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## Expansion of the Prophet Mosque as a Catalyst for Sustainable Urban Development in Al-Madinah Almunawarah in Saudi Arabia

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### HIGHLIGHTS

- Sustainable urban lifestyles can be achieved through effective urban planning and management.
- Today's smart cities tend to be smaller, compact, and more efficient.
- Sustainable development in Al-Madinah Almunawarah is in its very early years.
- Technology is clearly a necessary condition for a smart green city.

### ABSTRACT

Cities and towns have recently undergone significant transformation, from small forms with identifiable centers and the roles of bearing history and culture into sprawling, amorphous urban areas that have lost their cultural and social identities and functions. The city is defined less by its physical boundaries given the development of suburbia and vast areas with detached buildings. Al-Madinah Almunawarah has undergone major urban transformation due to the expansion of the Prophet's Mosque. It needs an urgent development plan to achieve a sustainable smart green city approach. It is expected that many houses will be razed and replaced with entities with different functions through expansion. This will change the city's urban form, including its network of architectural shapes and spaces. Hence, it is imperative that these changes reflect the character of the holy city and can add positively to the local way of living.

This paper's main goal is to develop an integrated coinage for the open space network in Al-Madinah Almunawarah and link it to the future expansion of the Prophet's Mosque. Moreover, the research aim to develop a comprehensive framework for the smart green city approach to be applied and examined on other cities.

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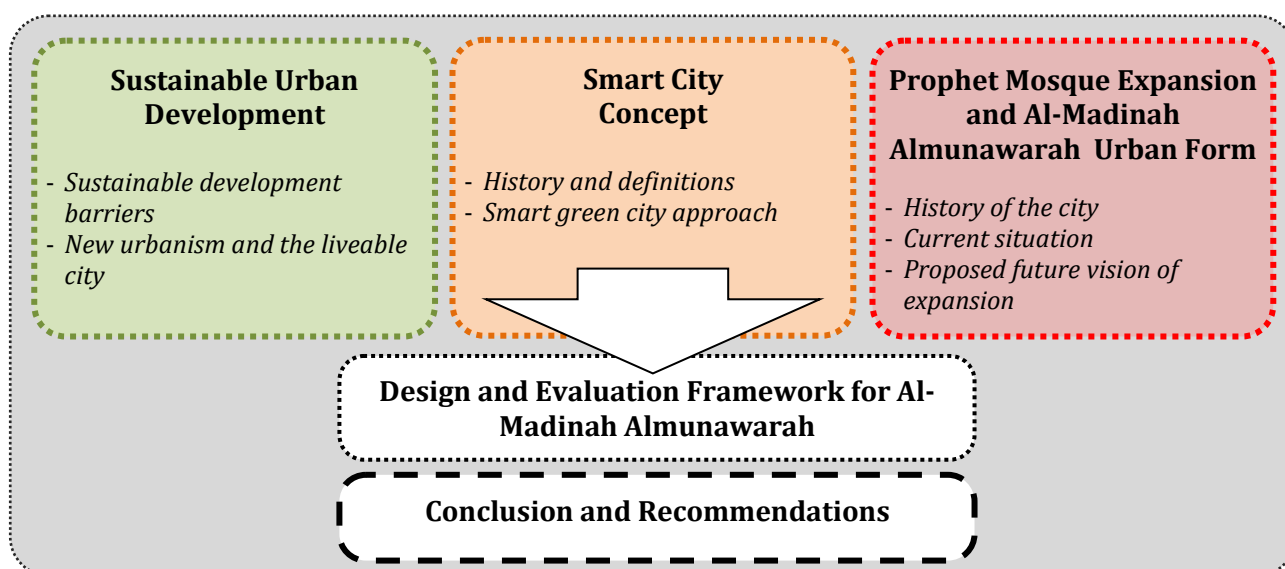
### KEYWORDS

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## 1. INTRODUCTION

Urbanization and sustainability are both immensely important topics at present. Due to the challenges that have followed their rise in prominence, the future envisioning of cities needs to take into account all the guidelines necessary for achieving a sustainable city and creating an urban space network to strangeness social life. Each city has local characteristics that it must achieve. This paper will investigate the city of Al-Madinah Almunawarah and its special urban form, which includes the Prophet Mosque in the center.

Another factor that should be considered is the concept of the smart green city. Its discussion and definition have been recurrent in recent years. Different academics have defined the concept of sustainability and the smart green city, and they seem to be in consensus because the latter is based on three fundamental pillars (social, economic, and environmental) (Ministry for the Environment, 2005). To achieve a deeper understanding of the complex processes that characterise sustainable urban strategies and smart cities, this research will explore all the definitions and studies and arrive at a general framework that will help to design and evaluate comprehensive master plans for cities. It will focus on Al-Madinah Almunawarah and its urgent need for a clear vision. Figure 1 shows the general outline of the process through which the paper will achieve that goal.



