Reinventing cities towards being smarter

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Abstract. A smart city concept is becoming more popular. Many cities shift directions for the development of to “smart” destination, which is able to address rapid growth in the urban population and climate change. The concept of smart development consists of four dimensions that encompass various elements of smart cities, one of them, the environ-urban dimension, is stressed in this paper. The elements of this dimension are studied as exemplified by nine architectural projects, which won in the Reinventing Cities competition, launched in many cities across the globe. The competition is a call for urban projects to drive resilient and sustainable urban regeneration, which contributes to the idea of smart development. Urban solutions designed for the competition are listed by the authors in order to analyze what are the newest trends to “fill” the environ-urban dimension of smart development. The paper gives recommendations of what principles of urban design should follow architects in order to create projects which can contribute to smarter urban development.

1. Introduction

Over the last century, there has been rapid growth in the urban population. In 2018, 55% of the world’s population lived in urban areas, a proportion that is expected to increase to 68% by 2050 [1]. Larger urban territories provoke less effective control of land use, economic development, urban efficiency, etc. To address these issues, the concept of “smart cities” emerged. The concept entails increasing urban efficiency, consistent with energy, transportation, land use, communication, economic development, service delivery, etc. Indeed, a smart city represents essential efficiency, which is based on intelligent management of urban systems using ICT (information and communications technologies) [2].

According to Smart Cities Council, a network of leading companies advised by top universities, laboratories and standards bodies; smart cities are those which have three core values:

- Livability: Cities that ensure healthy pollution-free environment.
- Workability: Cities that provide the enabling infrastructure — energy, connectivity, computing, essential services — to compete globally for high-quality jobs.
- Sustainability: Cities that has positive social, economic and environmental impact [3].

In the last few years, there was much questioning whatever the key elements that drive the transition of cities towards a smarter level would be found. Many cities worldwide were analyzed by architects, scholars, economists and information scientists regarding “smart” characteristics. Analyzing some empirical evidence of smart city projects, Camboim, Zawislak and Pufal, state that...
there is no fully-fledged smart city yet [4]. Pursuing a smart level is an ongoing process, in which different elements cannot be achieved simultaneously. Today, more than 300 cities across the globe participate in approximately 40 coalitions, and are being advised by organizations, in their attempts to co-define their innovative future [5].

This paper aims at unpacking the driving elements that make an existing historical city smarter from an architectural point of view. The purpose is to provide insights into understanding what urban planning and architectural design solutions are relevant for smart cities. The authors argue that the understanding of these elements enhances the smartness of cities and can be further applied to future practices in the area of smart city’s urban development.

1.1. The Concept of Smart City

The smart city concept consists of various components, for this reason, an official definition of a smart city is not published yet. Although the aim of this paper is not to discuss different definitions of a smart city, a closer look at several definitions is needed and presented further.

Bibri and Krogstie [2], along with other scholars, refer to the study of Caragliu, Del Bo and Nijkamp [8] when defining the characteristics of smart cities. They listed the aspects which makes a city smart:

- The utilisation of networked infrastructure to improve economic and political efficiency and enable social, cultural and urban development;
- An underlying emphasis on business-led urban development;
- A strong focus on the aim of achieving the social inclusion of various urban residents in public services;
- Stress on the crucial role of high-tech and creative industries in long-run urban growth;
- Profound attention to the role of social and relational capital in urban development;
- Social and environmental sustainability as a major strategic component for smart cities. [9]

These aspects suggest that a smart city is convivial and legible. From an architectural point of view, it provides equitable and inclusive access to work, housing and other essential utilities (water, power, education, health, and social care) and leisure amenities (shopping, green space) [10].

