Rapid Cities - Responsive Architectures

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Rapid Cities – Responsive Architectures

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INTRODUCTION

Rapid Cities – Responsive Architectures

This publication is the product of the conference *Rapid Cities – Responsive Architectures. A virtual conference examining design, planning & construction in the modern world*. November 2020, Dubai, United Arab Emirates.

The conference call centered around the rapid nature of today's urban and architectural projects, especially as could be seen within the cities of the Arabian Gulf. From 3D printed villas to rapidly deployed large-scale urban developments and architectures of 'spectacle,' the world of design appears to be changing fast and responding to technology and digital fabrication advancements. This change is not only in the construction methods, but it also finds its way into advances in materials, collaboration tools, development regulations, and sustainability measures, to mention a few. So, are we witnessing the dawn of a new era in design and construction? With the Expo 2020 site at its heart, Dubai appears to be the poster city for these new innovations, and an ideal setting for a conference focused on rapid change. The papers included in these proceedings were reflective of these notions and covered some of these diverse and exciting questions and much more.

This conference was initially planned to coincide with Expo 2020, yet Covid-19 became a global crisis in early 2020 seemingly overnight and managed to bring the world to a near halt. The conference, therefore, shifted from an on-site event to a virtual platform due to travel and safety concerns. The Expo 2020 itself has been delayed for a year, citing similar concerns. Meanwhile, Covid-19 challenged how we view and interact with the built environment and how we move about it. It also demonstrated that innovation in the built environment and its design and construction is somewhat overdue. The need for hospitals, quarantine facilities, urban green spaces, transport options, and all-new office, work, and housing typologies became immediate. A major rethink of our urban environment is currently underway and is much needed. Major emphasis on urban health, sustainability, and resilience are some of the apparent impacts of the pandemic on the built environment. While some of these themes were reflected in the conference papers, a much bigger debate is currently underway globally. There is no doubt, though, that fast-paced, rapidly designed, and deployed architecture(s) are here to stay, and the future of our cities, urban environments, and design disciplines is likely to be different.

Both the conference and the publication were organized by the research organization AMPS, the academic journal *Architecture_MPS,* and the Department of Architecture at the American University in Dubai.

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LOCALLY-BASED SUSTAINABLE DESIGN APPROACHES FOR WALKABILITY IN DUBAI

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INTRODUCTION

Since the discovery of oil in 1966 and its subsequent financial revenues, Dubai has been developing rapidly into a global city – while mainly adapting a western urban development style. Suburban growth exploded, with urban sprawl becoming an issue since the early 1980s. Local towns spread out and expanded in scale. Consequently, Dubai could be called 'Cities within a city,' representing many fragmented suburban communities connected by automobiles. People often attribute problems with walkability or the limited pedestrian-oriented activities to the harsh weather. Still, severe weather in Dubai lasts roughly four months out of the year, causing people to avoid the outdoors during that period. Nevertheless, the somewhat limited walkability continues throughout the year, even in the nicer weather. Then what is the leading cause of this phenomenon?

This paper argues that this limited walkability is not due to weather but due to the urban structure caused by mega-developments in Dubai, which do not consider human scale or local culture. For instance, old districts such as Satwa or Karama have a more compact scale; therefore, pedestrian activities occur naturally. Aggressive adaptation of western-style urbanization completely goes against locally-adapted sustainable design approaches that ancestors have fostered in the city. The narrow alleys (Sikkeek) and the past courtyard houses have been replaced by driveways and fenced-gardens. These drastically changed the structure of communities, therefore, impacting walkability.

This issue is a common theme discussed in the thesis courses and sustainability design studios, which I teach at the university. The paper will demonstrate potential design solutions for walkability and enhancing outdoor public space usage within existing urban areas.

DUBAI ORIGINS

Early Beginnings

History indicates that Bani-Yas Tribe moved from today's Abu Dhabi to an area known as Dubai in the early 19 century and officially established the Emirate of Dubai. The settlement started at the Creekside, where now Al Fahidi district, which the next section will explore, is located. Initially, it was a simple fisherman village and flourished later due to the pearl industry. In this era, the houses stood each other densely, composed of an organic compound in limited areas, and were vernacular in style and made of local materials. However, the pearl industry declined by the world recession and cultured pearl invented in Japan. The oil era began with the discovery of oil in 1958 in Abu Dhabi, to be followed by 1966 in

Dubai. The United Arab Emirates established in 1971, and hereafter, the world-rapidest urban modernization was started by the visionary leaders of the United Arab Emirates.

Al Fahidi District– The Original Local Sustainability

Since the traditional courtyard houses were arranged close to each other, Al Fahidi, now a historical conservation district, created an organic pattern with narrow shaded alleyways [1]. Sikka or Sikkeek means alleyways in the Emirati dialect. In the past, the paths' organic or irregular patterns (Figure 1) helped confuse outsiders and protect residents or keep their privacy. The Sikka worked as not only circulation. The network's irregularity created some spots that became semi-public spaces, such as kids' play areas who live nearby or outdoor seating areas for chatting. The streets allow for sociability and spontaneous encounters. The Sikka was the epitome of circulation and semi-public life.

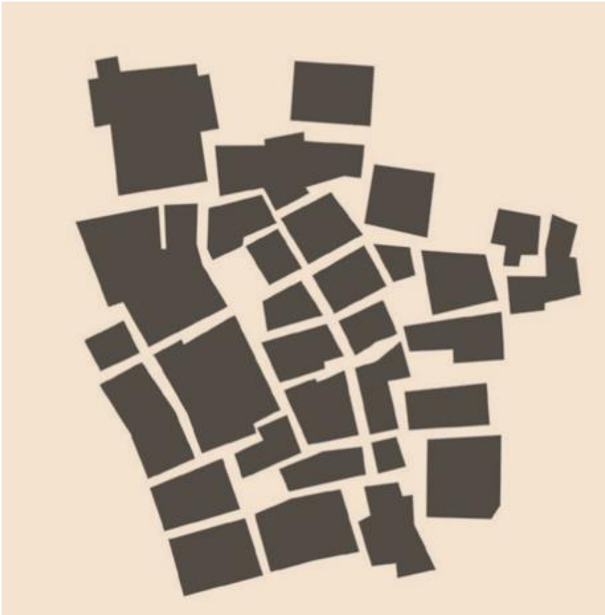

Figure 1. Al Fahidi Neighborhood Typology (Source: AUD Architecture)

The alleyways' narrowness causes the prevailing wind from the Creekside to increase in velocity as it breezes through and creates a comfortable climate for pedestrians[2]. Figure (2) is a digital airflow simulation in the Al Fahidi district conducted by an architecture student of the American University in Dubai. It clearly shows how breezes are well distributed to the alleyways.

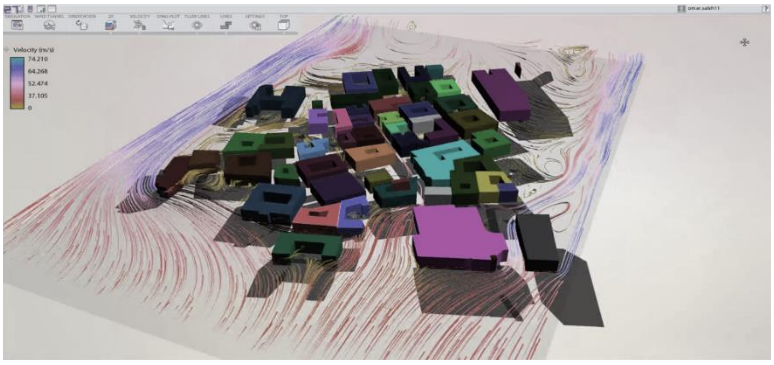

Figure 2. Digital Airflow Simulation of Al Fahidi (Source: AUD Architecture)

DUBAI GROWTH

Alawadi[3] (2018) analyzed the stages of development within the city of Dubai and identified six distinct phases: (Figure 2)

- Phase 1 (1900-1955): The city's physical expansion was limited. Dense, organic, and vernacular homes have adapted to the country's harsh climate.
- Phase 2 (1955-1970): The government started instituting housing programs for the citizens. Vernacular forms still dominated its dense, united arrangements.
- Phase 3 (1970-1990): With the benefit of oil money, planned suburban growth has begun with a preference of sprawl over density.
- Phase 4 (1996-2007): The formation of a global center focused on tourism. High-end residential compounds for ex-pats emerged in the city. Speed and efficiency of construction were set as a priority. Suburban sprawl continued to increase.
- Phase 5 (2008-2013): The economic crisis hit the city's developments. However, local housing did not have any significant transformation.
- Phase 6 (2014-present): Developments resumed. Suburbanization continued while local housing made a 20% increase in land size. Fragmented and low-density neighborhoods with dispersed and homogeneous forms continue to dominate the city

Each phase has affected Dubai's urban form and residential landscape, separating the local and expatriates housing. As a result, Dubai's residential landscape can be characterized into two major categories: compact traditional neighborhoods and newer suburban modern ones represented by mega-developments on a massive scale[4]. Figure 3 illustrates the apparent contrast of the size and scale between old local housings and new modern skyscrapers.

Figure 2. Six phases (Source: Alawadi, 2018)

Figure 3. The contrast between old and new(Source: Alawadi, 2018)

'Injecting' Western Modernity

Before Dubai's modern 'boom,' "traditional houses were modest, identical and low-cost," characterized by high density, connectivity, and dynamic pedestrian networks that evolved with the changing needs of the residing communities. As Dubai grew, automobiles, changes in zoning ordinances, and planning codes took part in forming new 'modern' blueprints for the city and what scholars call "detached leapfrog development."[5] Dubai followed Western models of spatial organization, specifically from North America. It formed a new urban grid system of large plot sizes, fewer connecting streets, and vehicle-dependent accessibility[6]. Figure 4 shows how the neighborhoods' density and scale have transitioned from the 1960s to the present.

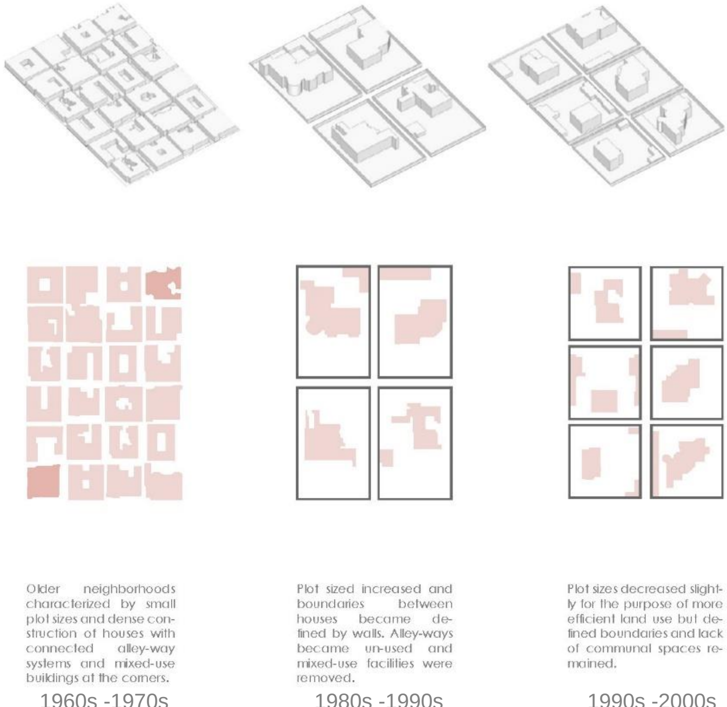

Figure 4. The transition of density and scale of neighborhoods (Source: Alawadi, 2118)

Dubai's development and emergence took a path of modernization and globalization as the city's economic and business status elevated. Like other Middle Eastern cities, in Dubai's growth, citizens perceived vernacular and traditional architecture that symbolized the original cultural and economic patterns inferior to technologically-advanced new space and design[7]. In an article titled "National Housing," X-Architects argued that traditional communities that valued compact community-centric ideas were replaced with Westernized visions that neglected the context and collective needs of the existing residents[8]. Figure 5 compares a compact historical compound, consisting of courtyard houses surrounded by an organic alleyway network, with Western-style garden houses enclosed with high concrete walls.

This transformation can be summarized as follows: Historical regional housing typologies were defined by the need for passive protection from the climate and the balance between privacy and neighbor interaction. Accordingly, just small windows punctured the thick external walls outward, whereas indoor spaces were open inward to courtyards. On the other hand, typical Western housing typologies are generally represented by a stand-alone house structure surrounded by a garden. Big windows are open outward toward the garden to enjoy the view and allow enough sunlight, but it needs fences around the garden to protect residents. Here, the relation between the indoor and outdoor, or in other words, the mass and void, are entirely inverted (Figure 6). The rapid implementation of Western housing typologies into existing regional land allocation patterns 'orphaned' the configuration of alleyways. The ones seen today are "side-alleyways," which are usually only in between compound walls and at the edges of buildings with few pedestrian activities. The original function of the alleyways as a communal *Sikka* has lost.

Moreover, in Western countries, fences are generally low and made of steel bars, and neighbors can still talk to each other through them, as often seen in American movies or dramas. However, the high priority for privacy in this region converted such fences into tall, concrete walls.[9] Now they renounced connection with neighbors entirely.

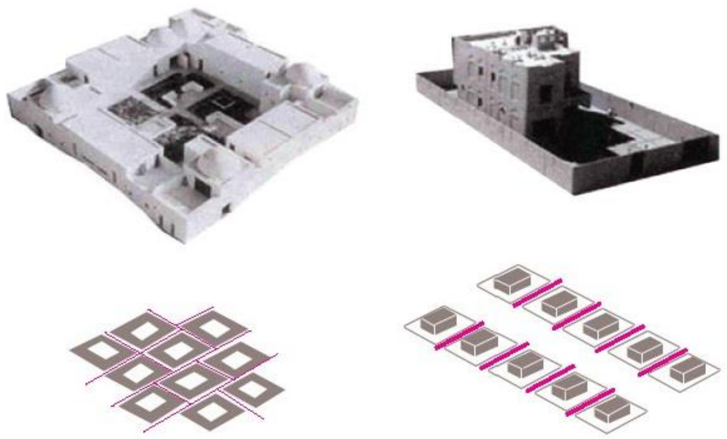

Figure 5. Courtyard house vs. Garden house (Source: X-Architects)

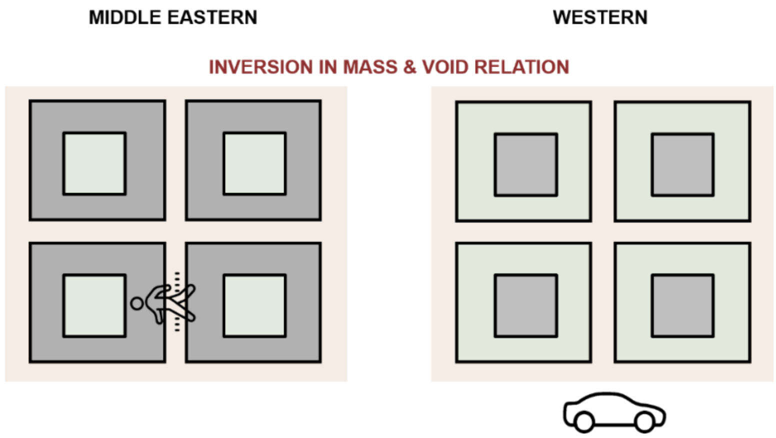

Figure 6. Inversion in mass & void relation (Source: Author)

HEALTHY CITY PLANNING

The urban transformation, from dense communities networked by walkable alleys into Westernized suburban mega communities only accessible by automobile, seems to be contributing to the issues related to public health in Dubai. In 2019, Gulf News, the major newspaper in the UAE, reported on a startling study which indicated that study which found that the majority of Emirati men under 30 are suffering from obesity, diabetes, and other lifestyle conditions[10] the study surveyed 33,000 male Emiratis between the age of 18 and 20.

The health issues appear to be impacting children as well. According to Khaleej Times, "the prevalence of obesity in GCC among children and adolescents ranges from five percent to 14 percent in males and three percent to 18 percent in females[11]. In the UAE, schoolchildren/youth are said to be 1.8 times more obese when compared with international standards." In the same article, Dr. Anjama Kannoth, a pediatrics doctor, identified a number of causes for this phenomenon. It included eating outside the home, television and computer viewing for long hours, eating while watching television, exposure to food advertising, extra snacking, and the lack of physical activity.

Global influences have also influenced the dietary lifestyle of people in Dubai drastically. The UAE's market value of burger fast food restaurants grew from $359 million in 2010 to $646 million in 2015[12]. There is no doubt that the dominant factor of obesity and diabetes is the fast-food couch-potato lifestyle. In parallel, suburbanization influencing Dubai's urban form has increased reliance on automobiles, at a disadvantage for pedestrians. Consequently, people who live in suburban communities provided and mega-developments were naturally limited in their ability to walk around the city. Vehicular reliant road load layouts have nurtured an absence of connection and created barriers for walking, even to the closest of destinations. The neglect of human-scale and pedestrian networks in recent developments has led Dubai to be one of the least walkable cities globally and caused a lack of physical activity among residents. As a result, it is quite normal in Dubai to see people who are unsafely jaywalking across wide roads. How would the government sustainably tackle this walkability issue?

SUSTAINABLE STRATEGIES TODAY

Governmental Visions, Regulations, and Preparations

Dubai has won the bid to host Expo 2020 in 2013 as the first Middle Eastern nation in history. And the Expo 2020 Dubai team has announced Opportunity, Mobility, and Sustainability as three pillars of the Expo[13]. It seems the government has diligently started reconfiguring Dubai into a more sustainable city since sustainability the main theme of Expo 2020.

In 2016, the Dubai Municipality published a booklet titled *Sustainable Dubai – The Dubai Municipality Report 2016.* Senior government sector key-figures presented their visions about sustainability - for example, increasing greenery in the city. In the same year, the government announced Dubai's own green buildings evaluation system named *Al Sa'Fat* – the mandatory energy-efficiency guidelines and rankings applicable to all new buildings[14].

The Road and Transportation Authority (RTA) and the vehicle hire company Careem announced bike-sharing services, enabling the hire of bicycles through smartphones. Careem will operate a total of 3,500 bikes across 350 smart docking stations in Dubai[15]. RTA has constructed cycling tracks extending 274 km. According to RTA, this bike-centered infrastructure helps people pursue an active lifestyle and provides them with mobility options. Pedestrian walkways and jogging tracks have been laid, for instance, along the Jumeirah beach to enhance people's walkability. However, the walkway and track are mostly exposed directly under the sunlight. The provided shading devices with seating areas cannot protect people's activities from the harsh sun rays in the hotter times of the year. Unfortunately, the focus on sustainability still seems like a diplomatic and rhetorical commitment to the world.

Imported Walkability Concepts

MERAAS, a major developer in Dubai, has completed many projects attempting to stimulate pedestrians' activity and walkability. The City Walk is one example that succeeded in attracting many people with cutting-edge modern designs -composed of pedestrian-oriented walkways covered with shading nets and lights. However, the ratio of the shade provided by them seems not that high. Boxpark is another development, but it seems the users do not stay in the area for a long-time. The concept of Boxpark is originally from London, UK, and MERAAS imported it to Dubai. The critical difference between the one in London and Dubai is connectivity to public transportation. For instance, Boxpark Shoreditch and Croydon juxtapose a metro station, integrating the new development to London's existing urban fabric.On the other hand, Boxpark Dubai is laid along the residential area on Al Wasl Street in the length ofone km without any connection to the metro station or other landmarks. (Figure 7). Regardless of the central concept of Boxpark to activate street life, the one in Dubai is wholly isolated from urban transportation. Consequently, it did not generate many pedestrian activities. Instead, it let people come by car to the destination shop, park, drop into the shop, and leave by car—in this automobile society; who walks for 1 km if they should come back to their parked vehicles, especially in scorching Summer? (Figure 8).

Figure 7. Boxpark site map (Source: Google Earth, edited by author)

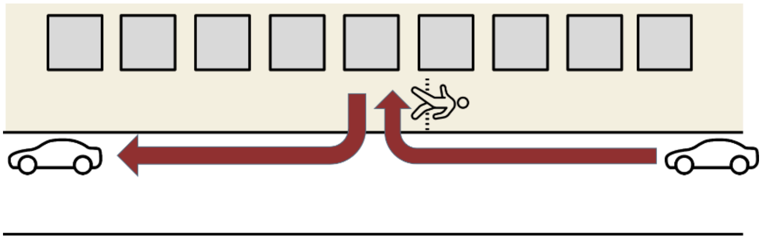

Figure 8. Walkability Diagram: Boxpark (Source: Author)

LOCALLY-BASED SUSTAINABLE DESIGN: A LOCAL CASE STUDY

In 2012, an Emirati client requested me to redesign an unused old facility building. The building was located in Safa park and was developed originally in 1975. The idea was to convert this old structure into a new café. The design aimed to fuse the traditional Arabic elements, such as the structural arches, with minimalistic black interiors and floor-to-ceiling to give it a slick, contemporary feel. Generally, public parks in Dubai are paid facilities enclosed with fences limiting access, whereas commercial activities such as shops are prohibited by law except for kiosks. These restrictions seem to discourage people's visits to the parks compared to the ones in other countries. However, this book café was exceptionally allowed to manage a café restaurant by negotiating with the authorities. As a result, this project gained enormous popularity among people and created a crowd around the building (Figure 9). It also derived seasonal or temporary events such as the Friday open markets. Visitors have to park cars around the park and walk from there to the building located in the center of the park. The project managed to promote walkability rather than door-to-door access by vehicles. The remote destination in the large park unexpectedly and spontaneously provoked people to walk by forcing them to leave their cars (Figure 10).

Figure 9. Crowd around The Archive (Source: Author)

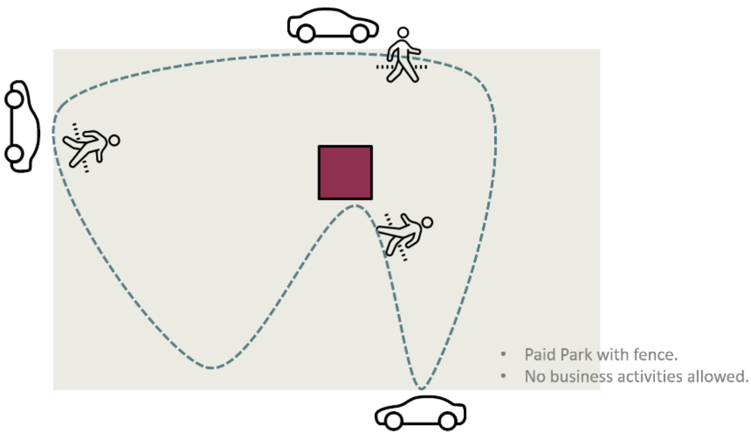

Figure 10. Walkability diagram of The Archive (Source: Author)

Reviving Sikkas with Modernity

As part of a senior thesis course in the AUD architecture program, Almulla[16] researched existing alleyways (*Sikkeek*) in *Jumeirah III, a* coastal and affluent residential district in Dubai (Figure 11). Through her detailed field survey, she concluded that these original alleys do not hold the past's original attributes and are underutilized in the neighborhoods[17]. This observation provoked her to propose a revitalization and re-socialization of the alleyways by inserting minimal, modular function units designed carefully considering the existing community within them. Some of the proposed functions include a passive ventilation tower inspired by the traditional wind towers in the region. This proposal, *'The Space In Between'* successfully showed a positive solution to retrieve pedestrian activity and walkability, which happened in compact community-centric neighborhoods (Figure 12). The project received international attention from architecture media. Dutch magazine *FRAME* featured the proposal as an example to transform street life to meet our 'new normal.' [18]

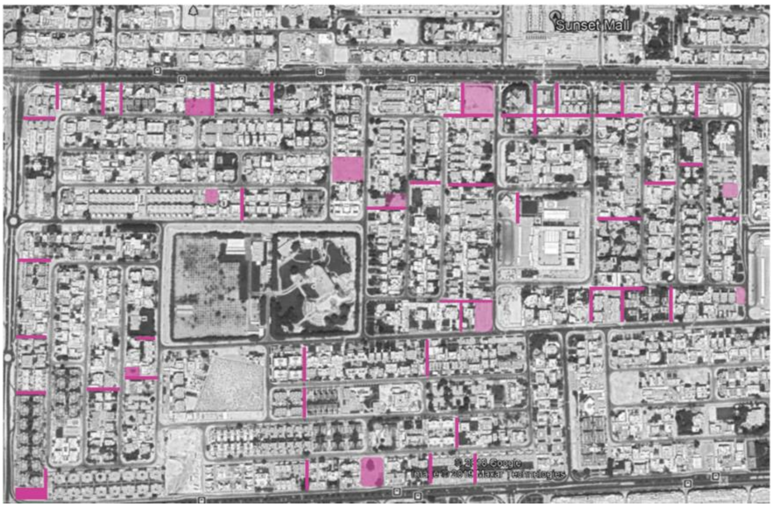

Figure 11. alleyways (Sikkeek) in Jumeirah 3 residential district *(Source: AlMulla,2019)*

Figure 12. The proposal "The Space In Between." (Source: AlMulla,2019)

CONCLUSION

The rapid growth that Dubai has embodied since the discovery of oil led to the importation of North American-style suburbanization and housing communities. As a result, the city lost a sense of human-scale and started relying on vehicle transportation. High-density neighborhoods with walkable alleyways were replaced with foreign-typologies, represented by garden houses enclosed with fences. The mega-development tended to neglect pedestrian spaces and triggered the lack of walkability in Dubai.

Looking toward the EXPO 2020 Dubai, the government has announced a series of sustainability strategies. And the Road and Transportation Authority promoted setting up pedestrian paths and cycling tracks with a few shading devices. However, they still look insufficient to protect pedestrian activities from the harsh sunlight in the mid of Summer. Developer MERAAS has imported European concept for commercial facilities attempting to enhance pedestrian activities. However, it seems not as successful as the other countries since the city still lacks mature public transportation networks and much needs connections.

As described in this paper, these sustainability strategies and attempts in Dubai feel rather superficial and are more of a façade. To be successful, they should be considered and customized based on the country's conditions. Moreover, looking back and retrieving the ancient traditional pearls of wisdom in this region, such as the Al Fahidi district, should be more critical for locally-based design approaches than other regions' reference. In the BArch Architecture program at the American University in Dubai, I emphasize this locally-based sustainable design approach in my courses. As a result, students' awareness of the locally-based design strategies is increasing year by year. The proposal *'The Space In Between'* introduced in the previous section is one of the fruitful outcomes of these efforts.

This paper hopes that young architects and designers born and raised in this rapidly globalizing city with glass skyscrapers and suburban gated communities will recognize the value of ancient wisdom and learn more about sustainability and walkability in their original culture and tradition. This knowledge has been here all along, and does not need to be imported from abroad.

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BETTER LIFE IN URBAN AREAS FOR ALL WITH INCLUSIVE DESIGN

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INTRODUCTION

Our world is undergoing rapid quantifiable changes. This paper explores how we could make our urban environments more all-encompassing, with inclusive and multispecies design approaches and discusses what 'better' could mean for all living species inhabiting and sharing the Earth. The paper shares forecasted figures for 2050 on expected population numbers and draws similarities between vulnerable groups' invisibility, illustrated with examples from industrial design and public furniture.

OUR WORLD IN FIGURES

Human population will reach 9.4 billion in 2050, and around 17% of this will be above the age of 65.[1, 2, 3] Today, one in three people either has a disability or is caring for someone with a disability.[4, 5] Furthermore, 80% of disabilities are invisible.[6] By 2050, 75% of the population will live in hyper-dense cities, and there will be 43 megacities[7]. Today, those cities cover 3% of the land surface,[8, 9, 10] with more than half of the total population already living there. This number was 10% back in 1900.[11]

These figures underline our imminent need to future-proof our cities, buildings, urban and domestic environments, and devices with which we interact daily; as these have a significant impact on our extent of ability or disability, on our daily experiences, and our ecological footprint.

Earth is Finite

Our biosphere is the sum of all living things and what matters to us most is the thin crust around the Earth with its atmosphere, called *the critical zone* by Latour.[12] Seas cover 71%, while mountains cover 25% and forests, 31% of the Earth's land surface.[13]

We are undeniably reliant on this finite and limited thin area to live and operate. It is also where our cities account for 2/3 of the annual energy consumption and produce 70% of global greenhouse gases.[14, 15, 16] Amid the rapid urbanisation, city dwellers have also lost touch with nature.[17]

Invisible Disabilities

Figure 1 below shows a night view map, in which the illuminated areas are where people agglomerate. For these crammed regions, think for a moment that 80% of disabilities are invisible.[18]

Figure 1. Night illumination map showing major agglomerations.[19]

Disability and old age represent a vast market of people, often under-catered-for and untapped. These include arthritis, musculoskeletal problems, heart disease, respiratory problems, mental illnesses, and nervous system disorders. In Australia, 4 million people have a chronic joint condition.[20, 21] Moreover, disability is part of life. Anyone can become disabled or overcome physical or mental disabilities in a lifetime, becoming forever disabled or temporarily, or even situationally disabled. An example of a situational disability could be talking on a mobile phone while walking in the street and crossing a red light. Additionally, we will all face it when it comes to old age.

Invisible Species in Decline

Experts estimate that around 2 million known different animal, plant, insect and algae species and that only 25% of existing life forms on Earth are known. By 2050, half of this wildlife will disappear.[22] Scientists recorded a 76% drop in insect biomass between 1989 to 2016,[23, 24] and animal species reliant on insect-heavy diets have been the most affected.[25, 26]

Losing biodiversity and species is described as "… burning a library without knowing the names or the contents of the books we are losing".[27] Animal and plant species are potential blueprints for solutions to problems, cures for diseases, inspirations for new technologies and innovation, and new material sources.[28]

"Today, more than ever, we need to re-develop compassionate empathy towards urban wild animals and their habitats, to address their needs within the fields of design, and to work with, and not against, vulnerability and interdependencies".[29]

DIVERSITY AND DISABILITY

People are diverse and function in distinct ways, and disability can affect anyone, anytime. Sometimes "you have to lose yourselves to find yourself". This quote, attributed to Willem Dafoe, can be illustrated by Michael Graves' example. Graves was an award-winning postmodern architect, who designed many iconic buildings and well-known domestic products. In 2015, a mysterious virus caused him to lose the use of his legs.[30, 31]

Graves' perspective on life changed radically after this, as he was now moving around on a wheelchair. He began to have significant issues in using hospital spaces and furniture. For example, he could not reach the sink's handle or the electrical outlet. He also famously said, "It's far too ugly for me to die here",[32] when talking about his hospital room. As a result, Graves designed a whole series of hospital furniture and spaces that would uplift people's spirit, and give them more independence, dignity, and

affordances in doing many of the daily things most of us do take for granted.[33] Graves was applying accessible and inclusive design approaches to his postmodern design process. He even had his employees spend a week in wheelchairs to empathise with hospital patients' needs.
Graves became a “reluctant health expert”,[34] and an advocate for accessible design. He explains his learnt awareness as: “I would not have been a health care nut if it had not been for my paralysis, so something good came from this.”[32] How could we learn from such experiences? What can we learn from accessible and inclusive design approaches for humanity to survive beyond our current era? Have we already lost ourselves completely, or is there still more to come?

Hidden Industrial Design

The environments where we live and the devices we interact with daily have a considerable impact on our experiences and extent of ability or disability. Most design solutions would be working quietly in the background to facilitate our interactions with products, services and environments. The following quote by Au[35] sums-up the role design plays in our lives: “Good design is like a refrigerator - when it works, no one notices, but when it doesn’t, it sure stinks.”
Good industrial design outcomes are often invisible, as they are embedded within the fabrics of buildings, systems and devices, making our practical, sensory and visual experiences as comfortable as possible. These include things such as apps, operating systems, AI personal assistants, architectural fittings and hardware, bathroom and kitchen furniture, heating and cooling systems, and lighting controls, among many others.

Models of Inclusion and Disability

Holmes presents two representations of inclusion and exclusion (Figure 2). The left circle explains exclusion, where people are either shut-in or shut-out from a space, an interface, an activity or a community. The right circle is the ideal inclusive situation where there is no barrier, either way, suggesting reciprocity, contribution and exchange, where both groups have a lot to learn from and contribute to one another.[36]

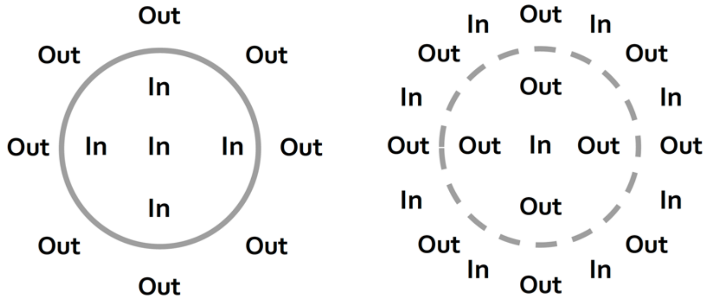

Figure 2. Representations for exclusion (left) and inclusion (right).[37]

There are two main models of disability. In the Medical model (Figure 3, left), the person with a disability is considered the problem, with disability caused by physical, sensory or mental issues. This model focuses on the medical profession, on the cure and on alleviating symptoms, where the person passively receives treatment and care. On the other hand, the Social model (Figure 3, right) focuses on social and physical barriers as the sources of the problem, where attitudinal barriers or the environments, such as buildings, services, products, and information become design problems requiring to be fixed.

Disability in this context is a socially constructed problem that requires removing barriers to full participation for all, as much as possible.[38]

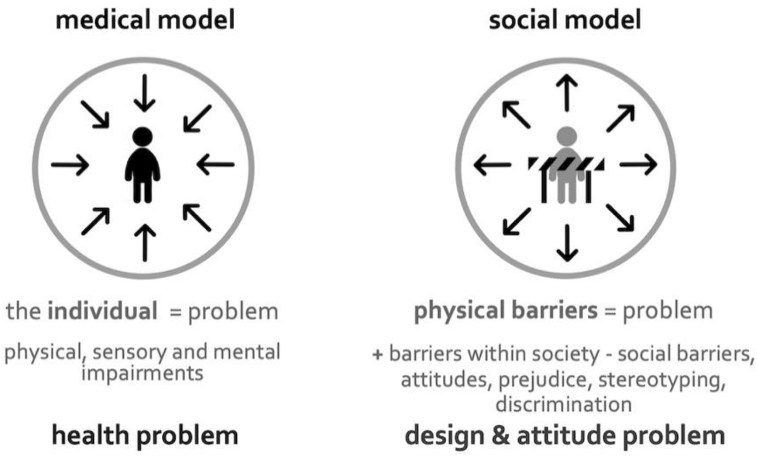

Figure 3. Two models for disability.

EXAMPLES OF DESIGN FOR INCLUSION IN THE CITY

Inclusion is a process and signifies that people are diverse and unique, with various levels of ability. It also means that everyone has the right to be valued and appreciated in their communities, regardless of background, race, sex, gender identity, age, religion, qualification, disability, or health care needs. Furthermore, people need to have an equal or equivalent right to access and to contribute to the physical, experiential, sensory and cognitive aspects of urban spaces, transportation systems, street furniture, parks, common property, buildings, interfaces and amenities.

Inclusion for Accessibility, Better Experiences and Safety

Inclusive and thoughtful design solutions can improve many of the disadvantages related to living in cities, by eliminating or minimising barriers causing negative impact, by including people in the process, widening accessibility and providing a better experience for all, as much as possible. For example, to help pedestrians find their way and safely navigate a city, sidewalks, pavements and crossing designs, information design, road signage systems, bus, train or subway maps, and smart device apps, among others, can all help in providing better access and experiences to making sense of the environments and interfaces interacted. These would guide people efficiently while ensuring they reach their destination safely and on time, benevolently controlling and herding people.

Figure 4. Sydney's iconic pedestrian crossing button.[39]

Crossings with traffic lights are among the most dangerous spots for pedestrians. Figure 4 shows Sydney's iconic accessible pedestrian crossing button,[40] with its audio, tactile push-button system, which for the last 35 years, has been making crosswalks accessible, the city pedestrian-friendly and provided safety and guidance for pedestrians with vision and hearing impairments. Until Covid-19 came along, these touch buttons were useful in directing people with vision impairments. Since the pandemic, the buttons have been officially turned off.[41, 42]

Inclusion for Human Diversity and Social Behaviour

To help make a city more gender-inclusive, Vienna has installed same-sex couple pedestrian crossing signals (Figure 5, a). On the other hand, Melbourne introduced pedestrian crossing signals with a female silhouette[43] (Figure 5, b). Both of these attempts respond to the unconscious bias built into our brains, as we are used to seeing a male silhouette icon in the traffic lights.

Figure 5. Three different traffic light examples: from Vienna (a),[44] from Melbourne (b),[45] and Sydney's countdown timer traffic light (c).

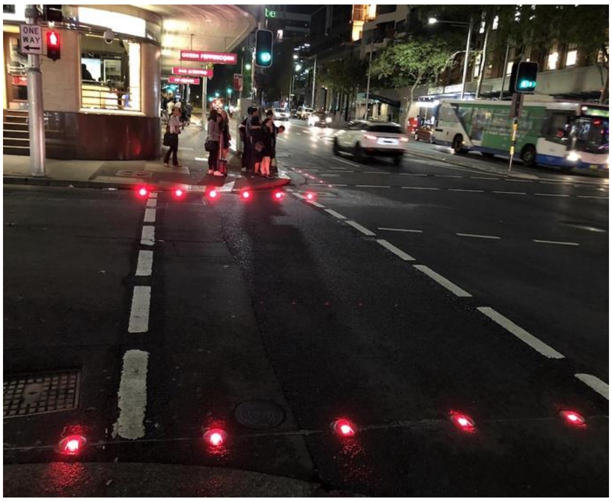

Figure 6. Sydney inground red lights.[48]

To help make pedestrian-light crossings safer, here are two more examples from Sydney. First, the countdown timer (Figure 5, c), that caters to people's impatience and tendency to overestimate the time waited to cross safely;[46] and in Figure 6, an in-ground pedestrian light system that turns red to signal pedestrians to stop and switches off when they can walk safely. This last example has been specially designed for a situational disability, for people engrossed in texting or playing on their mobile phones while crossing the street.[47]

Inclusion for Shared Human Experiences

The example in Figure 7 below is a temporary traffic light featuring a red stick figure that dances and attracts pedestrians' attention, making them watch and wait at the red light, enhancing safety, while entertaining. There is also a component of people participation, as people take turns to dance in a special box with their silhouette projected real-time, during the red light. Quite playful, engaging and fun. [49]
Another comparable example is *21 Swings*, the interactive public furniture by *Daily Tous Les Jours*, in Canada, where the street becomes an enormous interactive musical instrument. In this example, the designers collaborated with a scientist, a biology professor expert on cooperation amongst animals, and a local musician. They programmed pre-recorded musical instrument sounds into colour-coded swings that play a range of notes when in use. When the swings are swung together, in cooperation, they create more complex melodies. The result is a fun and thoughtful idea that helps create collective moments and acts as a beautiful metaphor, as a reminder to preserve harmony and collaboration in our lives. [50]

Figure 7. Different views of the Dancing Traffic Light Manikin.[51]

Inclusion for Multispecies' Visibility

'Design', as a human-centred problem-solving creative activity, has played a significant role in creating many of our era's material and cultural problems. City-planning, architecture, building construction and products are linked to the economic and social realities that co-produced the era we live in, termed the Anthropocene. This term denotes the Age of Humans, at the end of a prolonged Holocene period, that many connect with a period of conscious human-made disruption to ecosystems, the atmosphere, and Earth's crust.[52] Crutzen familiarised the term in 2002;[53] yet almost two decades later, experts are still disputing its scientific validity and meaning.[54]

As it is the case for most invisible disabilities, many wild animals, insects and plant species are also invisible to humans, in day-to-day life and within our cities' planning and design. We tend to forget that "Cities are comprised of, shared, and made by animals, plants, fungi, microbes, atoms and many other living and non-living beings, technologies and materials".[55]

For example, many birds migrate under cover at night, and artificial lights coming from tall buildings can disorient them. Panicked birds emit special calls resulting in calling more birds to the same location where most birds then collide with buildings and die.[56, 57]

The *Bat billboard* (Figure 8, a) is one example of wild species inclusion in urban life providing habitat for bats on existing billboards that act as an interactive display and translation board for people to understand the habits and activities of bats, via voice recognition software, enabling bats to communicate their needs in a visual, audio and playful way.[58]

In the next example, the *Living Seawall* tiles (Figure 8, b) help biodiversity by attracting marine organisms that absorb and filter pollutants in the sea. These tiles mimic native root structures and provide a habitat for marine life on existing human-made seawalls around Sydney's coast.[59, 60]

Figure 8. Two multispecies approach examples: The Bat Billboard (a),[61] *and Living Seawall tiles (b).*[62]

A third example for this section is a project that makes microbes visible in the city, to readjust human's germ aversion and anxiety (Figure 9). Presenting a "bioreceptive consciousness of cities and spaces",[63] this project asks whether New York would have a 'gut biome', similar to humans and whether that would be different for each district or city.[64]

Figure 9. Subculture: Microbial Metrics and Multi-Species Cities, living lab storefront.[65]

BETTER CITIES FOR ALL

In a megacity, who should be deciding what is better? Furthermore, what makes a city better than another one? How to decide what is right, from the many concepts and factors and how do we prioritise? The number of potential principles is overwhelming.[66]

To make sure that decisions are inclusive for all, the World Association of Major Metropolises proposes four basic principles for cities, relating to essential domains of social life: ecology, economics, politics and culture, and underlines that decisions should be the outcome of open dialogue with the people living in the cities. In other words, co-designing cities with their inhabitants.[67]

Co-Designing with People, the End-users

The following quote by Mark Wafer sums up why co-designing with people, i.e., end-users, is essential: "A person with a disability has to be innovative just to get through the day, imagine how that mindset helps a team".[68] People are experts in the various ways they live their lives and how they create workarounds for the many issues they encounter. Moreover, as co-designers, they provide research and design teams valuable first-hand insights on what people need and why they do what they do. Besides, the co-design process helps include end-users in decision processes and gives them a sense of ownership on the outcomes, ensuring that people care for and maintain the outcomes.

Cities Inclusive of Different Life Forms

We have many urgencies, from restoring biodiversity, phasing out fossil fuels, sustainable foods & farming methods, sustainable construction and production methods and materials, to sustainable transportation modes. These will require time and 100% commitment from, yet there is hope on what things could look like when addressing the urgencies. Among these, we need to make local wildlife and flora visible to city dwellers. We can do this with an inclusive and holistic approach to designing our cities, with a biodiversity and habitat perspective, allowing for pockets of habitats for local fauna and flora to thrive and no-go zones allowing for wildlife to regenerate. A critical indicator of ecosystem health is the species' interaction balance.[69]

Besides the apparent stress-reducing effects of vegetation, biophilic or biotope cities are beneficial for humans and other species' health, in terms of preventative health and well-being benefits, and mitigation of problems caused by the increase in epidemics.[70] Designing biotope cities will require ethical practices, policies, guidelines, and information to provide appropriate caretaking, monitoring, and maintenance and raise city dwellers' awareness and involvement. Inclusive biotope cities for all will be about saving ourselves, by relearning to live in the critical zone, and making the regeneration of ecosystems and wildlife possible, as they are our best allies.[71]

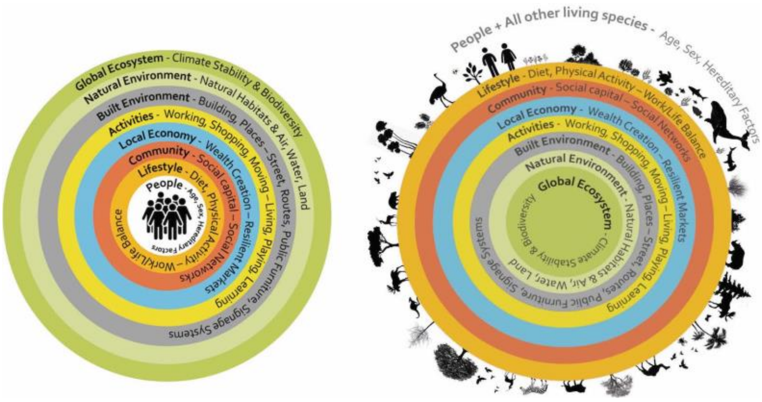

Figure 10. Determinants of health and well-being: Human-centred model (left),[72] and Ecosystem-centred model (right).[73]

Determinants of Health and Well-Being

Figure 10 (left) shows an adapted model of the human-centred determinants of health and well-being, with its interdependent layers.[74] The next model (Figure 10, right) modifies the previous one by turning it inside out, for a more inclusive and multispecies centred model, where we are no longer at the centre, but part of the balance, taking our place within the ecosystems and all other species.

CONCLUSION

Most diversities and disabilities are invisible. Most living species are also invisible. This invisibility results in being excluded and forgotten within the design and planning of human-made habitats and things. It boils down to seeing the invisible and developing compassionate empathy so that we can take action and help, in any way that we can. For this to happen, we need inclusive design approaches that will help us see and make visible the invisible and develop compassionate empathy for all living species, with sustained engagement with all the components of the 'critical zone' where we live.

Humans have the gift of imagination and visualisation. We can imagine possible and preferable futures based on current scientific developments and make it happen. We need to collectively rethink and reimagine how we live in cities, understand our humanness and our relationships and balance with the beings we share the planet. This rethink will be about how we live and cohabit with other living species, how we help maintain the balance of Earth's ecosystems, the stories we tell about that way of living and our roles in it, and about co-designing the solutions we imagine and produce for a future, where we all want to live.

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POPCYCLE: A MOBILE PLACEMAKING PLATFORM

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INTRODUCTION

The current issues of contemporary cities development with limited resources and lack of vacant lands or in turn, abandoned and disused land due to rising de-industrialization of towns, pose the challenges to advance the shortcomings and ever changing events of the existing built environment and urban spaces. The unprecedented circumstances and situations such as the current COVID-19 pandemic amplify these challenges through further isolation of communities and individuals. These changes not only introduce the opportunity to review the viability and sustainability of contemporary cities, but also potentially provide novel architectural interventions that can enhance the responsiveness and adaptability of the existing urban built environments and create a new sense of public place.

The port city of Geelong on Corio Bay, Victoria, Australia, is located 75 kilometres south-west from the state capital of Melbourne. In the past decade, Geelong city has undergone a process of deindustrialization with major manufacturing industries such as Alcoa's Point Henry Aluminium Smelter and Ford's manufacturing plant ceasing operations in 2014 and 2016, respectively. The closures have left empty buildings and land at the outskirts of Geelong, which has triggered further empty, disused sites in Geelong's city centre. Despite this, Geelong's population is growing fast, and with it, more cars, more traffic, and an accelerated increase of the pace of life. How to respond to the disused, empty building environments in such a fast-paced and growing city? The PopCycle project discussed in this paper proposes one potential response through a design-research practice. Specifically the project responds with a three-fold agenda. Firstly, creating economical and sustainable vibrant public sites that are presently abandoned and disused, through local community engagement. Secondly, developing research into ways of activating vacant pockets of land through mobile and responsive design. Thirdly, exploring how adaptable small-scale architectural interventions with low-technology and use of local-materials help slow down time within the current culture of speed. To expand on the above three agendas, the position of this paper is that disused public pockets of land in our cities is an area worth attending to, towards an economical and sustainable city model. Moreover, in following mobile and responsive architecture that has been explored since the 1960s, the PopCycle project introduced here proposes that such architectural design paradigms have potential to create responsive space for new and existing spatial design problems. Finally, the phenomena of a culture of speed has brought about a fragmented state of experiential time through what Paul Virilio illustrates as an "epileptic state of consciousness produced by speed" which has triggered a dissolution of the lived experience of space and architecture due to accelerated speed and movement.[1] In this rapid, fast-paced context, the paper seeks to examine through a design research practice, how the culture of speed affects our experience towards a sense of public place, where responsive and mobile architecture presents possibilities to ensure social integration and community-building platforms.

Specifically, this paper explores the potential of a mobile, portable, adaptable, sustainable, economical and responsive architectural intervention to revitalise the city of Geelong. The mobile intervention, namely PopCycle, is designed and manufactured by re-cycle bicycle parts that serves as a hybrid small scale market entity to promote local products of Geelong. The purpose of the PopCycle is to create a mobile and responsive placemaking platform to generate a place-activation phenomenon "differently" on the streets where the intent is for local suppliers of Geelong to use this platform to promote their products. The multiple and different arrangements and configurations of the PopCycles have potential to operate separately or join to make multiple temporary market and living spaces on the street. A prototype of the PopCycle is presented through this paper as a testing platform to evaluate the viability and feasibility within a selected site context.

RESPONSIVE MOBILE ARCHITECTURE AND THE CULTURE OF SPEED

In architectural discourse, there are notions that buildings are in some aspects a fixed entity, static and passive. However, the other aspects of permeability, appearance, and affordances for activity are capable of unpredictable and sudden change in response to different events and needs of the occupants.[2] The ideas of responsive and mobile architecture have been explored since the early twentieth-century and remain one of the novel architectural design approaches today.[3] In general, the notion of responsive architecture is associated with kinetic and transformative architectural features and components that perform adaptive functions to produce more energy-efficient buildings and to explore experimental aesthetic purposes.[4] Prominent precedents such as *Institut du Monde Arabe* and *Aegis Hyposurface* serve as significant examples to implement novel approaches and considerations that demonstrate possible implementations of responsive architecture.[5] Mobile architecture provides a similar paradigm of architecture that is able to move, to adapt and respond to the various conditions of the sites and locations.[6] In the 1960s, architecture Avant-garde group, Archigram, coined the initial radical idea of mobile architecture such as *A Walking City* and *Living Pod* to experiment aspects of mobility and change of structure with modular technology that move through the built environment with minimum demolition of the existing architectural history.[7] *A Walking City*, designed by Ron Herron in 1964, embodied a unique proposition that shifts away from the static, rooted and monumental architectural approach towards architecture with mobility, flexibility, transitoriness and indeterminacy, that moved beyond a simple emphasis on movement and speed.[8]

There are common focuses and visions shared by the two avant-garde architectural paradigms discussed above, where responsiveness and mobility are paramount to respond to changes with flexibility and adaptability, especially in the context of the existing built environment and cities. Although contemporary cities never lack the infrastructure and facilities to accommodate mobility (pedestrians, private and public transportation, etc.), there are rarely considerations to explore new possibilities for mobility and interactivity beyond buildings within the urban fabric. Responsive and dynamic-change buildings with architectural features such as media facades, active shading devices, and ambient smart energy control, are not new and have been developed since the late 1960s. However, there is an alternative to integrate the mobility and responsiveness of these features to promote a responsive mobile architecture. These have the capacity to serve as an urban intervention to revitalise the existing urban environment and placemaking with different conditions.

Such responsive mobile architecture is most pertinent in the culture of accelerated speed that architecture finds itself now. For instance, Zellner, in reflecting on the influence of digital technology advances, suggests that "…globalised liquid 'soft architectures' of digital media flow over, under and through the local, concrete and 'hard architectures' of our contemporary cities, creating an intermediate, 'floating' environment, an interface between public and private, collective and subjective, provincial and planetary."[9] In this sense, there is blurring of architectural spaces that have distinct physical qualities and through this, the emergence of a timelessness of architecture. This is in line with what Virilio argues on the uncertainty of physical environments or, citing Gogol: "Without even leaving, we are already no longer there."[10] In *The Third Interval*, Virilio further argues his concern with the speed of contemporary bodies, the built environment and cities in which "instantaneous transmission" and intensive time, that is, "real-time of immediacy and ubiquity" overpowers or deprives the "real space" of architecture.[11] Here, he coins the term "picnolepsy" or picnoleptic time, understood as "the epileptic state of consciousness produced by speed."[12] The effects of picnolepsy occur as the repercussions of a current culture of speed, that is, "a switch from extensive time of history to the intensive time of momentariness without history."[13] Therefore, picnoleptic time fragments our experiences of everyday life and its associated architectures that become immaterial or dematerialized. Virilio extends this dissolution of the lived experience of space and architecture due to accelerated speed and movement in noting that "urbanism is in decline, architecture is in constant movement, while dwellings have become no more than an amorphous of thresholds."[14] The notions of picnolepsy through accelerated speed and intense-fragmented movements are external phenomena that impact the human body in a way that causes disorientation. As Virilio argues accurately, we no longer control time but time controls us. Within such understanding of the current culture of accelerated speed, the paper presents the PopCycle project as a prototype of responsive and mobile design that has potential to slow down time and provide the platform for an authentic lived experience of space and architecture.

METHODOLOGY: RESEARCH THROUGH DESIGN

In this project, a design research (DR) approach serves as a method to investigate the research areas of responsive and mobile placemaking platforms for the existing urban environment. It is important to understand that in design research the process "operates through generative modes. Producing works at the outset that may be reflected on later".[15] This means that through doing, through design, one arrives at a research proposition. Furthermore, Fraser illustrates that this method "can best engender speculative thinking and experimentation through engagement with the normative practices of everyday life in the contemporary city".[16] Hence, this particular research approach directly intervenes into "real world" contexts and situations with the intent to effect change. According to Hevner et al., there are seven criteria or guidelines that must be considered in a DR project: Design as an artefact; Problem relevance; Design evaluation; Research contribution; Research rigour; Design as a search process; and Communication of research.[17] In response to this, this paper and the PopCycle project it introduces below, produces a design artefact in the form of a constructed mobile platform and seeks to engage in a rigorous evaluation process that analyses and reflects on the quality and efficacy of the design process and designed platform. Importantly, the PopCycle project, within the context of a city such as Geelong, shifts engagement with individual and autonomous practices to the collective community, and their everyday practices. The significance of design to explore the potential of such responsive placemaking platforms also highlights how a design research approach is useful to bridge different disciplinary approaches[18]– in the case of this project, intersecting manufacturing, architecture, art and design, as well as social practices.

POPCYCLE AS THE RESPONSIVE ARCHITECTURAL INTERVENTION TO REVITALISE THE CITY OF GEELONG

One of the motivations to select Geelong as the city to host the PopCycle project is to promote Geelong's UNESCO City of Design designation, as it seeks to expand the potential of design practice to bring about a positive, healthy, active change for the Geelong community. The design of the PopCycle as a collective, responsive and mobile architectural intervention encourages community participation, provides a sense of place, and serves to revitalise Geelong's disused pockets of land and public places.

The PopCycle is designed with "unpredictably" – in that it is mobile, portable, adaptable, sustainable, and economical in nature to respond to various conditions and events. The purpose of the PopCycle is to create a mobile and flexible placemaking platform to generate a place-activation phenomenon "unpredictably" on the streets, where suppliers of Geelong source everything locally (i.e. recycle parts for fabrication, locally roasted coffee and edible products from domestic urban farm). The adaptive, multiple, different arrangements and configurations of the PopCycles can operate separately or join to make multiple "living spaces on the street" with impromptu and unpredictable events. The creation of the possibility of such everyday life places, or as Knox describes it, "ordinary places,"[19] is a response to Virilio's concern on the quickened, accelerated pace of life, accompanied by the decrease of genuine social life.[20] The emphasis here is on PopCycle's capacity to facilitate a slowing down of time and to offer happenstance social encounters within a fast paced urban setting. Figure 1 represents this approach through an initial sketch to illustrate a popup flea market that is formed by a series of PopCycles with flexible configuration to provide a sense of place for the community, as well as market platforms for vendors to sell local-sourced products from Geelong.

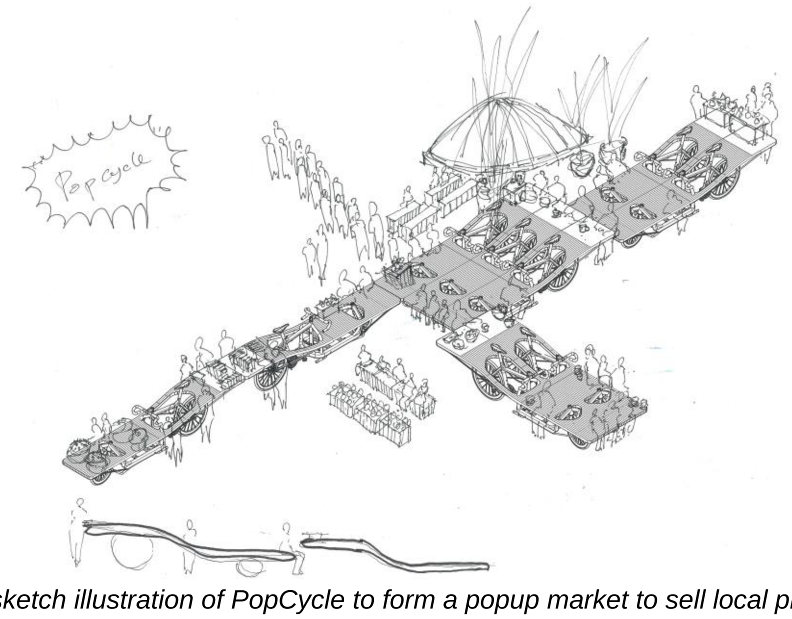

Figure 1. Initial sketch illustration of PopCycle to form a popup market to sell local products as well as create the new sense of place within the public space of Geelong.

The users and audiences of PopCycle are the local residents of Geelong and the city's growing domestic and international visitors. PopCycle serves as a mobile and interactive platform to promote locally made-in-Geelong products, design, and culture globally. This approach revitalises the existing place of Geelong to generate a new sense of place, such as at the The Pier, in the form of an open market place via the flexible configuration generated by the series of PopCycles (Figure 2). In addition to the supply of recycled parts for the fabrication of the PopCycle, local communities that produce food and beverages as well as small-scale design industries of Geelong are the supporters that directly fund the PopCycle project. In addition, local manufacturing businesses and NGO's provide the necessary resources to construct and fabricate the PopCycle with the recycled parts and components donated from a local non-profit bicycle shop to optimise the cost and time.

Figure 2. The pop-up market place in The Pier Geelong formed by a cluster of PopCycles as a place making platform.

The project is accessible to all people and has potential to be engaged by children, adults and elderly of the local community, bringing together generations with diverse backgrounds. Such potential intergenerational gathering that the PopCycle offers is critical in the current culture of accelerated speed, with declining levels of sense of community and growing distance, both physically and emotionally, between generations. As such, the project is a vehicle for community building and enhancing social connections. Aligned to this, the PopCycle does not impede access for people of mobility impaired – but rather encourages more active engagement at the street level and takes advantage of the accessible infrastructure of Geelong and existing surrounding environments, such as the established Deakin University located at the waterfront of Corio bay.

A hybrid mobile placemaking platform: The designing of PopCycle

Instead of solely as a conceptual approach and remain as an idea or concept, the design of PopCycle provides the insight of possible implementation. Prior to the prototyping process, the initial design idea of PopCycle includes a proposal to create a hybrid mobile placemaking platform that integrates mobility and gathering space. This design approach is achieved through the design implication to metaphorically combine a table, a chair, and a bicycle, as an integrated mobile entity of PopCycle (Figure 3). As noted above, besides serving as a single entity to perform the functions of seating and mobility, Figure 1 and Figure 2 illustrate how a series of PopCycles can form into different configurations to accommodate various events and adapt to the existing built environment. The flexible and reconfigurable nature of the PopCycle enables the placemaking platform to respond and adapt to different conditions and contexts of existing sites.

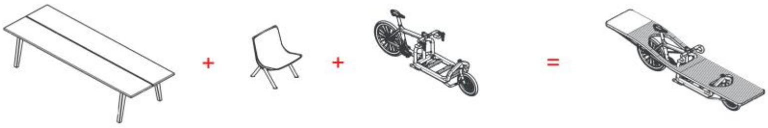

Figure 3. Design diagram of the PopCycle as the hybrid of the table, chair and bicycle to perform the various functions and mobility.

The prototyping of PopCycle

The purpose of the PopCycle prototyping presented below aims to provide a full-scale physical platform for a user study, to collect feedback of the project within an actual site context and event. The latter allows for the necessary reflective evaluation process embedded within a Design Research approach. As such, the prototyping phase of the PopCycle is critical in providing an actual platform to evaluate the applicability and feasibility with subsequent user study and interaction.

The PopCycle prototype is proposed to be tested within a suitable site context in Geelong city during the Geelong Design Week 2021. There are three stages to prepare and fabricate the prototype of PopCycle: collection, assembly and evaluation. The collection stage includes the search and collection of the recycle parts from various non-profit organisations of Geelong such as GoodCycles to provide the essential components for the PopCycle. These components are mostly sourced from abandoned bicycles and donated refurbished parts by the local manufactures. The second stage focuses on the assembly and fabrication of the PopCycle with the collected parts and components. This is a significant stage to compose the main structure and test the fixed and movable elements. After the assembly, the third and final stage evaluates the structural integrity and the ride capability of the PopCycle at an adequate test site.

The choice of constructing a bicycle is critical as it disrupts the norm of people's experience of streets. Through the stop-go, halt-accelerate jumps between the static (red light) and the moving (green light), our vehicles project a high-speed fragmented cityscape. Virilio refers to this as a picnoleptic experience where "nothing has really happened, the missing time never existed."[21] The PopCycle counters such phenomenon of disconnection, of disappearance, and offers through the slowness of cycling a more continuous, local and intimate rediscovery of the Geelong streetscape.

Figure 4. The initial stage for the fabrication of the PopCycle with the recycle components sourced from Geelong.

Figure 5. Assembly and welding the details of the PopCycle.

Figure 6. The stage to complete the undulating bench of the PopCycle.

Figure 7. Testing the plywood bench surface around the seating area.

Figure 8. The complete prototype of PopCycle without the plywood bench surface.

The fabrication process of the PopCycle prototype includes the assembly of the various recycled parts and components through simple welding technique (Figure 5). The undulating bench structure is also seamlessly welded on the overall main structure between the front and rear wheels to host the recycled plywood bench surface (Figure 6 & 7). On this bench, people sit, gather, wait, and objects are displayed, sold, consumed – where real time is experienced through a lived 'real' space. Indeed, a rare happening in our accelerated culture where, as Virilio contends and characterizes, space is consumed through "the tyranny of real time."[22] The complete main steel frame of the prototype enables the several tests and evaluations for mobility and durability prior to the user implications in an actual site context (Figure 8). This prototype serves as the physical proof-of-concept as an initial pilot study that allows all participants of the community to interact with it within an existing urban space to form a new sense of place.

CONCLUSION

Adaptability and mobility are becoming valuable aspects for contemporary architectural design especially in the existing dense and congested urban context. These aspects have potential to regenerate a new sense of place via the implications of an architectural intervention that redefine the original functions and programs to respond to ever-changing needs of the existing built environment. In addition, reflecting on Virilio's assertion that a culture of speed has conditioned a declining loss of sense-of-place and a change in patterns of human-interactions and time itself, it is important to question the role of architecture, technology and culture, especially, in the post-pandemic age. As Virilio further warns of the impending dematerialization of architecture where public spaces and streets are abandoned in place of evolving technologies and accelerated media, the PopCycle project represented in this paper is but one small design response to this urban condition. Through a construction of a responsive mobile intervention, the project intends to awaken the design community to the potential of a direct and material response within a real-life context and event.

The research outcome of this paper also demonstrates an initial physical proof-of-concept with the considerations of the aspects and the research through design method to investigate the research areas of responsive and mobile placemaking platforms for the existing urban environment. This newly developed platform serves as a responsive mobile architecture with the design factors of space, time and speed to regenerate and revitalise the existing places with flexible configurations and adaptations. In addition to the visual illustrations of the proposed pop-up events such as the instant market and cafe as small urban interventions for reactivating disused and vacant existing public places, the responsive and mobile placemaking platform in this paper is demonstrated further through a physical prototype. It evaluates the feasibility of implementation and applicability of design factors with the recycle parts and succinct assembly process. Future work will include the development and refinement of an additional number of prototypes that enable the formation of a cluster of PopCycles. This will be followed by a user study in a selected location such as The Pier Geelong for user feedback and reflection of the community.

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NOTES

[1] Paul Virilio, *The Aesthetics of Disappearance*, translated by Phillip Beitchman (Los Angeles: Semiotext, 2009/1980) (originally published in 1980 as Esthétique de la Disparition by Editions Balland, Paris).
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NOTHING NEW UNDER THE TROPIC SUN: COMPARISON OF BUILDING TYPES IN THE SATELLITE CITY PLAN OF KIGALI AT THE TIME OF CORONAVIRUS

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INTRODUCTION

"Kigali Yacu – Our Kigali!" The 2020 Kigali City Master Plan's motto reveals the main character of the future urban development: inclusiveness. The Rwandan Capital is building itself over time driven by a satellite plan structure composed by green settlements that have among others to incorporate different housing typologies in order to address the rapid urban growth and to meet the local market's demands. Each settlement represents and realizes the architecture of the city that begins from the design and the aggregation of the single unit, the house, through a compositional strategy. The paper explores the building typologies embedded in the two Gacuriro Satellite projects, Kigali 2020 and Kigali Vision, pointing the analysis to the twin houses and the apartments' buildings as quintessential cases to demonstrate that to pave the future there is a need to study the past understanding their impact in the next urban evolution with a special regard on spatial quality responses during the ongoing pandemic crisis. Only a critical study of the two types of building through their history and its relation with the context can suggest a repeatable and sustainable model. A model that must comply with the issue of affordability, local traditions, and global emergencies. In fact, the modern city or the city of tomorrow has to comply on one side with the SDGs (Sustainable Development Goals) for a sustainable future and on the other side with unpredictable events, such as the case of COVID-19 outbreak. The two types of housing are confronted in order to retrieve a possible way forward focusing on a case study of dwelling grouping system developed by Peter Behrens able to suggest an appropriate method of composing the dwelling units.

The continental rapid urban growth

According to United Nations, the urban population is expected to rise by 2.5 billion persons, from 4.2 billion to 6.7 billion, while the total world population is projected to grow by somewhat less, 2.1 billion, from 7.6 billion in 2018 to 9.8 billion in 2050[1]. A large part of the rapid urbanization is taking place in Africa with some exceptional conglomerations: Cairo, Lagos and Kinshasa. The two sub-Saharan capitals, Lagos and Kinshasa, are predicted to grow in 2050 respectively to a population of 35 million inhabitants and 32 million[2], redesigning the urban cosmography of the Continent. Kigali accounts for almost 60% of the Rwandan population with an annual incremental rate of 9% as reported by GGGI in

2015[3] and it forecasts an incremental growth of its population from 1.3 million up to 3.7 million in 2032. The Rwandan capital is tackling the effects of this phenomenon through the adoption of a sequence of Masterplans and policies towards a sustainable urban future.

Kigali 1885-2020

The independence that Rwanda achieved in the early sixties marked the birth of a new Capital, Kigali. Located in a strategic position controlling the convoys crossing the country, it historically served as colonial outpost. The first foreign resident, Dr Richard Kandt, settled the so called *Boma* ("fort" in Swahili) at the end of the 19th century, and his house now represents the only building survived to the Belgian occupation and by that time, the most practical passage for the merchant caravans[4]. In fact, the First Word War was the pretext to annex Rwanda as protectorate of the Belgian Congo together with Burundi. The population of Kigali, which had grown from the 6,000 inhabitants of 1962 to the 250,000 inhabitants in 1991, was subjected to a drastic reduction during the tragic events of the 1994 genocide. As illustrated in Figure 1, the central area of Kigali registered in 30 years (from 1940 up to 1970) a rapid process of urbanization, only partially planned. The morphological evolution of the City has been guided through different development plans. In 1964, 1970, and 1982 the so called *Schéma Directeur d'Architecture at d'Urbanisme* (SDAU) was adopted. In the most recent decades, the city has been experiencing an urban Renaissance characterized by three Masterplans: 2008, 2013, and 2020. All of these are based on the satellite city model.

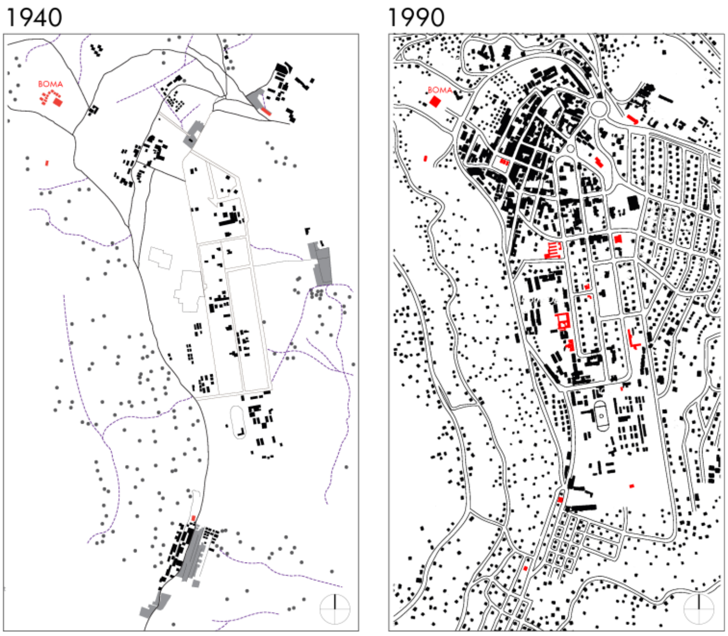

Figure 1. Urban evolution of Kigali from 1940 up to 1970.

The polycentric vision

The famous diagram of the Three Magnets, coined in 1898 by Ebenezer Howard, was proposing a city-exit towards the promise of fresh air and nature, offering sufficient work and a new social life. Built on the idea of a polycentric Social City, the Garden City of Tomorrow would be able to host 32,000 people, living in 1,000 acres of land and surrounded by a vast green belt. Once reached the limit of population, another satellite would be initiated a short distance away, interconnected by a rapid transit system[5]. 70%

of Kigali's territory is rural, thus the city and countryside merge into a *Howardian unicum* that the Masterplans seems to perfectly sum up. The adoption of a satellite city structure implies the re-shaping of the Rwandan Capital, starting from the single unit that aggregated and articulated in different residential typologies composes the settlements or *Imudugudu* in Kinyarwanda language. The *Imudugudu* represent a step forward in the achieving process of the 11th Standard Development Goal (SDG) titled "Sustainable Cities and Communities" which aims to make cities inclusive, safe, resilient and sustainable. In 2007, the OZ Architecture practice created the first Kigali Conceptual Master Plans (KCMP), complemented by the Singaporean firm Surbana-Jurong[6]. This Master Plan included a detailed planning and overall urban design accompanied by the transportation guidelines. The revised 2013 Kigali Master Plan is a comprehensive long-term plan intended to guide growth and development of Kigali City[7] while at the same time providing a road map for future expansion. Kigali's Masterplan underlines the principles of sustainable development and its vision is to make Kigali "The Centre of Urban Excellence in Africa". It adopts the structure of satellite city, with decentralized nodes and a development pattern along transit corridors mainly directed east and south, and with the Central Business District (CBD) being the center point of growth. The satellite structure was extended throughout the country with a six secondary cities network revolving around the Rwandan capital, as depicted in Figure 3. Recently, the City of Kigali launched the 2050 Master Plan which addresses the vision of building a local identity and the need to be an inclusive project: "Our Kigali". This upgraded version seeks particularly to introduce a flexible zoning plan, to boost the mixed-use structure in the CBD and to support green growth.

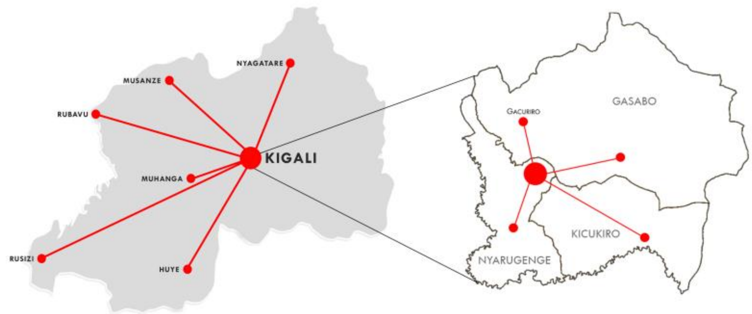

Figure 2. The polycentric plan of Rwanda and the capital city Kigali.

RESEARCH METHOD

The methodology applied in the paper is subdivided into two distinct phases. The first phase concerns the urbanization phenomenon, starting from the African continent up to satellite city development happening in Kigali. The aim of this introductory analysis is to contextualize the second phase mostly focused on a comparative approach. Once it had identified the satellite of Gacuriro and its main components, Kigali 2020 and Kigali Vision settlements, the paper explores the twin house and the apartment house in order to propose the most appropriate housing type for the next urban extensions. The type that has to be grouped follows a specific compositional pattern.

GACURIRO SATELLITE

The administrative boundaries of Kigali Province are divided in three decentralized entities or districts: Gasabo, Kicukiro and Nyarugenge. Since the first Master Plan proposal in 2007, new settlements have been planned and designed in the mentioned districts together with an infrastructural reinforcement with the intention of upgrading the existing rural areas. The Gacuriro satellite, located in Gasabo (see Figure 3), is part of the overall framework to shape and structure Kigali proposing the construction of two settlements, Kigali 2020 and Kigali Vision. As illustrated in Figure 4 the *Imidugudu* are placed in a low density area on the hill slow degrading towards the wetland located in the south. The satellite will be fully completed in the coming years, adding on the north side the project of Kigali Vision 2 that will provide more facilities and services.

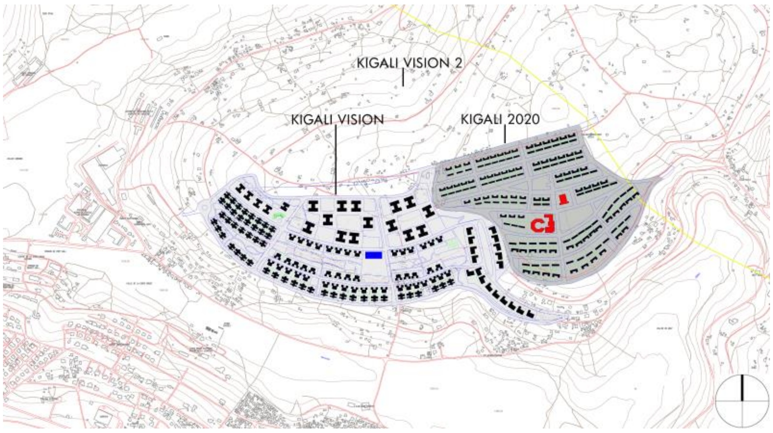

Figure 3. The Gacuriro Satellite: Kigali 2020, Kigali Vision and Kigali Vision 2.

The Kigali 2020 settlement

The Kigali 2020 settlement represents the first component of the satellite city project and at the same time one of the Rwanda Social Security Board's (RSSB) developments. Located in the Kinyinya sector, it is aggregated into 4 different semidetached housing typologies and placed along the contour lines following the slope of the land. In particular, the twin houses, type “1” and “2”, denote a tridimensional indoor spatial quality, a sort of *raumplan*, while the upper houses, type “3” and “4”, have a partition in two distinct floors. This approach of dealing with the existing context avoids invasive site works and reduces costs, thus enhancing environmental protection. Completed in 2015 and baptized “Belle Vue” Estate due to its remarkable view towards the opposite hills, 152 twin houses were partially injected into the real estate market and redistributed to the RSSB beneficiaries. Compositionally, the available public facilities, the church and the primary and secondary schools, surround the central green area that serves as community main space. It is recognizable by the inhabitants by its large size instead of a traditional or specific form–as shown in Figure 5. In fact, other green areas are provided, but they appear as gaps resulting from the housing dislocation on the ground. The roads’ hierarchy can be noticed as well as the pedestrian circulation scheme, and low density to some extent assures a low vehicular circulation. All edifices are filled, making use of locally produced materials, augmenting once again the importance of environmental protection. Granite stone is employed for the foundations, fired bricks for masonry, tiled/pitched for roofing, timber for ceilings and other features that guarantee a high indoor quality comfort. Moreover, the use of clay increases the thermal mass and at the same time decreases energy consumption. The main elevations of the units follow the north-south orientation while the east-west facades present few and small openings to avoid too much sun exposure during the day (see Figure

8). The typical, overhanging roof protects from the north side heat but unfortunately is not exploited to harvest rainwater, thus reducing the water efficiency. Each unit is provided a front and back yard, two spaces that allow residents to enjoy the social and economic benefits of urbanization while minimizing ecological footprints.