**Figure 1:** Research content necessary for achieving proposed framework. *Source: the researcher.*

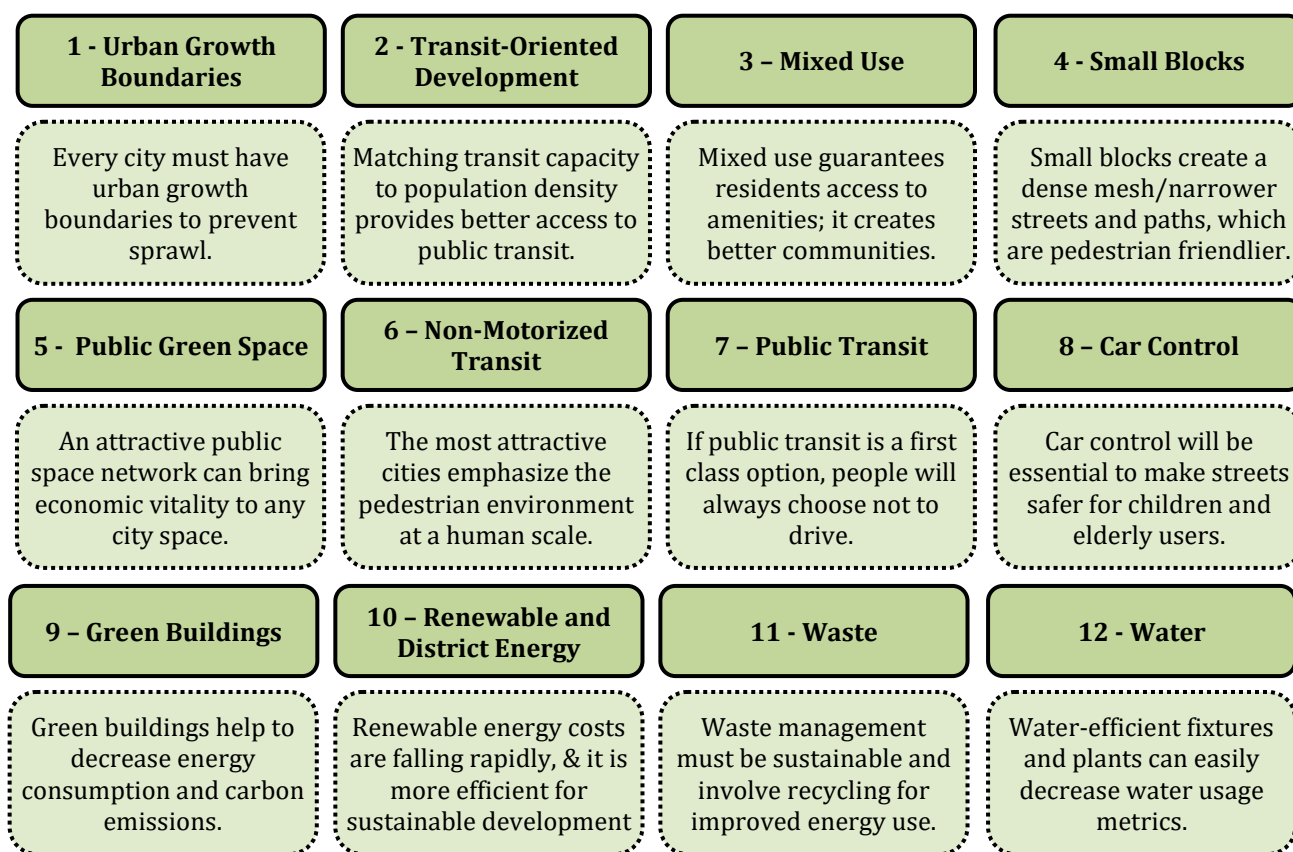
## 2. SUSTAINABLE URBAN DEVELOPMENT

Sustainable urban lifestyles can be achieved through effective urban planning and management (Girardet, 1995). There are options for an urban future that support green city development, which leads to health gains and high levels of productivity and competitiveness. In this context, it is evident that traditional political and spatial boundaries, as well as traditional planning and development paradigms, will become obsolete. Classical guidelines of urban design and developmental control are irrelevant and will undergo a drastic evolution as the green city concept takes root.

Nowadays, cities are seen as crystallization points within society, relevant entities within which people live. They create cohesion between individuals and businesses. It is in towns that motivation is found for innovation, renewal, and new levels of comfort (Hajer, 2011). Accordingly, cities are at the center of sustainability challenges; activities therein have been connected to climate change, environmental and resource efficiency problems, and social sustainability (Edelstam, 2016; Caragliu, Bo, & Nijkamp, 2009).

There is a growing need for new, creative ways to manage these complexities of urban living (Manville et al., 2014). In this context, the notion of the smart city has evolved and is spreading like a new urban strategy agenda that seeks to enable many governments worldwide to achieve better life and protect the environment (Luque-Ayala & Marvin, 2015; Chourabi et al., 2012).

China Development Bank Capital, in collaboration with Energy Innovation and Energy Foundation, recently presented a set of guidelines for Lightning China's new urbanization model. The Green and Smart Urban Development Guidelines capture the most valuable lessons learned from global experience in building a sustainable city (Pike & Huang, 2016) (see Fig. 2).



**Figure 2:** Green guidelines for designing sustainable cities. Source: Pike and Huang (2016).

### 2.1 Sustainable development barriers

Sustainable development and green buildings have many benefits for the society as mentioned above. However, driving factors, as well as obstacles, shape the current and future state of sustainable development at the local and national scales. Such factors and constraints are called motivators and barriers, respectively. Here, the barriers are classified under four categories:

- Economic barriers

Procuring green materials, installation, testing new systems, and coordinating or allocating labor for brand new implementations may cost developers extra money. So the fear of higher investment costs for sustainable building compared to those for traditional building, the risks of unexpected costs, and higher risks for clients are three prominent economic barriers (Häkkinen & Belloni, 2011).

- Technical and market barriers

Technical barriers emphasize the implementation dimension of sustainable/green buildings. To put sustainable development into practice, construction companies need green materials, systems, experienced labor, and sub-contractors.

According to Azizi et al. (2011), the lack of experienced consultants and contractors on green projects results in project schedule delays. Contractors in the market may lack the skills to implement the green-oriented technology correctly. This could hinder the technology's effectiveness.

- Social barriers

As mentioned in the technical barrier section, sustainable construction requires new technology and working methods. According to Häkkinen and Belloni (2011), resistance to new technologies or systems occurs because they require process changes, which entail the recognition of possible risks and unforeseen costs.

Winston (2010) describes the multiplicity of interest groups as a significant barrier. Many teams do very useful jobs, some voluntary, some paid, and some progressive, but they all have roles to play. This indicates that sustainable development initiatives are subject to disarray if due diligence is not exercised.

- Governmental and municipal barriers

The importance of the government's role in assisting sustainable development is well-recognized because the government has significant economic and legislative power. It is worth noting that, to make the built environment sustainable, local authorities, such as municipalities and local governmental agencies, should adopt a green mindset in their application of administrative power.

## 2.2 *New Urbanism and the livable city*

As Day (2003) stated, New Urbanism is an approach that supports design-based strategies to help arrest suburban sprawl and inner-city decline; it does so by building and rebuilding neighborhoods, towns, and cities. Congress for the New Urbanism (2002) states that the following three principles guide public policy, development practice, and urban planning:

- The region: metropolis, city, and town;
- The neighborhood, the district, and the corridor;
- The block, the street, and the building.

Many approaches to the urban design of the city form are based on the concept of livability. Livability is essential to the establishment of a sustainable community. It is an important part of the sustainability equation (Sustainable Community Development, 2006). Livable cities offer high-quality life and affect the health and well-being of local people. They are socially inclusive, affordable, accessible, and safe. They also feature attractive built and natural environments. The idea of livable cities is dual—the basics (i.e., clean air and water, energy, and waste management) need to be in place (Philips Publications, 2010). Hence, livable cities promote the benefits of sustainable urban transportation to encourage movement towards a healthy, safe, and attractive urban environment.

### 3. THE SMART CITY CONCEPT

In recent years, the idea of smart cities has attracted considerable attention in the urban development strategy arena regarding the design cities of the future (Schaffers et al., 2011; Caragliu et al., 2009). One of the important reasons for this is that the term “smart city” is multidisciplinary, touching on humans and on social, economic, and technical fields; hence, it has received increasing attention within the research arena (Dameri & Rosenthal-Sabroux, 2014). However, according to Manville et al. (2014), the notion of the smart city is embedded in the creation and connection of human and social capital and ICT infrastructure to generate more sustainable economic development and a better quality of life.

#### 3.1 History and definitions

The term “smart cities” is not new. It may have its roots in the Smart Growth movement (Bollier, 1998) of the late 1990s, which proposed new policies for urban planning. Portland, Oregon, is a widely-recognized example of Smart Growth (Caldwell, 2002). A large number of technology companies, such as Cisco (2005), IBM (2009), and Siemens (2004), have used the term since 2004 for the application of complex information systems to the integration of the operation of urban space infrastructure and services (such as buildings, transport networks, electrical and water design, and public safety). It later evolved to mean any form of technology-based innovation employed in the planning, development, and envisioning of cities, for example, the deployment of services for plug-in electric vehicles (Inukai-Cuffee, 2011). Table 1 presents common definitions of the term “smart city” in several publications over the past 10 years.