The combination of different definitions is being supported by various smart frameworks and benchmarking models [11], which merge various characteristics and perspectives during the evaluation of smart city levels with a number of indexes. These indexes estimate technological and urban parameters [5]. The European Smart Cities Ranking, a framework developed by Giffinger et al. [12], remains the most widely quoted and used [13]. The framework is based on six perspectives: smart mobility, smart environment, smart living, smart people, smart economy, and smart governance [12]. Accordingly, almost all industries participate in driving the smart destination, and provide innovative solutions, which can address the above perspectives: construction, cyber-physical integration, software engineering that generate smart applications and services, data science and business analysis [5].

1.2. Smart is not Only About ICT

Smart does not relate only to ICT and technology – it goes beyond. Today, to be considered smart, besides being connected through ICT, a city must provide human capital development opportunities, as a way to foster knowledge and creativity; must deal with sustainability solutions, to cope with the changing urban environment; and must offer, at the end of the day, quality of life to its citizens [3]. Thus, a smart city should be characterized by the smart city planning (modern accessible urban spaces and green infrastructure, sidewalks, etc.) and utilities' efficiency (transportation networks, bike and car-sharing, etc.), and then it is accompanied by the intelligence (creativity, wi-fi and App identification, smart stations, etc.) [6].

In contrast, CISCO criticized visions of smart city concepts that are dominated by the physical design, which, in its view, result in a “jumbled mess of engineering and architectural ideas supported by various technologies” [13]. At the same time, Batty et al. identified several projects belonging to
smart cities of the future, and arrived at the conclusion that these smart cities should be characterized by advanced mobility and travel behaviour, modelling urban land use; integrated databases across urban domains; sensing, networking, and the impact of social media; participatory governance and planning structures; modelling network performance; transport and economic interactions; and decision support as urban intelligence [14]. Hence, a smart city does not relate only to ICT and technology – it goes beyond, it relates to urban planning and architectural design considering the presence of ICT in the daily life of cities. This statement proves the importance of the identification of urban design solutions which can lead to smarter cities.

1.3. Dimensions of Smart Cities
Camboim, Zawislak and Pufal identified four dimensions that encompass various elements of smart cities: governance dimension, environ-urban dimension, socio-institutional dimension, and techno-economic dimension [4]. This paper will explain the environ-urban dimension as it has a focus on urban planning and architectural design.

The environ-urban dimension is composed of the built infrastructure, mobility, urban design, facilities and amenities, and natural environment [15]. This dimension stresses the importance of low-carbon modern means of urban mobility, that specify that a smart city should present multimodal accessibility to facilitate travel of citizens [9]. This dimension consists of five elements [4]:
- Urban design [16];
- Innovation districts [17];
- Living Labs Infrastructure [18];
- Smart Mobility [19];
- Leisure amenities and facilities [20];
- Natural resources [21].

Generally speaking, the environ-urban dimension is required to analyze the building potential of existing areas and to propose new uses to them if necessary, as well as to recover them to maintain attractiveness in the urban landscape [4]. While the smart urban design is the main element in the preservation of urban heritage buildings and districts at large [16]. Thus, when working on the environ-urban dimension, it will be necessary to study the design aspects of urban regeneration, as it aims to propose new uses while preserving built cultural heritage.

1.4. Urban Regeneration
Urban Regeneration is a process for enhancing the quality of life in urban areas through improvements in the vitality and viability of its activities and the quality of its environment together with a reduction in the disparities between areas and groups within the urban community. Smart urban regeneration participatory and responsive with economic, social, environmental and governance dimensions and invokes measured interventions in collaborative institutional networks [2]. A smart city is a goal of smart urban regeneration.

Urban regeneration is a concerted social, economic and physical action to help people in neighbourhood experiencing multiple deprivation reverse decline and create sustainable communities [22]. Urban regeneration, among other actions, may address climate change. Over the past few hundred years, human activity has transformed the planet but instigated mass extinctions and climate change, and undermined human health [23]. Climate change refers to the build-up of man-made gases in the atmosphere that traps the sun's heat, causing changes in weather patterns on a global scale. The effects include changes in rainfall patterns, sea level rise, potential droughts, habitat loss, and heat stress [10].

