جامعة محمد خيضر بسكرة
كلية العلوم الدقيقة وعلوم الطبيعة والحياة
قسم علوم الأرض والكون

مذكرة ماستر في إطار القرار 1275

ميدان: هندسة معمارية، عمران ومهن المدينة
شعبة: تسيير التقنيات الحضرية
تخصص: تسيير المدن
رقم: .....

إعداد الطالب:
عثماني مرابط محمد مصطفى

يوم: 2023/06/25

The role of technological innovation on building a sustainable city. Case study: the new town of Hassi Messaoud

---

لجنة المناقشة:

جميلة جغروري	أ. مح أ	جامعة بسكرة	مقرر
حورية عثماني	أ. مح ب	جامعة بسكرة	رئيس
سمية عرامي	أ. مس أ	جامعة بسكرة	مناقش
قطاف فيروز	أ. مح	جامعة بسكرة	ممثل الحاضنة

السنة الجامعية: 2022 – 2023

Acknowledgment

I would like to take this opportunity to express my sincere gratitude and appreciation to all those who have contributed to the completion of this thesis.

First and foremost, I am deeply indebted to my thesis advisor, Dr Djamila Djaghrouri. Your guidance, expertise, and unwavering support throughout the entire research process have been invaluable.

I would also like to extend my heartfelt thanks to the members of my thesis committee. Your constructive feedback and valuable suggestions have greatly enhanced the quality of this thesis. I am grateful for the time and effort you dedicated to reviewing and evaluating my work.

I am particularly grateful to my parents for their unwavering support, guidance, and sacrifices. Their unconditional love, encouragement, and belief in my abilities have been the foundation of my academic journey. Their constant presence and unwavering faith in me have fueled my determination to pursue this thesis.

I would also like to extend my heartfelt thanks to my mentor, Dr. Lotfi Belkhir, Director for Entrepreneurial Transformation at Qatar University. Your passion for innovation and technology has been truly inspiring, and your mentorship has played a pivotal role in shaping my understanding and love for these fields. Your extensive experience in sustainable and innovation-powered business creation has broadened my perspectives and enriched my research.

Lastly, I would like to express my gratitude to all those individuals who may not be directly mentioned but have, in some way, contributed to my academic and personal growth. Your inspiration, encouragement, and support have played an integral role in shaping my aspirations and achievements.

Table of Contents

List of Tables

Liste of Figure

Abstract:

English:

This thesis examines the integration of technological innovation in the development of sustainable cities, focusing on the case study of Hassi Messaoud's new town. The research addresses the importance of this topic in addressing global challenges and aims to analyze the potential of technological innovations in enhancing sustainability, efficiency, and livability.

Using a mixed-methods approach, including literature reviews, and stakeholder interviews, the study investigates the geographical context, urban composition, infrastructure, renewable energy potential, and global plans of the new town. The findings highlight the role of technological innovations in urban planning, renewable energy adoption, smart infrastructure, and citizen engagement.

The research contributes practical insights and recommendations for policymakers, urban planners, and researchers, emphasizing the importance of integrating technological innovation for sustainable urban development. It provides implications for both practical applications and theoretical understanding, informing future research and sustainable urban development strategies.

In conclusion, this thesis underscores the potential of technological innovation in creating sustainable cities. The case study of Hassi Messaoud's new town serves as a valuable example, offering lessons and guidance for future endeavors in sustainable urban development.

Keywords: Technological Innovation, Sustainable Cities, Urban Planning, Smart Cities, Digitalization.

French :

Cette thèse examine l'intégration de l'innovation technologique dans le développement des villes durables, en se concentrant sur l'étude de cas de la nouvelle ville de Hassi Messaoud. La recherche aborde l'importance de ce sujet pour relever les défis mondiaux et vise à analyser le potentiel des innovations technologiques pour améliorer la durabilité, l'efficacité et la qualité de vie.

En utilisant une approche mixte comprenant des revues de littérature et des entretiens avec les parties prenantes, l'étude examine le contexte géographique, la composition urbaine, l'infrastructure, le potentiel d'énergie renouvelable et les plans mondiaux de la nouvelle ville. Les

résultats mettent en évidence le rôle des innovations technologiques dans la planification urbaine, l'adoption des énergies renouvelables, les infrastructures intelligentes et l'engagement des citoyens. La recherche apporte des aperçus pratiques et des recommandations pour les décideurs, les urbanistes et les chercheurs, en soulignant l'importance de l'intégration de l'innovation technologique pour un développement urbain durable. Elle propose des implications à la fois pour les applications pratiques et la compréhension théorique, informant les futures recherches et les stratégies de développement urbain durable.

En conclusion, cette thèse souligne le potentiel de l'innovation technologique dans la création de villes durables. L'étude de cas de la nouvelle ville de Hassi Messaoud constitue un exemple précieux, offrant des leçons et des orientations pour les futurs projets en matière de développement urbain durable.

Mots clés : Innovation technologique, Villes durables, Urbanisme, Villes intelligentes, Numérisation.

Arabic:

تتناول هذه الأطروحة دراسة التكامل بين الابتكار التكنولوجي وتطوير المدن المستدامة، مركزةً على دراسة حالة مدينة حاسي مسعود الجديدة. يعالج البحث أهمية هذا الموضوع في التصدي للتحديات العالمية وتهدف إلى تحليل إمكانات الابتكارات التكنولوجية في تعزيز الاستدامة والكفاءة وجودة الحياة.

تستقصي الدراسة السياق الجغرافي والتكوين الحضري والبنية التحتية وإمكانات الطاقة المتجددة والخطط العالمية للمدينة الجديدة. تسلط النتائج الضوء على دور الابتكارات التكنولوجية في التخطيط العمراني واعتماد الطاقة المتجددة والبنية التحتية الذكية ومشاركة المواطنين.

يقدم البحث تطبيقات عملية وتوصيات لصناع القرار والمخططين الحضريين والباحثين، مع التركيز على أهمية تكامل الابتكار التكنولوجي لتحقيق التنمية الحضرية المستدامة. يوفر آفاقًا عملية وفهمًا نظريًا، ويُعزز البحث المستقبلي واستراتيجيات التنمية الحضرية المستدامة.

في الختام، تسلط هذه الأطروحة الضوء على إمكانات الابتكار التكنولوجي في خلق مدن مستدامة. دراسة حالة مدينة حاسي مسعود الجديدة تعتبر مثالًا قيمًا، وتقدم دروسًا وتوجيهات للمشاريع المستقبلية في مجال التنمية الحضرية المستدامة.

كلمات مفتاحية: الابتكار التكنولوجي، المدن المستدامة، التخطيط العمراني، المدن الذكية، الرقمنة.

INTRODUCTION

Introduction:

The concept of sustainable cities has become increasingly significant as urban areas face mounting challenges related to population growth, resource scarcity, environmental degradation, and social inequities. In response to these pressing issues, cities worldwide are exploring innovative approaches to achieve sustainable urban development. This thesis aims to present a comprehensive proposal for integrating technological innovation into the future development of the New Town of Hassi Messaoud, with the objective of creating a sustainable and technologically advanced urban environment.

Hassi Messaoud, located in an oil-rich region, is currently undergoing a transformation with the establishment of the New Town project. This endeavor presents a unique opportunity to incorporate cutting-edge technological solutions that can enhance the town's sustainability, resilience, and quality of life for its residents. By leveraging technological innovation, the New Town of Hassi Messaoud can become a model for sustainable urban development, effectively addressing environmental challenges and promoting economic prosperity.

Technological innovation offers a wide range of possibilities for sustainable urban development, from renewable energy systems and smart infrastructure to intelligent transportation networks and digital governance platforms. By embracing these innovations, the New Town of Hassi Messaoud can benefit from enhanced resource efficiency, reduced carbon emissions, improved mobility, optimized infrastructure, and increased citizen engagement.

This thesis seeks to propose a roadmap for integrating technological innovation into the planning and development processes of the New Town of Hassi Messaoud. The research will explore various dimensions of sustainable urban development, including energy, transportation, waste management, water conservation, smart governance, and digital infrastructure. By identifying specific technological innovations applicable to each domain, the thesis aims to outline a comprehensive strategy for the New Town's sustainable transformation.

Through an analysis of successful case studies from around the world, the research will highlight best practices and lessons learned in integrating technological innovation into sustainable cities.

By adapting these lessons to the unique context of the New Town of Hassi Messaoud, the thesis will propose tailored solutions that align with the town's objectives and constraints.

Furthermore, the research will address the challenges and barriers that may arise during the implementation of technological innovations. Financial considerations, technical expertise, infrastructure requirements, regulatory frameworks, and community acceptance will be carefully examined to ensure a realistic and feasible approach to integrating technology into the New Town's development.

In conclusion, this thesis aims to present a comprehensive proposal for integrating technological innovation into the future development of the New Town of Hassi Messaoud. By leveraging technological advancements, the town can enhance its sustainability, resilience, and quality of life for its residents. The research will provide valuable insights and practical recommendations for policymakers, urban planners, and stakeholders involved in shaping the New Town's future, emphasizing the importance of embracing technological innovation to create a sustainable and thriving urban environment.

Problem Statement:

The New Town of Hassi Messaoud project lacks a comprehensive plan for integrating technological innovation, which poses a significant challenge in achieving its goal of building a sustainable and future-ready city. The absence of innovative technologies and practices hinders resource optimization, environmental sustainability, quality of life improvement, and economic growth. This thesis aims to address this problem by proposing a roadmap and actionable recommendations to incorporate technological innovations across various sectors, ensuring the New Town of Hassi Messaoud realizes its vision of becoming a sustainable and technologically advanced urban center.

Key Questions:

1. How can technological innovation be effectively integrated into the development of the New Town of Hassi Messaoud to enhance sustainability and resilience?
2. What are the potential benefits and challenges associated with incorporating technological innovations in various sectors of the New Town, such as energy, transportation, waste management, and water conservation?
3. How can the successful integration of technological innovation contribute to the overall development and long-term success of the New Town of Hassi Messaoud?

Hypotheses:

1. The strategic integration of technological innovation in the New Town of Hassi Messaoud will lead to improved resource utilization, environmental sustainability, and overall quality of life.
2. The incorporation of technological innovations in energy, transportation, waste management, and water conservation sectors in the New Town will result in enhanced efficiency, reduced environmental impacts, and increased resilience.
3. The successful integration of technological innovation in the development of the New Town of Hassi Messaoud will attract investments, foster economic growth, and position the town as a leading example of sustainable urban development in the region.

Goal of the Thesis:

The goal of this thesis is to explore the potential of integrating technological innovation into the development of the New Town of Hassi Messaoud, with the aim of creating a sustainable and technologically advanced urban center. By examining the benefits, challenges, and outcomes associated with incorporating innovative technologies in various sectors, such as energy, transportation, waste management, and water conservation, this research seeks to provide a roadmap and actionable recommendations for effectively integrating technological innovations. Ultimately,

Reason for Choosing this Topic:

The decision to explore the impact of technological innovation on building a sustainable city, specifically through the case study of the New Town of Hassi Messaoud, was driven by three key reasons. Firstly, the rapid advancement of technology has transformed urban planning, making it crucial to understand how integrating innovative technologies can create more sustainable and resilient cities. Secondly, studying a real-world project in progress like Hassi Messaoud provides valuable insights into the planning and implementation of technological innovations in an urban context. Lastly, with sustainability becoming a global priority, investigating the role of technological innovation in achieving sustainable development goals offers practical strategies for building sustainable cities.

Methodology of the thesis:

This thesis employs a mixed methods research design, combining qualitative and quantitative approaches. Data collection primarily involves secondary sources, including official websites, databases, literature, and reports. The thesis is structured into chapters covering the concept of a sustainable city, technological innovations, case studies of successful integration, and a main case study on Hassi Messaoud. This methodology aims to provide a comprehensive analysis using diverse secondary data sources and contribute to the understanding of sustainable cities and technological advancements.

THEORETICAL PART

Chapter 1

The sustainable city

1. Introduction:

Cities are fascinating, complex, and dynamic systems that shape and reflect the human condition. They are the physical manifestation of our collective aspirations, desires, and needs and offer endless possibilities for innovation, creativity, and progress. However, cities are also the epicenters of many global challenges we face today, from climate change to social inequality, urban sprawl, and environmental degradation. These challenges threaten the livability and resilience of cities and the survival of the planet and its inhabitants.