The Kigali Vision settlement

In 2018, the second phase of the Gacuriro Satellite project was completed, finalizing the construction of the Kigali Vision. The 544 total units are articulated in a variety of housing typologies: apartment houses, twin houses, townhouses and villas - visible in Figure 6. Unlike Kigali 2020, the overall master plan displays an opposite approach for both the common area placement as well as the management of the site topography. Heavy retaining walls mark the land filling activities that create flat areas Between the highest building at the top of the site and the lowest at the bottom is a narrow green strip that physically connects the east and west parts of the settlement. The common facilities are located in the center and grouped around a main green cluster but are scattered all along the green park. The whole settlement is surrounded by a fence, giving it a protected compound nature that rejects future expansions and to some extent loses its urban nature. The main goal of Kigali Vision is for the modern citizen to have access to a modern lifestyle in a safe, quiet, and natural environment, but despite these premises, its construction reveals some criticality in terms of green innovation[8]. Regarding the building materials, there is prevalent use of cement blocks and concrete roofs that are not low embodied carbon. In addition, the design of two housing typologies, namely the villas and the townhouses, doesn't comply with the basic principles of tropical architecture, orienting the main facades north-south and the shortest east-west. The act of not orienting the buildings correctly affects the indoor environmental quality with an increase in temperature that leads to higher energy consumption. As seen in Kigali 2020, the Kigali Vision settlement doesn't adopt a water-harvesting system as the roof is not sufficiently sized to collect ample rain into the gutter system.

TWO HOUSING TYPES

This paper seeks to demonstrate that the relationship between the city and its architecture through an appropriate compositional structure is still fundamental to provide an acceptable environment during dramatic events like health crises. For this reason, it is important to conduct an analysis of existing examples to discern the prototypes applicable in the future of rapid urban growth. Assuming that the city builds itself over the time, two buildings' types from Kigali 2020 and Kigali Vision must be assessed for their degree of adaptability and sustainability: the twin house and the apartment house on the Gacuriro hill. The intent is to propose an appropriate model for the architecture of the city in its evolution, transforming a crisis into an opportunity to (re)discover its distinctive and foundational characteristics. Can an appropriate composition of twin houses or apartment buildings shape the modern city according to the vision of a city? Which of the two residential types can incorporate the traditional features linked to the local culture while at the same time mitigating the challenges derived from rapid urban growth? Will the issue of densification be tackled *horizontally* or *vertically*, semi-detached house or apartment house? These are the questions that will be addressed through the study of the chosen buildings in the search for a preferable and replicable solution. Kigali's territory is 70% rural, enforcing the idea that a community lives in symbiosis with its natural context, even when people are settled in urban areas. Coming up with a proposal for the future city housing developments first requires one to identify the most suitable ways to address challenges given by the rapid growth as well as the need to match the offer with the demand. The choice of housing types rests on three main factors: affordability, adherence with the local traditions, and response to emergencies. Affordability resides mostly in the environmental protection approach that was intended differently and applied in the settlements. Low carbon building materials and reduced soil movement rank Kigali 2020 better than Kigali Vision from the sustainability point of view. The area occupied by the apartment buildings in Kigali Vision settlement occupies a much smaller area than the twin houses in Kigali 2020 settlement, showing that only one third of people housed in Kigali Vision could be hosted in the semidetached houses. The vertical expansion limits the use of soil, freeing it for common activities but inevitably reducing private green spaces that are so important in the traditional way of life. In the next section, the analysis is concentrated on the impact of Covid-19 mitigation measures that were adopted to contain the spread of the virus, exploring their degree of adaptability.

Twin houses

The twin house, or semi-detached house type, is historically known and characterized by a definite structure. It is a single-family residence that shares a common wall with next dwelling unit. Largely used in the satellite garden city process that started in England at the end of the 19th century, this type shaped the city of tomorrow, from the crowded towns to the uncongested countryside. As previously stated, Kigali 2020 is composed of four different typologies of twin houses identified by different sizes, although the number of rooms (3) remains the same. Designed as affordable housing for various income classes of Rwandan society in 2015, it has become a reference for a number of other real estate projects. The smallest twin houses, model “1” and “2” are placed on the top of the site where the topography is relatively flat, while the model “3” and “4 “are located downward with an appropriate adaptation to the topographic context. This is known as a *raumplan*, a plan view organically articulated in three dimensions, coming from the site but not imposed to the site. During the Covid-19 crisis, the measures put in place, among others, have demonstrated how vital it is for the well-being an outdoor private garden. With the banning of gatherings in common spaces, the only way to remain in contact with nature is enjoying in one’s own back or front yard. Another added value of Kigali 2020 twin houses is the flexibility of extending the surface of the edifice - not only in the sense of providing more rooms, but more quality spaces. The planned layouts for the 4 typologies can be adapted to individual needs while refraining from breaking the overall skyline harmony – as shown in Figure 4.

Figure 4. Kigali 2020 twin house type “3” and example of its extension.

Apartment buildings

The Kigali Vision, compared to Kigali 2020, presents a variety of dwelling typologies targeting different income classes. In the case of the apartment buildings, the 2, 3 and 4 bedroom flats can be afforded by the same residents of the twin houses in Kigali 2020 settlement. In this regard, not only the similar size but also the rent and selling price can be compared. The apartment building has a long tradition in architectural history, starting from the Roman *insulae*, where housing units are composed as a whole in a building. The "H" shape edifices in the upper part of the settlement (see Figure 5) are related to the modern idea of free standing block with a common circulation area in the middle, made by a staircase that generates a double courtyard between the flats' wings. Immersed in the greenery of a linear park, the multi-story structures have just one common space on the roof top, which is mostly used as a drying area for laundry. During the Covid-19 lockdown, the imposed restrictionslimited the exploitable outdoor space to the tiny terraces of the living room and bedrooms. *Licht, Luft und Sonne!* – Light, Air and Sun! was the Modern Movement's slogan for the way of living in modern buildings. It becomes difficult to achieve these three requirements when also the basic principles for sustainable architecture are not taken into consideration. Wide loggias, or recessed balconies, can extend the living room outside while they provide an adequate shading to the building for increased internal comfort. This point raises the issue of orientation in the tropics, specifically under the equator line. In this region, main elevations have to be directed north-south limiting exposure to the eastern and western facades as much as possible. Addressing the traditional way of life in the apartment houses requires a direct connection with an outdoor space and an adequate store, which was so meaningful during the COVID-19 lockdown.

Figure 5. Kigali Vision apartment buildings: view from the main entrance.

Compositional patterns

An important role in designing the settlement masterplan is played by the overall compositional pattern. How the dwelling units are put carefully together, according to architectural rules, can be decisive in achieving certain objectives, as in the case of the Gacuriro Satellite. When compared to the typical apartment building typology, the twin house demonstrates a higher degree of affordability to better comply with the local traditions as well as the eventuality of emergency situation like the COVID-19 pandemic. An adequate architectural expression of the twin house can enhance the aforementioned features, as is found in some case studies from the past. In 1918, Peter Behrens and Heinrich de Freis published the book "Vom sparsamen Bauen[9]" ("On affordable building") which targeted the strategies for designing a *Siedlung*. They argue that the affordability of a new settlement it is not just about the use of local materials or standardized construction techniques as well as the utilization of the *Existenzminimum* principles, but in setting up a precise compositional pattern[10]. Grouping the twin houses differently and avoiding long narrowed rows increases the number of units per hectare while preserving the spatial qualities of the dwelling type. In the scheme represented in Figure 10, the two architects compare the variation of population density, from the detached house up to the *Gruppenbauweise* (System of group aggregation). The seven dwelling units group project, as illustrated in Figure 6, is built around a courtyard that offers a double view to all houses and a generous outdoor space. Transposing this pattern onto Kigali 2020, the place occupied by a twin house can be replaced by seven units to balance the density achieved in Kigali Vision through the apartment buildings.

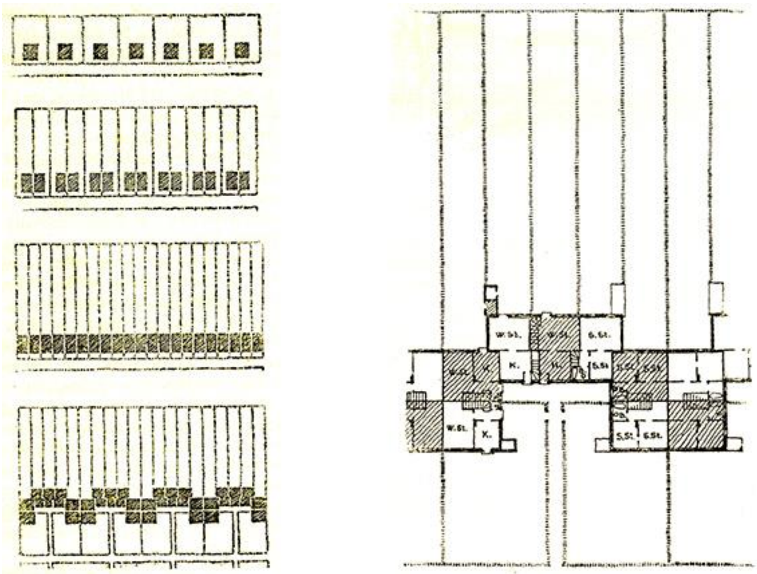

Figure 6. The *Gruppenbauweise* (System of group aggregation) by Peter Behrens.

CONCLUSION

The rapid city can contribute to rapid response with the success of an architectural solution. The recently approved Master Plan of 2020 traces the path of Kigali's future with the upgrading of affordable dwelling conditions. It is oriented on one side to an urban regeneration of the existing settlements and on the other side with the development of new projects. Once analyzed at different scales, from the continent down to the single unit, the study focused on two types of residence from the case studies in Kigali. The two types are amongst impressive case studies in the history of Architecture and have been utilized to compose the settlements shaping the Gacuriro satellite. The modern, polycentric Rwandan Capital is experiencing an urban Renaissance that points to the criticality of individual projects and their responses to the Sustainable Development Goals and the unexpected global events. In a society historically based on a strong relationship with the surrounding context, it is necessary to concentrate the housing efforts on types that can enhance this connection. The twin house is built up away from the congested downtowns and provides sufficient outdoor space mostly dedicated to garden. It includes major flexibility in terms of spatial expansion, which is also a feature in the traditional African house. Usually based on a central courtyard, the typical home built itself around an open area that progressively adds new structures according to the needs of its dwellers. The use of locally-produced materials with a low embodied carbon, such as clay bricks or tiles, allows for significant reduction of the urban environmental impact on climate change and assures internal comfort. Noting that the area occupied by the apartment buildings in Kigali Vision settlement has a density two-thirds greater than the same area occupied by twin houses in Kigali 2020, it can be deduced that the (re)discovery of proposals from the past can aid in the design of settlements made by a specific housing type, increasing the density and at the same time tackling issues related to eventual emergency situations.

NOTES

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RESPONSIVE MEGASTRUCTURES: GROWING FUTURE CITIES FOR GLOBAL CHALLENGES

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INTRODUCTION

In an era of rapid transformation and global uncertainties it is evident we need to forge new pathways for the design, delivery and sustainability of future cities.[1] In this paper, we propose a novel approach that aims to tackle such issues through our speculative design for a ‘responsive megastructure’, based on principles highlighted from our ongoing future visioning and prototyping research. We discuss the important role developing visions for future cities plays in seeking to address global challenges alongside how the development of a novel vision reveals and reframes key challenges in our prototyping research. By doing so, we define what a responsive megastructure might be and how it could be designed and fabricated to maximise its performative capacities and capabilities. The paper is structured into five sections. First, we provide a brief survey of past visions of megastructures to identify relevant key characteristics. Second, we then provide a definition of the criteria for our responsive megastructure. Third, we explain our design and fabrication approach for programming granular matter. Fourth, we present our vision for a responsive megastructure. Finally, we discuss the various benefits and challenges of this approach, prior to outlining several future research trajectories for this work. In doing so, we present a new vision for megastructures, where matter can be aggregated and scaled to grow future cities, that can embody the complexities of urban life in contexts around the world and respond to their situation and future challenges.

PAST FUTURES OF MEGASTRUCTURES

Future cities have long been dreamt up by a wide range of artists, architects, and designers.[2] As the impacts of industrialisation began to increasingly characterise urban landscapes around the world, these were reflected in visions of fast-paced future cities in the twentieth century and the technological thrust that drove many of these. Furthermore, as the complexity of urban life became apparent, the need and desire for architects and urban designers to respond to this situation led to a variety of attempts to envision future cities in spectacular ways.[3]

Through this impulse, the mid-twentieth century gave rise to the megastructure as physical embodiment of technological prowess to address the problems of urban populations.[4] For example, Kenzo Tange’s 1960 vision for the *Plan of Tokyo* included a network of transport infrastructures, floating residential islands, and concentrated urban centres to alleviate development pressures within the existing city. It took growth processes of biological organisms as a metaphor for future cities to illustrate how they could share capabilities of reproduction and responsiveness to their environments.[5] By contrast, Paul Rudolph's scheme for the *Lower Manhattan Expressway* project in New York City, 1972, sought to drive a megastructure through existing urban fabric. Here, the megastructure was conceived as a dynamic unstoppable force that aimed to integrate transport infrastructure with higher levels of monorails and people movers.[6]

Of particular relevance to this paper are those megastructures formulated from the outset as reconfigurable and responsive to changing needs. An important figure in this development was the British architect Cedric Price whose work investigated how architecture might promote social change through its adaptiveness. Price's collaboration with theatre producer Joan Littlewood, *Fun Palace*, 1961-1976, sought to integrate concepts of social participation and improvisation with technological interchangeability to produce a highly responsive environment. Price conceived the project in terms of process, with a core design principle committed to indeterminacy, thereby embracing the nascent fields of cybernetics, computer technologies, and game theory.[7] The endless adaptability of Fun Palace was to be able to both anticipate and respond to a constantly evolving programme.

In a similar vein, *Plug-in City* by Peter Cook, 1964, proposed a megastructure as a network of reconfigurable clusters and replaceable units. Based on principles of flexibility and functionality as well as being in thrall to science fiction, Pop Art, and the mundane technologies of the era, Plug-in City depicted the future through its kit of parts approach.[8] The project represents a powerful vision, premised on its ability to accommodate and actively encourage changes borne by obsolescence, as typologies of building nodes, each with a different lifespan, would plug into the main 'craneway', itself designed to only last forty years. Such fascination with social experimentation notably cooled down following the peak oil crisis as various countercultures imploded or were absorbed into the mainstream.[9] Yet, parallel to this decline there was a steady rise in future visions driven by technology, buoyed by advancements in computational processing power and software applications during the last three decades of the twentieth century.

From the mid-twentieth century the primary drivers for cities were industrialisation and globalisation, as urban development sought to maximise productivity via access to labour, resources and connectivity to markets. More recently, these drivers have been augmented and, in some contexts, replaced by those that emphasise people and their environment over profit.[10] As the manifold anthropogenic impacts of cities present major global challenges, it is clear we need new visions for future cities to respond accordingly. In order to open up the discourse concerning visions for future cities, in their analysis of such representations Dunn and Cureton propose three primary themes:

- Technological Futures - examines the optimism of those visions driven by technology and their dialogue with their expressions within science fiction.
- Social Futures - investigates the experimental and experiential visions for future cities led by an impulse to provide for a new society or create novel urban situations.
- Global Futures - takes account of those visions produced in response to the significant challenges of climate change and how we might enable collective life to be sustained.[11]

By placing emphasis on complementary types of futures, the value of this approach is that it enables different ideas and alternative pathways to be explored. We suggest that this presents an imperative for future cities to effectively bring together the technological, social, and global. We use speculative design to produce a vision for a responsive megastructure that seeks to achieve this in a manner that can be transferable and adaptable to a range of scales and contexts. In order to develop this proposition further, we next identify key criteria for such a vision.

IDENTIFYING CRITERIA FOR RESPONSIVE MEGASTRUCTURES

Past visions of megastructure highlight several key aspects that begin to inform how our responsive megastructure visualisations could extend their material resolution and responsiveness:

- Scalability - the use of space frame structures highlighted a scalable construction process based on modular units and universal interfaces between the material units. What assembly processes lead to scalable forms of manufacturing?
- Material interactions - the material units that make up the kit of parts were massive, heavy, inert and artificial. How can granular material units be interacted with to guide and grow structures that can respond in-situ?
- Resolution - the fixed dimensions and properties of individual material units dictated the resolution and types of responses the megastructures could produce. How can material units at granular resolutions enable a greater range of responses?

A major challenge evident in past megastructure visions concerns the scalability of their assembly process. Research at MIT's Self-Assembly Lab has illustrated material units can be programmed to assemble themselves by pre-designing the individual material units' geometries and their interfaces.[12] Thus, the fabrication system can: self-error correct without incorporating hardware/electronics[13]; self-reconfigure[14]; self-heal when broken apart; and generate structures not conceived within the design stage as the fabrication process is non-deterministic.[15] Furthermore, Tolley and Lipson demonstrate how modulating stimuli can begin to guide these material assembly processes.[16] This highlights the potential role modulating stimuli could play in programming matter at granular material resolutions.

By pre-designing individual units' geometries and fixing their material properties three main issues arise. First, the structures only generate reconfigurable geometric patterns that are recursive. Second, the resolution of the material units become fixed, which means local properties of the structure cannot be altered below the set dimensions of the individual units. Finally, the individual material units are materialised in advance and are artificial, meaning a surplus of parts could be generated. Alternatively, biological processes of fabrication are capable of materialising matter where and when it is needed. The ability to materialise matter on demand is particularly evident in bone remodelling via cellular activity[17] and in the meristematic zones of plants via cellular division (mitosis).[18] In the next section we set out the principles for such an approach for our responsive megastructure.

PRINCIPLES FOR A NOVEL DESIGN AND FABRICATION APPROACH

To explore the challenge of resolution and material interactions in regards to scalability as well as empirically grounding our vision for a responsive megastructure we present the design and fabrication approach developed through a series of iterative prototypes. Through our prototyping research, we aimed to increase the resolution of the material units and explore how they could be iteratively programmed to autonomously-assemble to:

1. Increase material capacities so multi-material responses are achieved with increasing sensitivities.
2. Develop the scalability of the assembly process by increasing material resolution.
3. Explore an approach for how granular matter can interact as part of large-scale architecture.
4. Understand how matter can be materialised when and where it is needed.

For these reasons we employed the mineral accretion process,[19] i.e. electrolysis of seawater, as the material platform across a series of prototypes.[20] The series highlighted several key principles for iteratively programming the matter of responsive megastructures, which we use to inform characteristics for our vision. First, creating scaffolds composed of physically separated cathodes can grow 2D shapes and 3D patterns and structures (Figure 1) from material units that autonomously assemble at highly granular resolutions i.e. molecular resolution, made possible by modulating localised parameters of stimuli.[21] Second, the mineral accretion process is a multi-material platform, enabling structures with variable material qualities to be manufactured, such as compressive strengths,[22] compositions, surface textures and densities.[23] Third, matter can be materialised when and where is it needed within our distributed cathode scaffolds by extracting material resources from the surrounding volume of water. Figure 2 illustrates matter being materialised away from the constraints of the pre-defined scaffold shape, which is possible as the material source surrounds the scaffolds. Finally, our prototypes reveal how highly granular units of matter can be iteratively programmed and interacted with by modulating parameters of stimuli, such as duration, magnitude, location, concentration, instead of pre-designing their properties. We term this approach 'tuneable environments.'

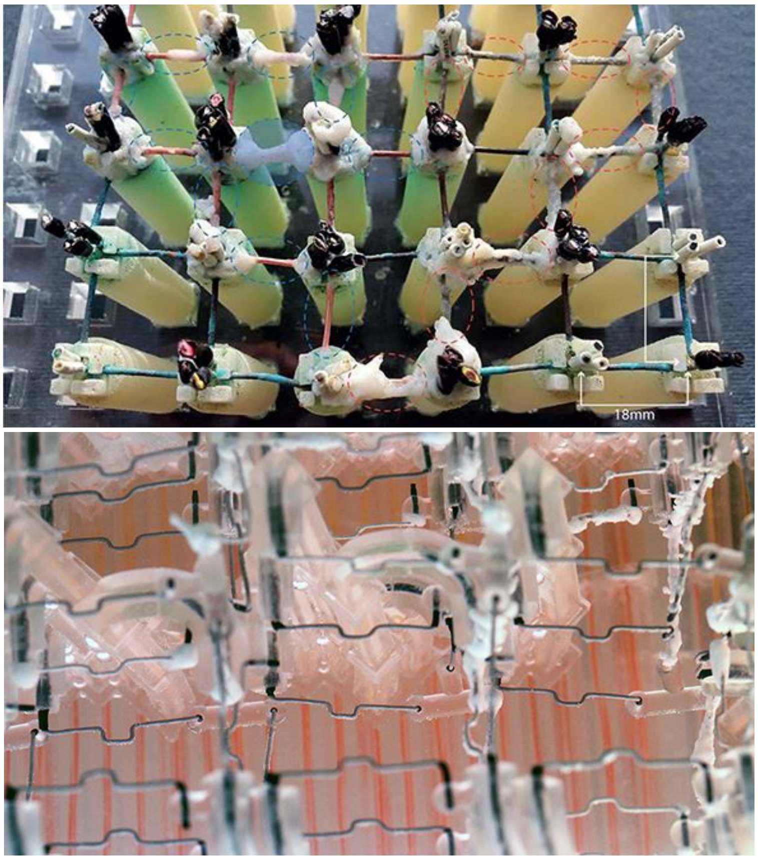

Figure 1. Upper image showing the growth of a 2D pixelated heart shape with various volumes of matter accreted. Lower image illustrates 3D shapes with various material properties.

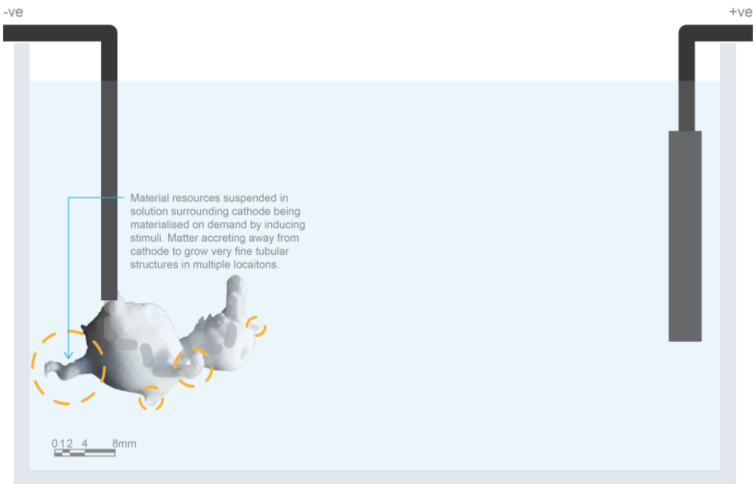

Figure 2. Illustrates how matter can be materialised away from scaffolds when surrounded by the material source as highlighted by the emergent tubular growth forms.

TOWARDS A RESPONSIVE MEGASTRUCTURE

We now present our vision for a responsive megastructure, which we deliberately chose to give expression to in a similar manner to past megastructure projects to aid its legibility. This decision is borne of the desire to better understand the implications of applying our approach at the scale of an urban region. We present these visualisations as a way to extend our inquiry and explore the potential of it as living-material system. Drawing inspiration from Constant's *New Babylon* project[24], 1959-1974, which was illustrated in a variety of contexts to demonstrate its relative impact, we situate our responsive megastructure within Paris, illustrated in Figure 3. It is intentionally located along the city's waterway network and main transport axis as we envision these could provide potential material sources as Figures 4 and 5 show. Specifically, the waterway network could supply abundant material resource to facilitate a materialisation process similar to the mineral accretion process. The major transport axis, meanwhile, could provide a carbon-based material source, extracted from the polluted air and transforming it into usable building materials.

Figure 3. Aerial render of existing Paris context.

Figure 4. Aerial render of responsive megastructure located in areas of Paris that generate materials that can be used materialise the structure and enable in-situ responses.

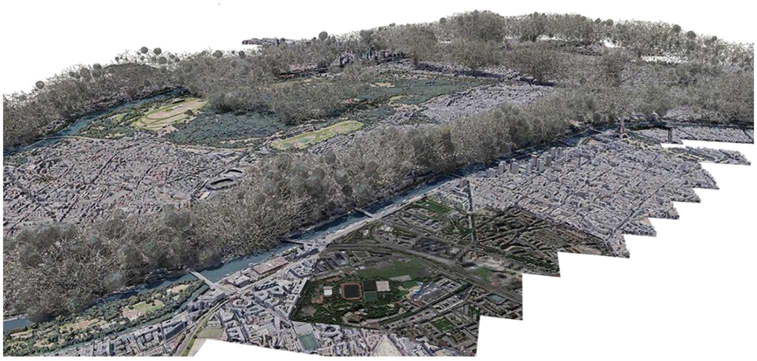

Figure 5. Visualisation illustrating the scale of the responsive megastructure relative to the existing Paris context.

Principles from our mineral accretion prototypes provide the rationale behind the world-building[25] for our speculative vision. Our prototypes highlight the ability to materialise small amounts of matter away from individual cathodes and on demand by modulating localised stimuli. This ability to generate matter on demand in relation to design associations resembles the process of mitosis (new matter being produced) within a plant's meristematic zones based on growth principles. However, new matter is materialised internally within the plant's 'skin', which acts as a flexible scaffold since it transports material resources, does not restrict the global and local shape changes of the plant during growth or a plant's position within 3D space. This highlights the significant impact scaffolds have on how responsive growth occurs in relation to geometric and material extent alongside the resolution of a structure. Our visualisations are informed by reflecting on these aspects and attempt to portray the requirements of a flexible scaffold.

First, the global form is based on creating a minimal surface volume along these material networks in which branching structures grow. This minimal surface envelope acts as a way to prevent uncontrolled growth that could be similar to issues with urban sprawl, including resultant drosscape.[26] Second, the structures resemble a branching network of roots or compartmentalised vein-like structures. We propose this acts as a flexible skin-like scaffold which is capable of growing with matter as it is generated. Third, for the materialisation of matter generated from liquid-based material resources the branching scaffolds would have to contain and transport material resource to where and when it is needed, ready for generating new, programmed matter. Finally, materialisation of matter has to be reversible to its original state. The use of state-changing materials could enable evolvable structures that are totally reversible[27] and still allow multi-responses at highly granular resolutions. As a result, large global and sensitive local responses could be achieved without the constant consumption of material resources. Instead, matter could be redistributed and reprogrammed to where it is needed most with minimal waste. In effect, this type of responsive megastructure would act as a living material eco-system by forming a material cycle that integrates with biological environments. These structures and processes would be capable of sharing resource when and where they are needed, potentially beyond the demands of an anthropocentric city and current material cultures. However, this also opens up new research challenges as we shall now discuss.

DISCUSSION

We conclude our paper by providing a critical evaluation of our vision for a responsive megastructure. Our speculative design and the visualisations developed to envision it has provided a valuable process through which we can reflect on, reframe and conceptualise key challenges raised through our prototypes. They provide a basis for reinvigorating ambitious architectural visions that were prevalent in countercultural movements evident between the late 1950s and early 1970s. Critically, our vision centres around the exploration of a design and fabrication approach that could enable a scalable and responsive architecture that is highly sensitive to external stimuli. We incorporate principles from our prototypes to illustrate how an assembly processes can be reimagined and how matter can be continually reprogrammed based on naturally occurring phenomena, such as stimuli, autonomous assembly and materialisation. Implementing these principles into an urban context to envision novel material interactions and a highly granular, multi-responsive architecture opens up new possibilities. One future trajectory points towards where architecture is capable of integrating with natural material cycles. This could address, perhaps even reverse, some of the anthropogenic impacts that cities produce due to the high demands they place on the environment based on current modes of assembly, which continually deplete and degrade natural resources. In addition, challenges of disassembly that currently exist within in the built environment due to aggregations of multiple materials could be tackled directly because the material make-up of our responsive megastructure can be iteratively reprogrammed at highly granular levels.

The speculative nature of our design necessarily raises questions that provide avenues for further research. First, determining the types of stimuli and how they are induced to create global, local and reversible responses within the overall megastructure will be crucial in shaping its ability to flourish in specific contexts. Second, there is a need for greater exploration into how non-linear associations can be created within a complex system and their interrelationships understood, so that it is possible to respond to competing interests from the social, global, and technological demands of urban life in a multi-scalar way. Third, being able to develop design strategies that can generate and reveal what a desirable response would be within a complex, multi-responsive system so material properties and current behaviours within cities co-evolve. Fourth, to create robust assembly processes that can prevent or reverse the hacking of the megastructure by those who could use stimuli to damage or exploit the materialisation of matter. Fifth, to examine suitable material platforms and processes that can lead to multi-material responses and interrelated, complex interactions that do not compromise unforeseen far future demands due to path dependencies including technological lock-in.

To conclude, it is our intention through developing a vision for a responsive megastructure to address the challenges of literally growing cities for the future. By drawing on our future visioning and prototyping research, we have sought to illustrate one way in which this might be achieved in practical terms. Despite the rigour of the underpinning laboratory work, we acknowledge the experimental approach of this inquiry. In this manner we have contributed our vision as a means of expressing the not-yet, since such imagery shapes our ideas of, and intentions towards, futures.[28] Through this example we have aimed to show that visions are powerful vehicles through which we can explore scenarios. Our ongoing work will delve deeper into the critical questions this raises including where cities can be located and where they cannot, what arrangements of density and settlement size are viable, and which materials will protect us and not further exacerbate environmental degradation.

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OVERHEATING AND OCCUPANT ADAPTIVE BEHAVIOURS IN NATURALLY VENTILATED WARDS IN THE TROPICS

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INTRODUCTION

Colonial pavilion-plan hospitals, which were built before the 1940s without mechanical systems for ventilation and cooling, constitute a significant part of the healthcare infrastructures across the Global South's equatorial zone [1]. Although architectural and medical historians have stressed the utilization of the pavilion-plan system in hospital design to facilitate segregationist practices, that fostered racial and class inequalities [2,3], to date we lack a comprehensive history of pavilion-plan hospitals in the British colonies.

This paper explores how colonial hospital architecture and environmental engineering define the thermal performance and adaptability of historical hospitals in today's post-colonial condition. Drawing on a mixed-methods case-study of four Nightingale and four modern wards, I will show how the hospital ward's conceptualization as an instrument for efficient ventilation and infection control transformed its layout and contributed to energy-conscious design. In so doing, the differences in thermal conditions, thermal comfort and occupant-adaptive behaviors between the Nightingale wards and the rest of the case-study wards were identified.

The complex environmental and behavioral processes determining the indoor thermal conditions were recorded in real-time over fieldwork of nine weeks in eight operational naturally ventilated wards at Connaught Hospital in Freetown, Sierra Leone. Archival research was conducted at the National Archives and the British Library in London, and the State Library in Freetown. Historical evidence was also reviewed in digitized medical reports, and reports by the Public Works Department, which were submitted annually between 1914 and 1961 by the British colonial government in Freetown.

Historical aspects of the Nightingale ward typology

Medical and architectural historians have found critical links between advancements in scientific knowledge and hospital architecture[4]. Theories of disease transmissions have influenced the conceptualization and design of ventilation systems [5]. Over the nineteenth century, and even until the birth of bacteriology in the 1870s, interdisciplinary discourses on the role of “vitiated air” on viral cross-contamination have formulated the theory and design of the Nightingale ward typology, which was a crucial component of pavilion-plan hospitals. Florence Nightingale was not the sole designer of the Nightingale ward typology [6]. However, her systematic work on the associations between poor sanitary conditions, overcrowding and inadequate indoor ventilation with high mortality rates among hospitalized patients, which began in 1854 at Scutari in Istanbul during the Crimean War, set the foundations for the conceptualization of the Nightingale ward as a spatial system facilitating the acceleration of patients' recovery through the strengthening of their exposure to higher levels of fresh air and daylight [7]. The auxiliary services were housed in separate wings while the open-plan multi-bedded area stood in the center with the patient-beds being placed with their heads facing the wall in only two rows, at opposite directions, and in pairs between each window [8]. Nightingale believed that better delusion of the polluted air was liked with higher volumetric spaces surrounding each patient's bed [9]. Therefore, she established a proportional correlation between the number of patient beds and the total volumetric space of the ward. The spatial configuration of the entire hospital complex had to advance the continuous circulation of air. Diverse hospital functions were allocated in detached pavilions connected with outdoor corridors, while patients with infectious diseases were isolated in autonomous buildings [10]. The parallel pavilions were separated with a distance that was equal to two times their height [11]. In 1864, Florence Nightingale was invited to contribute to a report about the necessary improvements for barracks and hospitals in British India [12]. Drawing on her extensive experience on European hospital design and on interviews with British officials, who had served in British colonies in India, she played an instrumental role in adapting the Nightingale ward typology for the British Indian Stations [13].

Contemporary ideas about natural ventilation, airborne infection control and climate responsive building design in equatorial climates

Nightingale influenced by experiments conducted at the Lariboisière Hospital, recommended a width-to-length ratio of 0.23 or lower to avoid draughts and stagnation of air in the center of the ward [14]. Latest evidence supports the association between the geometrical characteristics of a space and the reinforcement of natural ventilation performance. For cross-sided natural ventilation, it is recommended that the width of individual rooms should not exceed the floor-to-ceiling height by more than five times, whereas the width of the room should not be higher than 2.5 times of the floor-to-ceiling height ratio in the case of single-sided naturally ventilated spaces [15]. Although the effectiveness of infection control through natural ventilation remains a controversial issue, optimal ventilation performance combined with minimization of the duration of the exposure, and the viral dose, can strengthen the protection against airborne infection [16]. Quantitative studies in operational Nightingale wards have shown that high ventilation rates, which complied with recommended health and safety standards, could be achieved in these wards [17]. However, the uncontrolled dispersion of pollutants in these open plan multibed Nightingale wards necessitated an intervention, which contradicted Florence Nightingale ideas about the unobstructed circulation of air between patient beds, consisting in the addition of partitions between patient beds.

Dispersion of airborne pollutants can be controlled through displacement ventilation, which is suitable for single-patient rooms [18]. It is based on the principle, that warm air generated by occupants' bodies, and other heat sources within the breathing zone, can purge polluted air at higher levels close to the ceiling, if properly sized bottom-level and top-level openings exist in the room [19]. However, in rooms with windows and doors, but without top-level openings, warm air from the ceiling needs to be mechanically extracted. Empirical and experimental evidence suggests that even in hot-humid climates, where low temperature differences between interior and exterior spaces weaken the potential of natural ventilation performance, the combination of climate-responsive design and operation of the ventilation system and the building envelope coupled with low internal heat gains can maximize the cooling potential and the fresh-air exchange rates induced by natural ventilation [20].

THE DEVELOPMENT OF FREETOWN'S CONNAUGHT HOSPITAL (1817-1960) IN ITS COLONIAL CONTEXT

The Connaught Hospital was a critical case-study. Its historical buildings were built according to basic pavilion-plan typology principles while to date, it remains the main government-run tertiary hospital, with more than forty doctors and four hundred nurses, across fifteen departments and twelve medical and surgical wards (Figure 1). In 1817, nine years after the foundation of the British Crown Colony of Freetown, the Royal Hospital and Asylum for Africans was founded at the King's Yard site, as an institution for the provision of medical care and documentation to the newly arrived liberated African slaves [21]. In 1880, the Royal Hospital and Asylum for Africans became the Colonial Hospital and in 1910, the Colonial Hospital was renamed as Connaught Hospital in tribute to the visit in Freetown by the Duke of Connaught [22]. The Colonial Hospital was the first mixed-race and mixed-class medical institution for Western medicine in British West Africa [23]. It was probably also one of the first pavilion-plan hospitals in British West Africa. Although the exact spatial configuration of the Colonial Hospital's buildings remains unspecified, due to the absence of its plans from the National Archives in Kew, the British Library, and the State Archives in Freetown, a close reading of the colonial archives revealed that the Colonial Hospital was composed of a two-storey male ward block, and a two-storey female ward block, which were linked with an outdoor corridor. The complex also included a prison infirmary, an isolation cottage, an outpatients' block, and a mortuary [24].

By the end of WWI, a smallpox epidemic in 1915-1916 and an influenza outbreak in 1918 has brought the Sierra Leone Protectorate close to a financial collapse [25]. In February 1920, a catastrophic fire destroyed all the hospital buildings except the isolation cottage at its western side. By 1922, the first three ward blocks and the operating theatre were completed [26]. In 1925, the colonial architect Archer Betham drew a plan for future extensions at Connaught Hospital. In the proposed site plan, Betham followed the pre-established principles of the parallel position of ward blocks and the spatial dispersion of different uses in free-standing buildings, as these were originally applied at the Colonial Hospital [27]. By 1948, the Outpatients Block, the Medical Store Building, the Administrative Block and a fourth ward block were built and the Quarters for the Nursing Sisters, which also contained the new private wards, were ready for occupancy [28].

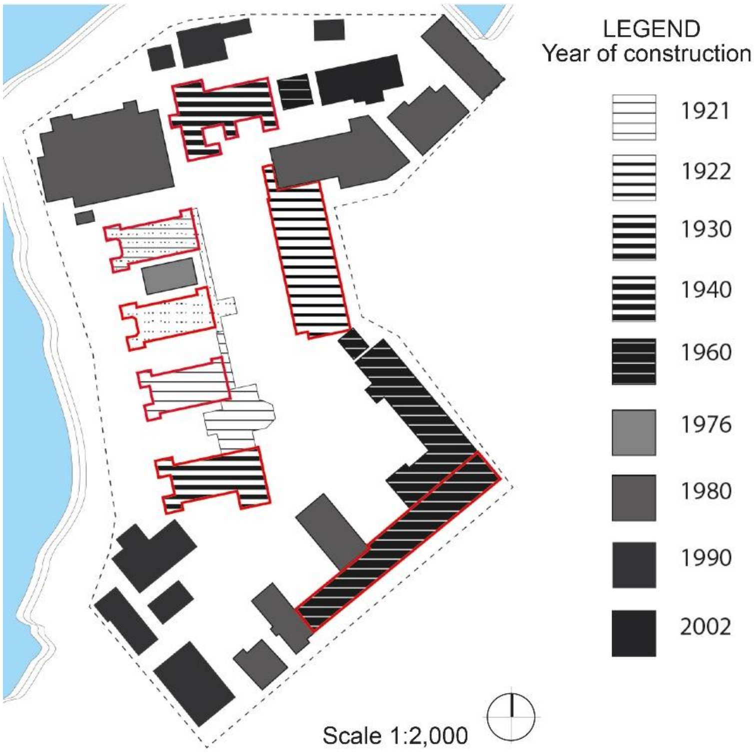

Figure 1. Historical evolution of Connaught Hospital's site plan (1921-2017). The case-study buildings are illustrated with red outline. Source: Author.

DESIGN OF PAVILION HOSPITALS FOR EQUATORIAL CLIMATES AND FLORENCE NIGHTINGALE'S CONTRIBUTION

Comparisons between the prototype ward for British India Stations and the ward for Europeans at the Singapore General Hospital (S.G.H.) with the Nightingale wards at Connaught Hospital were made to understand how the Nightingale ward typology was adapted for the equatorial climates and, how these ideas were reflected in the current pavilion-plan building at Connaught Hospital. These comparisons were justified by the fact that Arthur Betham, who was one of the key architects for the construction of Connaught Hospital, had worked as an assistant architect in Madras before arriving in Freetown. The comparison with the ward for Europeans at the S.G.H. was explained by the fact that the S.G.H is the only pavilion-plan hospital in the equatorial zone that has been thoroughly documented by an architectural historian.

In 1864, the B.H.I.C. driven by erroneous beliefs that the climatic extremes in the tropics reinforced the harmful effect of the "fetid" air on human health, rather than simply modifying the Nightingale ward typology to contain higher provisions of fresh air, they developed a climate-sensitive spatial system, where occupant adaptive behaviours were integral part of healthcare. As it is illustrated in the section of the prototype ward in British India Stations (Figure 2), the bedded area for in-patient accommodation was located at the first floor. A veranda run along the south, west, and north sides, separating the ward from the rooms with the auxiliary uses at the west side, while the east side remained attached to the bedded area. Shutters with angled louvres were installed between the pillars of the two storeys. The building's envelope was composed by cavity walls with air spaces while the roof had a suspended cross-ventilated structure and was covered with light-coloured tiles. The windows opened inwards and had external sliding angled blinds. The doors were equipped with moveable screens and top-hinged windows. The extraction of warm air from the ground-floor space was performed through an airshaft.

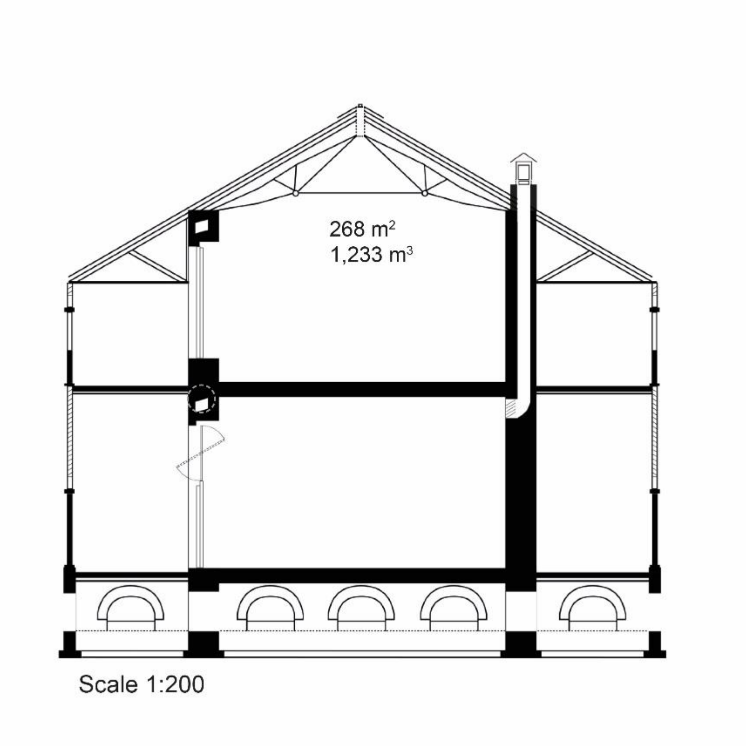

Figure 2. Section of the prototype ward in British India Stations. The section was adapted from the plan XXV[29]. Source: Author.

Similar to the prototype ward in British India Stations, in the Ward for Europeans at the S.G.H. (Figure 3), the bedded area was placed centrally, was cross-ventilated and was fully shaded with a series of arches with shutters situated opposite the ward's openings along the perimeter of the veranda while openable windows were installed at the north and south facades. The design of S.G.H. aimed at maximum levels of fresh air and daylight equivalent to an open-air space [30]. However, the design quality was hierarchically differentiated between the pavilions for Europeans and non-European patients. In the Nightingale wards at Connaught Hospital (Figure 4), the allocation of the narrow open-plan and fully shaded bedded area at the centre, and the auxiliary uses at the south-east and north-west wings at the front and back sides of the block demonstrated compliance with the recommendations by the B.H.I.C. (1864). However, the bedded areas in the Nightingale wards at Connaught Hospital had much lower volumetric spaces and they were not surrounded by an open-air veranda. Although the Nightingale wards at the S.G.H. had high coverages of openable windows without ventilated ceilings (Table 1), the windows at Connaught Hospital lacked shading and top openings.

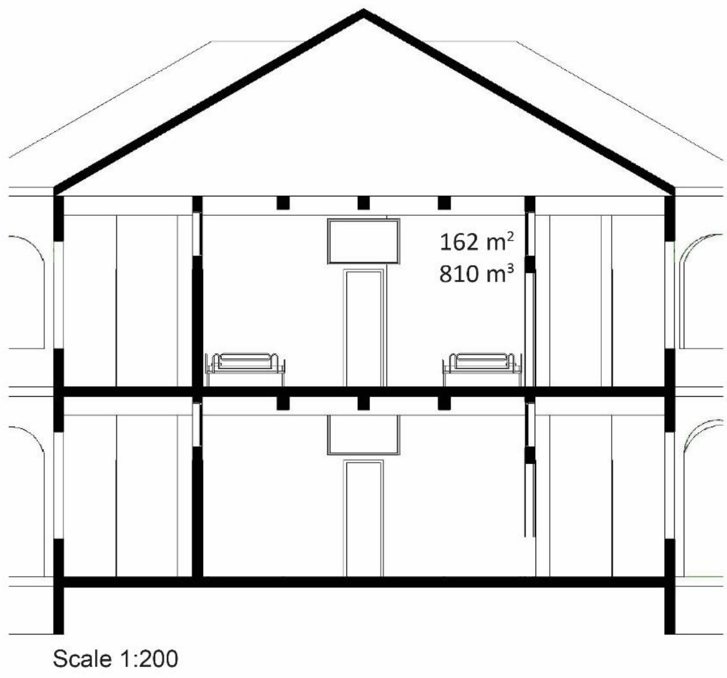

Figure 3. Section of the Ward for Europeans at the Singapore General Hospital. The section was adapted from a published plan [31]. Source: Author.

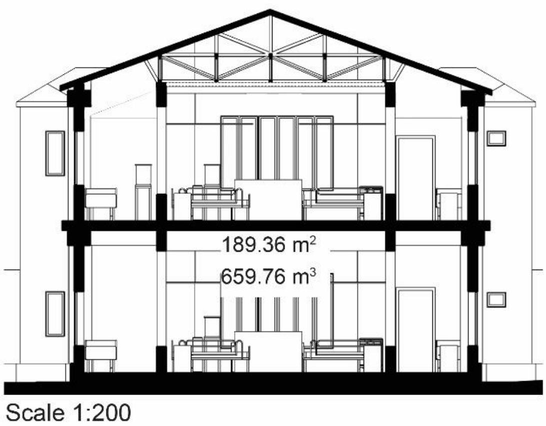

Figure 4. Section of a representative Nightingale wards in the Connaught Hospital, Freetown, Sierra Leone. Source: Author.

	Prototype ward for British India Stations	Ward for Europeans at the S.G.H.	Nightingale wards at Connaught Hospital
Cubic space per bed (m3)	≈ 51.38	≈ 75.00	≈ 40
Ventilation strategy	Stack-driven displacement	Cross-sided	Cross-sided
Width to length	0.23	0.50	0.45
Width to floor-to-ceiling height ratio	1.72	1.80	2.84
Openable window façade coverage (%)	27.00	40.00-44.0	20.00-38.00
External walls	Hollow blocks with air bricks	Stone	Stone
Horizontal shading	Veranda (3m depth)	Veranda (3.40m depth)	Enclosed veranda (2m depth)
Vertical shading	Louvered shutters (100% coverage of openings)		-

Table 1. Characteristics of layout, construction, and ventilation design in the Prototype ward for British India Stations, the Ward for Europeans at the S.G.H. and at the Nightingale wards at Connaught Hospital.

CONTEMPORARY BUILDING ENVIRONMENTAL PERFORMANCE AND OCCUPANT ADAPTIVE BEHAVIOURS

The case-study wards at the pavilion-plan building displayed the most optimal combination of spatial attributes for maximization of the natural ventilation performance. In these case-study Nightingale wards cross-ventilation was advanced by low width-to-length and width-to-floor-to-ceiling height ratios coupled with high coverages of openable windows (Table 2). However, as regards the drivers of environmental performance during contemporary operation, the windows in all selected wards lacked adequate shading devices and double-glazed windows while internal window curtains trapped solar radiation and by convection induced higher adjacent air temperatures. At the same time, heat gains by conduction through the heavyweight external and internal walls and by convection through the uninsulated ceilings and floors reduced the potential of nocturnal cooling contributing to higher night-time overheating.

	Pavilion	Building 2	Building 3	Building 4
Year of construction	1921-1929	1960s	1926	1948
Ventilation strategy	Cross-sided		Single-sided	Cross-sided
Width to length	0.45	0.48	0.92	0.54
Width to floor-to-ceiling height ratio	2.84	3.85	2.13	2.12
Openable window façade coverage (%)	20.00-38.00	58.00	10.00	26
External walls	Uninsulated stone walls with outer cement mortar and inner painted plaster			
Shading	Enclosed veranda (2m depth)	-		

Table 2. Characteristics of layout, construction, and ventilation design in the pavilion and the rest of the case-study buildings.

In Freetown, Sierra Leone, a climate-responsive building envelope would protect from overheating from nine in the morning to seven in the evening, when outdoor temperatures exceed 25°C [32]. It would also exploit the strong outdoor winds between one in the afternoon and six in the evening, while protecting from the indoor accumulation of humidity from three at night to eight in the morning.

Over the dry season, indoor environmental monitoring in the case-study wards showed that the periods with the highest indoor temperatures coincided with the nurses' and doctors' rounds and the highest exposure to solar radiation (Figure 5). Although, all selected wards began to cool down after five pm at different starting points only the Nightingale wards had the fastest cooling rates and the most extended periods of lower indoor night-time temperatures. As regards indoor relative humidity levels, an upward trend, which began after five pm, lasted until midnight and, although it became weaker, it continued until six am. All case-study buildings had mean twenty-four-hour indoor temperatures between approximately 28 and 31°C with the pavilion-plan building accommodating the wards with the lowest mean temperatures and the highest mean relative humidity both during the dry and the rainy seasons.

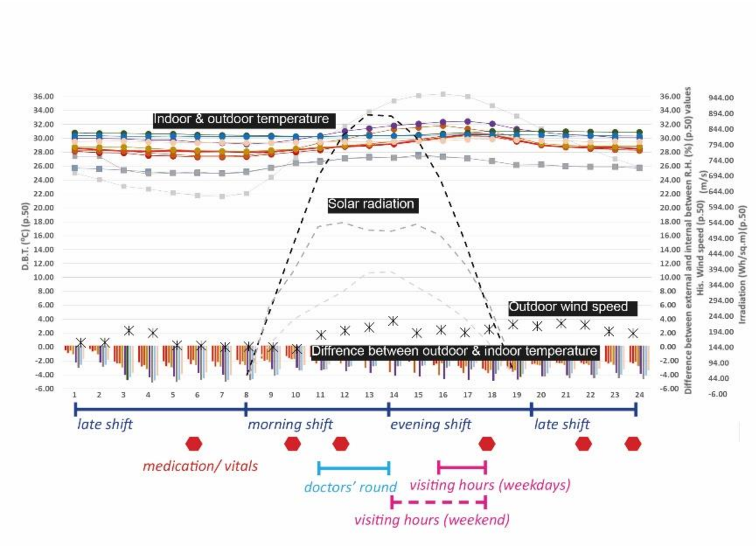

Figure 5. Combined graph of the median hourly indoor and outdoor temperatures (°C), their differences (°C) and the historical data of the global horizontal and direct normal solar irradiation (Wh/m²) and wind speed (m/s) and the Connaught hospital's schedule of the nursing activities, the doctor rounds, and the visiting hours per time of the day during fieldwork over the dry season. Source: Author.

Recorded window-opening behaviors during the morning and the evening shifts remained irresponsive to indoor and outdoor environmental changes with the median total percentages of open apertures slightly fluctuating around 40% over both the rainy and the dry seasons across all case-study buildings (Figure 6). Consistently more climate-responsive window-opening behaviors were not observed among occupants in the case-study Nightingale wards. However, interviewed occupants during fieldwork over the dry season in the selected Nightingale wards reported the highest levels of thermal comfort in relation to the recorded indoor operative temperatures (62.01%), relative humidity (57.81%) and airflow values (63.41%) (Figure 7). Overall, the patients reported the highest percentages of thermal discomfort. However, the experienced thermal comfort among patients was the highest in the pavilion building in terms of indoor operative temperature (79.22%), relative humidity (72.16%) and airflow values (80.21%) (Figure 8).

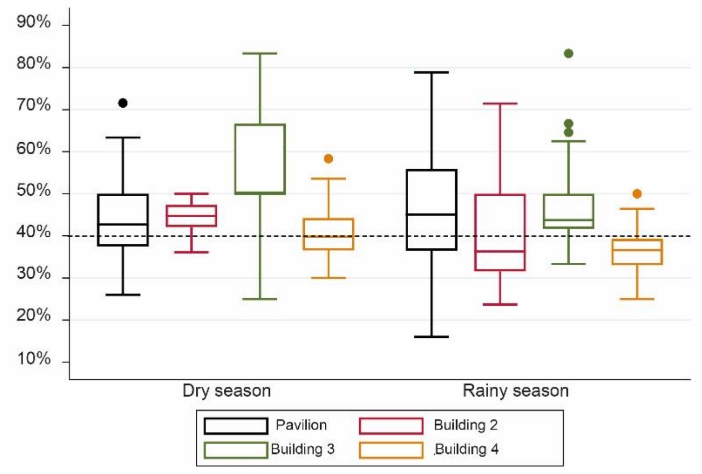

Figure 6. Boxplots of the recorded total percentages of open apertures during the morning and the evening shifts in the pavilion-plan building and the rest of the case-study buildings.

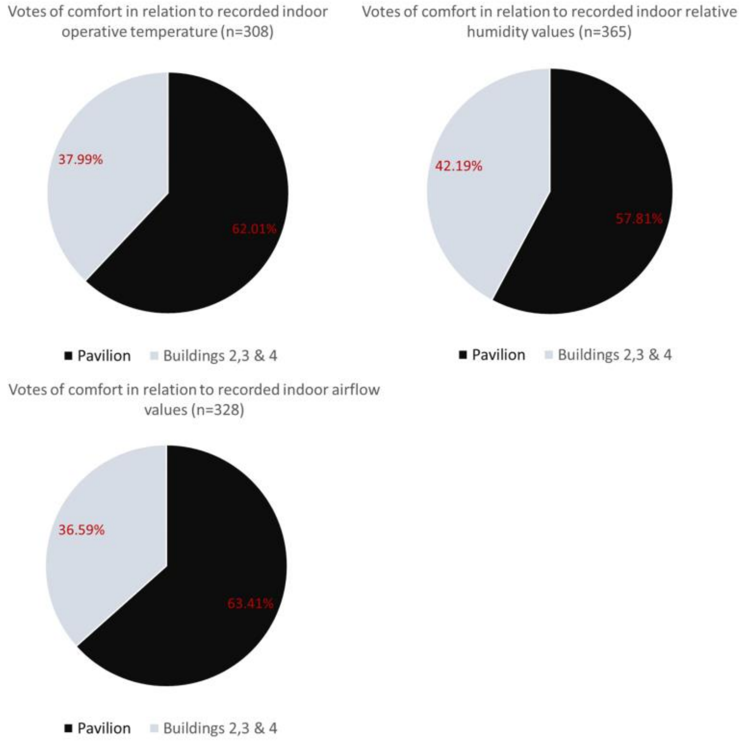

Figure 7. Comparisons of the percentages of comfort votes in relation to recorded indoor operative temperature, relative humidity and airflow values between the pavilion and the rest of the case-study buildings during fieldwork over the dry season.

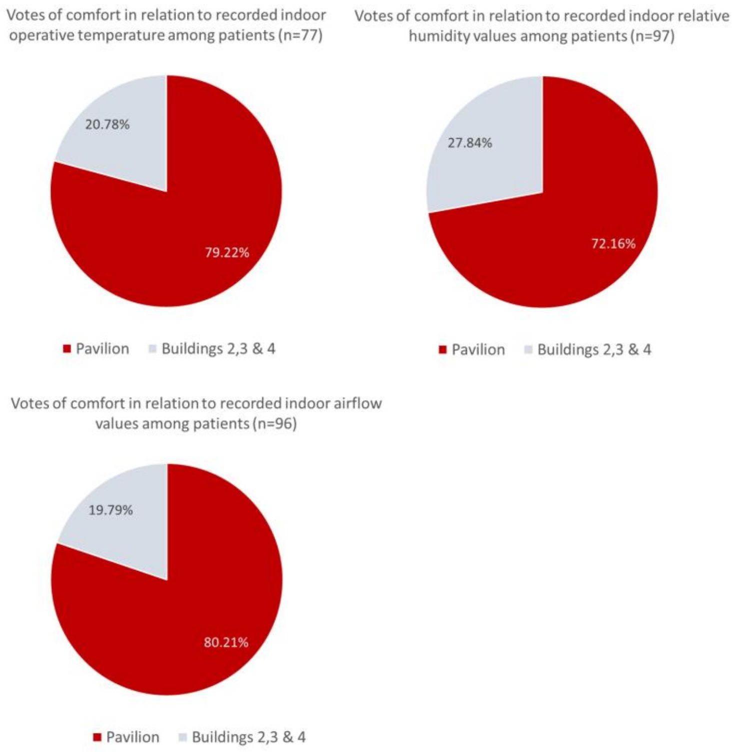

Figure 8. Comparisons of the percentages of comfort votes in relation to recorded indoor operative temperature, relative humidity, and airflow values, which were reported by patients, between the pavilion and the rest of the case-study buildings during fieldwork over the dry season.

CONCLUSION

Hospital occupants in buildings across the equatorial zone, where natural ventilation remains the primary mechanism for cooling and infection control, will be in higher risk of experiencing unhealth levels of indoor overheating due to the unmet cooling needs that are being accelerated not only by climate change but also by higher expectations of medical care as the CONID-19 pandemic evolves. In the late 19th century, architects and engineers building on Florence Nightingale's experience in hospital design developed and applied principles of environmental engineering for the maximization of the potential for natural ventilation in colonial hospitals across the equatorial zone. This is an indication that historical Nightingale wards might be more suitable to be repurposed for the treatment of COVID-19 cases cross the Global South. However, attention needs to be paid to interventions in the building envelopes and the operational schedules that might have reduced any embodied capacity for climate-responsive ventilation performance. Design of windows in hospital wards, which is primarily driven by security, safety and maintenance concerns and vector-control, limits the accessibility and the easiness of window operation. At the same time, hospital occupants in the strictly regulated hospital environments are not expected to act to restore thermal comfort at an individual level and through their interaction with building controls. However, in naturally ventilated spaces thermal adaptability needs to be strengthened and occupants need to be trained to operate the windows in climate-responsive ways.

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DEFINING CULTURAL DATA SCIENCE

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INTRODUCTION

Since 2019 a new term called "cultural data science" has emerged as a result of the increased utilisation of data within the fields of art and humanities, cultural studies and the built environment. It differs from a similar term called "cultural analytics" in that the latter is principally concerned with the "analysis and visualization of large cultural data sets and flows" [1]. Cultural data science, on the other hand, can be thought of as an extension of cultural analytics, urban studies and social science with a particular focus on applying advanced computational methods to various forms of cultural data to test hypotheses and devise new frameworks for policy, planning and market action within the creative and cultural industries.

At present there is no clear definition of cultural data science, therefore, the aim of this paper is to present the first definition of the field. Adapted from Irizarry[2], cultural data science is defined as the umbrella term used to describe the entire complex and multistep process used to extract value from cultural data with real-world implications to influence policy, placemaking and market dynamics within the creative and cultural industries. This new concept is a unification of several academic fields and hopes to respect and honour the ideas, methodologies and tools developed by these adjacent fields. Its intention is to assist purpose-driven collaboration between public and private organisations and has the potential to become increasingly important for stakeholders in the built environment and policy makers who want to apply novel frameworks and evidence-based methods to influence the artistic and cultural vibrancy of place, space, societies and our local economies.

This paper explains how the importance placed on the creative and cultural industries as key drivers of our economies and the increased volume and velocity of data within the industry has spurred a need for cultural data science, especially in the post-COVID-19 pandemic era where many aspects of the industry have moved online and have become digital. The paper first explains why cultural data science is required, it then discusses the distinct aspects of cultural data science, a definition of cultural data science is then provided for the first time, and finally it describes how the theory and methodologies can be applied and its limitations.

WHY WE NEED CULTURAL DATA SCIENCE

The cultural and creative industries have received much attention since the turn of the millenia as an important driver of our economies and stimulant for societal and urban change; more so in the developed world, but increasingly in the developing world too. As summed up by Montalto et al[3], the sector is known to be responsible for constituting important parts of local identity and quality of life, creativity and innovation, tourism, urban growth and regeneration, and well-being. Consequently, particular attention has been given to the industry by international organisations such as the United Nations, OECD and European Commission, and governments of the United Kingdom and Australia have produced dedicated strategy documents for the industry such as the Creative industries: Sector Deal[4] and Strategy: 2020-2024[5], respectively. Moreover, city-wide cultural megaevents such as the European City of Culture and UK City of Culture and policy initiatives such as the London Borough of Culture and Cultural Creative Spaces & Cities[6] illustrate the desire of policy makers to utilise targeted event-driven cultural programs and initiatives to stimulate culture-induced change.

It has become more common, and in some cases it has become a requirement, to undertake thorough and rigorous evidence-driven evaluation research prior to and following such initiatives, whether it is a mega cultural event, a sweeping cultural policy program, or a local creative initiative. A clear illustration of this is the London Borough of Culture Evaluation Outcome Framework[7] developed by the Audience Agency in 2018. Furthermore, the Coventry City of Culture Trust has devised a Performance Measurement and Evaluation Strategy document[8] alongside a theory of change for Coventry 2021 UK city of Culture. The justification for undertaking evaluations of this nature is to demonstrate the impact of cultural events and initiatives at a time when they have "increasingly come under the scrutiny of funders, policy-makers and planners"[9]. All of this is part of a broader trend of using data-driven methods to measure the impact of the cultural and creative industries. The UNESCO 2030 Cultural Indicators[10] are a bold step in this direction: "the development of a new framework for measuring and collecting data on culture is foundational both for advocating for the role of culture in the SDGs, as well as for integrating culture into development plans and policies at the national and urban levels and within the United Nations Development Assistance Frameworks (UNDAF)". Additionally, the European Commission's Cultural and Creative Cities Monitor[11], developed in 2017 and updated in 2019, is motivated by the desire to create composite indicators to benchmark the cultural vibrancy, creative economy and enabling environment of 200 European cities against one and another.

Alongside the growing interest in measuring and demonstrating the industry's impact to our economies and societies, an increasing volume and velocity of data is being generated from, with and by the creative and cultural industries. Indeed, it is noted by Bruce, Malcolm & O'Neill that "the driving force behind the industry's continued success is the growth in digital content consumption, along with the rapid development of new platforms and digital technologies, especially through the expansion of devices connected to the internet"[12]. Manovich describes a world where "billions of people create media, sharing them, and having access to trillions of media objects"[13]. Our global culture was already moving online before the COVID-19 pandemic struck; the rate of change sharply accelerated as a result of it.

Despite top-down strategies and requirements for evaluation, and with a new wealth of data being generated within the industry, cohesive data-driven initiatives are not being utilized from the bottom-up by most cultural and creative institutions. Bruce, Malcolm & O'Neill explain that "many cultural arts organisations generate value through the relationships they create and the networks they sustain, but far too often this data is not clearly articulated or evidenced to leverage insight, support and business opportunities"[14]. The institutions that made significant investments in upgrading their data infrastructure and making their labour pool more data literate while these seismic data trends were taking place would have survived, and even thrived, during the pandemic. For example, the National Theatre increased it's YouTube subscriber count from 76,000 subscribers to 700,000 during the first lockdown in Britain in 2020, and received 10 million views on NT at Home in 6 weeks on YouTube compared to 10 years for NT Live, their own platform[15]. Initiatives such as Europeana "empowers the cultural heritage sector in its digital transformation"[16]. Yet for many, old legacy data systems, a lack of data literacy and even resistance to new technologies has severed hadicapped data adoption, and the requirement to undertake evaluation has become a burden.

Clearly there has become an increased desire by the creative and culture industries to learn from their data, and advanced computational and data science methods offer an opportunity to analyse this data at scale. This has led to a term called *cultural data science* to appear on the international stage, and has even been turned into a university bachelors course at Aarhus University[17]. However, the term itself, theories and concepts of *cultural data science* are yet undefined and not clearly articulated for people to utilize it to its full potential. The industry needs a unifying set of frameworks, instructions and series of steps to explain how value can be extracted from cultural data by using advanced computational methods and how the results of their research can be used to answer policy questions and how data-driven insights can be used to defend against scrutiny and champion change.

HOW CULTURAL DATA SCIENCE IS DISTINCT

Before diving into how cultural data science can be applied by those in the creative and cultural industries, it's important to first clarify what the term means. The best way to explain what cultural data science means is by explaining what it does not mean; *cultural data science* is not *cultural analytics*, much like *data science* is not *data analytics*. The nuance is very subtle, perhaps a matter of semantics to some people, but there are differences.

First, one must understand the dichotomy between *data analytics* and *data science*. Data analytics is often referred to as a "process" or "procedure" that transforms raw data into meaningful information to find patterns[18], whereas data science, a term that still lacks consensus[19], found its roots in academia and is often referred to as a "discipline" or a "study" to "extract knowledge from information"[20]. Data science unifies "statistics, data analysis, machine learning and their related methods"[21] to question and test hypotheses with data by writing algorithms and building statistical models. In fact, a Harvard Data Science Review paper written by Meng explains that data science is "best understood as a collection of disciplines with complementary foundations, perspectives, approaches, and aims, but with a shared grand mission"[22]. Furthermore, Irizarry extends Meng's definition to describe data science as an "umbrella term" to describe "the entire complex and multistep processes used to extract value from data" with "real-world implications"[23].

The term "cultural analytics", invented by Lev Manovich in 2005, is "the exploration and analysis of massive cultural data sets of visual material". The way cultural analytics is framed in Manovich's 2007 whitepaper is about "mining data and then visualizing data", furthermore, Manovich (2015) explains that cultural analytics is interested in the "patterns that can be derived from the analysis of large cultural datasets". Here we see that the term cultural analytics is very similar to that of data analytics in that it is a process of discovering insights and patterns from cultural data.

Although similar, cultural data science, on the other hand, aims to be grounded as a science, one that poses questions, discusses and applies interdisciplinary methodologies to test hypotheses and extract value from cultural data to understand and positively influence the underpinnings of human culture and society. Cultural analytics presently lacks frameworks for influencing policy and instead focuses on "analyzing cultural trends". Cultural data science differs from cultural analytics in its focus on real-world, practical application, and hope to work alongside decision-makers and government agents to help guide cultural policy.

WHAT IS CULTURAL DATA SCIENCE

At present, there is no clear definition of cultural data science, therefore, this work presents the first definition of the field. Adapted from Irizarry[24], *cultural data science* is defined as the umbrella term used to describe the entire complex, multistep process used to extract value from cultural data with real-world implications to influence policy, placemaking and market dynamics within the creative and cultural industries. This process is initiated by the desire to answer a pertinent question within the creative and cultural industries using data and involves collecting and cleaning any form of cultural data that is relevant to the question, exploring and applying advanced computational methods to that data to test hypotheses, and presenting the findings of the study to stakeholders as well as devising new frameworks to influence policy and market dynamics within the industry. Figure 1 illustrates the seven-step *cultural data science* process to undertake research within the field.

Cultural data science is a unification of several academic fields (Figure 2) and hopes to respect and honour the ideas, methodologies and tools developed by these adjacent fields. In the broadest sense, cultural data science is at the union of arts & humanities, social science, computer science and mathematics; more specifically, it can be thought of as an extension of cultural analytics, urban studies and computational social science. Computational techniques are used to analyse both quantitative and qualitative data where machine learning and deep learning techniques can analyse text or visual data.

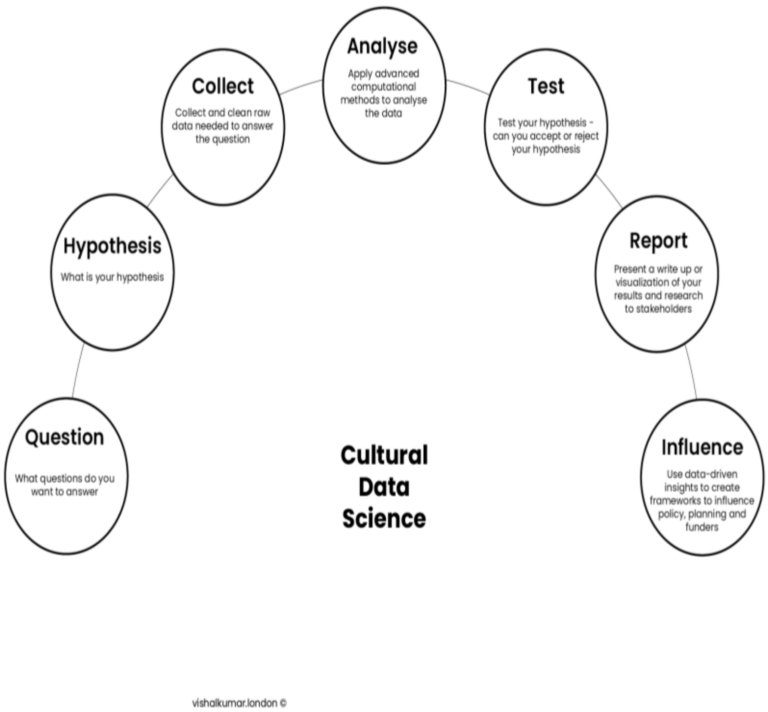

Figure 1. illustrates a seven-step process to undertake cultural data science.

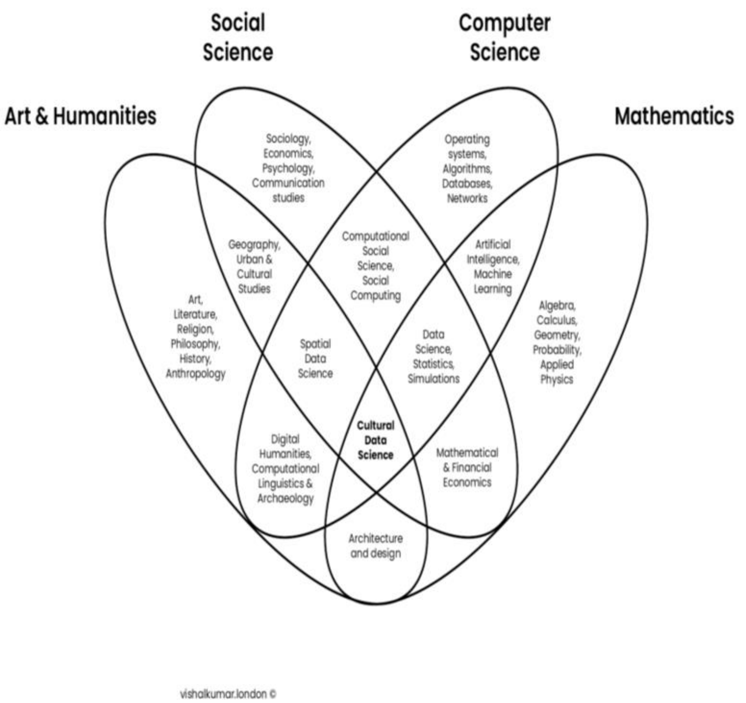

Figure 2. A Venn diagram explaining cultural data science

HOW CAN CULTURAL DATA SCIENCE BE APPLIED

Cultural data science cannot be undertaken without cultural data. But what exactly is cultural data? Handwerker and Wozniak describe cultural data as those that "reflect the social (interactive) process by which we construct our knowledge of each other and the way these social processes work"[25]. As our culture has moved more online, Manovich describes the four categories to explain our global digital culture that can be analyzed computationally at scale: media; behaviours; interactions; events[26]. Kumar describes several categories of cultural data within the creative and cultural industries[27]: historical cultural datasets - data about traditional cultural heritage and artefacts and the digitization of collections in museums and libraries, both visual data and textual data; contemporary cultural datasets - activity, user-created content and interactions on social media; art market transactions - data about art and cultural objects that are traded; socio-economic cultural datasets - data about our economies, preferences and societies that are usually collected using surveys; spatial cultural datasets - the location of cultural buildings, public spaces and public art; new forms of cultural data - data such as digital assets used in augmented and virtual reality.

Where does the cultural data come from? Institutions within the cultural and creative industries have their own proprietary data on audiences, tickets sales and cultural artifacts, and usually this data is stored in a data warehouse; many of these systems are old legacy data warehouses but some institutions have moved to the cloud[28]. Some institutions such as The Metropolitan Museum of Art[29], Victoria and Albert Museum[30] and The Wellcome Collection[31] have decided to open up these data to the public via an application programming interface (API). International institutions, national governments and city authorities are also collecting data and making them openly accessible through online portals. For example, portals by Arts Council England[32], data.london[33], and make.open.data[34] offer a trove of publicly available data. Social media platforms and tech companies such as Twitter, Foursquare and Google Places offer access to user-generated data through APIs. More recently, new mobile technologies and sensors are collecting data too[35].

Once cultural datasets have been collected, organised and cleaned, various computational methods can be applied to them to extract value and understand their economic, social, cultural, or environmental impact. First exploratory data analysis and the methods suggested by cultural analytics can help understand patterns and trends in the data. Then advanced computational methods can be applied to extract value from cultural data: statistics can be used to perform econometrics to understand the relationship between variables; spatial data science can undertake geographic-weighted regressions to understand the spatial relationship between variables; natural language processing can execute linguistic analysis to learn from text; computer vision techniques can learn from images and videos; and, network science can understand how data is connected. Moreover, data visualizations can be used to present the findings of the research; data visualizations are increasingly being used to present ubiquitous data information[36].

The process of collecting cultural data and extracting value from that data by applying advanced computational methods to answer pertinent questions in the cultural and creative industries will lead to novel insights being drawn. When those insights are written up, reported and presented they can be used to have meaningful data-driven conversations and discussions with policy makers, planners and funders, which allows for arguments to be made about the importance of the cultural and creative industries to drive significant change. The aim of *cultural data science* is to assist purpose and data-driven collaboration between public and private organisations and has the potential to become increasingly important for stakeholders in the built environment and policy makers who want to apply novel frameworks and evidence-based methods to influence the artistic and cultural vibrancy of place, space, societies and our local economies. For example, if a city were to take a data-driven evidence-led approach to implementing a new cultural policy in combination with architects, developers, local residents and cultural institutions, the entire procedure can be assisted and guided by the methodologies, frameworks and toolkits from cultural data science.

It's important for institutions to clearly plan and articulate a cultural data science strategy before beginning any project. This allows for the right data collection, data infrastructure and data analysis techniques to be to be implemented and then applied for evaluation, and can lead to the creation of indicators or benchmarking metrics to compare the value of the project against others.

LIMITATIONS OF CULTURAL DATA SCIENCE

The enthusiasm for the "datafication" of culture and society is not shared by all. Helen Kennedy's Post, Mine, Repeat explains that research should be weary of the negative consequences of the desire to mine social media data because of its effects on civil liberty and data privacy. Ethical considerations should certainly be consulted when undertaking cultural data science, and the theory could be strengthened by providing best practices. Yet, innovative civilian data initiatives such as the data commons, where citizens come together to pool their personal data, are being tested and trialed in European Cities such as Barcelona and Helsinki and offer a glimpse of how data relations can become more equitable in the future leading to better quality data generated for research purposes[37]. Additionally, there is a large extent to which cultural, creative and artist value cannot only be captured using objective methods[38], therefore, cultural data scientists must work with and alongside more subjective and emotional representations of value. There are also more practical limitations in terms of the lack of data literacy and data infrastructure within the creative and cultural industries. In the short term, it will be difficult to transition to a world that is completely data driven, but institutions should plan to be more data driven over time.

CONCLUSION

In conclusion this paper presented the first definition of the term *cultural data science*, an important step in genesis of a new field of research. Future research should dive deeper into exactly how these methods can be executed and what technologies can be used to perform cultural data science alongside relevant case studies. Finally, ethical considerations should be explored and best practices should be suggested.

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A SINGULAR LOGIC: NARRATIVE TRANSFORMATIONS IN THE RELOCATION OF EXPO '92'S GALICIAN PAVILION

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INTRODUCTION

On April 20, 1992, the Universal Exposition of Seville (Expo '92) opened, the first event of its kind since the world's fair in Osaka, Japan in 1972.[1] Expo '92 celebrated the quincentennial of Columbus's arrival in the Americas with the theme "The Age of Discoveries," inviting each of the participants to show off the many dimensions of human exploration and culture from the previous five centuries.[2]

The centerpiece of the Exposition was the artificial Spanish Lake (***Figure 1***), surrounded by seventeen pavilions dedicated to each of Spain's autonomous regions. Each defined their identities in conversation with their autonomy, Spain, and supranational unity. Among these, Galicia's response focused largely on the cultural heritage and iconography of its famous medieval pilgrimage route, framing it as an established narrative of unity with ongoing, deeply historical relevance, as the route continued to grow in popularity in preparation for the upcoming 1993 Holy Year.

The Galician pavilion (***Figure 2***) is unique among the buildings of Expo '92, for it was reconstructed back in Galicia's capital, Santiago de Compostela, at the close of the Expo and repurposed as the home of the Sociedad Anónima de Xestión do Plan Xacobeo, the organization put in charge of planning and managing events surrounding Xacobeo '93 and all subsequent Holy Years. In many ways, reusing the Pavilion for this purpose interrupts the motif that was established in the moment of Expo '92 and was accordingly reflected through its architecture. This paper examines how the building—and the connotations about unity and pilgrimage that it evokes—shifts in its two different environments.