**Table 1:** Overview of the definitions of “smart city”

Definition	Reference
“A city well performing in a forward-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive, independent, and aware citizens.”	Giffinger et al. (2007)
“A city is smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance.”	Caragliu, Bo, and Nijkamp (2009)
“Any adequate model for the smart city must focus on the smartness of its citizens and encourage the processes that make cities important: those that sustain very different—sometimes conflicting—activities.”	Haque (2012)
“A smart city is a well-defined geographical area, in which high technologies such as ICT, logistic, energy production, and so on cooperate to create benefits for citizens in terms of well-being, inclusion, and participation, environmental quality, intelligent development; it is governed by a well-defined pool of subjects, able to state the rules and policy for the city government and development.”	Dameri (2013)
This source defines smart cities as “places where information technology is combined with infrastructure, architecture, everyday objects, and even our bodies to address social, economic, and environmental problems.”	Townsend (2013)

*Source: adapted by the researcher*

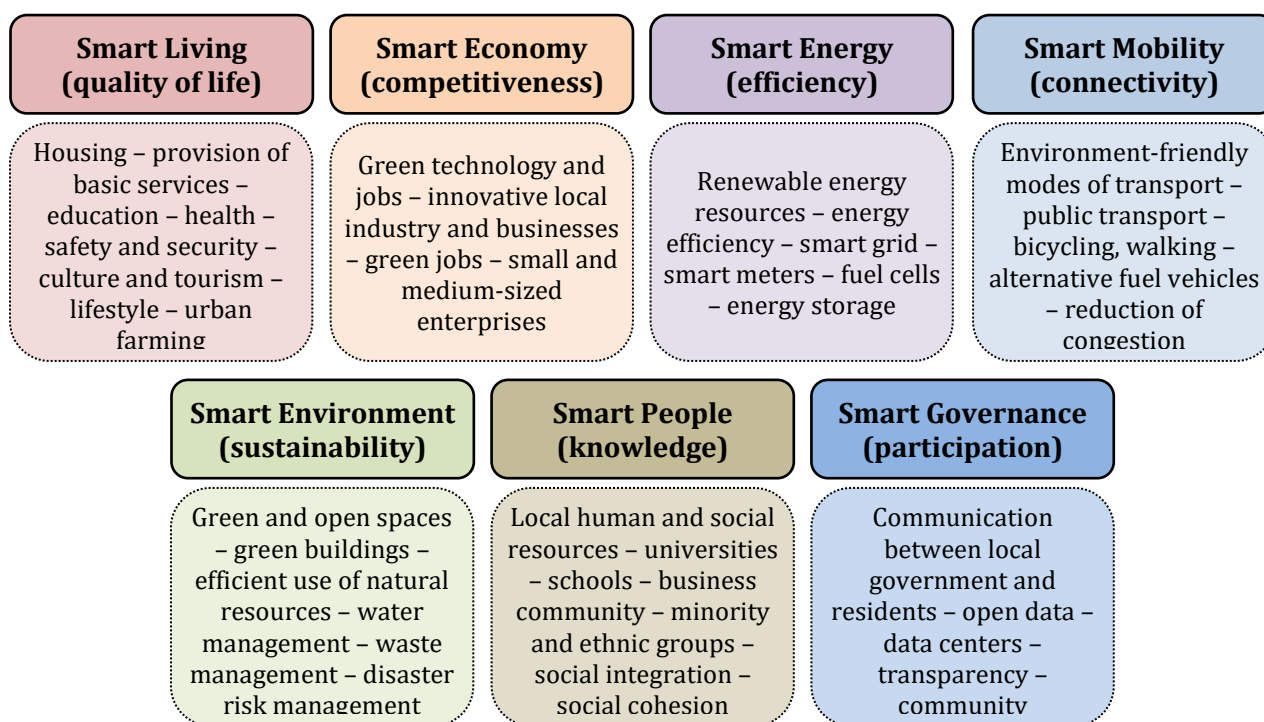
*Forbes* magazine released a list of the World's Smartest Cities in December 2009. These cities were analyzed and ranked according to three keywords: "environmental friendliness," "knowledge-based," and "self-sustainability." The outcome of the exercise was that today's smart cities tend to be smaller, compact, and more efficient (Kotkin, 2009).

### 3.2 Smart green city approach

The Smart Green City approach has at its heart the belief that the green element is vital to the long-term functioning of healthy, prosperous, livable urban spaces in the city. It is based on a design and construction system that enhances quality and environmental and social standards.

The development of sustainable green city models, or eco-cities, will be vital for the urban future of Arab countries. The countries in question are characterized by a growing regional economy, a need for energy, carbon consumption, and greenhouse gas (GHG) emissions. Though some see cities as a big problem associated with human living, others see them as the best cure for the planet (Kunzig, 2011). The sustainability of their futures will rely on their urbanization patterns, spatial structures, transportation systems, level of consumption of resources, and waste.

The urban dimensions shown in Fig. 3 represent the variety of layers that is necessary to create a smart urban structure. Such a model for the smart city approach has to be systemic, combining different dimensions of smartness and stressing the importance of integration and interaction across various areas. In the process of developing a smart green city model, the utilization of technologies can be - but does not have to be - an element. The ability to make use of locally available capabilities is much more important for smart cities.



**Figure 3:** Main urban dimensions for creating a smart green city. Source: Vogl (2012); adapted by the researcher.



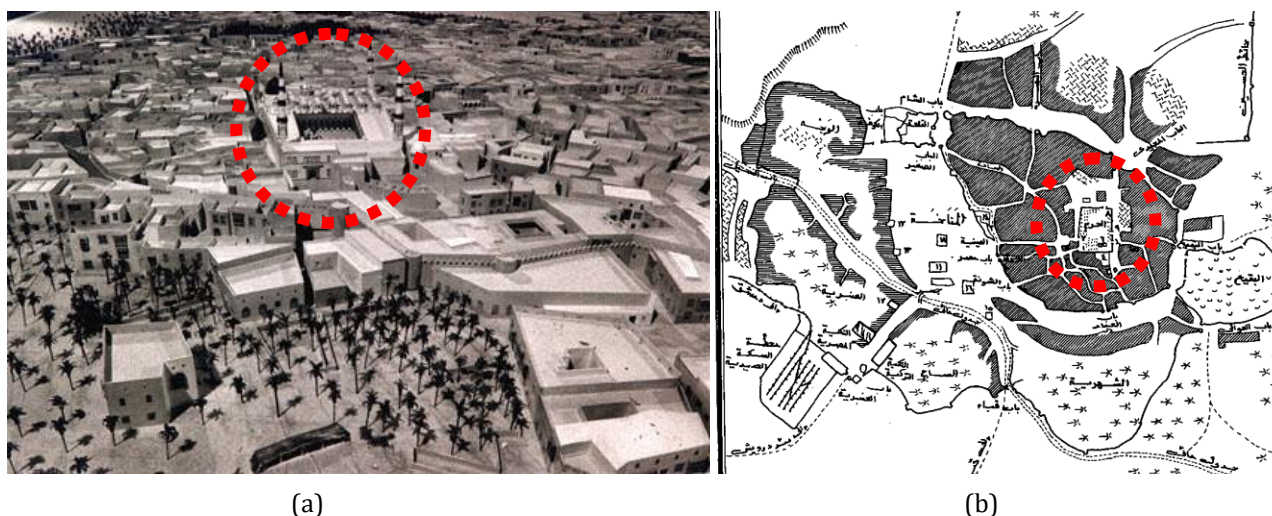
#### 4. PROPHET MOSQUE EXPANSION AND AL-MADINAH ALMUNAWARAH URBAN FORM

Al-Madinah Almunawarah population recently crossed the 1 million mark. It is considered the fourth-largest city in Saudi Arabia, ahead of national average growth at around 3.4 percent per year and expected to increase in the next two decades. On the other hand, around 6–8 million Muslims visit Madinah every year, and this number is projected to reach 34 million by 2024 (MMM Group and Moriyama & Teshima Planners, 2013).

