therefore not surprising that more people are looking towards urban farming initiatives as a potential solution.

These initiatives have demonstrated that urban agriculture has the potential to transform our living environment towards ecologically sustainable and healthy cities. Urban agriculture can also contribute to energy, natural resources, land and water savings, ecological diversity and urban management cost reductions.

The impact urban agriculture can have on the shape and form of our cities has never been fully addressed. How cities embed these new approaches and initiatives, as part of new urban developments and a city regeneration strategy is critical.

The 2nd International Conference on Urban Agriculture and City Sustainability addressed these challenges and the search for new solutions. The presented papers which form this volume detail research works looking at how urban agriculture can contribute to achieving sustainable cities.

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