Designed by Galician architect José Antonio Franco Taboada, the Galician Pavilion stands twenty-one meters tall and is composed of mainly granite and glass. The structure comprises two design motifs; the main entrance and view of the Pavilion mimics an ancient hypaethral, or open-air, temple, and the interior structure, nestled in the bulk of this outer temple, is tall, square, and faced with glass.[3] The thick outer facade of granite presses against a wide bulky staircase that forms a rooftop terrace about a third of the way up the inner structure, allowing more engagement with the entire Pavilion. The weight of the outer walls is repeated in the inner facade with two oblong columns of glass and metal that flank the main entrance of the structure and contain interior staircases. The appearance of the building is lightened by the addition of a metal-work canopy that bridges the outer walls. This canopy features a metal frame with two layers of overlapping small, mirrored panels, and is repeated in its reflection on the central glass building.[4]

The open-air design of the Pavilion intimates the way in which Galicia related with the federal and international goals of the exhibition. By jointly celebrating the global exploration five centuries earlier and the coming new millennium, the goals of Expo ‘92 were primarily to promote not only the past discoveries humankind had made, but the “discovery” of the potential in the newly-formed European Union and, more specifically, how Spain would champion and contribute to this new pact. Just as Spain led the world during the age of exploration, now too, at the turn of the century, it would become a leader in this new, pan-European venture. The championing of Spanish culture was not unique to Expo ’92: with Madrid’s designation as a European Capital of Culture and Barcelona’s hosting of the Summer Olympics, 1992 has been seen as the year in which Spain announced its re-entry onto the world stage. Galicia also sought to demonstrate its connection with the goal of unifying Spain and the world by promoting the means through which the region has always connected with Europe: the pilgrimage to Santiago de Compostela. Their actions to this end were two-fold. They first sought to construct a view of the pilgrimage as a hub for cultural interaction and pan-European understanding throughout history. Furthermore, their demonstration at the Expo and beyond sought to extrapolate this view onto the contemporary state of the pilgrimage as the cultural linchpin of contemporary Galicia.

Figure 1. Panorama of the pavilions for the autonomous regions of Spain on the Spanish Lake, Expo ‘92, Seville. (Photographer unknown. Wikimedia Commons)

To that end, the structure's use of granite and its directional emphasis towards the sky conveys the permanence of Galicia’s own temple to St. James in two very obvious ways. First, granite, the essential local material in almost all of Santiago de Compostela’s architecture, connects the structure to Compostela’s urban form. Secondly, the emphasis on the open-air temple and its star-like canvas recalls both one of the Jacobean pilgrimage origin myths and its consequent celestial directional thrust: the path of the Milky Way.[5] At the Pavilion of Galicia, this connection to the pilgrimage route continues throughout the interior of the structure: much of the promotional material inside the pavilion emphasized Santiago de Compostela and Galicia’s ties to the Way of St. James. In particular, Compostela's role as a long-time destination for travelers and its subsequent cosmopolitanism was stressed throughout the exhibition.

The direct connection to the pilgrimage to Santiago de Compostela recalls, then, a long-standing historical, yet intricately politically-constructed view of Galicia as a center of pan-European engagement. Similarly, the architecture physically invites interaction, beckoning to Galicia’s ongoing commitment to cultural promotion and understanding through the continued use of the pilgrimage route. The open-air pavilion’s interior staircases were open to the public to walk up and down, exploring the building and thus “Galicia” from multiple angles and viewpoints. As a visitor ascends the staircase, the play of light becomes more evident both on the canopy and in its reflection in the glass; the field of stars resides in two places at once, both in Galicia’s past and now foregrounded in its present.

Although subtle, these design choices are politically charged, especially in relation to the two other pavilions of the "historic nationalities"[6] positioned beside Galicia's, where the global stage presented to other regions an opportunity to demonstrate their independence. Directly to the right of the Pavilion of Galicia stood the Pavilion of Catalonia (Pere Limona; *Figure **3***, left), whose intentionally distorted floor plan represented a resistance to the urban grid. The entrance of the building includes commissioned graffiti (Antoni Tàpies)[7], which the architects intended to reflect Catalonia's proposal for the ultimate discovery of humankind: freedom and the right to exercise it. Here, idealistic views of a regionally-inspired unified Spain and Europe were displaced by a forthright display of moral authority in the form of access to fundamental rights.[8]

Figure 2. Pavilion of Galicia (José Antonio Franco Taboado) at Expo '92, Seville. (In Raúl Rispa, Expo '92 Seville: Architecture and Design, 1993.)

Figure 3. (Left) Pavilion of Catalonia with "Catalunya" graffiti. (Right) Pavilion of the Basque Country. (In Raúl Rispa, Expo '92 Seville: Architecture and Design, 1993.)

Likewise, directly beside the Pavilion of Catalonia, the Pavilion of the Basque Country (Luís Angoloti and Apolinario Fernandez de Sousa; *Figure **3***, right) boldly represented ideas of freedom and independence within its design. Here, the rectangular building's facade takes the form of an abstracted *ikurrina*, the Basque national flag. This autonomous region's entry into the European Union is proudly displayed on the building's facade: through the unity and unique character of the Basque Country. The design and architecture of the Pavilion does not incorporate any of the subtle nods toward pan-Europeanness or ecumenicism promoted by Galicia; rather the message displayed is wholly and singularly Basque.[9]

These bold statements juxtaposed beside the Galician Pavilion were especially emphasized during Galicia's day of recognition, when then-President of the Xunta de Galicia, Manuel Fraga, described the pavilion and its exhibits as demonstrative of Galicia's renewal and its embrace of Spanish federalism, in contrast to, say, the Basque separatist movement:

Today, Galicia is recovering its historical and cultural identity in an exemplary and balanced fashion by reclaiming its freedom without sterile inferiority complexes or overly aggressive and arrogant attitudes that are scarcely efficacious and lack solidarity.[10]

Despite these strong connections drawn between Fraga's federalist views and amicable Spanish unity, he also exclaimed, at the fair's opening ceremony, that the role of the Expo was not just to promote human achievement but also to exemplify the "Europe of the autonomies."[11] With a Jacobean-inspired design drawn from Galicia's historical connotation as a place of exchange for European culture, the region's showing at the Expo demonstrated the Xunta's underlying goals for maintaining the status quo of Galicia's engagement to broader politics by utilizing pilgrimage iconography. Here the establishment of Galicia as a fundamental building block of European history both erases other historical trajectories and smooths differences in political policy, situating contemporary Galicia into a longer narrative of European engagement.

Following the close of Expo '92, with most of the other structures and pavilions left to ruin, the Xunta de Galicia took a tangible step to maintain a connection with the Expo by carefully transporting the Pavilion back to Galicia. There, it was eventually re-erected near where the *Camino Frances* enters Santiago de Compostela proper and made the home of the newly-created Xestión do Plan Xacobeo (Xacobeo). While in previous years the management of and preparation for each year's pilgrims was shared between the archdiocese and the Ministry of Tourism, in recognition of the record number of pilgrims expected for 1993, the Xacobeo was formed in 1991 as a separate and distinct organization, wholly dedicated to this purpose. Xacobeo manages all advertising and event organization surrounding major Holy Years (also, confusingly, referred to as Xacobeos from 1993 onwards). It publishes guides to Santiago de Compostela for pilgrims and tourists and, in conjunction with the cathedral's Pilgrim's Office, maintains records regarding the number of travelers along the Camino each year.[12] Choosing to (re)construct a building for the newly-created tourism organization reveals the local government's perceptions of the long-term success of the Xacobeo program and also aligns the newly-recoined Xacobeo with the larger transnational ideals presented at Seville. In all of these changes, it is clear that the Xunta foresaw great success for this new program and the Xacobeo rebranding. On the whole, the initiative has been successful, in its husbandry of the route, continued maintenance over the past three decades, and ongoing cultural production in and around Compostela. Ultimately, the goal of this new campaign was to intertwine the promise of unity and discovery both from Seville and at home, specifically by physically manifesting Galician identity through pilgrimage and then resurrecting this identity within the actual landscape of the pilgrimage. It is, however, in housing itself in this iconic structure, that these aims come into question.

At this time, the city government was also actively and successfully initiating municipal works to preserve the city's history and to help transform the sleepy town into a cultural destination of the 1990s.[13] Specifically, then-mayor of Santiago de Compostela Xerardo Estévez, himself a practicing architect, had undertaken long-term urban renewal, advocating that Compostela "preserve and transform" and encouraging urban development and growth by emphasizing the city's historical and contemporary planning, its architecture, and its culture. Estévez's initiatives preserved the historic city center (resulting in two UNESCO World Heritage designations); created municipal spaces and administrative offices; renewed public space with infrastructure and parks; and all the while facilitated the construction of several important civic works.[14] These large-scale projects had been a core component of Estévez's 1989 General Plan for the City, which focused on creating high-quality architecture to help "shape" the layout of a contemporary Compostela, one both navigating a rich cultural history and primed for new contemporary engagements.[15] Within this plan, there was an emphasis on cultural pluralism where a sensitivity to the past while encouraging new encounters with the city and its citizens was key to all forms of intensive planning that went into the city's revitalization.[16] The Xunta's goals of connecting to Europe have a distinction to their city-affiliated counterparts.

While the Xunta and the city government often collaborated on these large-scale urban revitalization initiatives, the Fraga administration slowly began to shift the official cultural narratives to focus solely on marketing the Camino de Santiago above all other Galician cultural offerings.[17] This shift came with a larger portion of the cultural budget now devoted to projects- infrastructural, programmatic, and architectural— that fit within the landscape of Compostela as a hub of pilgrimage-based cultural tourism. Within this system, any dynamism was lost as systems of wealth interconnected public policy to political actors, leading to a "folklorized" Galician culture where tradition and cosmopolitanism were the representational motifs of the regional-populist right governing Galicia, thus stifling any other form of representation in the region.[18] By the first few years of the 1990s the cultural logic of Fraga was made evident—that the arts, both past and present, could be integrated into one project which would use culture to promote tourism to the region. Fraga's cultural policy depended heavily on the administration, a belief in the profitability of culture as an economic stimulus, as well as catering to private entities. In this system, consumption rather than cultural representation was the ultimate goal, with overt control put in the hands of the administration.

The changes occurring at this time through Galicia's spatial and visual production went beyond making the pilgrimage more ecumenical. In fact, in its new location, the historic thrust of the pavilion's canopy of stars is overshadowed by corporate logos of pilgrimage, highlighting more a municipal venture for economic gains rather than historic unity. Rather than a sense of pilgrimage *communitas*, the build-up to 1993 demonstrates a focus on touristic promotion on this final leg of the Camino. However, it would be a mistake to consider this merely a marketing strategy because it also expresses deeply felt connections to Europe and, it should be noted, some palpable aversions to their Spanish history.[19] Because of the nation's fascist past and the regional autonomies established in the post-Franco period, the idea of a European Spain was promoted as a way of formulating nationhood free of the associations with "nationalistic" rhetoric: in contemporary Spain, its identity is burdened by associations with the perceived "backwardness" of the Franco era and concerns of appearing "underdeveloped" to outsiders.[20] The concept of "Europe" provides a means of legitimization for the Spanish identity, not just in the political or economic spheres, but also in relation to the nation's emotional state, especially as it takes form regionally. For Spain, the reformation of its identity under the guise of Europe represents a way of re-establishing the national and regional self-respect lost during the early twentieth century.[21] However, the Pavilion's relocation directly interrupts the motifs established in its architecture that directly echoed these sentiments at Expo '92. Its new location in its role as home to the Xacobeo group, lies down a side street in a business park where, for pilgrims nearing the end of their journey, this monument to the canopy of stars they have been following across northern Spain is entirely out of view and out of mind.[22]

As such, while the Expo building is almost practically removed from the pilgrimage landscape that it references, it is emblematic of the larger systematic cultural production overhaul of Galicia that occurred during the Fraga administration of the nineties, one which would act as an agent and producer of a specifically globally-branded Compostellan culture, shored up within a framework of a cultural democracy.[23] In Galicia, the narrative of pilgrimage espoused at the Expo—that is, at the Expo, the pilgrimage to Santiago de Compostela functioned as Galicia's credentials for contemporary transnational unity, one which emphasized Galicia, however narrow of a representation—now became a continuation of the pilgrimage motif for the self-promotion of the Xacobeo group and by extension the efforts of the Fraga administration.

The Expo building secured the Xunta's ongoing cultural policy begun in the nineties of utilizing the values of spectacle and the Camino within an architectural schema to demonstrate Galicia's modernization through tradition and image. Here the overt connections between history and architecture are used as a political marketing tool to Europe—specifically one with traditional and moralistic overtones. That the Camino could attract visitors to Galicia by foregrounding its historical and cultural importance became the singular logic behind the late twentieth-century transformations of Compostela and resulted in several large-scale architectural projects in relation to the pilgrimage route, culminating in the 1999 announcement of Compostela's own "starchitecture" project with Peter Eisenman's *Cidade da Cultura de Galicia*, whose design contains the same symbolic preoccupations of historical pilgrimage motifs found in the Expo '92 building. This branding-via-architecture seems key to the government's choice of Eisenman's proposal, as, like the relocated Galician Pavilion, it overtly utilized typologies of the pilgrimage, thus facilitating the political underpinnings of the specific cultural ideologies supported by the Xunta by stylistically omitting all other elements of contemporary Galicia. Thus the Pavilion, when located in Galicia, functions as a monument to the ideals Fraga espoused at Expo '92: more than demonstrating the differences between city and state about what constitutes Galicia's European values, it instead solidifies the haunting persistence of Fraga's influence over Galicia's cultural policy and international presence, including the elements of its reputation made visible to the rest of the world. Furthermore, removed from the context offered by its placement at Expo '92, this one-time landmark-of-unity's specific architectural vocabulary is underutilized and lies stagnant among the business parks of San Lazaro— in fact the Xacobeo group moved to different offices in 2016 leaving the Expo building vacant.[24] The reinvention of the Pavilion of Galicia in this new location culminates, in fact, in a misinterpretation of the architecture: what once stood in Seville as a concrete materialization of unity throughout Europe and beyond instead misaligns its architectural connection to pilgrimage to become an out-of-the-way monument to the organizational exigencies of Galician cultural policy.

NOTES

[1] Running from April to October, Expo ‘92 spanned more than 500 acres, attracted nearly forty-two million visitors, and featured delegations from over 100 countries.
[2] Richard Maddox, *The Best of All Possible Islands: Seville's Universal Exposition, the New Spain, and the New Europe* (Albany: State University of New York Press, 2004), https://muse.jhu.edu/book/4822.
[3] “Pavillón de Galicia na Expo 92,” *AG* (blog), April 15, 2013, http://arquitecturadegalicia.eu/blog/pavillon-de-galicia-na-expo-92/.
[4] David Lombao, “Máis de 13.000 Euros Ao Mes Por Vixiar o Pavillón Do Xacobeo,” *Praza Pública*, April 15, 2013, sec. Economía, https://praza.gal/economia/mais-de-13000-euros-ao-mes-por-vixiar-o-pavillon-do-xacobeo.
[5] Santiago's mythical first pilgrim, Charlemagne, was told to follow the path of the Milky Way through Northern Spain until he would find St. James amongst a field of stars. Charlemagne's origin myth helped fuel the route's popularity and also, according to legend, gave the city its name.
[6] Maddox, *The Best of All Possible Islands*, 205.
[7] Raúl Rispa, *Expo '92 Seville: Architecture and Design*, 1993.
[8] Maddox, *The Best of All Possible Islands*, 211–12.
[9] Maddox, 210.
[10] “ABC, Seville Edition, Special Section on Expo '92,” *ABC*, July 23, 1992, 46–47. Cited in Maddox, *The Best of All Possible Islands*, 213.
[11] “ABC, Seville Edition, Special Section on Expo '92,” 61. Cited in Maddox, *The Best of All Possible Islands*, 133.
[12] Xacobeo manages revenues and expenses of a network of public albergues and other pilgrimage-related buildings, maintains some municipal management such as such as road signage. The organization is related to and associated with the Friends of the Camino and assist in coordinating activities around Jacobean culture.
[13] A. G. Abella, “Cidade Da Cultura. ‘Arquitectura Pura’ Para El Pueblo | Aaaaarte,” accessed January 9, 2021, https://web.archive.org/web/20110809050740/https://www.aaaaarte.com/noticia/2011/03/cidade-da-cultura-arquitectura-pura-para-el-pueblo; see also Llàtzer Moix, *Arquitectura milagrosa: hazañas de los arquitectos estrella en la España del Guggenheim* (Anagrama, 2010).
[14] *E.g.,* Juno Cano's Auditorium of Galicia (*Auditorio de Galicia*), Álvaro Siza's Galician Center for Contemporary Art (*Centro Galego de Arte Contemporánea*) and adjoining Bonaval Park (*Parque de San Domingos de Bonaval*), Josef P. Kleuhues's San Clemente car park (*Pabellón Polideportivo de San Clemente*), Alberto Noguerol's Congress and Exhibition Hall of Galicia (*Palacio de Exposiciones y Congresos de Galicia*), John Hejduk's Trisca Sociocultural Center (*Centro Sociocultural A Trisca*) and Álvaro Siza's Faculty of Communication Studies (*Facultad de Ciencias de la Comunicación*); Xerardo Estévez, “Opinión y Práctica En La Ciudad Histórica,” *Quintana. Revista Do Departamento de Historia Da Arte* 3 (2004): 25–44.
[15] This was a continuation of an older conviction- one acted upon in 1976 when renowned architects, led by Aldo Rossi, gathered in Santiago to discuss the recovery of historical urban areas (1st Seminar on Contemporary Architecture, SIAC). Miguel Anxo Rodríguez González, “Del Espectáculo Cultural y Sus Efectos: Arte y Políticas Culturales En Santiago de Compostela,” *Espacio, Tiempo y Forma. Serie VII, Historia Del Arte* 0, no. 3 (2015): 380; *c.f.* Seminario Internacional de Arquitectura en Compostela et al., eds., *Proyecto y ciudad histórica* (Santiago de Compostela: C.O.A.G., 1976).
[16] Xerardo Estevez, “Elogio de la ciudad,” *El País*, October 20, 1999, sec. Opinión, https://elpais.com/diario/1999/10/21/opinion/940456803_850215.html.
[17] For the most part these figureheads from different parties within the Galician government collaborated efforts. Along with the Xacobeo group, the Consorcio de Santiago was established in 1992 to manage the large-scale investments made within the city and included funds from the State, Xunta, and City budgets. Rodríguez González, “Del Espectáculo Cultural y Sus Efectos,” 397.
[18] “*La folklorización sumada al cosmopolitismo, son dos de las cualidades que definen la política de la derecha regional-populista que ha gobernado en Galicia durante tres décadas*”. Jorge Linheira, *La cultura como reserva india: treinta y seis años de políticas culturales en Galicia* (Madrid: Libros.com, 2019), 58–60. See Rodriguez Gonzalez's interview with Encarno Otero, Rodríguez González, “Del Espectáculo Cultural y Sus Efectos,” 381.. See de Toro's work on *movida*galega* for more information on the issues surrounding the establishment of Galician cultural identity, Xelis de Toro, “Bagpipes and Digital Music: The Remixing of Galician Identity,” in *Constructing*

Identity in Contemporary Spain: Theoretical Debates and Cultural Practice, ed. Jo Labanyi (Oxford University Press, 2002), 237–62.

[19] This connection to Europe helped to carve out the bidirectional structure of identity building under the direction of the European Union. Lähdesmäki discusses how the cultural aims of the European Union forge an "imagined" cultural community out of the obvious diversity present among the many peoples of Europe. She emphasizes that European cultural policy is grounded in the discourse of forming a shared community across all of Europe. In this way, Europe is actively engaged in the creation of a unified cultural identity for the continent. More specifically to this project, MacLennan notes that the EEC/EU had no explicit requirement that its member states have a democratic government until after Spain's application for entry. Thus, in addition to the concept of Europe being formative to Spain's national conception of itself, the country's interaction with the wider supranational organization spurred a further self-evaluation of the definition of European. See: Tuuli Lähdesmäki, "Rhetoric of Unity and Cultural Diversity in the Making of European Cultural Identity," *International Journal of Cultural Policy* 18, no. 1 (2012); J MacLennan, *Spain and the Process of European Integration, 1957-85.* (UK: Palgrave Macmillan, 2016); Juan Díez Medrano, *Framing Europe: Attitudes to European Integration in Germany, Spain, and the United Kingdom* (Princeton: Princeton Univ. Press, 2010).

[20] Pablo Jáuregui, "'Europeanism' versus 'Africanism': 'Europe' as a Symbol of Modernity and Democratic Renewal in Spain," in *The Meaning of Europe: Variety and Contention within and among Nations*, ed. Mikael af Malmborg and Bo Stråth (Oxford; New York: Berg, 2002), 80–81.

[21] Jáuregui, "'Europeanism' versus 'Africanism.'" Furthermore, for Galicia, this alignment with Europeanness provides an outlet for the calls for independence that were not quite satisfied under the new Spanish constitution. The concepts of being Galician, Spanish, or European are not neatly layered or easily separable, and thus inform these new centers for culture and heritage that were emerging at this moment. Thomas Risse refers to this as the "marble-cake" theory of collective identity and contrasts this with the "layer-cake" theory of collective identity in which constituents can deconstruct their relation to the collective (e.g., "Bavarian-German-European"). Thomas Risse, "European Identity and the Heritage of National Cultures.," *Rethinking Heritage / Ed. by Robert Shannan Peckham.* 7489 (2003): 74–89.

[22] For the rare pilgrim that does divert their path or return to the area, the openness originally promoted by the structure is also utterly missing. Its use as a governmental space erases the accessibility offered by the glass facades and the embrace of the staircases--in fact, during a recent visit to the site, the stairs were entirely blocked off due to disrepair and disuse. Furthermore, removed from the context offered by its placement at Expo '92, this one-time landmark-of-unity's specific architectural vocabulary is underutilized and lies stagnant among the business parks of San Lazaro.

[23] Linheira, *La cultura como reserva india*. Linheira references Raymonde Moulin to understand cultural democratization as "an effort of public institutions to convert a privilege of minorities into the common good of the people." It is therefore a process of opening an access for culture to the largest number of people. The idea of culture as a collective heritage emerges in Galicia in the early 1980s through policies which promoted a "cultural state." *C.f.* Raymonde Moulin and Pascaline Costa, *L'artiste, l'institution et le marché* (Paris: Flammarion, 1992); Marc Fumaroli and Eduardo Gil Bera, *El Estado cultural: ensayo sobre una religión moderna* (Barcelona: Acantilado, 2007).

[24] "Xacobeo Deja San Lázaro Después de Dos Décadas y Se Instala En A Barcia," accessed January 9, 2021, https://www.elcorreogallego.es/hemeroteca/xacobeo-deja-san-lazaro-despues-dos-decadas-instala-barcia-GKCG972501.

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CIRCULAR CITIES CAREERS: SUSTAINABLE CAREERS ENABLING SUSTAINABLE CITIES

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INTRODUCTION

In the light of rapid urbanisation, simultaneous unsustainable urban development going in hand with depletion of resources and GHG emissions that destroy the foundation of human survival on this planet is going on. Catalysed by the current global pandemic, the question for the future of the way we live and work on this planet is rapidly at stakes, yet prone to radical change to evolutionary processes. Urban environments must evolve to become a viable system as productive (e)co-players in food production, energy conversion and the cycling of resources like water and biomass while maintaining cities as hubs for ideas, culture, science, productivity, social, human, and economic development.

Future Urban Complexity

Beyond the warnings received from Donella Meadows et.al. in 1972 through the Report "The Limits to Growth"[1], the thereof resulting Sustainable Development appeals combined with the so-called digital revolution accelerates the quest how we think, plan, design, produce, consume the built environment. As one of the proprietors amongst other forward thinking economic think tanks, the current World Economic Forum emphasise that a shift in future skill, competencies and renewal of the above is adaptively needed to hold stand with this accelerated urban development demand.[2] Here the widened field between digital futures, new work models, entrepreneurship and inclusive markets in hindsight of the established SDG goals and targets will develop. A 'Smartification' of cities offers to be part of the solution to regulate an ever more interconnected world for an ever-increasing urbanisation of the globally growing population. Considering the spectrum of current urban developments, the complexity of urbanisation processes has risen. Careers, disciplines and professions involved in the making and managing of cities are clearly defined in their fields. However, in the needed change to higher complexity, an interconnected, networked and adaptable evolving approach is required.

Systemic Thinking as a methodological solution for complexity

Eco-System Thinking and Ecological System Principles teaches the aspects of co-existence and development interconnected and inherent in a complex system. Integrating into this earthly endeavour with all its sub-systems and elevating fractals towards balancing climate, natural resources, and social environments requires the development of competencies that must be different from the once that

caused the devastation of this planet. A reconsidering of interconnectivity methods between tunnel-visioned professions must be questioned and possibly restructured in an ongoing process.
This paper approaches a holistic system's perspective on rapid cities developments from the angle of responsive, adaptable, and resilient professions and skills needed to drive and develop regenerative urban metabolism. Like autotrophic organisms can produce their own food (using light, water, carbon-dioxide, etc.), this paper seeks to explore skills and careers needed to add solutions to drive heterotrophic (consuming) cities into autotrophic (producing) one as a basis for the concept of Circularity in Cities.

From Circular Economy towards Circular Cities

"A circular economy is characterised as an economy which is regenerative by design, with the aim to retain as much value as possible of products, parts, materials and resources."[3]
To translate this principle of resources/products/services flow management into the complex system of cities, the UNECE suggest in their guide to circular cities the following components: i) city assets and products, ii) circular action items, iii) circular cities outputs, and iv) circular city enablers.[4]
Reciprocally this future system of circular cities can only be enabled and supported through the human enablers. Such enormous shifts in the design, production and optimisation of cities require competent people who plan, design, build and improve the urban metabolism. A challenge for these people as circular cities enablers is to remain competent through renewal despite career turbulence. As we desire sustainable cities, project participants like architects, planners, engineers, project managers, etc., also wish career sustainability indicated by being healthy, happy, and successful. Project-oriented sustainable careers are fostered through periodic renewal to learn and develop new competencies to contribute to planning and development projects.

BACKGROUND

Dedicated Interdisciplinarity

To investigate what future urban disciplines and respective careers drive Circular Cities, but reciprocally also what learning pathways for circular cites make themselves sustainable careers, this paper's authors came together as an interdisciplinary team at the Centre for Comparative Construction Research (CCCR). Here its multidisciplinary members endeavour to create new insight into the evidence-based processes for the built environment from various angles:
1. Translate sustainable design into superior urban infrastructure.
2. Transform intelligent assembly into safer and more productive construction practices; and
3. Transcend benefits realisation into successful economic, social, political, and environmental outcomes.[5]

The discussions with colleagues from the field at the AMPS 2020 Dubai Conference proved the Circular Cities Careers proposal as a promising model for an interdisciplinary exchange to respond to the quest: rapid cities – responsive architectures, in particular to the significance of the changing nature of work and the shortage of skills required to address the many challenges.[6]

Sustainable Project-Oriented Career

DeVos has researched the changes to work and developed a sustainable career model from a vocational psychology perspective. The model includes the concept of turbulence affecting career sustainability (e.g., job loss, marriage and family, promotion, increased need for business travel, new technology, new

responsibilities, etc.). Skulmoski extended this model through a systematic literature review to better understand the drivers of career sustainability and error messages for impending career turbulence.
Skulmoski (2021) extended the DeVos career model to sustainable project-oriented careers where project managers, architects, planners, engineers, cybersecurity analysts and others contribute to diverse projects within the built environment (Figure 1). Often, project participants join an organisation, work through a series of projects and then leave for other project opportunities. In this outsourced model, project workers strive for career sustainability over a series of projects throughout their careers. If they are successful despite career turbulence, they may achieve life-career balance indicated by productivity, a healthy and successful life. Turbulence (e.g., job loss, promotion, new-born twins or disability) may cause an imbalance among productivity, health, and life success unless managed. Skulmoski's systematic literature review of sustainable careers in 170 databases resulted in a subsequent analysis of 302 peer reviewed journal articles. Career sustainability is a concern broadly held among German scientists, Australian general practitioners, European freelance workers, and in many other professions. There are two drivers to career sustainability: i) networking, and ii) skill renewal. Networking is essential to sustainable careers since one develops connections with others who may be potential collaborators or may be of help in times of need. Networking can also bring fresh ideas through collaborative work such as this collaboration about circular cities careers. Given the constant change brought forth from many directions, we may benefit through regular renew our competencies for a sustainable project-oriented career (SPOC).

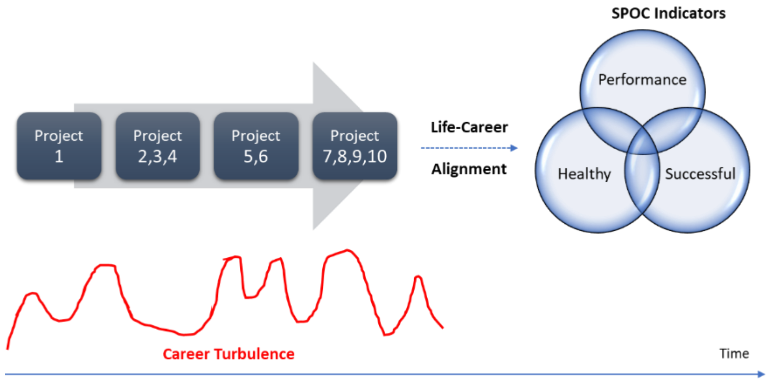

Figure 1. Sustainable project-oriented career

DRIVERS OF CIRCULAR CITIES

The Big Promise: Efficiency through Technology

Digitisation defines the working environment and standards thereof of tomorrow. It comes with a supposed increase in efficiency and, second, with a personalisation of the working environment. Consequently, future work requirements require primarily support by technology (e.g., via smart cities) because this helps to utilise the built environment in increased efficiency and increasingly automate jobs in offices and at all other workplaces - from factories to construction sites, from agriculture to Operating room. However, this approach falls short because in a perfectly efficient human beings function as extensions of algorithms and on the other hand, humans are at risk of embedding their socio-cultural non-algorithmic realms. To make tomorrow's working world sustainable, it is crucial, detached from the hype of digitisation, to apply a holistic view. A future framework combines both a framing of new career models as well as the education system and trendsetting development of new buildings and cities. Pabst and Sigrist (2017) describe the following tendencies:[7]

We are getting older - and we will work longer.

New models that allow flexible working hours, enable effective performance, and more flexible biographies are required. It is no longer about pension results, but rather life plans, in which sections of Work and non- Work are distributed more flexibly.

Work becomes more virtual.

New generations of virtual and augmented reality applications and hologram (cross-reality) technology, regardless of location to interact are increasing.

Automation relieves us of individual activities.

Repetitive work processes become intelligence, the wider use of robots operate -unlike their predecessors- are more mobile and interact more supportively with people. From logistics and building cleaning up to elderly care, robots could theoretically be employed based on clear rules and ethically sound guidelines.

The flexibilization of the world of Work is increasing.

Employment relationships are increasingly project-related within a suitable flexibility in the space use of cities and buildings. Not only will the number of employees fluctuate more strongly during the project and in cooperation with other companies run, but also the range of services Company will change and change accordingly require different infrastructures.

Megatrends

On a higher level, the future institute *Zukunftsinstitut* maps out the following megatrends that are to be considered for new career models as well:

- Medialisation
- Democratisation
- Individualisation
- Globalisation
- Ageing
- Flexibilisation
- Digitalisation
- Economisation [8]

Sub-Trends: Drivers of Circular Cities

For the Urban Environment, a cycled through-put of resources, energy and information through the urban metabolism is critical to enable Circular Cities. Within the megatrends[9] of medialisation, individualisation, globalisation, flexibilisation, digitalisation and economisation, the following sub-trends can be identified as affecting and accelerating circular cities transformers:

Circular Cities Sub-Trends

- Virtualisation
- Automation
- Deciphering nature

- Miniaturisation
- AI
- Additive manufacturing
- Self-organisation

Sub-Trend application: Smart Cities Case

Current smart cities such as in Malaysia, the Forest City by Country Garden Pacific View Developers LLC prove the 'smartification' of cities implementation of above mentioned subtends. The entire urban layout is digitised to add to 'smart living', smart industry and smart urban management (monitor, alarm, plan, filter, manage). Automation is used to fabricate, construct, manage and operate Forest City. AI (Artificial Intelligence) algorithms govern, manage and operate the infrastructure, resource flow thought put, and govern the inhabitant's attributes, lifestyles and activities.

Additive manufacturing is implemented in the construction and fabrication phases through a state-of-the-art world's largest concrete prefabrication factory that can produce just-in-time produced 40 story high residential towers in a noticeably short turn-over from the point of down-payment to move-in date. Such an application of subtends halts at a technological, mathematical and mechanical level.

Qualitative human factors as well as cultural achievements and qualitative social wellbeing of its city's inhabitants. So far inhabitants become data sources and nodes broken down into qualitatively measurable attributes that consequently can be used to rule and execute the legislative though collected evidence.

Circular Cities Expertise

The city we aim for!

To enable transformative commitments for sustainable urban development, the UN New Urban Agenda demands beyond “adopting a smart-city approach” [10]:

- The reduction of emissions of greenhouse gases from all relevant sectors.
- Equitable and affordable access.
- Sustainable management and use of natural resources.
- Compact, dense poly-centric, mixed-use.
- multifunctional areas for social interaction and inclusion, human health and wellbeing, economic exchange, and cultural expression and dialogue among a wide diversity of people and cultures.
- Resilient to disasters.
- Environmentally sound waste management.
- Smart-grid, district energy systems and community energy plans.
- Well-designed networks, accessible and sustainable infrastructure.[11]

A truly integrated urban network of disciplines and resulting careers pathways involved in planning, constructing and operating a circular urban metabolism requires further understanding beyond AI, the application immersive technologies, automated fabrication and the internet of things. Surpassing the future immersive hybridisation of the digital and physical world, a self-owned awareness, responsibility and governance of data and algorithms is utterly essential.

The further compilation of the Circular Cities Careers CCC model (Figure 2) of urban assets (CCC assets), urban enablers (CCC expertise, CCC disciplines) and urban resources (CCC resources), also encounters digital literacy, (eco-)systems science, life-skills, and qualitative competencies around inter- and trans disciplinarity.

CIRCULAR CITIES CAREERS CCC MODEL

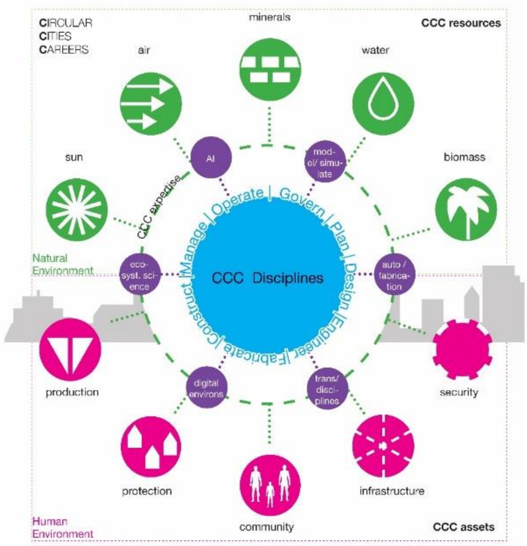

Figure 2. The Circular Cities Careers CCC Model

The compilation of the Circular Cities Careers (CCC) Model combines the findings in Megatrends and Subtends in combination with the Conference results on Housing and Sustainable Urban Development (Habitat III), declaration as endorsed by the UN member States. Furthermore, it adds to the UNECE urban components[12]: 'city assets and products' (here translated into CCC assets) and circular city enablers further define here as CCC disciplines I combination with CCC expertise. The underlying urban taxonomy model of Human Environments and Natural Environments stems from the "Urban Ecolution" model by Baumeister and Ottmann (2015). [13] The inner circles compose of dials that are themselves closed loops (e.g., phasing chronology of urban projects) but moreover can be combines with the six additional expertise streams that enable re-, up and inter-skilling towards enabling Circular Cities. Here the future needed CCC Expertise can be combined to any CCC Discipline Areas to plan, design, engineer, etc. CCC assets (infrastructure, production, protections, community and security) and CCC resources on the third dial. The CCC model lends itself as generator of life-long learning combinations were classic cities disciplines are merged and cross-linked with CCC expertise areas: AI, modelling and simulation, automation and fabrications, transdisciplinary, digital environs and an ecological systems science.

CCC Circular Cities Careers

Circular Cities Careers can be established through the combination of "CCC disciplines" and "CCC assets" and "CCC resources" implemented through "CCC expertise". This model combines 420 possible CC Career pathways to discuss further. Here some possible CCCs:

- Analyse Buildings through AI.
- Analyse Green/Blue Space through Interdisciplinarity.
- Simulate/ Model Green/Blue Space through Digital-Ecosystem.
- Design Waste flows through Modelling.
- Design Public Space through Whole-System-Science.
- Engineer Green/Blue Space through Automated Fabrication.

- Fabricate / Construct Public Space through Automated Fabrication.
- Manage Green/Blue Space through AI.
- Govern/Plan Public Space through Modelling.
- Govern/Plan Waste flows through Digital-Ecosystem.

Glossary CCC model

CCC Disciplines

Rather than describing exiting professions within urban development, the disciplines are staged according to chronological phasing (as loop) of typical urban projects: > Govern > Plan > Design > Engineer > Fabricate > Construct > Manage > Operate urban assets based on natural resources supported through CCC life-long expertise. In realty there might be no stating point, but the phases/disciplines might overlap and at a point of entry.

CCC Expertise

Competencies and Skills needed in combination to CCC Disciplines:

1. AI (machine learning, analytics, AI ethics, …)
2. Modelling and Simulation (3D, 4D, AR, VR, XR, CR: digital twins for flows, systems dynamics, structures, services, immersive technologies, …)
3. Automated Fabrication (additive, 3D/4D print, robotic assembly, prefabrication, ...)
4. Digital Environment (iOT, cyberSecurity, cyberGovernance, change management, …)
5. Inter-/Trans-Disciplinarity (Cultural attitude, life-skills, co-development, adaptation strategies, humanities, design thinking, ...)
6. Eco-System-Science (systems science, eco-literacy, human and natural environment science, evolution innovation, …)

CCC Resources

Natural Resources and environments as elements for a balance throughput of resources into a ‘closed’ urban metabolism integrated into ecological system principles. [14]

CCC Assets

Baumeister and Ottmann (2015) describe an urban taxonomy of the built environment, its functions and the correlation to natural resources for an ecologically integrated city.[15]

PATHWAYS TO ENABLING CCC

Higher education change enabling Circular Cities Careers

While there are changes emerging in the world of work, there are also changes occurring in higher education. These changes are both responsive to feedback from learners, as well as through innovations brought about through engaged educators in pursuit of excellence.

1. Diverse Degree Options: Universities are offering innovative degrees to responsive to the needs of the workplace and students.[16]

2. Dual Degrees: Students can enter a dual-degree program (e.g., a Master of Sport Management and Master of Project Management) where two degrees are completed in less time since electives and core classes are shared among the two degrees.[17]

3. Accelerated Programs: Some universities offer three rather than the typical two semesters per year, enabling students to graduate sooner.[18]

4. Intensive Classes: Access to education is improved when students attend intensive classes (e.g., Thursday, Friday and Saturday, twice per semester) and work the rest of the seek.[19]
5. Problem-Oriented: We see more subjects adding problem-oriented content such as design thinking[20]; learners apply what they learnt to solve practical; problems.
6. Personalized Learning: Learners have more learning choices to achieve their desired learning outcomes. [21]
7. Interactive: Students also see an increase in interactive learning [22] activities like discussions, serious games, collaborative concept mapping, peer review, etc.
8. Flipped Classroom: Students come prepared in the flipped classroom before they attend the class; they have read the assigned readings, and they are ready to work on activities that apply what they read with the instructor close by to assist with task completion.
9. Outdoor Learning Spaces: Students enjoy outdoor learning spaces that add diversity to the learning environment [23]especially with group discussions, role plays and small group activities.
10. Workplace Readiness/Authentic Assessment: Students will see that many university programs have revised their curriculum to include more practical content helping students to become more workplace ready. [24] [25]
11. Digital Badges: Learners can earn digital badges (micro-credentials) that recognize academic accomplishments and competence.[26] The online badge contains information such as course name and description, learning outcomes, date issued, etc. The student can add the digital badge to their CV to illustrate progressive learning.

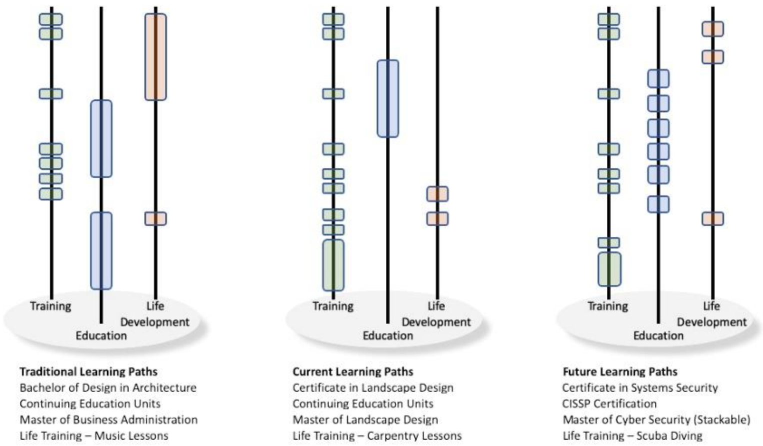

Figure 3. Learning Paths

Emerging Learning Pathways

Changes to higher education pathways open new learning pathways that align with a life-work balance. A traditional pathway might see a student complete a five-year engineering or architecture degree and then join the workforce (Figure 3). During employment, they may take short training courses offered by their employer (e.g., machine learning, analytics, AI ethics, design thinking, eco-literacy) and external training to earn PDUs (Professional Development Unit) for CCC disciplines. Some learners may develop new skills and acquire new knowledge in non-professional areas like joining an adult choir, learning a new language or coaching a junior sports team. These life development opportunities can contribute to life-work balance. In addition to the traditional pathway, a person might take a vocational training pathway beginning with certifications and eventually enter a graduate studies program. Emerging are new or future learning paths that offer smaller units of education in the form of stackable degrees micro credentials. Students can tailor their learning by stacking education, training, and life development courses from multiple providers until their stack of courses are sufficient to earn a degree and ultimately to have a Circular Cities Career.

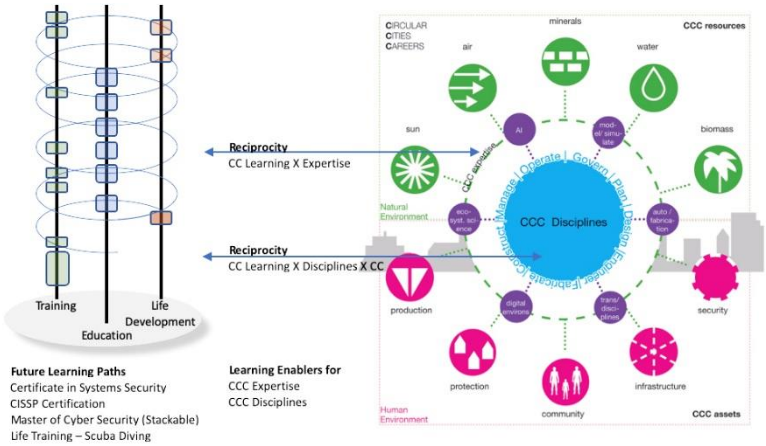

Figure 4. Learning Paths feeding into the Circular Cities Career (CCC) Model

CONCLUSION

For the sustainable and equitable evolvement from both the perspective of intrinsic individual careers development and solutions for a new urban agenda, we suggest an inter-related network approach supporting the evolutionary process needed for the transition towards Circular Cities. In their interdependence, 'city enabler' careers and cities that enable careers work in reciprocity (Figure 4). The proposed CCC model provides a transitionary platform to 'glue' together disciplines through CC expertise to achieve a circular approach towards implementing interconnected solutions of environmental, economic and socio-cultural development for Sustainable Cities and Human Settlements for All.

In his article on *Energy and Economic Myths* Nicholas Georgescu-Roegen recognises “that even the material universe is subject to an irreversible qualitative change, to an evolutionary process “[27] where the “real output of the economic process (or any life process, for that matter) is not the *material flow* of waste, but the still mysterious *immaterial flux* of enjoyment of life”.[28] Since the Entropy law busts a real circularity, the mentioned immaterial flux (or stock) could be the real aim of the co-evolution of sustainable careers enabling sustainable cities as a common cultural achievement.

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SUSTAINABLE PLACEMAKING IN RAPIDLY DEVELOPING CITIES: EXAMINING THE SCOPE AND IMPLEMENTATION OF DESIGN CONTROLS IN THE CITY OF DUBAI, UAE

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INTRODUCTION

Today's Dubai is an internationally recognized, popular destination known for its unique architecture, its beautiful winter and moderate climate in the months between October and April. However, Dubai is relatively a new city. Most of the built environment of the current city of Dubai, developed in the last fifty years. The rate of development experienced in Dubai has been remarkable considering that the modern city was almost built from scratch and that the first master plan developed for the city was only issued in 1960.[1] Particularly most of the newly built urban form (buildings, streets, infrastructure, etc.,) was built in the last thirty years. Many factors contributed to this incredibly rapid development, chief among which is the discovery of oil, the focus on trade and tourism, and the economic forces of globalization; which combined led to the phenomenal growth in the city's economy and population.[2] From the early years of development, the state had a role, as expressed in the rulers' vision and their aspiration for creating a modern city in the desert.[3] Globalization have influenced this outcome as well, as it has loomed large in the midst of the typical tensions that shape development.[4] Certainly, Dubai's urban scene is a product of the interaction between global and local forces; between advocates of modernization and those of preservation of culture, history and ecology; and between the role of the state and its policies on the one hand and the forces of unfettered market on the other.[5] As a result, Dubai's image in the international arena is often associated with its mega projects and iconic architecture, as these became the symbols of the city's readily recognizable brand of spectacle.[6] However, with all its apparent successes in securing a brand, still questions persist as to whether Dubai is committed to sustainable development.

This swift rise of the city onto the global stage as a tourist destination, a financial center, and commercial hub has been the subject of debate in many circles, with particular focus on the readily recognized built form. To some cities in the region, Dubai is seen as a model of success worth emulating. This is an aspiration often referred to as Dubaization.[7] Dubaization, a term with both positive and negative connotations, describes the process of rapidly transforming and branding a city through the development of mega projects and pioneering architecture that often lack any ties to a place geography and history.[8] Others argue that while there may be an element of truth in the Dubaization argument, Dubai still has its own place identity; progressive; experimental; and bold. It just lacks in place-specific architecture and urbanism, which can be addressed if the needed adjustments are identified and articulated into policy.[9]

This article examines the extent to which the rise of this seemingly 'built-as a whole' city was guided by sustainable development principles, and planning and design governance. Planning and design governance, as argued by Matthew Carmona, can be defined as the process of government-approved involvement in the means and processes of designing the built environment in order to shape both processes and outcomes in a defined public agenda and objectives.[10] With this background, this study considers the role planning and design governance played in facilitating Dubai's rapid urban development and transformation, particularly in the last ten years, as well as the successes and challenges it faced in realizing sustainable patterns of development.

More specifically, the study seeks to gauge the extent to which Dubai's planning governance is committed and involved in formulating sustainable development policies at the different scales of development, and more importantly in monitoring, guiding, and controlling the urban development scene.

Sustainable Development in the UAE

Sustainability as a composite concept with its economic, environmental, societal and liveability dimensions and its relationship to urban development is increasingly becoming a common concept in many parts of the world. The importance and benefits of sustainable development have been emphasized greatly in planning literature and practice especially in the last three decades. It is customary these days for cities around the world to promote sustainability goals and objectives in policy statements of plans and master plans. Whether these goals are realized in real practices however, is a different matter. In the United Arab Emirates (UAE) sustainability as a concept is well understood and often is clearly stated in government initiatives and plans.[11] The country also has its share of projects that are celebrated as icons of sustainable development. One famous example often boosted as a model for sustainable development is that of Masdar City in the Emirate of Abu Dhabi. Masdar is a city built primarily to function as a model solution to living sustainably. Another example is the emirate of Abu Dhabi sustainability program called Estidama which is the local equivalent to the US LEED program. Dubai also has its own attempt at such programs with its own program called Al Saafat. Both Estidama and Al Saafat are Arabic words, with Estidama literally meaning sustainability. Dubai is also known to have invested heavily in renewal energy, particularly solar energy.

However, the question is whether Dubai was able to translate such efforts together with other sustainable development goals that are often embedded in policy and plans objectives into patterns of sustainable development in the overall growth of the city.[12]

The paper focuses on understanding the role of the state in the development process and in promoting and monitoring sustainable placemaking; particularly in terms of the scope of its design policies and design controls, as well as the way these are applied and implemented in medium and large-scale development. Drawing on a qualitative research method involving document reviews, interviews with key stakeholders and field analysis, the study seeks to answer the question of how sustainable development is formulated as a policy statement and what mechanisms of design controls are used in monitoring and promoting context-relevant sustainable development in the city. The study also examines the city's policymaking capacity for learning by reviewing key practices and implementation in the last ten years. Understanding the role of the state in guiding and monitoring the development processes in the rapidly developing city of Dubai while considering the complex relationships shaping the process will lead to better understanding of the challenges and opportunities at hand and hence to improved policy making and efforts toward sustainable placemaking.

Sustainable development framework

Before responding to the question of how sustainable Dubai's urban development in the last ten years is, it is important to underscore the key ingredients of effective sustainable development. Many studies in urban planning, urban design and placemaking literature concluded that well-thought out sustainable development appropriately responds to its environmental, social, functional, and visual context.[13] The topic has been treated extensively in terms of both the process (i.e., what to consider in terms of mechanism and processes to ensure sustainability-enabling practices), and the outcome (i.e., the ingredients and features that can be considered characteristic of sustainable development). Studies on the characteristics of sustainable development has been consistently pointing to a number of strategies that are increasingly becoming common knowledge in planning literature. These often involve concepts such as smart growth, with all its principles such as efficient urban transit, mixed- use development, and urban growth boundaries.[14] Other important criteria include urban design and placemaking strategies that are focused on context, livability, and sustainable development such as those proposed by the Congress of New Urbanism (CNU).[15] These often involve having a design and context-oriented approach to housing types and supply, to city density and transit-oriented development, to connectivity, transportation and road network, to block size and open spaces, and to building types and environmental design.[16] As often discussed in urban planning and urban design literature these principles and strategies are interlinked and often best results are attained if they are integrated in a holistic yet principled approaches that are articulated and legislated in policy statements and most importantly translated to and supported by supplementary design criteria, guidelines, and action plans.[17]

It can be argued that stating sustainable development goals in planning policy is an indication of intent to adopt sustainable development practices. However, it is generally agreed, and as argued by John Punter, that merely stating an intent without supporting it with specific action plans or supplementary design guides and practices is not likely to result in development practices aligned with the stated sustainable development goals.[18] Thus, in order to realize meaningful large scale impact of sustainable development practices, it is critical to ensure that these key ingredients together with the needed capacities and levels of coordination in the governance structure, are in place and functioning properly.

RESEARCH METHODS

This is a case study of Dubai's experience with sustainable development and the role of policies and design controls if any, in implementing and monitoring city development in the last ten years. Case study research is more suited to exploring contextual factors that cannot be identified through cross-city generalization.[19] Building on the sustainability framework discussed above, this research investigates three components in Dubai's development scene. The first deals with the extent to which the city's master plans or structural plans do consider sustainable urban development principles and strategies in their policy statements. The second considers the make-up, if any, of the planning and design governance and the degree of its involvement in the development process. The third explores the processes and mechanisms in place that support the adequate carrying out of the stated sustainable development policy and goals. To understand the role of planning governance and policy in realizing sustainable development goals in the city of Dubai in the last ten years, this study adopted a qualitative research approach that consisted of semi-structured interviews, document reviews, and site visits to key development areas. The semi-structured interviews involved key stakeholders either active in Dubai's development or closely familiar with Dubai's planning governance and the processes of development in the city. Here the aim was to gauge the interviewees' interpretations of sustainability, reflect on Dubai's development scene including the role of planning policy and governance in promoting and adopting sustainable urban planning strategies, as well as explore opportunities and challenges the city faces in realizing sustainable development goals. Interviewees were also asked to describe the development processes and the role of planning governance, as well as reflect on whether Dubai's patterns of development could be considered sustainable.

Because comprehensive plans and visions are generally considered the main tools planning agencies use to influence and guide urban development, this study also considered reviewing a number of the city's master plans as indicative of planning policy. It primarily focused on identifying plans objectives that were followed with specific actions toward achieving sustainable development goals. The review of these also focused on understanding their legal and statutory implications and examining the supporting governance system if any, insofar as guided and monitored implementation. Documents reviewed are three of the available Dubai city master plans in the last 20 years, including the most current citywide structural plan issued in 2011, officially referred to as Dubai 2020. This is the plan that was intended to guide sustainable development in a span of 10 years and it is the first plan to address and articulate in a rather direct manner key sustainable development objective.[20] Other documents reviewed include photographs and video content documenting Dubai's development history. Secondary data considered for this study included other researchers' academic work examining different aspects of urban planning and development in Dubai. It also involved reviewing a number of background government reports and news concerning Dubai's development environment, addressing topics such as population change, housing, transport policy, and environmental issues.

In addition, the study investigated the contribution or lack thereof of the different government and semi-private agencies and entities involved in building, real estates and planning practice to the goals of realizing sustainable development. Investigation also consisted of site visits to major development areas in Dubai such as Dubai business center and Dubai new development near Dubai Expo site.

ROOTS OF DUBAI RAPID DEVELOPMENT

If there is consensus on the development of modern Dubai, it would be the speed with which it has developed. Indeed, few cities in the world have followed the speedy urban growth trajectory as that of Dubai. This rapid development was the result of many factors including the strong desire of its leadership to position the city in the global economy and to elevate its status as one of the most important regional trade hubs in the Middle East. From the beginning, Dubai's leadership envisioned a modern and unique city in the Middle East that is economically secure, progressive, and able to lure visitors, investors and job seekers from all around the world.[21]

Later on, this push to chart a different course for Dubai as a self-dependent city was more urgent as the Emirate's economy became less dependent on oil. Being part of the global economy also meant boosting the city globally by continually striving to gain a competitive unique image and a brand; an agenda that partly explains the idea behind investing in many unique and mega projects.[22] Indeed, investment in mega projects, unique architecture, and top of the line infrastructure, in a very short time led to the emergence of a Dubai brand that is progressive and avant-garde; bold and experimental- even when experimentation led to yielding less contextually sensitive outcomes.[23]

Thus, this urgent need to adjust the city's economy and diversify its composition beyond solely relying on oil was the primary driver behind the significant transformation in the city's urban form. It follows then, if looked at from an economic perspective alone, undoubtedly, Dubai's experience in building an identity for itself can be considered astounding success insofar as it succeeded in elevating its presence in the global arena. The city today is a destination in its own right, well connected and highly relevant to the global economy. However, how was the development scene managed and monitored? Moreover, to what extent was issues of sustainable development responded to and considered?

Planning documents review and in particular, master plans indicates that from the beginning urban planning was facing the challenge of keeping pace with the speedy growth of the city. This is evident from the early days in the 1960s when physical planning was introduced for the first time. For instance, Dubai's first master plan, prepared by the British architect John Harris in 1960, (and often referred to as the Harris plan), was intended to guide development for a period spanning 20 years.[24] However, this plan had to be updated and a new plan was issued in 1971 following the discovery of oil in the Emirate of Dubai in 1966 and the rapid growth in economy and population that ensued.[25] Another master plan referred to as Dubai Structural Plan, (developed in 1985 by the Greek planner Doxiadis), also had to be abandoned in 1995 for the same reasons; the significantly changed city economy and demographics, before completing its 20-year span.[26] By 1995, Dubai Municipality carried out another citywide structural plan, which also needed to be updated by the year 2003.[27] These changes were all a reflection of the rapid pace of development in the city, and the exponential economic and demographic growth the city has experienced. Thus, Dubai's spatial plans kept on evolving to keep pace with the rapid economic and population growth as well as changes in the planning governance structure. As a result they became more reactionary rather than setting and responding to clearly articulated planning objectives.[28]

SUSTAINABLE DEVELOPMENT AND DUBAI 2020 STRUCTURAL PLAN

The speed with which the city economy and investment in infrastructure, real estates, and mega projects has forced Dubai's leadership to reconsider its approach to developing master plans. Simply the city development was moving too fast and often plans were made obsolete by new realities. Thus, the span chosen for the 2020 plan, which was issued in 2010, was only ten years.[29] This plan is significant as it is the first master plan that explicitly stated sustainable development as a policy objective. Further, the sustainable development strategies proposed in this 2020 vision seemed very comprehensive and ambitious. They included an acknowledgement of the unintended consequences created by the unrestrained and somewhat uncoordinated rapid development that characterized the urban scene since its early days in the 1960s. For instance, it specifically called for revision, coordination and prioritizing of mega projects development. Moreover, it called for increasing urban density in the metropolitan area by rationalizing the city's carrying capacity, reconsolidating land use to curb the city's ever-sprawling development pattern, and putting a limit on constructing offshore islands.[30] This is clearly emphasized by a policy statement calling for setting an urban growth boundary to curb development from expanding into sensitive parts of the desert, coastal areas, and the shallow seabed.[31]

Likewise, the 2020 plan called for infill development and revitalization of existing dilapidated areas, as well as locating new development near and around the existing infrastructure networks.[31] Additionally, the 2020 plan also called for the adoption of the principles of transit- oriented development (TOD) and the integration of mobility and land use particularly in mixed-use development.[32] The plan also addressed non-physical aspects. On the economic dimension, the plan called for long-term support and stimulation of several economic sectors including finance, retail, business, entertainment, and tourism by preserving and promoting appropriate connectivity and land use.[33] On the socio-cultural, dimension the plan emphasized objectives concerning the provision of appropriate inclusive housing, housing for the nationals, as well as provision of affordable rental accommodation.[34] These clearly are sustainable development goals and strategies as discussed in the Sustainable development framework discussed above.

Role of the state in promoting sustainability

In this section, I consider the role of the state in promoting, monitoring and controlling sustainable development. Interviews with stakeholders and document reviews revealed that Dubai's rapid pace of development was also aided by a planning governance approach that prioritized efficiency and speed in plan review and building permit processes to the extent that there is a multiplicity of key players with varying degrees of responsibility in influencing urban development processes and outcomes. At the top of the planning governance structure is Dubai Executive Council (DEC), which is headed by Dubai's ruler, H.H. Sheikh Mohammed bin Rashed. This council is the main decision-making government entity in Dubai, with the area of planning and development being one of its responsibilities.[35] However, over the years, and in response to the city's rapid pace of development, more planning agencies were created and new land statuses and jurisdictions were carved out for different authorities, mainly to increase flexibility and efficiency in the plan approval processes. Efficiency and speed of execution were such high priority that even the jurisdiction for formulating master plans have been shared by different agencies, a move that further accelerated the already rapid pace of development. The volume of development taking place was too large for one agency or entity to handle. It was simply not conceivable for the municipality to deal with the review and approval process of thousands of projects being planned and developed at the same time. As one planner put it: "it would have meant a huge backlog in the plans review process and thus undesired delays in the overall development scene".[36] As a result, together with Dubai municipality there are other entities with varying degrees of authority and legislative control such as Dubai Road and Transportation Authority (RTA), and other government offices such as Trakhees (an Arabic word for permits) that are also involved. In addition, semi private large developer companies such as Emaar Properties; Nakheel; and Dubai Properties were granted special status in the urban development scene with access to free if not significantly cheap large tracts of land and a high degree of autonomy in deciding how such land can be master planned and developed.[37] As a result, there is no single planning agency that guides, manages, and monitors development. Instead, there are several agencies and authorities involved in these processes. This seemingly fragmented governance structure is still guided at the top by Dubai Executive Council (DEC), which sets policy, and vision for the city, and the emirate of Dubai as whole. Key components appear to be missing. As expressed in the reflective interviews of stakeholders, chief among these components is the lack of enforceable laws and regulations. Even when laws existed, often they are applied sporadically (as opposed to being consistent wherever they apply, partly due to lack of stipulation and articulation of appropriate definitions, lines of authority, processes, and procedures). This has led to a situation that is not conducive to deliberate, purposeful implementation of the sustainable development goals reflected in the various government strategies.

Thus, much of the planning and development practiced in the city is market-driven, generally responding to economic factors while relegating other development factors such as the environment with its emphasis on contextual and sustainable urban design.

The built environment produced, thus, seemed to deviate to a significant degree from the stated policy statements.

As indicated in the previous section, the 2020 Dubai Vision did explicitly articulate sustainable development goals. Interestingly, the 2020 master plan also clearly pointed out the need for a coherent legislative framework.[38] The desire to create a more efficient planning governance to support the development processes and plan implementation during the ten year period of the master plan was explicitly stated. Commenting on this very point while reflecting on Dubai's current development scene, one interviewee concurred that Dubai still lacks a coherent and well-integrated planning governance. He indicated that while it is true master plans did cover all pertinent issues related to sound, sustainable development, in some ways; these were often relegated to acting merely as advisory guiding frameworks that can easily be set aside if new priorities or opportunities arise. This is probably one of the main reasons why some of strong points of the 2020 plan were not realized. One of the planners I interviewed indicated this situation could be explained in two ways.[39] The city has developed exceptionally fast in the past, that master plans needed to be updated often. The second has to do with the city's economy and the drive of its leadership to put it on a pedestal similar to that of other competing global cities. Thus, economic forces and economic opportunities have been emphasized and at times given more priority than other aspects. While the second reason is understandable to some extent, the first can be addressed through design guidelines and principled action plans that can function as criteria or set of considerations. That is even if it becomes necessary that plans will require updating, the stipulated sustainable design guidelines will continue to be used to monitor and control development.

Challenges persist

Is Dubai sustainable? At this point, the answer has to be mixed. A critical view of the city's urban scene reveals that there are both aspects of strength indicative of practices of sustainable development and others that can be considered a challenge. One vivid example of a move in the right direction relates to the development and continuous expansion of Dubai light rail, which has been introduced in 2009. Currently it is 76 km long, and it continues to catalyze a mixed-use pattern of development along its corridor. Many parts of this corridor are walkable with wide sidewalks fronting many venues at the ground level with residential and office space in upper levels. A challenge often pointed out relates to Dubai roads system. While of very high quality supported by state-of-the-art infrastructure, they generally lack in appropriate connectivity. This often leads to high vehicle/mile traveled, more dependence on car mobility, and thus increased consumption of gas, all consequently likely to lead to increased carbon emission. The city has also invested heavily in upgrading its infrastructure and many of the most current features of smart cities applications and sensors have been installed to increase efficiency and reduce energy consumption. For instance, many of the general aspects of city management and government buildings have been upgraded with smart solutions to help in reducing the volume of face-to-face interactions with the public and thus minimizing road trips and traffic. Government initiatives also consistently promote many building principles and all new government buildings are now required to comply with Dubai's green building code called Al Saafat.

The private sector is also getting involved. A residential community project called the Sustainable City, which was introduced by a private developer, has attempted to highlight many aspects of sustainable development advocated in planning and placemaking literature. Although it has its critics who point its rather suburban location; its low density; and non-affordable residential units, it is still a model that can be emulated as many of its aspects are unique and innovative.

Perhaps the one pattern of development that may not be considered fitting the criteria of sustainable development is that of the low-density conventional residential communities that seem to be spreading in fringes of the city. These are typically master planned communities developed by large-scale developers. They seem to be the preferred housing type especially by the nationals. However, they tend to be of single use- for the most part residential villas, car-dependent, and connected to the city by expressways. Further, despite the definition of an "urban growth boundary" in the 2020 Structural Plan, there was no compliance with such policy. As a result, sprawl continues wherever developers find an opportunity to build. Large-scale developers that are semi-public companies with their access to vast land tracks often operate with high autonomy and often respond to market forces in the projects they develop. Consequently, they have created large, sprawling mono-use communities, especially in Dubai's outlying areas. Zoning is also a culprit in that it only allows mixing of uses in specifically designated areas, thus inherently encourages sprawl.

When asked whether Dubai has recognizable practices of sustainable development, the interviewees agreed that while there is a strong will to turn the tide toward more sustainable development a number of challenges continue to persist. First, among these is the sprawling and speculative nature of the real estate market, which keeps on pushing the city limits toward the desert and often lead to over-supply specially in the residential sector. The second is the generally car-dependent urban layout and configuration of urban blocks. Another is the architectural projects market, which lacks the necessary design controls that will require architects and developers to pay more attention to contextual issues, especially those of climate and geography. Most buildings specially the high-rise ones, are high consumers of energy and often with excessive use of glass on their exterior and minimum shading. Indeed, there is a need to develop environmental design considerations that are principled on contextually sensitive design.[40] In the absence of such guidelines, architects, including foreign firms, will continue to address context from the narrow perspective of aesthetics and visual referencing.

On the larger scale, city of Dubai can be thought of as the largest city in the metropolitan area that includes cities of Sharjah and Ajman. Its relationship with Sharjah is such that a large portion of Dubai's workforce live in Sharjah because Sharjah's housing market is comparatively more affordable. This often leads to high volume of traffic between the two cities especially during the rush hours. The traffic congestions and the pollution effect from such condition has been a serious problem in need of immediate attention, including exploring ways some of Dubai is housing supply can be made affordable.

CONCLUSION

From the first days of physical planning in the city, Dubai's economic vision has taken priority. The entrepreneurial strategy to promote the city produced a rather fragile and complex urban environment to manage. Thus, the urban development of the city is overtaken by its economic development as represented by the sectors of real estate, mass tourism and services. The completion of a series of mega real estate and infrastructure projects fueled by a synergistic relationship between global and local powers working to realize a vision of modernity and innovation is clear evidence of that. At times, this approach has meant severing ties with the historical and geographic context, aided by an overarching desire to seek knowledge and adopt practices from outside the country by commissioning international consulting firms, which eventually ended up playing a primary role in the production of Dubai's urban form. Local expertise is largely absent in drawing out design criteria and guidelines with the city continuously seeking learning or inspiration from international best practices and benchmarks.

At the time of the writing of this article, Dubai is engaged in developing yet another master plan named the 2040 plan. The plan aims to address many of the concerns or gaps in the planning process that need to be dealt with effectively. The call for building a robust and well-coordinated planning governance structure figure centrally among these. Setting processes and articulating guidelines and supplementary design criteria is another. These will need to be top priorities in this effort in order to clarify statutory, policy, regulations and processes. The 2040 plan was issued recently and was launched by Dubai ruler, his H.H. Sheikh Mohammed Bin Rashid, in a highly publicized event that took place on Saturday, March 13, 2021. Dubai's government issued information bulletin in different format broadcasted by many media sources generally describing Dubai 2040 Urban Master Plan as the most comprehensive vision for sustainable urban development in the city. It is hoped that the city has finally learnt from its experiences, as there is sufficient will to adhere to principles of sustainable development. Indeed, the issuance of this recent master plan constitutes a hopeful moment as the city and its leadership are known for their determination and capacity to take bold action. What was achieved in a span of three decades is indicative of this spirit. It also has this bold 'making it happen' attitude. Therefore, achieving goals of sustainability is conceivable if the right mechanisms begin to be put in place.

Commitment to sustainable development however, requires addressing issues of coordination, clarity of processes and supportive legislations and guidelines. It would also require building the necessary capacity by ensuring certain qualities in those tasked with reviewing monitoring and ensuring adherence to sustainable development. For instance, one such quality that needs to be embedded in the system is represented by urban design skills. Another is the need to require private and semi-public real estate's developer companies that benefit from large concessions in land acquisition to adhere to sustainable development criteria that is in line with the government stated policies. Architecture and the energy performance of individual buildings is another area that requires more attention. The city is in dire need to engage in efforts directed at developing context-relevant, environmentally conscious design criteria together with the needed processes and mechanisms that would ensure implementation. Dubai can still do so and maintain its unique brand of innovation and creative design.[41] Further, innovative approaches that are contextually relevant will need to be promoted as the right response place-specific aspects of livability and placemaking unique to the culture and geography of Dubai. Whether it is through local or international design competition, the city has the opportunity to promote a culture of context-specific responses that are still unique and respecting of its local character; environmentally and culturally. This is highly important, as contextual design is a key ingredient of meaningful sustainable urban form. Contextual design considers the climatic conditions of the place as well as issues of culture and history and weave these into relevant and contextually sensitive places.

Having multiple actors operating in the development scene may not be a problem in itself. It is the coordination and cross-referencing that needs to be articulated and practiced. This effort at coordination can start with operationalizing the master plans by supplementing them with clear spatial design strategies utilizing smart growth and urban design principles. Lastly, it is advisable to improve on the quality of the locals' involvement in review of proposed designs, as critical discussions should be had especially in assessing projects that respond to heritage and local character through mere visual mimicking or referencing. Such responses should be required to address contextual issues substantially and meaningfully and in alignment with sustainable development goals

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INNOVATIVE RESPONSIVE SHADING SYSTEM: MULTIFUNCTIONAL CASE STUDY IN MILAN

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INTRODUCTION

The buildings indoor environments are the key role in maintain the welfare of occupant's life. In developed countries, people spend their 90% of their time indoor [1]. Indoor environments effectiveness is mainly including the building envelope and interior components. As the building envelope is the link between the indoor and outdoor spaces, the challenges have been raised for innovative façade design. The façade is one of the first components that is affecting the energy performance of buildings; besides, it is significantly linked to the indoor comfort on several aspects, such as thermal and visual comfort [2,3]. Responding to climate changes, serious actions are taken to maintain the highest comfortability indoor with the least energy consumption. As the changes are starting to be unpredictable, the facades are needed to be more adapted to the new trends on daily, seasonal or annual basis. The term adaptive implies the responsive behaviour of the building facades to face the outdoor climatic variations to meet the efficient comfort requirements for well-being necessities either in term of productivity or relax [4,5]. Since the reduction of energy consumption of the building sector is the priority now on wide level, a number of innovative façade design and corresponding materials have been developed and more innovative solutions are expecting to come out [6]. Importantly, the aimed function/s of the responsive façade should be defined in prior. However, the optimum solution should be an integrated compromised solution to decrease the energy consumption and assesses the thermal and visual comfort indoor [7,8]. As the lighting is significantly affecting the thermal comfort and the total energy use in many buildings, maintain the natural lighting with comfort aspects is one of the main aims to be assessed.
The facade adaptive system is composed of several components including the plants as prefabricated units or supplied on site to ensure the integrity of performing in the building [9]. Different designs are associated with different mechanical and any other subsystems of the building [10,11]. Concurrently, the dynamicity of the innovative façade including materials and operation method is offering a complex systems and subsystems to be either predicted or controlled. However, there are a number of responsive

dynamic façade in the market so far with innovative solutions. The choice of these ones are critical in terms of needs, adaptation to specific climatic zone, desired design, operation complexity and maintenance solutions [12]. As the Lombardy Region (Italy) assimilated the directive 91/2002 (energy performance building directive), as of 2006, with regional legislation for energy efficiency of building, last few years in market noticed a great grown in issuing almost 7500 energy performance certificates for buildings of Class A and A+ [13]. From this approach, this project carried out the sustainable principles to design an innovative responsive façade to perceive the best indoor comfort.

METHODOLOGY

Study Concept

The concept of this study was built on two axes in context of designing a responsive innovative building façade that responds to the climate changes and annual variations and the conservation of city of Milan identity. The concept included the culture, urban context and the municipality approach to reach a sustainable city. Accordingly, the architectural design concept has been created out of one of Milan's myth that oriented to functionally perceive the highest thermal and visual comfort sustainable built environment throughout lowest energy consumption. The methodology of the study has been carried out through a defined structure as shown in Figure 4.

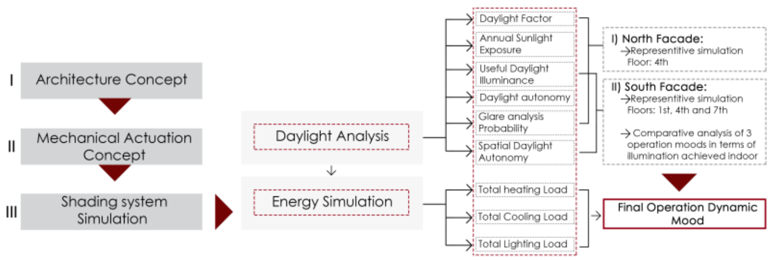


Figure 4. Study Methodology

Adaptive Component Design

A novel approach of the shading system - the "Dragon shade" – is emphasizing Milano city. The symbol of Milan city is centralized around a myth legend of a dragon like-creature named Tarantasio that repeated in several carving historically and logos presently. The idea came up to include the same sense of the dragon scales pattern into a defined shade designed element. The development was done over several stages as shown in Figure 5. An approach for a practical responsive shading system, is the mechanism conceptual design for the ease of the adaptation movement with least use of actuators and lightweight design. The shading system is divided into two main elements; connected several fins and a gear actuator that controls the movements and overlapping of these fins as shown in Figure 6. All fins are anchored at an upper rotational point and movable middle strip rail with metal screw. The consequent movement of fins one by one to open and close starting from the outer fins is controlled by the middle rail that has a stoppable fix to constraint the overlapping of fins on each other.

In the preliminary studies, an optimization analysis was applied to reduce the number of fins depending on the structural load design and several modules overlapping fins efficiency for solar shading. Accordingly, the final module design was compromised of 5 fins of 1.4 [m] * 1.4 [m] – including the actuator height- using light metal frame and perforated metal sheet with 0.7 visual transmittance as shown in Figure 6.

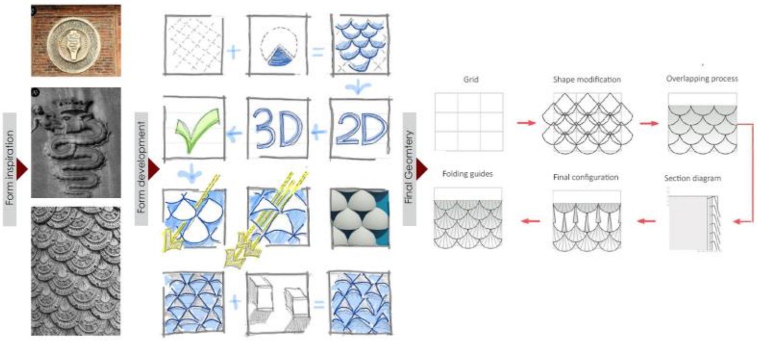


Figure 5. Concept development stages from the form inspiration to final geometry on a defined grid

Operation States

The movement of this shading system in order to be responsive to climate change annually is defined by three main configurations: closed, semi-closed and open as shown in Figure 7, where completely closed configuration is representing maximum shading on the façade with spread and overlapped fins to prevent direct exposure to high sun radiation then semi closed configuration is considered as an intermediate stage to give partial shading by the three fins out of five and finally when sun radiation is needed as much as possible then the open configuration is considered where it allows maximum exposure of the façade to direct sun light. The different shading states are controlled through internal sensors sensitive to illuminance level and determined by an optimization approach for the best fit illuminance range given for each state by considering both visual comfort and minimum energy consumption.

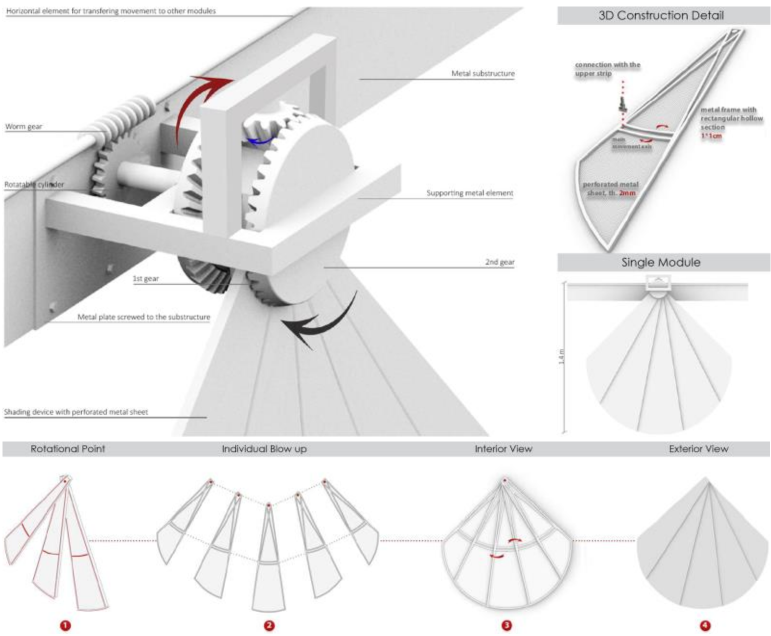
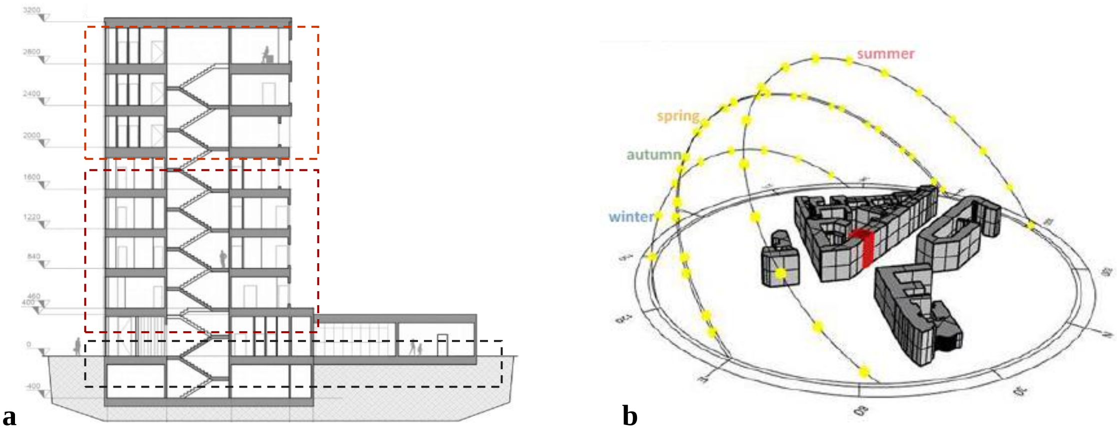


Figure 6. Mechanism concept description and detailed fin design. The total module height equals 1.4 [m].