Considering the Haram's expansion and the need for an extra urban extension area for the city, there is a huge opportunity to develop a new vision for Madinah's public space network that will serve local users' and visitors' needs. Meanwhile, adapting new green city theories and smart development guidelines will create a unique model of the city and turn it into an international destination. This paper will review the history of the city and its current urban form then present the latest master plan proposal for urban development.

##### 4.1 History of the city

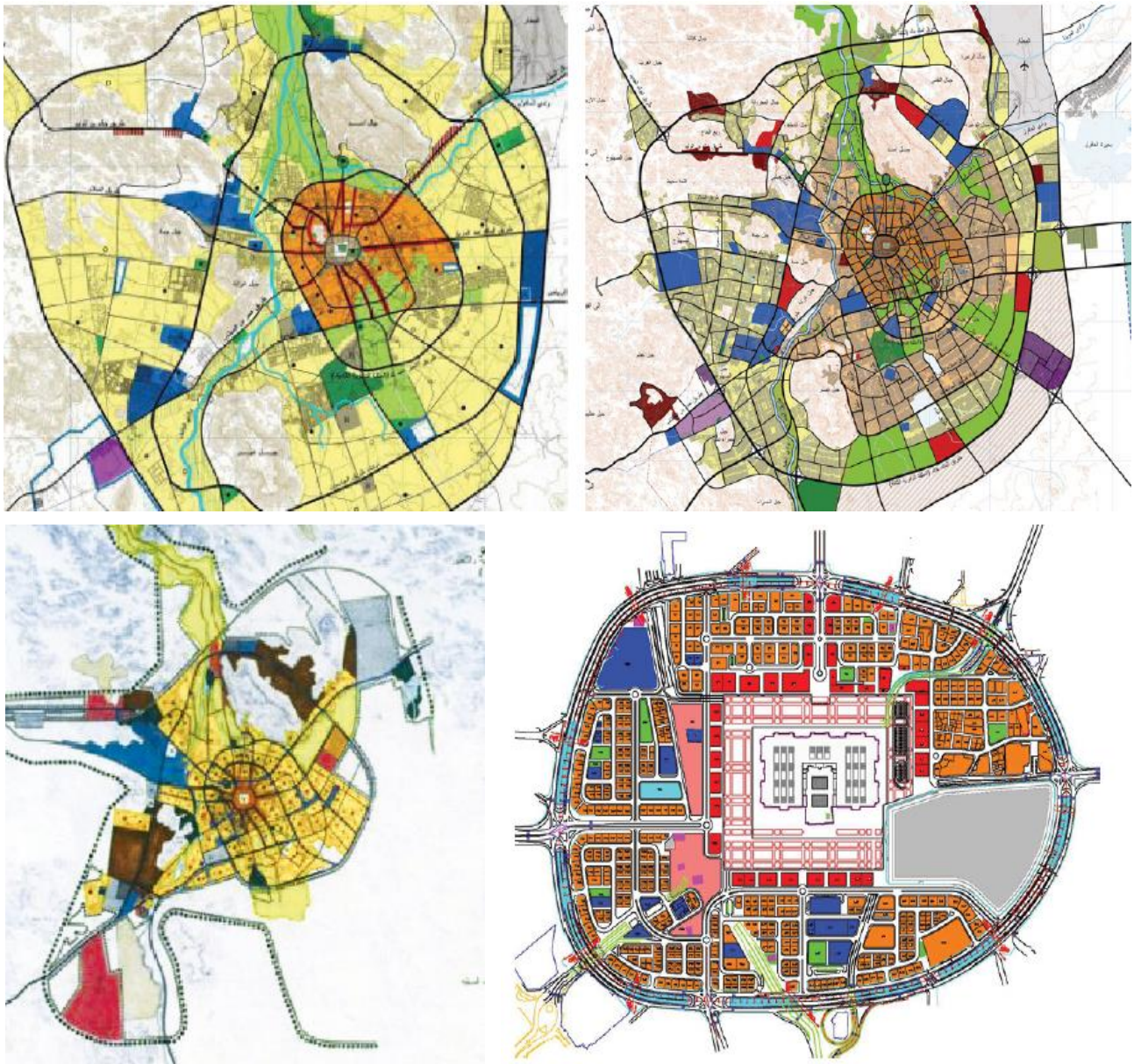
Al-Madinah Almunawarah started to take its unique urban form between 1850 and 1950; before then, it lacked urban documentation and the only data were a few old pictures (Alsafdi, 2007). The Prophet Mosque was the node of the old urban form. Its surroundings comprised mixed residential and commercial uses, which took the old Islamic city form, with narrow streets and no special urban pattern. Figure 4 shows the study model for the old urban form of the city, derived from old maps and urban documentation. The Prophet Mosque was in the middle of an area of houses with no clear vision for future expansion.



**Figure 4:** Old urban form of Al-Madinah Almunawarah. (a) The Prophet Mosque before the expansion. Source: Alsafdi (2007). (b) Street urban form: 1925. Source: Mostafa (1990).

##### 4.2 Current situation

The current urban form of Al-Madinah Almunawarah is traditional; it was developed to have a radial street network around the Prophet Mosque. In the last three decades, the population has increased rapidly in the city; it has attracted a majority of Muslim residents and visitors. Most of the previous master plans for the city proposed the current radial urban pattern with levels of ring roads around the mosque. Figure 5 shows some of these proposals.