2. Methods
The environ-urban dimension of smart cities is unpacked in this section of the paper through the study of real architectural projects designed for the promotion of smart development. The winning projects in Reinventing Cities competition help to understand what solutions of urban design are relevant for
the smart development of historical sites. Importantly, that all the projects entail urban regeneration as effective mean to enhance the smartness of existing urban districts.

Reinventing Cities is a competition organized by Cities Climate Leadership Group (C40). C40 is a network of the world's megacities committed to addressing climate change, founded in 2006, and working in the smart city domain [5]. The Reinventing Cities competition is a call for urban projects to drive carbon-neutral and resilient urban regeneration in cities across the globe and to implement the most innovative ideas to transform underutilized sites into beacons of sustainability and resiliency. Smart urban design proposals can be used to promote environmental sustainability, as a pillow of smart city concept development.

The Reinventing Cities winning projects serve as models for new ways of building and living, demonstrating how the alliance between the public and private sector can shape the future, delivering healthier, greener and economically feasible urban development [24]. The projects show “smart” solutions of urban design applied for historical districts and buildings during urban regeneration. 20 winning projects for sites, located in Auckland (New Zealand), Chicago (USA), Houston (USA), Madrid (Spain), Milan (Italy), Montreal (Canada), Oslo (Norway), Paris (France), Reykjavik (Iceland), and San Francisco (USA) have already been announced. Each city formed a multidisciplinary team of architects, planners, developers, entrepreneurs, environmentalists, start-ups, neighbourhood collectives, innovators and artists to submit proposals of smart development. This paper will further analyze the proposed solutions used in 9 out of 20 projects, with a focus on those which address the environ-urban dimension of smart city development.

2.1. Auckland, The Alderman Carpark, Te Kopua
Former use – Open-air car park.
New use – Mixed-used development with medium-density residential blocks.
Natural environment – Protection of natural environment.
Green – Community garden.
Energy – Renewable energy, positive energy – sustainable consumption (photovoltaic panels).
Carbon – Zero carbon.
Water – Sustainable water management (water consumption from water recovery, on-site water treatment, the use of living plants to clean up water).
Mobility – Smart mobility. Low-carbon mobility: limited number of parking spaces, charging stations for electric vehicles, car-sharing program as well as many services for bicycles.
Other – Acknowledging communities who used the plot before.

2.2. Chicago, East Garfield Park, Garfield Green
Former use – Vacant lots.
New use – Mixed-use: residential, retail, office.
Natural environment – Promotion of urban agriculture.
Green – Oak arboretum and a rooftop garden dedicated to urban agriculture, park.
Energy – Generating 100% of its power on-site, net-zero energy.
Carbon – Net-zero carbon.
Water – 100% of its storm water is processed on-site.
Mobility – No data.
Other – Designed to Passive House standards. Holistic development of the neighbourhood – the project will offer the temporary use of its facilities to the neighbouring high-school and associations. It is an innovative modular building developed by local factory. The project helps to palliate the heat-island effect.

2.3. Houston, Sunnyside Landfill, Sunnyside Energy
Former use – Landfill.
New use – Mixed-use: Sunnyside energy solar farm, agricultural hub, training center (aquaponics, bee keeping, bioremediation and native plants are to be promoted here), community center.
Natural environment – Promotion of urban agriculture.
Green – Promotion of the green infrastructure with native plants for this region.
Energy – Cost-saving electricity plan for lower-income residents.
Carbon – Carbon positive status by its fifth year of being operation.
Water – No data.
Mobility – Low-carbon mobility by limiting parking, including electric charging stations and incentivizing biking and walking.
Other – The project contributes to local economic development, social cohesion and heritage preservation. Sunnyside community solar promotes the ideas of sharing use of public spaces and conviviality.