Figure 7. Different configuration of shading units

Case Study Description

For validating the new façade design, a case study in Milano city is used for practical application. In viale Doria, Milano city, a multifunctional building is meant to be designed throughout the green building strategy framework of Lombardy region and municipality of Milan. implementing the “Dragon Shade” system is to fulfilling the indoor comfort limits visually and thermally has been assigned. The building is composed of eight floors 32 [m] high including a commercial ground floor [~665 m^2], four hotel functioned floors [each~402.5 m^2], the upper three floors are open-space styled offices [each~402.5 m^2] and a basement. The building is in row-centred from east and west directions, the north façade is overlooking the Doria street and the south façade is on the back yard that is 15 [m] from the attached neighbour starting 2nd to 8th floor as shown in Figure 8. An annual preliminary study on the climate analysis of Milano has been done in terms of temperature and its fluctuation, solar radiation and irradiation horizontally and vertically, sky coverage, humidity, wind analysis and shadow analysis. As Milan is classified under the CFA region by the Köppen-Geiger system, the results implied a humid and hot summer, cold and foggy winter with an average temperature of the city that reaches 13.1 c°. The glazing stratigraphy for the studied envelope is a double glazing with 3[mm] for each pane, 13 [mm] air gap, 2.8 [W/m^2.K] total thermal transmittance and total G-value equals 78%.



a **b**

Figure 8. a) Project section that indicates three different functions; offices, hotel and commercial. b) Sun path diagram on the layout of viale Doria street (building in red) during the four seasons.

RESULTS AND DISCUSSION

Baseline Analysis (without shading)

Hotel room at 4th floor on the south side is analyzed as a base case before applying comparative analysis with other rooms function as shown in Figure 9. The same daylight metrics (Daylight Autonomy, Useful Daylight Illuminance, Daylight Factor and Annual Sun Light Exposure) used to analyze north façade is used to compare both room performances against each other at these two different orientations. Glare probability check for a distance of 2 m at level of 0.85 m has been also done to ensure whether glare is a problem to be controlled or not. As shown in **Error! Reference source not found.**, 67.91% of the floor area exceed a defined threshold of 300 Lux for at least 50% of the time while for useful daylight illuminance there is 45.77% of the floor area ranging between 300 and upper threshold of 3000 Lux for at least 50% of the time considering that illuminance above 3000 lux is not wanted for potential glare or overheating. Comparing theses values to the north room, less than 2% difference in terms of Daylight Autonomy but more than 10% difference when useful daylight illuminance is considered. Daylight factor shows no change where the same floor area of 61.1% has value of more than 2%. On the other hand, annual sunlight exposure shows 69% of room area with more than 1000 Lux for at least 250 hours. Daylight glare probability checked at the most critical hour with highest illuminance value on 17th of December at 13:00 PM where it found to be 0.345 which is almost rated as imperceptible glare therefore glare is not considered a critical issue to be controlled for the south hotel room on the 4th floor.

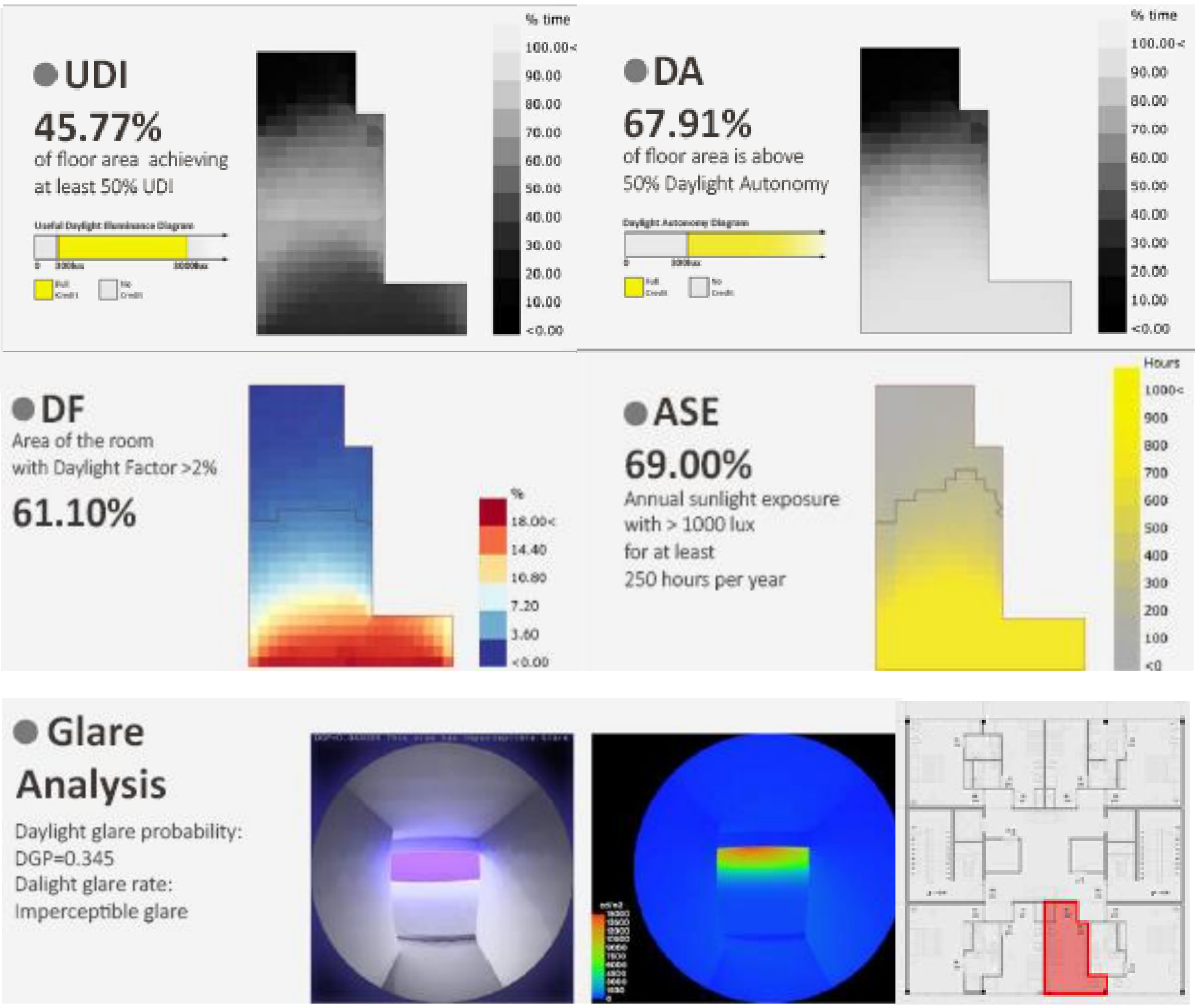


Figure 9. Daylight analysis of representative south room at the fourth floor in terms of UDI, DA, DF, ASU and glare probability at 2 m position from window

Shading Operation Analysis

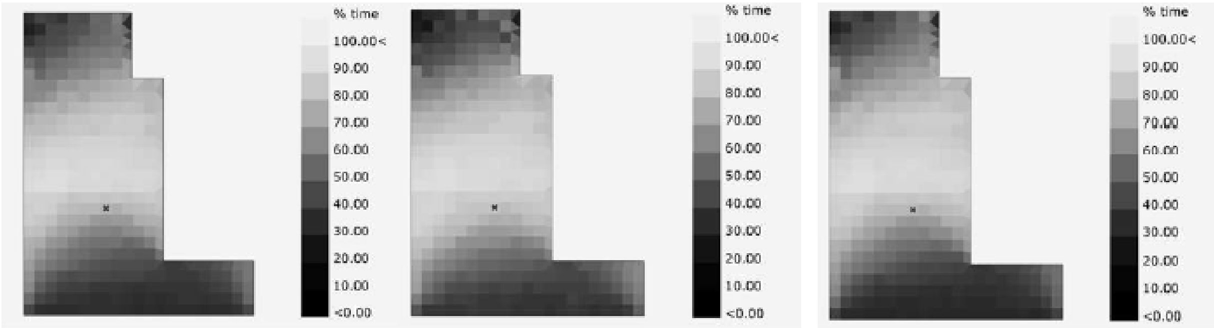
The purpose of analysis is to try different illumination range of three options as defined in
, and apply comparative analysis for later decision-making process to choose the optimum operations. As
illustrates, option 1 and option 2 consider the shading devices to be opened when the the range of illuminace is below 300 lux for a workplan of level at 0.85 [m] where maximum light is need while shading state defers once it is above or equal to 300 lux as option 1 consider the shading to be semi closed for illuminance range from 300 to 3000 lux and obove that it is closed. In option 2, the shading system is considered to be semi closed with much lesser illuminance range from 300 to 1000 lux and the shading is closed for illuminance above 1000 lux. Nevertheless, for option 3, the open state of the shading system has a wider range from 0 to 1000 lux then it is considered to be semi closed until illuminces reach 3000 lux and get closed for the illuminance values mentioned.

Options	Illumination range for each state		
	Open	Semi closed	Closed
Option 1	0 – 300 Lux	300 – 3000 Lux	More than 3000 Lux
Option 2	0 – 300 Lux	300 – 1000 Lux	More than 1000 Lux
Option 3	0 – 1000 Lux	1000 – 3000 Lux	More than 3000 Lux

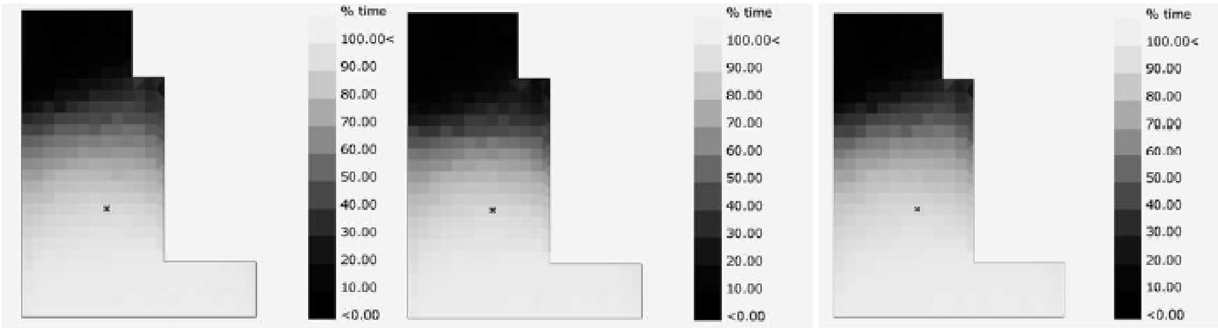
Table 1. Different options for shading operation based on illuminance range at 0.85 [m] work plane with 0.2 [m] sensor grid

Daylight Analysis

The hotel room at 4th floor is analyzed after applying the dynamic shading system which operates through previously described three options to check the best performing option in terms of daylight by using the two main factor of Daylight Autonomy (DA) and Useful Daylight Illuminance (UDI). As shown in Figure 10 useful daylight illuminance of option 2 has the best performance with 67.16% of room area has at least 50% UDI considering that useful illuminance is within a range from 100-1000 Lux. However, the difference between option 2 and other options is within only 1%. In terms of daylight autonomy, it is shown in Figure 10 that option 3 is the best where 65.67% of the room area has at least 50% DA considering that useful illuminance is within a range of more than 350 Lux. The difference between option 2 and other options is within only 1% compared to option1 but more than 2% compared to option 2.



Option 1: 66.17% of floor area achieving at least 50% UDI	Option 2: 67.16% of floor area achieving at least 50% UDI	Option 3: 66.42% of floor area achieving at least 50% UDI



Option 1: 64.93% of floor area achieving at least 50% DA	Option 2: 62.94% of floor area achieving at least 50% DA	Option 3: 65.67% of floor area achieving at least 50% DA

Figure 10. Hotel room at 4th floor analysis for Useful daylight Illuminance (UDI) and Daylight Autonomy (DA)

Comparative Analysis for different building functions

For the analysis of south shading performance, rooms in three different levels of the building such as first floor, fourth floor and seventh floor are selected to represent different functions of restaurant, hotel, and office spaces as show in in Figure 11. As shown in Figure 12, the comparative analysis for each floor in case of Daylight Autonomy (DA) shows that option 1 and option 3 have no noticable differences and almost he same except for the the hotel room where a slight increase in floor area covered with at least 300 Lux for 50% of hours is noticed at option 3.In case of Spatial Daylight Autonomy (sDA) metric, it has been found that option 3 shows a slight improvement for hotel and hotel where more area is covered with at least 300 lux for 50% of annual occupied hours. When Useful Daylight Illuminanace (UDI) is considered with minimum threeshold of 100 and maximum threshold of 2000, then Option 2 shows a slight improvement in terms of room area covered with useful daylight.

(a) **(b)** **(c)**

Figure 11. Representative south rooms for each function. (a) Restaurant, (b) Hotel room, (c) workspace Zone

Daylight Analysis

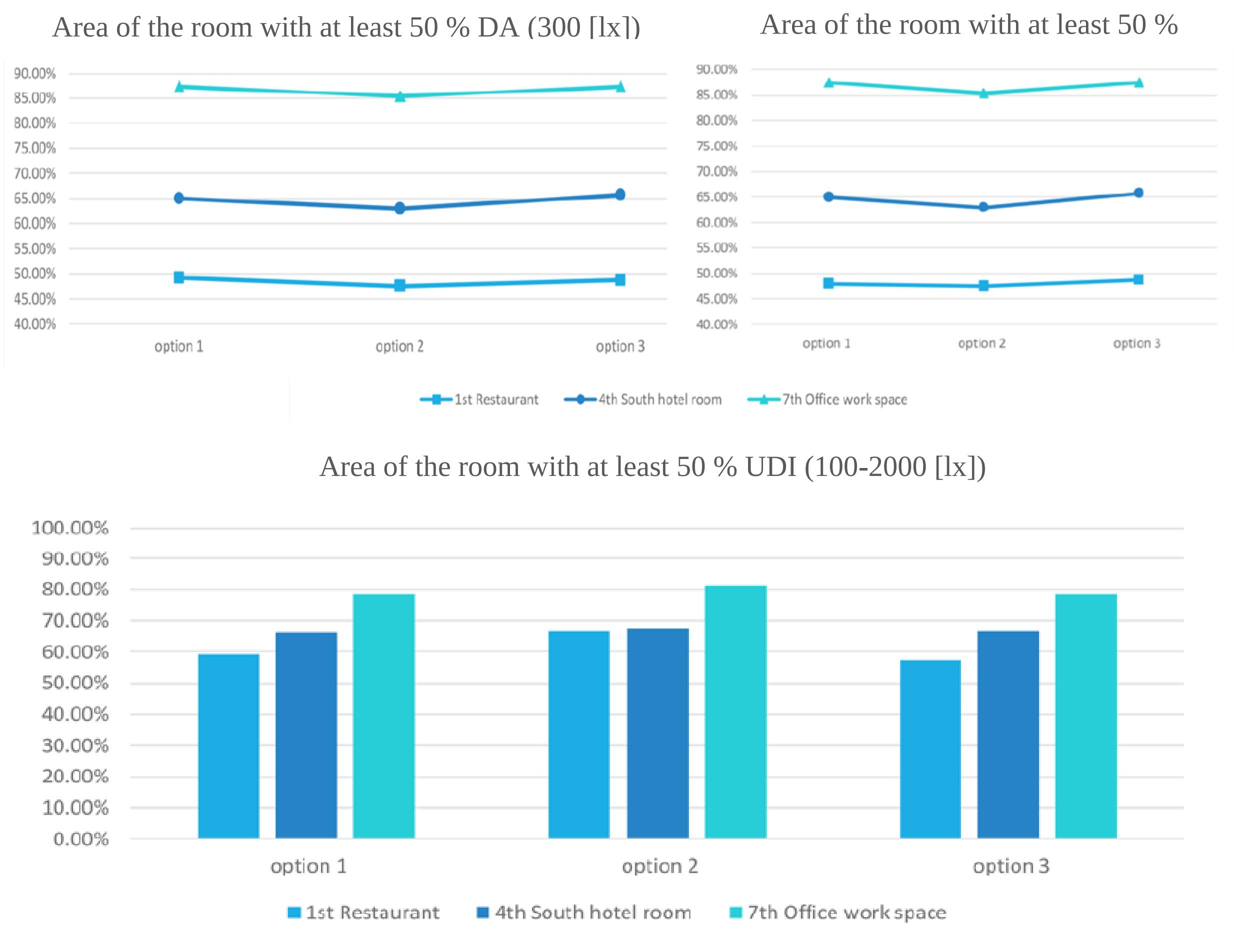


Figure 12. Comparative analysis for each floor in rems of of daylight autonomy (DA), spatial daylight autonomy (sDA), and Useful daylight Illuminance (UDI))

Glare Probability Check

In order to confirm glare control, the worst hour for each room has been chosen to check glare probability. For the first floor where the restaurant, the critical hour was on the first of January at 12:00 PM with maximum glare is equal to 0.3548 which is rated as perceptible glare with only 0.0048 over imperceptible limit.

For the 4th floor and 7th floor where hotel and workspace, the critical hours were on the seventeen of December at 13:00 PM and on the first of January at 12:00 PM respectively with the daylight glare probability less than 0.35. Therefore, both floors are rated as imperceptible glare.

Based on the competitive analysis of the three options above for daylight in different metrics, it can be concluded that option 3 is the best performing operation mode for restaurant and hotel floors in terms of daylight autonomy and spatial daylight autonomy while option 2 is the best performing when useful daylight illuminance is considered.

Energy Analysis (Thermal Loads and Lighting)

To finalize the decision for the optimum operation of shading system, a comparative analysis of energy consumptions has been done in terms of heating, cooling, and electrical lighting loads for all the options in addition to a baseline without shading and different states of shading as a static one. In Figure 13, the energy consumption comparison for each floor is demonstrated. Option 2 is the best energy performing solution with much fewer cooling loads for restaurant and hotel floors while very slight decreases in energy consumption for the office/workspace floor. Option 2 also have showed the best performance in terms of useful daylight illuminance. Therefore, it is considered the optimum solution for the shading units. Moreover, the shading states for each room are summarized in Table 2.

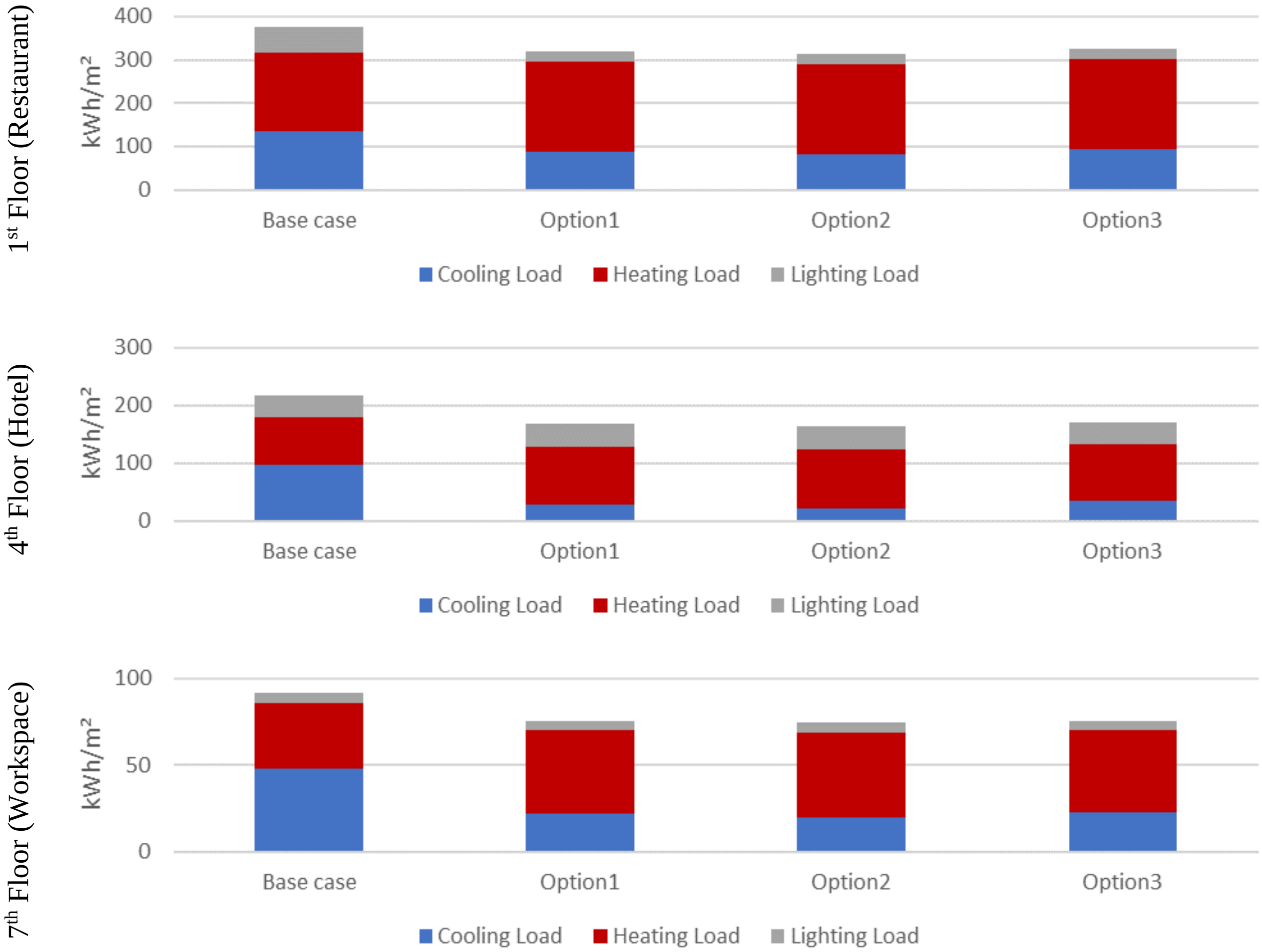


Figure 13. Comparative analysis of energy consumption for each representative room

Rooms	Open State	Semi-Closed State	Closed state
Restaurant (1^{st} Floor)	67%	16%	17%
Hotel Room (4^{th} Floor)	60%	15%	25%
Workspace (7^{th} Floor)	56%	10%	33%

Table 2. Shading state percentage for each floor as per the second option

CONCLUSION

In summary, the case study represents a multifunctional building with only two exposed facades where north façade daylight is controlled with no problems in terms of illuminance values and glare while the south façade was targeted to be shaded to control sun radiation. The innovative design of dragon shading system creates an attraction pole raising the awareness of Milan symbol. The shading units have been optimized for their operations to achieve maximum energy savings coupled with visual comfort conditions. The final module design of shading system was optimized and compromised of 5 fins of 1.4 [m] * 1.4 [m] – including the actuator height- using light metal frame and perforated metal sheet with 0.7 visual transmittance. The optimum operation mode achieved energy savings of 16.68% for the restaurant at first floor and 23.96% for the hotel at fourth floor and 18.62% for the workspace at the seventh floor. All rooms showed almost 100% glare control with useful daylight illuminance of at least 300 lux covering more than 65% of rooms area. The optimum operation of shading units showed that for all room, the shading units are open for more than 50% of the time where workspace has the greater percentage of closing hours - 33% of the time – while restaurant has the least percentage of closing hours with only 17% of the time.

ACKNOWLEDGMENT

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NOTES

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MILAN: THE CITY IN CONSTANT AND RAPID CHANGE. THE FUTURE IS GREENER

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INTRODUCTION

If we take as a reference Marc Augè's description of the work of the photographer Basilico Milan represents the planetary city.[1]

This metropolis has always been an exception compared to other modern Italian cities, in fact, if on the one hand green has always played a central role in urban planning, on the other, speed and technology have characterized its development. In this way, Milan differentiated itself from all of Italy, held back by a strongly consolidated historical-cultural background. Milan is the only Italian city that over time has proven to change rapidly, respecting the past, but projecting itself into the future. The spectacular rapidity of changes with an equally rapid adaptation, conversion and design of buildings, of former industrial areas, of services and of transport has always been accompanied by numerous green projects. In recent years, numerous strategic projects have been launched with the aim not only of increasing the city's green spaces, but also of limiting its sprawl, of creating a link with rural suburban areas, of improving suburbs, of reconverting industrial areas. or abandoned railways. Furthermore, the main objective is to restore the waterway system (canals, canals and dock) with the creation of a blue and green infrastructure system, restoring quality multifunctional public spaces to citizens.

Figure 1. Map of the city of Milan with the green areas mentioned in the article highlighted - Watercolor by Mario Manfroni.

THE PUBLIC PARKS OF YESTERDAY

The development strategies of the city of Milan have always been innovative and, in particular, those in progress in the contemporary era started with first master plan by Beruto (1888).[2] This was based on the same principle, according to which until then the city had evolved, that is in a regular manner in the same way as the crown of a tree grows and according to a uniform grid. The large Sempione public park is an exception. This was built in the late nineteenth century in the green area around the Castello Sforzesco, transforming the vast old parade ground into an English garden. Even today, together with the semicircular Foro Bonaparte behind the Castello Sforzesco, they represent a green space isolated from the whole city.[3]

Before this there is the important Cavalchina Plan, drawn up at the end of the 18th century by Piermarini to provide the city with adequate public spaces within the historic walls. This involves the construction of a large garden between Porta Orientale (now Porta Venezia) and Porta Nuova. Like Hyde Park opened to the public in 1637 or the Luxembourg gardens in Paris, the first public gardens in Milan, today Indro Montanelli, were inaugurated by the Habsburg administration in 1787.[3] They were built on those land owned by the royal and other of religious orders for the public, who recently moved to the city. In the mid-1800s, the initial project with regular flower beds according to French fashion, today called the 'old garden', was transformed and expanded into a landscape garden, only to undergo another transformation at the beginning of the 20th century. The park includes the old gardens equipped for walking, for resting, for football and for popular festivals. Another element of the Montanelli park similar to other nineteenth-century built in Europe is the reuse of the historic walls in disuse: in this case the Spanish defensive bastions at the Porta Orientale draw the boundary between the park and the new boulevard according to the fashion of the time.[4] Even the choice of the species used in the green project are those of the fashion of the time: majestic trees of the first size isolated in large lawns or in rows to emphasize the pedestrian walkways or in small groups to separate spaces or to screen the noises of the city [for example: *Aesculus hippocastanum* L., *Platanus acerifolia* L., *Ginkgo biloba* L., *Styphnolobium japonicum* (L.) Schott, *Cedrus libani*, A. Rich., *Cedrus deodara* Roxb. ex (D.Don)

G.Don, *Cedrus atlantica* (Endl.) Manetti ex Carrière, *Quercus rubra* L.] or at the edge of lake basins [*axodium distichum* (L.) Rich.]. The botanical heritage is enriched with shrubs [for example:*Viburnum tinus* L., *Cornus* sp.pl., *Hydrangea* sp.pl., *Chimonanthus praecox* (L.) Link., *Spirea* sp.pl.] and collections of ancient roses, which alternating in the periods of flowering and in the seasonal colors of the foliage, create spaces of high aesthetic value.[5,6]

If under the Habsburg rule the design of the city was very innovative, unlike that of the public park, which followed the fashion of the time, the QT8 settlement designed by Bottoni on the occasion of the VIII Triennale in 1947 is configured as one of the experimental districts of the polycentric development proposed by the PRG of 1946 AR (Architetti Riuniti).[7] The design of the new district is opposed to the traditional urban logic, based on strict rationalist conception, but rather is inspired by the Anglo-Saxon model of the garden city. Unfortunately, today the QT8 is incomplete, because the green and multipurpose central axis, designed to accommodate a sequence of squares and collective spaces, has not been built. In part, the lack of the multifunctional element is compensated for by the construction of a neighboring public park. This becomes the background of the newly built neighborhood, but it can also be understood as a reinvention of the monumental historic gates to the cities. Monte Stella, named in honor of the wife of the architect Bottoni, Elsa Stella, is made up of an artificial hill. In the place on which it stands, once occupied by a large quarry in abandonment, he intended in the initial master to large mirror of water, then filled with the ruins and rubble of the war. Since it already looked like a mound in 1947, Bottoni decided to transform the place (375,000 square meters) into a poetic 'Milanese Mountain'. This has a height greater than 50 meters and consists of a system of terraces, sinuous at the foot of the river Olona, culminating in a circular clearing, from which to admire the view of the new residential complex and the entire city. If you think that one of the aspects that characterizes the contemporary city is the reuse of disused infrastructures or former industrial areas, including all recycled materials to create new open spaces, the concept of the Monte Stella park created in the post-war period was very progressive. Unfortunately, the design of its green elements is not equally so, which follow the traditional patterns of the nineteenth-century public park, for the time now outdated with respect to both the innovative design of the QT8, and the visionary projects of the Modern Movement (for example: La Ville Radieuse by Le Corbusier and Broadacre City by Wright), widespread and applied for some time, especially in the Anglo-Saxon world.

Figure 2. 'The Present': the most imposing hill of the Portello Park- Watercolor by Mario Manfroni.

The revolutionary example of the QT8 / Monte Stella in 2002 was connected to the Portello park through a system of pedestrian walkways. The latter is part of the reconversion master plan in the former Alfa Romeo industrial area, which is one of the intervention programs for brownfield sites and urban redevelopment (PRU) planned by the Municipality of Milan in the 1990s. The intervention is emblematic of this particular historical moment and is part of the so-called 'brownfield' recovery interventions, characterized by reclamation, re-infrastructure and the reorganization of mobility and large urban functions, with the aim of limiting the land consumption. The designers were Valle, Canali and Zucchi, while the park was designed by Jencks and Kipar.[7] The concept of Monte Stella, in this case through the use of landfill from the excavations of the new district, is transformed into a landmark characterized by a very articulated morphology: a double elongated S and a large spiral with their grandeur become the figures protagonists, at the same time establishing a dialogue between them, with the park and with the city. The large movements of earth in this case are not only a perceptive visual element that relates to the urban landscape, but they perform a precise and very important task, in fact they become sound-absorbing barriers useful for shielding the noise of the surrounding fast-flowing roads and to accommodate the water basin, surrounded, as in an embrace, by a very long circular bench in a sheltered position due to the presence of the large embankment. The large green sculptures take on a symbolic meaning the hill of "Prehistory", which surrounds the lake. Its shape takes up the first great structure of the universe, the spirals of the galaxies and, finally, the theme of speed in memory of past activities. Going down from this hill you come to that of the "History", a crescent, which separates the "Time Garden" from the rest of the park. The most imposing hill, which looks towards the city center, is dedicated to the "Present", with a path that unravels on a double helix culminating in its highest point (22 meters). At the top is a fountain and a metal DNA sculpture, in homage to the theme of life. The "Time Garden" is the most intimate and protected space in the park with astronomical symbolisms on Earth, the rotation axis, the alternation of seasons, the days ……. Finally, a small *hortus conclusus* was designed within the urban park, a type of garden that refers to small medieval green spaces, such as in monasteries and convents, where plants for medicinal purposes were grown. The space was designed for Alzheimer's patients from the nearby Don Gnocchi hospital and rehabilitation center.[8] The plant species used and their arrangement are completely linked to the concept of the park: the shape of the foliage, the color of the bark, of the foliage, of the blooms underline the spaces in their multifunctionality and enhance their symbolic meaning. There are hedges of *Laurus nobilis* L, *Photinia* × *fraseri*, *Abelia* × *grandiflora* (Rovelli ex André) Rehder, *Buxus sempervirens* L., *Elaeagnus* × *submacrophylla* Servett., rows of *Cupressus* sp.pl., first dimension trees or thickets (the most used species: *Acer campestre* L., *Acer platanoides* L., *Carpinus betulus* L., *Liriodendron tulipifera* L., *Quercus robur* L., *Fagus sylvatica* L.).[6]

THE PUBLIC PARKS OF TODAY

Since 2000, the municipal urban planning policy has been oriented to intervene through major urban transformations, but at the same time to introduce the themes of sustainability, resilience, soft mobility. An example is Porta Nuova, because it is made up of various parts, it tackles different themes in an innovative way: re-cladding, the new skyscrapers with consumption '0' and with sustainable technologies (Palazzo Regione Lombardia), greenery in the city and prevalence of slow mobility, without, on the other hand, sacrificing the fast one. Today, for the most part, it is an urban metamorphosis of the three Milanese districts, Garibaldi-Repubblica, Varesine and Isola. In particular, the Garibaldi-Repubblica area, after the decommissioning of the railway yard around 1950, was for years a "non-place", without an identity due to the sense of abandonment transmitted, whose pedestrian crossing alone was dangerous. The project has returned to the city a large usable area near the historic center, well served by roads, which identifies a new type of 'Green City'.

Figure 3. La Biblioteca degli Alberi: a new public park in the Porta Nuova urban area- Watercolor by Mario Manfroni.

The connecting element is the 9.5-hectare park, designed by Petra Blaisse of Inside Outside (first place in an international competition) with over 1500 trees, which functions as an urban connector, cultural campus and botanical garden.[9] The strong idea is that of the Biblioteca degli Alberi: a public park with a variety of Lombardy trees where you can meet, have fun and get educated. The extensive surface is covered by a network of linear paths, with precise hierarchies, which, crossing each other, generate geometric fields, circular forests, overcome the unevenness of the underlying infrastructural system, become acoustic barriers and bridge roads. Following the example of important interventions of the Anglo-Saxon tradition, including Central Park in New York, the high-level maintenance program for the park is guaranteed due to the presence of a prestigious building near the park and along its borders.[10]

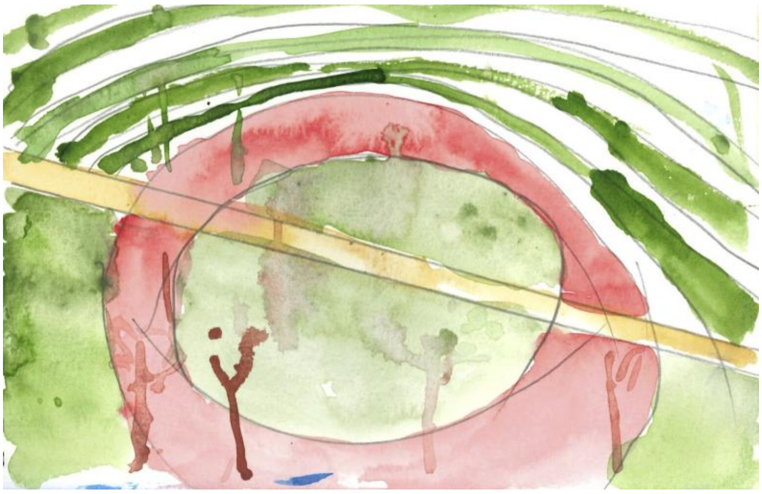

Figure 4. La Biblioteca degli Alberi: detail of a circular forest - Watercolor by Mario Manfroni.

The Wheatfield installation by Agnes Denes is very interesting and provocative. This was built on the occasion of Expo 2015, before the area was completed with the park, and consisted of a 5-hectare wheat field. In this urban transformation project there are three other interesting landscape interventions. The first is the new promenade designed by Kipar,[11] where the vertical lines of the adjacent skyscrapers are reflected in the geometries of the green spaces, underlined by the use of plant species arranged to form dense carpets with rigid geometric shapes or arranged as linear elements that become fluid for the movement created by the wind that passes through the leaves and spikes of grasses or the crowns of trees. The other is Piet Oudolf's garden, where the herbaceous and low shrub species, mixed with great attention to shape, colors, dimensions, create a space that inspires naturalness, emotions and different atmospheres in different seasons and hours of the day; a space, which however, has high management / maintenance costs.[12,13]

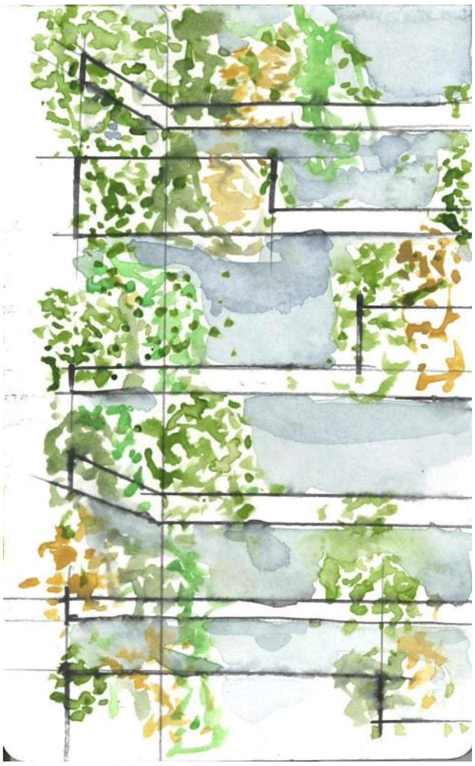

Figure 5. Il Bosco Verticale: scheme of a part of the green facade- Watercolor by Mario Manfroni.

Last but not least, it is the first Boeri Il Bosco Verticale, an international model exported worldwide. The presence of vegetation at the various levels of the skyscraper favors the presence of insects and birds. From a visual-perceptive point of view, the building appears green due to the plantations on the balconies. The arrangement and sequence of the greenery on the facade is designed so that the plants have the best possible exposure and create good radiation inside the houses. The biodiversity, albeit artificial, has been recreated with the use of over 100 species and the composition of 800 trees with a height ranging from 3 to 9 meters, 4500 shrubs and 15,000 ornamental plants.[14]

The first proposal for a slow city with the identification of nine parks connected by three avenues with landscape value is contemporary with the PRUs, from the end of the 20th century. In the same vein, in

2007 I Raggi Verdi project by Studio Land and the Metropolitan Interest Association (AIM) was presented, later promoted by the Municipality of Milan. I Raggi Verdi are the idea of a green belt made up of parks and avenues, which, starting from the city center, join radially to the peri-urban parks. Compared to Olmsted's project of the Emerald Necklace in Boston at the end of the nineteenth century, Milan intervenes within the consolidated city, trying to mend a green plot between pre-existing elements, instead in the American case the system of avenues and parks planned before development urban still works very well today, with no signs of aging.[4] In the Italian city, the new network of pedestrian and cycle paths enriches the urban area with greenery, improving movement in the city and the daily life of all citizens. I Raggi Verdi are intended as linear spaces shaded by trees, where it is possible to walk, laze, run, ride a bicycle enjoying the green already present and planned on the urban territory: a garden, a tree-lined square, a neighborhood park, a large park urban. The project initially envisages 8 Raggi Verdi with an average length between 7 and 12 linear kilometers: each Raggio, starting from the city center, reaches one of the large urban parks or the Milanese belt.

THE PUBLIC PARKS OF TOMORROW

The current and future guidelines are to create not only large parks, but also new avenues, small green spaces belonging to buildings or roads and technological green (such as vertical green and green roofs), which do not have a mere function aesthetic and social, but which perform a multiplicity of ecosystem services, such as the increase in biodiversity, the mitigation of climate change, the abatement of atmospheric pollutants, the storage and assimilation of carbon dioxide, the mitigation of soil erosion and surface runoff. Milan 2030 is moving towards a new urban ecology, with a multiplicity of projects (involving a multiplicity of governance actors, researchers, designers, associations and ordinary citizens - such as ForestaMI, Clever Cities), which are based on the key concepts of sustainability and multifunctionality, which take place through the adoption of Nature Based Solutions (such as drained trenches, rain gardens ..). These solutions have already been adopted in recently designed parks. An example is the Cascina Merlata Park (by AG&P greenscape) which extends behind the homonymous farmhouse restored on the occasion of EXPO 2015 and embraces the new district which is currently being completed and which will host about 12,000 inhabitants including civil dwellings, affiliated housing and social housing. The park, largely completed, has an area of 30 hectares, incorporates a pre-existing mixed plain forest and has about 10 km of cycle paths connecting not only with the nearby areas, but also through the 7th Raggio Verde with the Sempione Park. and the Castello Sforzesco in the city center.[6] The plant species chosen for the park are mainly Lombard autochthonous and their arrangement follows the spontaneous arrangements of the vegetation, creating highly resilient natural ecosystems. Even the water in the park is not a merely ornamental element, but performs functions of support for spontaneous flora and fauna and implementation of biodiversity; the hygrophilous species also perform a natural action of water phytoremediation and the system of canals and water mirrors help mitigate extreme rain events and make urban drainage more efficient. A park that combines socio-cultural functions with high ecological-environmental performance and low management and maintenance costs. Milan, the first in Italy and among the first in Europe, wants to demonstrate how quickly a green city with a low ecological impact can be created, where the built is closely linked to green spaces, allowing its citizens to work and live in sustainable spaces and ecologically performing.

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TRANSIT AND MEGA-EVENTS: THE ROLE OF TRANSIT STATIONS IN PLACE-MAKING

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INTRODUCTION

Large international events have become increasingly important for cities and regions as they have acted as catalysts for urban, economic, and cultural development, strengthening cities' international image. Among the required supporting infrastructures, transit plays an essential role in delivering mobility and accessibility; and its stations, as permanent facilities, can work as drivers of urban transformation with long-lasting effects. Transit stations can thus have a significant contribution in place-making and in creating an identity through their architectural design and urban integration, not only for the event itself but also in legacy. This paper assesses the role of transit stations built for mega-events as components of place-making strategies in different cities and its outcomes in legacy. A place-making assessment framework related to transit stations can provide valuable insights to plan and build more connected, thriving and people-friendly places.

CONCEPTS

In a globalized world, mega-events are seen as opportunities for cities to implement rapid urban transformations aiming to foster economic growth, promote a worldwide image, and enhance connectivity [1] [2], thus overcoming the resistance to change from the several stakeholders.
The impacts of mega-events in hosting cities can have different forms, influencing land-use planning, transportation, economy, and social and cultural development. While some have short-term impacts related to the event itself, others will remain due to the city's urban transformation in the long-term. Mega-events can be used as an opportunity to improve transportation infrastructure, launch major urban developments, regenerate derelict industrial areas, and environmental rehabilitation of significant city areas [3]. Hosting a mega-event can also be the opportunity to catalyze a broader change towards a greener economy and more sustainable lifestyles with the development of low carbon public transport systems [4], while enhancing urban mobility.
Mega-events are accelerators of rapid urban transformation, setting the opportunities to create new places and landmarks to attract global investment. For the host cities, it is critical to have transport projects related to mega-events linked to strategic long-term planning goals [5-7], aiming to improve living conditions in the urban areas by integrating transit and land-use [8] [9]. As landmarks creating a strong identity, stations determine people's perceptions and appropriation of a place. In addition,

whereas aggregating transit, public realm, and other services, stations build lively places for mega-events while promoting identity and social cohesion for the communities when events are over.
The terms *mega-events* and *place-making* are widely used and require a concept definition framing their understanding in this study. Considering the different understandings of what makes a mega-event [10, 11], we adopted Müller's definition as a threshold, which proposes that **"***Mega-events are ambulatory occasions of a fixed duration that attract a large number of visitors, have a large mediated reach, come with large costs and have large impacts on the built environment and the population"* [12].
Place-making [13] [14, 15], in turn, refers to a process of strengthening the connection between people and the places where they live as a way to increase the livability in cities, neighborhoods, and public spaces. As definition of place-making we have adopted the process that builds or improves the public space, connects neighborhoods, supports the community, catalyzes economic development, promotes environmental sustainability, and builds a sense of place [16].
A place-making strategy goes beyond the station boundaries and creates a network of pedestrian routes, which links to key-points of the development and merges with the surrounding communities [17]. Urban design features and their pedestrian friendliness are key features of transport and land-use integration[18]. Stations can be the centerpiece of place-making [19] by creating a sense of place and building a vibrant mix of land-use and transportation options enabling a successful Transit-Oriented Development (TOD)[20], where the station is the centerpiece. These place-oriented TODs highlight the design qualities of attractive public spaces, human scale, connected, memorable and comfortable places [19]. Place-making is one of the strategies to highlight each place's uniqueness and compete for investment, fostering the economy, and ultimately improving residents' quality of life.

METHODOLOGY

To better understand the role of transit stations in building places during mega-events and legacy, we developed an assessment framework to measure their performance. This assessment framework was based on the values identified in the place-making definition and the key attributes set by the Project for Public Spaces [21]. We considered four main criteria that capture the relations of transit stations with the surrounding built environment. Each criterion is constituted by a set of sub-criteria defining the different measurements, as detailed in Table 1.

Criteria	Sub-criteria
[A] Connectivity	**A1** –Adds new transport services **A2** – Improves multimodal connections **A3** – Links with the urban context **A4** – Connection with the event
[B] Economic Development	**B1** – Revitalizes existing sites **B2** – Increases commercial and retail activities **B3** – Direct connection with new developments **B4** – Promotes new developments adjacent to stations
[C] Land-use	**C1** – Acts as driver for diverse and new land-uses **C2** – Builds urban continuities **C3 -** Strengthens integration with the urban context **C4** – Sets active street frontage
[D] Image and Sociability	**D1** – Has an iconic design/promotes a new identity/ creates a landmark **D2** – Improves public open space and adds green areas **D3** – Increases recreation / community services **D4** – Projects the city image

Table 3. Assessment framework

Our approach is based on AHP (Analytic Hierarchy Process) method used to rank the multiple criteria under analysis. Each sub-criterion is scored according to its performance using a five-level scoring matrix.

The case studies

The selected case studies, detailed in Table 2, represent different event types, hosted in cities of different sizes, economic performance, and culture, where the event was an opportunity for urban change with new or upgraded mass transit systems.

Mega-event	Year	City	Country
World Expo	1998	Lisbon	Portugal
UEFA Euro	2004	Porto	Portugal
World Expo	2010	Shanghai	Popular Republic of China
Olympic Games	2012	London	United Kingdom
Olympic Games	2016	Rio de Janeiro	Brazil
World Expo	2020 (2021)	Dubai	United Arab Emirates

Table 4. Selected Case Studies

Except for Dubai, where the Expo was planned to create a new city district in an empty area, all other cities implemented environmental rehabilitation plans, with urban renovations of derelict industrial areas or run-down neighborhoods. All selected cities established long-term strategic plans linked to new urban development areas, modernization of city infrastructures, and new transport systems. These urban changes were planned to serve the events while developing new centralities in legacy, attracting global investment, building new landmarks, and promoting a new urban image through place marketing for the city [22]. The Chair of London's 2012 bid for the Olympic Games has summarized the idea as "*Legacy is probably nine-tenths of what this process is about – not just 16 days of sport*." [23]

Mega-events require cities to provide the necessary means of transportation for the event. These transport systems' modifications remain tangible legacies, promoting a change in how people travel [1]. For the Expo'98 in Lisbon, a new metro line and a new intermodal transit hub were built, comprising an international, regional, and commuter train hub, a metro station, a bus station, taxis, and parking. Apart from being the gateway to the Expo, Gare do Oriente station has become one of Portugal's main transport hubs and an architectural landmark in Lisbon [24]. The station is linked to a mall and represents the main point of convergence of the surrounding urban area. It creates a strong identity while fostering urban development and improving the area's quality of life [25].

The UEFA Euro 2004 in Porto required the implementation of a mixed-use urban plan to revitalize an abandoned area setting a structure of diversified land-uses and public spaces. A new metro extension and a new station were built using the space available under the motorway. As a result, the station is located in a peripheral area, without connection to the neighborhoods across the motorway, and with no direct link to the new mall. The station offers three metro lines, underground parking, and bus services.

Figure 14. Transit stations in Lisbon, Porto, Shanghai, London, Rio, and Dubai (from the top, left to right)[1]

In Shanghai, the World Expo 2010 was the opportunity to regenerate the city waterfront by integrating mixed uses developments and cultural and recreation areas [26]. The metro network was extended with four new lines and three extension lines [27], developing TOD models that improved accessibility to central Shanghai [28]. The present study focuses on the Expo south area, crossed by two metro lines, and Shibo Avenue station (line 13), located inside the event area. China Art Museum station (line 8) only opened after the event in 2015. Despite the small entrance pods, these underground stations enhanced mobility and contributed to a greater land-use mix and more liveliness in the area.

In London, the 2012 Olympic Games introduced a significant change in the East London urban area and transport facilities [29, 30], that included two stations. The present study focuses on Stratford station as it was the primary access for the Olympics. It offers a wide range of transport modes, including metro, railway, light rail, bus services [31], and soft modes. The station improved the neighborhoods and adjacent mall's connections, enhancing accessibility, mobility, and the public realm. The significant changes in the environment and economic development arose from the transportation improvements, making Stratford station the seventh interchange on the ranking of English stations, turning the area in a better place to live [32].

2016 Rio's Olympic Games included a new Light Rail line and a Bus Rapid Transit (BRT) network as the main plan to reduce traffic congestion and increase mobility for the event (and in legacy). The present study focus on Parque Olímpico station included in the BRT line serving the main Olympics Park at Barra da Tijuca. The station has a functional layout with a central platform placed on a road median, with no additional services or amenities. Moreover, it is poorly integrated with other transport modes and has some accessibility barriers [33]. As it is disconnected from the neighborhood, it had no significant impact on the public realm, although it contributed to the real estate speculation in Barra da Tijuca [34].

Expo 2020 in Dubai (postponed to 2021 due to the Covid-19 pandemic) was planned to build a new centrality with a mixed-use community and is expected to contribute to Dubai's growth supporting tourism, logistics, construction, and real estate [35]. A new metro line was built ending at Expo 2020 station. This station presents an iconic design that build the place's identity. It connects directly to the event's main entrance, and provides seamless connections with the adjacent mall and the surrounding urban fabric. The public realm around the station, directly connected to the event area, builds a pedestrian plaza connecting to buses, taxis, and soft modes - thus addressing the Expo goal of offering an urban experience that connects people [36].

Assessment

To rank the different criteria considered in this work (connectivity; economic development; land-use; image, and sociability) and the correspondent sub-criteria, an AHP method was used, enabling pairwise comparisons as detailed in tables 3 and 4.

CRITERIA	[A] CONNECTIVITY	[B] ECONOMIC DEVELOPMENT	[C] LAND-USE	[D] IMAGE & SOCIABILITY	WEIGHT %
[A] CONNECTIVITY	1	3	3	9	54.4
[B] ECONOMIC DEVELOPMENT	1/3	1	1	5	20.5
[C] LAND-USE	1/3	1	1	5	20.5
[D] IMAGE & SOCIABILITY	1/9	1/5	1/5	1	4.7

Consistency ratio: 1.2%

[A] CONNECTIVITY	A1	A2	A3	A4	Weight %
A1	1	1	1	5	30.3
A2	1	1	1/2	3	22.3
A3	1	2	1	9	41.5
A4	1/5	1/3	1/9	1	5.9

Consistency ratio: 2.9% (<10%)

[B] ECONOMIC DEVELOPMENT	B1	B2	B3	B4	Weight %
B1	1	7	1	1	32.5
B2	1/7	1	1/5	1/7	5.1
B3	1	5	1	1	30.0
B4	1	7	1	1	32.5

Consistency ratio: 0.5% (<10%)

[C] LAND-USE	C1	C2	C3	C4	Weight %
C1	1	1	1	7	31.7
C2	1	1	2	5	35.9
C3	1	1/2	1	7	27.3
C4	1/7	1/5	1/7	1	5.0

Consistency ratio: 3.9% (<10%)

[D] IMAGE & SOCIABILITY	D1	D2	D3	D4	Weight %
D1	1	1	9	5	42.0
D2	1	1	9	5	42.0
D3	1/9	1/9	1	1/7	3.4
D4	1/5	1/5	7	1	12.6

Consistency ratio: 8.8% (<10%)

Table 5. AHP criteria ranking

Table 6. AHP sub-criteria ranking

To assess each sub-criterion, according to the station performance, a five-level (from 1, very low, to 5, very high) matrix scoring was set as shown in table 5. Each sub-criterion scoring is based on technical and economic reports, site visits, literature review, and empirical site analysis. Scoring for Dubai is estimated based on the legacy plans and existing site conditions.

RESULTS

The place-making assessment for each station is determined by the different criteria and, sub-criterion weights, and as well as their scoring. Table 6 gathers each location's scores considering the impact that the respective transit station has on each sub-criterion, thus leading to the final scores of the four main criteria.

CRITERIA	1- VERY LOW	2 - LOW	3 -MODERATE	4 - HIGH	5 - VERY HIGH
CONNECTIVITY (weight: 54.4%)					
A1	1 transport service	2 transport services	3 transport services	4 transport services	5 or more
A2	no connections	1 connection	2 connections	3 connection	5 or more connections
A3	deficient connection	connection with gaps	indirect connection	direct connection	seamlessly connected
A4	deficient connection	connection with gaps	indirect connection	direct connection	seamlessly connected
ECONOMIC DEVELOPMENT (weight: 20.5%)					
B1	no revitalization	minor changes on site	changes but keeps most of the existing conditions	strong revitalization, new roads and public spaces	builds a totally new site as part of a wider regeneration plan
B2	1 or no retail	2 to 3 small units	4 to 10 units	11 to 15 units with one large unit	major mixed-use development integrated with the station with more than 15 units
B3	no connection	Indirect connection, not close	connection with external access	direct connection	full integration with developments
B4	no plan	in plan but as secondary	important element but not the most relevant	central element in the plan	critical element with influence at city scale
LAND-USE (weight: 20.5%)					
C1	no impact or minimal	reduced impact	moderate influence	strong influence	huge influence
C2	no impact or minimal	reduced impact	Moderate-not consistent	strong attraction at local scale	major driver at city scale
C3	None or very low	integration with gaps	builds continuities	strong integration/linking different activities	builds the entire urban context/integrates all adjacent areas
C4	no street frontage	2-3 activities	4 to 6 activities	6 to 10 activities	more than 10 activities
IMAGE AND SOCIABILITY (weight: 4.7%)					
D1	very low impact	low impact	moderate contribution	high impact design setting the place identity, not relevant at city scale	iconic design building the place identity and creating a new landmark in the city
D2	no improvement	minor contribution, no green areas	improved with a functional layout, small gathering spaces / green	public realm with quality landscape design/ large green areas	high quality public realm with large plazas and large green areas acting as meeting points for the

Table 7 . Scoring criteria

The place-making assessment for each station is determined by the different criteria and, sub-criterion weights, and as well as their scoring. Table 6 gathers each location's scores considering the impact that the respective transit station has on each sub-criterion, thus leading to the final scores of the four main criteria.

This preliminary assessment allows us to identify the places where the overall strategies implemented achieved better results in terms of place-making. However, further studies, that include all stakeholders, are required for a more accurate assessment.

ASSESSMENT FRAMEWORK		LISBON	PORTO	SHANGHAI	LONDON	RIO DE JANEIRO	DUBAI
A - CONNECTIVITY (weight: 54.4%)	WEIGHT %						
A1- Adds new transport services	30.3	5	2	2	4	1	3
A2- Improves multimodal connections	22.3	4	2	2	5	1	3
A3- Links with the urban context	41.5	4	2	3	4	2	4
A4- Connection with event	5.9	5	5	5	4	4	5
	score	**4.36**	**2.18**	**2.59**	**4.22**	**1.59**	**3.53**
B - ECONOMIC DEVELOP. (Weight: 20.5%)							
B1- Revitalize existing sites	32.5	4	4	4	4	2	4
B2- Increase commercial and retail activities	5.1	4	1	1	3	1	3
B3- Direct connection with new developments	30.0	4	1	1	3	1	4
B4- Promotes new developments adjacent to stations	32.5	4	2	4	4	2	4
	score	**4.00**	**2.30**	**2.95**	**3.65**	**1.65**	**3.95**
C - LAND-USE (weight: 20.5%)							
C1- Acts as a driver for diverse and new land-uses	31.7	4	2	3	4	2	4
C2- Builds urban continuities	35.9	4	3	3	4	3	3
C3- Strengthens integration with urban context	27.3	4	2	3	3	1	4
C4- Sets active street frontage	5.0	2	1	1	2	1	2
	score	**3.90**	**2.31**	**2.90**	**3.63**	**2.04**	**3.54**
D - IMAGE & SOCIABILITY (weight: 4.7%)							
D1- Iconic design, new identity, new landmark	42.0	5	2	1	4	1	5
D2- Improves public open space and add green areas	42.0	3	2	2	3	1	3
D3- Increase recreation and community services	3.4	2	1	1	1	1	2
D4- Projects the city image	12.6	4	1	1	3	1	4
	score	**3.93**	**1.84**	**1.42**	**3.35**	**1.00**	**3.93**

Table 8 . Place-making assessment matrix

Through this preliminary place-making assessment, we can conclude that strategies implemented at stations in Lisbon, London, and Dubai led to the best results. These stations created connectivity nodes and worked as drivers of urban and economic growth. Moreover, they built a strong image for the event and the city identity, influencing people's perceptions and appropriation of the place during the event and in legacy.

Stations in Porto, Shanghai, and Rio improved mobility but showed to be weak as economic development drivers, did not build urban continuities with the surrounding urban fabric, and did not create new places with a strong identity and opportunities to meet and socialize.

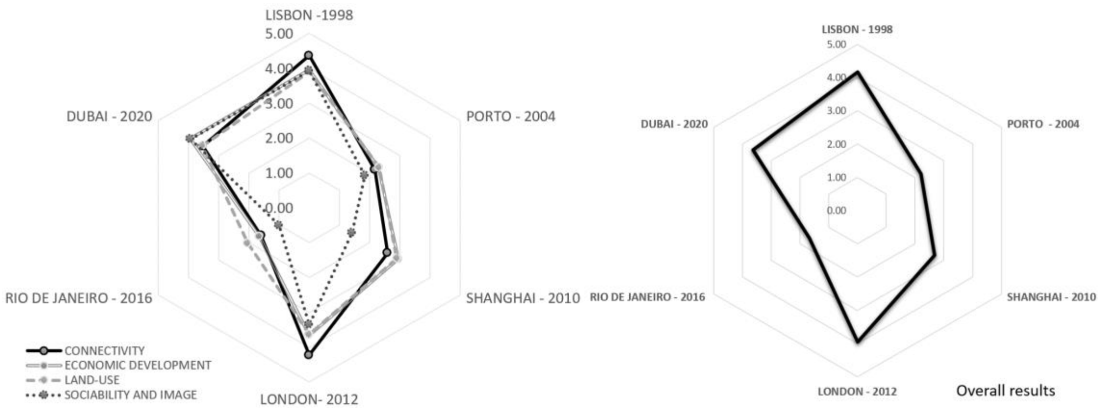

Figure 15. Place-making assessment results

From these preliminary results we can identify the factors that need to be considered during the overall plan and design stages of transit stations, when we want to implement better place-making strategies (figure 2). The study also identifies the areas around transit station where place-making strategies can be implemented, aiming to create better place-oriented TOD´s. However, additional studies are required to confirm in detail these findings.

CONCLUSION

From this preliminary assessment, we can conclude that transit stations have a significant impact in building the place for mega-events and in legacy by:

- improving mobility and connecting the city;
- acting as drivers for economic development;
- shaping the surrounding built environment and land-use;
- building identity, meeting points, and livable places in a high-quality public realm.

Despite being temporary, mega-events are catalyzers of rapid urban transformations, where the transport systems remain tangible legacies shaping city growth. Transit stations planning and design must go beyond creating just mobility nodes; they must be the backbone of urban planning, connecting economic growth and place-making as part of a TOD plan. Place-making strategies strongly determine people's perceptions and appropriation of a place for a mega-event and legacy by de community. Cities that implement place-making strategies linked to sustainable transport modes, building high-quality and connected public spaces, diverse and lively places with a strong identity, thriving economic development will become better places to live.

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IMAGE REFERENCES

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REGENERATION AND SUSTAINABILITY: A COMPARISON OF PRACTICES

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INTRODUCTION

In a view of a city as a living system reframing urban theories and images starting from the 20th century, *regeneration* is the organic metaphor with which a contemporary city was represented,[1] as well as a very common term in political programmes and latest generation planning tools. The biological meaning applied to the urban environment does not only mean rebuilding spaces and renewing functions, but restoring new dignity to places for life where citizens can identify with. The concept of "urban regeneration" implies policies and intervention projects to improve abandoned, unqualified or socio-economically, spatially and environmentally degraded urban areas.[2] This notion has evolved over time to meet the growing needs of an even more dynamic reality, shifting from punctual rehabilitation action within the urban fabric to integrated programmes extended to the entire urban area aimed at promoting economic activities, restoring sociality, recovering urban ecosystems.[3] The purpose of regeneration is to take into account the complexity of urban habitat by encouraging development and improvement in many sectors simultaneously, so as to foster economic growth, decrease social and cultural inequity, strengthen community cohesion and social capital, minimize climate change risk.[4] Such all-embracing nature of urban regeneration is also its greatest limitation: difficult challenges along with the need to satisfy multiple interests have produced partial and incongruent outcomes favouring people or business alternatively.[5] This is why *sustainability*, in its various declinations, is embedded with urban regeneration policies, especially regarding the interaction of initiatives to support the city economy, living standards, climate change adaptation and mitigation. Regeneration aims to favor new urban life processes capable of generating social and economical dynamics, but mainly environmental ones: indeed, awareness and protection of the built environment form the basis of the whole concept of sustainability. However, including sustainability in the urban practice is to be supported by a significant cultural change, in the absence of which the essence of sustainability remains a mere label with no real content. Regeneration goes far beyond the objectives, aspirations, and results of urban upgrading. The main risk is that there will be a process of physical modification in which the final purpose is not clear: in terms of revitalization, regeneration would fail to exactly indicate methodology and approach.

Highlighting the importance of sustainable development as a guiding criterion in regeneration practices and as a part of the climate protection actions indicated by the European Commission in the Urban Agenda, this paper presents a few case studies implementing EU policies and plans. Special emphasis is given to virtuous processes and the most relevant intersectoral outcomes, by outlining the key elements of urban regeneration able of orienting Europe towards a more livable future, in full respect of the human and environmental needs.

Sustainable urban regeneration

Living in cities and metropolitan areas offers better job and life opportunities, economic and cultural advantages that make them privileged centres of knowledge, experimentation and entrepreneurship.[6] Furthermore, they are focal points of national growth as well as places of inclusion and social integration.[7] As the most coveted places to live, over half of the world population is concentrated in urban areas which have become the main causes of resource consumption, pollution and GHG emissions putting their own survival at risk. Thus, they are contributors and at the same time victims of climate change.[8] If urban regeneration is the only real way of reducing the environmental impact, to be truly effective and efficient it must satisfy the principle of sustainability articulated in three components interdependent from each other: environmental, socio-economical, and institutional. Through flooding, heat waves, droughts, the current climate crisis has a direct physical impact on the built environment, infrastructure and citizens' health, while it indirectly impacts local economies that depend on key resources, limiting investments both social and financial capital.[9] The incremental rate migration flows from outside and inside the EU has exacerbated socio-economic inequalities and intensified the conditions of urban vulnerability due to rising poverty, ethnic diversity and social exclusion. Institutional challenges to urban sustainability are often linked to tensions between top-down technical and managerial approaches and mostly lack an organic, global and participatory vision. In spite of the importance and urgency of acting within the limits of non-renewable resources, sustainability has not yet completely imposed its own rules, but it has now become an even greater priority in architectural design as well as in urban planning and regeneration.

Integration, cohesion and sustainability in the Urban Agenda for the EU

With around 359 million people living in cities, Europe is the world's most urbanized continent. European urban areas host more than three quarters of Europe's population, they generate up to 85% of Europe's GDP but account for about 80% of energy use and they are also places where unemployment, segregation and poverty are mainly concentrated. Cities play a key role in the Urban Agenda for the EU as a driving force for territorial, regional and cross-border development, including anthropogenic and natural landscapes, environmental and cultural heritage. The Urban Agenda was created to improve the quality of life in urban areas, to ensure the growth potential of cities and to successfully tackle social challenges by promoting cooperation between Member States, Cities, the European Commission and other stakeholders. It is based on three operational and interrelated pillars: sustainability, cohesion policy, integrated approach. A special focus on sustainability is the foundation of many European initiatives from the 1990s[10] to the most recent Paris Agreement on climate change (2015) that established the 17 *Sustainable Development Goals* (SDGs) and related 169 *Targets*. In terms of urban regeneration, even the Leipzig Charter on Sustainable European Cities (2007) is an important reference in addressing important issues: physical and social degradation of entire districts; quality of public spaces; strengthening of the urban economy; integration and social support policies; recovery of existing assets. In addition to overcoming the economic recession in recent years, the current programming intends to achieve a series of objectives already defined by the European Commission in 2010 within the document "EUROPE 2020: A Strategy for Smart, Sustainable and Inclusive Growth".[11] They are five specific fields aimed to direct the EU's Regional Policy: employment; research and development; climate and energy; education; social inclusion and poverty reduction. Cohesion Policy is the EU's strategy to promote and support the 'overall harmonious development' of its Member States and regions. To this end, the EU has allocated 50% of the European Regional Development Fund (ERDF) to urban development as an investment priority. This will be translated into sustainable mobility, regeneration of deprived communities, greater employment opportunities, research and technological innovation, support to SMEs, reduction of urban inequity, delinquency and the feeling of insecurity.[12] The establishment of an urban development platform has strengthened capacities and exchanges of experience between cities and regions, notably through building rural-urban partnerships. Cohesion Policy beyond 2020 is designed to a smarter, greener, connected, and social Europe and a new cross-cutting objective to bring Europe closer to citizens by supporting local investments. Each of these goals requires an *integrated approach* to sustainable urban development. The European Commission provides a general understanding of what they consider an 'integrated approach': the various dimensions of urban life – environmental, economic, social and cultural – are interwoven and success in urban development can only be achieved through measures concerning physical urban renewal combined with measures promoting education, economic development, social inclusion and environmental conservation. Secondly,–Cohesion Policy is upheld by a strong partnership between citizens, civil society, industry and the various levels of government as an essential prerequisite.[13] Thus, 'integrated' is a synonym for *inclusive* since it meets bottom-up schemes, whereas the involvement of actors generally excluded from traditional programming tools offers higher guarantees for the feasibility of actions. Analyzing the development of regenerative policies over the last few decades, it is evident how the tools provided by the relevant legislation are accompanied by a series of integrated planning programmes, focussing on urban management and on processes of economic growth, participation and promotion of sustainable issues.

EU PROGRAMS AND EXPERIENCES

If urban regeneration is a key focus for public policy throughout Europe,[14] cooperation, inclusion and sustainability are the starting points towards a common European methodology for urban development. In compliance with the *Leipzig Charter* and the *Cohesion policy*, many recent EU-funded programmes have contributed to renewing cities across Europe by incorporating integrated approaches and encouraging cooperation between multi-level urban authorities through online resources. Among these is the *Reference Framework for Sustainable Cities* (RFSC), an interactive tool to translate the pillars of sustainability (Economy, Society, Environment, Governance) into practice by providing exemplary cases and information for the development of new solutions compatible with the specific needs of each city.[15] On the basis of a sustainable model devoted to the least use of resources, these projects have been implemented by adopting green and low-impact strategies: recycling land and buildings, contributing to the *compact city*; promoting low-carbon and renewable systems; drawing on local resources; reducing energy consumption; fostering alliances.[16] Sustainable development is the main principle of many community regeneration programmes. That is the case:

- **Environment Action Programme** (EAP): It sets out a strategic agenda for addressing the main environmental challenges Europe faces, for protecting and enhancing natural capital, for encouraging more resource efficiency and accelerating the transition to the low-carbon economy;
- **INTERREG**: Launched in 2002, this program provides funding for interregional cooperation across Europe;
- **LIFE+**: It is the European Union's financial instrument supporting environmental and nature conservation projects. Since 1992 LIFE+ has co-financed some 2,750 projects with a total of €1.35 billion;

- URBAN: Launched in 1994 in two rounds (URBAN/URBAN II), the programme, aimed at solving social-economic problems in deprived neighborhoods in European cities, has acted as a catalyst for new forms of cooperation, helping city administrations to enter the European scene;
- URBACT: It is the European exchange and learning programme promoting integrated sustainable urban development. It works to enable cities to share good practices and lessons learned with all professionals involved in urban policy throughout Europe. Jointly financed by the European Union (ERDF) and the Member States, URBACT is active in 550 cities, 29 countries.

Regenerating Europe: case studies

In an attempt to identify the best practices of urban regeneration and with reference to the programs abovementioned, we proposed a few case studies where the urban transformations have triggered significant processes of economic, social, environmental and cultural revitalization.
Within the INTERREG framework, the project "Modernizing schools as community centres for lifelong learning", in Bremen, led to a rethink of the role of schools as multi-functional institutions that play a crucial role in urban development. Robinsbalje, a former car park in a deprived neighborhood, was transformed into a centre which offers education, health, sport and employment services in one facility to give people of all ages better future prospects. The *learning neighborhood* concept applying a holistic approach to education within integrated planning, a lived partnership by different stakeholders and the active involvement of local communities and NGOs in all the phases of the project, are key success factors of a complex intervention. This case shows remarkably how education, social inclusion and urban regeneration can be linked to the revitalization of a deprived urban area. Many post-war inner-city housing estates across Europe have to face a number of urban, economic and social challenges that the physical regeneration alone cannot tackle and needs to form part of a wider package of neighborhood renewal solutions. The IMAGE Project, funded by INTERREG, has been working on new concepts around image enhancement as a strategic element of integrated-development programmes. The *Neighbourhood branding* approach was developed and tested in the five European cities and related high-rise residential areas: Europark (Antwerp), Barton Hill (Bristol), Poptahof (Delft), Ballymun (Dublin), and Schwamendingen (Zurich). Communities and stakeholders were involved in the development of their brand, while project actions were incorporated into existing local regeneration strategies.
The URBAN II programme area in Turin lies on the southern outskirts of the city which needed intensive urban regeneration of the public housing stock, the low-quality public and green areas, and new central functions. The model adopted for this initiative, focused on the cooperation of partners and local stakeholders, can be synthesized into three guiding actions: find a new centre; get things going again; gain a new focus. With regard to innovation and sustainable results, one of the most important achievements of this initiative is the 'Forum for Local Development' aimed to provide effective monitoring by district committees and businesses, public undertakings and private companies. The Urban Pilot Project in Bilbao focused on the former industrial area of Otxarkoaga, a suburb of the city built in the 1950s, and addressed three different problem areas: environment, commercial development and economic activity. Amongst the measures to improve the environment was a recycling centre dedicated to the repair and recovery of various items from all over the city. It encouraged employment and economic activities, by financing training courses in management, ICT and customer services. In addition, it favored the association of local commercial enterprises in sectoral networks.
The URBACT RE-Block network focuses on the regeneration of large-scale housing neighborhoods. Ten partner cities exchange knowledge and experience on how to improve houses, public spaces, and

the social environment. Vilnius municipality joined the network in 2013 with the “Zirmunai Triangle” project, chosen for its strategic location and because it is one of the oldest and most deteriorated housing neighborhoods in Vilnius. A Local Support Group was formed by local residents and institutions to define an action plan, including new public and green spaces system, redesign of community buildings and development of ownership over the common land around the buildings, optimization of soft mobility. Overall, the URBACT RE-Block network has prompted Vilnius’ government to carry out this project in a different way, involving representatives of residents and various local stakeholders to apply experiences from partner cities and test the proposals.

Providing a cooperative platform between two Swedish cities - Borlänge and Falun - the “Swedish Urban Pilot Project” aimed to persuade existing companies to incorporate environmental technology into their working practice, as well as support new business activity in areas with growth potential in the fields of ecology and energy. The medium-term goal of the project was for sustainability to become a standard concept in urban regeneration, local economy, and citizens' life. The focal point was the ‘Dalarna Natural Resource Centre’, located halfway between Falun and Borlänge, coordinates the cities’ activities, hosts three specific institutions (‘European Urban Research Park’, ‘Economic and Technology Centre’, ‘Centre for Environmental Information’), stimulates the transfer and use of environmental technology within the private sector. The project’s strength is the paradigm shift that establishes the principle of environmental sustainability as a driving force for change and regeneration in medium-sized towns.

KEY ELEMENTS OF SUSTAINABLE REGENERATION

On the basis of the experiences illustrated above, sustainable urban regeneration requires an integrated and systematic approach can be summarized in the following strategies:

1) Investing in places and people: Regeneration measures invest in places and simultaneously in people. If local communities have gained enough confidence, expertise and commitment during the period of EU-funded schemes, they will move from mere participation to be at the heart of regenerating process to address future challenges. New financial instruments, such as *Neighbourhood Budgets*, motivate them to become involved in urban change with immediate benefits who take up the reins of promoting their territory.

2) Integration of policies and plans: The interventions are more effective if integrated with local and/or regional policies in the short and long term and related to strategic areas (land-use; equal opportunities; inclusion and safety; protecting the environment and responsible use of natural resources; demographical trends; training and employment; training and qualification; technological innovation and research).

3) Intersectoral and cross-scale approach: The complexity of urban development requires intersectoral measures and engagement of public and private actors to improve both the built and the natural environment, promote social cohesion and competitiveness in attracting business, enhance urban living standards. The urban initiatives go further than individual projects and geographical limits of a specific urban area, as they affect the surroundings with echoes at a regional and national level as well.

4) Cultural values and diversity: Physical heritage, traditions and knowledge of local residents are key factors in maintaining collective self-esteem and encouraging more active citizenship. Furthermore, strengthening social capital is crucial to develop the local identity and a sense of community.

5) Multilevel cooperation: A successful programme requires strong local and regional partnerships. Public resources are limited, so there is a need to secure work with the private sector to access sufficient finance and to bring in new entrepreneurial expertise to be integrated into public political know-how and residents' local know-how. The very nature of partnerships contributes both to reinforce the horizontal dimension of policies and to enhance vertical cooperation among local, regional and national bodies, by profiting from exchanging experience of urban governance, administration, and management.

6) Attention to the environment: The urban operations contribute to European environmental objectives and guidelines, especially with regard to a reduction in the use of energy, protection of the natural environment and containment of the ecological crisis.

7) Ongoing monitoring: Ex ante, interim and ex-post evaluations should be an integral part of each development. This can then form the basis of any adjustments in policy to achieve the best use of all possible resources.

Sustainable urban development is reached only through integrated, long-term visions for cities and neighborhoods into their regional context and geared towards specific target groups. Area-based integrated plans can have a much higher impact if do not divide problems and potential along with administrational responsibilities but treat and use them in a comprehensive way. Physical regeneration has to include multiple dimensions of urban life, by putting sustainability at the core of an indispensable reunification of planning, ecology, economy, and landscape.

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A CITY BY THE CITIZENS: THE OPEN SOURCE MODEL AND ITS ROLE IN URBAN DEVELOPMENT

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INTRODUCTION

With the urban population share in the Global South growing at an ever-increasing pace, new ideas and methods of 'shared ownership, digitization and open access are being considered by the governments as sustainable alternatives for urban development[10]. The relevance and practice of architecture and urbanism is moving from the sole authority of the designer to participatory equity of the stakeholders and users[11]. Furthermore, the Human Capital Theory of regional development posits that the Creative Class - the largest and fastest growing group of working individuals in the cities - values openness to diversity and opportunities to express their creativity over the physical attraction of malls, apartments, infrastructure and such. Citizens are more interested in the process over the product. The notion of 'access' - to tools, information, design etc. - has become the single most important factor determining perceived quality of life in urban centres.[12]

(Free/Libre) Open Source in design exemplifies a new model of production with a social vision, building on the emancipatory potential of non-hierarchical and equality-driven setups where users can access, modify and distribute the knowledge and technologies they possess.

VISION – FEEDBACK – RESPONSE LOOP

Building upon the concepts and principles of 'open source' for cities, the research establishes a design framework based on a vision – feedback – response loop that serves the current user requirements while allowing for future citizen-driven modifications:

Vision: Grounding in physical and socio-cultural context

The first part focuses on interpreting the project context with respect to:

1. Socio-economic status and mindset of the users who will engage with the project
2. City- level forces such as capital and political influence that cause changes to the city fabric
3. Emerging consumer trends – such as the rise of shared culture- generated by technological and creative innovations

This study and analysis is then used to design the project development parameters (area programme, typologies, architectural and urban character etc.)