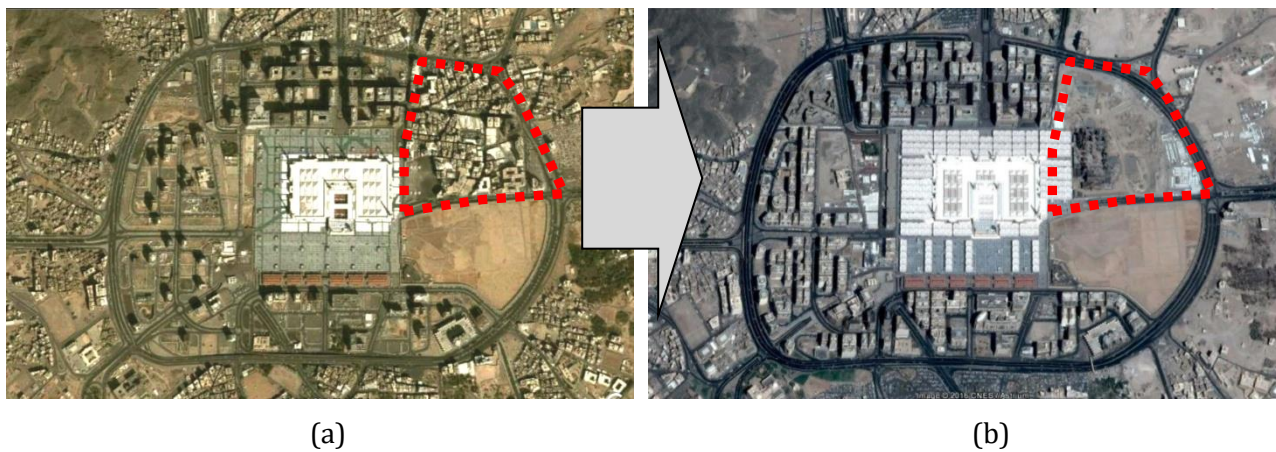


**Figure 5:** Previous master plans for Al-Madinah Almunawarah. Source: MMM Group and Moriyma & Teshima Planners (2013).

Over the years, many land uses changed around the mosque; the government replaced many housing areas with hotels and commercial uses to cope with the increasing number of visitors. Figure 6 shows the development of land uses around the mosque inside the first ring road as described below:

- The Prophet Mosque in 2003, with adjacent old urban tissue inside the first ring road and low hotel density inside the ring road;
- The Prophet Mosque in 2017, after the demolition of the housing area and its replacement with future construction for mosque expansion, with increased hotel building density.

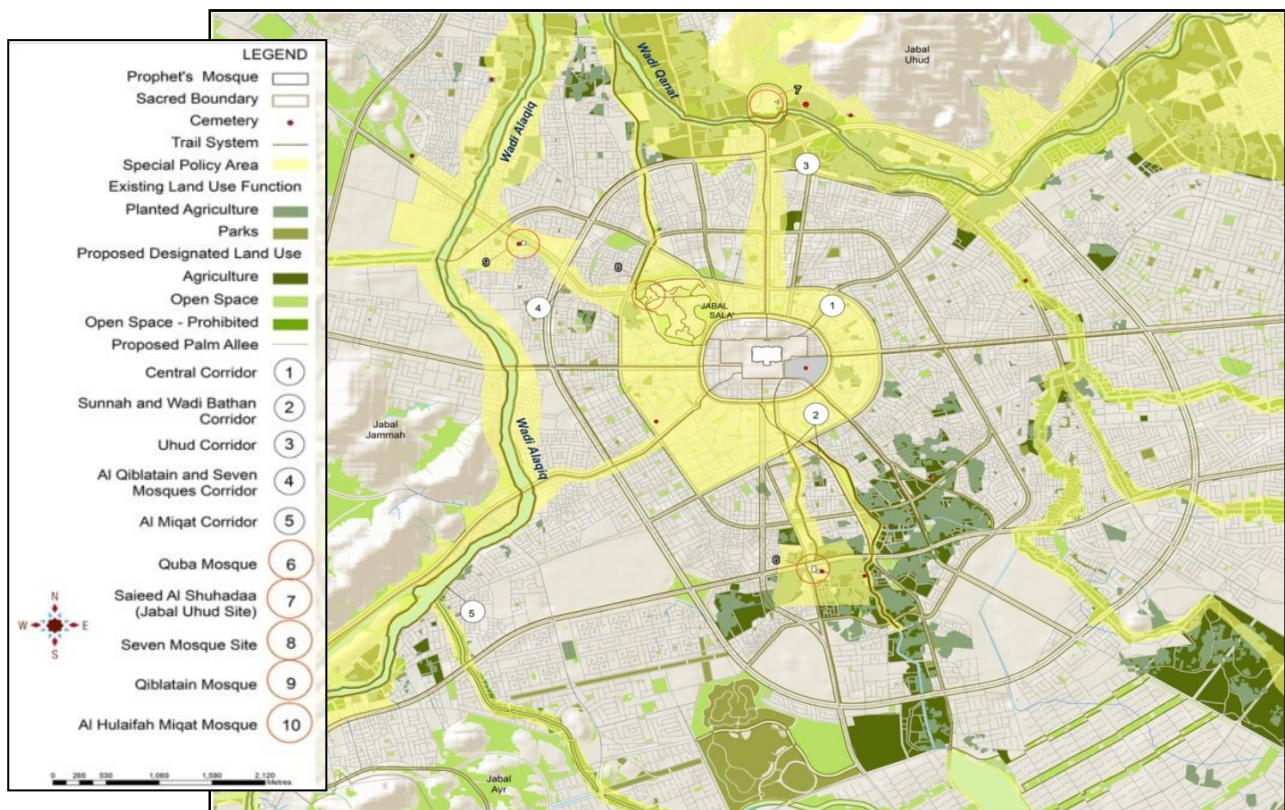




**Figure 6:** Recent image of the center of Al-Madinah Almunawarah. (a) The Prophet Mosque in 2003. (b) The Prophet Mosque in 2017. *Source: Google image, adapted by the researcher.*

### 4.3 Proposed vision of future expansion

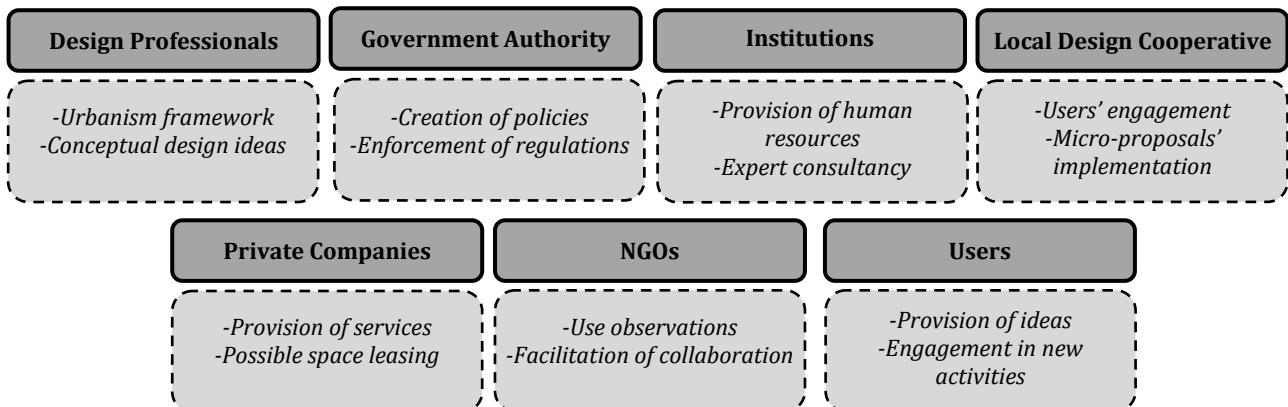
Figure 7 presents the most recently proposed vision for the future urban spaces of the city, taking the prophet mosque expansion and all the necessary uses around it as a starting point. The paper will evaluate the proposal in detail later, according to the proposed framework.