Climate change, in particular, poses an urgent and existential threat to the sustainability of cities. It is a complex and multifaceted problem that requires global cooperation, collective action, and innovative solutions. According to the Intergovernmental Panel on Climate Change (IPCC), human activities, mainly the burning of fossil fuels, have caused the Earth's temperature to rise by 1.1°C above pre-industrial levels, and this trend is projected to continue unless significant and rapid action is taken. The impacts of climate change are already being felt in many parts of the world, from heatwaves to hurricanes, from droughts to floods, from sea-level rise to biodiversity loss.

Therefore, creating sustainable cities has become a critical goal for urban planning and development, as it offers a way to address the challenges of climate change and other sustainability issues. Sustainable cities balance economic, social, and environmental factors to meet the needs of the present generation without compromising the ability of future generations to meet their own needs. They are cities that are designed, managed, and operated in a way that minimizes their ecological footprint, maximizes their resource efficiency, and enhances the quality of life for their residents. Sustainable cities are good for the planet and the people who live in them, as they offer opportunities for health, happiness, and prosperity.

The purpose of this chapter is to explore the concept of a sustainable city and its relevance to urban planning. It aims to provide a comprehensive understanding of the key features, benefits, challenges, and tradeoffs of sustainable cities and analyze the role of urban planning and design in creating them.

2. Sustainability - Sustainable development:

The concept of sustainability originated from a forestry handbook published in 1713. Over time, the term "sustainability" expanded to encompass how humans live on the planet. The most widely accepted definition of sustainability is that of sustainable development, as defined by the United Nations' Brundtland Commission in 1987. According to this definition, sustainable development refers to development that meets present needs without compromising the ability of future generations to meet their own needs.

In 2000, the United Nations Millennium Summit established eight development goals known as the Millennium Development Goals (MDGs) with the aim of eradicating poverty by 2015. While the MDGs were considered somewhat successful, they were not comprehensive enough. In 2012, the member states of the United Nations convened in Rio de Janeiro to formulate a new global agenda for sustainable development. After three years of deliberation, in 2015, they reached a consensus on a document titled "Transforming Our World: The 2030 Agenda for Sustainable Development," which encompasses the 17 Sustainable Development Goals (SDGs). (1)

Figure 1: Sustainable development goals.

Source : United Nation Website

3. Sustainable cities :

The concept of sustainable cities emerged as part of the broader concept of sustainable development in the 1980s. By 2015, the United Nations established the Sustainable Development Goals (SDGs), which include Goal 11 specifically focused on sustainable cities. Achieving sustainable cities involves various aspects such as fostering job opportunities and business growth, ensuring access to safe and affordable housing, developing resilient economies and societies, creating green public spaces, and enhancing urban planning and management through participatory and inclusive approaches. (2). Cities can work as a string that connects all other sustainable development goals since they collect economy, energy, environment, science, technology, and society together. (3)

3.1. Definitions of sustainable cities :

There is no fixed definition of a sustainable city; the definition of a sustainable city came as a city that improves the quality of life for citizens, including environmental, cultural, social, economic, political, and institutional aspects, without leaving a burden on future generations (4), Sustainable cities are carefully designed and managed to minimize their economic, social, and environmental impact. They aim to create a resilient living environment for current residents while ensuring that future generations can enjoy the same benefits. (5), a city that improves its quality of life improves access to services and opportunities, be socially inclusive, economically productive, and environmentally livable (6).

3.2. Sustainable cities goals:

The goal of sustainable cities is to address urban challenges in a manner that enables them to thrive and develop. This involves ensuring that all residents have access to suitable, secure, and affordable housing and essential services. Additionally, sustainable cities strive to provide safe, affordable, and environmentally friendly transportation systems, as well as accessible green and public spaces that cater to the needs of diverse populations, including women, children, the elderly, and individuals with disabilities. These cities also prioritize the protection and preservation of cultural heritage, ecosystems, and biodiversity within urban areas. They work towards reducing the environmental impact of cities, mitigating the negative consequences of natural disasters, efficiently utilizing resources, minimizing pollution, and mitigating the effects of climate change. (2)

3.3. Pillars of access to sustainable cities:

Cities are increasingly seeking sustainable approaches to ensure a better quality of life for their residents. This requires effective urban governance that promotes environmental management and urban planning. Key elements of this governance include decentralized decision-making, minimizing ecological footprints, efficient resource management, and effective coordination between national and local authorities. The concept of sustainable cities encompasses the integration of four essential pillars: environmental management, economic development, social development, and urban governance. Addressing these pillars is crucial for creating sustainable cities, as failure to tackle these issues would hinder the achievement of sustainability goals. (6)

Social development	• Education and health • Food and nutrition • Green housing and buildings • Water and sanitation • Green public transportation • Green energy access • Recreation areas and community support
Economic development	• Green productive growth • Creation of decent employment • Production and distribution of renewable energy • Technology and innovation (R&D)
Environmental management	• Forest and soil management • Waste and recycling management • Energy efficiency • Water management • Air quality conservation • Adaptation to and mitigation of climate change
Urban governance	• Planning and decentralization • Reduction of inequities • Strengthening of civil and political rights • Support of local, national, regional and global links

Table 1 Pillars for achieving sustainability of cities

3.4. Properties of sustainable cities:

The European Union (2010) has outlined the key attributes that contribute to attractive and sustainable cities, categorizing them into four main areas: Clean and healthy, Efficient and sustainable, Green and pleasant, and Well-managed and democratic.

Clean and healthy	**Green and pleasant**
- Safe water to drink - Clean air to breathe. - Collection and disposal of solid waste - Toxic free	- Green urban areas - Biodiversity friendly - Quiet places - Respect for urban heritage - Sustainable land use
Efficient and sustainable	**Well-managed and democratic**
- Resource efficiency - Energy efficiency - Green mobility - Local actions on climate change - Technological innovations and green jobs	- Integrated Environmental Management Systems - Green public procurement - Participatory urban planning - Assessing environmental impacts - Tracking progress

Table 2 Properties of sustainable cities

3.5. Advantages of sustainable cities :

Sustainable cities prioritize the use of renewable energy sources to foster healthy and livable environments, while also minimizing their environmental impact. This is achieved through energy-efficient practices, reducing reliance on fossil fuels, and actively working to decrease environmental pollution. Additionally, sustainable cities implement proper waste management systems, ensuring the safe disposal of solid waste and wastewater, and promote the responsible use of materials and resources by encouraging recycling and reusing. These cities also prioritize the preservation of biodiversity and ecosystems and aim for local self-sufficiency in food, materials, and energy to reduce economic burdens and foster a strong connection between the community and the local environment, heritage, and culture. Effective land use practices are implemented, including preventing mixed-use development, eliminating slums, and establishing limits on urban expansion to protect agricultural lands. (7)

4. Sustainable Cities Indicators:

The Sustainable Cities Indicators provide an evaluation of cities, considering their livability and environmental impact. These indicators enable the identification of issues and pressures faced by cities and help determine areas where interventions can be implemented for improvement. They also allow cities to track the effectiveness and outcomes of sustainability initiatives. Various organizations and research groups have developed and tested numerous indicator tools based on the three dimensions of sustainability: social, environmental, and economic. These tools have been applied in real cities to assess their sustainability and guide decision-making processes. (4)

Sector	Indicator	Measures
Economy	Unemployment rates/ Jobs	• employment, Underemployment, unemployment rates • Percentage of green jobs in the local economy • Average professional and education years of Laboure force
	Economic growth	• Annual GDP growth rate and Annual GNP growth rate • Net Export Growth rates • Foreign Direct Investments
Environment	Green spaces	• Percentage of reservoirs, waterways, parks in relation to total land area • Percentage of trees in the city in relation to city area and/or population size
	Reduce greenhouse gases/ Energy efficiency	• Total amount of GHG emissions per city and per capita • Percentage of total energy consumed in the city that comes from renewable sources.
	Mobility	• Percentage of each mode of transportation, private, public, bicycles, pedestrians • Average commute time and cost
	Water quality/ Availability	• Proportion of population with access to adequate and safe drinking water • Total amount of water availability • Water quality score
	Air quality	• The average level of pollutants
	Waste/ Reuse/ Recycle	• Recycling rate • Volume of solid waste generated
Social	Complete neighborhood/ Compact city	• Access to local services within a short distance • Crime rates • Measures of income distribution and inequality

	Housing	• Percentage of social housing • Breakdown of housing sector by property type
	Quality public space	• Percentage of roadways in good condition • Percentage of green space in relation to city area and/or population size
	Education	• Number of schools with environmental education programs • Adult literacy rate
	Sanitation	• Percentage of population with access to sewage infrastructure
	Health	• Mortality rate/ Life expectancy • Percentage of population with access to health care services

Table 3 Sustainable Cities International's Indicators for Sustainability list

5. Planning Actions Toward Sustainable cities:

The four pillars serve as a framework for implementing specific planning actions aimed at achieving sustainability. These actions encompass various aspects, including land use, housing and building, transportation, open space and recreation, economic development, infrastructure, watershed planning, floodplain management, and planning processes and education. It is important to note that the specific actions will differ from one community or region to another. Therefore, effective planning involves engaging the community in a participatory planning process to develop a planning and policy agenda for sustainability, utilizing the four pillars as a guiding framework. (8)

5.1. Land use:

Implementing comprehensive land management strategies at the city level that align with social, environmental, and economic development goals is crucial. These strategies aim to ensure equitable access to affordable social and green spaces, promote sustainable land use practices, address the issues of slums and deteriorated areas, prevent encroachments on agricultural lands by both human activities and natural forces, and uphold the preservation of ecosystems and biological diversity. (9)

5.2. Transport and mobility:

Transportation and mobility play a vital role in linking individuals to essential goods and services, facilitating social and economic progress, and promoting sustainable development within cities. Sustainable transportation aims to foster improved economic integration while respecting the environment, enhancing social equity, and supporting the health and well-being of individuals.

This involves providing safe, clean, convenient, time and energy-efficient, and affordable transportation options that are accessible to all members of the community, ensuring seamless and flexible movement between cities. (10)

5.3. Housing and Building:

Ensuring housing accessibility for individuals across all income levels, facilitating proximity between housing and workplaces, promoting the use of renewable energy for cooking, heating, and cooling purposes, minimizing waste generation and promoting recycling of construction materials, utilizing eco-friendly, low-energy, and cost-effective building materials, and creating homes that are healthy, durable, secure, and conveniently connected to employment opportunities, retail establishments, healthcare facilities, childcare centers, educational institutions, and other essential services. (11)

5.4. Economic Development:

Encourage the advancement of inclusive and sustainable economic growth by implementing policies that foster productive activities, generate full and productive employment opportunities, and sustain annual per capita economic and domestic product growth. Facilitate the creation of decent jobs for all individuals, ensuring the protection of labor rights and the promotion of safe and secure working environments for all workers. (12)

5.5. Open & Green Space:

Ensure the availability of ample green and open spaces that are safe, easily accessible, and cater to the needs of diverse population groups, including children, women, older persons, and individuals with disabilities. Foster the development and maintenance of well-designed public parks, gardens, recreational areas, and other open spaces that promote physical activity, social interaction, and relaxation. Implement inclusive design principles to make these spaces inclusive and welcoming for all, with features such as accessible pathways, seating areas, play equipment, and facilities that accommodate the diverse needs of individuals of all ages and abilities. (2). Preservation of wilderness and biological diversity of area ecosystems. (13)

5.6. Infrastructure:

Establish robust sanitation systems and regional infrastructure that facilitate equitable, safe, and affordable access for all individuals, promoting economic and social development. Ensure the provision of high-quality sanitation services and essential infrastructure, fostering inclusive growth and enhancing the well-being of communities. (14)

5.7. Floodplain Management:

Direct urban development away from vulnerable barrier beaches and floodplains, while concurrently preserving and restoring wetlands along rivers to serve as natural flood control mechanisms. This approach safeguards communities from flood risks and promotes the conservation of important ecosystems. (11)

5.8. Watershed Management:

Ensure that every individual has equal and widespread access to affordable and uncontaminated drinking water, while simultaneously mitigating pollution to enhance water quality. Implement comprehensive strategies for managing water resources, safeguarding and reviving vital ecosystems such as wetlands, rivers, aquifers, and lakes. Support initiatives and programs that promote efficient water usage, water harvesting, desalination, recycling, and wastewater treatment. Encourage active community participation in enhancing water and sanitation management. (15)

5.9. Resource Conservation:

Promote the reduction of fossil fuel consumption while fostering the development and utilization of renewable energy sources. Make renewable energy easily accessible and affordable for all. (16). Work on recycling solid waste and Encourage Purchasing Products Made from Recycled Materials (17). Promote the establishment of local farms to minimize the reliance on long-distance food transportation, preserve soil biodiversity, and conserve and plant trees and vegetation that act as natural carbon dioxide and air pollutant absorbers. (18). Rational water use, using recycled water from wastewater and rainwater for fields not potable, such as Irrigation for agriculture. (19)

5.10. Planning Processes:

Implement sustainable strategies for urban development, aiming to achieve carbon neutrality, enhance eco-efficiency, conserve materials and resources, promote energy-efficient services, establish sustainable transportation systems to mitigate environmental impacts, expand the use of renewable energy sources and local food production, and encourage community engagement in prioritizing urban development initiatives. (6)

6. Challenges and Tradeoffs of a Sustainable City:

Creating sustainable cities is a complex and challenging endeavor that involves various tradeoffs and tensions. Despite the numerous benefits of sustainable urban planning, several political, social, economic, and technological challenges must be addressed.