Feedback: Socio-spatial analysis

The second phase focuses on generating a transaction log between the user and the spaces he/she uses with respect to:

1. Level of engagement with the existing typology – physical, social and economic
2. Appropriation of spaces to perform recreational and livelihood functions
3. Modification of spatial infrastructure for personal use

The documentation and its analysis is used to define the character and spatial tectonics of the project.

Response: Creating responsive tectonics through open systems

The last part of the loop generates a design catalogue for the project with respect to:

1. Sub-divisions of the city-building process clearly demarcating the lines of decision making and responsibilities between the stakeholders
2. Design specifications for connections between building parts
3. 'Ultimate consumer' on each level/front: for instance, consumer on the infill level, developer at the support front etc.

This loop is applied to all 5-scales of design - master planning, urban design, architecture, tectonics and modularity - and through trial-and-error, is used to create a prototypical open-sourcing framework for urban development. The architect, designer and urbanist, here play the role of 'middlemen' - providers of an open infrastructure that can be appropriated by the user as per his/her requirements.

URBAN OPEN SOURCE: APPROACH

The approach to an Open-Sourced Urban Development, after multiple case reviews and experiments carried out under the research, is suggested under 3 stages: to set out the project intent, formulate a response, and devise an open source design framework, elaborated as under.

Setting-out Project Intent

The first stage aims to clearly conceptualize the project ideology, formulate development objectives and identify broad design elements through a comprehensive understanding of the socio-cultural character of the region, requirements of the people residing in the development area, and references to global precedents, using a 5-part process:

1. Regional Character

The project groundwork shall be laid out on a historical and socio-cultural premise of the region undergoing development. This is done through:

- Historical Grounding: Analysis of evolution of the fabric through secondary sources and/or primary interviews.
- Socio-Cultural Grounding: Region-specific identity analysis, focused group techniques for collecting primary information from citizens, and everyday life observational studies.

2. Context-Specifics

A citizen grievance analysis is carried out to synthesize specific issues that need redressal. It is extremely important to carry out this process on grassroots level so that an un-biased, up-to-date picture of the citizen requirements and aspirations can be generated. This process is carried out at 2 scales:

- City-Level: Digital surveys to understand the broader scenario in the city as a whole through generic questions and development aspirations.
- Region-Specific: Personal interviews to gauge specific interests for the region.

Focused group techniques should be avoided for collection of information under this part of the process so as to avoid any information suppression.

3. *Proposal Brief*

The identified needs and aspirations form the broader objectives for the proposal, which are to be further broken down into micro-objectives to be specifically addressed by the proposed project. The micro objectives shall be achieved using specific ideological and/or theoretical tools that are appropriate to be used as per the nature and complexity of the issues. Such tools, which take the form of broad proposal ideas, should be identified after a thorough analysis of their global precedents.

4. Design Elements

Selected ideological / theoretical tools shall be elaborately studied to comprehend the influencing factors and parameters that need to be dealt with, with detailed case studies of these tools carried out to understand the nitty-grities of their application and impact. The intent of such studies and review is to identify specific design elements that shall be incorporated in the proposed project.

5. Conceptualization

The design elements are organized as a conceptual premise, under key project features that will incorporate them, to create a thematic urban development proposal for selected region.

Formulating the Response

Open source design works on a user need-product design-user modification model to ensure that the experts in the field - the software developer in this case - can grasp people's requirements and convert these into specific design solutions, while allowing for continuous change by the users. This seemingly simple process as an urban development model is suggested to be carried out in 5 steps:

1. Identification of user requirements using surveys, interviews and data collection techniques.
2. Mediation between the current user requirements, development protocols and possible future uses of the development to arrive at a design vision and objectives.
3. Design development to achieve all objectives, under a constant guidance of the vision.
4. Impact analysis of schematic proposal using simulation and on ground tactical experiments.
5. Detailed design of identified pivot points across the proposal.

Open Source Development Framework

The 5-step design process, carried out at 5 respective scales, aims at devising a complete model for open sourcing all urban development initiatives. The same loop of user need-product design-user modification, as defined in the theory of open sourcing, is employed at each step. It is imperative to note that the user-inputs, tools of analysis, process objectives and approach to design change drastically across these 5 scales; however, the underlying idea of open source is constant throughout.

Step I: Creation of an Inclusive Urban Fabric

The city is a complex metaphor for retention and evolution, simultaneously. It has a history, that gives it a sense of identity and a present, which in turn constantly tries to build upon or move away from that identity[13]. Aligning the past and the present leads to the most astute basis for future development: a 'vision'. Step 1 of this framework aligns the development aims of the proposed project with the larger vision of the city, and is undertaken as follows:

1. Aligning the past and the present using detailed condition mapping.
2. Forming basis for future development using wider development plans and policy.
3. User group identification and recording of their responses.

Step II: Alignment with Urban Vision

Architecture operates on the interdependencies created by urban ecosystems, and hence needs to acknowledge its criticality. The 21st century urban fabric can no longer by segregated into neat rows as the hybrid urban elements that have formed due to the changing dynamics of the city beg to be accounted for[14]. Step 2 aims to create an inclusive urban fabric spanning complex user groups and diverse built uses by a further development of the masterplan framework sketched in the last stage:

1. Categorization of programmes into 'Urban Driver' groups.
2. Analysis of user - to - programme nature of each driver to create plausible combinations.
3. Spatial placement of the selected programmes.
4. Zoning, massing development and overall distribution of built-use.

Step III: Addressing Rapid Programmatic Mutations

The conventional definitions of 'function' and 'program' no longer work: they are rapidly changing, and so is the subsequent essence of architecture. There is a need to use combined investigations that explore these unlikely confrontations and relationships[15]. Step 3 aims to identify and harvest the potential of these mutations: creating possibilities that accommodate programmatic dynamism. These investigations are used to further develop the massing and proximities:

1. Identification of critical programmatic debates to be addressed by design framework.
2. Debates: character mapping, activity mapping, occupancy and area requirement calculation, and development of volumes.
3. Development as per National Building Codes and Byelaws.
4. Setting of design rules.
5. Spatial Placement as per laid-out design rules.

Step IV: Incorporating Spatial Temporality

The conventional design process seldom takes this into consideration the thermodynamic 'time' associated with creation, formation, degradation, and process[16]. In this process, architecture is seen as a transient formation that, like all physical objects, is a system of matter and energy that incessantly transforms with the flows and processes that constitute its actuality[17]. Step 4 aims to further develop the massing, proximities and spaces based on activity patterns and time-based spatial configurations:

1. Mapping out programmes: active hours and nature of use.
2. Creation of activity combinations based on similarity of nature and use hours.
3. Placement of created combinations in spatial fabric.
4. Prioritizing tectonic requirements, and subsequent evaluation as typical day simulations.
5. Development of tectonic systems incorporating activity and use requirements.

Step V: Optimization through Modularity

The ordering and arrangement of forms determines how architecture might promote endeavours, elicit responses, and communicate meaning.[18] The ideas of aligning with a vision, creating inclusivity, responding to mutations and harnessing temporality can only work if provided impetus at the most primitive level: Spatial Modules. Step 5 aims to engrain the idea of open source at the most fundamental level, where even a single person can harness its potential. It attempts to create spatial modules deep rooted in the principles of open sourcing:

1. Simulations of space to identify spatial pressure points during transitions.
2. Geometrical vocabulary for each module based on use, function, logistics and aesthetics.

Figure 1. Open Source Development Framework

OBSERVATIONS AND OUTCOMES

The observations throughout the research process, and the achieved outcomes have been classified under various baskets as key pointers and parameters to help in field application of the Open Source Development Framework.

Design Process

Design Process	Objectives	User Input	Area of Analysis	Open Source Vision
Aligning with City Vision	Mediating between existing conditions and future plans	Development process must cull out and retain the integral parts of fabric	Understanding the identity of the place and reacting sensitively	*Create Development Plans in synergy between the User, the Existing and the Proposed*
Creating an Inclusive fabric	Create a social ecosystem & subsequent responsive massing	There must be a strong balance between dense and breathing zones: built & program-wise.	Understanding elements of architecture as cogs in the larger urban dynamic	*Create clusters and character that can integrate with the urban dynamic*
Addressing program mutations	Mediate critical architectural debates that arise out of program behaviors	Interpretation of conventional programs must be re-visited & changed as per to-day's needs	Understanding architecture through Movement, Event and Program framework	*Create programmatic proximities and dynamics that accommodate changing use patterns*
Addressing Temporality	Maximize spatial efficiency through creation of an efficient & adaptable tectonic vocabulary	Spaces must be designed to allow for change in use and expansion-contraction through a day	Understanding architectural spaces through the lens of anachronisms and temperament	*Create spaces that can overcome the limitations of time-based occupation & tectonic-bound activities*
Optimization through module	Simplify transition logistics to integrate adaptability & optimize micro details	Construction and assembly details must be simple enough to be useful to the lay-man	Understanding human-perception of spatiality and devise basic required modules for adaptability	*Create configurations and details whose simplicity gives them relevance to lay-man*

Table 1.

Application and Feasibility

Scale of Application	**Regional Considerations**	**Possible gaps between user needs and existing development**	**Methods and tools for creating an Open Source solution**
Master Planning (Scale 1)	Preservation of site ecology, reduction of motorized transport, integration of site identity with proposed development	Disregard for specific-needs of sub-strata of demography, and existing character of site of intervention	*Collage City: Colin Rowe, 5 Points: Kevin Lynch*
Urban Design (Scale 2)	Integration of existing informal economy, optimization of existing pedestrian networks, maximization of habitable space & density	Absence of networks creating cross-demographic interaction, inequitable distribution of critical infrastructure	*New Urbanism: Rem Koolhaas,* *Urban Artifacts: Aldo Rossi*
Architectural Tectonics (Scale 3)	Incorporation of current trends of spatial occupation, application of local material and construction procedures	Refusal to re-calibrate the currently abandoned social infrastructure, disregard for informal markets	*Movement&Event: Bernard Tschumi* *Theoretical Geomatics*
Spatial & Volumetric Design (Scale 4)	Promotion of time-bound occupation of spaces, optimization of volumetrics for maximized user-engagement	Creation of single-use inefficient spaces, spaces incapable of rapid response to user requirements	*Metabolism in Architecture:* *Kisho Kurokawa,* *Ephemeral in Architecture: Anastasia Karandinou*
Modularity & Detailed Design (Scale 5)	Cater to critical individual-requirements of citizens, maximize user modification of spaces at the detail level	Disregard of individual requirement in favour of the generalized whole, use of unviable logistics in the user-oriented details	*Performance over Shape: Rem Koolhaas,* *Prefab Architecture: Ryan Smith*

Table 2.

Design Framework

Using observations and inferences from the experiment, a development model is suggested for Open Source Development. This model involves a 5-part process that brings contextual specificity, while creating a participatory and constantly adaptable environment for development projects:

Part I: Regional Character

Laying the historical and socio-cultural premise for understanding the project background.

Part II: Contextual Specifics

Identification of region-specific citizen requirements, and subsequently project vision and objectives.

Part III: Proposal Framework
Identifying programmatic features required to achieve the objectives and their translation to spatial and physical form using precedent case studies and tactical experiments.
Part IV: Prototype Assembly
Grouping spatial features into chronological design stages and integrating 'open-source' with development framework.
Part V: On-ground Manifestation
Stage-wise execution of the development framework in a step-by-step User Input-Theoretical Grounding-Design Evolution loop.
After the 5-part process, it is suggested to continuously monitor the project for post-occupancy performance and/or failure-analysis. These auxiliary 2-parts result in continuous appraisal and renewal of the process itself, refining it before its re-application in the same or next project.
Part VI: Appraisal of Project
Summarization of project output to update the replicable open source development model, its circulation for peer review & post occupancy analysis.
Part VII: Refining for further testing
Incorporation of review and feedback from experts and stakeholders to refine the open source development model and subsequent implementation on next site.

OUTLOOK AND WAY FORWARD

The future of the city is being driven by the culture of collaboration and the creative class' need for creation as opposed to the traditional thought of consumption[19], and promises to have expertise of all fields - from the technical to the creative - providing the tools to people to shape their environment. People will inhabit naturally, based on their preferences, yet exist harmoniously in the shared built environment[20]. With each new development, however, rise completely new urban scenarios and dynamics. The framework derived in this research, therefore, cannot be seen as an absolute solution but as a basic toolkit to be applied as per contextual requirements[21].
The research suggests a new model for participatory urban development with an on-ground implementation methodology. Based on multiple appraisals of the methodology across various pilot cases, it has been observed that this method can produce satisfactory results for urban development projects with significant demographic, cultural and social diversity. Furthermore, the interactive nature of the methods and tools employed allows the designer and authority to explore a vast array of plausible solutions.
The peer reviews and expert feedbacks from collaborating architects and urbanists suggest that the open source development framework can gradually be incorporated in the urban processes in practice. In the modern urban practice, where public participation is an ever-important pillar for creating sustainable design, the open-source model allows for specific requirements of the people and the contextual region in question.
The research is a simulated site-specific empirical analysis, to obtain a suggestive outcome based on explored pilot cases. In consequence, this experiment is only the beginning of a process that will see it evolve with continuous appraisals: an initiative for an Open Source Development Framework.

NOTES

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MEDIATED URBANITY AND DISRUPTIVE PERCEPTION

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INTRODUCTION

Representational technologies have long been used to reconfigure our sense of reality, as well as to make sense or meaning of the world we inhabit. Certainly, one doesn't have to look very far to experience the contemporary culture of technological perception in our daily lives; for example, 360-degree video streams, online or computer-based games, augmented reality (AR), virtual reality (VR), and volumetric video capture—the latter which is actually used to allow augmented and virtual reality to seem more *realistic*. Other experimental projects underway include projection mapping, and drone-augmented human vision. These tools offer us opportunities to alter or expand our experiences with 'reality' and reshape our world. However, should we be concerned about the transformative power that these technologies can have over our day-to-day experiences with reality? Through the lens of Paul Virilio's scholarly work as a point of orientation, let us briefly consider characteristics and functions of contemporary and emerging representational technologies in relation to possible experiences we can have through our engagement.

Paul Virilio is a very influential scholar regarding debates on technology and culture, and one of the first who raised the issue of accessing the urban or *entering the city*; presenting us with his postmodern time and space concerns, as well as describing a new form of urbanity. *"In this new perspective devoid of horizon, the city was not entered through a gate nor through an arc de triomphe, but rather through an electronic audience system... From this moment on, continuity no longer breaks down in space... [it] is ruptured in time."*[1]

One of the questions he posed for accessing or entering the city demonstrates that today, the city/urbanity is not limited or referred to as a geographical site, but a temporal regime sustained through telecommunication devices. *"Deprived of objective boundaries, the architectonic element begins to drift and float in an electronic ether, devoid of spatial dimensions, but inscribed in the singular temporality of an instantaneous diffusion. From here on, people can't be separated by physical obstacles or by temporal distances."*[2]

In this sense, being *away from the city* and our social practices are heavily influenced and reliant by our relationship with our use of the screen, and screen media. And, our rapidly increasing screen time social functions are becoming more accessible thanks to an ever increasing hyperconnected worlds and the rollout of 5G.

As we see above, and throughout his work, Virilio draws our attention to how modern technologies shape our bodily experience in time and space. His perspective and interest in bodily experiences originates from the philosophical project of phenomenology and its attempt to characterize consciousness. For Virilio, the issue arises from the geographical expansions of Modernity and the mental effects of such a radical break. As cinema and photography created and developed spatial relations and shaped the conventional spatial thinking of the modern mind. "*Depth of field"* was a metaphor for the whole modern mental framework, in which things existed in space by being visible, or "*in focus"*; and the cognitive and informational processes were designed according to such visible spatial existence. Out of Modernity came a new condition dominating our life-world—now, *"events happen in time"* rather than *"things taking place in space". "Representation now stretches beyond the real."*[3] For Virilio, this is the *"crisis of representation."*[4] His arguments point to a situation based on the experience we have with representations; either in the form of technical details—an experience related with temporal presence, or in the form of *"overexposure"* or super-visibility; these representations exceed the experience we possibly can have with reality itself. But for Virilio, such loss is not only a spatial one, yet a sequel to a new ontological format, and it also erodes our sense of reality. We will refer to this new sense of reality as *Post-Reality.*

POST-REALITY

Post-Reality could be characterized as *a second reality*[5]*—a reality-effect*[6], no longer *presented as a space–time reality*[7], brought on by the *phenomenon of acceleration*[8] and one created by an *outcome* of the culture of technological perception. Technological perception means an overturning of natural perception, and a visualization created by accelerated modes of *cinematic energy of transmissions*[9] of image surfaces through the interaction of information and communication technologies. The image surface of technological perception is a *sequential phenomenon* and *the motorization of art*, (moteur)[10] which includes interactivity. *To be 'interactive' means to be here, but to act somewhere else at the same time.*[11] Interestingly though, the creation of interactive screen media image surfaces produced by computers use software referred to as *time-based programing*. Yet, previously Smith (2011) claimed that it would be more appropriate to call this software *time-amplification or time acceleration programing* as *everything I see is in principle* NO longer *within my reach, at least within reach of my sight.*[12]

If we consider computer and/or online games and the creation of imaginary cityscapes or worlds, as well as interactive screen media like AR and VR, then *post-reality* can be applied. Cinematic techniques are often used in the game space to reproduce cityscapes that closely resemble existing ones. Like many representational technologies, games provide a deep sense of presence and dramatic sensation. Games like *Sleeping Dogs*[13] provide an aesthetic experience of moving through the city of Hong Kong. The game reproduces a strikingly close resemblance of the narrow streets and alleys of dense cityscape including neon signs flashing from buildings, and small stalls of vendors selling clothing, food, or other gadgets. *Grand Theft Auto 5*[14], provides eerily similar aesthetic experiences to roaming an urban center similar to Los Angeles. However, the laws of physics do not apply in the screen space and maybe that is what makes screen space experience so dynamic.

SIGNIFICATION OF POST-REALITY

If *Post-Reality's* signifier is acceleration, then could we say that its signified is a loss of distinction, or *disorientation*? As the mode of transmission accelerates there is a loss of distinction, or disorientation. As the space increases so vastly, it becomes nearly impossible to scan its entirety, reducing interpretation. By this we mean that a characteristic of *post-reality* is the obscuring of the world with the image surface of the screen, and is now under the control of the scanning machine of the screen, or machine eye. The machine eye obscures the reconstruction of the image surface as it scans. "*Without knowing it, there is a restriction of the visual spectrum, and one loses lateral vision.*"[15] The machine eye select data (bits) from *cinematic energy of transmissions*[16] of information flows and arranges miniature rectangular shapes—pixels, according to its interpretation on the screen and into something which the viewer may or may not recognize. Yet another issue is whether or not the machine eye allows for any amount of space for *imagination*, as it carefully calculates and projects the image surface onto the screen. What is important is that images, *function as good models of experience and perception, help orient us, and transform us by our processing of it*. We are programmed by *images, and as images are sped up we become less critical of them.*[17]

Computer and online games, augmented and virtual reality experiences are said to be representations of the same experiences we have in the *actual* world; however, through screen interactions, it is more likely that our lives become a function of the images that these media technologies create. Specifically, these media technologies split the image surface into a *stereo-reality made up on the one hand of the 'actual reality' of immediate appearances and, on the other, of the 'virtual reality' of media trans-appearances.*[18]

It is obviously clear that at the *denotative level of post-reality* regarding the convergence of media and electronic information—as in cyberspace for example, information loss is a common theme due to the impact of the massive amounts of information flows. This loss of information, or reduction in perception, is leading to new *time amplification logic*[19] for making informed decisions regarding society and social life. So to summarize the denotative-level of post reality; acceleration signifies distance in time amplification, disappearance signifies information loss, disorientation signifies loss of distinction, and interactivity signifies the obscuring of the image. As Virilio explained, *…the more information flashes by the more we are aware of its incomplete fragmentary nature. …We're still here in the domain of the cinematic illusion, of the mirage of information precipitated on the computer screen—what is given is exactly the information but not the sensation; it is apatheia, …it's the speed of light itself which limits the reading of information and the important thing in electronic information is no longer the storage but the display.*[20]

POST-REALITY EXPERIENCES

If we consider the current culture of technological perception through augmented reality, virtual reality, and online or computer-games, what are the possible experiences of *post-reality*? For one, we could say that our daily experiences are moving towards multi-sensory engagement through the integration of the screen space with the lived space. However, is agency being placed in the hands of the user or in technological apparatuses? Biometric information and other sensorial cues are monitored for assessment of interaction performance levels in the screen space. Also, whether we are aware or not, we regularly have conversations with AI *chatbots* that are present to answer our questions or organize certain aspects of our lives. Artificial Intelligence systems are modeling our behavior patterns and selection preferences. As we defer our lived experiences to the function of the screen space, one could argue that anticipating our needs would create a highly homogenous, limiting, or even mundane experience. Are we comfortable with our *post-reality* experiences being scripted by algorithms and artificial intelligence? Yet, more critical questions should be posed. At what point will we not be able to *go-off-script*? More importantly, what happens when technological apparatuses or AI algorithms *go-off-script*?

Our *post-reality* experiences are becoming more immersive and especially as technology developments move away from heavy and awkward head gear to something like holographic glasses. Product designers are rapidly developing more innovative approaches to the idea of the screen space. For example, in 2018, Intel launched a prototype of eye glasses with Virtual Retinal Projection[21], which uses a very low-powered laser, (VCSEL*)* vertical-cavity surface-emitting laser.[22] A small image is projected onto a holographic reflector on the right side lens of the glasses, which in turn reflects that image into the back of the user's eye and directly onto the retina. It uses Bluetooth technology that can be connected with a number of devices like a smart phone.

Another screen using microelectronics will come in the form of a smart contact lens—Mojo AR Contact Lens.[23] The company claims to provide "*information without distraction.*"[24] How is that possible? Smart phones are highly distracting as with most electronic gadgets. If we are truly experiencing *stereo-reality* as Virilio claims, then wouldn't distraction be one of its defining characteristics? Every sensorial notification seems to be exactly that—a distraction.

Another consideration is the issue of touch. What happens with the disorientation of touch in the *cinematic energy of transmissions*? Although technologies like VR provide a deep sense of presence, the subject is not able to be physically present in the screen space, except through the dimension of perception. The subject perceives touch through cognition, yet these are two very different things—cognition and perception. Cognition is something perceived mentally through judgment, reasoning, imagining, conceiving, recognizing; however, perception of cognition is an immediate or intuitive recognition, an appreciation or an aesthetic quality, or insight. To touch something is to both perceive it and to be cognitive of that very thing. In *post-reality*, the disorientation of touch means we no longer can perceive or be cognitive of sensa except through the virtual visualization of touch. "*Sensa are not only a more or less exact, more or less pleasurable or coherent way of informing ourselves about the external environment, as well as a means of acting and existing in it, not to mention occasionally dominating it. They are also messengers of our internal environment, which is just as physical and just as relative because it possesses its own laws.*"[25]

For example, an avatar in cyberspace is capable of touching an object through the actions of its user by technological apparatuses, whether that is programming through code or the actual physical use of a connected device such as a controller, a keyboard, a joystick, et cetera. In this situation, the user's physical touch is *disoriented* because there is no possibility of *perceiving through cognition* the object that the avatar touches. The user of the device can only be cognitive of the avatar's ability to touch the object in the perception of the operator. The avatar's ability to touch is visualized by the user in the screen space of the avatar. So in *post-reality*, the disorientation of touch in the *cinematic energy of transmissions* no longer allows the subject to perceive the object through cognition. The user is only able to touch the object through a virtual visualization, *which is supplanting the vision of the real world around us*.[26]

Although several companies produce haptic body suits for gamers and other VR/AR uses, by using *force, vibration, or motion*, the goal of haptic technology is to create the experience of touch. Some haptic suits measure biometric data for analysis of the user's experiences. However, and more recently, there are several technology companies moving away from any sort of wearables. These companies are offering next-level haptics and hand-tracking motion controllers including some that use *ultrasonic waves to create tactile mid-air sensations*. Touchless Ultrasonic Haptic Technology *employs electronically controlled phased arrays of ultrasound speakers(or transducers)to create high acoustic pressure points in mid-air that can be felt with bare hands.* According to *Ultraleap*, the goal is to *make the digital world feel more human*.[27]

Whatever sign is the nature of our *actual* world, it may not necessarily be part of a new mode of perception in the nature of an experiential world created by the *cinematic effect of transmissions*. Could mediated experiences be categorized differently in each of us? This may seem somewhat naïve or idealist; however, this question is pointing towards a hypothetical modality that can be used in a positive position. Before *the invention of photography, of the photogramme, that is of instant photography, and of cinematography*,[28] did the *persistence* of art not alter reality? If so, then we could say that the *shift* from material to cognition is not a result of disorientation from speed, but a *shift in memory*?

CONCLUSION

For Virilio, the *phenomenon of acceleration* overturns natural perception resulting in *disorientation* and obscuring of the world with the culture of technological perception. In *Post-Reality*, new representational technologies bring a whole different set of perceptual challenges and shape our bodily experience in time and space. From this point forward, social functions and activities previously carried out in physical and geographical space are replaced in the virtual space of the screen. In coming years, more immersive devices will find their way into many and possibly all aspects of our lives and will not simply be for novelty or entertainment. *Actual* spaces will become *virtual* spaces for shared AR and VR experiences. We will learn to manage multiple embodiments and move between identities. Our experiences will become reinvented and amplified including participation in real-time events across the globe. In addition, more group and creative collaborations will occur in the space of the screen and/or virtual world instead of physical locations. Although new mediated experiences will provide dynamic opportunities for exploration, it will also come with more vulnerabilities, heightened risks, and legal issues which are yet to be explored. As technological representations become overlayed onto our urban life-world, perhaps the mediated experiences we can possibly have with reality will only become impaired ones.

NOTES

[1] Paul Virilio, *The Lost Dimension* (New York: Semiotext(e), 1991), 11.
[2] Virilio, 13.
[3] Paul Virilio, *The Vision Machine* (London: British Film Institute, 1994), 111.
[4] Virilio, 112.
[5] Paul Virilio, *From Modernism to Hypermodernism and Beyond*. (London: Sage Publications, 1999), 43.
[6] Paul Virilio, *The Vision Machine* (London: British Film Institute, 1994), 5.
[7] John Armitage, *Virilio Live: Selected Interviews* (London: Sage Publications, 2001), 70.
[8] Paul Virilio, *The Vision Machine* (London: British Film Institute, 1994), 4.
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DIGI-COMPONENT: AUGMENTED REALITY REAL-TIME IMMERSIVE DESIGN AND ROBOTIC FABRICATION WORKFLOW FOR PARAMETRIC ARCHITECTURAL STRUCTURE

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KEYWORDS
Augmented Reality (AR); immersive design; holographic assembly instruction; robotic fabrication; real-time interactive modification

INTRODUCTION

AR is a new technology field that involves the seamless overlay of computer-generated virtual images on the real world, in such a way that the virtual content is aligned with real-world objects, and can be viewed and interacted with in real-time.[1] AR can produce a virtual model in a real environment while making the virtual object and information to coexist with the real world.[2] AR aims to bridges the gap between the virtual world and the real world. The characteristics and functions of AR give this technology unique benefits: AR could create flexibility in architecture and interior design; AR can save energy, time, and money; AR can be useful in construction projects; Hologram in scale 1/1 enables the user to walk through the project before the actual construction and teaches unskilled labors step-by-step during the construction process.[3]

Over the past decade, the assembly of complex structures required detailed 2D drawings and skilled labor to interpret and operate. This method costs time to compare the drawings with the actual construction by the skilled labor.[4] To reduce the gap between 2D graphic instructions and 3D assembly actions, the use of AR technologies has been applied to visualize assembly operations.[5] It deliberates a method by using high precision and detailed AR 3D on-site holographic drawings in the architectural assembly and construction process – as illustrated in Figure 1.[6]

Figure 1. Holographic Construction of the Hobart Hospital by Fologram. (left)

It has been proposed that, after the internet age, we are now entering a new era of the 'Augmented Age'.[7] The current design process is lacking a fast and intuitive means of visualizing models. AR offers a new tool in the architectural design process, where designers can show their designs in a 3D space.[8] Human-computer interaction is becoming personal and machines are getting close to our bodies. Direct hand-based gesture recognition and paddle-based inputs are considered as the main trends and capabilities for AR interactions.[9] Based on the above internal research, AR design has the possibility to combine interactive design inputs and intuitive 3D on-site design preview. The impact of this development will help allow designers to present and evaluate work in more intuitive and simpler ways.

Figure 2. AR robotic operation intention in Augmented Robotics workshop (RobArch 2018). (right)

Robotic fabrication is also an important part of the digital construction process when the material is not suitable for manual handwork. Most robots are controlled by teleoperation, since the many uses that imply it, involve inaccessible, distant, dangerous, or in any other way, remote locations.[10] Besides, the robotic operation process requires specific expert computer science knowledge and skilled programming code workers, which is not in line with the designers and labors allocation of the architecture industry.[11] The AR technology enables the users to visualize and interact with 3D holographic models easily through a simulation on mobile devices or AR headsets.[12] This visualized property of AR makes robotics operation simpler and safer with intuitive visual stimulation and provides faster and more intuitive robot programming than conventional techniques – as illustrated in Figure 2.[13]

AR technology has been around for many years and a growing number of projects have shown the application of AR in various fields, such as architecture and digital fabrication. It is important to note that the practical use of AR remains limited and scattered in the field of digital fabrication.[14]

RESEARCH METHODOLOGY

Digi-Component is a research project developed in the Centre for Architecture and the Visual Arts (CAVA), the School of Architecture, University of Liverpool. This project departed and elaborate on the concept of AR immersive design and fabrication workflow for parametric architectural structure which can be effectively managed manually or robotic assisting by unskilled labors according to different behaviors of material and holographic introductions. This research has the potential that it can be applied at a full architectural scale, such as façade constructions and manual-unachievable material fabrications, which could provide a new workflow for human-robot collaboration through the AR environment – as illustrated in Figure 3.

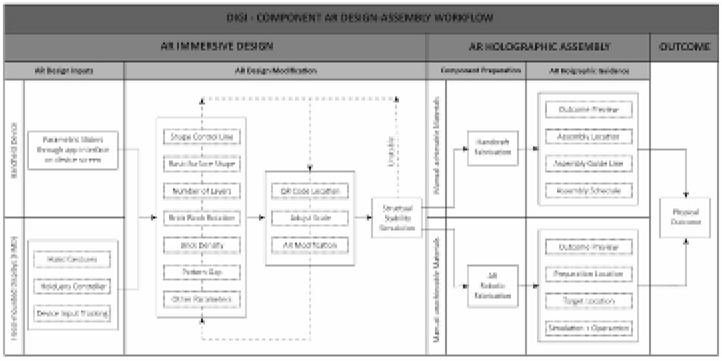

Figure 3. Digi-Component AR design-assembly workflow.

Digi-Component test 1 – augmented brick column

Digi-Component test 1 (augmented brick column) explores the feasibility of AR immersive design and assembly process through an augmented environment with virtual information on handheld devices.

In test 1, this research mainly studies the different methods of AR immersive design input such as human gestures and mobile device input, and explores the 3D virtual introductions for unskilled labors to use in manual assembly process instead of translating traditional 2D drawings to the on-site. To achieve that, we need a material which suitable for manual work, easy to operate in the AR system, and convenient for parametric design in Grasshopper. After several material tests, the standard UK brick is chosen as the main design and assembly material. The UK bricks are mated to a standard size of 215 x 120.5 x 65mm, which are easy for AR device to track, recognize, preview, and operate. They can also be re-used and re-design at any process and state. It innovates how to apply new technology for traditional architectural materials to achieve unique outcomes.

According to the basic concept of AR – overlapping the virtual instructions in the real world, the researcher decided to use handheld devices to achieve that, such as iPhone and iPad. The Visual-inertial Odometry (VIO) system in Apple ARKit 3 is a technical process called visual-inertial ranging. This process combines the information captured by the iOS device's motion-sensing hardware (CoreMotion) with the computer vision analysis of the scene visible to the device's camera. The depth API the LiDAR Scanner also allowed users to get per-pixel depth information about the surrounding environment and location information. Apple iPhone 11 is used to receive the immersive input from designers and to illustrate the 3D virtual model for un-skilled labors in the assembly process.

For the AR immersive design part, the Digi-Component test 1 sets up different parameter variable inputs that will affect the result of the outcome in AR immersive design. Different from the traditional design method, this research will show the on-site basic brick column structures in the AR environment and provide several interactive input parameter sliders for designers to interact with during AR immersive design process. The adjustable parameter sliders are divided into different parts which cover the entire design process such as basic layer shape, the number of layers, column rotation degree, column deformation control line, and the pattern gap distance. These sliders are connecting with the parameters in Grasshopper directly and showing in the Fologram AR app interface on the mobile device's screen in real-time for designers to modify with. The outcome will be shown dynamically on the handheld device according to the real-time immersive inputs - as illustrated in Figure 4. This on-site dynamic design method will give both designers and participants an intuitive view of outcome preview and a sense of immersive design, compared with reading 2D documentations and transforming 3D preview in software through the traditional design method. After the shape is designed, it will be transformed into PX Simulate plug-in in Grasshopper and preview in AR environment for structural stable simulation to calculate for a stable shape - as illustrated in Figure 5.

Figure 4. Interactive AR immersive design process through mobile device screen inputs.

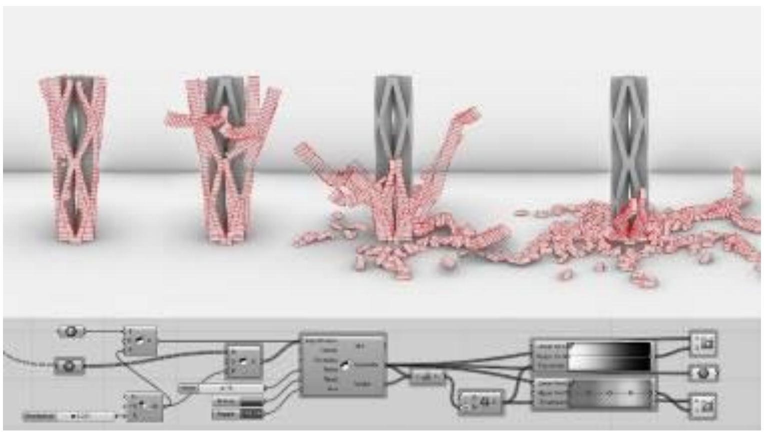

Figure 5. Structural stable simulation in Grasshopper and AR.

For the AR virtual guidance assembly part, the Digi-Component test 1 provides unskilled labors a step-by-step virtual guidance assembly instruction. After the shape of the brick column was decided, users can switch the toggle on the interface of Fologram from “AR Design” to “AR Assembly”. When the assembly interface is activated, the user will first preview the number of bricks to be used and will be guided to the place of each brick by the virtual model shown on the mobile device.
For example, the user can see the red target lines of the location of the brick in the first layer virtually and place the brick one by one to align them with the red target lines of the first layer. After that, the user can change the sliders through the app to continue the following layers for assembly. The virtual model of the layers that are already finished will be blocked. Only the layer under construction currently will be highlight and displayed in red target lines intuitively. What users need to do is following the on-site red target lines and complete the assembly of the whole brick column according to the virtual model shown on their mobile phone device step-by-step - as illustrated in Figure 6.
Test 1 provides that AR immersive design can give users the possibility of stimulating creativity and an intuitive method to make on-site design immensely. AR virtual assembly guidance can reduce the time for translating 2D documents to 3D real projects and improve the efficiency of construction for unskilled laborers.

Figure 6. AR visual assembly guidance on iPhone and the mobile view during assemble.

Although the result of this test 1 is quite successful, it has a massive limitation through this handheld device AR system. In this way, the designers can only import parameters by adjusting the sliders and using limited actions on the mobile phone screen such as ‘on press’, ‘on drag’, ‘on hold’, and ‘on release’. Although the penetration rate of handheld devices is high and the price of the device is cheap, this kind of mobile AR experience has not fully reached the full-scale requirements of AR immersive design. It is because all the virtual on-site models, virtual instructions, and interactive inputs happened on the device screen which will be a lack of real virtual experience. Human recognition of the virtual holographic guidance from the device screen will cause uncontrollable errors compared with the real on-site location. Moreover, the labors need to use one hand to hold the device and the other hand to carry out the assembly process, which will bring safety hazards and operational inconvenience to construction. The best solution is to find an AR device and method to offer a 3D holographic fabrication introduction instead of using a handheld device to improve the accuracy of physical outcomes.

Digi-Component test 2 – augmented brick wall

Digi-Component test 2 (augmented brick wall) explores the possibility of AR immersive design and assembly process in AR holographic guidance with Head-mounted Displays (HMD).

To solve the limitation of handheld devices such as inconvenient one-hand operation, lack of immersive experience, and low precision, the researcher decided to use an HMD device for improvements such as the Microsoft HoloLens. The Microsoft HoloLens was invented to show 3D holographic and animation overlaying in the real world, which can illustrate 3D fabrication guidance. Microsoft HoloLens enables the user to engage with digital content and interact with holograms in the real world.[15] There two main features of HoloLens: a) support the see-through holographic lenses (waveguides) for optics; b) gestures and voice commands to assure a hands-free experience to control.[16] The advantages of this head-mounted display device will improve the deficiencies of the previous test.

For the AR immersive design part, the research involves more intuitive immersive inputs. Different from the immersive design method in test 1, this experiment will use hand tracking, gesture recognition, and device location recognition methods to give designers more possibilities and experience of real AR immersive design through HoloLens. First, the Microsoft HoloLens will scan the surrounding space of the on-site project location, using special mapping technology and transferring the OBJ 3D mesh to Grasshopper. The special mesh will be optimized and shown through the AR headset. Second, the designer can draw the control baseline of the brick wall in the on-site immersive AR environment by ‘tap and hold’ hand gestures or on the mobile device screen. The user can live preview the on-site holographic shape and adjust the control baseline at any time in AR. Last, the designer can adjust the wall shape by ‘tap and hold’ the control points shown on the wall surface. After the shape is determined, users can preview the brick wall as an on-site holographic model in an AR headset and can adjust the numbers of bricks, the angle of bricks, the brick structure density, and the brick pattern arrangement by interacting with the AR sliders through real-time immersive design process.

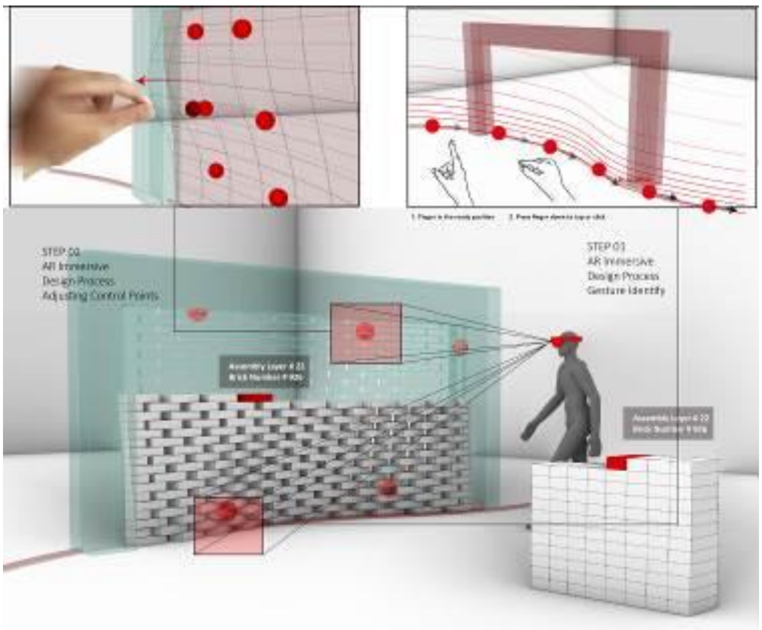

Figure 7. AR immersive design process of identifying hand gestures inputs and adjusting parameter controllers.

For the AR holographic assembly part, test 2 provides the users with an intuitive immersive holographic assembly guidance through HoloLens. When the user wants to build the brick wall, just need to switch the toggle from 'AR Design' to 'AR Assembly' and follow the red target lines as same as the process in test 1. Designers can walk around the on-site holographic model and use hand gestures to operate the assemble process state. The main difference is that test 2 is a hand-free workflow that gives users more flexible manipulation and a more immersive AR surrounding experience - as illustrated in Figure 7.
Test 2 provides that it is a more immersive workflow in an AR environment using the hand-free HMD device. It is worth discussing the initial approach, as this process can help the unskilled labor who is wearing the Microsoft HoloLens to transform an on-site digital model into a physical one from the design and preview process to assemble process.
However, as the Microsoft HoloLens sensors are affected by the surrounding environment and light, the holographic model sometimes has a bit drift from the specific location which needs to restart the device and scan the QR code for correcting construction location for several times. During the assembly process, the users should pay attention to reducing the impact of the surrounding environment on the AR headset device. Test 2 targets at the manual-achievable material – bricks. Moreover, for the large-scale architectural construction projects, the material might beyond the range of manual-achievable such as concrete blocks, large-scale woods, metal blocks, etc, Developing the interactive robotic fabrication in the AR environment for man-machine collaborative workflow seems that the solution for the construction of manual-unachievable large-scale architectural materials.

Digi-Component test 3 – augmented robotic fabrication

Digi-Component test 3 (augmented robotic fabrication) uses bricks as an example and studies the feasibility of robotic fabrication in an AR environment for promoting this AR design-assembly workflow to manual-unachievable materials.
Digital fabrication techniques which are defined as the process of constructing objects determined by a digital tool path through the use of computer-controlled robotic machines, have provided the ability to design and construction that are very expensive or difficult to construct using traditional fabrication methods.[17] Traditional robotic operation needs specific expert computer science knowledge and skilled programming code workers to plan the movement and it is dangerous for users in physical when some errors occurred beyond simulation. AR provides an on-site holographic robotic trajectory simulation preview and interactive virtual robotic control methods - as illustrated in Figure 8.

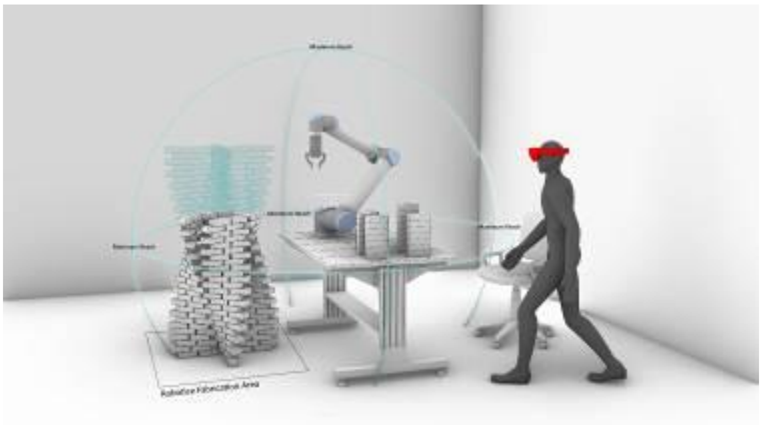

Figure 8. view robotic operation maximum reach to protect the safety of operators.

For the AR robotic fabrication part, we design a simple robotic operation ‘pick and place’. The user can preview the brick location in the material preparation area and the target location in the assembly area through HoloLens. After they place a physical brick in the preparation location, the user just needs to ‘tap’ the holographic on the preparation brick and ‘tap’ the target location in the assembly area. It will send an operation to the robotic arm from the HoloLens sensor to FURobot plug-in in Grasshopper. The user can preview the whole holographic simulation through HoloLens and switch the toggle to ‘Operate’ to complete manipulation.

Test 3 provides that it is a safer and more effective method to operate robotics in an AR environment with on-site gestures command and holographic trajectory simulations. All the computer science programming technics have been pre-coding in the grasshopper, the user just needs to point out the ‘preparation location’ and the ‘target location’. In this way, the robotic fabrication workflow will not require specific computer science knowledge and skilled programming workers, which matches the basic attributes and the knowledge category of the architecture designers. The current function of Digi-Component test 3 is very limited. The material of the experiment is also limited to brick or brick-shaped materials because of the technical issues and the equipment limitations. But these will be resolved in future research.

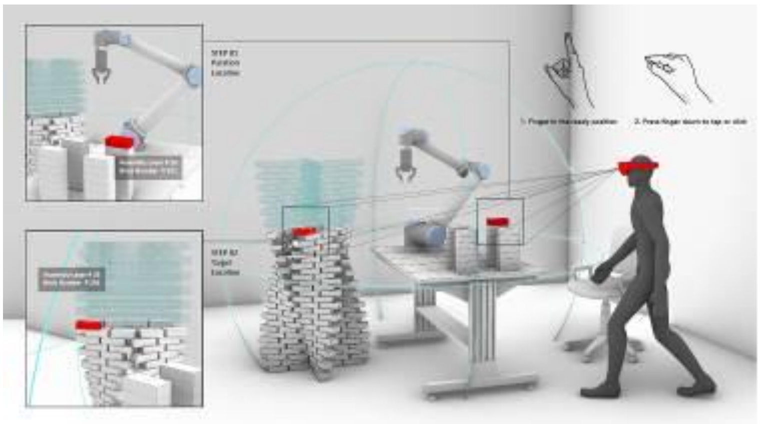

Figure 9. AR Robotic assembly process: view robotic operation maximum reach, preparation area, target area, and robotic operation trajectory.

CONCLUSION AND FURTHER WORKS

The Digi-Component prototype tests give an overview of the current state of AR technologies such as AR immersive design, AR holographic assembly, and AR-robotic operation. This paper also indicated the potential for these applications in the field of building elements and architecture scale designs - as illustrated in Figure 10.

For AR immersive design, it has been approved that, AR technology can translate the designer’s gestures into corresponding parameter adjustments and control line pickups in Grasshopper to preview the generated design in real-time. This method gives users a new way to design and preview on-site location design through an AR environment intuitively. This research tries to change the traditional design way into a more intuitive and dynamic way through AR immersive experience.

For AR holographic assembly, it was initially confirmed to have the possibility to improve the efficiency and accuracy in the assembly process for unskilled labors. This method also can save time for translating 2D documents into 3D on-site locations. Although there are still tolerances that occurred during transforming the assemble commands from the one who has AR 3D holographic guidance device to the other workers, this situation will be improved by adding multiple AR devices for all assembly workers.

For AR robotic fabrication, it has been certified that planning robotic movement trajectory and operating holographic simulation is safer for human operators compared with the traditional industry robotic operation method. It offers the designers, who don't have special computer science or programming knowledge, a convenient way to operate the robotics for the construction of manual-unachievable materials directly through AR.

In conclusion, the Digi-Component project tries to bridge the gap between digital design and physical outcome by designing a workflow that includes AR immersive design, AR holographic assembly, and AR robotic fabrication. Using this workflow, the AR device and computer can detect and identify the designers' thinking and idea at any time; transform their gestures and reactions into digital outcomes calculated by parametric rules in Grasshopper; preview the hologram overlapping on the real world in real-time through AR device, and get the physical outcomes either in AR holographic assembly method or AR robotic fabrication method depends on the material behaviors. It brings the possibility to interact with AR and get the enormous advantage of feedback through Artificial Intelligence (AI) to designers in real-time.

The further work will take in premeditation the additional development of involving multiple AR participants to the whole workflow to reduce the tolerance due to the command transformation - as illustrated in Figure 11. More sensors will be used to catch complicated human gestures in the immersive design part. Multiple robotic arms and diverse robotic operations will be developed for the man-machine collaborative fabrication part through AR environment. The final goal is to make the whole AR design and assemble workflow simplified and modified for architectural scale elements and applications.

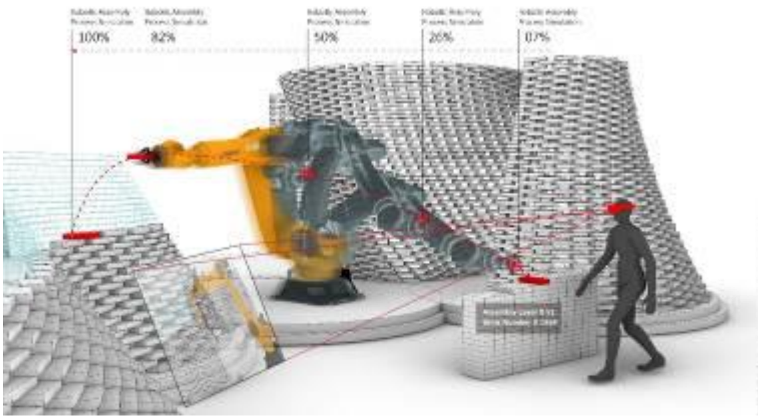

Figure 10. The holographic of robotic trajectory simulation in AR-Robotic assembly workflow for man-machine collaborative fabrication process in large scale architectural application imagination.

Figure 11. The holographic of robotic trajectory simulation in AR-Robotic assembly workflow for man-machine collaborative fabrication process in large scale architectural application imagination.

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THE BODY AS THE MAIN CHARACTER REGENERATING GUEST SPACES IN MIDDLE EASTERN HOMES

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INTRODUCTION

This paper was inspired by a short film called 'Split 'that presents and investigates the invisible void between the human body and the surrounding space and objects[1]. It is quite captivating how human body proportions ultimately rely on the space and the objects utilized regularly. The short film raised the question of the body relationship with the surroundings.

Throughout history, epidemics have long transformed the built environments and social lives. During the lockdown, people became increasingly aware of the mutual effect the body and space have on each other. On the other hand, designers observed the need to reevaluate interior environments to accommodate the unknown future.

Middle Eastern Houses, especially in Arab culture, are shaped by influential factors of tradition, privacy and hospitality, which is reflected by guest areas' dominance compared to other spaces. Unfortunately, because guest areas are only designed for guests, they are rarely occupied by household members. This research seeks to reimagine the guest space in Middle Eastern homes based on the body as the main character. Spaces are usually programmed to continuously give signals to their inhabitants of what to do, where to go and unconsciously mould their feelings, behaviours and actions[2].

The literature of many scholars acknowledges that changes made on interior spaces are likely to increase occupants' resilience, as they are utilizing spaces more efficiently to overcome unforeseen events such as the lockdown due to the Covid-19 pandemic. The approach taken in this paper will focus on physical change on the body and its co-existence with space to explore a new research area compared to the saturated field of space redesign[3].

Individuals perceive themselves as if they exist independently from their environment, segregated from their physical realities, unaware of their bodies; they ignore the power of their very presence in space and do not question the possibilities or outcomes of their interactions with the spaces of their daily lives[2].

The project seeks to integrate the guest space into the household fabric to challenge the conventional way we think about the body and its relationship with the space via experimentations to raise awareness of the significance of 'body-centred design' to fulfil the needs and desires of its inhabitants.

The first aspect of the research project uses the body as a medium to study the anatomy of guest space to increase the user's spatial awareness. Second, it reveals the human body potentials to reconfigure the guest space by performing a series of experiments. Body movements that might seem minimal with no influence fundamentally create various spatial compositions. According to philosopher Edward S. Casey, "A body occupies a place and, through movement, activates it"[4]. Afterwards, the project proposes a new design methodology based on costumes to adjust and reactivate guest spaces.

LITERATURE REVIEW

The paper was inspired by various artists' work discussing the relationship between space and body and what the body can become and perform. Recent artists tend to think of the body parts beyond their normalized standards of movement by drawing attention to the limitations of the human body and define it as a productive system striving for potential metamorphoses [5,7,9]

A video Interview by Judith Butler discusses the life challenges of disabled person and how they managed to live a normal life by using their body parts beyond their conventional movement standards. Their intervention challenge a range of conventional legal assumptions about the body[6].

The interview raised the question about human boundaries and what becomes non-human.

It is fascinating how space and objects reprogram body behaviors. Inhabitants have been taught to read the signs of objects and to behave according to the received information. Thus, their movement is predictable, and the body has become machinery like, performing the tasks automatically and acting unemotional.

Artist Rebecca Horn in her project 'The Finger Gloves', discussed the human body's ability to extend beyond its normal boundaries. She designed a series of bodily extension pieces (prostheses) such as Finger Gloves, Arm extensions and Head extensions. All pieces work as tools serving to draw attention to the limitation of the wearer's body and improve the human capability[5].

'We as humans have an inherent desire to go beyond our capabilities, push the extent of our limits and make machines to produce more than we can with our hands'[5]

The finger gloves project presented a new sensation of touching with respect to the participant. Horn described it as if her fingers were extended. In her mind, an illusion was created that she was touching the objects that the extensions were interacting with. Horn has described how wearing these gloves altered her relationship with her surroundings.

The presented theories draw attention to the postulates imposed upon the body and ask individuals to rethink their relationship with their bodies and question its' potentials and powers. Austrian artist Valie Export focused on the relationship between body and space, using her body in a sculptural way to underline the lines, spaces, and constraints of her surroundings. She positioned herself in several points around the city and reacted to the built environment completely different from the one implied by the urban design. Export's experiment focused on actions representing her states of mind, communicated by her postures and gestures[7].

On the other hand, Erwin Wurm, in his work 'One Minute Sculpture', released photographs illustrating alternative ways of using the space by dislocating any rules. His work was mainly about loosening up the body, enjoying the space surrounding it, and interacting with the objects in unconventional ways. His collection showed the ability to shape the surrounding by the power of body postures[8].

As a mean to liberate the body from its physical restrictions and enlarge the freedom of movement, it is essential to rethink the body's normalized standards of behavior and movement. In his book 'The Body as a Machine', Barney suggests suspending the natural limitations of the human body to be able to adapt to the surrounding space, hence, extract new outcomes and develop new interactions[9].

Various projects showed costumes' capability to reveal the constraints we have engineered for ourselves and affect the personal perception and behavior. Critical Costume exhibition in 2015 presented the work of costume-based practitioners that seek to address the implications of costumes on the body, movement, experience and interaction[10].

One of the main interests of Critical Costume 2015 is proposing new ways to research through costumes. Each project proposed critically examines how costumes perform an educational tool that makes people aware of their bodies' different parts. They generate new qualities of movement, experiences and awareness of the body linking people with their environment and create a real physical connection between being, others and space[10]. It was thought-provoking to see how costumes could be employed to extend the body to develop a constructive dialogue with the outside world.

METHODOLOGY

Since the project is process- oriented aimed to explore the co- existence of body and guest spaces, a qualitative approach was chosen. A series of staged experiments were designed and conducted in April 2020 in the researcher's house due to the lockdown. The experiments were proposed on a snowballing basis (one experiment led to the other). Then an in-depth analysis and critical reflection took place. The methodology is developed to combine the aforementioned theories with pragmatic empirical interventions.

A survey was designed including several diverse questions that targeted houses of different areas and complexes in the West Bank in Palestine to investigate their residential interiorities. The survey questions the resident's relation with guest spaces, specifically during Covid-19 lockdown. The survey deployed non-probability sampling, where ten individuals were explicitly chosen from the researcher surrounding community (due to research timeline and lockdown limitations). Nine out of ten responded. The survey was the starting point of the project because it provided an overview of respondents' relationship with their guest spaces (refer to Appendix).

After undergoing a comprehensive literature review, a sequence of in-house experiments were conducted to merge the body and design, movement and architecture, emotion and technology to break the limits between body and space.

Costumes were used as the primary tool to investigate and acknowledge the guest space's features and its implications upon the human body and behavior. Photography was the primary archival tool for capturing the movement of the body in the space. The photographs were then analyzed by underlining the body postures.

EXPERIMENTS AND RESULTS

To examine how costumes aid users and designers in generating guest spaces alongside the presented theories, various experiments were undertaken in the researcher's guest space. The first section focuses on exploring ways to use body movement information to explore space through translating body postures, layout and behavior.

Figure 1. Body layout documentation in the guest space. Source: Author.

The first experiment was intended to capture the layout of the body while in the guest space through photographs, which were then analyzed into body postures. The analysis highlighted the boundaries imposed on the human body from the surrounding space and objects, limiting the body from its free movement. (Figure1). This finding relates to Valie Export's focus on the relationship between body and space by analyzing the body postures within an environment inspired to experiment with the body and observe the invisible constraints of the physical surroundings that impede its movement.

Figure 2. Capturing body postures while picking a glass of water. Source: Author.

The following experiment underlined the idea of reading the signs from the surrounding objects in the guest space. It showed how the participant acts without being aware of the outcome of his interaction with the spaces.

The experiment meant to acknowledge the guest space through the body while performing a very simple action captured through pictures of different body postures and continuous movement while keeping the picture frame constant.

Pictures were then dissected into its elements featuring the response of the body's different parts to the space. The outcome indicated the boundaries imposed on the human body from the surrounding space layout and objects. (Figure2)

The anatomical study of space allows the discovery of the in sidedness of architecture. Thus as a continuation for exploring the guest space in unconventional ways and inspired by Wurm's work, the body was used in a sculptural way by positioning it in several strange points to underline the lines, the spaces, and the powerful constraints of the surroundings. (Figure 3)

Through those interactions, the goal was to study the anatomy of space, understand its properties, functions and discover how they form a working system. The experiment enhanced the interaction between the body and space and increased the user's spatial awareness.

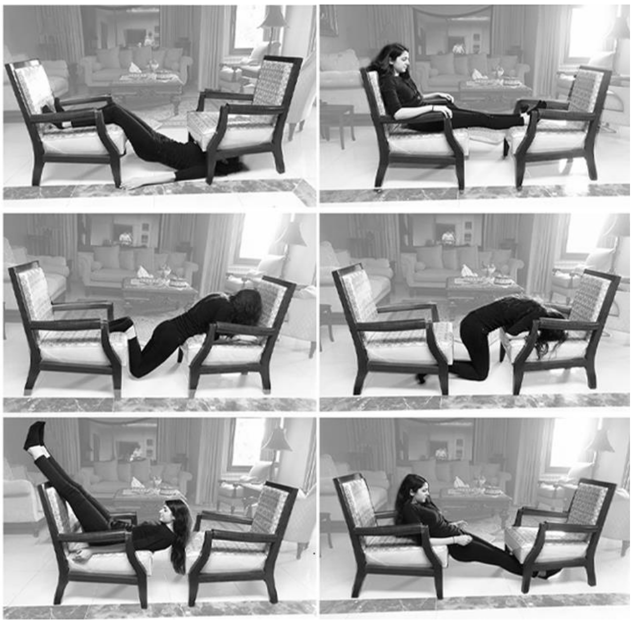

Figure 3. Body engagement with the guest space against standard customs. Source: Author.

In an attempt to enlarge the body's freedom of movement, the human body was considered a field that could be modified and redesigned. According to Barney, the reorganized body allows the human body to overcome its natural limitations[9].

Figure 4. Experimenting with finger gloves in the guest space. Source: Author.

Inspired by Rebecca's work 'Finger Gloves', the finger extensions as a new mode of reconstructing the body are composed of wood sticks fixed to the fingers using rubber bands. The artefact was worn and experimented in the guest area to further explore the space through the self against the standard customs. (Figure4)

The experiment took about 40 minutes of exploring and touching each aspect and object in the guest space (opening the door, switch on the lights, sitting on the chair, grab a napkin… etc.). It aimed to explore the feelings passing through the finger extensions.

The experiment highlighted the fingers extensions as any other costume surrounds the body, which raised the question of the role of costumes and how they affect people's perception of the space. Therefore, the upcoming experiments investigate the transformation of the human body and experience due to costumes and the costumes' ability to work as a research tool to investigate the features of the guest space.

This work explores the spatial boundaries through the body's costume interaction with the arranged space.

Figure 5. Experimenting with costumes in the guest space. Source: Author.

Experiment one with formal clothing as the required dress code for guest spaces. The experience of the whole body was different; it restricted the body's freedom to move and created an invisible boundary between the body and the surroundings losing the ability to explore the various textures, materials, temperatures …etc.

Experiment two with casual, comfortable clothing. It gave the chance to indulge more in the space, interact with it and break its formality by reconfiguring its elements. This experiment increased the awareness towards the guest space.

Experiment three, creating a 'pillow' costume as a body extension. The costume was comprised of a pillow attached to the front of the body with a belt. It was tested using gesture, motion and movement to interact in and with our day-to-day contexts. This costume made it difficult to interact with the space, sitting on the sofa or trying to pick an object from the table. However, it was able to point out the different configurations of the space (e.g. the distance between the sofa and the table, the shape and volume of the sofa, the circulation along with the guest space …etc.).

It was interesting to see how people are shaped and moved by external factors. Costume seems to affect the wearers through their material, texture, weight and form. It generated different movement qualities and experiences in the space. It created new limitations, directed the movement and heightened awareness of certain areas of the body.

An attempt to make the costume from a kinesthetic response, rather than just a visual one. The extracted information from the body movement, experience and interaction was used to inspire costume-making experience.

Figure 6. Experimentation with the Bin Bag costume. Source: Author.

Bin bag costume, composed of two large black inflated bin bags attached with a string wrapping the subject's waist, forming an extension to his waist. This experiment deployed an external participant as a mean to receive new insights and rich observations. The participant's experience and emotions were stimulated while wearing the costume and engaging with the guest space. (Figure6)

The costume created an experience of lightness. According to the subject, "I felt as if I was floating in the space, I was not able to see or access anything beneath the bags".

The costume makes the body more comfortable, thus willing to take more risks and indulge more with the surrounding space. This will consequently enhance the relationship between the body and the environment. The costume will no more create a boundary between the skin and the surrounding, yet it will create a bridge between the body and environment, thus enhancing both the internal and external bodily awareness.

Create a costume from the experience of the body: Inflatable Costumes.

Figure 7. Inflatable costumes. Source: Author.

Design a costume to have a moving/ changing costume in relationship to a moving/ changing body. Such responsive costume creates an extension to the body that functions without restricting movement or natural, fluid freedom. Here, the costumes feel less decoration and more like a disruption to standard conventions of form and shape.

The layout of the costume and used material meant to provide flexibility for movement and exploration of the surrounding space. The costume focused on expanding the boundaries of the body and encouraging the participants to enjoy investigating their relationship with their selves, others and space. The costume managed to be fabricated and given to two participants to experience along with their guest spaces. The participants were asked to highlight the features, objects, layouts in their guest spaces that the costume helped them reveal.

Results (Quotations from Participant1)	**Analysis** (Reflections of the Researcher)
I was able to acknowledge a volume surrounding my body.	The costume was able to make the participant aware of the extension of his body.
-Felt I was ready to experience the space because I was wearing the costume for this reason. -Felt I was ready to make changes in the space.	He felt that because he was able to expose his real self, hence, rushed to experiment in the space and test his new abilities.
Changes to the space: -Remove the pillows that are dominating the sofas. -Remove the center table to make more use of the space.	The participant was asked what features within the guest space the costume helped him to acknowledge. According to the participant, the center table was creating an obstacle in the space where he was not able to move or walk freely around. Moreover, he felt the dominance of the pillows controlling the posture of sitting.

Table 1. Reflections of participant 1 experience with costumes in the guest space.

Figure 8. Participant one experimenting with the inflatable costume. Source: Author.

The result of experimenting with the costume directed participant one to erase the center part of the guest room, in which according to the participant, restricted the movement of the body along the space and therefore minimized the interaction between the two. (Figure9)
Small interventions to the guest space help in evolving new activities, hence, temporarily transforming the environment of the guest space when the guests do not inhabit it.

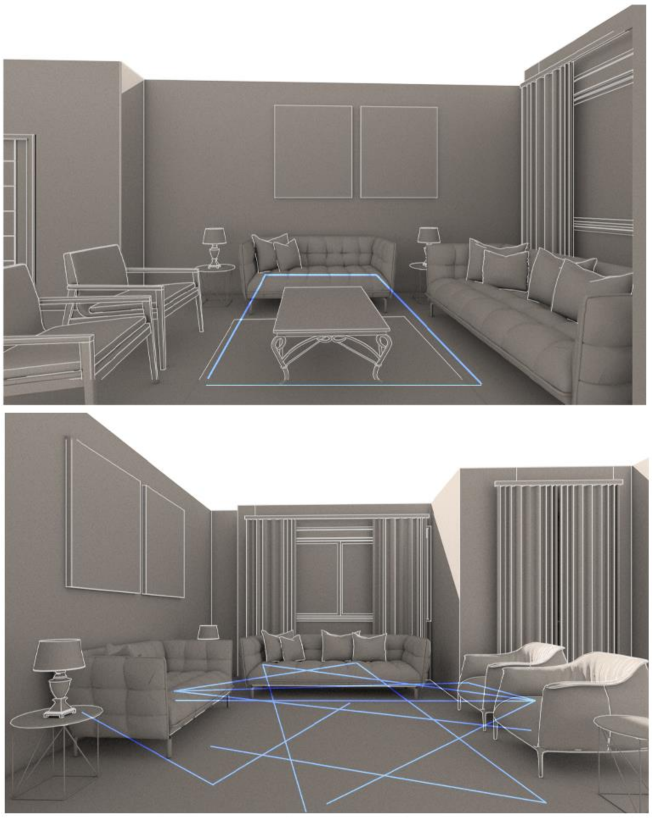

Figure 9. Footprint diagram along the guest space. Source: Author.

DISCUSSION

The guest space was the focal point of the project because these spaces demonstrate the least integration between the body and space. According to the survey, it was due to its layout, configuration and previous implanted thoughts concerning cultures and traditions. The project started with investigating the body through a series of bodily experiments that exposed a lot about the role of the body in space and its ability to activate it.
According to Baruch de Spinoza, the body’s power extent and its potentials have not been understood yet[10]. Thus, the project found the urge to break the conventions applied to the body and stop treating it as a machine that acts and performs tasks unemotionally.
The physicality of the body was the main character of the project's method. The project started with exploring the senses and consciousness of the different textures and materials and then incorporating the whole body throughout experiments.
During the experiments with all the prepared costumes and body extensions, the participants established a new enhanced physical connection between their bodies and the surrounding space.

Figure 10. Transformation of human behavior in the guest area. Source: Author.

The photos show the transformation of the body behavior and character within the guest space during the period of the project. It did break the conventional behaviors of humans in guest space yet reserved the atmosphere of the space. The body became more comfortable, thus willing to take risks in the space and enjoy it. Eventually, the role of the inhabitants will transform from isolation to integration in the guest space.

The understanding of our own body is an essential requirement for our daily interaction with the outside world. In everyday life, people take for granted their ability to perceive the location of their limbs in space across many different postures and control their spatial actions accordingly.

If other practitioners decided to take this project further or apply the same methodology to other domestic spaces (e.g. kitchen, bedroom, living area...etc.), the outcome and observations would be different because the behavior changes from one space to another.

There might be a lack of connection between the body and other daily used spaces in the house, yet users have taken their spaces for granted and live within them unconsciously; this disconnection is not as apparent as in the guest space.

This research performed only ten experiments, yet in the near future, it aspires to create a ‘wardrobe library’ that is accessible to a wide range of ages, backgrounds and abilities. This library aspires to stimulate participants’ experience and curiosity towards spaces, trigger specific senses, asks people to let their bodies perform intimate interface with the material world, and accordingly extract interventions for change.

This helps not only to examine the experience of oneself, one's relationship to others, and the environment but also how these experiences vary across cultures and diverse cultural forms of human embodiment.

CONCLUSION

Architectural spaces remain primarily unutilized, especially when inhabitants become accustomed and no longer see the inefficiency, such as guest spaces in Middle Eastern houses. Therefore, the project provided an experimental approach to reorient spaces based on the living body to enhance the co-existence between the body and space, hence increase the ability of dwellers to cope and adapt to unforeseen conditions such as pandemic lockdowns.

The research showed that submission to culture shapes and moulds the vision of interior environments, where spaces are configured and designed to reflect the local values. This thesis is not an attempt to undermine the significance of guest spaces, instead to unlock unconventional ways of using the body in these spaces to leverage them, especially in adverse conditions. Therefore, the project investigated the body through classifying everyday activities and analyzing body movements accordingly.

Practical design approaches lack integration of body movements with spatial design. The experiments showed that designers need to consider a body-based approach; otherwise, interior environments will yield in predictable outcomes. The intervention to solve this problem in this thesis was to adopt an experimental strategy to investigate the space based on the qualitative features of the moving body.
The experimental-creative efforts put in this thesis are an attempt to enhance inhabitants' relationship with their spaces and inspire designers and users to join the unique stream of thinking, which comprise involving their movements and behaviors to reactivate spaces while prioritizing the body.

APPENDIX.

Survey

The survey showed that 30% of the respondents' houses is dominated by guest area. Thus, as the diagram shows, regardless of the size or the number of available rooms, each house allocates a space with certain criteria and values to welcome guests.

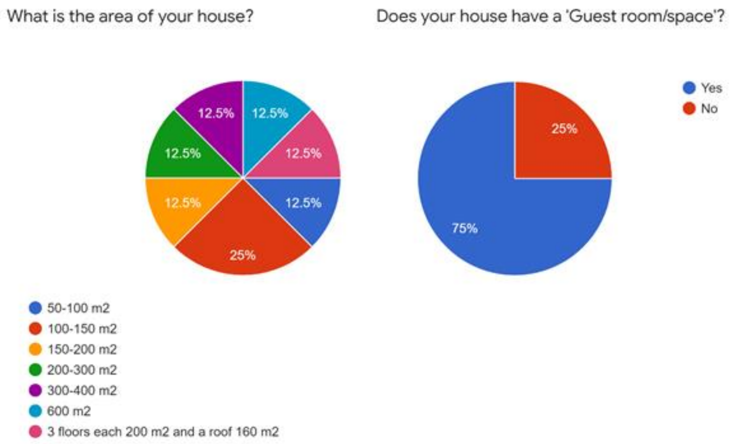

Figure 1. Domination of guest areas in the participants' houses. Source: Author.

When asked about the function and layout of the guest area, the participants highlighted the restrictions imposed upon the guest space. They are not allowed to enter it nor use it unless to welcome guests. "The guest space is highly. Maintained by my parents. They want it always clean and sharp, always. This put pressure on us to use it or change it in any other way".
I am restricted in terms of taking action to make changes in the house because of clashing mentalities with my parents".

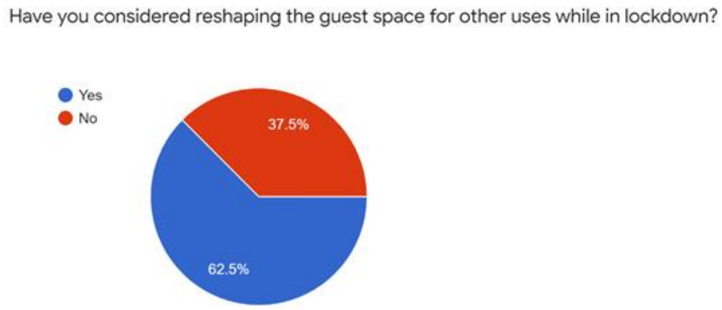

Figure 2. Percentage of willingness to shape the guest space. Source: Author.

On the other hand, for the participants themselves whose ages range around the (20 - 30), they consider it as an efficient room. The survey showed that the participants mainly wished to change the walls and layout of the house to enhance the natural lighting and revive the dead spaces. Additionally to change the furniture because it is too bulky which all makes the room narrower and restricts the circulation.
During lockdown, 60% of respondents took small actions to reconfigure their guest spaces. They mainly transformed those spaces into working areas, which acts as “good background for zoom meetings, and entertainment area.
Moving aside the furniture to create space for workouts, moving furniture closer together to create more comfortable seating for entertainment”.
Concerning the question that asked about the movement of the body in the guest space. Most of the answers were negative because in their cases, their bodies did not' shape the surrounding configuration. The results confirmed the incomplete relationship people have with their guest space because they are unaware of their bodies’ potentials to change the configuration of the space.

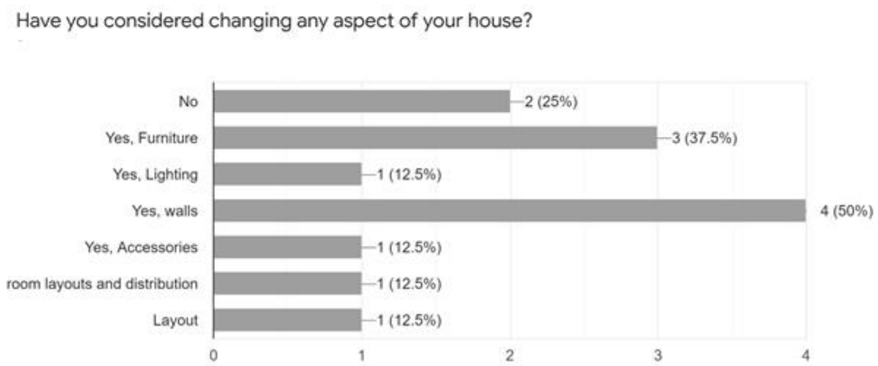

Figure 3. Aspects to change in the guest space. Source: Author.

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URBAN DISPUTES FROM THE SOCIAL AND TECHNICAL ASPECT

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INTRODUCTION

This work starts from questioning the material reality with which it looks, such as Magritte's famous painting, “The betrayal of images” which in allusion to the image of the city, would be added: “this is not a city ”, and if it is not, then what is it?
Before entering the matter at hand, it is considered convenient to clarify that by reality, it refers to the designed reality, which in this research is called existential instrumental materiality, such as the rabbit stick for the Chichimeca or the fork or the city itself for us.
That design interface which human beings have created between their fragile nature and the world that surrounds them in their desire for life.
From this perspective, Guattari is approached on the generality of semiotic procedures in the manner of regimes of signs constantly at stake between productive processes (capitalist machine) and social groups (society or social system). What he considers as “collective equipment” (assemblage) refers to the “concatenation of semiotic chains” that are fundamentally different from each other and that function from the beginning not as a significant discourse, but as many other machines of a-signifying signs.” (Guattari, 1984a; 1997b)
Consequently, the subject is considered as the center of theoretical concerns (López, 2004); however, “neither structures nor subjects…” (Op cit., 2004), that is to say; the need to position the discussion on the ontological status of the place is more than evident… (something that Malpas claims and that Paloma Puente (2015) clarifies it on pp. 249 and on pp. 251 when she explains the constructivism of Harvey (2015) always based on social practices that build certain types of spatiality and that cause disputes over the meaning of place, that is, understand the processes of existential instrumental materialization of the subject who unfolds as an urban being: we are witnessing a phase of relocation of the processes.
Thus, the action and matter in the construction of the place are questioned: What types of assemblages are given for certain practices? Likewise, how is the language structuring pattern (orderings) that such assemblages inscribe in urban space explained?
According to Deleuze and Guattari (1984a; 1997b), territorialisation is the process under which all power is conveyed through the agency. The agency is the active medium of the actions that enclose a determined state of flows that in turn characterize a process endowed with particular components within a system.

On the other hand, Bruno Latour (1994a; 1997b; 1996c) considers that the reality of events is made up of constant processes of hybridization between nature and culture that modern metaphysics knew how to split into two well differentiated worlds: on the one hand, things themselves, the knowledge of them, that is, their nature; and on the other, the interest, meaning, power and politics of humans in society, men.

These quasi-objects, as Latour calls them, have as their characteristic their constitution (no longer modern), the composition of facts that all the time is found referencing the subtle web of implications in a round trip (non-linear) of each event of significance, that is to say, of each moment of insertion in the social group and the objects.

However, these hybrids of culture and nature continue to be cut today by the bias of criticism that separates them into three categories: nature (epistemologists), politics (sociologists) and discourse (deconstructivists).

Therefore, both science and the technique are considered vehicles that allow reaching the exact knowledge (nature of things) that have been separated from the exercise of power (culture-society).

López Rangel recalls that:

“We require the analysis of the meaning of objects ... [...] in terms of discovering and knowing their social, class, and language management, and its historical character to come to consider it as a process. The study of objects will thus go beyond the traditional formalist schemes to conceptually integrate the multiple determinations that intervene in their generation as well as the transformations of the (social) subject through their use and circulation.” (1981)

DEVELOPMENT

The forms of desire in the dispute for meaning: action and place (through the inscription of complexities)

The architectural discipline in its general aspects has seen its theoretical concerns bifurcate since the discursive crisis in the last two decades - a product of tendencies and their corresponding cancellation of history - into a diversity of perspectives tending to reinstate a new political discourse as a counterpart to the deconflictivization of their discourses until now in the hands of the hegemonies. The issue of the complexity comes to position itself in this plane as an unavoidable reference that tries to retake -from the bases of its epistemology- the transversally of the lost processes in the disciplinary field in contrast to the reductionisms to which we are accustomed when modern science explained them.The linguistic turn operated in the late 60's by the human sciences and whose echo in architecture and urbanism was revealed by Venturi & Scott Brown from their controversial text *Complexity and Contradiction in Architecture*, positions or rather focuses the discussions on the symbolic character of subjectivity thus inaugurating postmodernity in architecture.