**Figure 7:** Strategy for urban space network in Al-Madinah Almunawarah. *Source: MMM Group and Moriyama & Teshima Planners (2013).*

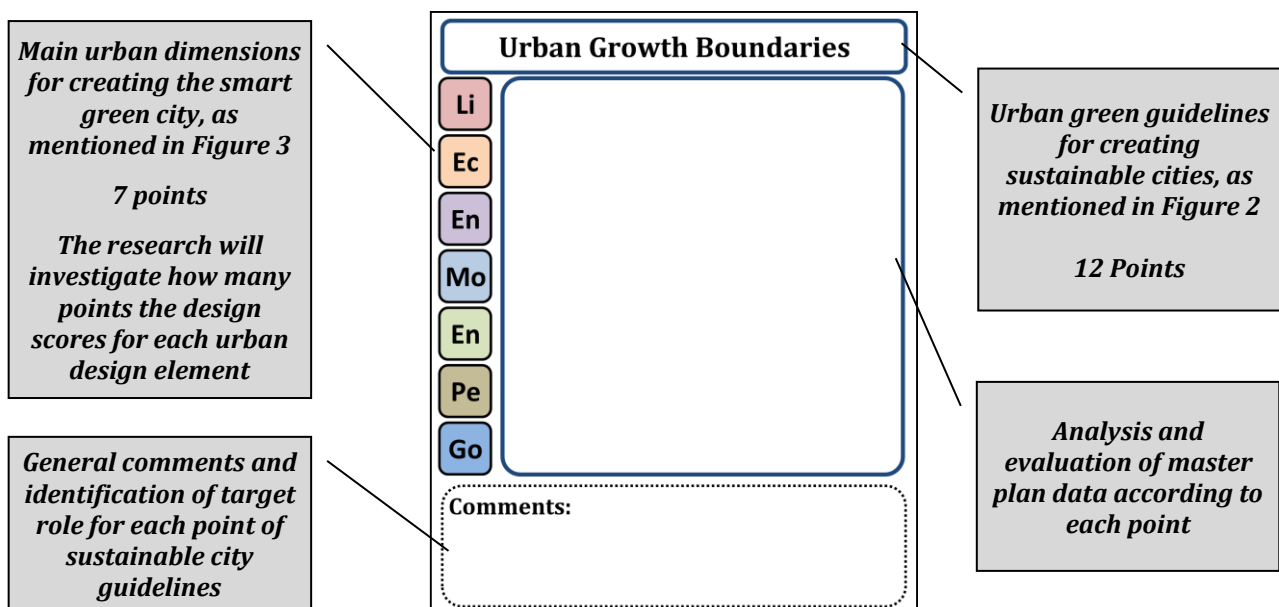
## 5. EVALUATION AND DESIGN FRAMEWORK FOR AL-MADINAH ALMUNAWARAH

In a proposed evaluation and design process—to be applied to the greater Cairo region—of the smart green city that covered green urbanism principles, Nassar (2013) stated that each actor's input had an impact and influence on the design process scale and the implementation of micro-projects (e.g. Fig. 8). The research will continue to focus on and analyze the complex network and examine expansion vision of the Prophet Mosque and the proposed urban space network in Al-Madinah Almunawarah according to individual actors in the design process. Moreover, it will combine this with Figure 2 and 3 to create a comprehensive framework for evaluating the proposed master plan for the city.



**Figure 8:** Task of each actor in the design process of the proposed sustainable green city.  
Source: Nassar (2013).

Figure 9 illustrates the methodology for combining the green guidelines for the design of the sustainable city with the new urban dimension for creating a smart city, alongside the identification of the specific roles in each item. Table 2 shows the research connection between the two.



**Figure 9:** Forming the basis for the design and evaluation framework. Source: the researcher.

**Table 2:** Case study correlation matrix between green guidelines for sustainable cities and urban dimensions for creating the smart green city

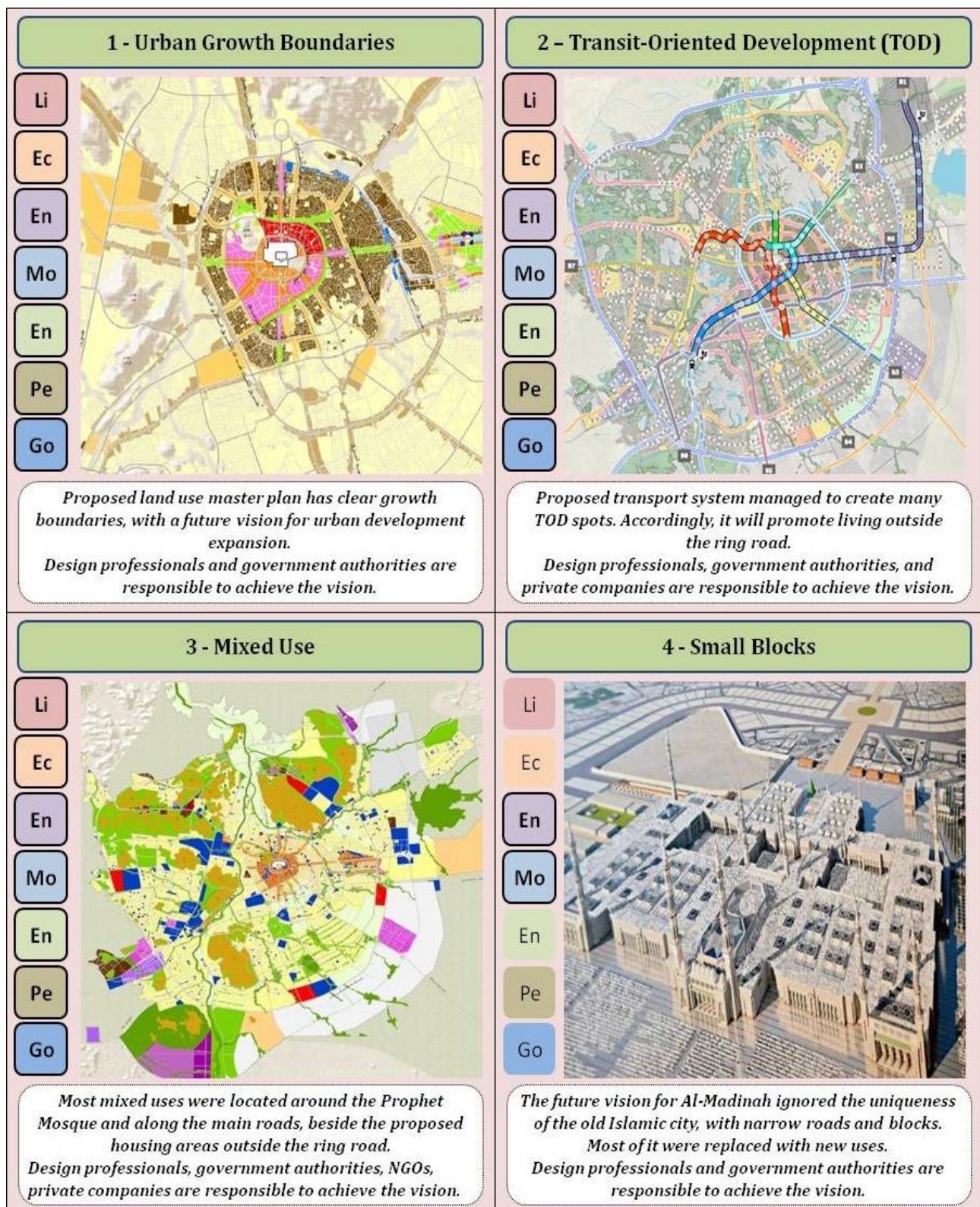
Green guidelines for Designing sustainable cities		1 - Urban Growth Boundaries	2 - Transit-Oriented Development	3 - Mixed-Use	4 - Small Blocks	5 - Public Green Space	6 - Non-Motorized Transit	7 - Public Transit	8 - Car Control	9 - Green Buildings	10 - Renewable and District Energy	11 - Waste	12 - Water
Main urban dimensions for creating a smart green city													
Li	Smart <b>L</b> iving (quality of life)												
Ec	Smart <b>E</b> conomy (competitiveness)												
En	Smart <b>E</b> nergy (efficiency)												
Mo	Smart <b>M</b> obility (connectivity)												
En	Smart <b>E</b> nvironment (sustainability)												
Pe	Smart <b>P</b> eople (knowledge)												
Go	Smart <b>G</b> overnance (participation)												