One of the primary challenges of creating sustainable cities is resistance to change. Many stakeholders, including politicians, developers, and residents, may resist new sustainability initiatives due to concerns about costs, inconvenience, and perceived risks. This resistance can be exacerbated by a need for more understanding and awareness about the benefits of sustainability and the potential risks of not pursuing sustainable development.

Another major challenge is the need for more funding for sustainable urban projects. Sustainable urban planning often requires a significant upfront investment, such as building public transportation systems, retrofitting buildings to be energy-efficient, or implementing green infrastructure. These investments can be expensive, and securing funding from public or private sources may take time and effort, especially in the face of competing resource demands.

Technical complexity is also a challenge in creating sustainable cities. Many sustainability initiatives require advanced technology and specialized expertise, which may only be available in some communities. Additionally, implementing sustainability measures may require changes to existing infrastructure and systems, which can be logistically challenging and time-consuming.

Beyond these challenges, there are tradeoffs and tensions between sustainability and other priorities, such as economic growth, social equity, and cultural diversity. For example, sustainable development may require limiting urban sprawl and reducing the amount of land available for development, which can conflict with economic growth objectives. Similarly, efforts to promote sustainability may inadvertently exacerbate social and economic inequalities by pricing out low-income residents or neglecting the needs of marginalized communities.

Finally, there can be tensions between sustainability and cultural diversity. Sustainable urban planning may require imposing new standards or regulations that conflict with existing cultural practices, which can lead to resistance and cultural backlash.

Overall, creating sustainable cities requires careful consideration of these challenges and tradeoffs. It is essential to balance the benefits of sustainability with the competing demands of economic growth, social equity, and cultural diversity to ensure that sustainable urban planning truly benefits all community members.

7. Conclusion:

Based on the extensive research and analysis conducted in this chapter, it is clear that sustainable cities are critical in addressing the pressing challenges of the 21st century, particularly climate change, rapid urbanization, and inequality. While numerous benefits are associated with sustainable cities, it is essential to acknowledge the challenges and tradeoffs involved in their planning and implementation.

The political, social, economic, and technological challenges of creating sustainable cities cannot be overstated. Resistance to change, lack of funding, technical complexity, and the need for coordinated action among different stakeholders are significant challenges that must be addressed. Additionally, tradeoffs and tensions between sustainability and other priorities such as economic growth, social equity, and cultural diversity require careful consideration and strategic planning.

However, the potential benefits of sustainable cities far outweigh these challenges and tradeoffs. Sustainable cities can reduce greenhouse gas emissions, mitigate climate change, promote resource conservation, improve public health, enhance economic development, and foster social inclusion. By adopting a holistic approach to planning and implementation, it is possible to balance these competing priorities and create sustainable cities that meet the needs of present and future generations.

The findings of this chapter have significant implications for urban planning and sustainability in Algeria. As the country continues to experience rapid urbanization, there is an urgent need to embrace sustainable urban development practices. By prioritizing sustainability in urban planning, Algeria can achieve its development goals while mitigating the negative impacts of urbanization.

In conclusion, sustainable cities are critical to addressing the world's complex challenges today. Despite the challenges and tradeoffs involved in their planning and implementation, sustainable cities offer numerous benefits that make them a worthwhile investment. Adopting a comprehensive and strategic approach to planning and implementation makes it possible to create sustainable cities that promote the well-being of both people and the planet.

Chapter 2

The Technological innovation

1. Introduction:

Technological innovation has been a critical driver of human progress and development. From the invention of the wheel to the discovery of electricity, from the steam engine to the internet, technology has transformed how we live, work, and interact with the world. In urban planning, technological innovation offers enormous potential for promoting sustainability, as it can help address many of the challenges facing cities, such as climate change, energy consumption, waste management, transportation, and water scarcity.

This chapter aims to explore the role of technological innovation in promoting sustainability. It aims to provide a comprehensive understanding of the types and impacts of technological innovations and analyze their potential for improving the sustainability of cities. This chapter also discusses challenges and opportunities associated with implementing technological innovations in urban planning, including governance, equity, and social acceptance issues.

Technological innovations in the city can be broadly categorized into three types: hardware, software, and Edgware. Hardware innovations refer to physical devices, materials, and infrastructure systems like solar panels, green roofs, and smart grids. Software innovations include digital tools, algorithms, and platforms like GIS, BIM, and IoT. Orgware innovations refer to organizational and institutional arrangements, such as public-private partnerships, citizen participation, and co-creation. Each type of innovation has its strengths and limitations, and their impacts on sustainability depend on their context, scale, and integration. (1)

Understanding the types and impacts of technological innovations is crucial for urban planning practitioners and policymakers, as it can help them identify the most appropriate and effective solutions for promoting sustainability in their cities. However, technological innovation is not a panacea for all the sustainability challenges facing cities, and it needs to be complemented by other strategies, such as urban design, policy, and social innovation. Moreover, implementing technological innovations in urban planning requires a collaborative and participatory approach involving multiple stakeholders and perspectives to ensure that the benefits and risks are distributed equitably and transparently.

In conclusion, This chapter concludes that technological innovation is crucial for sustainability but must be carefully integrated into a broader strategy. Urban planners and policymakers should consider innovations' social and ethical and engage with communities to ensure alignment with their values.

2. Understanding Technological Innovation :

2.1. Defining Technological Innovation:

2.1.1. Definitions of innovation:

- An invention is essentially the creation of a new device. An invention is essentially the creation of a new device. An innovation entails the commercial or partial application of the new device ... first application of an invention. (2)
- Innovation is the process by which an invention is first brought into use. It involves the improvement or refinement of the invention, the initial design, and the production of prototypes. Pilot plant testing and construction of production facilities ... diffusion is spreading the innovation into general use as more and more users adopt it. (3)
- ... we look upon innovation as the total process from the inception of an idea to the manufacture of a product and finally to its ultimate sale. It, therefore, includes invention and the many stages of implementation, such as research development, production, and marketing. (4)
- Innovation = invention + exploitation. (2)
- Innovation is the process by which an invention is first brought into use. It involves the improvement or refinement of the invention, the initial design, and the production of prototypes. Pilot plant testing and construction of production facilities ... diffusion is spreading the innovation into general use as more and more users adopt it. (3)
- ... we look upon innovation as the whole process from the inception of an idea to the manufacture of a product and finally to its ultimate sale. It, therefore, includes invention and the many stages of implementation, such as research development, production, and marketing. (4)
- Innovation = invention + exploitation. (5)

To understand the meaning of innovation, we can refer to its Latin origin. The Latin term 'innovare,' which means 'to make something new,' provides insight into its deeper implications. Breaking it down into three parts. To make something new, one has to:

- Generate or realize a new idea (invention and creativity).
- Develop this idea into a reality or product (realization).
- Implement and market this new idea (implementation).

2.1.2. Definitions of technological innovation:

The ‘to make something new' implies the process of replacing outdated concepts or products with newer ones, constantly enhancing and updating them. When incorporating technology into the concept of innovation and defining 'Technological Innovation,' the following modifications are made to the aforementioned definition:

- Generate or realize a new idea based on technology, capability, or knowledge (Invention).
- Develop this into a reality or product (realization).
- Diffuse, implement, and market this new idea, technology, capability, or knowledge (implementation).

Therefore, technological innovation is an integral aspect of the broader field of innovation. Its primary focus lies in effectively incorporating technology into products, services, and processes. Technology, as a reservoir of knowledge, serves as a fundamental element in the various stages of research, design, development, manufacturing, and marketing that underpin technological innovation.

Technological innovation is the act of developing and applying new or enhanced technology with the aim of achieving specific goals. It can be driven by diverse factors such as addressing specific challenges or opportunities, enhancing the performance of existing technology, or creating novel and unique solutions. (6)

Technological innovation is an essential factor in advancing urban planning towards sustainable development. Technological innovation involves the creation of new ideas, knowledge, and technologies that enhance the efficiency, effectiveness, and sustainability of urban systems. In urban planning, technological innovation refers to developing and applying new technologies to address urban challenges and promote sustainable urban development.

The Organization for Economic Cooperation and Development (OECD) defines technological innovation as the "implementation of a new or significantly improved product (good or service) or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations." (7) This definition underscores the significance of innovation in stimulating economic growth and fostering competitiveness.

The National Science Foundation (NSF) defines technological innovation as the "design, development, and implementation of new or improved products, processes, or services, or the modification of existing ones, with the intent to improve performance, efficiency, or effectiveness."

(8) This definition emphasizes the significance of innovation in enhancing the efficiency and effectiveness of current urban systems.

The European Commission's Joint Research Centre (JRC) defines technological innovation as "the application of new or improved technologies to create new products, services, or processes that deliver economic, social, or environmental benefits." (9) This definition underscores the significance of innovation in tackling societal issues and advancing sustainable development.

2.2. Types of Technological Innovation Relevant to Urban Planning:

Various types of technological innovations can be used in urban planning to promote sustainability and efficiency. These innovations can be grouped into four main types:

2.2.1. Incremental innovation:

Incremental innovation, also known as continuous improvement, involves enhancing a product or service within its existing market. While it may not be as striking or immediate as other forms of innovation, incremental innovation proves effective when addressing internal transformation or change processes within a company.

Moreover, incremental innovation is an especially participative approach in the sense that it can involve employees. Modern human resource development leaders have made it an asset in building a collective culture of improvement. (10)

The iPhone is a good example of incremental innovation, going from the iPhone 12 to the 13 and probably to the 14. Similarly, a city implementing smart traffic lights that adapt their timing according to real-time traffic flow exemplifies incremental innovation. This advancement can result in improved street efficiency, reduced congestion, and a positive impact on the environment and residents' quality of life.

2.2.2. Adjacent innovation:

Adjacent innovation exemplifies a successful growth strategy by utilizing existing capabilities, such as technology or knowledge, to target a new audience or penetrate a different market. This approach grants a competitive edge to the original product or service, enabling it to stand out and differentiate itself in the marketplace.

To illustrate the concept of adjacent innovation, we can take the example of big companies that buy innovative startups to integrate their groundbreaking products and services into their portfolio. (10)

A relevant example of adjacent innovation in the city could be using drones for urban infrastructure inspections and maintenance. Drones can be equipped with cameras and sensors to inspect bridges, buildings, and other structures quickly and efficiently for any signs of damage or wear and tear. This technology can improve safety and save time and money for municipalities.

2.2.3. Disruptive innovation:

Disruptive innovation refers to the actions taken by a smaller company to shake up an industry by targeting its large, existing competitors' overlooked segments.