2.4. Madrid, Mercado de orcasur, Laboratorio-sur
Former use – Unused market.
New use – Mixed-use: social center, market, multi-purpose space, accommodation for the elderly.
Natural environment – Promotion of local and organic production.
Green – The creation of new green infrastructure.
Energy – The use of renewable energy through the configuration of photovoltaic panels on the facades and on the roof. Net-zero energy. The project intends to become fully energy self-sufficient.
Carbon – No data.
Water – No data.
Mobility – No data.
Other – Encouraging the local produce of resources. Good practices in terms of food production, cultural energy. The building is self-managed. Urban catalyst of good health, sustainability and social cohesion. Creation of new social habits, developing activities. Organization of public workshops. The use of certified wood, local and recycled construction materials.

2.5. Milan, Serio, Vitae
Former use – Vacant plot of a former productive area.
New use – Mixed-use: a multi-purpose space for public events and research with roof gardens and vineyard.
Natural environment – Fostering biodiversity of the vegetation.
Green – Terraces and vegetable gardens on the roofs, hydroponic gardens.
Energy – Clean energy, a 40% energy reduction. 95% of electricity is certified green. Photovoltaic panels and heat pumps.
Carbon – 26% carbon emission reduction.
Water – Recovery of rainwater, reuse of greywater.
Mobility – Low-carbon mobility, electric vehicles, pedestrian facilities.
Other – The project provides spaces for public events for nutrition and education, molecular oncological research and guesthouses for international researchers. Green catering.

2.6. Montreal, De la Commune Service Yard, Demain Montréal
Former use – Satellite service yard.
New use – A fabrication laboratory, grocery store, restaurants, and educational services.
Natural environment – The new use aims to promote ecological behaviour. Aeroponic farm for local food production.
Green – Urban forest, orchard.
Energy – 100% renewable energy.
Carbon – Reduction of the embodied carbon. Capturing carbon during the operational phase.
Water – No data.
Mobility – No data.
Other – Promotes inclusivity and education. Co-design process and citizen engagement at each stage of the project. The project follows the idea of circular economy. Zero waste. Stress the idea of sharing, co-living, co-working. 100% renewable construction materials. On-site food production. The promotion of sustainable behaviour.

2.7. Oslo, Bygata Furuset, Urban Village Team
Former use – Car park.
    New use – Single use: housing with a high degree of communal spaces.
    Natural environment – The project promotes urban agriculture and biodiversity with a large greenhouse for herbs and vegetables.
    Green – Green infrastructure under the roof: greenhouse.
    Energy – Photovoltaic panels that cover the sun-exposed roofs and facades, heat pumps.
    Carbon – Low carbon footprint by opting for wood products.
    Water – No data.
    Mobility – Car-free.
Other – Designed to Passive House standards. The use of local materials. Compact building blocks.
The project reinforces community as a modern village.

2.8. Reykjavik, Ártún, Malarhöfði, Lifandi Landslag
Former use – Unused and unbuilt.
    New use – Mixed-use: apartments, offices, shops, kindergarten, glasshouses.
    Natural environment – Shelters a local ecosystem. A courtyard will be home to indigenous plants, local rocks and topographic surfaces. The project creates a rich environment between urban and natural conditions.
    Green – Re-vegetation. Green space will cover 75% of the site. Green roofs, gardens, shared greenhouses.
    Energy – No data.
    Carbon – Zero-carbon. The reduction of the carbon footprint at each phase of the project’s life.
    Low-carbon mobility.
    Water – Industrial waterfront and polluted site cleaning up.
    Mobility – Electric vehicles. Expanded walking and cycling infrastructure. Promotion of soft mobility.
Other – Passive House principles. Cohabitation between the urban and nature. Shared use of communal spaces.