Source: the researcher

Table 2 presents the existing correlation matrix between the approach for the sustainable city and urban dimensions for creating smart green city. Each point of the seven main urban dimensions for creating a smart green city is examined to determine whether or not they are achieved through the available master plan from Al-Madinah Almunawarah studies (which could be an actual proposed action plan and future recommendations) or through field studies to achieve the city master plan's vision.

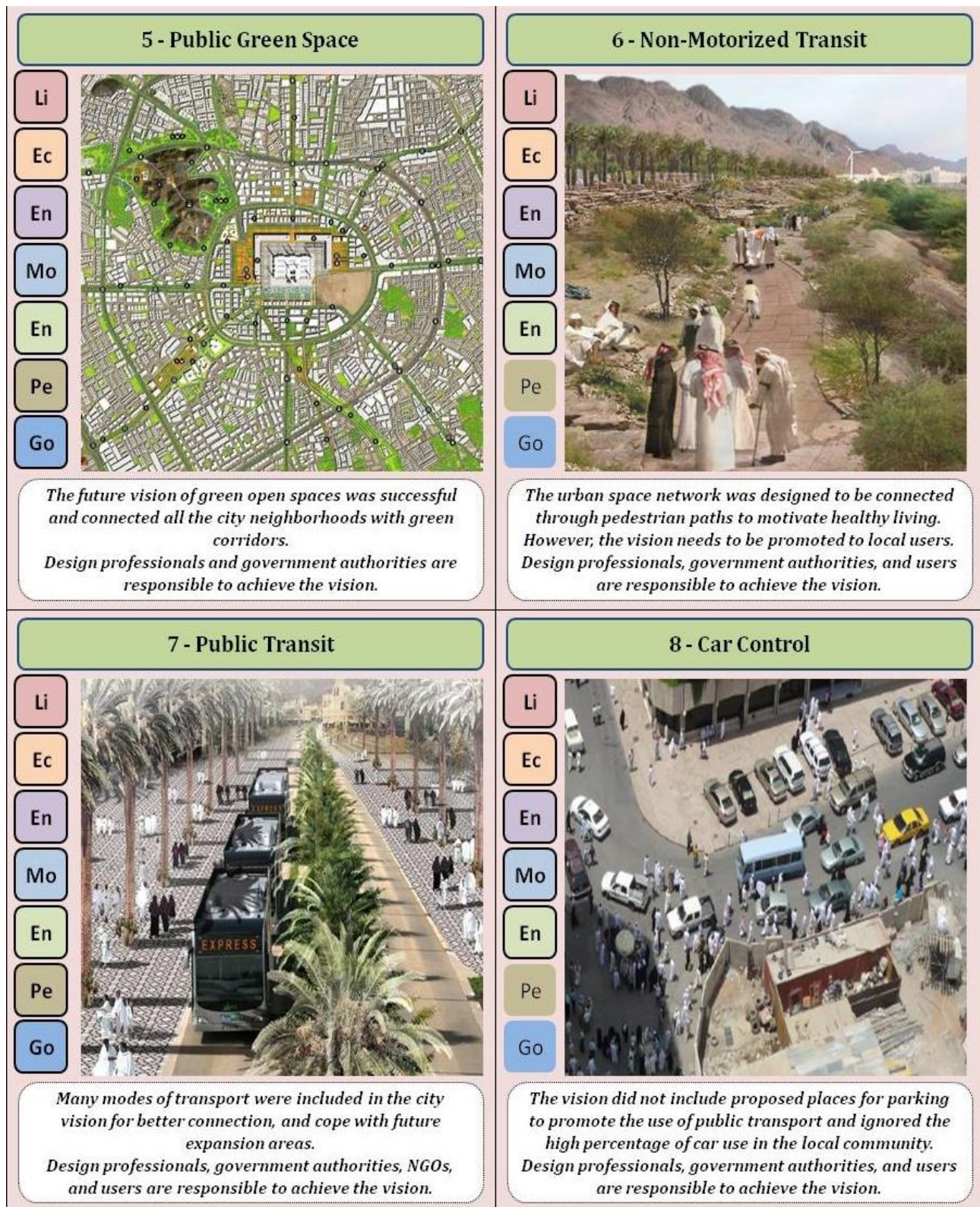
The research uses the 12 green guidelines (Pike & Huang, 2016) as a starting point for its collective vision and covers all the design elements and tools necessary to achieve a sustainable city. Figure 10 (a), (b), (c) illustrates the detailed evaluation framework derived from Table 2 for Al-Madinah Almunawarah Masterplan vision, followed by general conclusion to refine the framework and present the major findings follows.