Over time, the disruptive innovation party will accelerate and start taking over the main segments of the industry. When the main segment's adoption of the new innovation happens, we speak of disruptive innovation.

Netflix is a very good example of disruptive innovation. The company started by targeting a less essential segment of Blockbuster's audience with its relatively unpopular offer of mailing rental DVDs. They then moved on to improve its services while keeping a low price, which ultimately appealed to and conquered Blockbuster's main audience. (10)

An example of disruptive innovation in the city is the emergence of autonomous vehicles. This technology has the potential to revolutionize transportation in urban areas, reducing traffic congestion, improving safety, and providing more efficient and convenient travel options for residents.

2.2.4. Radical innovation:

Radical innovation is the creation of a brand-new product or service that nobody expected and tends to impose itself on the life of users.

Television and smartphones are two typical radical innovations that have changed our daily lives. (10)

A radical innovation in the city could be the creation of smart cities that use advanced technologies to optimize urban life, such as transportation, energy consumption, and waste management. This could involve using sensors, machine learning algorithms, and other technologies to collect and analyze data in real-time, aiming to improve the overall quality of life for residents.

Each type of technological innovation has the potential to bring significant benefits to urban planning, including increased efficiency, improved sustainability, and enhanced public

participation. However, each type comes with challenges, such as resistance to change, lack of funding, and technical complexity.

In implementing different types of innovation in the city, several challenges exist. Incremental innovation may only sometimes address the root causes of urban challenges and may require significant investments. Implementing adjacent innovation can be difficult to integrate with existing infrastructure and may require regulations and support systems. Disruptive innovation can disrupt existing systems and industries, potentially leading to job losses and requiring changes to infrastructure and regulations. Finally, radical innovation requires significant investment and may face stakeholders' resistance to new technologies or changes to the status quo. It may also have unintended consequences not fully understood until after implementation, such as concerns about privacy and data security in using sensors and data analysis for smart cities.

Understanding the different types of technological innovation and their potential benefits and challenges is critical to effective urban planning in the 21st century. By leveraging these innovations, cities can become more sustainable, efficient, and livable for all residents.

3. Examples of Technological Innovations and their Impacts on Sustainability:

In cities, technological innovations have been developed to address their sustainability challenges. These innovations aim to reduce the environmental impact of cities, improve residents' quality of life, and increase cities' economic competitiveness. The main technological innovations in cities include smart traffic management systems, mobile apps, waste management technologies, intelligent street lighting systems, advanced public transportation systems, electric vehicles, and charging stations. These technological innovations significantly impact sustainability, as they help reduce greenhouse gas emissions, conserve natural resources, and promote social and economic development.

When we classify these technological innovations per category, we can see that they fall into several categories: energy, circularity, water, mobility, economics, housing, safety, and security. For example, smart traffic management systems and electric vehicles fall under the mobility category, while waste management technologies and urban farming technologies fall under the circularity category. By classifying these technological innovations, we can better understand how they contribute to sustainability in cities and how they can be further developed to address the challenges that cities face.

3.1. Energy:

3.1.1. Solar photovoltaic systems:

A photovoltaic system is a unique electrical system that produces energy from a renewable and inexhaustible source: the sun.

a PV panel, commonly called a solar panel, consists of PV cells that capture sunlight and convert it into electricity. These cells are made of semiconductors, typically silicon, which allow the transmission of power. Multiple cells are connected to form a module, and a standard rooftop solar panel usually contains around 30 modules. When sunlight is absorbed by the semiconductor in the photovoltaic panels, electrons are released from their position, generating an electric current. These electrons, carrying a negative charge, move across the cell towards the front surface, creating an imbalance between the front and back. This imbalance creates a voltage potential, similar to the positive and negative terminals of a battery, resulting in the production of electricity by the photovoltaic cells. (11)

Solar photovoltaic systems (PV) deliver substantial benefits to the environment compared to conventional energy sources, supporting human activities' ecological benefits with sustainable development. (12)

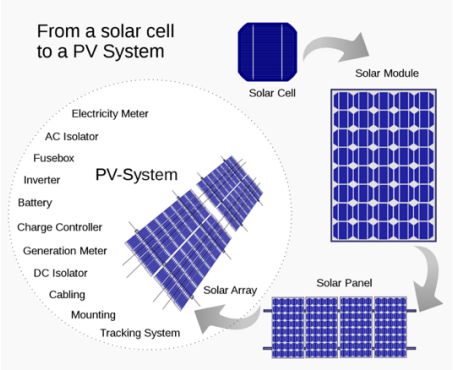

Figure 2 Diagram of the possible components of a photovoltaic system. Source: EWS solar power website

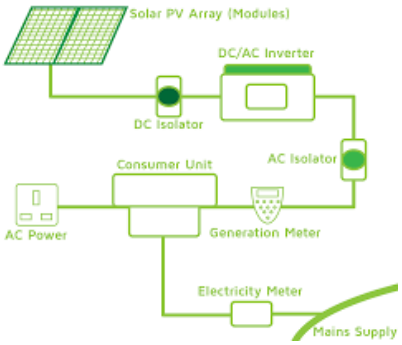

Figure 3: How Solar PV Systems Work. Source: EWS solar power website

3.1.2. Wind energy systems:

Wind energy, also known as wind power, involves harnessing the kinetic energy of air movement to generate mechanical power or electricity. This renewable energy source is considered a form of solar power since it is generated by the interaction of air with the Earth's surface. (13)

Wind power is experiencing rapid growth as one of the fastest-developing technologies in the renewable energy sector. Over the course of two decades, the global capacity for onshore and

offshore wind generation has surged from 7.5 gigawatts (GW) to approximately 564 GW. In 2018, the United Kingdom ranked as the third-largest producer of wind-generated electricity among European OECD countries, trailing behind Germany and Spain. (14)

While land-based wind sites are typically situated in remote areas, small wind turbines have the potential to be installed in urban regions, including on the rooftops of residential and commercial buildings. However, the effectiveness and environmental sustainability of these roof-mounted turbines are subjects of ongoing debate and discussion.

Figure 4: picture of wind turbine.

Source: Sakchai - stock.adobe.com

3.1.3. Green hydrogen technology:

This technology is based on hydrogen generation — a universal, light, and highly reactive fuel — through a chemical process known as electrolysis. This method uses an electrical current to separate the hydrogen from the oxygen in the water. If this electricity is obtained from renewable sources, we will produce energy without emitting carbon dioxide into the atmosphere. (15)

As the IEA points out, this method of obtaining green hydrogen would save the 830 million tonnes of CO2 emitted annually when this gas is produced using fossil fuels. (15)

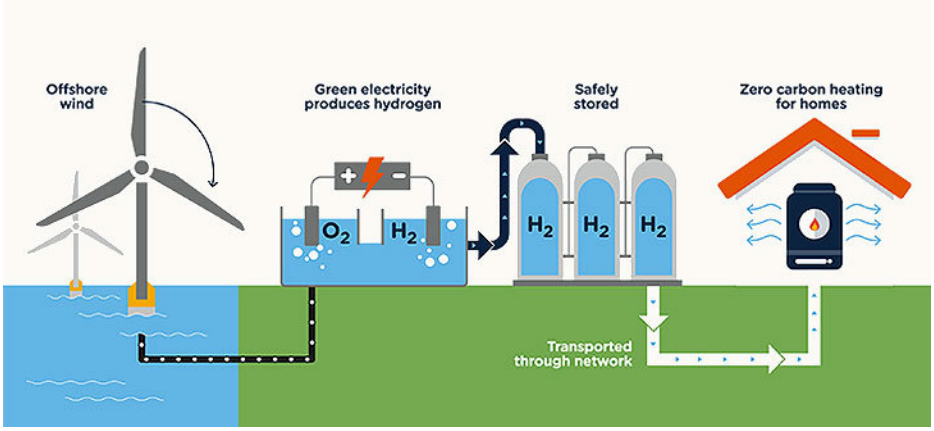

Figure 5: Green hydrogen production.

Source: https://e360.yale.edu/features/green-hydrogen-could-it-be-key-to-a-carbon-free-economy

3.1.4. Biomass energy systems:

Biomass is a renewable energy source from burning wood, plants, and other organic matter, such as manure or household waste. It releases carbon dioxide when burned, but considerably less than fossil fuels. (16)

For example, urban regions in Guatemala utilize electricity produced from sugarcane biomass, commonly called bagasse. This practice has been adopted by sugarcane producers since 1990. In the 2017-2018 harvest season alone, the use of bagasse helped save an estimated 4 million tons of carbon emissions. (17)

In Manouba, a city in north-eastern Tunisia, a family-managed agricultural enterprise developed 2015 an innovative form of biofuel using a pear and olive tree waste.

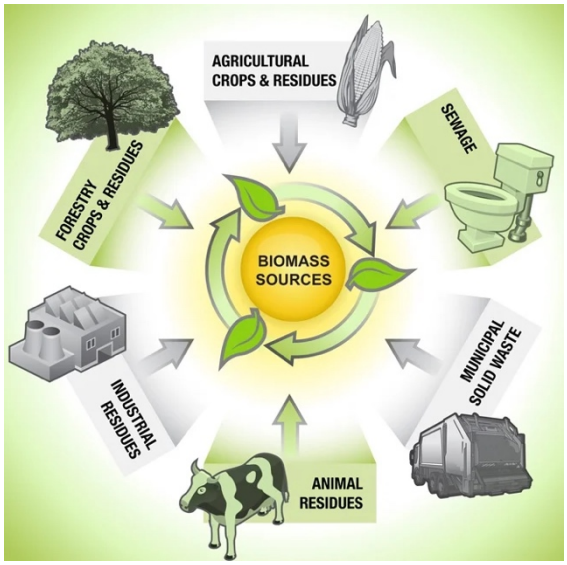

Figure 6: sources of biomass.

Source: https://lotusarise.com/biomass-energy-upsc/

3.2. Circularity:

3.2.1. Food traceability systems:

Food intended for both urban and rural populations often goes to waste during its production and distribution process. To address this issue, digital traceability and tracking systems are employed to identify inefficiencies in food supply chains at an early stage. The AMBROSIA project primarily concentrates on enhancing local food safety and traceability measures. Its main outcome is a digital system that enables municipalities to track the origin and shipping processes of food. Additionally, the system records all transactions, monitors the status of foods during transportation, and tracks environmental conditions. (18)

3.2.2. Food sharing networks and technology:

Food waste is an escalating global issue, prompting the implementation of innovative solutions in urban areas to enhance the food supply chain and repurpose generated waste. Companies, supermarkets, and hospitality facilities can transform their food waste into organic waste for other processes. Online food-sharing platforms like Ollio and FoodCloud facilitate the collection and redistribution of surplus food among urban and rural residents in need. Additionally, redistribution organizations play a role in managing unused food. With the support of the United Kingdom Food Reduction Fund, eight redistribution organizations have saved 2500 tonnes of food from ending up in landfills, redirecting it to individuals who require assistance. (19)

3.2.3. Smart bin solutions:

The smart bin is the new high technology that integrates waste containers with smart sensors, which allows you to track the waste management processes. For example, with the smart waste bin system, you can control the occupancy ratio of your smart waste bins. (20)

To enhance municipal waste management, the implementation of sensor-equipped compacting bins interconnected through a digital platform can be advantageous. These bins automatically transmit data about their filling levels to the platform, facilitating the identification of areas and times requiring waste collection services.

For instance, the Selçuklu Municipality in Konya, Turkey, has employed the Waste Scada System to monitor garbage containers in real-time. This system harnesses solar energy and eliminates the need for additional wiring. Moreover, the technology can be easily installed on existing containers, vehicles, and other elements without necessitating modifications to the current infrastructure.

3.3. Water:

3.3.1. Smart metering infrastructures:

Enhancing water-use efficiency, demand management, and leakage control is a critical priority in urban areas, and smart technologies offer valuable assistance in this regard. These technologies can promote behavioral changes in urban households by providing real-time information and personalized feedback. For instance, Smarter Homes, a company specializing in smart metering and automated leakage prevention systems, has successfully installed their devices in 40,000 households in India. Through their implementation, an average water consumption reduction of around 35 percent has been achieved. (21)

3.3.2. Nanotechnological applications for desalination processes:

To address the increasing demand for clean water in urban systems, many countries have turned to desalination technologies as a means of producing additional drinking water. These technologies involve the removal of salt from seawater and filtering it to obtain water of drinking quality. As of 2018, there were 16,000 desalination plants operating in 177 countries.