2.9. Paris, Hall de découvage Pleyel, Odessee Pleyel
Former use – Industrial heritage building.
    New use – Mixed-use: living, workshops, sports, restaurants
    Natural environment – Reuse of excavated soil from the neighbouring construction site.
    Green – Green infrastructure under the roof: greenhouse.
    Energy – Renewable energy. Self-sufficient building. Clean energy. The project uses hybrid photovoltaic and thermal solar cells. Zinc-air batteries are used for energy storage.
    Carbon – Carbon-neutral.
    Water – Rainwater recuperation.
    Mobility – No data.
Other – The project promotes inclusivity and education.

3. Results
Each winner project of the Reinventing Cities competition offers a number of modern high-quality solutions for a smart sustainable urban environment. The projects propose the creation of a variety of
new urban elements through urban regeneration in order to take advantage of what is already built. The elements are listed in Table 1, the analysis of them aims to understand what “fills” the environ-urban dimension of smart city development more effectively and delivers smart values for the cities’ neighbourhood.

Table 1. Environ-urban elements of the projects.

| Element                                      | Projects | Score |
|----------------------------------------------|----------|-------|
| New single use                               | - - - - X - - | 1/9   |
| New mixed-use                                | X X X X X X X X | 8/9   |
| Enhancement, preservation of heritage        | - - - X - - - X | 2/9   |
| Sense of place                               | - - X X - - X X | 4/9   |
| Preservation of natural environment          | X X X X X X X X | 9/9   |
| Legible public realm                         | X X X X X X X X | 9/9   |
| Preservation of building traditions          | - - X X - - - X | 2/9   |
| Accessible public spaces                     | X X X X X X X X | 9/9   |
| Shared public spaces                         | X X X X X X X X | 9/9   |
| Enhancement and recovery of existing green infrastructure | X X X X X X X X X | 7/9   |
| Private green infrastructure                 | - X X X X X - - | 5/9   |
| Public green infrastructure                  | X X X X X X X X | 9/9   |
| Promotion of urban agriculture               | - X X - X X X - | 5/9   |
| Use of vernacular solutions                  | - - X - X - - X | 2/9   |
| Use of local construction materials          | - - X X - X X X | 4/9   |
| Walkable neighbourhood                       | X X X X X X X X | 9/9   |
| Variety of transport means                   | X - X - X - X - | 4/9   |
| Reduction of cars                            | X - X - - - X X | 3/9   |
| Human scale                                  | X X X X - - X X | 6/9   |
| High building energy efficiency              | X X X X X X X X | 8/9   |
| Use of renewable energy sources              | X X X X X X X - X | 8/9   |
| Reduction of carbon pollution                | X X X - - X X X X | 8/9   |
| Passive House standards                      | X X X X X X - X | 3/9   |
| Promotion of sustainable habits              | X X X X X X X X X | 9/9   |

The study of the winner projects of the Reinventing Cities competition allows summarizing what elements and principles of urban design contribute to the smart development of cities. Each of the above-mentioned projects provide all kinds of public services that are close to the daily life of people in cities, such as housing, workplace, kindergarten, restaurant, grocery store, market, educational services, etc. These smart solutions of urban design do not change the life of neighbourhood radically, they rather offer alternatives for making it healthier, greener and more efficient. Each project
prioritizes the preservation of the natural environment, that should address climate change. Architects propose to serve neighbourhood as urban villages with public green infrastructure, walkable streets, piazzas, courtyards, and accessible public spaces. The solutions, which “fill” the environ-urban dimension of smart development, help to unclog the streets where the urban neighbourhood are the manifestations of a green and natural life, which is closer to the life of rural neighbourhood.

Community involvement is the most synergic characteristic of a smart city at the city level [19]. As such, the studied projects stress the importance of shared use of public spaces, co-design process and the engagement of citizens. These elements of smart development intended to raise the sense of citizens of their belonging to the neighbourhood and make the establishment of smart cities a common goal.

All the projects promote sustainable habits of citizens through the creation of a legible public realm. The reinvented districts offer special public amenities and facilities to ensure the quality of life. Eight out of nine projects promote new mixed-use of the buildings. Thus, architects aim to ensure the daily life of people in an integrated way inside the districts.