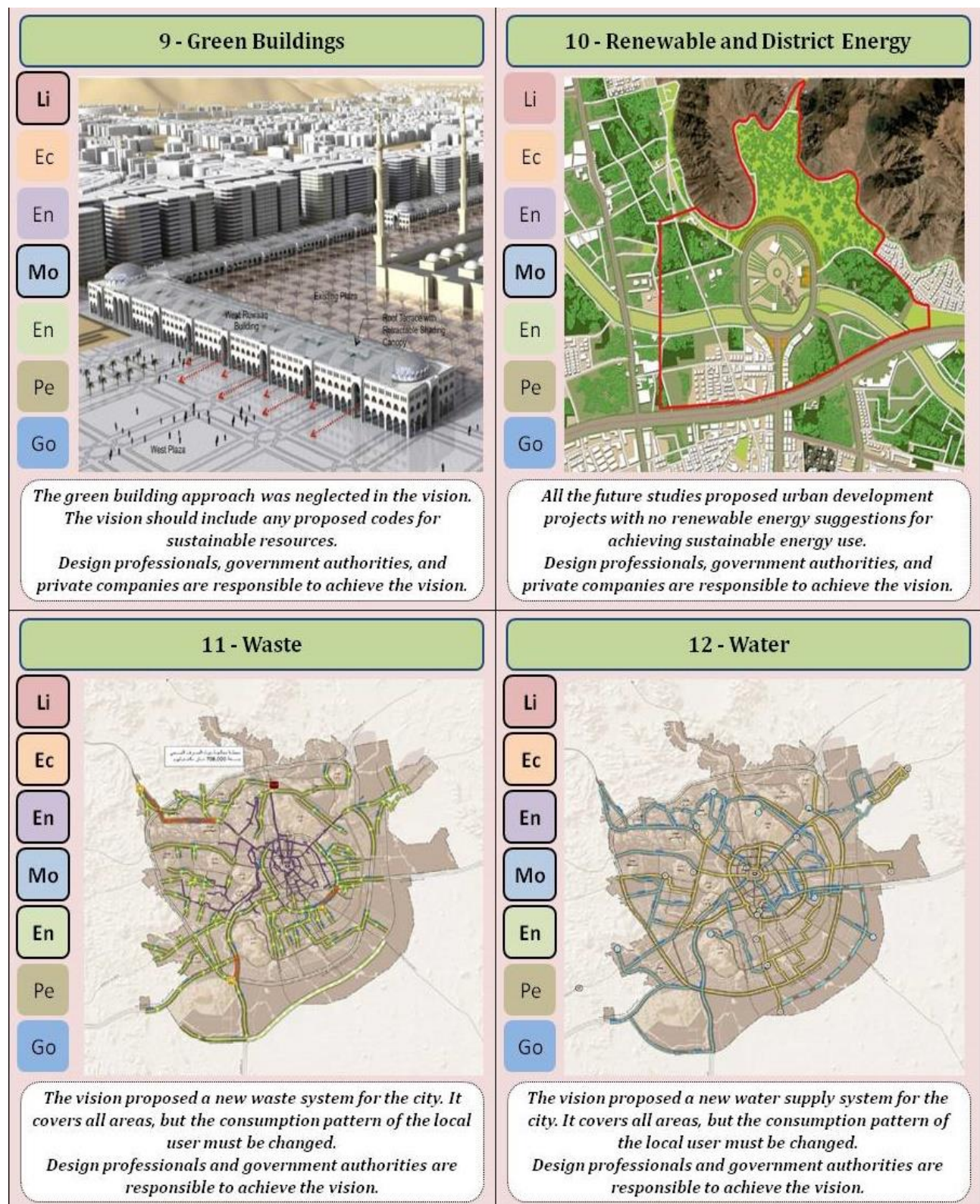
**Figure 10 (a):** Evaluation framework for the Smart Green City (Part 1). Source: MMM Group and Moriyama & Teshima Planners (2013), adapted by the researcher.





**Figure 10 (b):** Evaluation framework for the Smart Green City (Part 2). Source: MMM Group and Moriyama & Teshima Planners (2013), adapted by the researcher.

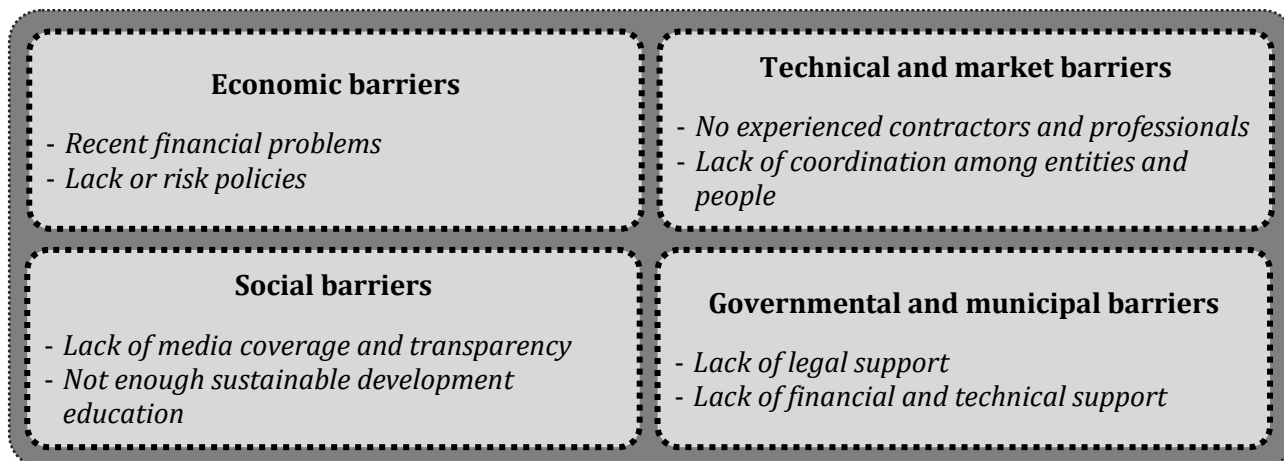




**Figure 10 (c):** Evaluation framework for the Smart Green City (Part 3). Source: MMM Group and Moriyama & Teshima Planners (2013), adapted by the researcher.

## 6. CONCLUSION

Sustainable development in Al-Madinah Almunawarah is in its very early years compared to that in developed cities worldwide. Hence, before its maturation, there is a suitable environment for the adoption of proactive approaches in the market. Exponentially expanding human settlement in the city already makes sustainable solutions essential. Most of the sustainable development barriers presented in the literature review have also been validated for the local market in the city. See Fig. 11



**Figure 11:** Sustainable development barriers in Al-Madinah Almunawarah. *Source: the researcher.*

There is an urgent need to establish better connections between city managers and the people. This was clearly a weak point in the city master plan vision: Most of the studies ignored the characteristics of local people and did not propose any ideas to enhance it, especially where car control and the renewable energy approach were concerned. Al-Madinah Almunawarah should target a particular level of energy consumption reduction for the long term and generate new regulations.

The general conclusions of the research follow:

- Technology is clearly a necessary condition for a smart green city, but people's understanding of the idea concerns the development of urban society for a better quality of living. The adoption of conventional technologies does not guarantee the success of smart green city initiatives.
- The correlation matrix in table 2 should be achieved for any smart city vision, with a special focus on people and government as a start point.
- Enhancing green intelligent transportation systems in cities can facilitate the achievement of sustainable urban design processes and a livable environment.
- Applying the concept of transit-oriented development (TOD) will support the sustainable green city vision. The primary goal of TOD is the intensification of the usage of areas that are highly accessible by public transport. It mainly concerns rail-based modes of transportation (railway, metro, tram), which are believed to be the models with the lowest environmental impact.
- Further research should be undertaken to explore the relations between design professionals, stakeholders, government policies, and users, particularly with more focus on the possible impacts of these relations on the social sustainable city.
- It could be relevant to apply the framework and evaluate it in different places to see if the results vary between cities.

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