Nanotechnological applications have emerged as a more sustainable alternative to commonly used methods like reverse osmosis, which can lead to pollution of seawater. For instance, the European project NAWADES (Nanotechnological Application in Water Desalination) has developed self-cleaning membranes based on nanotechnology for water desalination. This innovation has been implemented at a plant located in the metropolitan area of Barcelona, Spain, yielding promising results. (22)

3.3.3. Mobile applications for waste monitoring:

Images serve as a primary means of safeguarding land and water from pollution, facilitated by the emergence of mobile services that are free, easily accessible, and user-friendly in numerous countries. As an illustration, the Environmental Protection Agency has developed a mobile application that allows citizens to report instances of water and land pollution. By capturing and sending a photo of the affected area, citizens can bring environmental issues to the attention of authorities. The application also utilizes a built-in Global Positioning System, aiding authorities in locating and investigating the reported areas. (23)

3.4. Mobility:

3.4.1. Low-emission vehicles (LEVs):

Low Emission Vehicles emit significantly lower volumes of greenhouse gases during operation than fossil fuel vehicles. The term LEVs can encompass a range of vehicle types and technologies with various emissions levels, including biofuels, hybrids, and electric cars. LEV technology results in significantly lower emissions than conventional vehicles, increased health benefits through improved air quality, reduced noise pollution, increased energy security, and the potential for grid balancing. (24)

For example, the Basel Agency for Sustainable Energy (BASE) has played a supportive role in Bogota, Colombia's endeavor to electrify its transportation system by facilitating the acquisition of approximately 1,500 hybrid buses. This initiative is in line with the government's strategy to limit the proliferation of fossil fuel-based vehicles. Hybrid buses have proven to save 35 percent of fuel compared to diesel buses. Since 2013, BASE has provided technical, financial, and operational analysis and modeling assistance for similar initiatives in Argentina, Costa Rica, and Peru. (25)

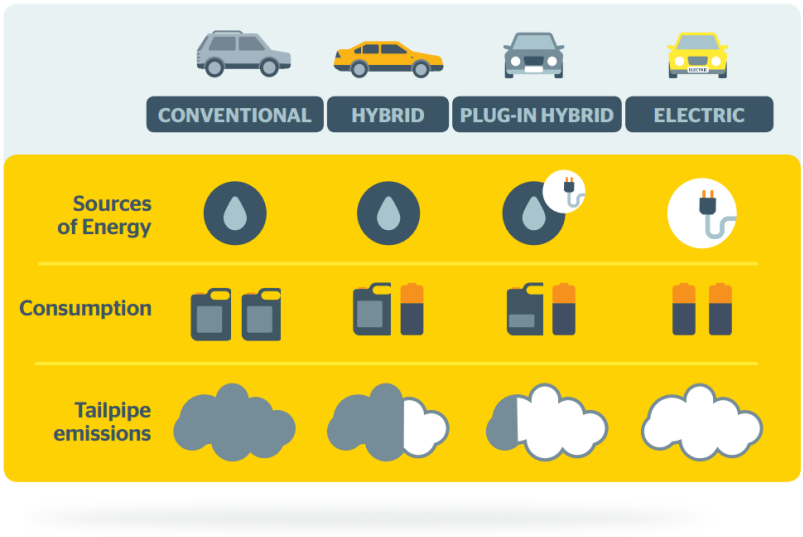

Figure 7: The main types of LEVs

Source: Low and zero-emission vehicles, from: https://rac.com.au/about-rac/advocating-change/low-and-zero-emission-vehicles

3.4.2. Journey planner applications:

Urban mobility is improved through the utilization of journey planner applications, which furnish users with real-time information. These mobile applications enable individuals to plan their journeys by providing constant updates on traffic conditions in various parts of the city and the availability of public transportation options at specific times.

The Aberdeen City Council in Scotland, United Kingdom, introduced a journey planner application named GoAbz in late 2020. GoAbz serves as a valuable tool for both residents and tourists in planning their travels within Aberdeen. The application supplies details on travel durations and expenses while offering recommendations for alternative transportation modes, including cycling, walking, buses, and trains. (26)

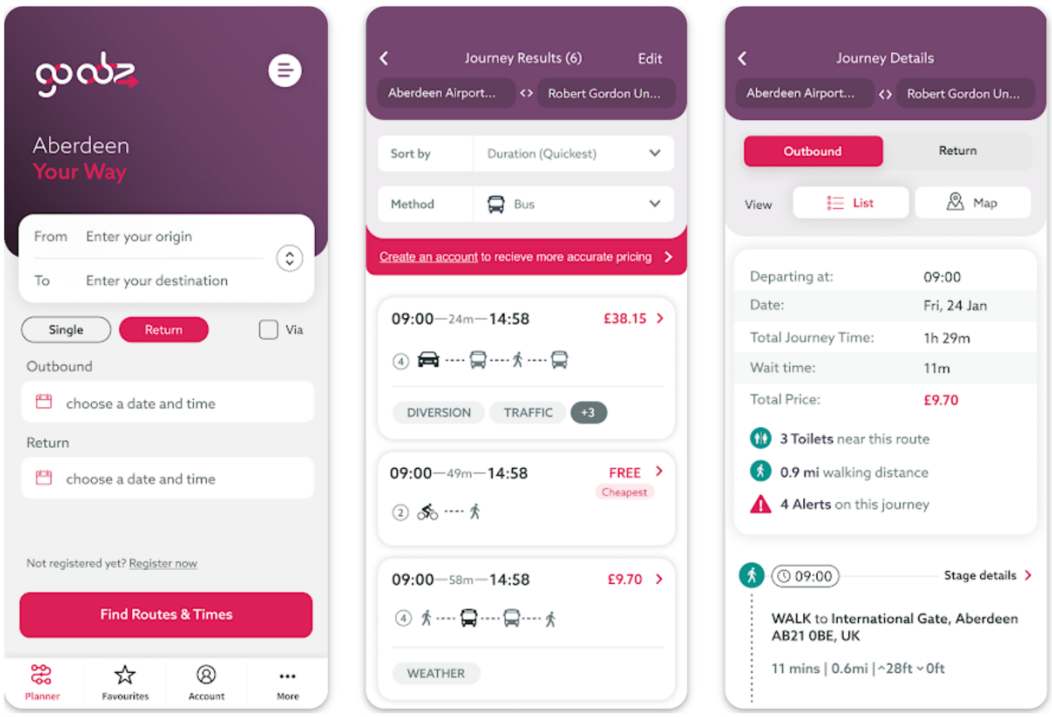

Figure 8: Screenshots from the GoABZ journey planner app
Source : App Store

3.4.3. Smart traffic management systems:

An essential aspect of smart city planning is the incorporation of a comprehensive smart transportation solution. It can be contended that a city achieves true intelligence when equipped with a smart traffic management system. Intelligent transportation systems (ITS), or smart traffic management systems, offer a coordinated and integrated approach to mitigating traffic congestion and enhancing safety on urban roads through the utilization of connected technologies. (27)

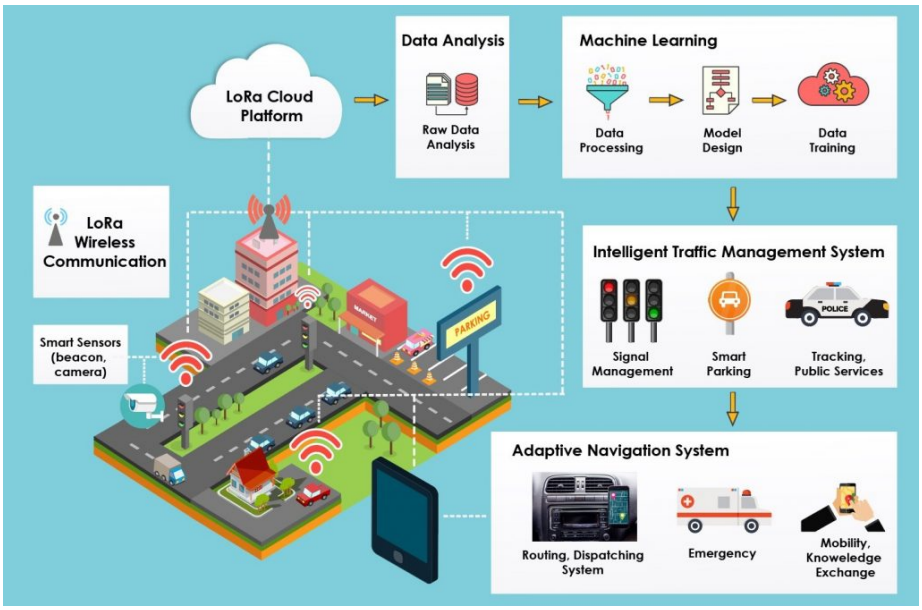

Figure 9: LoRa-based smart traffic management system.

Source: LoRa official website

A real-time traffic management solution has been developed and tested in Bengaluru, India, by the Electronics City Township Authority (ELCITA) in collaboration with Siemens. This solution offers complete automation of traffic control and monitoring operations. It includes automated functions for vehicle detection, estimation of traffic density, identification of traffic accidents, and control of traffic lights. (28). In the Philippines, the government has developed Local Traffic Simulator (LOCALSIM), a microscopic traffic simulation software designed to be used by road and traffic engineers as a decision support system for traffic management. (29)

3.4.4. Mobile ticketing:

The utilization of mobile e-ticketing solutions has the potential to enhance the adoption of active travel, such as cycling, and increase the usage of public transport. Take Oyster, for instance, a pay-as-you-go card introduced by Transport for London. Both residents and visitors can conveniently recharge their cards through kiosks or online platforms. These cards can be utilized on various transportation modes, including buses, subways, trams, and other available options. Additionally, as part of their pay-as-you-go initiative, Transport for London enables city users to make payments for tickets using contactless credit and debit cards or mobile devices across all transportation services in London. (30)

Additionally, an e-ticketing system has also been introduced in Amsterdam. The service is called iAmsterdam and provides visitors access to public transport, bike-sharing schemes, and the main attractions in the city. The iAmsterdam card is also available as a mobile application, which provides information on activities and tourist attractions. (31)

3.4.5. Mobility as a Service:

The concept of integrating multiple transportation modes in urban mobility is referred to as Mobility as a Service (MaaS). This system enables users to conveniently purchase tickets for various public and private transportation options while providing real-time information about their availability. An early example of an integrated digital transport service platform is MaaS Madrid, which the Madrid City Council launched. This technology combines services such as buses, cableways, and the city's bike-sharing system, known as BiciMAD, within a dedicated mobile application. (32)

The city of Helsinki in Finland utilizes a comparable Mobility as a Service (MaaS) platform called Whim. Whim integrates data on bike-sharing systems, taxis, car-sharing services, traditional rental cars, and public transport, providing users with comprehensive information. Moreover, Helsinki's MaaS solution facilitates convenient payment processing directly through the mobile application. (33)

3.5. Economic prosperity and decent jobs:

3.5.1. Digital finance:

Digital finance has emerged as a financial initiative to support urban lifestyles by offering electronic financial products and services like digital banking, peer-to-peer lending, e-trading platforms, and digital payment services. This technology can help local authorities overcome barriers to economic productivity, entrepreneurship, and employment, as well as promote financial inclusion for low-income groups facing financial instability. It enables the distribution of crucial financial resources and targeted funds to local businesses, supporting stabilization and recovery during emergencies such as the COVID-19 pandemic.

The CloQ application serves as a notable example by providing access to microcredit through mobile platforms for the unbanked population in urban areas. Since its launch in 2018, CloQ has facilitated credit access for urban entrepreneurs, initially focusing on Brazilian territories during its first two years of operation. (34)

3.5.2. E-commerce platforms:

The E-commerce platform is a technology that has been proven important for businesses in boosting sustainable development in urban areas. In particular, e-commerce platforms have been helping micro, small, and medium-sized enterprises by providing online spaces to sell products or services, expanding their market opportunities beyond their geographic boundaries. Additionally, given that demand traffic in e-commerce platforms comes from urban areas, labor force absorption occurs to support the logistics sector to cope with the surging demand. This relation was amplified during the COVID-19 pandemic when people switched to e-platform to buy their daily needs due to public health-related mobility restrictions.