On what is given in the urban scene: actions and matter

From this perspective, the main question is retaken: what implications do the phenomena of inscription of action and matter (assemblages), product of the disputes for political action between the Social System (ST) and the Technical System (ST) have for the urban space?

The structuring of the actions that constitute the processes of subjectivation willing to signify what is already given or what is inherited in the urban scene is the motive of certain literature deployed tending to discern between what belongs to us as products of our objectifying capacity and what due to circumstances inherent to the immanence of the facts, they are inseparable from the essence of the subject.

Consequently, the transcendence of the subject is no longer found in his being, but in what defines him, what explains it.

In this way, the need to transcend - in the sense of an active and therefore reactive permanence - is now defined by an emancipatory policy where what is given does not imply the acceptance of an exterior that legitimizes all existence and understanding from the power of the structure. The subject is no longer described by its transcendence as an explanation of all nature of the real. Rather, nature is explained as the given plus the delivered; and here, individuals have much to say, to reflect.

The system condition (Luhmann) evidences the fact that meaning is one more action of all those deployed in its natural functioning, only that by establishing a relational difference that allows introducing a disturbance or novelty (López), they are enabled as a chain reaction, certain negotiations that involve losses and/or gains of power.

These reactions are the symmetrical part of the structure since they take it as a reference to incorporate a dynamize based on current affairs and emergencies. But, who composes or organizes such actions deciding their actuality or emergency?

According to Geertz (1973) ... the analysis of culture should not be an experimental science in search of laws but “an interpretative science in search of meanings” and its expression is a warp composed of "meaning webs" that must be revealed in deeper layers of the enigmatic language that social expressions have on their surfaces.

A dialectic between event and meaning, which the author of reference -Niklas Luhmann- attributes to the way in which social systems construct complexity with respect to their dynamic environment as reassurance of their access to understanding, which can direct their processes of designation, selection and discrimination of events.

It is a complex process since it involves encoding and decoding or non-linear decomposition actions, that is, devoid of a coordinated teleological action between the social system and the technical system.

Furthermore, materiality serves as a bridge between the subject and the world, defining in this way and according to its characteristic, being that it frames the possibilities and effectiveness of that relationship.

Therefore: how and under what logic, are the practices of the social system that produce meaning develop?

To reflect on the search for the answer to the above, it is considered: unity and difference in relation to the subject: Enrique Dussel (2006) in his book “*20 Political Theses*” writes that all human action is motivated by a fundamental and first principle. This principle is the will to life.

Human beings act because they want to live, but they want to do it in a certain way ... in a community, healthy, safe, fairly, respecting the environment, with the opportunity for development, with the possibility of managing the environment according to their needs, etcetera.

Unity and difference in relation to urban space: the social system and the technical system from the sense that their differences acquire.

The change established by Luhmann (2009a; 1998b; 1997c; 1996d; 1984e) in his theory of social systems as a critique of modern foundations goes from the idea of unity - around the constitution of the transcendental subject that explains everything from his subjective position, that is, as a possibility of constitution of everything he experiences and also of the rest of the subjects he has experience with (consciousness) - to the idea of difference established by the environment where the subjects act.

Action thus becomes the vehicle for intersubjective communication between the components of society that can no longer explain their unity of legitimation of all reality but from what is particular in the context of their relationships.

And this is similar to what Latour raises when in his symmetric anthropology, he inverts the logic of the modern foundation that in two simultaneous operations tended to separate and then unify in the fundamental action the natural (the given) and the social (the culture).

Action is the possibility of difference happening from the potentiality of the context. It is from this need for differentiation that society as a unit requires the construction of a meaning for its survival (surely parts of the individualization process).

In other words, society is based on the ability to construct meaning from an environment that stimulates its constitution within a complex field of action. This is how the surroundings (that is, the physical and relational context) become the film that reveals -through the configurations and their involved flows of action- the senses that direct its support (from a functional need), to the time they explain it by the tenor that their hybridizations reveal.

That is, if socio-spatial fragmentation -as a primary problem in today's urban reality- implies the separation in space of the different components of society, that same spatial separation becomes the sense that continues to direct their actions by the sole functional necessity of its reproduction in a vicious circle that allows the foundation to be carried out by making its existence necessary.

What remains to be defined is the constitution of that difference that the environment stimulates by its capacity for hybridization of the various natures involved in the action: its possibility of foundation. An interesting example could be given in the spaces that have been defined in a functional way in the urban context between the different socio-economic groups since the existence, maintenance and extinction of certain flows of action that crystallize socio-technical hybrids (Latour, 1997a; 1996b; 1994c) such as the feeling of insecurity that causes higher levels of introversion and closure of spaces, while such degrees of closure imply that insecurity is based on the functional need to close.

This recurrence to physical closure as a mechanism, inevitably leads to the commitment of hybrid entities to be carried out.

On one hand, the socio-cultural nature as the feeling of insecurity of a social group that sustains -from a disturbance of the environment- the justification of its discomfort due to the threat that insecurity implies.

On the other hand, the scientific nature of the explanation of poverty and inequalities promoted by the concentration of wealth only confirms the symmetry necessary for the resulting objects to continue to proliferate under the same logic. Luhmann attributes to this process a crucial property that characterizes self-referential systems, which reproduce the elements and tricks of what is made, constituted. That is an ontological difference that establishes units of meaning.

To the latter, we compare it with what Aleman (2012a; 2013b), placing him in the Lacanian condition of politics based on desire, attributes to surplus value as the counterpart that capitalism opposes against Plus de Goce. The same Plus that the subject in the solitude of his enjoyment, commits himself to accept, for example, “exploitation as if in itself it were another feature of the necessary and eternal human condition, and, at present, one step away from being founded”.

This is an absolute difference -as Lacán calls the loneliness/common opposition-, which means that what is at stake is the transformation of social ties, that is, a new politics of the collective, in the common of enjoyment, in front of the ontological difference that capitalism presents to it from the solitude of its homogeneous and unlimited repetition of the commodity form. (Op cit., 2012a; 2013b).

New approaches: objectives from this approach

At first instance, it is intended to raise the absence of knowledge related to this approach, managing to describe and analyze the theoretical-philosophical conceptions involved in the process of dispute for

narrative action in urban space that, based on the Theory of Social Systems (TSS) by Luhmann, allows the definition of expressions (parts) that constitute it, a product of the dialectic between the different authors involved and of the Abstract Machine (TMA) of Deleuze and Guattari, from their concepts, definitions and principles, managing to recognize the whole tending towards the parts.
In the second instance, formulate the problematization of said theoretical relationship based on a dialectical hermeneutic that allows understanding and explaining the mutual implications of the process of dispute over language in the territory (existential instrumental materialization), taking as reference the differential and particular aspects of the interaction, that is, the process of the parts to the whole.
Finally, for third and final instance, to interpret the synthesis of the proposed dialectic, schematizing the singularities of the events -phenomena or critical moments- in the entire process as phenomenal results of a systemic articulation for a gnoseological contribution whose scientific correspondence later repairs in the approach to a concrete urban reality, achieving the recognition of the parts tending to the whole or everything.

Research Questions

It is questioned, at a general level: what implications do the phenomena of inscription of action and matter (assemblages) have for the urban space as a result of the disputes for political action between the Social System (ST) and the Technical System (ST)?
From the above, we seek to reflect on how and under what logistics of the social system that produce meaning develop? Consequently, what type of assemblages are given for certain practices?
Likewise, how are the language structuring patterns (orderings) that such assemblages inscribe in urban space explained?
The scope of this publication is intended to present what is related to a research protocol that allows visualizing relevant issues for future research from an interdisciplinary field.

Rethinking the hypothesis

From this perspective, it is considered that the technical system (independent variable to be investigated) -as a process of ordering, agglutination and hierarchical stratification of capital- conditions the form and type of communicative actions (dependent variables) established by the social system with its environment by the way of desiring production, that is, the complex process of subjectivation that organizes the matter available in the territory for the production of meaning as a narrative structure.
Said structure is composed of forms and actions that are the singular relational and physical events of such dispute and that reflect the critical moments of the process mentioned.
Although, what is at stake are the social ties that structure desire and that lead to the transformation of the subject in solitude, trying to ensure that what is involved is not the complexity in the form of a homogenizing tradition that blocks the transformation process towards the collective, as, for example, a monument, a myth or a legend, but precisely a new relationship of forces that acts outside the mechanism of the merchandise.
If capitalism has a systemic condition due to the way in which it reproduces in an unlimited way the circuit of the merchandise from the logic of surplus value, the subjects in their need for a common constitution based on desire, will recursively reproduce a type of communication based on the designation and selection of the necessary stimuli to define the type of action to be registered, to manage in the face of the void that homogenization proposes; and this, is also a condition of every system.

CONCLUSION

From the meaning of the dispute to the dispute over the meaning

Both systems, the Social System and the Technical System that constitute capitalism, will carry out a dispute process that will have the meaning as the object of a dispute over the foundation.

If we return to Luhmann, self-referential systems produce their complexity according to the stimuli -or disturbances- that the environment provides, although the process of selecting the disturbance that will enter the game is a cognitive function strictly proper to the relational condition of the system to direct their actions.

The subsistence of the system, that is, the establishment of its difference with the environment, will then be defined by the complexity in directing the actions of designation and selection of the aspects of the environment that are necessary for its operation.

Therefore, intra-system intersubjectivity is not a condition that is determined by the structure, but becomes at every moment where the absolute difference between loneliness and the common is at stake, therefore, it is the pure power of the event.

“The structure of meaning is based on the instability of the actuality and the stability of the possibility; thus, the world is to live simultaneously the stability and instability with a gradual direction in the complexity […]. In this way, the problem of the constitution of knowledge is framed in the characteristics of dynamic and autopoietic systems, where complex organization is based on the selectivity of possibilities and the senses that direct it. For this reason, complexity has a teleological and at the same time analogical character in its constitution.” (Luhmann. 1998)

However, and in tune, for Deleuze (1984a; 1997b), desire is mechanic and not symbolic or imaginary and therefore it decodes flows from codes that select which flows are blocked, which others pass and finally what it must make happen or stay.

Under this characterization, desire does not respond either to structures or to the symbolic, but rather captures from codification - what in Luhmann would be designation and selection - the flows that circulate in the environment, territorializing it.

Consequently, what are the consequences of this highly static and fragmented materiality in relation to the dynamics of human life?

From the anthropogenic world, as Ricard (1982) catalogs it, a phenomenological manifestation of power unequivocally reveals the partial designation: each one does what they can for themselves in the measure of their fragmented and peculiar universe.

The city and with it all its institutions, represent the materialization of the heterogeneous organization of power, where each one of them pursues a particular purpose.

And on this “throw everyone to their side”, dominates the force of habit, the typical, the convenient, or in the best of cases, what is fashionable but always within “sameness” with a distinctive appearance: standard houses, standard subdivisions, and standard parks, among other manifestations.

Faced with this runaway development of fragmentation, specialization and typification, each power group structures its field according to its imagination, materializing its ideology with the sole purpose of being able to reproduce, maintain and develop the conditions that are conducive to their subsistence.

In the present, the city is populated by different languages, with isolation reigning, exacerbating the differentiation according to each group. The spaces that Bauman described proliferate in each corner: the emics, the phages, the empty spaces and the non-spaces, some for being intolerant, others for being illegible, the most for being recursive, who do not see beyond their own figure.

Design and urban planning professionals are no exception. The specialization of knowledge of the designer, architect, urban planner has been transformed into his own imagination, forgetting the true purpose: the city.

Sudjic (2007) explains that:

“Along the path of history, the architect has lost a large part of his attributes and knowledge to focus on a supposed essence of architecture and leave fundamental responsibilities to others… […] Currently, all this has led to the architects being mere producers of symbols, images and decorations with an extreme ignorance about the way in which these possible buildings are supported and constructed.”

Anthropologically and ethically speaking, for some, the minority, the space expanded while their distances became virtual and shorter, for others, the majority, tied to territory, physically lengthened them, which on the one hand requires another type of transfer and with it, other conditions in the exercise of power, conditions of cost, time, money and effort, but above all technology.

If these new conditions affected everyone, they did not do it equally. For the vast majority, moving to the city today to go to work, school or simply for a walk, requires great and different efforts.

Depending on who does it and the materiality available, will your requirements be in time, money, effort, knowledge, skills and abilities.

Today some fly in helicopters go from one place to another, most of them face an all-out fight daily. If they want to get to work on time, they will need to take a couple of hours in advance. Houses three meters wide and five meters deep with seven-centimeter-thick concrete slabs and block walls in an area that registers temperatures of more than forty degrees Celsius in summer.

The final questions would be: will the designer have any idea of life within it? Furthermore, is there any cognitive trace of the indispensable link between the subject and nature, therefore, society and the natural environment.

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SPATIAL PROPHYLAXIS: THE TACTICAL APPROACH OF POST-COVID PUBLIC SPACES IN CAIRO

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INTRODUCTION: WHAT IS THE NEW NORMAL?

Donald Schön's 1972 book, *Beyond the Stable State*, illustrates the current global system as a moulding reservoir of social interactions, organizations, and values[1]. The global spread of the coronavirus, which started in early 2020, has been perceived as a wake-up call for systems to adapt to the novel changes spreading across the globe instead of operating within the same structure. Not only has the pandemic spotlighted the inaccessibility of most citizens to virtual networking infrastructure, but has also defined the unequal access to public spaces throughout megacities. Taking a closer look at Cairo, where social rights to use public spaces are limited[2], the share of green space does not exceed 2 square meters per person, which is around 7% of the adequate area[3]. Hence, most of the social interactions take place inside closed settings[4].

The term prophylaxis, despite not being a new term, has been a trending architectural approach since the lockdown period. Originally a medical term that means preventive healthcare, prophylaxis refers to measures taken to prevent further contamination of diseases. This paper uses prophylaxis as a theoretical backdrop to emphasize the importance of public spaces during the Post-COVID era. The research work highlights local initiatives of tactical urbanism that have redefined the usage and perception of public spaces. Through the examination of a broad range of urban cases, this paper argues that by creating prophylactic spaces it is possible to have public gatherings with decreased numbers of viral infections.

Health and Modernism

History shows that cities have had significant response towards the progressiveness of societies. The challenges resulting from the rapid urbanization of the population during the Industrial Revolution were faced by the construction of city parks as urban lungs to enhance mental health through exposure to nature[5]. Similarly, the modernist movement in architecture and design witnessed major transformations during the outbreak of the tuberculosis pandemic in the 1800s, where minimalist forms and simple lines were extensions of sanitation and public hygiene.

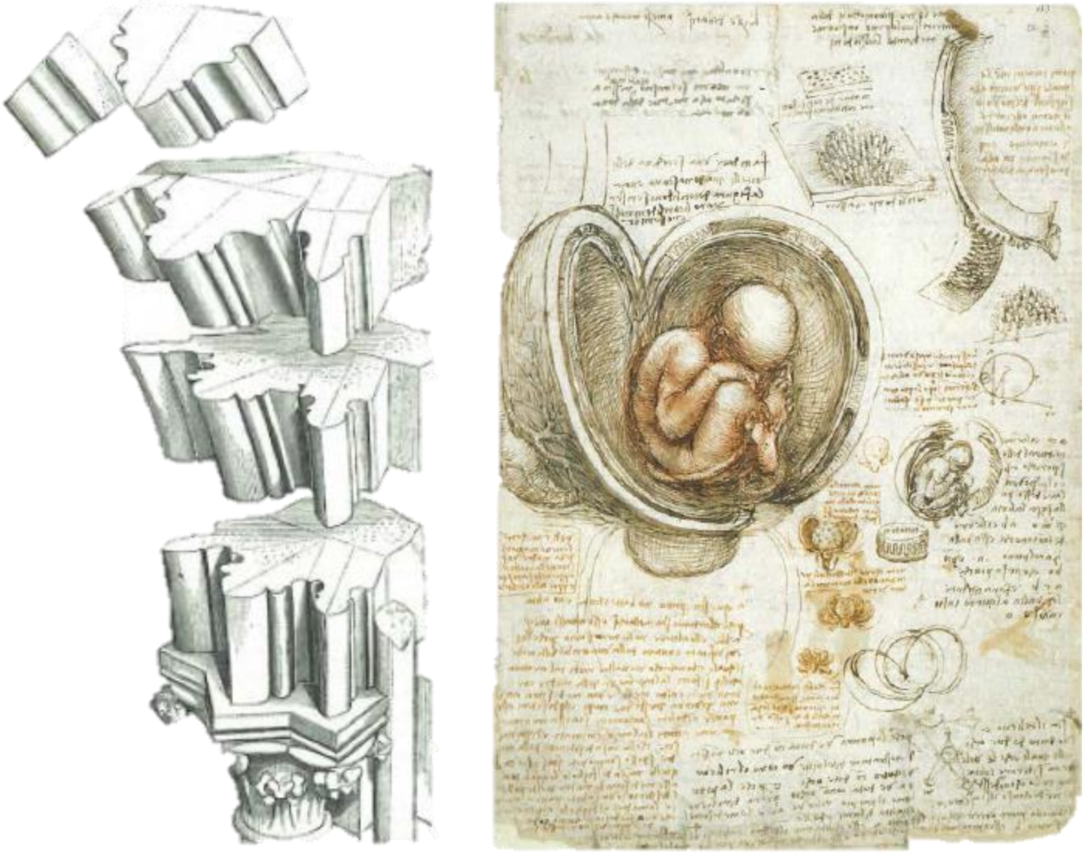

Figure 1. Illustrations by Vitruvius showing the similarity between the internal structure of the building and the baby inside the womb.

The architects at the time embodied haruspicy in their work, which trails back in time to the *Ten Books of Architecture* by Vitruvius[6]. Throughout his work, Vitruvius discusses the internal parts of the building in the same manner as he illustrates the internal system of the human body, metaphorically drawing the baby in the womb as a reflection of the compositional behavior of a physical setting's internal structure[7] – as illustrated in Figure 1.

The introduction of the 20th century revealed the deficient conditions of 19th-century buildings as depressing and unhealthy with limited ventilation and sunlight exposure. Modernism, incepting the era with the works of Le Corbusier, transformed the perception of the architecture of health simultaneously with the invention of x-rays. Le Corbusier expanded the medical argument from the residential unit to the whole city through the exact air theory. Being rejected from two major international competitions at the beginning of the 1930s[8], Le Corbusier's shift from a reliance on machine solutions toward acceptance of the natural environment furnished his approach to creating healthy cities through curing mis-planned streets. Similar to the metabolic process of the human body during exercise, where air circulates inside the body to disinfect it from negative factors, Le Corbusier's idea was to cut through the urban fabric to allow air to pass through the streets cleansing the environment from dust and other harmful particles. The outbreak of tuberculosis was believed to have created modern architecture[9].

Public Health in Current Cities

Much of modernism, despite being safe on the microphysical scale, did not show similar efficiency on the macro open space level. Currently, leap changes in technology and economy are not always translated to improved public health, specifically ones that are established at the expense of the environment. Mass production of products, scaling up to commercialization and privatization, has transformed public spaces and marked their decline, a dominant feature of 21st-century planning. Eventually, in some megacities such as Cairo, the culture of publicness has declined as well to the level of national rejection. Cairenes do not enjoy the right to use public spaces as a result of either privatization or militarization. During the outbreak of COVID-19, participatory research was carried out on citizens' behavior and the use of public spaces in the light of the pandemic, and one question was asked about their normal days spent outside the household. The results of the people going to other indoor places were more than 50%, while around 2% carry out a few outdoor activities such as walking or sports[10]. The pandemic has spotlighted the inequity and inaccessibility of a national culture to the idea of using public spaces. Hence, this paper aims to address the main question: How can architects and planners create bottom-up prophylactic spaces as a sustainable futuristic proposal for megacities?

TACTICS TO PROPHYLAXIS

Tactical urbanism is simply engaging the community by taking the initiatives to make short-term and low-risk actions required to improve and change the urban context in the long term with higher benefits[11]. This bottom-up process proved effective since it made a direct connection between the citizen and the surrounding public space[12]. Following the spread of the COVID-19 in March 2020, social distancing was applied as a rapid tactic solution needed to control the spread of the virus. Despite being effective in the primary stages of the outbreak, public space requires different types of tactical urbanism to create a resilient and non-contiguous open space. De-familiarization and Re-familiarization are types of tactical urbanism to ensure safe adaptation with the current pandemic. De-familiarization means to familiarize and identifies the major changes required to adapt to the sudden changes, as it is the new normal. While Re-familiarization is to utilize the hidden and unused spaces within the city and to re-inhabit it as a public space[13].

To utilize tactical urbanism in the creation of a prophylactic space, this research work takes a closer look at some examples of tactical urbanism in public spaces to determine the characteristics of the prophylactic public spaces after the pandemic.

Re-Thinking Architecture 2025

Since the beginning of the spread of COVID-19, the main question asked was: What is the future of public spaces after the pandemic? In response to this question, many organizations and institutions opened the opportunity for architects and urban designers to discuss the effects of the pandemic on architecture and urban design. In June 2020, the Royal Institute of British Architects *RIBA* announced the competition *Rethink: 2025 – Design for life after COVID-19*. The competition aimed to envision the future of our cities after the pandemic at any scale from the scale of a single room to the scale of a city. Creating a paradigm design that provides a genuine response to the concerns raised by the pandemic[14].

Post-Pandemic Exchange by Elle Thompson, University of Nottingham, is one of the entries that envisioned the future of public spaces after the pandemic. Elle's proposal discussed the idea of retrofitting the function of three building types along with the surrounding streets. He suggested boosting the start-up business in the shape of open markets in the main plaza and rooftops used for exercise classes. Moreover, he created green boundaries between the seating areas and the streets, which retrofitted into walkways, and bicycle trails to reduce the use of cars. Instead, cable cars are used for transportation on a higher level from the street level. Prefabricated extensions were wadded to extend the front gardens of houses to take over the streets – as shown in Figure 2.

Figure 2. Post-Pandemic Exchange, one of RIBA's competition entry by Elle Thompson.

This project adopted the de-familiarization tactic as the main approach for the idea. Where it took advantage of the spaces that lost their original purpose, due to the pandemic, to retrofit it in a way that will boost the economics whilst maintaining the public health in the space. The addition of the green fences created a healthy social distancing by separating between seating areas and walkways to reduce the number of people gathered in one spot. Furthermore, increasing the green area mitigates the level of contagious of the virus in the space, as plants are natural purifiers and cleansers for the air. Also, increasing the interaction between people and nature, especially during the period of lockdowns acts as a psych healing therapy that relaxes the inhabitants and reduces the depression caused by long periods of self-quarantine.

Kodak Passageway – CLUSTER

The Usage of tactical urbanism methodologies in developing public spaces is not a new technique in Cairo. A private entrepreneur called *CLUSTER* took the initiative and worked for a year on mapping Cairo's downtown passageways, that either encompasses a historical background or lie in proximity to a vital area[15]. The main idea is to develop these passageways and design interventions to be a public hub[16], creating an exquisite experience as a haven from Downtown's hustle and bustle environment.
Kodak passageway, located in Adly Street in Downtown, is CLUSTER's pilot design intervention project. The reason why they choose the Kodak passageway as a start for the project was that, originally, the Kodak passageway was a services alleyway, before it was neglected and underutilized for a significant amount of time. The alleyway is bounded by two high buildings and faces the Jewish synagogue, which made it difficult to host different activities for security reasons. It also includes a Kodak store, a garage, labs, a warehouse, and a Brazilian coffee shop.

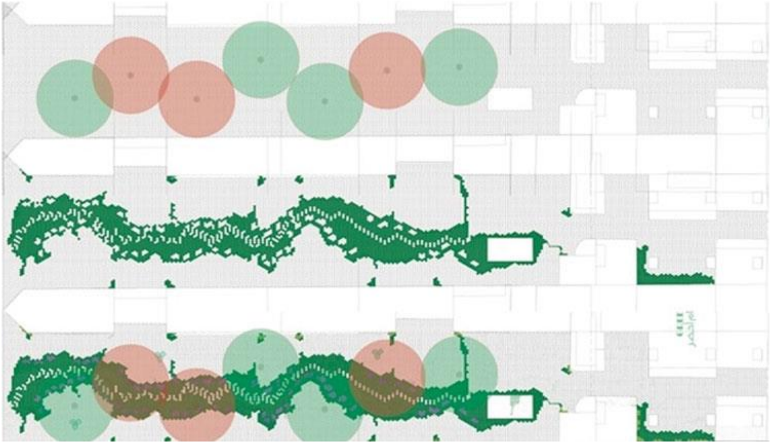

Figure 3. Schematic Design for the Green Oasis by CLUSTER.

Figure 4. The Green Oasis in Kodak Passageway.

The main objective for the Kodak passageway project is to engage both stockholders and residents of the street to reach an optimum solution to revive the deserted passageway. The design aimed to redefine the public space of downtown Cairo, by designing a Green Oasis that brought nature back to downtown Cairo, that megacity that lacks the existence of green areas. Creating a serene space for the public to enjoy away from the busy and noisy vital areas in downtown during the day. At night, an area where it could be decorated to accommodate different types of events to increase the interaction between people from diverse backgrounds – as illustrated in Figures 3 and 4.

The strength of this project is in taking the biophilic approach along with a re-familiarization tactic in the concept of the design. That is not only revived the passageway and became a public hub that helped the stockholders in the passage flourish their businesses, but also it became a cure for the area on different levels. The creation of the green fragmented parts, environmentally, acted like natural air purifiers adding a fresh breath in the middle of a highly dense, busy centre. Psychologically, an experiment that took place in Japan in 2013 resulted that plants and nature contain psych healing merits that help in reducing depression and tension and gives the feeling of calmness and peace[17]. If we gave this project a second look after the pandemic, the tactics used in the green oasis, acted like green boundaries that created natural social distancing, divided the large social gathering into smaller groups in limited spaces. Moreover, the environmental and psychological impacts of the natural plants are a huge necessity for mitigating the spread of COVID-19.

Characteristics of Prophylactic Space

During the previous pandemics accrued throughout history, there were no specific definition for prophylactic spaces rather than it is a space to prevent the further contamination of the disease. However, with each pandemic, there were new characteristics for the prophylactic space. As COVID-19 imposed the idea of social distancing, thus there will be defiant changes in the space measurements to ensure public health. Returning to nature, as nature has the power to purify the air in the surrounding area and increasing the amount of oxygen in the air since the nature of the COVID-19 virus causes shortness of breath, a biophilic approach in the design became a necessity (Figure 5). Using the proper urban tactics with the new measurements and a biophilic approach should develop a healthy environment for people to interact safely during the pandemic.

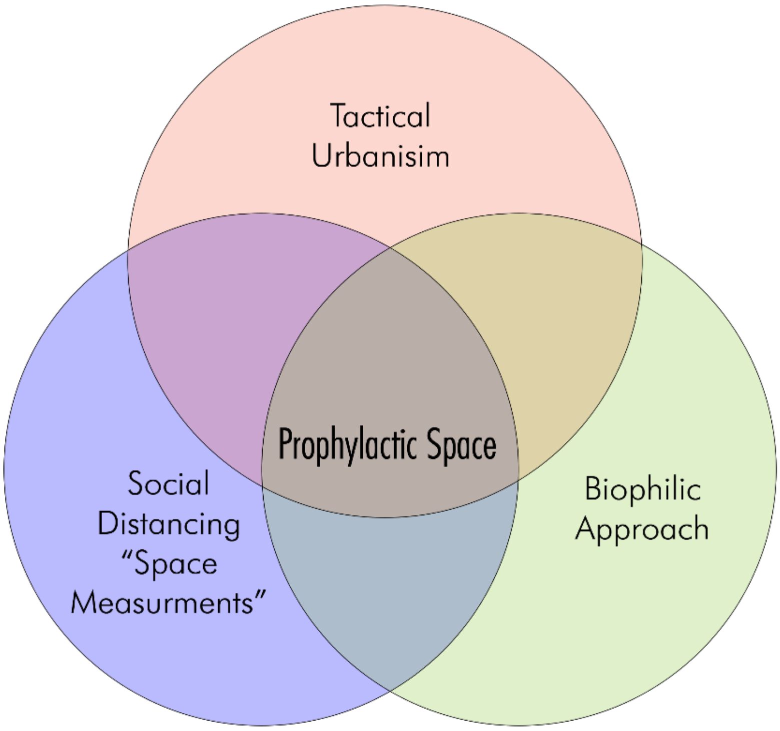

Figure 5. Main pillars of prophylactic spaces as suggested by the authors.

ARE PROPHYLACTIC PUBLIC SPACES APPLICABLE IN CAIRO?

In the case of Cairo, the main issue is the lack of public spaces within a spacious megacity. However, the application of the spatial prophylaxis concept does not need a prior specific condition for the space to apply it. Every space in Cairo could transform into a prophylactic space, with the application of the proper tactics on different levels, ranging from plazas, squares, passageways, to residential rooftops. In fact, there is a possibility to transform rooftops into huge interconnected, elevated prophylactic public spaces. However, this idea will need further research to examine its application.

Abdeen Square is one of the largest squares in Egypt. Located in front of Abdeen Palace and almost one kilometre away from Tahrir Square. During the last decade, specifically after the revolution in 2011, Abdeen Square was in total lockdown by the military for security reasons till early 2014. After a comprehensive development process from the government, it reopened back to the public in 2014[18]. Since then it back one of the most important and rare open public spaces in Egypt. Additionally, because it is located in the vital area of downtown, this research work suggests that Abdeen Square could be an initial space to apply the spatial prophylaxis concept.

Abdeen Square occupies nine acres of space. It includes open green areas surrounded by trees. Its central walkway is a paved open multifunctional space with seating areas in the edges. The main way to transform this square into a prophylactic space is to consider the new social distancing measurements by increasing the green barriers to decrease the create separation between people. Seating could be designed in a way that accommodates one or two persons at a time. Also, overlapping between the locations of the seating areas intermediated with green elements to decrease the spread of the virus and ensure public health. The main advantage of the suggested tactics is that the application will be a simple rearrangement for the elements already existed in the square but following the new social distancing measurements to create the prophylactic space (as seen in Figures 6 and 7).

Figure 6. Abdeen Square on a normal weekend outing.

Figure 7. A conceptual proposal for Abdeen Square as a prophylactic space.

CONCLUSION: DO SOCIETIES NEED A NEW TYPOLOGY FOR PUBLIC SPACE?

The pandemic has already revealed some fabric gaps in the socio-spatial composition of cities, which will force architects and planners to redefine public spaces and create a new vocabulary for their new forms of occupancy. Additionally, they will have to face forces of neoliberal policies that have established their definitive structure onto democratic and participatory execution.

The pandemic has made it clear that urban planning is crucial for better public health, especially within highly dense areas. With the global rejection of the idea of shutting cities off, the demand for access to open spaces remains valid. What this paper discussed was a theoretical blueprint for future proposals of creating inclusive spaces in a way to reduce the further spread of viruses among the inhabitants. There has been some significant emphasis on the role of large parks in accommodating a high number of people, thus, reviving the human-nature connection that has been gradually deteriorating since the industrial revolution.

Designing cities plays a distinctive role in preventing chronic diseases and, in return, has a consequent impact on the quality of life. Public spaces are to enter a novel transformational phase with new definitions and dimensions that might intervene in the very core of human lives.[19]

NOTES

[1] The author suggests that business and institutions must become ‘learning processes’ and organize themselves around functions rather than products.
[2] “The Right to Public Space”, TADAMUN, accessed January 11, 2021, http://www.tadamun.co/the-right-to-public-space/?lang=en#.X_w_XNgzaUk.
[3] “The city is your playground: Public space and the new normal”, Ahram online, accessed January 11, 2021, http://english.ahram.org.eg/NewsContent/7/47/377951/Life--Style/Style/The-city-is-your-playground-Public-space-and-the-n.aspx.
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[5] “Pandemics Will Change the Architecture of Health”, The Urban Developer, accessed January 14, 2021, https://theurbandeveloper.com/articles/what-is-the-the-impact-of-urban-design-on-health-architecture-design-pandemics.
[6] In ancient Rome, Haruspex was the inspection of the livers of sacrificed sheep that was placed in certain places to determine whether such places are healthy or not. This process was explained in detail in the first series of the ten books of architecture by Vitruvius.
[7] Beatriz Colomina, *X-Ray Architecture*. (Switzerland: Lars Muller Publishers, 2019), 13-15.
[8] Harris Sobin, “From l’Air Exact to l’Aerateur: Ventilation and its Evolution in the Architectural Work of Le Corbusier” in *The Green Braid: Towards an Architecture of Ecology, Economy and Equity*, eds. Kim Tanzer & Rafael Longoria (London: Routledge, 2007), 140-153.
[9] “How the Coronavirus will Reshape Architecture”, The New Yorker, accessed January 13, 2021, https://www.newyorker.com/culture/dept-of-design/how-the-coronavirus-will-reshape-architecture.
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[11] Mike Lydon & Anthony Garcia. *Tactical Urbanism: Short-Term Action for Long-Term Change* (Washington: Island Press, 2015), 2-3.
[12] Lana K. Alisdairi. *A Cry and a Demand: Tactical Urbanism and the Right to the City*. [Unpublished] Master Thesis (University of Washington, 2014), 5.
[13] Margaret Crawford, “Rethinking ‘Rights’, ‘Rethinking Cities’: A Response to David Harvey’s ‘The Right to the City’, in *The Right to the City*, eds. Zanny Begg & Lee Stickells (Sydney: Tin Sheds Gallery, 2011), 33-38.
[14] “The Top 12 Ideas from the Rethink 2025 Post-Pandemic Design Competition”, Bustler, accessed January 12, 2021, https://bustler.net/news/7887/the-top-12-ideas-from-the-rethink-2025-post-pandemic-design-competition.
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[16] Shaimaa Ashour & Bedour Braker, “Private Initiatives Versus State Interventions in Downtown Cairo: An On-Going Debate Questioning the Sustainability of Newly Pedestrianized Streets: The Cases of Kodak and Al-Alfi Passageways”, *AUEIRC’18 Conference Proceedings* (2020): 138.
[17] Kazuko Koga & Yutaka Iwasaki, "Psychological And Physiological Effect In Humans Of Touching Plant Foliage - Using The Semantic Differential Method And Cerebral Activity As Indicators", *Journal of Physiological Anthropology* 32 (2013): 2.
[18] “Abdeen Square in Cairo: From a Revolution Icon to Entertainment Space for the Public”, Al-Arab Online Magazine, accessed January 12, 2021, https://alarab.news/.

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SUDDEN SUBURBS AND THE CHALLENGE OF 21ST CENTURY URBANISM: VINEYARD, UTAH

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INTRODUCTION

The tiny village of Vineyard, Utah has the advantage of location in a rapidly urbanizing region and used strategic planning to become the fastest growing city in the nation. The growth of this municipality demonstrates the pervasiveness of New Urbanist planning but also highlights the challenges of implementation.

Setting

Vineyard, Utah is located in Utah County, about an hour South of Salt Lake City, the capital of Utah. The west side of the town is bordered by Utah Lake, the largest natural freshwater lake in the state,[1] and on the east side, Vineyard is defined by I-15, the major north-south interstate highway. It is bounded by Lindon and Orem, two other suburban communities, on the north and south.

The rail line that runs through its borders is integral to planning and design of the new city, and it carries freight trains as well as an Amtrak passenger train. In 2012, the Utah Transit Authority expanded its commuter rail line, FrontRunner to include Utah Valley.[2] The commuter train allows people to live in the Utah Valley and commute into Salt Lake City (or other stops along the way) and avoid the congestion of I-15. To further facilitate mass transit, the commuter train connects with TRAX, a light rail system in the Salt Lake Valley. The light rail was originally built to support the 2002 Olympic Games and now includes 3 lines which connect most parts of the Salt Lake Valley. There are future plans to expand TRAX into Utah County.[3]

History

The Utah Valley was initially settled around 1850 when Mormon[4] settlers moved into the valley and established farms. In 1941, US President Theodore Roosevelt determined to locate new steel plant in Vineyard, Columbia Steel Company because there was a large enough tract of land well served by two railroad lines, a large water supply for cooling ponds, and ample housing for workers.[5] The arrival of the steel mill began the abandonment of agriculture and eventually made the 21st century city possible. In 2002, Geneva Steel laid off 1400 workers and filed for bankruptcy.[6]

PRESSURE TO GROW

As growth occurred in Utah Valley, there was pressure from the adjacent communities. In 1989, the village of Vineyard incorporated as a way maintaining their identity and "preserving a sense of community."[7] Orem, in particular, wanted to annex the land and had invested significantly in water and sewer infrastructure, but the citizens wanted to maintain their agricultural way of life and were worried about uncontrolled growth.[8] In 1990, the town council "placed a moratorium on building and temporarily dissolved its Planning Commission while the council developed a master plan to govern the development in Vineyard."[9]

The village was able to remain rural for a while. In 2010, the US census lists 139 inhabitants. Randy Farnworth, the mayor from 2003-2018 explains that the city started to grow when,

Farmers started selling their property to developers. When you sell property to developers, developers don't sit on the ground, they develop. That brought in a bunch of negotiation. Hours and hours of learning how to zone.

It really started growing because we started entertaining these developers and how to get the best product in Vineyard. And how to come out with a town that's viable and could support itself because Vineyard only has 3800 acres and 1400 of the acres are under the Geneva Steel plant. So basically, we had to come up with the design of a city that would be self supporting.[10]

Early city leaders recognized that to build a city that could support itself in such a small area, they would have to think differently.[11]

Figure 16. View of old Geneva Steel Plant, looking northeast with Vineyard Connector in foreground. New Vineyard Commuter Train Station to be located approximately at left center. Drone image: Ben Anderson, 2020.

THE CHALLENGE OF DENSITY

With the loss of tax revenue from the Geneva Steel plant and the tiny footprint of the municipality, Vineyard needed to grow with more density than the rest of the county.[12] Community Development Director, Morgan Brim notes that "A lot of Utah County, and Utah in general is built off of a suburban model of density: single family, detached houses and 3-4 houses per acre. Many people consider that medium density. Low density is a half acre [per house]." [13] Much of the valley was developed in the 1950s-70s and so medium and low-density housing became the norm. Multi-family housing meant densities of up to 30 units per acre. "To those people who grew up most of their lives in a single family detached neighborhood where there're 3 units per acre, that's very dense. It's been hard for a lot of people to understand"[14] and caused some growing pains. However, Brim explained that although density is often considered a bad word locally, it's essential to have people walking on the streets to create a vibrant and safe downtown.[15]

The 21st century city plan sought to balance the need for a tax base with creating the type of town people would want to move to. As they were making long-term plans, Farnworth asked, how big can we grow? He wanted to ensure that the infrastructure was sufficient to support the eventual population. When Farnworth asked how large Vineyard could grow, "one number came back at 40,000 and another number came back at about 70,000. And another number came back and said that if we can go vertical, we can go to 90,000. We sat down and said, we don't want to build for 45,000, we are going to do all of our infrastructure at 90,000 [inhabitants]."[16]

Figure 17. View of Vineyard, Utah, October 2020 looking south from Vineyard Connector. Showing variety of housing types: townhouses in foreground, small lot detached houses in the middle ground and low density housing in the background. Drone image: Ben Anderson, 2020.

Advantages

One of the advantages Vineyard had was the explosive growth in the state. Babs DeLay, realtor and former chair of the Salt Lake City Planning and Zoning Commission explained that "Utah is a destination state," meaning that people are moving to Utah, primarily for tech and banking jobs. "It's cutting out affordable housing and first-time home buyers because the inventory for that is so little and it's forcing people to move to suburbs that they hadn't though of before or that might be a half hour or 45-minute drive away."[17] Because of the commuter train, Utah County is becoming more attractive for new housing developments, even among people who work in Salt Lake County.

The transit system is the second of Vineyard's advantages. Currently, Vineyard is served by the Orem Front Runner station which is conveniently located at the South edge of the city. Construction on a new rail stop in the new Vineyard downtown will be completed in 2021. This will link residents to jobs elsewhere in the valley and in the Salt Lake Valley, as well as facilitating commuters to downtown Vineyard jobs and shopping. There are also long-term plans to connect a new light rail line to the Front Runner station, making Vineyard the most connected location in the valley.[18] Early on, city officials identified transit-oriented design as a principal feature of the new town plan. The recognized the limitations of commuting exclusively by interstate and the environmental impact of all of the cars.[19]

Utah Lake is another one of the advantages of Vineyard. The lake's natural setting, being surrounded by mountains on all sides made it popular in the late 1800s and early 1900s for bathing resorts and recreation. But in the 20th century, a lack of care polluted the lake and introduced invasive species. Most of the cities along the lake have turned their backs to it and not taken advantage of the views and opportunities for outdoor experiences.[20] Making the lake accessible and an integral part of downtown was one of the core principles for the design of the new city.

The largest advantage, however, was the large tract of land vacated by the Geneva Steel plant. Rarely do such large areas become available, especially adjacent to a freeway with four adjacent highway exits, multi-modal transit, and a beautiful lake. Recognizing this opportunity, city officials did extensive research to determine how to design this new city.

Figure 18. Utah Lake forms the western boundary of the City of Vineyard. Photo: Marika Snider, 2020.

Daybreak Precedent

One of the precedents was the Daybreak Development in Salt Lake County. The Daybreak community, located on lands formerly owned by the Kennecott Copper mine and remediated in the 1990s and early 2000s, was designed with New Urbanism principles including walkable neighborhoods, smaller lots, sustainability, and traditional house design.[21] The development has been hugely successful and remains an area with high home values.[22] Vineyard planners took the ideas from Daybreak and integrated them with transit-oriented design.

FUNDING THE INFRASTRUCTURE

The financial challenge was to fund enough infrastructure for a city of 90,000 with a tax base of a few hundred inhabitants. Secondarily, the Geneve Steel plant required a significant amount of environmental clean up to be safe to build on. Developers asked Randy Farnworth, the then current mayor, to establish a Redevelopment Agency (RDA). He explains that,

An RDA is where we take a certain amount of money out of their taxable income for the next seven to ten years and everyone in the county pays to clean up Geneva. I felt that was fair because Geneva was the economic engine of Utah County for many years… All of the cities had gotten the benefit from Geneva, even though it was in Vineyard. We ended up with $350 million over 35 years to clean up Geneva.[23]

The RDA also influences the speed of development. There is a trigger in 2021 and the taxes to clean up the area will be based on the existing development in this year so the incentive to build quickly is strong.[24]

PODS

Some of the early developments in Vineyard in 2015-2016 followed a “pod plan.” Brim explains that “instead of there being a grid where all of the houses face the street and the whole city is interconnected, each neighborhood was built in a Pod and all of the houses in the neighborhood face internally. So, there’s a lot of connection within that specific neighborhood but it made the city kind of disjointed. Because each neighborhood was its own thing and they were separated.”[25] These “pods” were antithetical to ideas of a walkable new urbanist city and continued the trend of automobile-central development. To ameliorate the situation as much as possible, the city designed and is building a trail network to connect the discrete neighborhoods to the larger city.[26]

Another one of the early mistakes was the decision to locate rental apartments on the east side of the railroad tracks and the privately-owned houses on the west side. The idea was the maintain property values for the homeowners be segregating them from rental properties.[27] The problem was that they city also located the amenities on the west side of the tracks, so the rental communities were isolated from municipal amenities and schools and sandwiched between an active rail line, an industrial area, and the interstate.

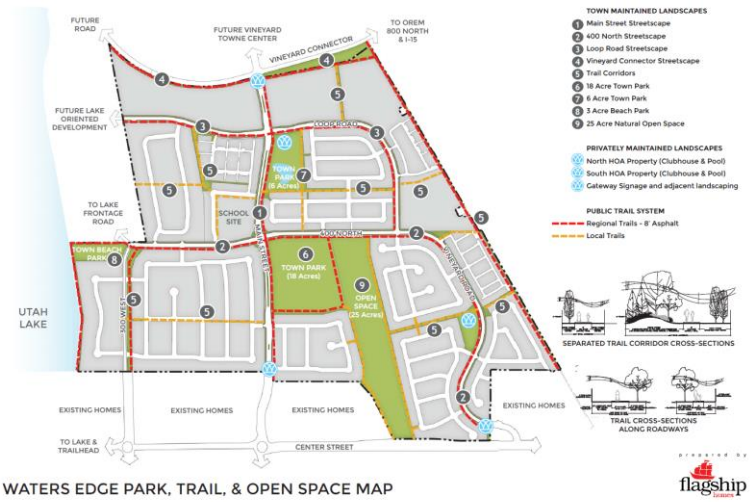

Figure 19. Partial plan of Vineyard, Utah showing POD plan with connecting trails.

THE APPROVED PLAN

The downtown city plan is a form-based code, similar to the New Urbanist principles espoused by the firm Duany Pater-Zyberk. The cornerstone of the plan was the FrontRunner train station and intermodal transit hub. The main organizational elements are a monumental plaza, the promenade, which connects the train station to the lake and Main Street, a large shopping boulevard. The area is broken up into large blocks with a Town Center Station zone near the train station, a centrally located mixed-use zone, a lake front retail zone, an office zone on the north end, and open space on the periphery where ground conditions don't allow construction of buildings.

The first problem with this plan is that the main street was imagined to be both a walkable shopping street and a high-speed boulevard. Slow speed cars or pedestrian-only zones are most conducive to shopping. Second, The Promenade bridges over Main Street requiring the street to dip down and be covered for a block. This type of modernist planning has never resulted in a friendly walkable street. Second, the blocks were zoned by use so that the office area, which will use transit daily, was the furthest from the train station and housing was limited to one area. Third, the Vineyard Connected a high speed, high volume road cut off the main downtown from the lake front.[28] Planners conceived of the lake front as a festival marketplace or lifestyle center, principally for shopping. However, because of the Vineyard Connector, pedestrians had no safe place to walk from downtown to the lake front and would be required to drive to a series of cul-de-sacs to shop in this district. It also failed to take advantage of the great views of the lake and connect downtown to the water.

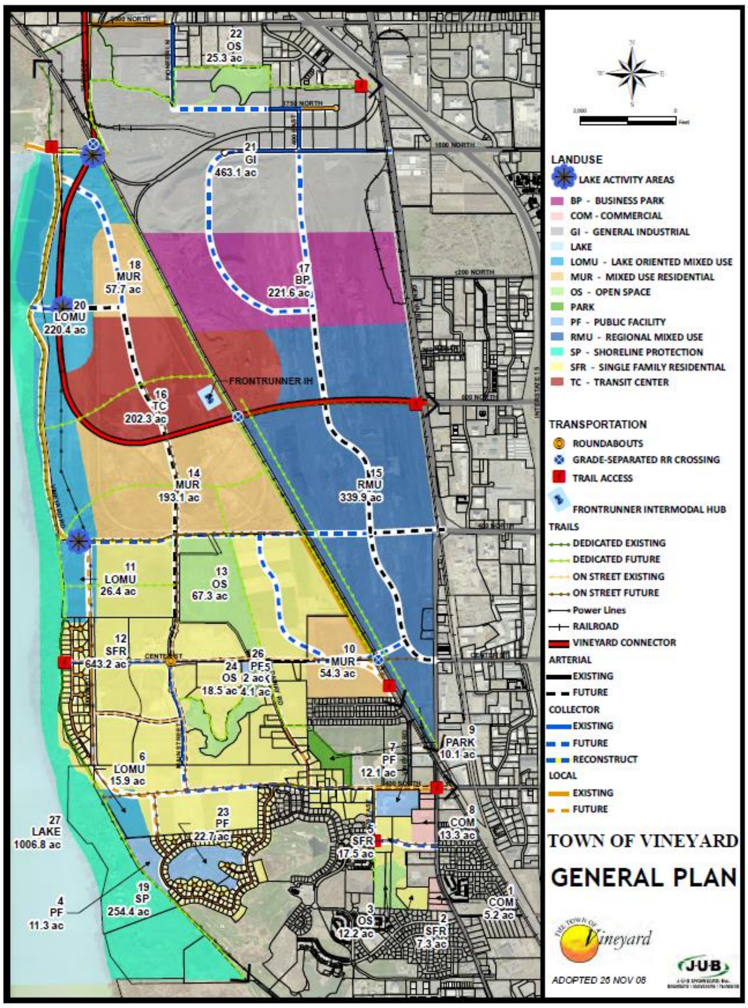

Figure 20. Approved Plan, Vineyard, Utah, 2008.

Affordable Housing

The strong demand for housing is an advantage for developers but also means a scarcity of affordable housing. In 2020, the median sales price of a single-family house was 40% higher in Vineyard than in Salt Lake County.[29] At these levels, young families and first-time home buyers are priced out of the market. Government affordable housing programs and subsidies are administered at the county level so the city searched for ways they could bridge the gap. The city used zoning to help with affordability. First, they offer a wide range of housing types. The town center will include commercial space on the ground floor and apartments above and townhouses in the downtown area. As houses are further away from the train station, they become less dense and larger. So, the town includes everything from apartments to townhouses to single family houses on small lots and some larger single-family houses on large lots. Additionally, the city permits accessory dwelling units inside single family houses so that homeowners can finish their basements as separate apartments and rent them out. Unlike the surrounding suburbs, when Vineyard is completely built out, it will be 80% multi-family.[30]

SOLUTIONS

In 2019, Jeff Speck, spoke about walkable cities at a regional planning meeting in Salt Lake City. At the conference, developers working in Vineyard contacted him and said, "We hear that you're this walkability guy. Would you look at our plan and tell us how walkable it is?" They showed him the approved plan and he shook his head. Although it had "some positive features and enough of a framework to become something good, it had some very clear impediments to being successful." He told them that it would not turn out well. Rather than be offended, they invited Speck to design a new plan.[31]

The first thing was to create a neighborhood structure by designing two neighborhood centers. One of the foundational principles of New Urbanism is to have a five-minute walk from the center to the edge of a neighborhood. These centers are mixed-use development with institutional buildings and "at least a place to get cat food."[32] As with the previous plan, the train station is the core of the downtown. A market hall is located in the center of the station plaza and wraps it with buildings to take advantage of shopping and dining opportunities from all of the people traveling to the intermodal hub. The station plaza connects to the squareabout through a narrow shopping street. A squareabout works like a round about to distribute traffic around its perimeter. This way, traffic entering the downtown area can be quickly dispersed to smaller roads which are more walkable. This avoids the necessity of building high speed traffic arteries. The squareabout connects to the second town center via a leafy boulevard.[33]

In general, the plan becomes less dense as one moves away from the train station. Emanating from the train station is mixed-use mid-rise buildings with apartments, offices, and retail. Townhouses, which were not part of the original plan were added in the mid-zone, in order to create a neighborhood feel which would generate more real estate options in order to absorb the new construction more quickly. On the periphery, where soil conditions don't allow structures, sports facilities and recreation are located.

The Promenade was edited so that it was no longer a monolithic plaza. "It's a series of different experiences that starts as a dense main street, and broadens into the squareabout, becomes a longer corridor heading towards the lake, and then widens further into a city park, and then steps down to the waterfront, even wider."[34] At the lake front, the roads reconfigured to connect to the rest downtown and add a dedicated bike road along the street that hugs the lakeshore.

Parking was concealed in the centers of blocks and at the perimeter. By distributing it throughout the site, a person is never more than a block and a half from parking. Because the largest parking structures are at the edge, along the railroad tracks, it creates pedestrian activity through the downtown.

Figure 21. Vineyard City Master Plan, DPZ Design. Annotations by author.

Speck notes that the Vineyard project is an example of how New Urbanism principles have finally pervaded American planning. When he first started working in the 1980s, very few municipalities knew what urbanism was and few "wanted anything different from the sprawl they were currently building."[35] After decades of work and many publications, typical municipal and planning officials are at least familiar with new urbanism. "And so, the pinch yourself moment I had arriving in Vineyard was, here's a small city, one doesn't necessarily expect it to have sophisticated leadership, it doesn't have large government, it's kind of in the middle of nowhere between larger places and yet, there was not only an openness to receive this sort of planning approach but a direction to provide this sort of planning approach from the top down, this is what people wanted."[36]

The City of Vineyard is an example of how the American suburb is reinventing itself as 21st century citizens demand more urban amenities and lifestyles. It is an excellent case study for the implementation of new urbanism planning principles and future viability of American suburbs.

NOTES

[1] "Utah Lake State Park," Utah Department of Natural Resources, 2021, https://stateparks.utah.gov/parks/utah-lake/
[2] "History Fact Sheet," Utah Transit Authority, April 2017, https://www.rideuta.com/-/media/Files/About-UTA/Fact-Sheets/2017/History_FactSheet_April2017
[3] Lee Davidson, "UTA board is exploring expanding TRAX, streetcar," *Salt Lake Tribune*, Jan. 30, 2020.
[4] Also known as members of the Church of Jesus Christ of Latter-day Saints
[5] Don Norton, "Our Vineyard Heritage: A Wellspring of Tradition and Change, 1899-1999." Vineyard, Utah: Vineyard Press, 2000.
[6] Tara Duggan, "Steely Resolve. Industry determined to survive." *Provo Daily Herald*, 2002 March 3, p. A1
[7] Josephine Zimmerman, "Newest town has only 148 people but one big asset." *Provo* Daily Herald, April 25, 1989.
[8] Randy Farnworth (Mayor of Vineyard: 2003-2018), interview by Marika Snider, October 2020.
[9] Norton, p. 274
[10] Farnworth interview
[11] Ibid.
[12] Ibid.
[13] Morgan Brim (Director of Community Development, City of Vineyard), interview by Marika Snider, November 2020.
[14] Ibid.
[15] Ibid.
[16] Farnworth interview
[17] Babs DeLay (Realtor and Former Chair of Salt Lake City Planning and Zoning Commission), interview by Marika Snider, September 2020.
[18] Farnworth interview
[19] Salt Lake Valley and increasingly Utah County suffer from debilitating smog when winter cold air is trapped due to inversion.
[20] Brim interview
[21] "Our Story," Daybreak Utah, 2021, https://www.daybreakutah.com/daybreak-story/
[22] DeLay interview
[23] Farnworth interview
[24] Julie Fullmer (Mayor, Vineyard, Utah), interviewed by Marika Snider, October 2020.
[25] Brim interview
[26] Ibid.
[27] Ibid
[28] Jeff Speck (City Planner, Speck and Associates), interview by Marika Snider, December 2020.
[29] DeLay interview
[30] Brim Interview
[31] Speck interview
[32] Ibid.
[33] Genelle Pugmire, "Vineyard prepping new downtown area for predicted large population increase," *Provo Daily Herald*, December 7, 2019.
[34] Speck Interview
[35] Ibid.
[36] Ibid.

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DAYLIGHT AS CULTURAL ENERGY FOR THE CITY

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INTRODUCTION

Within the decade between the EXPO hosted by Shanghai in 2010 and by Dubai in 2020/2021, these two cities confidently rose to global significance.[1] Both are port-cities formed at the crossroads of different cultural realms and forces; their renowned skylines emerged within the three last decades; they both intend to appear as rapid cities par excellence.[2] Ambitious design and construction projects aimed to make the cities be taken seriously by the world. Over the 21st century, these massive, complex made-environments project fresh hubs of urbanism and modernity, which now offer significant inspiration for many other cities.

Urban advances are particularly noticeable in each city's approach to lighting, a key part of transforming communication infrastructures of a city. Planners now connect traffic and interiors splendidly and orchestrate lights in shows that glow, glitter, and show off each city's bold success. Every day and night smart lighting flicks on and off, and gatherings move and marvel. Lit up Shanghai Tower and Burj Khalifa (two tallest buildings in the world) are set as crowning jewels of spectacular urban development and notable innovation in light displays. Both cities are among world leaders in lighting, and their EXPO agendas have been explicit about bringing into view well-being associated with themes of delivering more while taking less. With multiple initiatives like Light Middle East or Dubai Airports Retrofit Project, Dubai aims to become a leading global example of energy efficiency.[3] For Shanghai, too, sustainability was an important goal, with emphasis on LED technologies in the creation of nightscapes combining technology, design and art.[4]

In this paper, a bit out of defiance, but mostly out of strong conviction that things can be done otherwise, we aim to consider whether a very different understanding of "urban lighting", than that confidently projected by Shanghai and Dubai, can magnify city branding resources, and allow cities to maintain continuity in their distinct identities--despite the ongoing homogenization of urban nightscapes. Shanghai and Dubai, alike, associate light in the city primarily with spectacular nocturnal illuminations, we observe. 20th century experiences have imposed on many cities an urban culture valuing above all speed, spectacle, technology, production, circulation and global expansion. Bigger is greater. More is more, but never enough. Growing concerns with environmental costs of urban splendour result in searches for more sustainable solutions to excessive urban lighting, but cities obsess still with the night as a loci for experiencing, energy, allure, and reputation with ever greater arrays. We inquire about alternatives. Even if cities like Shanghai or Dubai continue on course, it remains important to work out tactics which could encourage different paths – not only for the sake of sustainability, but also to help shift travellers' expectations for urban beauty and attraction, and gradually level chances among cities with smaller financial or technological resources. We propose to reconsider whether it is possible to increase the value of light in the city without increasing environmental costs and light pollution[5]—initially, by simply reconsidering the meaning and opportunities behind the natural light. Thus, we would re-invite daylight into the city in all its glory and to question the most common connections among sunlight, renewable energy and a renowned urban lightscape, of which the iconic shade structure (flexible solar canopy) covering most of the EXPO site in Dubai is in fact a perfect exemplification. This shade is made of photovoltaic fabric as part of the plan to generate at least 50% of EXPO energy on site, and at night it is meant to become canvas for spectacular digital projections. This seems to be a much broader trend—daytime as the time when city harvests sustainable energy, night as the time when it engages with light, reveals its beauty through more or less excessive illuminations or digital projections, and receives desired and deserved tribute. But what if this pattern of appreciation could be flipped for the benefit of the city and its inhabitants? What if the sunlight can be reclaimed beyond its utility, and a global city can still reconnect with the sun as primary source of its light and life? What if daytime in the city is time of underestimated yet easily brandable beauty?

We believe that in any attempt to brand the city using its lightscapes it is essential to pay attention not only to the distribution and significance of artificial lights, but also to the natural light, inherited by each city together with the rest of its biome. Lightscape has been equated largely with data inferenced uses building, using and aggregating sensor-scapes.[6] In fact contemporary illuminated spaces are just one of the multiple components of a city's lightscape. Recognition of both the existence and the huge potential behind the other light scene components seems crucial for supporting development of truly thriving creative and cultural industries and unique – even if global – urban characteristics. Therefore we advocate to minimize intrusion into the original light ambience – both for the sake of the non-human inhabitants of the metropolitan area[7] and for the sake of maintained or enhanced local specificity of a city. According to our understanding, true innovation in approaching urban light infrastructures, shows and performances in the 21st century should imply active search for inventive ways to take the best advantage of the local combination of daylight, moonlight and artificial light,[8] to lead us towards an era of global cities eager to attract, seduce and entertain inhabitants and visitors alike in multiple ways exceeding merely mesmerizing nocturnal glows.

LIGHT AS CULTURAL ENERGY

"Light has been virtually invisible in the social sciences" and "as material culture, as infrastructure, as a physical feature of social landscapes – has virtually no literature" sociologists Don Slater, Joanne Entwistle, Mona Sloane conclude.[9] Yet, "light and lighting design are fundamental to our everyday life. Light is an enabler of all social interaction and experience and plays a central role in how cityscapes are shaped."[10] Lighting projects preponderantly work to generate cultural energies for "nocturnal spaces" and interiors. The greater possibilities of day light remain invisible to our lighting labours. Natural light varies depending on geographical conditions and seasonality of an area. "A biome is a large community of vegetation and wildlife adapted to a specific climate. The five major types of biomes furnish substrates "for aquatic, grassland, forest, desert, and tundra" habitats.[11] Traditional cites occupy points of advantage on a river basin, open port, or cross-roads. Modernity expands city networks through supply chains that cross biomes. Yet, each city nests in a unique light- scape, which should be perceived as a comprehensive entity of certain continuity – chronologically and spatially – fluctuating between different areas and districts, evolving over the year, between day and night, and over time since the city was created. The challenge then is to relearn how to appreciate the genius loci; to pay equal attention to light which is cyclical, or temporary, or accidental, or ever changing – not just that which is consistent, designed, controlled, and managed. Natural light resources, are certainly much less controllable, but if approached thoughtfully and creatively, they can generate a welcome to a city as well. The subjective, local, lyrical, unpredictable aspects of light persist, even if fugitive from the foregrounded lighting of technology and the travelling discourses of modernity. What if the distinctive natural light of a region—upon which city life impresses its angles of motion and colours repose—can release unique cultural energies?

Electric lighting has been incorporated into many cities' mythologies of transformation. Today the modern equation that associates burning fossil fuels with electricity and light is on the cusp of reversal. Instead energy stolen from the sun with little physical labour is supposed to ensure sustainable functioning of our cities in the future. The post-industrial reversal from the depths of the dark worlds of coal, oil, and gas below the earth to the heaven of the sun almost begs to become closely associated with different forms of cultural and hallowed energy, and yet it is difficult to point out to renowned examples of the cities engaging in such a powerful storytelling.[12] In fact though solar energy once used to be a fable, it has been gradually turned into technology.[13] Today the sun glows increasingly not in its cosmological splendour, but in its commodifiable desirability. The battery has become the equivalent of a sacred fire and a new object of paradoxical secular solar worship. The newly acquired logic of storing and releasing energy reshaped the relation which a contemporary city maintains with its own lighting displays. The sun is set in ritual of obeisance and belief in urban growth – it glows but does not inspire, burns but does not warm. It displays power and volatility, which are classified as forces and reaction. The transformation of the solar myth leaves us but the routinization of daylight hours, a secular plenitude of light. How to change the course of things? Can light be retrieved still for the city as transcendental and organic, and as autonomous of our imagination or virtual realities we generate using advanced technologies?

DAYLIGHT AND THE CITY

We bring to the conversation about spectacular yet sustainable cities an important and vastly undervalued asset: daylight. We suggest that every city is in fact gifted by a number of enthralling – though usually unnoticed – truly sustainable light shows, which occur without any additional technology or infrastructure. Examples are numerous, but for the sake of brevity we will signal only three of them:

1.Reflections created by the sunlight on glass facades of the buildings, and continuously contributing to the cityscapes across the seasons. They are in fact fascinating image displays of its own – different in every city, evolving over time depending on weather conditions and transformation of the surrounding urban tissue, as well as over the year with the change of light due to the rotation of the earth. These endless though temporary urban collages/palimpsests of different textures, temperatures and colors, absorbed or filtered through the urban surfaces and crevices, are often visually thrilling and equally photogenic as nocturnal shows, but they usually pass unnoticed neither by urbanites nor city branders.

Figure 1. Shanghai's Pearl Tower reflected in the glass façade of another building.

Figure 2. Tenement house reflected in the window glass in Lublin.

2. Sunsets and sunrises. They somehow became romantic cliché and seem to be approached commonly as pleasant backdrops for advertised allures and consumption opportunities, rather than one-time light

shows having a dramatic dynamism of change of and over time – just with different pace and display than artificial lights. Shifts in work and consumption patterns lead to asynchronous rhythms of activity and sleep, which often make it objectively difficult for people to participate in sunrises or sunsets, and as a result splendid daily gifts of the sun and earth, eternally diversifying in every location in the world, pass by increasingly unwitnessed and unreceived. Perhaps nocturnal illuminations are meant to compensate for this illusion and create an illusion of pleasant life in the city, with desirable balance of work and leisure, toil and delight.

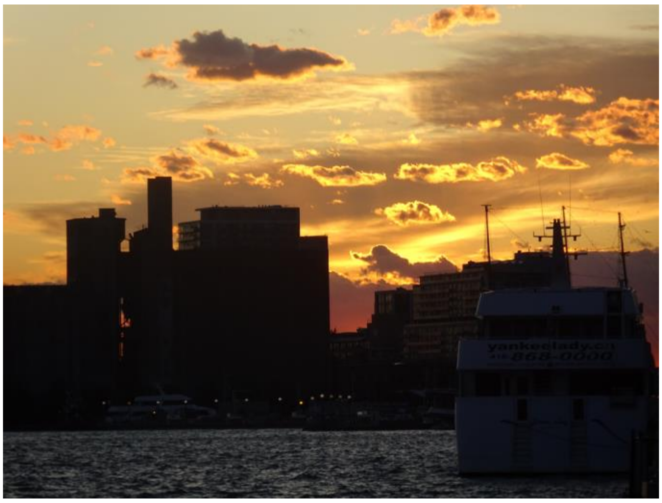

Figure 3. Dark silhouettes of the buildings against the skies lit by a sunset in Toronto.

Figure 4. Sunset over Kyoto, enjoyed from Kiyomizu-dera Temple.

3. Shadows cast by the sun in every city throughout the year, which with the great variety of cityscape components able to cast them (from architecture structures through humans to insects or tiny plants growing in the clefts of the pavement) easily result in stunning multidimensional shadow plays. The challenge is then to refocus attention from the solid structures surrounding us in the city towards the

textured fragile, short-lived and never guaranteed shadows; to access ‘secret garden’ of the soul, abounding with illusions and blurring established perceptions of urban spaces. Just like sunsets these moving shadows could and perhaps should be perceived as an autonomous attraction, worthy of setting aside time for enjoying. In fact in Chinese tradition, mostly noticeable in the classical gardens, ability to appreciate shadow lead to development of sophisticated structures and space layouts, increasing splendid views of shadow ascending and descending across the garden throughout the day.

Figure 5. Shadows cast by the winter sunlight in Chicago.

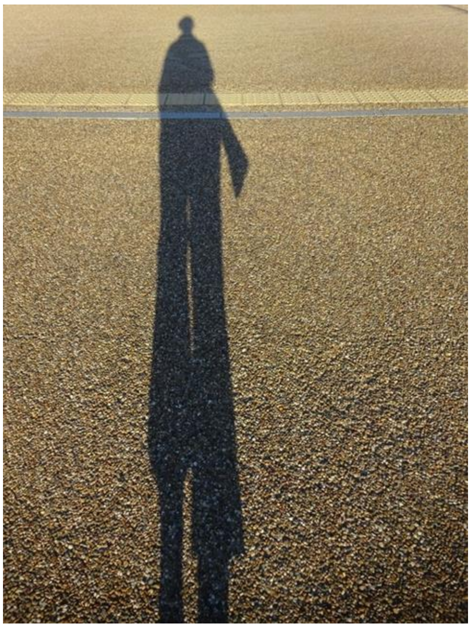

Figure 6. Autumn shadow of a pedestrian in Tokyo street.

Figure 7. Wooden lattices casting shadows in one of the classical gardens in Suzhou.

Possibly every city, after re-seeing its cityscapes more attentively along the year, could make its own stunning catalogues of present natural light phenomena. Depending on the location and climate these can involve fog, heat lightning or spider webs glistening with dew. Such handbooks could feature the sunny and passionate tropics or moody winters of dark Northern landscapes. It could bring into play the mottled lighting of jungles, the whisp of breezes and light across grasslands, or the peculiar shifts in the play of wind, sand, and sun across dunes surrounding cities. Perhaps pursuing such narratives could challenge our weather-watch habits of hoping always for the best sunny days for our visits to other cities, by revealing for instance the unique beauty of rainbow cascades descending between the drizzles from autumn skies into the sea – for instance to Baltic Sea in the city of Gdynia. What if residents and travellers alike were encouraged to tell the tales of a place with much greater attention to the variety of natural light experiences? The northern lights offer remote revel; the everyday, too, is alive with possibility. What if every season in a city had its natural lighting signature which would be actively promoted? What if Shanghai was known not only for the spectacular skyline glowing in the synchronized light show, but also for its summers with gracious shadows somewhat thickened by cicadas chirping, or soft and warm autumn radiance saturated with sweet osmanthus fragrance? What if Burj Khalifa was known around the world not only as the tallest tower enabling miraculous light shows with LED lights, lasers and fireworks, but also – as it is among the Dubai dwellers – as an exquisite structure having its two hours magical moment when sun is going down and the building glows with reflection of sun beams, making its shining top to be seen from every corner of the city?

What if cities waste enormous creative resources by overlooking their natural lightscapes, and perceiving sunlight merely as green energy but not one of the cultural energies of the city? Why can we organize marathons through the city, to express our commitment to the healthy lifestyle or pride in our cities, but can't we have events allowing people to rediscover meaning and abundance of daylight in their city, and its positive impact on their well-being? Just as research is developing to identify and measure urban soundscapes, so analogous moves need be made with city activities, not imagined to be reducible to ambient emergent orientations. Rather, ontologically considered, lightscapes are dancing arrays of disclosive vividness, silhouette, and shadow.[14] Why can we have light festivals celebrating night time illuminations, like lantern parades or various Nights of Culture, but we can't enforce development of analogous events teaching us to cherish and share with others the radiance and reflection of sun, moon, and stars, which we inhabit together with the rest of our biome? Does reluctance come from the fact that celestial sight really has not been noticed yet, or rather from the fact that many cities are actually looking for very different economic and political outcome, which predefines desirable approaches to light? Each of the examples of daytime natural light shows mentioned above could be branded by the city in ways similar to nocturnal illuminations above the waterfronts, yet together with a very different spectatorship model and environmental impact they would possibly imply also a very different revenue. Thus perhaps the question to be raised is whether the core problem is that it usually seems unlikely that a thoughtfully branded shadow descent in a Chinese garden, or jam concert engaging with changing lights of the sun setting above the city can generate revenue comparable to what a bar can bring if it overlooks a famous illuminated skyline.[15]

HERITAGE AND LIVELIHOODS

There are multiple reasons to reimagine relationship between the light and the city seriously when promoting lifestyles, leisure and fashions. First, people's activity in day time light is healthier.[16] Second, light intersects with cultural heritage maintained both outdoors and indoors in the city. Already back in 1933 Jun'ichirō Tanizaki was making insightful observations of the radically different experience and apprehension of same spaces, cultural practices or craft objects depending on the source and intensity of accompanying light.[17] Shaping perception of light in the city, implies more or less directly altering apperceptions of cultural heritage. Daylight activity aids sustainability goals and mitigates the controversial trend of international investment that eradicates distinct cultural heritage and livelihoods, while rendering cities like appear as if floating in a transnational and nonlocal space. Global cities sometimes seduce and generate billions of profit, but disconnect, virtually, from their biome and lose distinct signatures of attraction. More opportunities to see the beautifully disclosing work of natural lightscapes, and thereby experience the actual urban tissue, as opposed to a digitally projected reality, could also help people to bond with the place, and nourish meaningful personal, emotional connections. Further, nocturnal illumination are not the only option to communicate about global presence. In fact the sun and moon, more than anything else, connect people above any differences or geographical distances – both as a shared resource and a component of climate change which needs to be faced together, beyond any national borders. Last but not least, thoughtful adjustments in distribution in financial resources spent on branding of the cities, together with innovative approaches to attract visitors, will be perhaps of even greater value and relevance when global cities and small towns alike strive to recover the economy after or throughout the pandemic. Shifts in our understanding of the relationship between the city and its lights are in fact, at least partly, already taking place on the microscale, as urban inhabitants have been forced to reconsider their connections with the urban surroundings due to the decreased mobility and limited access to nightlife.

Cities like Shanghai or Dubai are unlikely to change their approaches, but it should be strongly emphasized that present night oriented practices do not have to dominate urban futures. The final question then, which we intend to open for further conversation, is who dares to become the first city able to challenge the persistent dream of glittering nights and is willing to lead the way for the cities to rise gloriously into the light of their region, and harmonize different forms/meanings/usages of prevailing moon and sun for a better future?

NOTES

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[11] "Biome," accessed January 9, 2021 at https://www.nationalgeographic.org/encyclopedia/biome/ A biome is a large community of plant and animal wildlife adapted to a specific type of location and climate. We explain the geographical and climatic features of all the major terrestrial biomes, including: polar, tundra, boreal forest, temperate forest, tropical rainforest, grassland, savanna, desert, and freshwater ecosystems (including lakes, rivers and wetlands)" each with unique mixes of sunlight and climate. Jenny Wang, 9 Major Biomes of the World, May 20, 2020. Retrieved January 9, 2021 at https://nomoreplanet.com/biomes/.
[12] Katowice, today a Polish city, built on heavy industry, but aiming at transition to a more sustainable model furnishes an interesting example of such a conceptual attempt. In one of the short creative videos produced when Katowice participated in the competition to become designated by European Union as European Capital of Culture for 2016, Polish director Lech Majewski reimagined coal as "the form of Sun's negative", a form of solar energy which had been intercepted by all sorts of plants to be later compressed by the force of tectonic movements. He also suggested that this results in a unique vibration with which the place reverberates[12], making a fascinating attempt to transform a technology into cultural energy of the City. A radical gesture where cultural energy for the city is released even from resource which used to be associated with the opposite of clean energy, which over the years enabled growth of design and cultural events reimagining industrial heritage of the city, enable successful rebranding of the city and facilitates commitments towards responsible and inclusive urbanism. Another fascinating example of such an approach, gradually unfolding before our eyes, is celebration of the sun in "Follow the Sun" theme pursued by Los Angeles for the 2028 Olympics. "Follow the Sun" Los Angeles Olympics, video. ("ESK 2016 Katowice - Lech Majewski", video. Accessed January 9, 2021 https://www.youtube.com/watch?v=bd36z00pc7M; "LA 2028". Accessed January 9, 2021 at https://www.olympic.org/la-2028.)

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OVERWHELMING AHMEDABAD MEETS INSURGENT PUBLIC SPACES

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INTRODUCTION

Cities can be articulated as the densest expressions of infrastructure. Be it the traffic-congested roads of Bangalore or Beijing, the unavailability of drinking water in informal settlements of Mumbai or Lagos, or the extensive and crowded public transport networks of Mumbai or London, these anecdotes are all varied experiences of the infrastructure – urbanisation connect. In contemporary times everyday urban life is intrinsically connected with the infrastructure systems, hence increasing dependency on infrastructure is implicit in the process of urbanisation. In recent decades, globally, cities have witnessed extreme changes in their urban and social makeup because of rapid urbanisation (751 million in 1950 to 4.2 billion in 2018).[1] This raises the question on the nature of urban development and further on the infrastructural building's nature.

Unlike many of its global south counterparts, India is only 33% urbanised.[2] Hence, infrastructure building will continue to be a key focus.[3] This development trajectory, coupled with the inequality that plays a critical role in Indian urbanisation, tends to distort the infrastructure-urbanisation connection. Under these circumstances, infrastructure becomes the site/tool/medium to propagate urban inequality through exclusionary practices of building and the consequent use of infrastructure, giving rise to a situation best explained by ' 'Orwell's famous phrase, "all are equal, some more than others ".

This paper is located as part of an already rich literature on the infrastructural theme. By studying the case of Ahmedabad, it aims to understand the dynamics of infrastructure and urbanisation. By spatial mapping of the everyday violation of infrastructure, it is possible to understand the inherent problems in everyday living culture in the big Indian cities and read the values and criteria to define a site-specific and cultural approach for coherent future urbanisation.

INFRASTRUCTURE AND MORE

Infrastructure has been defined as the background to urban life that fundamentally underpins the numerous city life processes in different ways.[4] According to several studies,[5] infrastructure is often simplified as rigid, physical, complex, and technical, to name a few. Furthermore, consequently, the infrastructural imaginaries have been dominated by elements above and below ground, more specifically highways, flyovers, roads, airports, bullet trains, dams, sewers networks, electric grid, power plants, and other large infrastructural edifices (mega-projects) that exemplify narratives of 'global' or "world-class' city.[6] Consequently, these infrastructure ideas also help feed into the dichotomies of the "developed & developing ", wherein the developing world is waiting to be developed.[7] These understandings of infrastructure are limiting when attempting to articulate the complex experiences of urbanisation and infrastructure, as they relegate infrastructure to omnipresent objects that occupy a particular geographic, technological, and imagined space. Moreover, do not account for the inherent biases that are sometimes part of infrastructure systems - when built at the expense of the many or when access to infrastructure is denied/interrupted or does not exist.[8]

While the aforesaid incidences are prevalent globally, it is far more normalised and exacerbated in Indian cities and other cities in the global south, where inequalities foreground the everyday lives of large parts of the urban population. Within this context, infrastructure has been elaborated differently and challenges the notions of "ubiquity "and "permanence ". This is evident from the studies that are cited below.

In the lives of the street vendors in Mumbai, the street/public space infrastructure holds a precarious role owing to their erratic and frequent removal by government officials.[9] The case of the Pushta settlement that was living on the banks of river Yamuna since the early 1970s faced evictions without sufficient rehabilitation in 2004 to make way for a riverside promenade to boost tourism.[10] Here, the promenade, a tourist infrastructure, was the site for violent evictions. The same was articulated by Salamanca, who elaborates on the role of road infrastructure as a tool to propagate dispossession and segregation, as the *express route 443,* which connects Tel Aviv and Jerusalem and cuts across Palestinian villages hence drastically impacting their everyday lives.[11] In the context of Mumbai, Graham et al. elaborate on how middle-class water revanchism led to the disruption of many 'illegally' acquired water pipes by informal settlements, indicating infrastructural systems as biased and political.[12] Simultaneously, it is evident that in such circumstances, the resulting impacts are differential, as those in power or privileged can normalise or insulate themselves from uncertainty or instability induced by infrastructure.[13] Made evident during the ongoing COVID-19 pandemic when comparing the differential access to sanitation.[14] In all instances, infrastructure has been utilised or resulted in inequality and violence.