High building energy efficiency and the use of renewable energy sources are two significant elements in achieving the environ-urban dimension of smart city development. Likewise, the reduction of carbon use, which is a crucial element to address climate change, is strongly suggested.

The winning proposals show the importance of enhancement and recovery of existing green infrastructure. The focus on the preservation and efficient use of green infrastructure should be included on urban plans and building restrictions in order to take advantage of the urban regeneration of what is already built. Green infrastructure can be also a mechanism for addressing climate change mitigation [10]. According to the International Valuation Standards Council [25], and that was proven by the study of the Reinventing Cities winning projects, green infrastructure improves the quality of living space and stimulates added property value.

Two-thirds of the projects propose the creation of human-scale architecture. Although, this element of smart development is not compulsory, but it is still suggested to follow in driving towards smarter cities. The human scale of buildings is able to catalyze the shared use of public spaces and raise the awareness of citizens of their belonging to the neighbourhood.

Private green infrastructure and urban agriculture are optional elements, although all projects may benefit from them. More and more projects promote urban agriculture, which is usually associated with the ideas of sharing, cohabitational use of public spaces, inclusion, sustainability, and accessibility. Urban agriculture enhances the creation of innovation ecosystems while preserving and protecting the natural environment. Moreover, the urban agriculture contributes positively to the sense of place, as well as the use of local construction materials, vernacular engineering solutions and preservation of building traditions.

The promotion of alternative transport means, and the reduction of cars can address effectively the climate change, while it is not the key element of the environ-urban dimension of smart cities.

4. Discussion
The study of the projects from the Reinventing Cities competition proves the notion, stated by Camboim, Zawislak and Pufal [4], that smart cities should offer high living conditions. The scholars also argued the importance of mixed-use buildings with efficient use of private and public spaces, which was typical for the majority of the analyzed projects in this paper. Although, Houston [10] proposed to create the hierarchy of places (individual, friendship, householders, neighbourhood, communities, pedestrian pocket) which the authors of this paper would not agree. The studied projects show the trend of sharing spaces. Architects and urban planners promoted the idea of “blurring” walls between different spaces, making them accessible for all groups of people.

Walkable neighbourhoods highlighted by Houston [10] are also widely proposed by the studied projects. The reduction of cars and the use of alternative means of transport was mentioned in the winning projects but not as a compulsory element of the smart development, as it was argued by Camboim, Zawislak and Pufal [4], Houston [10] and Kauko [26].
Several elements, such as high building efficiency, renewable energy sources, human scale, preservation of heritage, promotion of sustainable habits, enhancement of existing green infrastructure, unpacked in this paper, are in phase with studies of many scholars across the globe. Nevertheless, the authors discovered that scholars do not stress the importance of urban agriculture, which was typical for half of the projects. The urban agriculture is aimed at preserving, enhancing and protecting the natural environment, the need of which was written by Mattoni, Gugliermetti and Bisegna [19].

To summarize, the winning projects of the Reinventing Cities competition propose similar elements to those which were explained by many scholars. The projects enhance the elements of sustainable development which lead to smarter city performance. Although, the authors discovered a new element of smart city development - the manifestations of a green and natural life when cities become as green, vernacular and “natural” as rural settlements. Architects proposed the return to natural life, whereby a city is becoming smart through vernacular behavior rather than through the mainstreaming of ICT.

5. Conclusions

It is safe to assume, that the approach to achieve the environ-urban dimension of the smart city concept through urban regeneration should include the elements of urban design analyzed in this paper. To attract and retain people, the smart city should offer high living and working conditions, which can be created with the use of these elements. Importantly, that all the explained solutions of smart urban design promote well-being primarily, which will further lead to the smart development because the smart city concept is not only about the use of ICT, it is also about a city that is a better place to live, work and play.

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