3.6. Housing:

3.6.1. Digitalization of construction operations and manufacturing processes:

The wider adoption of digital fabrication techniques, which involve the use of IT-controlled production environments, has the potential to enhance efficiency and accelerate production rates. This is demonstrated by the construction industry in China, where digital fabrication technologies and offsite manufacturing techniques were utilized to build a 30-story hotel and a 57-floor skyscraper in less than 20 days. In comparison, employing traditional construction methods would have taken over a year of on-site construction activities to complete these buildings. (35)

Many factories have been equipped with additive manufacturing technologies – 3D printing. This technology is used frequently during prototype phases but can also help build new houses. This is the case of the non-profit organization New Story, which introduces 3D-printed homes in the slum areas of the Plurinational States of Bolivia, Haiti, and Mexico. Using 3D-printing technology, New Story can produce a 600-square-foot (about 56 square meters) home in only one day, with an overall cost of $4,000. (36)

Digitalizing the housing construction sector and actualizing the “Industry 4.0” vision can truly push sustainable urban development. However, it also exposes digital skills gaps that may prevent these technological developments from taking place and being effective. For example, approximately 70 percent of the population in lower-income economies does not possess basic digital skills.

3.6.2. Digital twin technology in construction:

Digital twins are used in construction projects to create exact replicas of real-world spaces. These 3D models allow construction teams to interact virtually with the physical property during the design and planning stages.

Digital twins provide project teams with immersive access to crucial building information in real-time, leading to various advantages in several important areas:

- Faster and easier collaboration among project stakeholders.
- Increased productivity.
- More efficient workflows between contractors and trades.
- Reduction of issues and RFI's

By integrating digital twins into the Building Information Modeling (BIM) process, contractors and architectural engineering firms can tackle numerous significant challenges in the industry. These challenges include issues such as low productivity, profitability, performance, and high rates of errors and accidents. Digital twins in construction can also assist companies in reducing costs associated with virtual design and construction, and potentially increase their chances of winning more bids. (37)

3.6.3. Green building technologies:

Such as green roofs, low-emissivity windows, and insulation materials have significant potential to improve energy efficiency and reduce environmental impacts in urban areas. Green roofs, for instance, can help reduce the urban heat island effect, enhance air quality, and promote biodiversity. Meanwhile, low-emissivity windows and insulation materials can reduce building heat loss and gain, reducing the need for heating and cooling systems and associated energy consumption. (38)

3.7. Urban planning:

3.7.1. Digital twin technology for urban planning:

In its simplest sense, a digital twin is a linked virtual model of a physical object. By connecting the real-time data of the physical object or process into its digital representation – programmed with mathematical models, AI, and pattern recognition to faithfully recreate its sibling – the digital twin comes to life. (39)

Virtual reality can also be employed to develop urban digital twins, which are virtual representations of entire urban systems. A notable example is Herrenberg, a small city in Germany, where a digital twin has been utilized to gather data on the emotional reactions of citizens. Local authorities leverage this information to guide their decision-making processes. (40).

Similarly, Buildmedia – a company specializing in 3D visualizations of urban infrastructure – has created a digital twin of Wellington City. The digital twin builds on a combination of smart city technologies that connect streams of urban mobility data. This data describes the real-time functioning of the urban infrastructure and provides different types of urban mobility and transportation statistics, including air traffic data. Using the digital twin, local authorities can acquire data for supporting decision marking and collaboratively work on unbuilt developments, which can be integrated as virtual models in the existing built environment of the city (41).

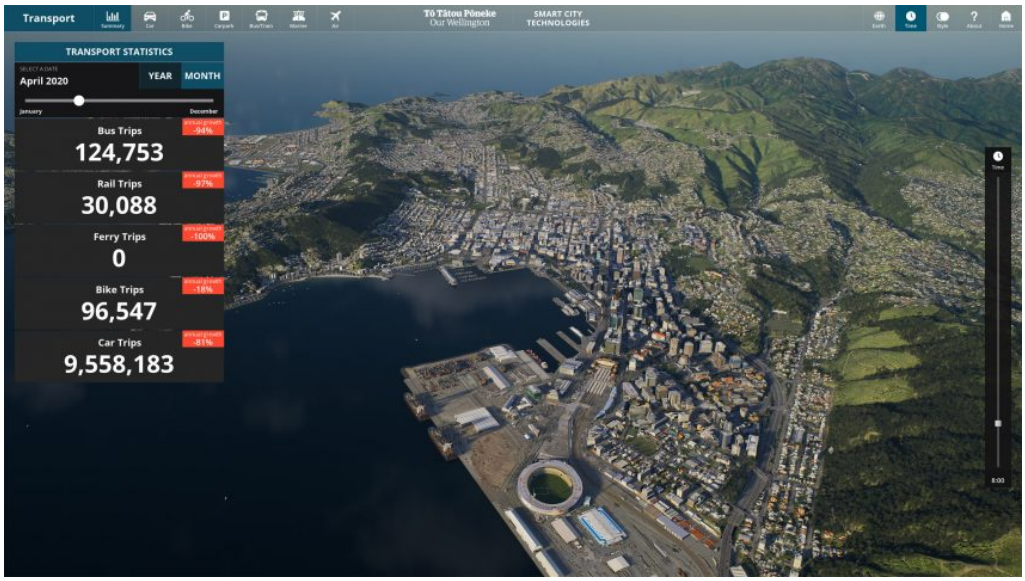

Figure 10: Buildmedia has created a digital twin of Wellington, New Zealand.

Source: Dezeen.com

3.7.2. Online crowdsourcing platforms:

Local authorities and planners can also use a low-tech apparatus, such as social media channels and online platforms, which can help stimulate inclusive discussions on planning ideas and better understand the preferences of key actors affected by urban planning decisions, including citizens (42). Online platforms that pool crowd-generated data can help generate collective knowledge and

awareness around urban planning challenges and can also be used to increase the accessibility of urban spaces.

For example, the German non-profit organization Sozialhelden has developed Wheelmap, an online map for wheelchair-accessible places identification. Wheelmap provides information generated with a Wikipedia approach; anyone can access the online map – generated by using OpenStreetMap data – and share knowledge on the wheelchair accessibility of the locations they have visited. Users can pick any public place around the world, rate their level of accessibility for individuals with mobility impairments, and upload photographs. Wheelmap provides data on more than 1.5 million public places and is available in 33 languages. This data helps people with reduced mobility to make informed travel plans and contributes to making owners of wheelchair-inaccessible public places and local authorities aware of existing barriers (43).

3.8. Safety and security:

3.8.1. Gunshot detection technology:

Technological solutions for crime prevention have also been implemented. For example, different variations of gunshot detection technology – an audio-based analytical tool – are sprouting up. Gunshot detection technology offers automated analyses of urban soundscapes and builds upon a network of acoustic sensors to identify the sound of urban gunshots. Data generated from gunshot detection technologies become a source of information on firearm-related crimes, which can be relayed to context-aware emergency services. (44)

Moreover, this knowledge can also support police forces in determining the position of gunshots in real time. Gunshot detection technology uses algorithms that identify particular acoustic frequencies at different points of public transport networks (such as underground routes or bus lanes). This differentiation helps to timely distinguish gunshots from other noises and compute the spatial coordinates of the location where the crime occurs. (45)

3.8.2. Crime mapping tools:

Computerized crime mapping technology enables law enforcement agencies to analyze and correlate data sources to create a detailed snapshot of crime incidents and related factors within a community or other geographical area. (46)

In central London, police forces use crime mapping to analyze vehicle crime patterns, understand the routines and behaviors of criminals, and determine the most probable location where these

crimes occur. They could happen in the future (47). Similar practices are also implemented in cities of the Global South, such as Mexico City, wherein heat maps are created by local authorities to identify hotspots prone to violence against women (48).

Moreover, researchers at the University of Pretoria have showcased the usefulness of crime mapping in the context of African cities by developing a robbery risk model for Tshwane, South Africa. The model is based on a geospatial analysis in which commuter nodes and urban public facilities become points of interest (49).

Technological innovations in urban planning can significantly impact sustainability, such as reduced greenhouse gas emissions, improved resource efficiency, and enhanced quality of life. Examples of such innovations include renewable energy, smart city, sustainable transportation, and green building technologies. However, careful consideration and planning are required to ensure that these technologies are implemented to promote sustainability and social equity while minimizing any potential negative impacts.

4. The Benefits of Technological Innovation in Sustainable Cities:

The impact of technological innovation on sustainable cities can be significant, resulting in improved resource efficiency, reduced environmental impact, increased economic competitiveness, and enhanced quality of life.

Improved resource efficiency is one of the primary benefits of technological innovation in sustainable urban planning. Technologies such as smart grid systems, energy-efficient buildings, and green transportation options can significantly reduce the consumption of energy and resources. According to a study by the European Commission, implementing smart grid systems alone can reduce energy consumption by up to 9% and CO2 emissions by up to 10%. Additionally, using green building technologies such as low-emissivity windows and insulation materials can reduce heating and cooling costs by up to 50%. These technologies save resources and reduce the cost of utilities for residents and businesses.

Reducing environmental impact is another significant benefit of technological innovation in sustainable urban planning. Technologies such as renewable energy systems, green infrastructure, and waste reduction programs can significantly reduce the environmental impact of cities. For example, renewable energy technologies like solar, wind, and geothermal can reduce greenhouse

gas emissions and air pollution. Additionally, green infrastructure technologies such as bioswales and permeable pavement can help manage stormwater and reduce the impact of urban heat islands, mitigating the impact of climate change.

Increased economic competitiveness is also a benefit of technological innovation in sustainable urban planning. Cities that invest in sustainable technologies often attract new businesses, creating jobs and boosting the local economy. According to a report by the International Energy Agency, investments in renewable energy technologies can generate up to three times as many jobs as investments in fossil fuels. Additionally, implementing green transportation options like bike-sharing systems and electric vehicle charging stations can attract environmentally conscious businesses and residents.

Enhanced quality of life is a significant benefit of technological innovation in sustainable urban planning. Using green space and implementing green infrastructure can improve air and water quality, reduce noise pollution, and promote physical activity, leading to better overall health and well-being. Smart transportation systems and digital platforms for citizen engagement can also improve accessibility and community involvement.

In conclusion, technological innovation can significantly impact cities; with the right investments and strategies, cities can create a more sustainable future for their residents and the planet.

5. Challenges of Technological Innovation in Sustainable City:

As technological innovations continue to revolutionize how we live, work, and interact with the environment, cities worldwide are increasingly turning to these tools to address pressing sustainability challenges. From renewable energy technologies to smart city solutions, these innovations promise to improve resource efficiency, reduce environmental impacts, and enhance the quality of life. However, as with any new technology, significant challenges must be addressed to ensure that these innovations are deployed in an equitable, sustainable, and effective way. In this regard, it is essential to identify and address the potential challenges associated with using technological innovations in sustainable urban planning.

5.1. Limited financial resources:

One of the main challenges facing cities in Algeria regarding technological innovation is a need for more financial resources. Many cities in the country need more budgets for implementing new technologies, making investing in sustainable solutions difficult.

5.2. Resistance to change:

Another challenge is resistance to change from both government officials and citizens. Many people are comfortable with the status quo and may resist the implementation of new technologies, even if they are beneficial for sustainability.

5.3. Limited technical expertise:

Implementing new technologies requires specialized technical expertise that may be limited in many cities in Algeria. This can make developing, implementing, and maintaining new systems difficult.

5.4. Data management:

The practical implementation of new technologies requires access to large amounts of data, which may only be readily available in some cities in Algeria. Additionally, there may be challenges with data quality and management, which can hinder the effective use of technology to improve sustainability.

5.5. Infrastructure limitations:

Implementing new technologies may require significant infrastructure changes, which can be costly and time-consuming. Many cities in Algeria need to have updated infrastructure that may not be compatible with new technologies, making it difficult to implement sustainable solutions.