Further, as Rao underlines, these situations have also resulted in citizens establishing alternate systems of support, small acts of appropriation[15], and - as we also note - at times larger social movements. Subtending this statement, infrastructure has also been understood in these contexts as relational, as a set of transactions/operations that constitute inhabitation. These relations enable access to opportunities for employment, survival, shelter, resources, etc.[16] , which are otherwise absent or inadequate. According to the aforementioned studies, we can ascertain that infrastructural systems move beyond a collection of technical systems and are critical sites in the city, especially concerning the global south's context. Moreover, this system possesses a diversified existence driven mainly by citizens who live in diversified ways. The aforesaid emphasises the role of urbanity/urbanisation in shaping and creating complex infrastructural systems and relationships. Besides, for this paper, Indian urbanity is to be explored.

INDIAN URBAN EXPERIENCE

Nowadays, like all the global south countries, India faces constant demographic growth, especially in the urban environment. This phenomenon has been intensified by a strong political will to make India a World economic power.[17]

The rise of the service sector and the factories localisation on the margins of large cities have contributed to a migratory flow of population from rural areas to cities, resulting in a large-scale impact on society's fabric on society itself. Indian cities are characterised by a myriad of physical and cultural contradictions, producing landscapes of extreme pluralism, inequality, negotiation, and contestation. India's post-liberalisation has created an exacerbation of problems linked to different aspects connected to social, economic, and political exclusion, "invisibility" of the marginalised groups, fused to urban economic modernisation.[18] Urban spaces emerge from a negotiation between cultures, which rises in a temporal articulation and an informal space occupation.

To underline what enables Indian urban culture, we identify three main characters that distinguish the inherently dense and diverse Indian environment in its complexity. These must be taken into consideration for the definition of projects concerning infrastructure planning of Indian cities and the definition of their public spaces.

As Mehrotra and Vera pointed out[19], Indian cities are in "constant flux ", which composes Indian cities into two existences that occupy the same physical space: the "static city "and the "kinetic city ". The first is formed by permanent materials and is perceived in architectural terms. The second is the "city in motion", incomprehensible as a two-dimensional entity and defined as a three-dimensional construct in progressive development. The Kinetic City has a temporary character, is continually modified and reinvented, and is perceived in terms of spaces and occupation patterns. It is indigenous urbanisation with its particular "local "logic.[20]

The second element is the informal-formal symbiotic relationship between an existing conflict in the city. The informality is an inextinguishable part of it, showing greater potential for growth[21]. Informality cannot be understood as an element opposite to "formal" or extraneous planning. As several authors underlined,[22]it is not linked to a sector or social class or limited to spatial manifestation, but it is a form of governance[23] and is present in the state and its administration.

The third element is what Jeffrey Hou[24] defines as "rebellious public space" to describe and articulate expressions of alternative social and spatial relationships, in which public space and public realm are constituted "in support of a more diverse, just, and democratic society ".[25] Unlike the conventional practice of urban planning, groups of citizens and individuals' ability to play a distinct role in shaping the contemporary urban environment are suggested, despite official rules and regulations.

Therefore, the Indian Urban (public) Infrastructure design must include aspects of informality and temporality because these dynamic processes form the basis for correct urbanisation and infrastructure of the space.

Figure 1. Multiple uses of the infrastructure, Ahmedabad
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METHODOLOGY

Our research stresses two main arguments from the studies referred to on the infrastructure-urbanisation connect. Firstly, infrastructure is not merely an object but a complex system that enables and is also part of metabolic processes in cities' everyday lives. Moreover, it encompasses the physical elements and their relation to its users (citizens). Here "relation "stands for the "practice of use ". Secondly, these practices, often perceived as illegal, informal, etc., are intrinsic to Indian urbanity hence ought to be understood as rooted in the cultural context of Indian urbanity. Moreover, as Bateson has said, "what can be studied is always a relationship or an infinite regress of relations. Never a "thing "[26] hence the study of the infrastructure-urbanisation connect is achieved by the spatial mapping of the everyday violation through the tool of drawing.

The methodology to be adopted for understanding the infrastructure-urbanisation relationship places spatial mapping as a foundation through the survey of "everyday violations ". Here, the term draws its epistemological underpinnings from "violation " articulated by Sunderasan and "disorder "by Sendra. Then according to Sundaresan, the daily violation can be understood as a geographical site in which the infrastructure construction (the design + construction process) must be theorised concerning the violation (how it is used).[27] Furthermore, from Sendra, we can understand how everyday violation is dynamic and shifts to challenge the systems in place by proposing alternative ways of use and understanding infrastructure.[28] Hence "everyday violation "represents an opportunity to inform infrastructure building from the bottom-up.

To ground the study, the infrastructures selected are public infrastructures such as Char-rastha (intersection), Sadak (street) and Bazaar (market) in Ahmedabad (Gujarat). This investigation will highlight and make visible the "everyday violations "through a series of maps and reflect upon the theoretical concepts previously expressed.

Figure 2. Common scene of everyday urbanism in Ahmedabad
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AHMEDABAD - AN EMBLEMATIC CASE

Ahmedabad is the seventh-largest metropolis in India and the largest one in the state of Gujarat.[29] The city combines the intangible value of the cultural tradition with a growing urban landscape and has been identified as a UNESCO World heritage since 2017.[30] Simultaneously, the city has and is heavily investing in building urban infrastructure projects such as MEGA, Janmarg BRT, New CBD, Transit-Oriented Development and is also selected among the first 20 Smart cities in India.[31] The aforesaid contributes to shaping the city as one of the most important centres for history, trade, and commerce in western India.[32] Ahmedabad, like many other cities in India, is going through rapid urbanisation (from 5.8 Million in 2001 to 7.2 Million in 2011)[33], which is putting enormous pressure on public spaces (infrastructure), both public and private.[34] Which are the stages for a myriad of activities, such as vending, celebrating, or resting, where simultaneously different actors as people, animals, or vehicles are using the infrastructure. This is particularly clear in the Walled City, which is affected by heavily congested traffic, intricate roads, polluted air, broken footpaths, etc. This rapid growth rate is thus likely to perpetuate further damage to the city's public spaces and, by consequence, putting immense pressure on upgrading the infrastructure.[35] All the above qualifies Ahmedabad as an apt city for this research since it embodies all the main features and contradictions of the (Indian) megacities.

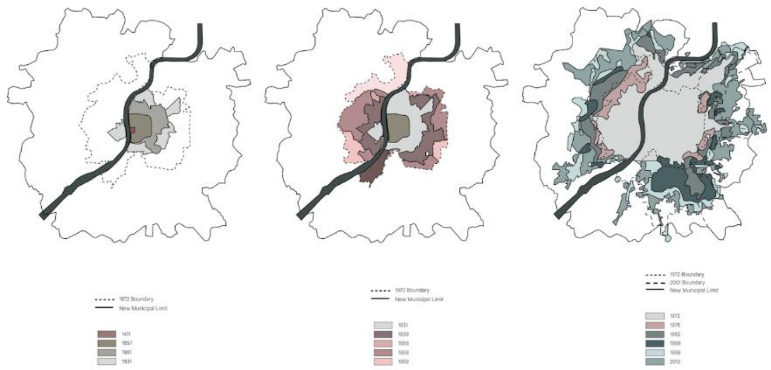

Figure 3. Urban growth of Ahmedabad, from 1411 till 2012
© Sara Rossi 2020

Char-rastha - Netaji Road cross Ashram Road

This *Char-rastha* (crossing) is an important node in the city as it connects east to west and north to south, hence witnesses considerable vehicular movement. At the centre of the crossing is a temple with no defined entrance, and although the temple is tiny, its position is strategic, especially for those who do not have much time and want to stop and offer their prayer just long enough for a red light.

In the morning, the crossing sees reduced vehicular movement, and the temple is almost empty. People come to pray in intervals of 15 - 20 minutes. Furthermore, along the later street, there are no activities, except for men cleaning the streets and some people that are preparing flowers' crowns to be offered at the temple. In the evening, the space dramatically transforms, especially around 7 p.m. when the daily prayer begins, and it is also the peak hour for vehicular traffic. The number of people visiting the temple at that time is higher, and loud music starts to be played and spreads from the temple into the nearby streets. Across both times, conflicts between vehicles and people are quite evident.

From the mapping, it is evident that there is no real distinction between the temple and the infrastructure. The temple, the supporting activities (vendors), the users (who offer their respects to the deity), the road, and vehicles are all integrated into the city's mechanism. Hence, the crossing works as a traffic regulatory node and as a place of worship. However, this design is much more appropriate for vehicular movement than human movement/practices, and the infrastructure constitutes an obstacle to the everyday practices, exposing them to vulnerabilities.

Figure 4. Netaji Road cross Ashram Road in two different moments of the day, in the morning and in the evening. The maps highlight the presence of vehicles and human activities in the space. © Sara Rossi 2020

Sadak **- Gulbai tekra Road**

The street is located on the informal settlement *Hollywood Basti* border, and it can be assimilated to a private space of the houses. The citizens of this settlement use the road as an extension of their communities, a space for living, where the public open space is considered as "home".

The activities in this sector are several: the vehicles run side by side with children who play, women who wash clothes and hang them in the roadblock in the middle of the two carriageways of the road, vendors who sell vegetables on the traditional *lari*[36], temples, stationary or walking cows. In the morning, the activities are slow, linked to daily commitments. In the evening, the street becomes extremely vibrant, lively of sounds, and gathering space for the whole community. Looking at this portion of the city in the evening as external spectators, we have the perception of observing a large family between men, women and children gathered in a common space where eating together and spending time at the end of the day.

Here the violation is caused by the informal settlement's presence and is clearly recognisable in all aspects of the kinetic city, such as processions or festivals, and is also an example of informal appropriation of public infrastructure. Alongside recreational and social activities, there is economic sustenance, which consists of the trade of multiple products and statues,[37] both activities that normally occur inside the houses. Every event in space, private and public, has a strong value in the Indian urban context and is reflected in the infrastructures surrounding it.

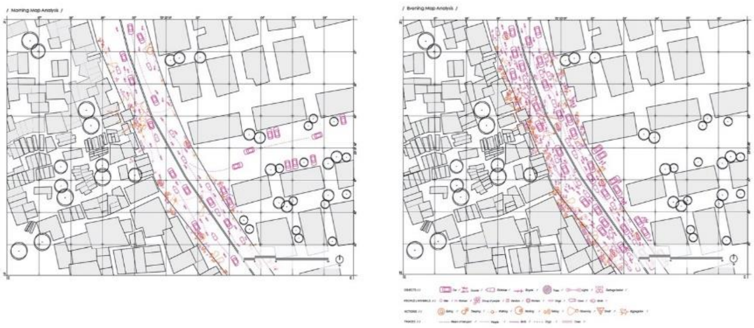

Figure 5. Gulbai Tekra Road in two different moments of the day, in the morning and in the evening. The maps highlight the presence of vehicles and human activities in the space.
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Bazaar **- Sunday Market**

The market space is perhaps the most evident case that shows the temporality and the frenetic life of the Indian public space, suspended between tradition and modernity.

The "Sunday market "[38] project has also led to a broader transformation of the surrounding areas: public spaces and many adjacent precincts were created along the Sabarmati river, leaning against the ancient walled city.

On a weekday, the market space is completely empty, characterised by low podiums. The human presence is reduced to few homeless families and stray dogs. The scenario is completely reversed during Sunday, while the architectural elements can hardly be detected in the space. The site is completely saturated with men, women, children, and objects and textiles to be sold. The "violation", as defined in this study, is due to the lack of a specific function during the week, when space is not used as a market.[39]

In this specific case, it is important to consider the design phase's daily performance and how this infrastructure will interact with users or events over weeks, months, or years. The design of public space must include time variations and the ability to be a variable space because this will affect daily life and its violations. In the Sunday market, the "metamorphosis "of the public space is clearly perceptible due to the drastic change between weekly days and Sundays. This aspect of the Indian city perfectly embodies a rapid city concept, a change that, however fast, may seem imperceptible but inevitable.

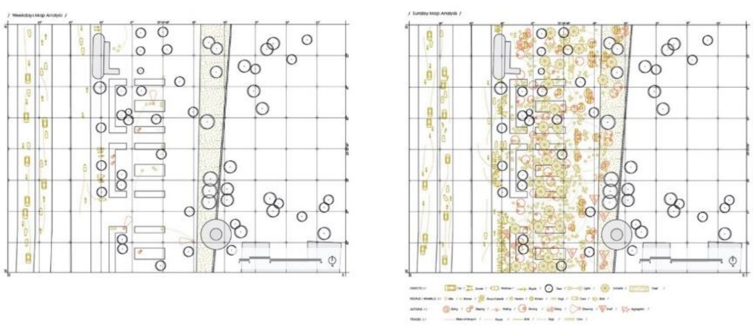

Figure 6. Sunday market in two differet moments of the week, on a weekday and on a Sunday. The maps highlight the presence of vehicles and human activities in the space.
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WAY FORWARD

By mapping and analysing everyday violations, we are made aware of the practices that are continuously making and remaking, appropriating, and re-appropriating Urban infrastructure. Simultaneously, what is also evident are the inherent biases that are either programmed (systemic) or unintentionally part of the design and building of infrastructure and the meaning of infrastructure. In the case of the crossing and street, the design was more conducive for vehicular movement. In comparison, there was little or no consideration for the everyday practices (walking, vending, praying, cooking, etc.) of the other users. This can be attributed to a limited understanding of infrastructure's meaning and limited knowledge of the cultural context in which we find ourselves intervening. As this research is an ongoing process, the conclusions we highlight below are to be read as a way forward rather than complete solutions.

First: Infrastructure from monofunctional to multifunctional. The various studies we have referred to, it becomes evident that infrastructure has to be multifunctional, especially in the contexts of the global south. It is owing to the multiple claims and varied practices associated with the urban realm and urban infrastructure.

Second: Infrastructure building as an ongoing process. The making of infrastructure should be seen as an ongoing process because, even if infrastructures are static components in the city, they are immersed into a changing context, which will over time take form and shape based on the context and its inhabitants. One needs to go further than what is flexible or adaptive and look towards practices rooted in the cultural context of the site/city.

Third: Everyday Violation as a bottom-up approach. As reiterated and demonstrated in this paper, studying and beginning to understand the practices associated with infrastructure from the perspective of an everyday violation highlights a more contextualised approach to design infrastructure in an inclusive manner.

These statements should help into the definition of a narrative concerning design approaches for a context in constant motion.

NOTES

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[36] "Lari" in a traditional Indian street carts, a movable-urban device for selling vegetables, foods or multiple purposes.
[37] This informal settlement is particularly known for Lord Ganesha sculpture's production in various sizes fabricated for Ganesh Chaturthi Festival. In this period, the whole informal settlement is dedicated to this activity, and the street is crowded with sculptures and sellers.
[38] The case study chosen is an emblematic location. It has been the subject of a large urban regeneration project since 2012. The project, coordinated by HCP has worked along the riverbank, creating a new riverfront to regulate the flood-prone (Sabarmati Riverfront Development (SRFD) Project). The development project involved the demolition of an entire informal settlement that was established along the west wall of the Old City over the years (10,000 families have been relocated in other places), "Sabarmati Riverfront Development," accessed January 8, 2021, https://www.hcp.co.in/project/sabarmati-riverfront-development.
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MULTI-CRITERIA EVALUATION FOR THE CONSTRUCTION OF A VULNERABILITY MAP TOWARDS THE URBAN HEAT ISLAND IN THE METROPOLITAN AREA OF BARCELONA.

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INTRODUCTION

Climate change has been evidenced during the last decades, representing a crucial topic due to its potential impacts on health, economies and ecosystems. Global warming induced by greenhouse gas emissions is a phenomenon that takes place all around the globe and its effects are evident in different scales (local, regional, global). One of its more palpable consequences is the outbreak of heat waves that bring along high temperatures during day and night.[1] The impact of heat waves is magnified by the formation of the thermal island in urban areas.[2]

The loss of vegetation cover that is being more and more often replaced by the growth of cities and the expansion of urbanized areas by non-permeable surfaces like roads, cement buildings, brick and other construction materials, has caused changes in the ground and air temperatures, in the balance of heat in populated areas, and especially in areas with higher densities. This increase of temperatures in the city center in comparison to adjacent, less urbanized and/or rural areas is known as *urban heat island*.[3] [4]

It is known that climate change exacerbates social inequalities.[5] The concept of vulnerability is not only associated with the individual conditions of the people, but it is also influenced by the characteristics of the environment that we interact with in everyday life. Thus, being vulnerable implies a certain degree of fragility, a situation of threat or greater susceptibility and exposure to harm, generating a condition of de-protection.[6]

This work adopts a definition that relates vulnerability with human conditions (people centered vision). To that end, it considers the way in which the society is vulnerable to climate change and how it adapts.[7] [8]

This paper was written in the framework of the Research Seminar on Climate Change (Master in Urban and Architectural Management and Valuation) from the Technical Superior School of Architecture of Barcelona (ETSAB), Polytechnic University of Catalonia (UPC) and is also within the CLIM-CAP Project.[9] It focuses on the urban heat island phenomenon in the Metropolitan Area of Barcelona (AMB), which is also the case study area of the CLIM-CAP Project. The goal of the paper is to construct a map of social vulnerability towards the urban heat island (UHI) in the Metropolitan Area of Barcelona (AMB) using a multi-criteria evaluation method.

The AMB includes 36 municipalities, with a population of around 3.23 million, 42.8% of the total population in Catalonia Autonomous Community. It is one of Europe's most populated areas, with an urbanization of 48% of its 636 square km of land. The remaining territory is mainly occupied by 25km of beaches as well as more than 25,000 hectares of natural areas.[10]
Between the different municipalities, districts and neighborhoods that build up the AMB, there are some inequalities that require special attention and research. The distribution of wealth, the age of the buildings, the different land use, among others, have implications on the way in which the different communities respond to the urban heat island. This is the starting point of this work that aims to construct a synthetic index of vulnerability and then map its findings.

Figure 1. AMB municipalities[11]

The impacts and risks of UHI are not uniformly distributed among the urban population. It is possible to identify some social groups with specific characteristics such as people over 65 years old, low level education, widowed, divorced or separated people that live alone, low and middle income and low quality housing.[12] [13] These are the groups known to be especially vulnerable to the effects of UHI. Likewise, low-income communities offer a lack of close access to parks, air conditioning and health services, and can also be especially affected by the serious damage caused by natural disasters.[14]

OBJECTIVES AND METHODOLOGY

The objective of this article is to explore the geospatial relations between the urban heat island of the Metropolitan Area of Barcelona and the distribution of the most vulnerable population. The final purpose is to obtain a georeferenced synthetic index of the vulnerability linked to the UHI, in order to establish which areas should be prioritized for intervention with a view to mitigating its effects. Therefore, a Multicriteria Evaluation was implemented for the spatial distribution of the vulnerability to the UHI in the AMB.
In order to create a map of vulnerability to the UHI, the need to construct a synthetic index emerged. To delimit the areas for the research, this paper focused on the urbanized or built surface of each of the

2,163 census tracts. This work identified the different dimensions of vulnerability with the processed information obtained from the INE, Idescat, AMB and Cadastre official sources.

It was quite difficult to merge the different databases information, since some census sections lacked information and its quality depends on each Municipality of the AMB. In any case, the data was normalized and synthesized in order to obtain a single global index of urban vulnerability towards the UHI in the AMB.

The starting point of the work was the construction of a large database that allowed the research to establish the distribution of certain demographic, economic, architectural and urban indicators for the smallest research area (census section) of the AMB. The selection of these indicators, which contemplate different dimensions to study vulnerability, responds to different methodologies used in Spain by other researches,[15] [16] which have focused their attention on one or more variables to construct their own synthetic vulnerability indexes. The contribution of this work has to do with the view of investigating vulnerability on a metropolitan scale, as well as the relation to the UHI, a topic less addressed in this type of work. In addition, special emphasis was placed on the values obtained for women, children and elderly population, which are especially vulnerable to the UHI.

Once the information had been obtained and the database was constructed, the indicators were grouped as they were related to each other, forming four groups:

Sociodemographic indicators:

- People over 65 years of age
- People under 65 years of age
- Women over 65 years of age
- Boys and Girls under 5 years of age
- People originating in low-income countries
- Foreign women

Socioeconomic indicators:

- Income less than 5000 euros
- Women with income less than 5000 euros
- Illiterate people, without studies or only primary
- Illiterate women, without studies or only primary
- Illiterate foreign, without studies or only primary
- People with unemployment benefits

Built environment indicators:

- Dwelling built before 1951
- Dwelling with low quality energy certificates (EFG)
- Number of people by dwelling
- Dwellings smaller than 54 square meters

Socio Urbanistic indicators:

- Built area per habitant
- Industrial land use
- Green canopy

Although it was based on around 40 indicators, after conducting some tests to account for their representativeness, the 18 indicators specified above were the ones selected. Once the values for the census sections were obtained, the database was exploited. To do this, the indicators were loaded into the SPSS program (IBM) to normalize their values, which would allow mathematical operations between variables with different units.
A series of alternatives were then offered for grouping the indicators and reducing them into larger groups. Some works have reduced indicators in common factors based on factor analysis;[17] other studies make up an "expert panel"[18] to weigh the relative weight of each indicator to the global measure of vulnerability to which it is desired to arrive. In this case, a factorial analysis was conducted, but its results were later dismissed since a below 0.7 KMO and less than 70% of variance with 7 factors were obtained throughout these tests. Thus we opted for the second option, creating an online survey - given the limitations of the health crisis caused by Covid-19 - to be answered by the teaching staff of the Master in which this work is framed.
The values obtained from the panel of experts resulted in the following weighting:

Sociodemographic	Socioeconomic	Socio urbanistic	Built environment
People over 65 (*2)	Income less than 5000 euros (*1,8)	Built area per habitant (*1,8)	Dwelling built before 1951 (**1,8)
Women over 65 (*2)	Women with income less than 5000 euros (*2)	Industrial land use (*1,6)	Dwelling with low quality energy certificates (EFG) (*1,2)
Boys and girls under 5 years of age (*1,4)	Illiterate people, without studies or only primary (*1,6)	Green canopy (*2)	Number of people by dwelling (*1,6)
People originating in low-income countries (*1,6)	Illiterate women, without studies or only primary (*1,8)		Dwelling smaller than 45 square meters (*1,4)
Foreign women (*1,6)	People with unemployment benefits (*1,8)		

Table 1. Weighting of indicators in SPSS from a panel of experts.

As can be seen, the indicators that appear in the previous table are the most highly valued in relation to vulnerability to the heat island. After normalizing them, their values were multiplied by 2 or 1.8 or 1.6, following the panel of experts. The indicators that do not appear in the list are those whose initial normalized values were taken as they were, since they were not especially important, according to the consulted experts.

Once the values corresponding to each indicator were weighted, they were distributed in deciles, obtaining values from 1 to 10 for each case, being 1 the most vulnerable value and 10 the least vulnerable. This allowed us to add the values corresponding to each of the groups of variables, forming 4 global indexes for each group of indicators. These results were georeferenced.
Finally, the 4 indexes obtained were added with the purpose of conforming the synthetic vulnerability index towards the UHI for the entire AMB. Its distribution was also georeferenced, and put into relation to a temperature map for the hottest night of 2018 (an especially hot year in the area), comparing those areas where the temperatures were higher, and the vulnerable zones obtained from the synthetic index. The main findings and conclusions are detailed in the next section.

RESULTS

The first result of the research is the synthetic index of vulnerability to the urban heat island, which includes information on a set of partial variables representative of the different study factors. The combination and the sum of them results in a single *global index* which would be applicable to this and probably other similar or different study cases.
The second result is the calculation and application of the index to the context of the AMB. Regarding this index, the mapping of the results is presented below. Some photographs are presented as support.

Sociodemographic vulnerability indicators and urban heat island

The sociodemographic vulnerability in relation to the urban heat island is distributed throughout the entire artificialized surface of the AMB, but concentrations can be observed particularly in some areas within the city of Barcelona. This indicates that there are sectors where there is a greater presence of vulnerable groups such as an aging population, especially of women, as well as other groups of foreigners belonging to low-income countries, among other characteristics.

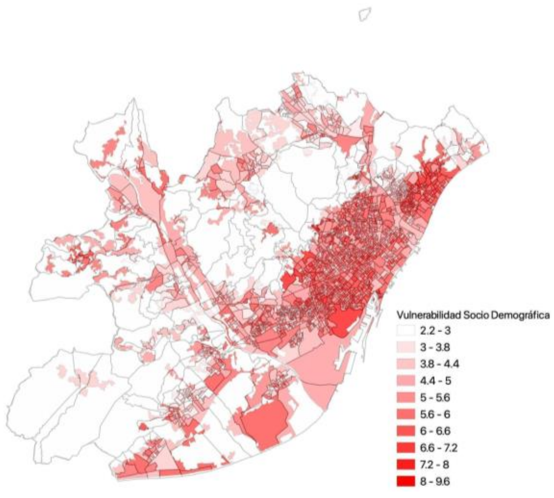

Figure 2. Sociodemographic vulnerability and urban heat island. Own elaboration with QGIS.

Socioeconomic vulnerability indicators and urban heat island

In relation to the indicators corresponding to the socioeconomic dimension of vulnerability, it is possible to account for very high values especially around the Besòs river area and towards the north of the city following the seafront, which coincides with the localization of the most vulnerable municipalities with populations with lower incomes. However, as here we consider indicators of female income and educational level, it is possible to identify an area of extreme vulnerability in the Ciutat Vella district in Barcelona, as well as in the central area of the city, which could be Guinardó and Nou Barris districts, as well as the area of l'Hospitalet de Llobregat municipality.

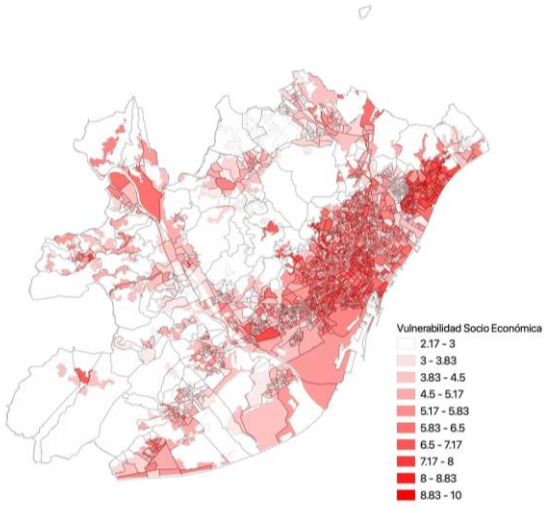

Figure 3. Socioeconomic vulnerability and urban heat island. Own elaboration with QGIS.

Urban environment vulnerability indicators and urban heat island

In relation to the vulnerability of the urban environment - including the presence of green spaces (NDVI) per inhabitant, the uses of industrial land per inhabitant, and the constructed area per inhabitant - it is possible to account for a rather random distribution of this subindex, although it affects the city of Barcelona and more clearly, the area adjacent to the river Besós surroundings.

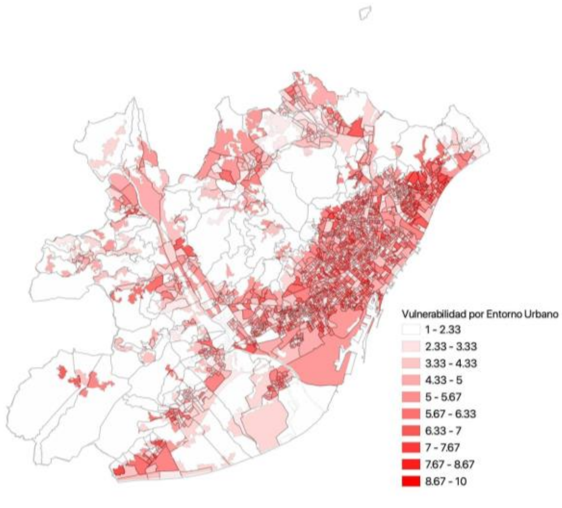

Figure 4. Urban environment vulnerability and urban heat island. Own elaboration with QGIS.

Figure 5. City of Barcelona.[19]

This figure allows us to see the degree of urbanization of the city of Barcelona, giving the idea of a compact and densely populated city, coinciding with some of the maps recently presented.

Physical architectural vulnerability indicators and urban heat island

Finally, in relation to the physical and architectural vulnerability which includes indicators related to the quality and state of buildings and dwellings, a concentration of vulnerability is observed again towards the north of the Besòs river, as well as in some neighborhoods of the city of Barcelona, especially towards the Ciutat Vella district and l'Eixample neighborhood.

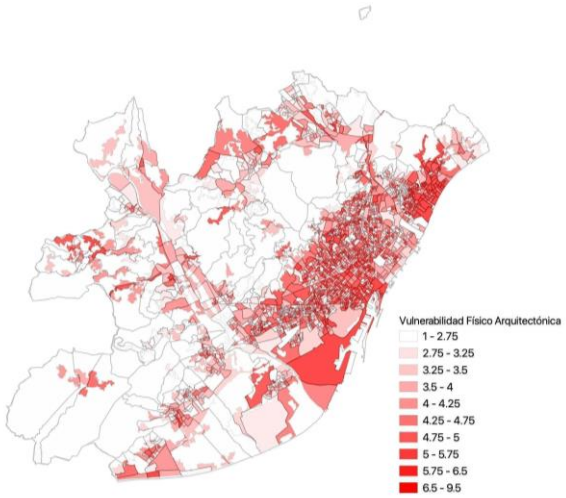

Figure 6. Physical architectural vulnerability and urban heat island. Own elaboration with QGIS.

Figure 7. Typical view of the El Besós-Maresme neighborhood, Barcelona.[20]

Global synthetic index of vulnerability and urban heat island

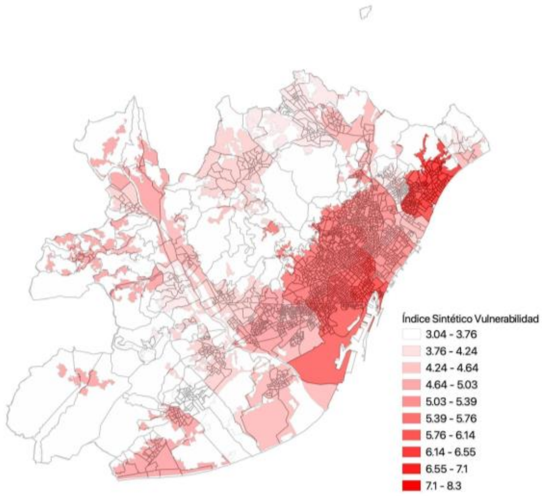

Figure 8. Global synthetic vulnerability and urban heat island. Own elaboration with QGIS.

The synthetic index of vulnerability to the UHI makes it possible to identify those areas that are especially vulnerable to high temperatures. This map shows that the area following the Besòs river, parallel to the sea (Badalona, Santa Adrià de Besòs, Santa Coloma de Gramenet municipalities), as well as the Ciutat Vella district, have values higher than 7.1 and are especially vulnerable to the UHI. In contrast, the higher areas of the AMB, which coincide with higher incomes, greater presence of green areas and lower densities, are clearly the least vulnerable ones.

By relating the global index to the following map of night temperatures on the hottest day of 2018, an attempt is made to show that any type of action that seeks to improve the living conditions of the vulnerable population should begin with interventions in the areas which concentrate not only higher temperatures, but also social, economic, physical and urban vulnerabilities.

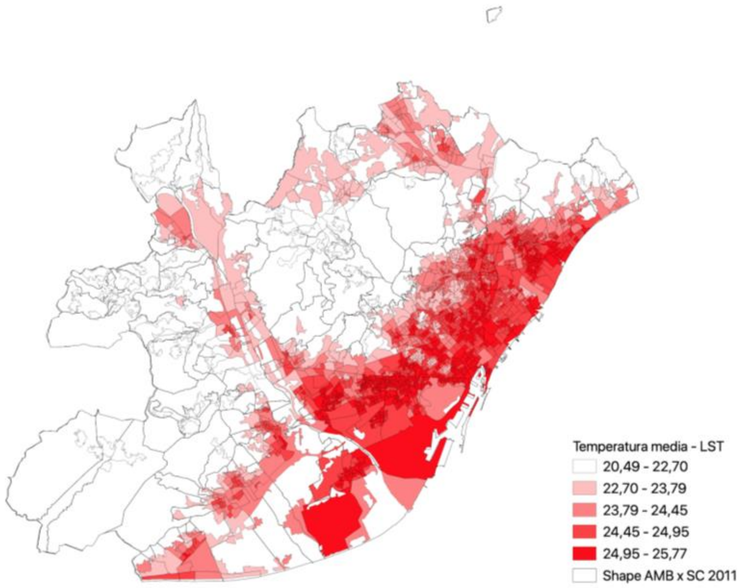

Figure 9. Average night temperature map, own elaboration.

The Ciutat Vella district is a very dense area, with a great concentration of immigrant population, especially from low-income countries, and with very old buildings, besides some rehabilitation actions that have been taking place throughout the years before the 1992 Olympics. It is at the same time a very touristic area, facing a gentrification threat that makes its traditional population especially vulnerable. As for the municipalities towards the north of the Besòs river, Badalona, Santa Adrià de Besòs, Santa Coloma de Gramenet have been historically relegated areas, and are the places that concentrate most social problems.

Both the central area of Barcelona and the municipalities towards the north of the city following the coast line are the two places identified as especially vulnerable towards the UHI and would need special consideration by urban planners.

FINAL CONSIDERATIONS

The UHI is an increasingly frequent phenomenon, and its study is necessary to generate redistributive policies that seek to improve living conditions in cities, especially for the most vulnerable populations. Although four groups of vulnerabilities or sub-indexes were presented, it would be possible to include further dimensions for each one of these, considering qualitative indicators for the perception of users that are beyond the scope of this work, but that could be the focus of future studies.

By doing this work, it has been possible to account for:

- the difficulty of accessing data, especially when dealing with more than one level of the administration (as has been in this study case: the metropolitan area of Barcelona includes 36 different municipalities)
- the added value that a methodology such as multi-criteria evaluation provides, in relation to the study of vulnerability, and the possibility to study metropolitan areas such as the AMB
- the potential applicability of a vulnerability index to the UHI in the AMB or other contexts, and the added value of geospatial instruments
- it was possible to identify the areas in which the vulnerability synthetic index is more concentrated:

Barcelona city and its surroundings, following the pattern of high temperatures

- it is also possible to conclude that the sociodemographic and socioeconomic vulnerability is unevenly distributed among the different areas of the AMB, encountering especially unfavorable conditions on the outskirts of the city of Barcelona
- however, when two other dimensions of vulnerability, the physical-architectural one and that of the urban environment, are added it is possible to account for the concentration of areas especially vulnerable to the urban heat island in the AMB. Most municipalities towards the north of the Besòs river, as well as in the Ciutat Vella district in the city of Barcelona are the most vulnerable areas
- by overlapping the identified vulnerable areas with the temperature map of 2018, it is possible to identify coincidences between the both of them, meaning that economic, urban, architectural and social interventions would need to start from the more vulnerable areas in order to plan a more resilient, sustainable and equal metropolitan city with ability to confront and adapt to the effects of climate change and the UHI.

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PHASE CHANGE MATERIAL (PCMS) FOR BUILDING ENVELOPE APPLICATIONS

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INTRODUCTION

In 2018 the building industry has absorbed 36% of global energy consumption and produced 39% of annual greenhouse gas emissions. These data surely are very alarming, but are nothing compared to the 2050 outlook, when the energy demand will increase by about 50% and the demand for building cooling will triple compared to 2010 values[1].

In the building industry, the building envelope can be a crucial building subsystem to reduce energy consumption and CO_2 emissions in the atmosphere, contributing to a prospective energy saving that the European Union estimates at 32.5% by 2030[2, 3]. The strategic role of the building envelope is also confirmed by the Global Alliance for Buildings and Construction[4]. It reports, among the various actions to be implemented, also the creation of adaptive envelopes useful to overcome the progressive limitation and non-renewability of natural resources and to create buildings with high energy efficiency and low CO_2 emissions, allowing to contain, on the one hand, the increase in the average global temperature well below 2 °C compared to pre-industrial levels, and on the other, the growing energy demand for cooling. These guidelines must certainly be coupled with adequate policies that the countries will have to implement and the dissemination of best practices in which heating and cooling are regulated by adaptive and 'passive' envelopes[5].

In the light of these premises, the paper, after having highlighted the importance of 'adaptive' envelopes as a possible solution to the environmental issues, focuses on the characteristics and potentialities of Phase Change Materials (PCMs) that change to 'answer' temperature variations, changing their state, from solid to liquid and vice versa, depending on the amount of heat they absorb. In particular, the paper will highlight the advantages, limits and fields of application of PCMs, as documented in reference scientific literature, especially in relation to the research carried out at micro and nano scales to enhance the properties of PCMs to be used in the building industry.

A NEW PARADIGM: THE FACADES, FROM ENVELOPE TO OSMOTIC AND ADAPTIVE MEMBRANE

The gradual awareness on the environmental emergency have pushed the researchers and designers towards new envelope concepts in general and facades in particular, accelerating innovative practices with new approaches characterized by dynamism, adaptiveness, smart control, responsiveness, integration-hybridization, biomimicry, etc., fostering a new paradigm[6]. In this paradigm, these sub-systems are not intended anymore as elements opposing to a flow, but – on the contrary – as 'filters'[7] that receive by controlling, or oppose in a 'smart' way to, the external weather stresses by intercepting and capturing them in different directions depending on the seasons and the exposures[8], therefore assimilating the frontier envelope to a 'technological Janus'[9] (Tab. 1).

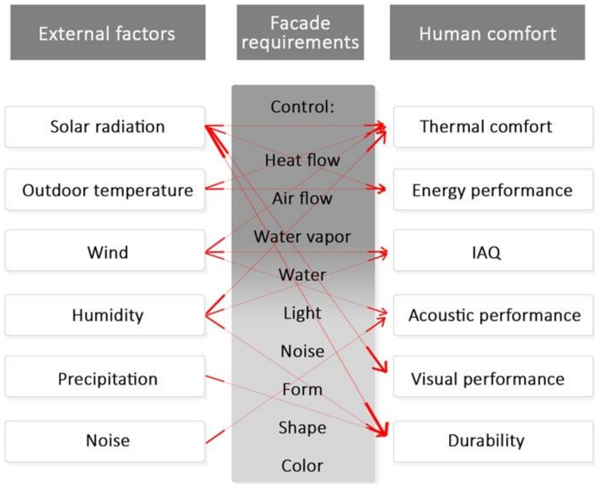

Table 1. Schematic role of adaptive facade (source: Aelenei, Aelenei and Vieira, 2016).

The 'mitigation' strategy, among the strategies identified to respond to these solicitations, is consolidated, but many experiments and recent achievements suggest the need for it to be coupled with an 'adaptation' strategy, using a range of 'adaptive solutions' involving the 'micro' scale[10] through the use of components (often derived from transfer of technology) capable of providing increasingly extreme performance responses to external stresses (in terms of indoor comfort) with low energy consumption, or the 'nano' scale with materials already used in the first biomimetic applications in envelope systems. Some examples of resilient facades are: 'dynamic' envelopes, which control the relation between the external environment and the building by managing the different energy flows through integrated systems capable of changing their shape, alternating functions and organizing spaces[11, 12]; 'smart' envelopes capable of improving the energetic and environmental management with sensors and built-in actuators connected through the devices of the IoT thanks to the real-time analysis of data on the operating conditions of the envelope and by 'biomimetic' envelopes that, by mimicking animals and plants nature as 'model, measure and mentor'[13] and learning from its behavioural and performance paradigms, use only techniques and technologies, materials and components that react to environmental stimuli in an 'organic' and 'passive' way[14].
Therefore, the research is oriented towards biomimetic applications emulating, through materials designed at a 'micro' and 'nano' scale, the behaviour of living organisms originating a functional, morphological variability of the objects concerned, and often also to their appearance[15]. Consequently, the dynamism is no more linked to the action of a mechanic actuator hidden from view but, for example, to photochromic coatings that regulate glass transparency, or to brise-soleil moved by phase-change actuators or even to external coating membranes that change their geometry and volumes, according to the incident solar radiation on surfaces[16] (Figg. 1-4).

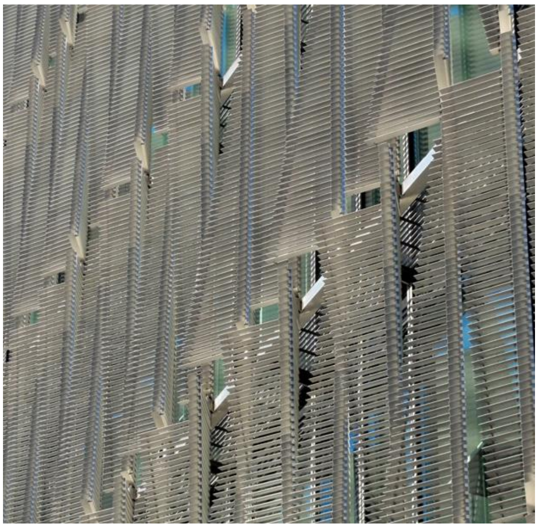

Figure 1. Q1 – Thyssenkrupp Quartier, JSWD Architek- ten, 2010, Essen Germany (credits: www.jswd-archite kten.de/projekte/thyssenkrupp-quartier/).

Figure 2. Shiver House designed by NEON: a kinetic 'animal like' structure which moves and adapts in re- sponse to surrounding natural forces, Korppoo, Fin- land, 2019 (credits: www.neon.uk/?utm_medium=web- site&utm_source=archdaily.com#/shiver-house/).

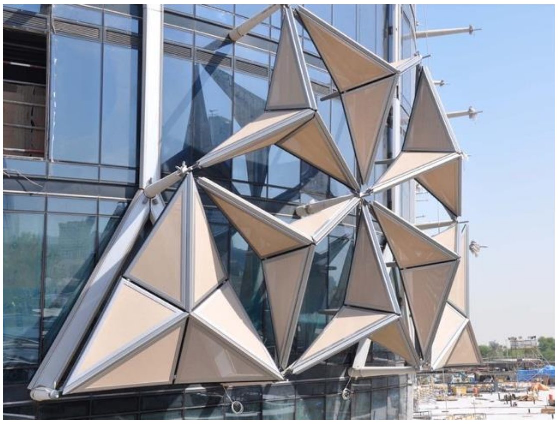

Figure 3. Al Bahr Towers, Abu Dhabi, 2012 (credits: www.arup.com; www.re-thinkingthefuture.com).

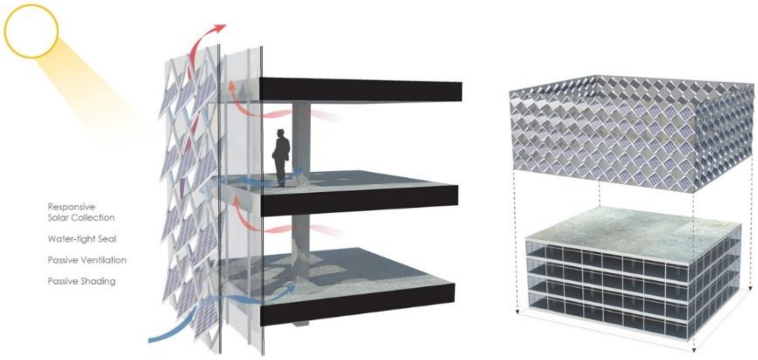

Figure 4. Adaptive Sola Skin, self-supporting solar collection façade: prototype with removable panel (credits: danielraznick.com/about/adaptive-solar-skin/).

Besides the different definitions[17] and specificities[18], every type of facade goes through three stages: (i) detect the environment (ii) process the acquired information and (iii) take physical action (movement or change in material property) to optimize internal environmental qualities in response to adverse external conditions. The level of adaptability (gradual or immediate) can be uniquely linked to the reaction time (seconds, minutes, hours, day-night cycle, season, year, ten-year span) and to the spatial scale (nano, micro and macro) according to when and where the change occurs. Daniel Aelenei[19] (Tab. 2) have presented a classification scheme that combines the strengths of the different typologies through seven objectives/purposes that, on the one hand, help to understand the peculiarities (and philosophies) of the different adaptive facade systems, and on the other, define the tasks that an adaptive facade can perform, usually by balancing overall energy consumption, CO_2 emissions and life-cycle costs.

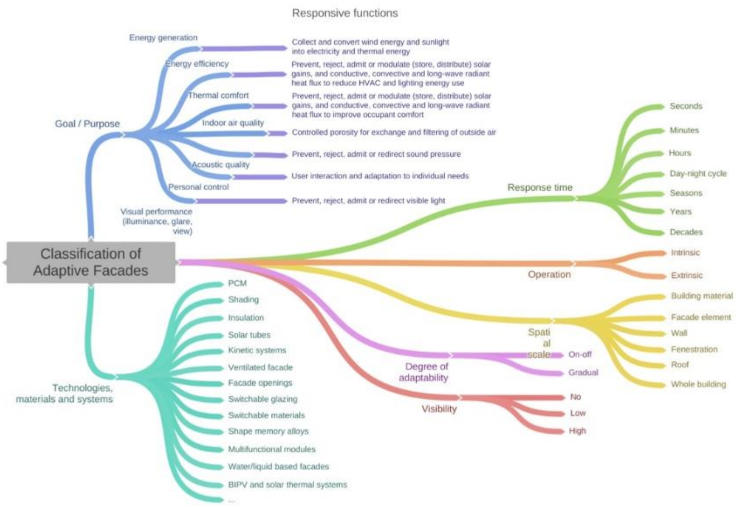

Table 2. Conceptual overview of a classification scheme for adaptive facades (Aelenei et alii, 2019).

In general, the adaptive components are controlled and managed in two ways[20]: an ‘intrinsic control’, self-regulated and triggered by environmental stimuli that allow low-cost operations and maintenance (typical of passive systems); an ‘extrinsic control’ which can start after finding information (through sensors) and data processing with actions to be taken (through actuators).

ADAPTIVE RESPONSES FROM 'MICRO' AND 'NANO': THE PCMS

Among the different materials developed with the research at 'micro' and 'nano' scale, the Phase Change Materials (PCMs) can be a possible solution to reduce the energy demand in the building sector by reducing heating and cooling demand of buildings[21]. The Thermal Energy Storage (TES) systems allow to 'store' a certain amount of energy in the accumulation stage to be used at a later time[22], and among the different methods used for the heat energy storage, the Latent Heat Thermal Energy Storage (LHTES) uses the characteristics of phase change materials. The PCMs are materials capable of changing their status from solid to liquid and vice versa, depending on the amount of heat they absorb which becomes 'latent heat' during warm weather and 'released heat' during cold weather[23]. These materials are in a solid state at room temperature, but when it rises, they become liquid and accumulate energy in a latent form. The cycle is inverted when the temperature decreases again, they return to the initial temperature. In this case, the PCMs return to a solid state and in this phase change they release the previously stored energy as heat in the environment. Their **thermal storage ability is higher than the one of a traditional material** having with a certain mass. Thermoregulating materials represent an innovative technological solution in building design, as they give the possibility to reduce the daily fluctuations of the room temperatures through the reduction of indoor temperature peaks, and therefore of the energy consumption necessary for air conditioning the rooms. Furthermore, as a not negligible advantage, it must be noted that they are functional and operational without any type of external power source, and give dynamism and adaptation flexibility to external weather conditions.

One of the first PCMs used in passive solar systems is water. The Water Drum Wall – tested for the first time at the end of the 1940s by Hoyt Hottel and Massachusetts Institute of Technology of Boston's students – works in a rather simple way: the rays of the sun crossing the glass surface are intercepted by a mass of water or another liquid that converts them into heat, distributed by convection or radiation from a ventilated cavity to the served room, through the wall's internal face. Starting from Hoyt Hottel pioneering initiative, through the years, other scholars have made an important contribution to the research and experimentation of Water Drum Wall[24], entailing the thought that in the near future we might use water as real building material[25].

Many studies have been, and still are, carried out on the use of PCMs in buildings to store heat energy, demonstrating the considerable interest for these materials allover the world[26, 27, 28]. However, to use the PCMs we should verify a series of thermo-physical, kinetic and chemical requirements, those that have the greatest impact on their effectiveness, among others, are: High latent heat of fusion, High specific heat, High thermal conductivity of solid and liquid phase and liquid phases, little or no sub-cooling during freezing, non-toxic, low price and effective availability[29] (Tab. 3).

The various types of PCMs known to us do not have all the caracteristics listed in Table 3. The PCMs are categorized in organic, inorganic and eutectic: paraffin and non-paraffin are: organic PCMs; salt hydrates and metallics are inorganic PCMs; eutectic PCMs are divided into organic-organic, inorganic-inorganic and inorganic-organic (Tab. 4).

Thermo-physical Requirements	Kinetic Requirements	Chemical Requirements	Economical & Environmental Requirements
Appropriate melting temperature in the required operating temperature range	High nucleation rate in order to avoid super cooling of the liquid phase	Long term chemical stability of the PCM	Low price and effective availability
High latent heat of fusion	High rate of crystallization to satisfy demands of heat recovery from the storage system	No degradation after freeze/melt cycles	Non-polluting
High specific heat		Complete reversible freeze/melt cycle	Low environmental impact
High thermal conductivity of solid and liquid phases		No corrosiveness	Good recyclability
High density		Non-flammable, non-toxic, non-explosive materials for safety	Low embodied energy
Congruent melting of the PCM			Facility of separation from other materials
Cycling stability			
Small vapor pressure			
Small volume changes			
Little or no sub-cooling during freezing			
No segregation			

Table 3. Thermo-physical, kinetic, chemical, economic and environmental requirements of PCM (source: Konstantinidou, 2010).

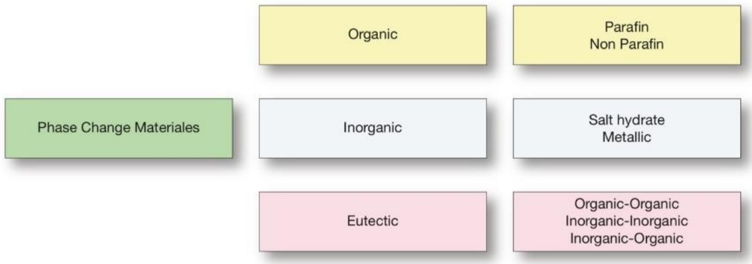

Table 4. PCM classification (source: Memon, 2014).

The PCMs – whether organic, inorganic or eutectic – have some lacks of performances , as stated in Tables 5 and 6. As it can be deduced from the Tables 5 and 6, the organic PCMs are available in a wide range of temperatures, are chemically stable, non-corrosive and nontoxic, do not undergo supercooling or segregation and have a high latent heat of fusion; at the same time they have a low thermal conductivity that could be improved by using a thin encapsulation. Inorganic materials have a good thermal conductivity and a high latent heat of fusion, and are not expensive and non-flammable, but for example salt hydrates have some limitations such as supercooling, segregation and corrosion. On the other hand, metal PCMs do not have a suitable temperature range to be used in the building sector.

Among the most significant criteria for the selection of PCMs there is the melting temperature, whose value has to be compared with the climate zone where the materials will be used in the buildings. Several studies agree that high melting temperatures of PCMs seem more effective for warmer climates, while low melting temperatures can be more efficient for colder climates. Specifically, for the Mediterranean climate the best melting temperature range in winter goes from 18 °C to 22 °C, while in summer it goes from 25 °C to 30 °C[30]. Paraffin is the most used PCM for indoor cooling, even if in some cases salt hydrates and fatty acid were used. In the future, it would be advantageous to use within the same material and/or components, PCMs with different melting temperatures, to improve the energy performance both in warm and cold seasons[31].

Organic (paraffins and non-paraffins)	Inorganic Salt hydrates	Eutectics
They are available in a range of temperature	They possess high volumetric latent heat storage capacity	They exhibit application-specific sharp phase change temperature (melting temperature)
Values of latent heat of enthalpy are high (e.g., acids have much higher heat of fusion than the paraffins)	They possess low vapor pressure in the melt state	Exhibit slightly high volumetric thermal storage density than the organic compounds
Supercooling degree or superfusion effect is normally low during freezing process	They are non-corrosive, non-reactive, non-flammable, and not dangerous	They possess low or no segregation. Thermal reliability is good with congruent phase transition characteristics
Relatively low segregation even after several thermal cycles (thermal reliability). High thermal stability, congruent phase transition process	Have good compatibility with the conventional construction materials. Recyclable, cost-effective, and ease of availability	
Show self-nucleation and growth rate properties	Exhibit high latent heat of enthalpy and sharper phase transformation. High thermal conductivity with lower volumetric changes during phase change. Safe to the environment in terms of handling and disposing when compared to the paraffins	

Table 5. Merits of the LTES materials (source: Parameshwaran and Kalaiselvam, 2016).

Organic (paraffins and non-paraffins)	Inorganic Salt hydrates	Eutectics
Density, thermal conductivity, and latent heat of fusion are inherently lower	Relatively high supercooling properties	Analysis of eutectics for thermal energy storage applications is limited due to the insufficient and non-availability of the thermophysical property data
Inflammable, less compatible with plastic containments	Low degree of nucleation (requires nucleating additives and thickening constituent materials)	In some cases, fatty acid eutectics evolve pungent odor, making them less suitable for PCM wallboard thermal energy storage applications in indoor environments
Larger volumetric changes are possible during charging and discharging (applicable to some grade of organic compounds); expensive by nature	Incongruent phase change and dehydration occur during freezing and melting cycles	
	Decomposition associated with phase separation. Compatibility with some building materials is limited. Exhibit corrosion properties when subjected to most metals. Slightly toxic in nature	

Table 6. Limitations of LTES materials (source: Parameshwaran and Kalaiselvam 2016).

Given the above-mentioned limits, many studies to ameliorate the mechanism of latent heat energy storage of PCMs have been carried out. They focus on the integration methods of PMCs in building materials such as plaster, plasterboard, cement, insulation and glass[32, 33] and the use of nanotechnologies[34]. PCM incorporation methods are mainly divided into two categories: direct and indirect methods. The direct methods of incorporation, both the wet mixing and immersion, were mainly used in the past and have been abandoned due to the possible loss of PCMs and the direct interaction between PCMs and building material which can cause the deterioration of the mechanical and physical characteristics of the materials[35]. To avoid loss and incompatibility problems caused by the direct contact between building materials and PCMs, most of the studies carried out in recent years have focused on indirect methods, that involve PCMs encapsulation. The encapsulation methods are mainly of three types, based on the size of the capsules: macro-encapsulation, micro-encapsulation and nano-encapsulation (Figg. 5-8). These sizes influence the stability of the PCM, since the smaller the capsule size is, the more durable a product is[36].

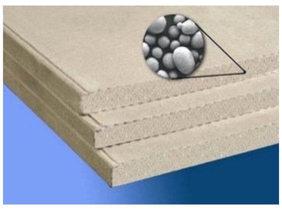

Figure 5. BASF's Micronal phase- change microcapsules enhanced gyp- sum board (credit: materialdistrict. com/material/micronal-pcm/).

Figure 6. GAIA PCM Energy Storage Ball: encapsulation of Phase Change Materials in a spherical shape with a diameter of 63, 80, 100 or 125 mm (credit: www.global-e-systems.com).

Figure 7. Macroencapsulation CSM (Compact Storage Modules): PCM in aluminum case (credit: www.rubi- therm.eu/en/index.php/productcate- gory/makroverkaspelung-csm).

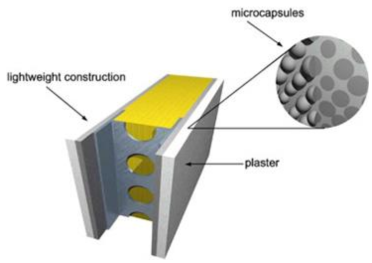

Figure 8. Schematic view of light- weight wall with PCM microcapsules integrated into the interior plaster (source: Schossig et alii, 2005).

The macro-encapsulation method consists of integrating the PCM in containers such as tubes, bags, spheres, porous materials or panels which are generally bigger than 1 cm. Some of the containers developed as PCMs capsules are steel spheres[37] or porous structures of light-weight aggregates – LWA[38, 39, 40] to them is usually applied a highly conductive protective coating material to avoid leaks and at the same time increase the speed of heat transfer. Microencapsulated PCM refers to PCM particles enclosed in a thin solid shell (microcapsule) which is usually made of natural and synthetic polymers ranging from 1 μm to 1,000 μm[41] which prevents the leakage of the phase change material during the solid to liquid phase. Besides preventing PCM leakages during phase change, microencapsulation provides a quick heat transfer through its great surface area per unit of volume[42, 43], improving chemical stability and thermic reliability, since the phase separation within the material, during the phase transition, is limited to microscopic distances.

Microencapsulated PCM can also be integrated in concrete. Most of the studies that have integrated microencapsulated PCM in concrete have used the replacement method – replace a specific quantity of fine aggregates with PCMs in the concrete mixtures[44], since they have a lower loss in resistance compared to mixtures in which PCM is used as an additive[45]. Integrate PCM in concrete[46, 47, 48],

especially organic paraffin[49], can increase its heat storage ability, although PCMs can have some negative impacts on physical and mechanical properties of concrete, which depend from the PCM integration method used during the creation of the composite PCM-concrete[50].
Researchers currently tend to reduce the size of the encapsulation to the nanoscale, to maximize the effects of its size and the surface area involved in the heat transfer[51]. Nanotechnology is the understanding and control of matter at dimensions between approximately 1 and 100 nanometres (a nanometre is equal to one billionth of a metre), where unique phenomena enable novel applications[52]. On this level, fundamental properties such as force, surface/mass relation, conductibility and elasticity can be improved to create materials that can provide a better performance than present materials. In the architectural field, the advent of nanostructured materials concerns the entire building, from the basic structure to the wall-coatings, from lighting to energy production, and most important of all, it is considered crucial for energy efficiency in buildings.
The nano-enhancement of PCMs can be achieved with their encapsulation inside a nano-shell[53] or a nano fibre[54]: there are several experimentations that have used PCM nano capsules to improve the thermal properties of cellulose nano fibres[55] or PCM nano-encapsulated in a silica shell[56], highlighting how the use of nanomaterials can help overcome some limits of PCMs, such as low thermal conductivity[57, 58]. Other researches concerned the improvement of paraffin thermal conductivity through the dispersion of titanium dioxide nanoparticles[59] but also the development of new phase change materials enhanced with carbon nanotubes (C-PCM) and with a polymer-organic hybrid shell which reduce internal temperature variations and absorb more heat[60].

FINAL CONSIDERATIONS AND FUTURE DEVELOPMENTS

In the near future, the aim of the projects will no longer be to control natural phenomena to subject them to contingent short-term needs but to support the (unpredictable) dynamics of natural systems, ensuring the operating conditions of systems, subsystems, components and building materials in the long term.
In the ‘rapid transition’ scenario for a sustainable future promoted by the International Energy Agency high-performance and near-zero-energy buildings will be more than half of new buildings in 2030, more in advanced economies. If, in the next decade, every country implements specific energy standards for each geographical area, nation, region and climatic zone, especially by enhancing passive adaptive systems and innovative materials for insulation to limit heat loss in cold climates and reduce solar gain in hot climates.
To this purpose, it is essential to organize a strategic plan to lead the building industry in a (quick and aimed) transition stage towards clean energy, low energy consumption and reduced CO_2 emissions and based on three key pillars[61]: Sufficiency – reducing the energy demand and limit expensive unnecessary technological/plant investments through adequate and careful planning and design of buildings without reducing the well-being standards for users; Efficiency – improve the energy performance of building materials, components and technologies through market policies and actions encouraging the transition to efficient and innovative solutions; Decarbonisation – development, promotion and immediate marketing of already tested technologies that allow to enhance renewable energy sources. The implementation of this strategic plan is technically possible if the best performing products already available on the market are used since the beginning, through specific ‘mandatory performance targets’ and ‘incentives’ useful to cut the high costs of these new materials.
The research on PCMs – which can play an important role in controlling energy consumption for heating and cooling in indoor environments – certainly refers to these three pillars. Taking into account the experimentation and afore-mentioned research, PCMs can take the role of new ‘thermoregulatory’

paradigm for architecture. To do so, it will be necessary to invest more in research, reasonably assuming that the return on the investment will not only be economic (management costs are significantly lower than mechanized adaptive systems) but also social and environmental and examine in depth a number of issues on various subjects. About environmental issues, it will be necessary to define a new 'adaptive' energy model, based on the physical and thermo-hygrometric characteristics of PCMs, tending, due to their high capacity to absorb latent heat, on the one hand, to the almost energy self-sufficiency in relation to the heating and cooling needs of a building, on the other, to the transfer of surplus heat energy to neighbouring more energy-intensive public buildings, through a system of heat storage and networks.
Conversely, regarding the technological issues, some research areas can concern the creation and development of new PCMs for specific geographic and climatic contexts and building elements and components in which integrate them. It would be important to focus on materials having PCMs with different melting temperatures, to improve the performance of buildings both in warm and cold seasons. Regarding the environmental issue, it should not be overlooked that these innovative storage materials/systems should be analysed especially by taking into account their whole life cycle. Currently, there are only few LCA studies and researches available, limited to paraffin which has significant GWP and PENRT impacts, and to salt hydrates that have a minor impact[62, 63, 64, 65].
For the elements and components integrating the PCMs it will be necessary to research on 'multifunctionality' requirements, minimizing the number of technical, durability and endurance elements, while evaluating the overall performance of the system according to an adaptive response to variable (and not always predictable) mechanical and thermal stresses. Moreover, since the new multifunctional components will characterize future architectures with their own shape, size and section, it will be necessary to deepen studies on manufacturing systems – for example digital manufacturing[66] – allowing, according to the individual needs of designers, the personalization of the components and an adequate integration with PCMs, and also a linguistic and formal variety, suited to the intervention background.
In conclusion, to use PCMs as 'thermoregulatory' materials to be integrated into 'adaptive facades' there is definitely a long road ahead but, with thanks to the above-mentioned experimentation and research, it seems set. On the one hand, it seems that, thanks to the use of nanotechnologies, the limit of these materials can be found in the visionary skills of researchers, and on the other, we still must understand how much and when these technologies and materials will be widespread enough to allow a significant reduction of the energy necessary for heating and cooling buildings.

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ANALYSIS OF THE INFLUENCE OF ENVIRONMENTAL FACTORS ON THE ENERGY CONSUMPTION OF A BUILDING WITH A DYNAMIC FACADE

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INTRODUCTION

Architecture is an industry with high energy consumption. Nowadays, with the global energy shortage, energy conservation in building has become a topic of widespread concern. The technological developments brought about by the Industrial Revolution separated the building's structure from its enclosure, bringing about a new architectural form. The Chicago School developed the architectural language of high-rise frame structures and Mies's 'skin and bone' buildings developed accordingly. Gaining higher independence and flexibility, the architectural skin provides more space for architects to create. However, the increasing dependence of modern buildings on air-conditioning equipment has led people to seek various energy-saving methods in their design, and the environmental adaptability of buildings has become more valued. In this context, the dynamic facade of a building has become a widely used strategy and energy-saving method. Different from traditional and static building facades, dynamic facades can be changed according to environmental factors, such as time, temperature and light, so as to improve the indoor physical environment and achieve the aim of saving energy.

REGULATION OF FOUR FACTORS ON A BUILDING'S ENERGY CONSUMPTION

The energy-saving strategy of a dynamic facade is to adjust itself to changes in the external environment. This paper will explore the influence of dynamic facades on a building's energy consumption in regard to four factors: solar radiation, ventilation, heat storage performance and thermal resistance.

Regulation of Solar Radiation

Solar radiation affects the heat gain of the building, thereby affecting the indoor temperature and having a greater impact on indoor comfort. Many research projects have been carried out on the adjustment of solar radiation by sunshade shutters. Li et al.[1] proposed the concept of total radiation net benefit and analysed the ability of fixed sunshade louvers to adjust the amount of solar radiation entering a room. Dou et al.[2] explored the influence of fixed sunshade louvers on the temperature and comfort of non-air-conditioned rooms in summer. Kim et al.[3] explored the summer light and heat performance of horizontal dynamic louvers and the effect on indoor comfort through actual measurements. Li et al.[4] incorporated lighting into evaluating a building's energy consumption, finding the best energy-saving inclination angles for horizontal and vertical shading louvers through conducting simulations, and explored the energy-saving potential of dynamic louvers as a control group.

Adjustment of Natural Ventilation

As a passive energy-saving strategy, natural ventilation improves indoor thermal comfort while taking away indoor heat. The natural ventilation potential of Chinese cities can be compared through various evaluative criteria such as wind pressure, heat pressure and air quality[5]. Among types of natural ventilation, hybrid ventilation systems have the best energy-saving qualities[6], which can not only maximise passive energy saving but also maintain satisfactory indoor comfort[7]. Chen et al.[8] also studied the variations in energy saving when using mixed ventilation methods controlled by different intelligent levels, and Srisamranrungruang et al. used a double-skin facade with ventilation holes to create the best energy-saving skin type that balances indoor ventilation and lighting. However, due to the imperfect evaluation standard of wind environment, there is little research on ventilation adjustment using dynamic facades.

Thermal Storage Capacity

The heat storage performance of a material refers to the ability of a material to store heat. Materials with good heat storage performance can effectively reduce indoor temperature fluctuations caused by external temperature changes under the same thermal resistance of materials. However, phase change materials (PCM) use the latent heat from the process of phase change, which greatly reduces the required thickness of a building envelope on the basis of high heat storage. In addition, compared with traditional materials with high heat storage performance, PCM's temperature threshold for heat release and absorption is very narrow, almost equal to the melting-point of the materials, making the heat storage of PCM have certain variability. Therefore, the combination of using PCM and building a variable sunshade skin can effectively improve energy-saving efficiency.

As early as 1980, PCM were considered as heat storage building materials. During research into different regions, Wang et al.[9] studied the energy-saving effect of walls built with PCM in light buildings in the area of Shanghai. The study showed that the suitable phase-change temperature was 22–26℃, and the energy-saving efficiency of PCM applied in the south was the highest. Sharma et al.[10] studied the effect of applying PCM in hot regions such as India and proved that PCM had an effective energy-saving effect in India. Zou et al.[11] simulated and studied the energy-saving effect and optimal parameters of PCM applied in Shenzhen, China. On the topic of energy-saving strategies, Diaconu et al.[12] proposed a new type of composite wall made of PCM in which a layer of PCM with a higher phase-change temperature and a layer with a lower phase-change temperature were placed on the outside and inside of the wall.

Thermal Resistance

Thermal resistance reflects the heat transfer capacity between media. By controlling the thermal resistance of a building's skin, the heat transfer capacity of that skin can change correspondingly with fluctuations in the external environment.

Variable thermal resistance has increasingly attracted the attention of international researchers in recent years. In evaluating the effects, Qian et al.[13] used the method of multi-objective optimisation and building performance simulation to assess the energy-saving effect of the variable thermal-resistance skin in an office in Shanghai, and the results showed that the variable thermal-resistance skin can save 25%–35% in energy consumption. Wang et al.[14] simulated the energy-saving effects of a wall with variable thermal resistance, a window with variable thermal conductivity and a window with a variable solar heat gain coefficient in four climatic regions. In the field of variable thermal resistance technology, Cui et al.[15] summarised five technologies for changing a wall's thermal resistance, evaluated the theoretical effect of variable thermal resistance technology and put forward the possibility of improvement.

METHODOLOGY

Building Model

The model used in this study is a single-storey office building with a double-glazed window on the south side, located in Xiamen, China and built using design software – Grasshopper and DesignBuilder (Figure 1). The building is located on a north–south line, with a breadth of 3.3m, a depth of 6m and a height of 3.15m. The height of the window sill and the window are 1.15m and 1.6m, respectively. The building's total energy consumption and energy-saving rate, including lighting, air conditioning, cooling and heating, are taken as evaluation indexes.

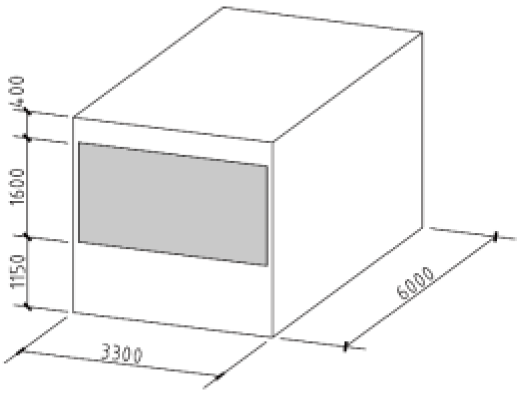


Figure 1. Single-story office building model.

Parameter	Construction	Thickness (mm)	Conductivity (W /m·k)	Thermal resistance (m^2·K/W)	Specific heat (J/kg·K)	Density (kg/m^3)
Wall	Plaster	10	0.8	0.11	840	1300
	EPS	32	0.06	0.43	1340	35
	Aerated concrete blocks	200	0.18	0.51	1000	2000
	Plaster	10	0.8	0.11	840	1300
Floor	Insulation board	50.8	0.03	-	1210	43
	Heavyweight concrete	203.2	1.95	-	900	2240
Roof	Lightweight concrete	101.6	0.53	-	840	1280
	Air gap	180	-	0.18	-	-
	Acoustic tile	19.1	0.06	-	590	368
Loads		Value				
Occupancy		0.1 people/m^2				
Lighting		9 W/ m^2				
Equipment		15 W/ m^2				
Illuminance on the work plane		300 lx				

Table 1. Model parameter settings.

Simulation Software

The energy-saving effect of the room was mainly studied by using Ladybug Tools and DesignBuilder. Ladybug Tools, as a plug-in of the parametric software Grasshopper, can model and simulate buildings in a Rhinoceros 3D environment. DesignBuilder is a comprehensive graphical interface simulation software with EnergyPlus as its kernel. Compared with Ladybug Tools, DesignBuilder can set PCM and combine with the Energy Management System (EMS) function of EnergyPlus. Therefore, the adjustment of solar radiation and ventilation was simulated by Ladybug Tools, and the thermal storage capacity and variable thermal resistance were simulated by DesignBuilder.

Numerical Model

Group A: Solar radiation

The outside of the window is equipped with venetian blinds with a width of 200mm, a spacing of 200mm, a reflectivity of 0.65, a transmittance of 0, an emissivity of 0.9, a thermal conductivity of 221w/m·K, and an opening angle of -60°, -30°, 0°, 60° and 90°, respectively, as illustrated in Figure 2.

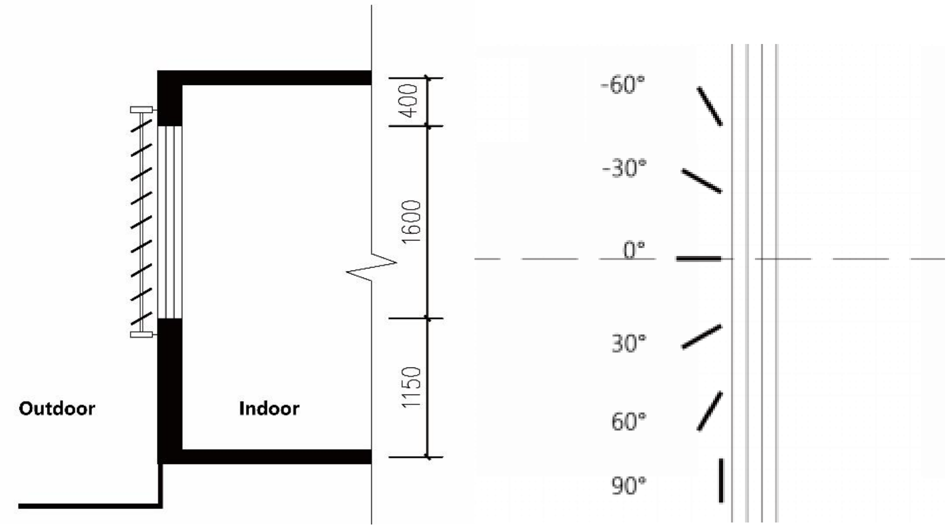


Figure 2. Left: Location of venetian blinds. Right: Opening angle of venetian blinds.

The opening of the venetian blinds is controlled by the outdoor temperature and solar radiation intensity. The opening setting and opening angle of the blinds were combined in different ways to form multiple groups of dynamic sunshade skins. After importing the EPW files from Xiamen to obtain the relevant meteorological data, the energy consumption was simulated by Ladybug Tools, and the total annual building energy consumption, including cooling, heating and lighting, and the comfort time percentage estimated by Predicted Mean Vote (PMV) were obtained. The opening angle of the venetian blinds, the dry bulb temperature and the solar radiation intensity that controls the opening of the blinds were analyzed and compared as experimental variables. The control group has no sunshade louver. And other parameter settings are shown in Table 2.

Group	Venetian blinds opening control		Opening angle of venetian blinds (°)
	Venetian blinds opening control	Solar radiation intensity (W/m^2)	
A1	18	40	-60
			-30
			0
			30
			60
			90
A2	15	40	90
	16		
	17		
	18		
	19		
	20		
	21		
	22		
A3	18	40	90
		60	
		80	
		100	
		120	
		140	

Table 2. Properties setting of Group A.

Group B: Ventilation

The temperature range for comfort obtained by the adaptive thermal comfort (ACS) model is formed into a cooling set point schedule and a heating set point schedule, and the natural ventilation time is controlled by the opening of windows. Taking the window-opening ratio as a variable, the indoor ventilation is adjusted by changing the window-opening ratio, and the air-conditioning cooling or heating is carried out while the windows are closed. By importing the EPW files from the Xiamen region to obtain the relevant meteorological data and using Ladybug Tools to simulate energy consumption, the total energy consumption of the building for the whole year, including that for cooling, heating and lighting, and the comfort time percentage of the PMV evaluation can be obtained.

Group C: Thermal storage capacity

To discover the energy-saving performance of a dynamic facade, the test walls were incorporated with PCM layers while retaining the same K value as the reference wall. The properties of PCM were in line with Climator's products, with a thermal conductivity of $0.93W/m \cdot K$, a density of $1400kg/m^3$ and a latent heat of 170kJ/kg. It has been assumed that PCM in either a solid or liquid phase have the same properties in this paper.

In this study, the results obtained with different variables in the location and thickness of walls and in the phase-change temperature and orientation of the PCM were compared and analyzed. The configurations of the reference wall and the test wall with varied locations for the PCM layer are shown in Figure 3, and the thickness and the phase-change temperature of the PCM layer are given in Table 3. Four models with diverse orientations were then established to test the effect of the PCM layer's orientation on energy consumption; Figure 4 illustrates their locations. The energy saving rate of the model in each orientation was compared in order to exclude the energy consumption caused by different orientations. Finally, the energy saving rate of the combination of a PCM wall and adjustable shadings was tested. Two movable shadings were added to the PCM-enhanced model, as shown in Figure 5; they were installed on the upper part of the south wall as well as under the window and were 1m and 0.6m wide, respectively. The shadings opened between 10:00 and 16:00 in summer and remained closed otherwise. In the models with only movable shadings and only PCM layers as well as installed the both, were simulated respectively, in comparison with the reference model.

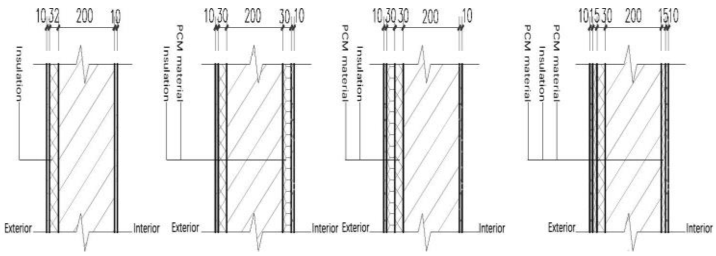


Figure 3. C1: The configuration of reference wall and test wall added PCM layer in different location.

Variables		Melting temperature (℃)	Thickness (mm)
C2	Temperature 1	21	30
	Temperature 2	23	
	Temperature 3	25	
	Temperature 4	27	
	Temperature 5	29	
	Temperature 6	31	
C3	Thickness 1	27	10
	Thickness 2		20
	Thickness 3		30
	Thickness 4		40
	Thickness 5		50

Table 3. Properties setting of PCM layer.