5.6. Regulatory barriers:

Finally, regulatory barriers can pose challenges to the implementation of new technologies. There may be bureaucratic obstacles, such as complex regulations or conflicting laws, that hinder the implementation of sustainable solutions in Algeria.

6. Conclusion and recommendations:

After exploring the role of technological innovation in promoting sustainability in cities, it can offer numerous benefits, including improved resource efficiency, reduced environmental impact, increased economic competitiveness, and enhanced quality of life. However, it also faces various challenges, including equity, privacy, and cybersecurity issues.

Considering these challenges, cities must approach technological innovation thoughtfully and intentionally. This includes investing in research and development to ensure that technology is deployed to benefit all residents, regardless of income or demographic status. It also involves engaging with stakeholders throughout the community to ensure that the benefits of technological innovation are equitably distributed.

For Algeria and specifically the new town of Hassi Messaoud, several recommendations can be made to promote sustainable technological innovation. Firstly, it is essential to establish strong partnerships between the government, industry, and academia to ensure that innovative solutions are developed and deployed effectively. This can include establishing research and development centers to encourage technological innovation tailored to the local context.

Secondly, investing in sustainable infrastructure, such as green buildings, smart grids, and sustainable transportation systems, is critical. This will require a commitment to public-private partnerships and the allocation of financial resources towards sustainable infrastructure development.

Finally, promoting education and awareness about sustainable technological innovation among the public is important. This can include workshops and seminars that educate residents about the benefits of green technology and encourage them to adopt sustainable practices in their daily lives.

By following these recommendations, Algeria and the new town of Hassi Messaoud can become leaders in sustainable technological innovation, promoting a healthier, more equitable, and more sustainable future for all residents.

PRACTICAL PART

Chapter 3

The State of the art:

Providing case studies of cities that have successfully integrated technological innovation with sustainable city.

Introduction:

Cities around the world are at the forefront of innovation, striving to create sustainable and livable environments for their residents. The integration of technological innovation with sustainable city practices has emerged as a powerful approach to tackle urban challenges and promote sustainable development. From smart city solutions to green infrastructure, cities are leveraging cutting-edge technologies to enhance their environmental, social, and economic performance. In this chapter, we will delve into the exciting world of cities that have successfully embraced technological innovation to build sustainable urban environments. Through case studies of two cities, Masdar City, and Singapore, we will explore how these cities have leveraged technological innovation to drive sustainable urban planning and development and draw insights that can inform best practices for other cities looking to follow suit.

The purpose of this chapter is to provide a comprehensive analysis of cities that have successfully integrated technological innovation with sustainable city practices. By examining the strategies, approaches, and outcomes of these cities, we aim to identify key factors that contribute to their success in integrating technological innovation and sustainability in urban planning. Through an in-depth analysis of Masdar City, and Singapore, we will explore the opportunities and challenges associated with leveraging technological innovation for sustainable city development. Additionally, this chapter will highlight the relevance and applicability of these best practices for the case study of the new town of Hassi Messaoud, providing practical insights for implementing technological innovation in the context of urban planning in Algeria. By understanding the innovative approaches adopted by these cities, we can draw valuable lessons and recommendations for other cities seeking to create sustainable, smart, and resilient urban environments for their citizens.

1. Case Study 1: Masdar City, UAE

1.1. General city overview:

The creation of a green and sustainable city in a desert landscape is the ambitious goal for Masdar City in Abu Dhabi. The project is founded on a number of urban planning principles, with a focus on optimal utilization of the region's resources. (1)

Masdar City is located in the United Arab Emirates, 17 kilometers south-east of the city of Abu Dhabi. The city is dedicated to the use of solar energy and other renewable energy sources and is designed to be a hub for cleantech companies. The Masdar Institute of Science and Technology and the headquarters of the International Renewable Energy Agency (IRENA) are already established on the site. (1)

In partnership with Masdar City, Ramboll/Atelier Dreiseitl is preparing a Landscape Plan and Conceptual Landscape Design to establish city-wide guidance for design of the public realm of the city.

The estimated construction cost of the city is between US$18.7 and US$19.8 billion. (2)

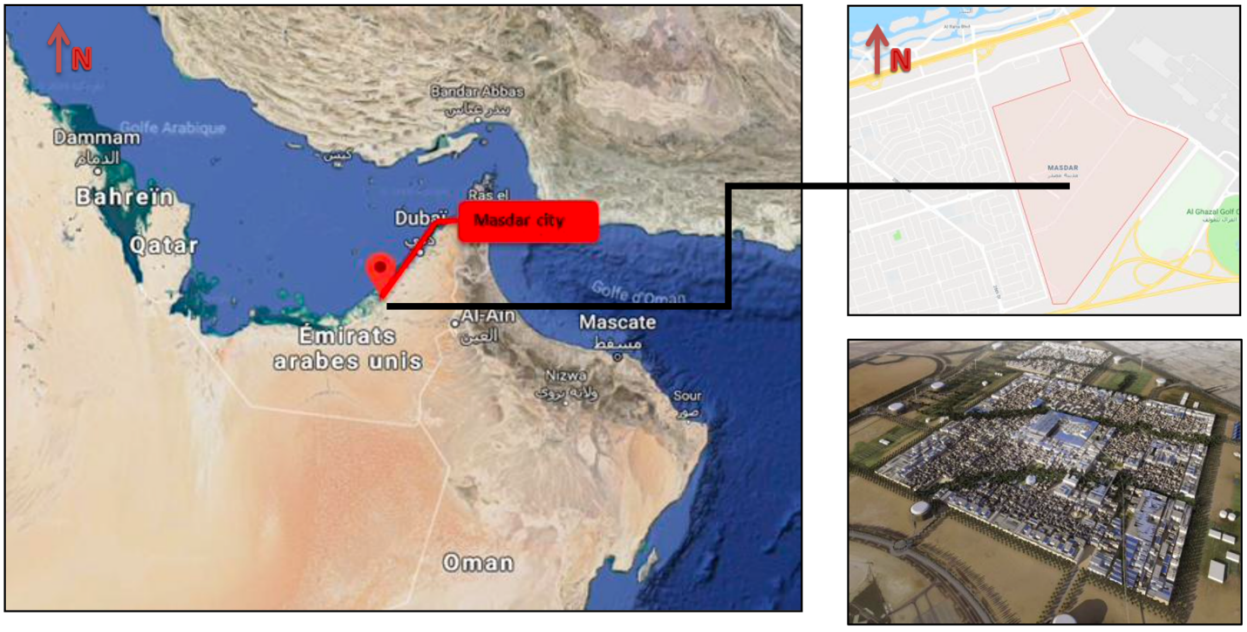

Figure 11: Masdar city's location.
Source: Author's creation

Figure 12: The Masdar City master plan in 2008.
Source: S. Griffiths, Masdar Initiative: Rationale & Research Opportunities, MIT Green Islands Workshop: Focusing MIT Research on Sustainable Regions, Massachusetts Institute of Technology, 2008.

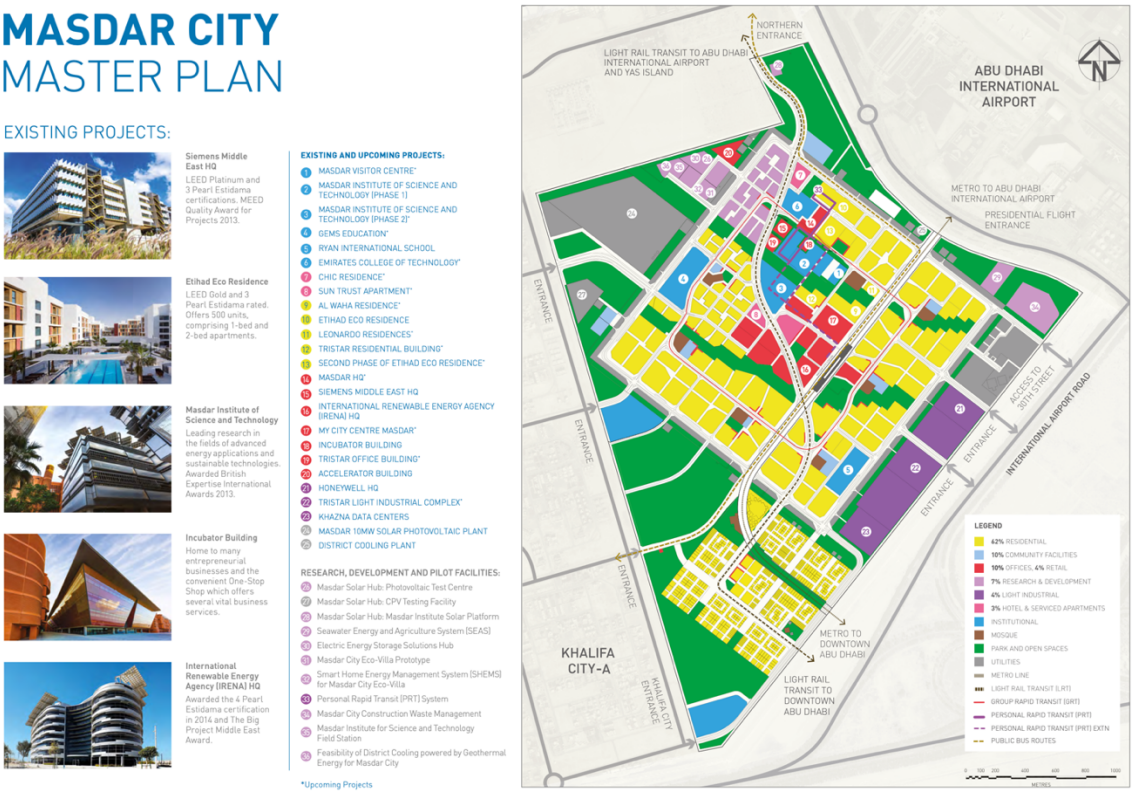

Figure 13: The Masdar City master plan in 2018.
Source: Masdar, Masdar City Master Plan, https://masdar.ae/-/media/corporate/downloads/masdar-city/masterplan_21-12_english_v2.pdf (2018).

1.2. Sustainable city goals:

The aim of Masdar City was to:

- Specialize in greenhouse gas emission reduction projects and develop large-scale renewable energy projects.
- Rely entirely on solar energy and other renewable energy sources. (3)
- Become a hub for cleantech companies.
- Provide homes for about 50,000 people.
- Provide facilities for 1,500 businesses, primarily commercial and manufacturing firms specializing in environmentally friendly products, and create 10,000 new jobs, with more than 60,000 workers expected to commute to the city daily.
- Create a new tertiary education institution, the Masdar Institute of Science and Technology (MIST), modelled on MIT, which was founded in 2007, a year after the Masdar initiative began, and admitted its first students in 2009.