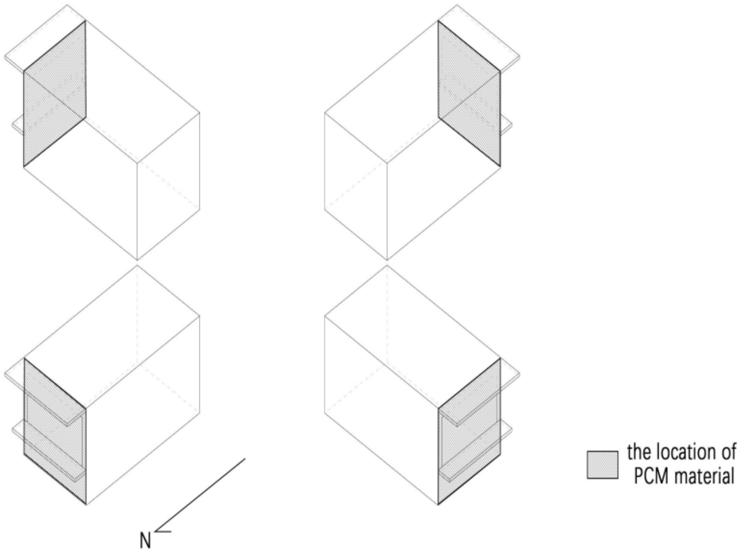


Figure 4. C4: Different orientation of the test room.

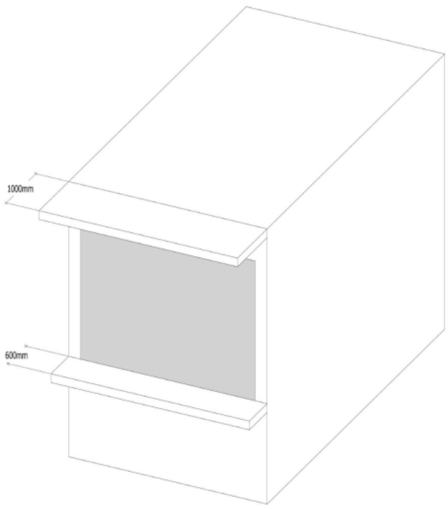


Figure 5. The test room loaded with mobilizable shadings.

Group D: Thermal resistance

There are two main aims in this group's simulation: one is to test whether the dynamic insulation systems can help to save energy and the other is to explore the change in the energy saving rate when the highest or lowest thermal resistance is altered. The variation ranges of the thermal resistance of the dynamic insulation layer came from reference papers that had specific experimental data to ensure the validity of simulation results. The properties of the insulation layers are listed in Table 4.

Variation	Condition	Thickness of insulation (mm)	Thermal conductivity (W /m·k)	Thermal resistance (m^2·k/W)
Reference	Constant thermal resistance	30	0.06	0.43
Group 1[16]	max thermal resistance	1.4	0.0028	0.43
	min thermal resistance	1.4	0.189	0.0064
Group 2[17]	max thermal resistance	85	0.17	0.43
	min thermal resistance	85	0.56	0.13
Group 3[18]	max thermal resistance	35	0.07	0.43
	min thermal resistance	35	0.35	0.086
Group 4[19]	max thermal resistance	10.5	0.011	0.43
	min thermal resistance	10.5	0.017	0.28

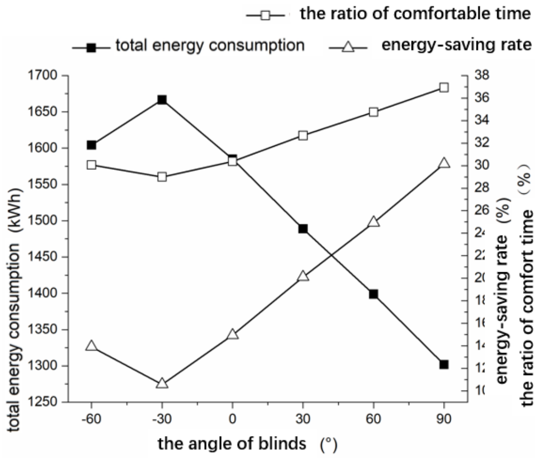
. Table 4. The properties of insulation layer in Group D1.

To further explore the influence of a envelope with dynamic insulation system, the thermal resistance of the envelope was set to increase when the ambient air temperature was higher than or equal to 25℃ and lower than or equal to 18℃, decreasing when air temperature is between 18-25℃. The data of Group 1 in Table 4 was then selected to change its maximum and minimum thermal resistance by a gradient of 10%; the modified parameters are shown in Table 5.

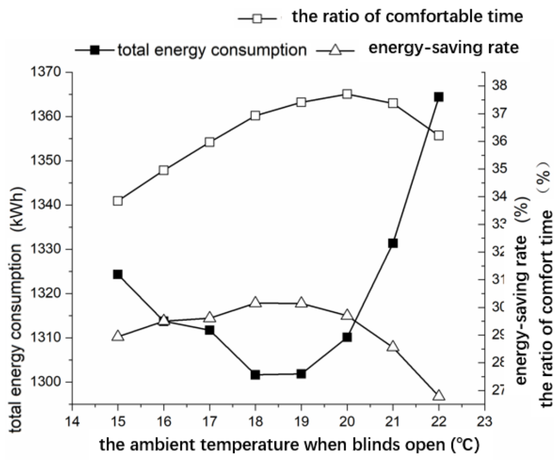
Variation	Increase the maximum thermal resistance					Reduce the minimum thermal resistance				
Gradience	10%	20%	30%	40%	50%	10%	20%	30%	40%	50%
Maximum / minimum thermal resistance (m^2·k/W)	0.43	0.473	0.559	0.602	0.645	0.0064	0.0058	0.0051	0.0045	0.0032

Table 5. The variation of thermal resistance in Group D2.

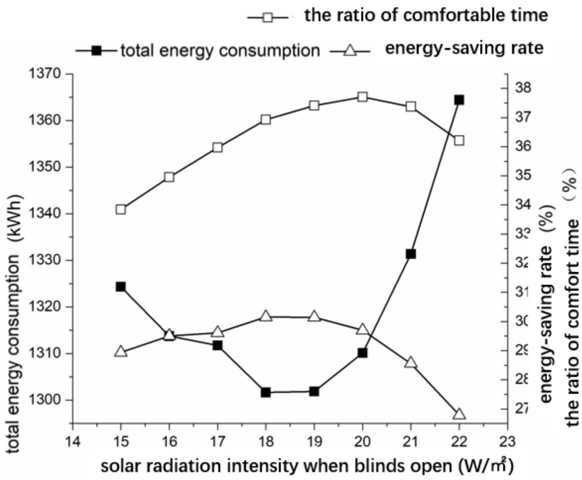
SIMULATION RESULTS AND ANALYSIS
Group A: Solar Radiation



A1: The opening angles of the blinds as variables.



A2: The ambient temperature when blinds open as variables.



A3: The solar radiation when blinds open as variables.

Figure 6. The total energy, energy saving rate and comfort time percentage of mobilizable shadings in Group A.

As shown in Figure 6 A1, the building's energy consumption reduced as the opening angle of venetian blinds changed, and it reached the maximum value with an opening angle of -30° while the energy saving rate was lowest at 10.57%. Furthermore, the comfort time percentage was lowest with this opening angle, but the reduction in energy consumption increased gradually as the opening angle increased and it achieved a maximum energy saving rate of 30.15% when the opening angle was 90°, which also led to the best indoor thermal comfort.

As illustrated in Figure 6 A2, the measurements of total energy consumption formed a parabola roughly related to the outdoor temperature when the blinds opened, and the energy saving rate ranged from 26.79% to 30.15%. The highest energy saving rate was achieved, but the best indoor thermal comfort was not, when the opening temperature for the venetian blinds was set at 18℃.

As shown in Figure 6 A3, the total energy consumption had a linear relationship with the solar radiation intensity for controlling the movement of the blinds, and the energy saving rate varied from 29.89% to 30.15%. In addition, both the energy saving rate and the percentage of indoor comfortable time were highest if the blinds were set to open as the solar radiation intensity became higher than 40 W/m^2.
In conclusion, the building installed with venetian blinds had lower energy consumption when compared to the reference model. On the whole, buildings with dynamic shading facades can adjust the amount of indoor solar radiation and consequently regulate the indoor air temperature, as a result, reduce energy consumption, as shown in the Xiamen model. The energy saving rates ranged from 10.57% to 30.15%, depending on the different parameters, and the indoor thermal comfort changed as well. The lowest values of total energy consumption and the maximum energy saving rates were achieved when the blinds were set to open beyond an ambient temperature of 18℃ and solar radiation of 40 W/m^2, with an opening angle of 90°, coinciding with a better indoor thermal comfort.

Group B: Ventilation

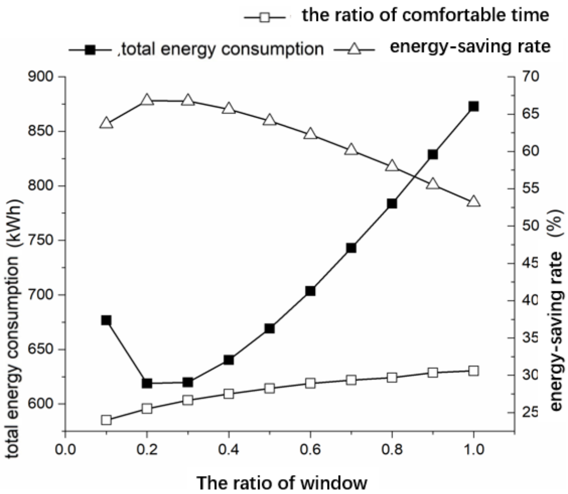


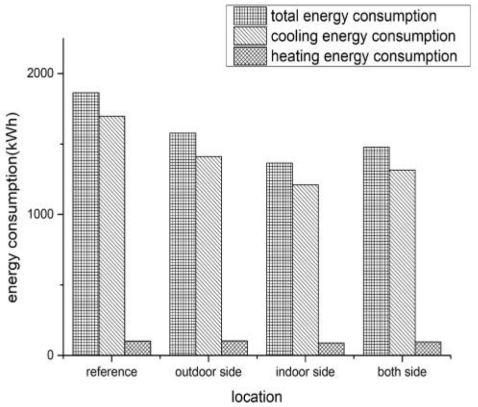
Figure 7. The total energy consumption, energy saving rate and comfort time percentage for different window opening ratio in Group B.

Figure 7 shows that a parabolic relationship was formed between the total energy consumption and the energy saving rate. The total energy consumption decreased and the energy saving rate increased as the window-opening ratio grew from 0.1 to 0.2. The highest energy saving rate of approximately 66.79% as well as the lowest energy consumption of 618.82kWh occurred when the window-opening ratio was 0.2. The heating and cooling energy also increased with the increased window-opening area, and the total energy consumption showed an upward trend while, simultaneously, the energy saving rate gradually fell to 53.16%. The percentage of indoor comfort time was positively correlated with the proportion of window opening, and the percentage of indoor comfort time rose from 23.98% to 30.59% with the increase of the window-opening ratio. The window-opening ratio that saved the most energy was 0.2, and there was also a high indoor comfort percentage at this ratio; although, the maximum percentage of indoor comfort time was not achieved.

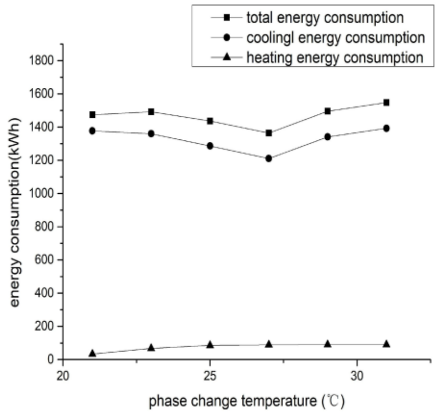
Group C: Thermal Storage

It is clear from Figure 8 C1 that the optimal location of the PCM layer, which provided the best energy saving performance, was in the interior side of the wall. This was followed by the outer side, and incorporating the PCM layer on both sides displayed the worst energy performance.

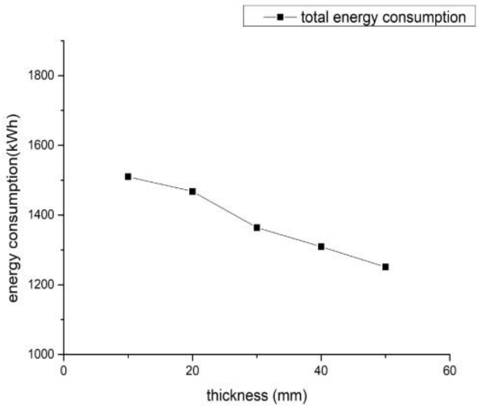
Figure 8 C2 shows that the highest energy saving rate was 26.80% when the phase-change temperature of the PCM layer was 27℃ and, for the lowest heating load, the optimal phase-change temperature was 21℃.



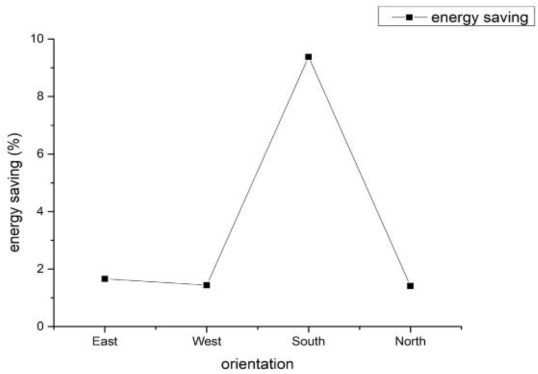
C1: Energy consumption for different location of PCM layer.



C2: Energy consumption for different phase change temperature.



C3: Energy consumption of different PCM thickness.



C4: Energy saving rate of different orientation.

Figure 8. The effect on the energy performance of different variables of PCM enhanced wall in Group C.

As shown in Figure 8 C3, the highest growth rate existed between a thickness of 20–30mm; the improvement in energy saving then reduced as the thickness increased. As a result, a 30mm-thick PCM layer is relatively economical.

The energy saving rate of the four orientations are illustrated in Figure 8 C4, and the result suggests that the energy saving performance was significantly better when the PCM was installed in the south wall compared to other orientations.

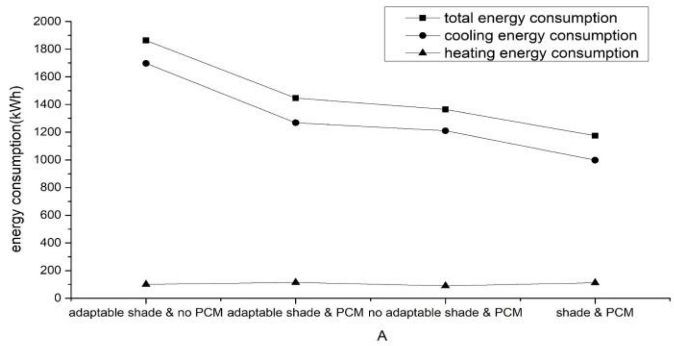
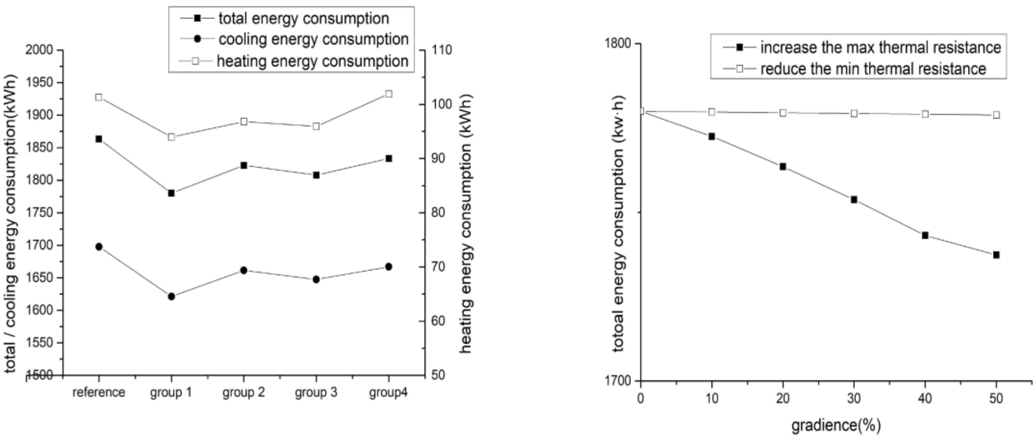


Figure 9. The effect on the energy performance of the building integrated with dynamic shadings and PCM.

Furthermore, Figure 9 shows the energy-saving effect of dynamic shadings and a PCM-enhanced wall; the combination of both can save as much as 36.99% in energy consumption.
Consequently, the building integrated with PCM made an obvious reduction to the annual energy consumption, the cooling load and the heating load in Xiamen. A phase-change temperature of 27℃ and a location of the inner side on the south wall were suggested, caused an energy saving rate of 26.80%. In addition, the energy saving rate could be further improved if the PCM-enhanced building also incorporated movable shadings; it could reduce its energy consumption by 18.82%, compared with the model that only has integrated dynamic shades.

Group D: Thermal Resistance



D1: Energy consumption of each test group.

D2: Total energy consumption with increasing/decreasing the max/min thermal resistance.

Figure 10. The effect on the energy performance of dynamic insulation in Group D.

The result displayed in Figure 10 D1 shows that all of the test groups had lower total and cooling energy consumption, apart from the heating load of Group 4, which was higher than the reference group, and the energy saving rates ranged from 2.19% to 4.49%. Xiamen is in a subtropical region where the cooling energy consumption takes up quite a large part of the annual energy consumption; therefore, the dynamic insulation envelopes can be seen as effective in reducing energy consumption. According to Table 4 and Figure 10 D1, the difference between the maximum and minimum thermal resistance in each group was positively correlated with the energy saving rate.

In Figure 10 D2, the reduction in energy consumption from increasing the maximum thermal resistance was much higher than that from decreasing the minimum thermal resistance. Accordingly, increasing the maximum thermal resistance is a more efficient method to further improve the performance of an adaptable insulation facade.

In conclusion, the dynamic insulation envelope controlled by the ambient air temperature has a certain energy-saving effect in Xiamen, with an energy saving rate of up to 4.49%, and the energy-saving performance can be improved by increasing the difference between the maximum and minimum thermal resistance. Furthermore, increasing the maximum thermal resistance is more beneficial for the optimisation of a dynamic insulation envelope.

CONCLUSION

In this paper, the energy-saving effect of the building in Xiamen was studied by numerical simulation, taking solar radiation, ventilation, thermal storage and thermal resistance as the controlling factors for the dynamic facade. It can be discerned from the numerical simulation that each of the four factors display a good energy-saving performance as variables to control the dynamic facade. The energy saving rate was 10.57%–30.19% with regulated solar radiation, and it was 53.16%–66.79% and 1.62%–4.49% for ventilation and thermal resistance, respectively. Buildings integrated with PCM and adaptive shadings can save up to 36.99% in energy consumption. Given the above, the most efficient energy-saving method is to adjust the ventilation, while the dynamic insulation facade offers the worst energy-saving performance.

Therefore, regarding the buildings in Xiamen, a dynamic facade with the means of controlling ventilation can save more energy compared to other facade types, followed by a facade that uses a combination of PCM and movable shades. Currently, dynamic insulation envelopes are still in the preliminary stages of development and better effects may be achieved through improvements in the future. Furthermore, the simulation and relative analysis in this study were based on single factor, so the energy-saving performance under a combination of multiple factors needs to be studied further.

ACKNOWLEDGEMENTS

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"DOOROOM": FROM THE DOMUS TO THE ROOM. RETHINKING LIVING TODAY AND TOMORROW

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INTRODUCTION

The body of the house hides within itself many transformations of its being.
From the autonomy of the wall passage with the use of reinforced concrete of the last century, up to the present day, where the Sars-Cov2 pandemic required the adaptability of its characteristics in a very short time, the house has undergone a silent and invisible revolution that it has progressively altered its image into something different, unclear and defined.
The paper summarizes a research focused on rethinking the private spaces of contemporary living starting from a physical and material reconstruction of the house which, from the functional analysis of its generative structure, identifies a winning strategy in the room and the starting point in construction and definition. of new spaces indispensable to the life of contemporary man.[1] The neologism "Dooroom" symbolically summarizes the stages of this story of conversion of the private room into a single place, a paradigm of living, to reveal what the homes and cities of the near future look like and what they will be.

A new domesticity

In the West, the residential heritage kept within the thick walls of historic cities has remained essentially the same for centuries. Yet the real signs of how much the idea of living has changed enormously today compared to only the beginning of the twentieth century is clearly visible as soon as you cross the threshold of many contemporary residences.[2]
Precisely within those internal and closed spaces (which for simplification of the lexicon we have trivially defined "private" to distinguish them from the external and open ones, "collective" and shared by all), living appears as a survival game that sees the contemporary man opposing the built. This phenomenon of resistance, which recognizes in the individual of the present (not immune to the dictates of global living) the overcoming of the concept of localism and territorial limits, strengthens the idea of a citizen more aware of his individuality but not of what the world outlines his body.[3] An attitude that makes even the most distant geographies and cultures close and similar and that, going beyond the idea of physical and material space, makes houses and cities indistinct entities.[4] Dense organisms where inside/outside, private/public are recognizable among the traces of the physical perimeters of the room. A place on the sidelines of the compositional and strategic processes of the city, albeit the only one to be truly perceived and recognized as indispensable.

The private room as a common good

No longer able to respond to the renewed needs of globalization, property owners and users have literally adapted the spaces available to them by modifying them in complete autonomy through uncontrolled actions which, in an attempt to make immediate gains, overshadow the functional and aesthetic with a clear decrease in housing quality.

Although these spaces, regardless of their size, have great potential, the new operational strategies to be applied on the body of the city should take this aspect into account, interpreting it as an opportunity. By not building the new, in fact, the free land can be used for other functions useful for improving the quality of human life outside the domestic space, which can be leveraged to strengthen the request for a substantial renovation of the home system.

Furthermore, by limiting the waste of energy resources and reducing the constructive action in practice, it is possible to respond to those principles of environmental, economic and financial sustainability, obtaining a satisfactory return that focuses on greater profit through less use of means (which makes it easier and streamlines its application also in the regulatory field). Enhancing the minimum spaces, with an adjustment of the quantitative or dimensional parameters based on standards that do not meet the needs of contemporary living, thus represents the first concrete step for the radical rethinking (in terms of distribution and functionality) of the living space.

WHICH HOUSE AND CITY FOR THE CONTEMPORARY MAN?

A delicate and difficult issue to address because the present[5] is a time in itself where many realities and imprecise models of space/house and space/city coexist that seem to find no point in common anymore. Although the city is an indisputable mirror of the inhabitants who live on the ground and its built spaces, it is visible to the eyes how in the last thirty years human life has changed with such rapidity that it does not allow the adaptation of places with the same speed.[6]

The increase in energy problems linked to the growth of the world population, industrial revolutions, technological progress, natural disasters, war conflicts, political changes and social struggles, migratory phenomena, global pandemics are just a compressed list of events that have determined some of the most evident alterations of public spaces and relationships,[7] in particular by influencing the construction of the domestic space.

Factors that radically change the places of life and people also affect the use of the web connection network in communication systems.[8] Moving social actions *en plein air* into virtual rooms, true refuges of the mind from reality, has never worried designers and experts in the sector who believed in the classic and eternal image of the city as an immutable heritage in the determination of the relational processes of the social animal. that only today is being questioned.

In addition, the pandemic gives us back a doubly different world, with an indistinguishable and still ongoing transformation.[9]

Faster than any other event that has occurred to date, the Sars-Cov2 pandemic shows us the importance of not underestimating the coexistence of physical and virtual spaces. Well separated concepts in the generative logic of the living space but currently indispensable for each other to ensure life and contact with the world outside.

The transformations summarized, clearly visible in the body of the house,[10] are crucial in understanding the significant change in the habitat of contemporary man who, in the internal and private physical construction of the room, identifies the symbolic and compositional element of living capable of declining the features and needs of the new space for the modern man.

ONLY ONE PROTAGONIST

It must be said that the room has always been an unconscious protagonist of the space, a true heroine of the architectural project.

To trace the compositional aspects and physical characteristics closest to our case it is convenient to start from the early twentieth century, in particular by focusing on the interpretative reading of the room in the work of Charles Eduard Jeanneret Gris, the original name of the Swiss Master Le Corbusier, where the use of specific elements and actions go beyond eras and architectural languages transversally reaching our days in the same way.

The image of the room with its compositional system seems more and more to spring from the interpretation of a shared ideal, a symbolic place from which the determination of the space to live starts.

The room in the past

The interpretative intuition of the room as a compositional element and generative matrix of modern living, in a completely unconscious way, coincides with Le Corbusier's journey to the East, a journey of knowledge that began in 1907 and ended in 1911.[11]

The visit to the Carthusian monastery of Galluzzo, a monastic complex located south of Florence on Monte Acuto founded by Niccolò Acciaiuoli in 1342, reveals to Le Corbusier how much the modern house should have been born from the symbolic interpretation of a casket.[12] A metaphor that identifies the need to live in a unique place where art, collective and private life come together to blend perfectly with the design of its spaces and furnishings. Not surprisingly, the characteristics of the monastic accommodation, a single block in itself closed and self-sufficient, with minimal surfaces designed to satisfy a sum of single individuals, led him to study the harmony between the internal and neighboring spaces of the room, adopting this idea of a functional-distribution system for its modern homes.[13] The incredible system of the housing unit of Marseille, or even earlier, the experiments applied to the prototype of the *immeubles villas* seem to derive from all this.[14]

Likewise, the meeting, which decreed the point of contact between past and present, took place on the ground of the city of Pompei, a Italy town at the foot of Vesuvius which in 79 AD. it was brutally destroyed by its eruptive violence.[15]

For the Swiss Master, in fact, the remains of the city of Campania revealed the essence of the generative principles of modern living and most likely the 5 points of architecture he celebrated and summarized in the Ville Savoye[16] project a later and mature phase. Starting from the distributive composition and the symbolic arrangement of the houses of the past (based on the functional power of the room), the archaeological site of Pompeii is a direct testimony of the evolutionary genesis of living. From the remains of the Roman domus that unites the principles of the ancient Italic domus to those of the Greek house, it is possible to reconstruct in the city of Pompeii, four centuries of development of the private house. This was built with a planimetric system that placed the functional aspects of collective and social life at the center, in indoor and outdoor areas called *atrium* and *peristilium*, while the *cubiculum*, located around the common heart, were the private rooms where the body rested. and lies while spending time devoted to oneself.[17](Fig.1)

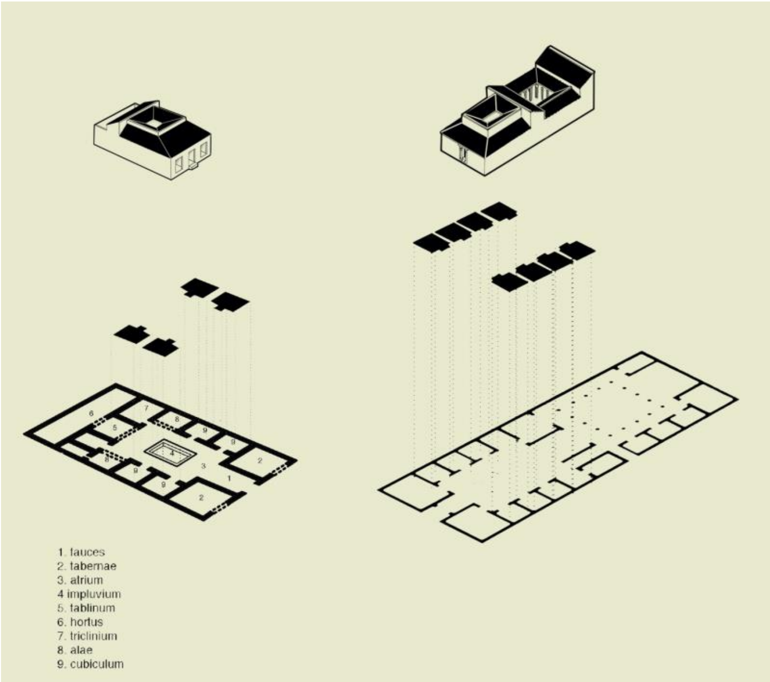

Figure 1. Planimetric diagram of the Italic house and the Pompeian house with the identification of the private rooms

From the idea of autonomy and the need to separate public and private functions launched by Le Corbusier's theoretical writings to the scientific community, the twentieth century becomes the temporal place in which the interpretative need for private living emerges with the attempt to define objective parameters useful to prefigure the image of places suitable for the life of modern man.

Trying to summarize as much as possible what happens in parallel, it is necessary to mention the reasoning on living linked to the experience of the early twentieth century *Existenzminimum*[18] where the room is at the center of a debate based on the concept of standardization of living its useful surfaces are essential, focusing attention on an idea of the quality of the space that for the first time is openly independent of its size.

In the evolution of compositional processes related to residential living this idea returns in many authors of the last century where there is really a lot of literature. Just think of the architectures of famous exponents of the Modern, such as Gio Ponti, Franco Albini, Richard Buckminster Fuller, John Hejduk, Pierluigi Spadolini, Marco Zanuso, just to name a few, up to becoming a specific research in the work of Antonio Monestiroli, Giuseppe Pagano, Joe Colombo.

The 1972 exhibition celebrated at MOMA *Italy: the new domestic landscape* curated by Emilio Ambasz[19] is the terminus in which to identify the point of maximum research that over the years and for the first time combines design and architecture in an attempt to tell the new domestic rituals in the renovated private space of the house.

The room in the present

Living in your home and your own private spaces no longer means living only inside a well-defined surface. Over the years, contemporary man seems to have shifted the concept of living from the home to the city, delegating the performance of some primary functions and other actions of living to the spaces offered by the latter.

The possibility of using the services and all the opportunities for relationships that the city offers in the outdoor spaces or near the house is one of the reasons that induces people to give up large private spaces. A room of a few square meters, in fact, is able to satisfy the needs of a young audience willing to share, an attitude that mainly brings together the new generations and young families who fall within the age group between 20 and 40 years.

The ideal imagery of the room, as a symbolic place of perfect living, has been transformed into the creation of the latest generation of housing types, such as tiny-houses, student-hotels or collective housing, structures of a certain charm recently built on the ground of several Italian and European cities.[20]

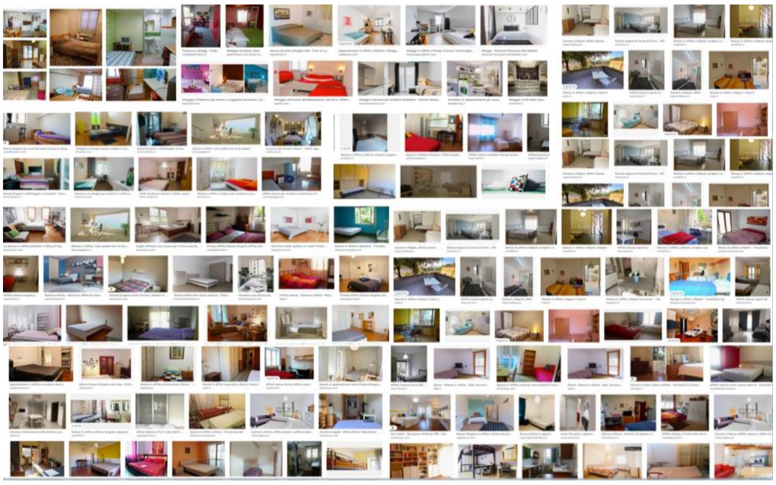

Figure 2. Images of private rooms rented as accommodation for students or young families in Italy.

Hybrid housing types, which work on the composition of spaces by reinterpreting the distribution structure of a monastic accommodation, where private and public spaces are well located, furnished and equipped with all comforts, with the aim of satisfying the most diverse needs of their users.

Alongside the new buildings designed according to the downsizing of private space, the economic and easy-to-manage logic that sees the compartmentalization of large-sized housing units into smaller accommodations, identifies an important trace and one of the largest and most significant transformations of the living space, in the last thirty years, it has taken over by questioning every distributive and functional logic of the home space consolidated in the experience of the Modern (Fig.2).

The large number of houses halved by the owners due to the impossibility of management[21] and the new constructions with housing that have ever smaller surfaces, are the symptom of a slow change of living, hidden in the walls of the historicized city, based on obsolete quantitative standards and no longer responding to reality.

Changes that mostly involve metropolises such as Milan, Rome, Naples, through methods that, by similarity, link the Italian experience to that of many similar European cities due to the high population density within highly historicized urban centers.[22]

The room in the reality of Italian and European cities and the habits of the new family

In recent years, following the increase of a strange migratory phenomenon, which involves young people (especially students in training or workers), it has emerged that the choice of cities to live in is based on the offer of better social services and services, not excluding the compromise or the possibility of facing the difficulties of living together with strangers.

The houses of the past, the large noble apartments of considerable size that became unmanageable following the strong economic crisis after 11 September 2001, are fragmented, becoming containers of small private rooms where autonomous realities and micro-communities of individuals share the ancillary rooms, often, in precarious conditions.

These transformative actions, while not compromising the solidity or aesthetics of the building from the outside, affect and undermine the quality of those who experience the spaces from the inside.

For this reason it is necessary to pay the right attention and implement a coherent and effective programmatic action in the construction of a process for an adaptation project that regulates the development of this phenomenon now widespread on a large scale.

The lack of a shared policy at the European level does not standardize the issue of housing, becoming one of the crucial points that should be discussed at the international level.

Each member state regulates the characteristics attributed to the residential space (new construction or not) according to its own rules and provisions, demonstrating how ineffective it is to speak of domestic reality in response only to quantitative aspects.[23]

Furthermore, the time spent in the home is increasingly limited.

In fact, it is estimated that a family with average social status, made up of 4 people (two working parents and 2 children aged 6 to 18) spends no more than 8/10 hours a day in their home.[24] (Fig.3)

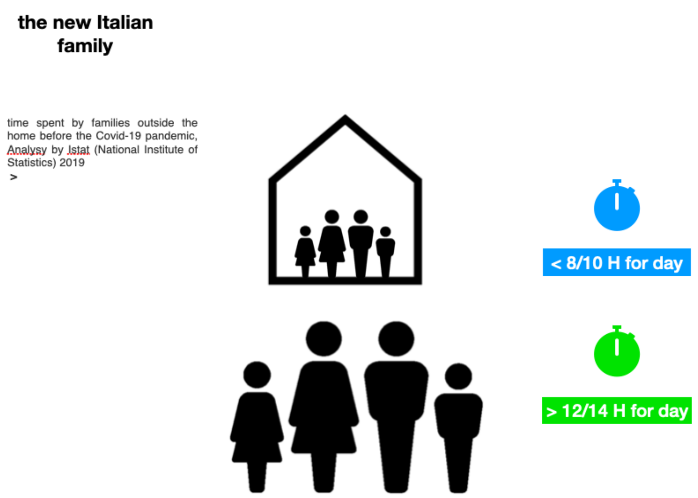

Figure 3. Time spent by Italian families outside the home before Covid-19 pandemic. Istat, 2019

Hours that coincide with the nocturnal band of the physiological need linked to daily rest. Furthermore, surveys on current behaviors and preferences clearly show that people consider the social experience outside the home to be more important, lived in the relational spaces entrusted to the city or on the social platforms of various renowned networks.[25]

A further and significant change concerns the composition of households. More widespread in Europe and, with a significant increase in Italy, the modern family is reflected in couples with a maximum of one child, revealing the significant increase in single-member families[26], composed of only one member (mainly singles, widowers, newly separated and workaholics). (Fig.4)
A not just dissimilar fact emerged following the Western trend as well. In United States of America, in fact, these types of families represent respectively 20% and 30% of the population, and the data shows a growing trend.

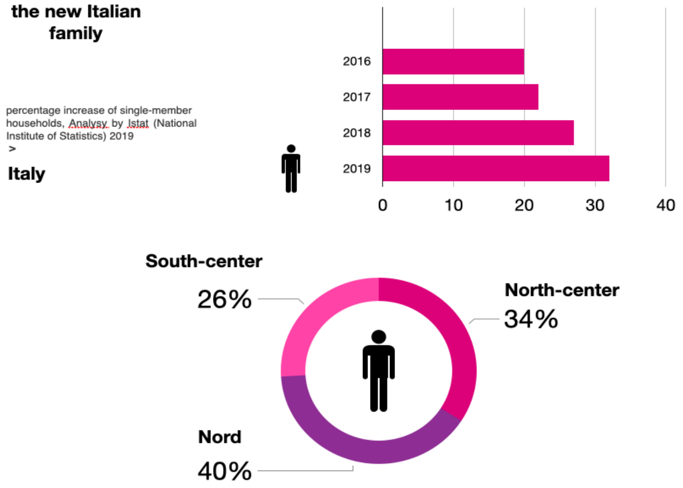

Figure 4. Single-member households in Italy, Istat data 2019

DOOROOM TO RETHINK LIVING

The neologism *Dooroom* identifies that private place no longer just a house or room, in need of an ideological and physical renewal of living. A new name, suitable for explaining what and how the home of contemporary man should be.
First of all, it is important to consider the possibility of enhancing the functionality of the home space through the correct composition of its environments, interpreting the minimum size as an opportunity. Objects and furnishings should be arranged according to the relationship between body and mind, listening to emotional and psychological factors deriving from embodies cognition.[27]
The idea of working on the existing, reformulating the distributions of the internal spaces of apartments already built, can be the quickest attempt to put an immediate response to the needs of the contemporary inhabitant, taking into account a design application based on a program precise intervention that start from the buildings built and consolidated, actually, the most lacking and in need of an accommodation suited to the needs of the people, to then move on to new buildings.
Designing every minimum space looking for the maximum functional performance thus becomes a necessary and indispensable warning.
In addition, the home space must include the insertion of a point of contact with the outside world through balconies or loggias especially, when these are missing.
Therefore, it is necessary to equip the houses with what is lacking because the individual needs to carry out outdoor activities, work or establish a new form of contact with the neighborhood, even more useful actions when the city becomes inhospitable or is forced. necessarily to limit the use of its spaces.

The room, in its compressed dimension but in a rearrangement that takes into account the well-being of the body and mind, can demonstrate its great potential in its addition and define a self-sufficient macrostructure also from an energetic point of view, where well-being it belongs to the single inhabitant but also leans towards the idea of social comfort.
Rooms / houses of 8, 16 and 25 square meters thus become pauses between collective spaces managed by private entities in which to limit the sense of material possession and private property of users (as Plato stated the worst evil of those who live in society).
And these principles were applied to the "Dooroom: the city / house" project where an inhabited wall of rooms circumscribes blocks of 104 x 104 meters, taking up the theme of the Agricultural city[28] designed by Kisho Kurokawa in 1960, transposed, however, to the urban dimension and contemporary reality for what concerns internal functions and distributions of private space.
Retracing its historical traces and reverberations in the present, the room clearly becomes the primary element-structure of contemporary living. It starts from there to activate the first attempt to respond to the need to compose the new living space based on new life needs.
For this reason, *Dooroom* represents a model of design direction useful for reconsidering the space of man with its renewed gestures, where proxemics and haptic perception are further guides in the redetermination of space for contemporary man.

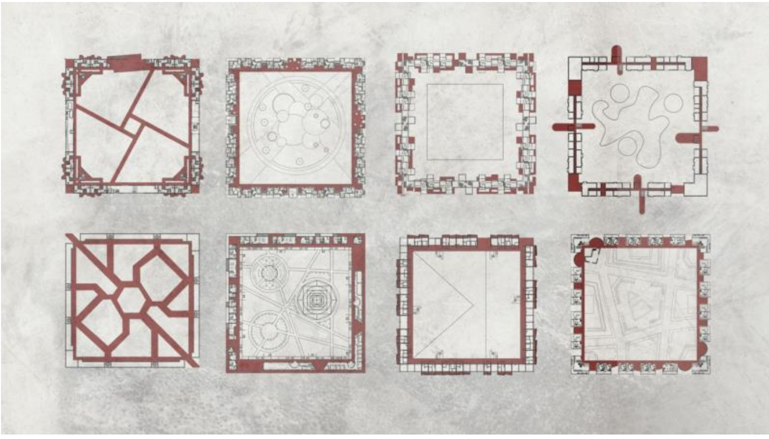

Figure 5. "Dooroom: The city house" planimetry. Theme of the Laboratory of Architectural design 2020/2021 directed by Prof. Maria Gelvi with the students of the Department of Architecture and Industrial Design of the University of Campania L. Vanvitelli

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[1] Maria Gelvi, "Elements and neologisms of contemporary living for the construction of the space of the present*"* in *VIII Proarch forum the architecture project as an intersection of knowledge for a renewed notion of heritage* ed. Alberto Calderoni, Bruna Di Palma, Antonio Nitti, Gaspare Oliva, (Neaples: ProArch Società Scientifica nazionale dei docenti di Progettazione Architettonica SSD ICAR 14,15 e16, 2020), 1284-1287.
[2] On the whole of the significant changes in the city and the house and on the role of architecture see Serge Latouche. Marcello Faletra, *Hyperpolis. Architecture and capital* (Milano: Maltemi editore, 2019).
[3] Cfr. Zigmunt Bauman, *Longing for community* (Roma-Bari: Laterza edizioni, 2001).
[4] Cfr. Kevin Lynch, *The image of the city* (Venice: Marsilio edizioni, 2018).
[5] On the concept of space and time in the present, see the volumes by Sigfried Giedion, *The eternal present: the origins of architecture*, (Milan: Feltrinelli, 1969); Enrico Bonadei, *Time does not exist* (Milan: Giuliano Landolfi publisher, 2015); Rossano Baronciani, *Time does not exist. Man in the eternal present* (Florence: Effequ, 2020)
[6] Cfr. Yona Friedman, *The architecture of survival. A philosophy of poverty* (Paris: Bollati Boringhieri, 1978).
[7] Cfr. Eric Hobsbawm, *The Short Century 1914-1991* (London: Penguin group, 1994).
[8] Cfr. Deborah Lupton, *Digital Sociology* (London: Pearson, 2018).
[9] "Coronavirus, we will never go back to normal. Here's what life will be like after this pandemic: the analysis by MIT in Boston ", Ilaria Mauri for Il Fatto Quotidiano, accessed 20 March 2020. https://www.ilfattoquotidiano.it/2020/03/20/coronavirus-non-torneremo-piu-alla-normalita-ecco-come-sara-la-vita-dopo-questa-pandemia-lanalisi-del-mit-di-boston/5743121/
[10] The appropriate definition of home and its importance in human life derives from an intuition of David Benjamin that the home is «the physical structure and the spatially localized, temporally defined, significant and autonomous conceptual system for the , the transformation and interpretation of the physical and abstract aspects of daily domestic life on multiple simultaneous spatial-temporal scales, normally activated by the connection to a person or a community such as a family unit ». David N. Benjamin, *The Home: words, interpretations, Meanings, and Environments* (London: Avebury, 1995).
[11] Giuliano Gresleri, *Le Corbusier travels to the East. The unpublished works by Charles Eduard Jeanneret photographer and writer* (Venice: Marsilio editori, Fondation Le Corbusier, 1985).
[12] Ibid.
[13] Charles Edouard Janneret-Gris (Le Corbusier). *Vers une architecture* (Paris: ChampsArts, 1923).
[14] Soline Nivette, *Le Corbusier et l'Immeuble-villas. Stratégies, dispositifs, figures* (Paris: Mardaga, 2011)
[15] Verena Lindtner, *Il Vesuvio - Un Vulcano Nella Letteratura E Nella Cultura* (Berlin: GRIN Verlag, 2008).
[16] Jacques Sbriglio, *Le Corbusier. The Villa Savoye* (Basilea: Birkhauser Architecture, 2008).
[17] Maiuri Amedeo, *La casa pompeiana. Struttura, ambienti storia della magistrale descrizione di un grande archeologo* (Naples: Procaccini, 2020).
[18] Alexander Klein, *Lo studio delle piante e la progettazione degli spazi negli alloggi minimi. Scritti e progetti dal 1906 al 1957.* Curated by Matilde Baffa Rivolta, Augusto Rossari (Milan: Mazzotta, 1957).
[19] Emilio Ambasz, *Italy: The New Domestic Landscape Achievements and Problems of Italian Design* (New York: MoMA The Museum of Modern Art NY, 1972).
[20] On the theme of the small house, the volumes by Lloyd Kahn, *Shelter* (London: Pubns, 1973). Sarah Susanka, *The Not So Big House, A Blueprint for the Way We Really Live* (London: Taunton Pr, 2009). Lester Walker, *Tiny Houses. Designs for 43 Tiny Houses* (Overlook Books, 1987). Furthermore, it is worth remembering the small mobile home project created by Jay Shafer, a 9 square meter accommodation that leads him to found two of the world companies focused on the enhancement of living in small dimensions called respectively "Tumbleweed Tiny House" and the "Four Lights Tiny House Company"on September 6, 2012.
[21] "Homes as an investment: the rent pays off the installment, but watch out for other expenses" Paola Dezza for Il sole 24 ore, accessed 7 November 2019. https://www.ilsole24ore.com/art/case-come-investimento-l-affitto-ripaga-rata-ma-occhio-altre-spese-ACuV6ur
22 "Eurostat report on the quality of life in European cities conducted in 2019" European Commission, accessed 5 March 2020. https://ec.europa.eu/regional_policy/en/information/maps/quality_of_life
[23] "Housing Policy in th EU member states" Directorate-General for research, Working documents, Social Affairs series W-14, European Parliament, accessed 5 February 2015. http://www.europarl.europa.eu/workingpapers/soci/ w14 / text1_en.htm

[24] For further information, please refer to the publication of the report conducted by Istat: National Institute of Statistics in Italy entitled "The times of everyday life - Work, reconciliation, gender equality and subjective well-being" (Rome: National Statistical Institute, 2019).
[25] Ibid.
[26] To deepen the theme of the family in Italy, it is possible to consult the analysis conducted by the IREF Institute of Educational and Training Research curated by Federica Volpi "The true face of the Italian family: a story through data" (IREF: 2019) where analyze the data developed from Istat for the year 2019.
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[28] This utopian project by the Japanese metabolist architect Kisho Kurokawa was exhibited at the "Visionary Architecture" exhibition at the MoMA, Museum of Modern Art New York from 29 September to 4 December 1960

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DEEP-CITY LIVING IN A SOFTWARE-BASED SOCIETY

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INTRODUCTION

Architecture at all period aims to create lasting solutions. To this end, new materials and new spatial arrangements are invented from time to time. Durability in ancient times meant solid and robust constructions, thick walls which resist stress. As opposed to today, when durability means the maximum of flexibility, with the less possible rigid structures. Architecture wants to create configurable solutions, but not evanescent. The challenge lies in the durability for future times; otherwise, customisation could have been understood as temporary or provisional. The triplet of Vitruvian architecture principles - usability, beauty and durability - besides other qualities has already emphasised long-lasting, which significance has altered during the epochs. (Fig.1.)

Industrial building techniques led to the free plan as the highest resilience of the space. Now computational design together with industrial construction techniques provides further opportunities towards customisable interiors. In terms of the exteriors, investigating the dynamics of the whole building, the initiatives are rudimentary. Today two waves emerge. One is looking at static systems' resilience, while the other seeks the solution in dynamic arrangements. The tools given by robotic production opens excellent perspectives for the later one.

Deep-city shows how computation and information interweaved settlements result in a different level of resilience with more integrated social patterns. Significant historical events trigger the development of technology, besides accelerating the acceptance and adaptation of novel ideas. Today living in the digital revolution’s epoch, the Coronavirus pandemic accelerated digital technologies' implementation even for the hitherto sceptics. This essay focuses on the spatial transformations dependent on information technologies in two related levels: building scale and urban scale. How building scale architectural typologies today become patterns arranged by information. Together with how these patterns become the element of a broader network of deep-cities, where deep echoes deep-learning algorithms used for circulating Big Data processing.

Figure 22. Vitruvian pillars of architecture

CITIES AND INFORMATION

Today's urban life became immensely saturated by information transmitted by digital platforms, due to the ubiquitous availability of internet distributed data throughout all possible locations in the city. The access and share of digital information are no longer done at a limited number of privileged locations at definite periods, but now actually possible everywhere and anytime. Deep-cities based on data circulation requires new typologies.

The modern industrial city plans to inhabit cars were designed for mobility and transportation with wide motorways and closed building blocks. Today we also started to inhabit technology and information, parallel with green, sustainable and environmentally friendly solutions. Suppose all vehicles go electric and become driver-less and software-lead, while people will have everything locally. In that case, there will be no need for daily routine transportation, only for long-distance locomotion. Current urban settlements are instead organised by digital patterns, which might replace traditional typologies. The borders of precise building classification are blurring, and new multifunctional arrangements are evolving.

Deep-city shows how can information reorganise urban settlements equally in physical and virtual dimensions in the era where technology and artificial intelligence dominates. Deep cities such as deep-learning contain multiple layers between the input and output. (Fig.2.) Deep learning as a sub-set of machine learning operates based on artificial neural networks. The system's simplified structure illustrates how raw input data transformed into higher-level information through in-between layers, similarly to how information is processed in biological systems. Deep-cities are complex systems based on physical spaces enriched with various computational data. Where the data processing software influences the social logic of space embodied in various platforms. In these augmented environments, spatial geometries and focal points lead the GPS navigation for optimised suggestions instead of instinctive bio-navigation.

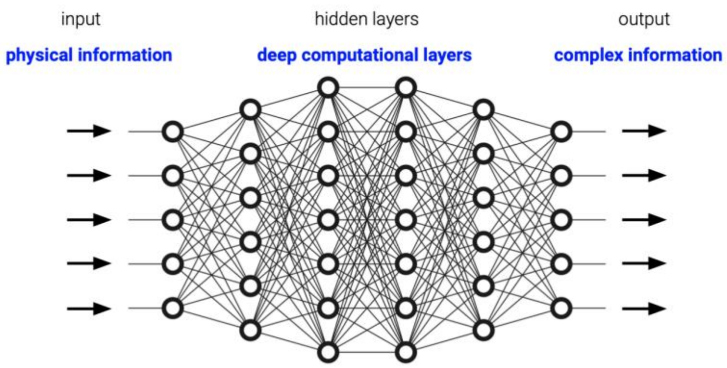

Figure 23. Deep-learning neural network.

Cities interweaved by information besides complex morphologies results in more integrated social patterns. Information as structured data is the basis of deep-networks. Networked units are ubiquitous, from interacting proteins in cells to neural connections in the human brain or social relationships in virtual platforms, such as Twitter or Facebook. They provide a useful tool to model complex systems whose interacting constituents give rise to emergent behaviour which can not be caused by single units separately.

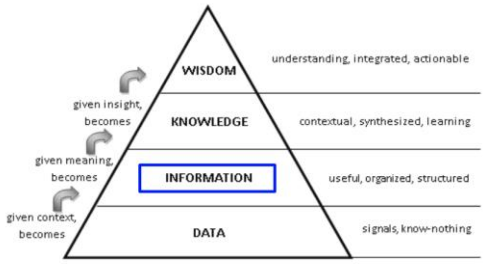

Figure 24. Information as structured data.

MULTI-BUILDINGS

The components of urban settlements are buildings, which structure and logic determine the city's whole operation. The phenomenon of multipurpose buildings is not the direct result of digitalism, but rather the result of how digitalism changed human attitude to the physical world. Having quasi every belonging on our smartphones, we do not reserve space for divided functions; today we have a place for plenty of features. Humans got used to multitasking and variability with the omnipresent information, which also embodies in the physical environment, where multipurpose buildings came alive. Nowadays, it becomes more common to build multicultural centres, including a museum, theatre, conference hall, cinema, café or restaurant.

Multifunctionality resembles data processing logic, where not the data travels for being examined, but processing algorithms visit the static data sets instead. Researchers say what data science does with data, instead of moving data from one place to another, data scientists inbuild the examining processes into data sets; thus, it becomes less time-consuming and more cost-effective evading data's continuous movement.[1] It is already implemented in the car industry where instead of investing new vehicles (hardware), remote updates keep the cars up to date. Following this logic, one way of achieving resilience in buildings is not to be rebuilt, only reorganised based on current needs.

By AI and Machine Learning, computers use the methodology of finding patterns and similarities for navigating in massive data sets, rethinking the human logic of categorising. Typologies were made for a better human understanding of buildings. In The Alphabet and the Algorithm, Mario Carpo[2] points out that usually, people create categories and systems to categorise and systematise their elements, whatever the situation is. Which contradiction was also highlighted by Nicholas Negroponte[3] when he wrote: people think generalities, machines in particular pieces. Which argument might be a little bit extended today by Harari, as machines think in the network of particular pieces.[4] This zeitgeist approach will change how we treat buildings in their physical embodiment, such as their virtual extension.

Looking at a particular example, libraries perfectly mimic the current attitude to information processing. A traditional library with its catalogues and endless bookshelves made a canon and grouping of the most relevant written information. At the same time, today's libraries provide access to the world wide web and physical space for undisturbed deepening. In a multifunctional building, the sorting principle becomes the information. The common set of technology, society and ecology physically is the evolutionary successor of the library. In the Post-Anthropocene, it is still essential to create multipurpose spaces where the previously sharply divided functions can operate together. For instance, Techrary – the notion created by the fusion of technology and library - can function as a mediator between history, present and future at a period without time (Fig.4.). Data sharing, information and knowledge have one common root, which physically can turn into the one most important public space of the city extending its virtual borders planetwide.

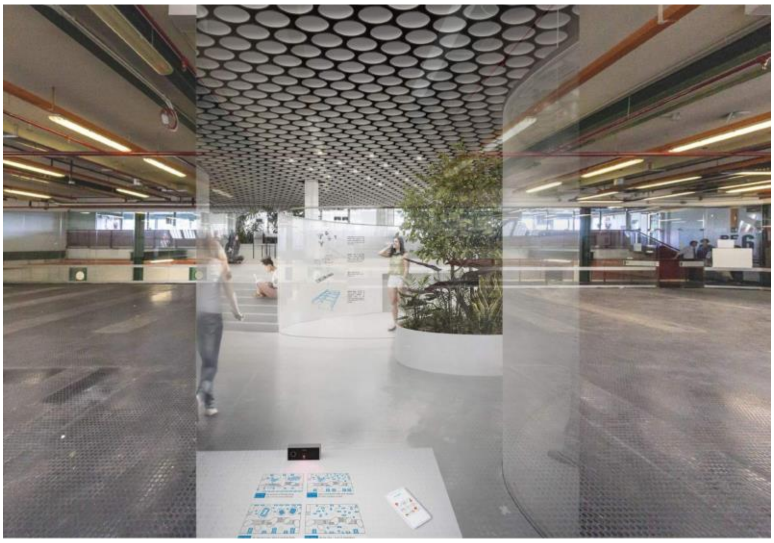

Figure 25. Techrary.

Multifunctional spaces this way can not only blur the borders of different functions, but they can also extend the physical space into virtual. Binary spaces might come to alive as digital twins. Since a digital twin is a virtual representation of a physical object or system across its lifecycle, using real-time data to enable understanding, learning and reasoning[5], the updates are guaranteed and provides new perspectives of the building experience. Thus information spaces can mediate resources between every domain, leading to the realisation of deep-cities.

DEEP-CITY AND SOCIAL NETWORKS

Multifunctional buildings are the phenomena of urban settlements. Today 3% of the earth's surface is occupied by cities and 97% is not, whilst 55% of the world population lives in these urban areas, by 2050 it might be 68% - which increases the spatial and social challenges of urban living.[6] At the same time, the facts of today questions the further relevance of globalisation on multi environments. Isolation, sovereignty and individualisation are particularly fostered by the COVID19 pandemic, where the sharing economy might get a new interpretation. Social solitude might increase in the next decades when people live in urban settlements but in a segregated form.

Ecological impact of the information society might be examined in terms of technological revolutions. After the industrial revolution, the increase in food production and delivery led to advanced urbanisation. New living models and strategies for inhabiting an urban context over a broad expanse of 30 years is a challenging question. Today one standpoint considers homes as temporary facilities, which might only serve as recovery points instead of a Cartesian coordinate system's constant origin. Furthermore, the area, which is home at night, might transform to co-working area inhabited by strangers during day time, like the ALIS project of UCL Computation lab. (Fig.5.)

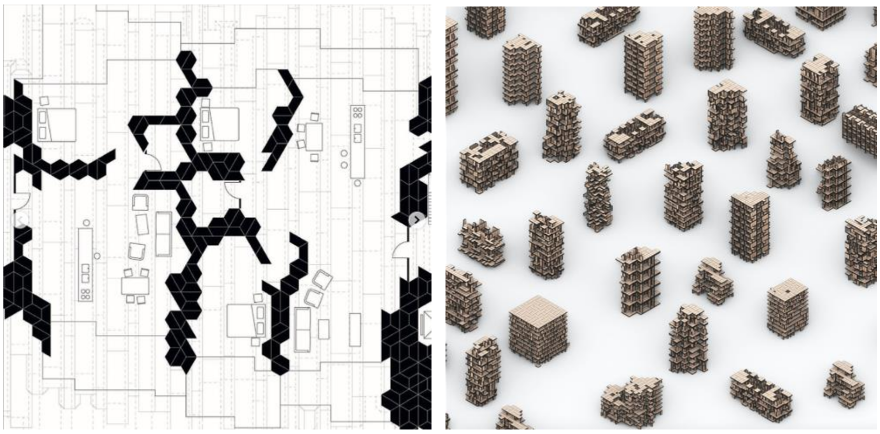

Figure 5. Organic floor plan of discrete elements. UCL AUAR Lab, Plan drawings from "Autozoid" (Justin Yuk Pong Hui, Liam Kuhnell, Prisca May Yan Kwan) Source: gillesretsin.tumblr.com, 2020

Living and working were situated in separated urban areas, but the differentiation eliminated with the spread of the internet. From the humanistic approach, the living must be at some point, separated from working and production. Home is the only place which is not necessarily connected and affected by digital tools even if this statement is not entirely accurate considering IoT. The omnipresent internet provides connection everywhere. Today such as remote learning and remote working is easily manageable if we utilise the adequate platforms. Platforms are a newly predominant type of business model premised upon bringing different groups together. Facebook and Google connect advertisers, businesses, and everyday users; Uber connects riders and drivers, and Amazon and Siemens are building and renting the platform infrastructures that underlie the contemporary economy.[7]

Benjamin Bratton in The Stack[8] a comprehensive political and design theory proposes a six-layer system of the User, the Interface, the Address, the City, the Cloud and the Earth. This is a horizontal arrangement and a vertical stack, which leads to planetary-scale computation network. *The Stack* is an interdisciplinary design brief for a new geopolitics that works with and for planetary-scale computation. Interweaving the continental, urban, and perceptual scales shows how we can better build, dwell within, communicate with, and govern our worlds.

The physical environment guided human networks for a long time. Now, these built guidelines become secondary or even tertiary as Bratton says. Software and algorithms in the form of different platforms are more influential today, then typological urban patterns. Thus urbanisation not necessarily means the growth of population and bigger cities but might indicate a complex network system.

In a deep-city, the development of the network from a centralised organisation has become distributed. The role of social networks in natural resource governance: What relational patterns make a difference? Network theory is the representation of either symmetric relations or asymmetric relations between discrete objects. (Fig.6.) Deep-cities are multi-layered systems, from the micro-scale to the mega-scale, which in terms of architecture relies on customisable buildings resulting in dynamic urban patterns. Technological development, computation, and big data are defining urban arrangements, which are resilient and sustainable instead of constant.

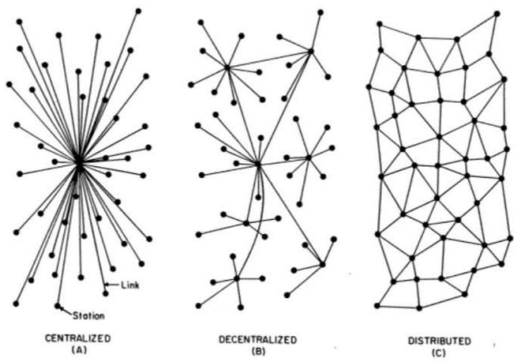

Figure 6. The evolution of networks from centralized to distributed.

SOCIAL LOGIC

Architectural trends show such a diverse perception of the urban scale. Rem Koolhaas offers the countryside to be the future, in terms of fully desurbanisation. At the same time, Doxiadis[9] proposed planetwide city in Ecumenopolis in 1968, which might be synthesised in deep-cities a software-based sustainable solution. To quantify and examine urban social patterns, one of the most well-known methods is space syntax.

Space syntax is the title given to a set of mathematical and computational theories and techniques for analysing an architectural or urban plan's social and cognitive characteristics. Several of the most famous of these techniques convert the spatial properties of a plan into a graph. After that, graph theory is used to derive various measures interpreted in the context of the original plan or against benchmark data for particular building types.[10]

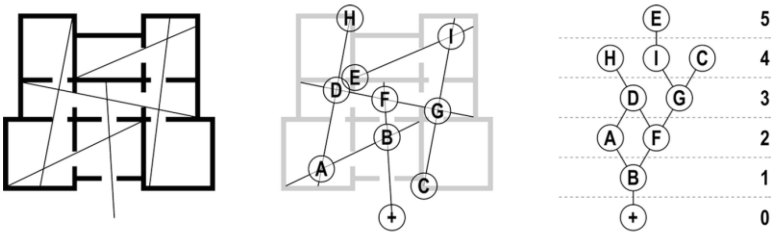

Figure 7. Space Syntax Analysis.

This approach looks back on the morphological qualities of spaces, and the results do not necessarily overlap with results of the statistical results of human questionnaires. Human responses sometimes nominate distinct places to gather or more frequented locations to pass through. This contradiction is especially meaningful, proof that physical patterns cannot be matched anymore with social patterns.

CONCLUSION – INVESTIGATIONS OF THE FUTURE

In a software-based city, the production is fused by the outstanding advancements in areas of mobile communication, big data, AI, blockchain, cloud computing, facial recognition, robotics, quantum computing, nano- and biotechnology, which conditions spark several innovations, such as identical copy made by 3D printers, virtual and augmented realities, smart cities, drones and self-driving cars. Predicting the future is a tough question. Charles Jencks' evolutionary timeline grant a detailed overview of the past 100 years and predicts politics, economics, social, medical and cultural discoveries until 2050. He says that forecasting is a strange and fascinating art. Mixes divination and existing trends into an unlikely cocktail.[11] Based on unforeseen biological catastrophes, humankind's task in the next decades will be to protect the planet, which might lead to the countryside's redevelopment, as Rem Koolhaas suggests in his current MoMa exhibition. Mixed-use cities must remain hubs for collaboration, while automated machine-landscapes would serve production and countryside to recover humanity.

The emergence of deep-cities interweaved by digital patterns are a big challenge for architects, who socialised in the era of physical building design. It becomes necessary to consider the invisible software-based patterns as well, and the balance of the physical and digital becomes more urgent than ever.

NOTES

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[8] Benjamin Bratton, *The Stack. On Software and Sovereignty* (Cambridge, MA: The MIT Press, 2015).
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EXPLORING THE DISCONNECTION BETWEEN SMART CITY POLICY AND PRACTICE AND SOCIAL INCLUSION AMONGST OLDER PEOPLE

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INTRODUCTION

In response to the challenges of rapid urbanisation and ageing populations, innovative and creative urban solutions are required. The smart city agenda has been a key policy driver in recent years, aimed at delivering urban interventions and assets and resources that support quality of life.[1] However, research has critiqued the implementation of smart cities, suggesting a largely top down approach which has failed to deliver on individual, social and community wellbeing outcomes.[2] At the same time, there has been an ageing-in-place policy driver, focused on how we can support the delivery of age-friendly cities and communities which enable people to live at home and in their communities as they age through improved: transport, housing, social participation, respect and social inclusion, information and communication[3], outdoor spaces and buildings, community support and health services, civic participation and employment. In bringing these two agenda together, there has been a lack of research exploring the translation of smart city policy rhetoric into the delivery of improved social outcomes at a city and community level for older people.

This paper aims to contribute to that discussion by exploring the notion of social inclusion and the smart city amongst older people in China drawing upon semi-structured interviews with older people and professionals in the smart city of Chongqing. The findings identified a series of disconnects between the experiences of older people and professionals in terms of how social inclusion, participation and the age-friendly cities and communities agenda is supported in a smart city context. We use these findings and disconnects to identify recommendations for policy and practice including the need for a more a coordinated and integrated approach to addressing ageing and social inclusion within the smart city agenda. This points towards the need for more cross-sectoral approaches but also a clearer alignment between age-friendly policy and smart cities if our urban areas are to embrace technological innovation on the one hand, whilst ensuring that older people are afforded the assets and resources to age well.

AGEING, SMART CITIES AND SOCIAL INCLUSION

Our cities are facing unprecedented urban challenges compounded by the COVID-19 pandemic, which has resulted in increased health and wellbeing challenges across the world, raising pertinent discussions about how to design urban environments that best meet the needs of its citizens. [4] In recent years, the role of technology and smart urbanism has played a fundamental role in addressing some key urban challenges e.g. transport, mobility, housing, employment[5]. The smart city concept has gained increasing traction, emphasising the collection, analysis and interpretation of data using Information and Communication Technologies (ICTs) to make better informed decisions in urban planning policy and practice.[6] A central part of these smart city agenda is delivering citizen-led change, the empowerment of communities and improved quality of life.[7] Globally, China has been at the forefront of attempts to deliver smart cities as a means to address key urban challenges.[8] Since 2013, the Chinese government unveiled a programme to build a hundred smart cities, towns, and districts while launching a surfeit of polices to support smart city development.[9]

Whilst smart city growth has grown exponentially in China,[10] debate has emerged as to the extent to which smart urbanism can address social challenges, in particular as the ageing population has become a critical strand of social policy in the country. In China, by the end of 2019, the number of people aged 65 and above constituted 176 million, accounting for 12.6% of the total population.[11] In supporting an ageing population, the concept of social inclusion is seen as a vital dimension of the age-friendly city agenda, underpinning the drive towards 'ageing-in-place'[12] i.e. the ability remain living at home, independently and with a high quality of life[13]. The concept of social inclusion focuses on ensuring older people can achieve their full potential in life;[14] addressing equity, rights, social cohesion and participation and engagement. Social exclusion and isolation continue to have detrimental impacts on health and wellbeing outcomes amongst the ageing population resulting in lower levels of active ageing, fewer opportunities for social participation and withdrawal from community life.[15]

In ensuring smart cities can fulfil their potential in supporting an ageing population, there is a need to consider the experiences of older people and their role in shaping the smart city agenda. To fill this gap, he aim of this paper is to critically explore the challenges and barriers in delivering smart cities that address social inclusion in later life from the perspectives of older people and professionals (including city and local government, technology companies, health and social care services, and the third sector).

RESEARCH DESIGN AND METHODS

This paper presents data collected as part of a PhD study exploring the impact of smart cities on social inclusion among older people living in urban environments. The study undertook a case study approach across three diverse communities (with varying population densities, ageing demographics, income levels, and smart city interventions) in Chongqing, China, to capture older adults' experiences of living in a smart city. Chongqing is located in western China with a population of 31.24 million (as of 2019), and is one of the municipality cities in China. The number of older people over 60 years old in Chongqing has reached 7.21 million, accounting for 21.1% of the total population.[16] The city of Chongqing was chosen as one of the key cities to develop the smart city concept and the city government launched a master plan for supporting Chongqing's smart city development. This has included, for example, plans to develop an 'Artificial Intelligence (AI City)' as the new centre of innovation for China.[17]

The research adopted a multi-methods approach, including semi-structured interviews, walking interviews and focus groups, with a total of 64 older people (age range 60-90, mean age 72.57, 39 female and 25 male). A further 46 semi-structured interviews were undertaken with professionals involved in either ageing policy and practice or the delivery of the smart city agenda, including city government, service providers, private companies and social care providers.

All audio recordings were transcribed in both Chinese and English and then thematically analysed in NVivo 12 using an approach adapted from Braun and Clarke.[18] Initially, the transcripts were read and re-read by the PhD researcher to gain familiarisation with the data. After reading the transcripts, the second phase involved identifying the preliminary codes in response to the research questions. The next phase involved finding repeated codes as well as sorting codes into potential themes. The stages were repeated, and themes were reviewed until all the transcripts had been analysed leading to the development of the thematic framework. Subsequently, the researcher (in collaboration with the supervisory team) organised the themes, renamed and refined some of the themes, before finalising the overall thematic framework.

The next section of this paper reports on a subset of the key themes that emerged from the research in respect of exploring older people's experiences of social inclusion and the delivery of smart cities including: Differing Perspectives of Social Inclusion; Perceptions of Public Participation and Empowerment; and Integrating Age-Friendly and Smart City Policy and Practice.

FINDINGS

Differing Perspectives of Social Inclusion

When discussing the notion of social inclusion within the context of the smart city, there were different interpretations between older people and smart city policymakers/practitioners. Older people conceived the concept of social inclusion as a process of engagement, which constituted participation in social and community life and inclusion within the wider community. Older people identified a number of key domains which they felt were important to their social inclusion including: health and wellbeing (e.g. accessibility to healthcare services); social wellbeing (e.g. opportunities for social connectedness and social activities); familial wellbeing (e.g. intergenerational and family ties); and respect and feeling valued (e.g. assuming purposeful roles in old age and being valued for their expertise and knowledge). Many older people felt that technology had an important role to play in supporting social inclusion and there was evidence of everyday technology use to support participation, for example, the use of online social media, networking sites and online classes. However, there were also barriers to using technologies (lack of skills and expertise; the 'digitally disconnected'; increasing 'internetisation' of services) and a concern about the pervasive impact of technology on people's lives and how much this may compromise their independence and face to face care from family (as key components of social inclusion). In terms of smart cities, there was a lack of awareness amongst older people about what it might mean conceptually and practically, and some mistrust over how specific interventions might be deployed to monitor the everyday lives of older people including avoiding unnecessary intrusion, surveillance and monitoring, and the commodification of smart city interventions (e.g. used by private companies to 'monetise' old age).

Smart city practitioners, on the other hand, perceived social inclusion as an outcome in relation to smart city policy and practice, and seen as entirely determined through the ways in which smart services and policies which could be deployed. This often led with technology led discussions rather than on how these would deliver on social outcomes or the everyday lives of older people. For example, increasing technology provision in care homes and day care facilities was seen by some professionals as a proxy measure for social inclusion without considering how that technology provision might be perceived and used by older people across those specific settings. There was little articulation of the ways in which technology could support social inclusion as a process e.g. to enable people to lead more fulfilling lives or to ensure that technology supports improved social participation. For professionals, smart city interventions were often framed a 'one size fits all' approach to the ageing problem, without considering the various challenges that older people might have and which might require a more nuanced approach to smart city interventions which are shaped around the changing experiences old age. For older people, there was a need to consider the heterogeneity of the ageing experience (‘older people are not all the same’), which might require more tailored technological solutions to meet the challenges and opportunities of ageing in place or at least a deeper appreciation of the differential ways in which ageing is experienced. Social inclusion was a nuanced and multi-faceted concept for older people which changed across the lifecourse. For many older people, there was an inter-dependency between people and place that was important in shaping social inclusion, and agency was important in that i.e. older people wanted to be actively involved in shaping their environments. Yet in the interviews with professional stakeholders, older people were often framed as a ‘passive group’ and interventions and supports were largely addressing ‘functional’ needs i.e. supporting activities of daily living, rather than how it might support deeper forms of engagement for older people i.e. social needs.

Perceptions of Public Participation and Empowerment

Public participation and engagement are central themes of the smart city policy agenda in the city, particularly how better to engage citizens in the development of smart city interventions. Despite this being a policy aim, smart city professionals revealed that public participation had developed very differently in practice. Findings from the research revealed that there was no explicit agreement on what constitutes effective participation nor general assessment to ensure its inclusion in the smart city planning process. As a result, there was little consensus among smart city professionals and urban planners on what participation is for, and how should it be delivered.

Local residents reported that they experienced psychological and physical barriers to participating in the planning process. They lack information on what is going on in the development of policy and practice around smart cities and felt public participation within smart city development was tokenistic or disingenuous i.e. tick box exercise. This was reflected through the lack of opportunities to share experiences, the absence of two way communication in the participation process and the absence of older people’s voice in the design of interventions and in smart city policy. Thus, when public participation did not work so well, it had the effect of increasing social exclusion and marginalisation amongst older people, leading to further mistrust around the smart city agenda. When recommendations were put forward by older people and advocacy groups, they were given little consideration by the authorities.

Although effective participation was illusory, professionals did concede that engaging citizens in the planning process should be considered early in the visioning of the smart city and others recognised that this was important in developing successful interventions. Many also felt that the notion of the smart city itself should be built on understanding the needs of older people who live in the cities and communities as a key priority. In delivering on this, professionals confirmed that consultation and participation in the smart city agenda had failed to engage with local citizens in the ways originally envisaged. However, in these failings, professionals shifted responsibility for that lack of engagement to older people themselves. For example, some reported that residents were ‘unwilling to engage’ in the consultation process or in one case that older people ‘lacked the wherewithal’ to participate. Thus, older people’s knowledge was not prioritised in the planning process, with an emphasis on prioritising the experience of the ‘young urban elite’ (as the key market for smart cities), whilst undermining the value/expertise of older people. As a result, smart city interventions failed to incorporate the views of older people in their development and subsequently undermined older people’s rights to participate in the planning process around smart cities.

Integrating Age-Friendly and Smart City Policy and Practice

Older people and those professionals responsible for delivering services to older people identified the importance of more clearly integrating age-friendly approaches in the development of smart city policies and practices. There was a current disconnection between these strands of policy, with ageing existing in the realm of social policy and associated interventions, at a distance to urban planning and smart city policy. There was also a strong desire for a comprehensive and integrated vision for age-friendly communities which identified how smart city supports can cut across each domain: social participation, respect and social inclusion, civil participation and empowerment, community support and health services, outdoor spaces and buildings, transportation and housing.[19] This needed to recognise the priorities and gaps in existing practice, but also how different sectors and domains can work together to deliver smart cities. For example, mobility was identified as an important aspect of social inclusion for older people. This involves the need to consider integrated transport needs, housing requirements and walkable environments together. Thus, a more holistic and whole systems approach is needed to understand how social inclusion can be supported in smart city development.

To improve the social inclusion of older people in smart city interventions, there is also a real need to address the requirements of older people ‘before’ implementing smart city initiatives. Otherwise, there is a risk that smart city interventions will be ‘technology push’, failing to support the priorities of older people. Professionals did identify that there was a requirement for greater cooperation and partnership between stakeholders and civil society and recognised the role of human capital and people in driving smart growth. The principle of the smart city, therefore, needs to ensure that growth considers social processes and outcomes, and where there is a closer fit between the needs of the people and technological interventions, alongside greater partnership working.

In discussing smart city policy interventions in the context of supporting older people, a number of other key priorities were identified. First, there needs to exist a framework of supports for older people that demonstrates a commitment to addressing the broader issues of equity in terms of access to services otherwise smart cities will remain the purview of the more affluent. Second, there is a need to ensure that other aspects of wellbeing are being addressed as part of supporting older people e.g. financial security and digital inclusion to ensure older people can participate in the smart city agenda. Third, there needs to be a programme of education and information and awareness such that the benefits of smart cities to older people can be realised. Finally, there is the need to ensure the closer involvement of older people in smart city practice e.g. co-design of interventions with older people that draws upon their experiences. Involving older people in the development process is crucial and smart city interventions need to create clear opportunities for older people to have a voice in the planning process and decision-making.

CONCLUSION

The notion of social inclusion is a construct through which we can understand the experiences of older people and place within the context of smart cities, urban transformation and physical change. Closely aligned to the concept of social inclusion is well-being, the ability to age-in-place and social connectedness. In delivering a smart city programme that addresses ageing as a central priority, understandings of social inclusion need to be better understood, articulated and evaluated within the context of smart city policy. Moreover, social inclusion needs to be seen as a process in the lives of older people, and this needs to be reflected in smart city interventions that best support the changing needs of older people. Without which we will have smart city interventions that address technological requirements at best, but which fail to deliver improved quality of life.

Although public participation is highlighted in smart city policy as an important component, attempts at consultation and engagement suggest that the inclusion of older people is marginal, and where the opinions of older people are given lower order priority in smart city design. It is important that smart city approaches are inclusive, provide a platform for people to find their voice, share knowledge and feel empowered as part of the process. This is crucial if we are to have technological interventions that are an embedded part of the everyday lives of older people.

In terms of delivering effective policy and practice, the requirements and experiences of older people need to be recognised as nuanced, complex and wide ranging. They cut across different sectors e.g. health and wellbeing, social care, transport, housing, outdoor spaces. Smart city policy needs to be more closely aligned with these agenda, adopting a more cross-cutting approach where smart solutions are an embedded part of age-friendly interventions. These cannot be seen as separate policy strands otherwise approaches to supporting ageing and the smart city are likely to remain disconnected. If smart city interventions are going to achieve the social transformations that they promise, then they also need to reflect a more holistic and whole systems approach in their conception and design.

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