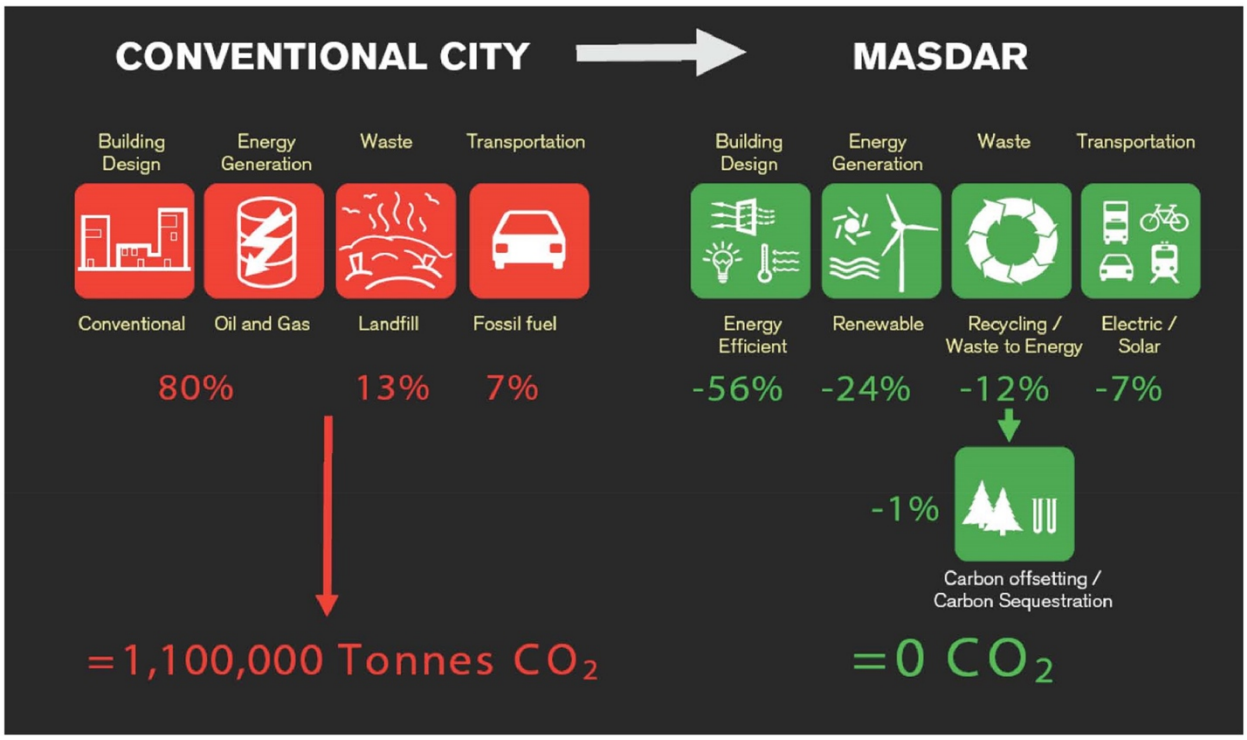

Figure 14: Masdar City objective in 2008 to become a zero-carbon entity.
Source: S. Griffiths, Masdar Initiative: Rationale & Research Opportunities, MIT Green Islands Workshop: Focusing MIT Research on Sustainable Regions, Massachusetts Institute of Technology, 2008.

Regarding transportation, Masdar City initially planned to be car-free and leverage an iconic driverless Personal Rapid Transit (PRT) for nearly all vehicle-based movement within the city (see Fig. 19). This would have made Masdar City one of only five elite cities around the world to deploy a fully functioning PRT system,

Figure 15: Masdar City objectives in 2008 for transportation.
Source: S. Griffiths, Masdar Initiative: Rationale & Research Opportunities, MIT Green Islands Workshop: Focusing MIT Research on Sustainable Regions, Massachusetts Institute of Technology, 2008.

1.2.1. Increased livability through urban planning:

The goal of Masdar City is to create a walkable, vibrant mixed-use community through creation of interconnected neighborhoods and public places focused on the human experience and programmed to support multiple activities. The master plan is intended to guide the designers of the public realm of Masdar, and to be an implementation tool for Masdar City.

The scope of the project includes everything outside the buildings, including the streets and public plazas, parks and open spaces. Public spaces, parks and streetscapes will be designed to encourage walking and outdoor activity throughout the day while planting, shading and water strategies will all contribute to reducing the radiant temperature and maximizing cooling breezes to extend the time that people can spend outdoors.

The master plan is centered on five guiding themes that support the creation of a fully integrated sustainable community:

1. Livable Community; prioritizing walking and cycling, providing connectivity throughout the city and offering recreational opportunities.
2. Outdoor Comfort; shaded and cooled walks and public spaces
3. Environment & Natural Systems; Hydrozoning Planting strategy that conserves water and achieves a balance between dry and lush areas and creation of productive landscapes where food is grown for local markets and for research purposes.
4. Precious Water: establishing a water use and reuse system that acknowledges water as a precious resource, for example by using treated sewage for irrigation and recycling waste water
5. Sustainable Urban Systems: creating a suite of urban systems that embody sustainable principles, minimize resource use and contribute to the creation of a livable mixed-use community. (4)

1.2.2. Part of Abu Dhabi's future sustainability plans:

By 2020, Abu Dhabi intends for 7% of its energy to come from sustainable sources, and the Masdar initiative has already come far in terms of introducing solar energy, greenhouse gas reductions, hydrogen power plans and carbon capture.

The project is very much about future proofing Abu Dhabi by looking for alternative and sustainable energy sources. In this way, the Emirate is taking a leadership role in sustainable urban planning, says Talitha Fabricius.

Through the implementation of the Landscape plan and Conceptual Landscape Design, Masdar City will contribute to Abu Dhabi's 2030 goals and future economic and societal vision. (4)

1.3. Innovative Technologies:

Masdar City has implemented a variety of innovative technologies to promote sustainability, including solar panels, wind turbines, smart grids, and sustainable building design.

1.3.1. Personal Rapid Transit (PRT):

Personal Rapid Transit (PRT) is a state-of-the-art form of public transport (PT) that uses small, automated electric 'podcars' to:

- provide a taxi-like service for individuals or small groups of travelers.
- provide demand responsive feeder and shuttle services connecting facilities such as parking lots with major transport terminals and other facilities such as shopping or exhibition centers.

The podcars run on a segregated guideway in order to ensure unhindered direct trips between origin and destination. They provide clean, green, efficient and sustainable transportation. With high vehicle speeds and very small headways, PRT provides fast, individual, on-demand and point-to-point PT with very short waiting times. (5)

There will be no fossil fuel cars within Masdar City. The city will be a pedestrian-friendly environment, with a Personal Rapid Transit system (PRT) available for longer journeys. The PRT vehicles will travel at speeds up to 40km/h, with the longest routes in the city taking around 10 minutes. Ultimately there will be 3,000 PRT vehicles serving 130,000 trips/day over the 85 stations. (6)

Figure 16: The PRT vehicle developed for the Masdar eco-city project in Abu Dhabi. source: courtesy of '2getthere'

1.3.2. Photovoltaic Power:

Masdar utilizes the three most commercially viable types of solar panels to convert the sun's energy into electricity. These photovoltaic (PV) technologies include monocrystalline silicon panels, polycrystalline silicon panels, and thin-film panels. Depending on the solar potential, geographical location, and financial requirements of a specific solar PV project, a suitable PV system is implemented to meet the project's needs.

The 10-megawatt (MW) Masdar City Solar PV plant employs 5MW of polycrystalline silicon modules manufactured by Suntech and 5MW of thin-film solar modules manufactured by First Solar.

Masdar also implements advanced technologies to further enhance the performance and efficiency of its solar PV plants. The first 200MW stage of Phase 3 of the MBR Solar Park is one of the largest solar power projects in the world to use technology that tracks the path of the sun to maximize output and the largest of its type in the Middle East and North Africa. It also uses 50 custom-made robots that clean the panels without the need of water, further improving the plant's performance while reducing its dependence on water - a precious resource in the desert. (7)

Figure 17: A 10 Megawatt(MW) solar photovoltaic power plant at Masdar City

1.3.3. Concentrated Solar Power:

Concentrated solar power (CSP) systems use mirrors to focus a large area of sunlight onto a much smaller area. When the concentrated light is converted into heat, it drives a heat engine connected

to an electrical power generator. CSP systems are considered a promising solar power technology for large-scale power generation. When CSP is coupled with thermal energy storage (TES), it is capable of producing constant power (baseload) for up to 24 hours a day, making it well suited for integration with the electricity grid. (8)

Figure 18: The Concentrated solar power (CSP) systems.
Source: Masder Website

1.3.4. Waste-to-Energy:

Waste-to-energy is the process of generating energy in the form of electricity or heat from the processing of municipal solid waste, or rubbish.

In 2017, Masdar signed a joint development agreement with Bee'ah of Sharjah to develop the UAE's first waste-to-energy power plant. On completion, the plant will divert more than 300,000 tonnes of solid waste from landfill each year and produce 240,000-megawatt hours of clean energy, helping the UAE to achieve its 2021 goal of diverting 75 per cent of its solid waste from landfill sites. (9)

1.3.5. Energy Storage:

As the penetration of solar energy in the grid rises, grid-level energy storage becomes critical. Storage solutions provide the flexibility that transmission systems need to accommodate the variability of the wind and the sun. The good news is that much like the prices of solar panels and wind turbines in the past decade, battery prices are declining rapidly. The average price of a lithium-ion battery pack is down to US$209/kilowatt-hour, and the prices are set to fall below US$100/kWh by 2025, according to Bloomberg New Energy Finance (BNEF). (10)

The city's main source of renewable energy is a 10-megawatt solar photovoltaic plant, which generates enough electricity to power the entire city. The city also has a 1-megawatt wind turbine that generates additional renewable energy.

To conserve water, Masdar City uses an innovative air conditioning system that reduces water consumption by up to 60% compared to traditional cooling systems. The city also uses treated sewage effluent for irrigation, reducing the need for freshwater.

In addition, Masdar City's sustainable building design includes passive cooling techniques, such as natural ventilation, shading, and thermal insulation, which reduce the need for energy-intensive air conditioning (Masdar City, n.d.). Buildings in Masdar City are also designed to be energy-efficient, with features such as high-performance windows, efficient lighting systems, and low-flow plumbing fixtures.

1.4. Implementation Challenges:

Despite the ambitious sustainability goals of Masdar City, the implementation of these technologies has not been without challenges. One major challenge has been the high cost of implementing renewable energy and sustainable building technologies. The development of Masdar City has required significant investment, with estimates suggesting a cost of up to $22 billion. Another challenge has been the need to balance sustainability goals with economic development and the needs of residents and businesses.

To address these challenges, Masdar City has implemented various strategies to reduce costs and increase public engagement. For example, the city has partnered with private sector companies to finance renewable energy projects and has launched educational programs to raise awareness of sustainability issues among residents and visitors.

1.5. Impact on Sustainability:

The impact of Masdar City's innovative technologies on the sustainability of the city has been significant. The use of renewable energy sources has allowed Masdar City to reduce greenhouse gas emissions and achieve its goal of becoming a carbon-neutral city. The city's air conditioning system and sustainable building design have also reduced energy consumption and improved indoor air quality, promoting a healthier and more comfortable living environment for residents.

Moreover, Masdar City's commitment to sustainable transportation has resulted in the development of walkable neighborhoods and bike-friendly infrastructure, reducing the city's reliance on cars and promoting a more active and healthier lifestyle.

The projected impact is focused on making the urban environment cleaner and greener: (4)

- Compared to American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards, the buildings in Masdar City consume 40% less energy and water
- Buildings in Masdar are designed in accordance with Estidama Pearl Building Rating System baselines.
- Nearly 1.5 gigawatts of clean energy is in operation or under development.
- The design of the walls of the buildings (cushions of air limit heat-radiation) helps reduce demand for air conditioning by 55 percent and has also established a naturally cooler temperature, almost 10°C less than in the rest of Abu Dhabi.
- The entire community of Masdar City is powered by a 22-hectare field of 87,777 solar panels with more on the roofs of the buildings.
- There are no light switches or taps - sensors are used in their place, which helps cut electricity consumption and water usage by almost half.
- Masdar City was named “Best Free Zone for Start Up Support” in 2017 by fDi magazine, part of the FDI intelligence services portfolio provided by the UK's Financial Times. (11)

2. Case Study 2: Singapore

Singapore has its ambition to make its country the world's first true Smart Nation by harnessing technology to the fullest with the aim of improving the quality of life, strengthening businesses, and building stronger opportunities. The country has already begun its journey to bring about the vision it calls 'E3A': Everyone, Everything, Everywhere, All the time.

2.1. General city overview:

Singapore, officially the Republic of Singapore, and also known as the Lion City, is a leading global city-state that is situated 137km north of the equator, and just south of Peninsular Malaysia. Singapore is one of the most densely populated independent country in the world. The total area is 597km2 with population of 5.5 million. It has a diverse populace which is made up of Chinese, Malays, Indians, Eurasians as well as other Asians of different origins, owning a rather distinctive cultural characteristic.

Singapore's territory consists of the main island (commonly known as Singapore Island) and more than 60 smaller islets. Singapore historically experienced extreme turbulence in its early years. During the Second World War Japan had occupied the country, but then it was overtaken by Britain once the War ended. It became independent from Britain in 1963 by uniting with other former British territories to form Malaysia but was separated after two years due to ideological differences. A small island had to stand up as a nation of its own.

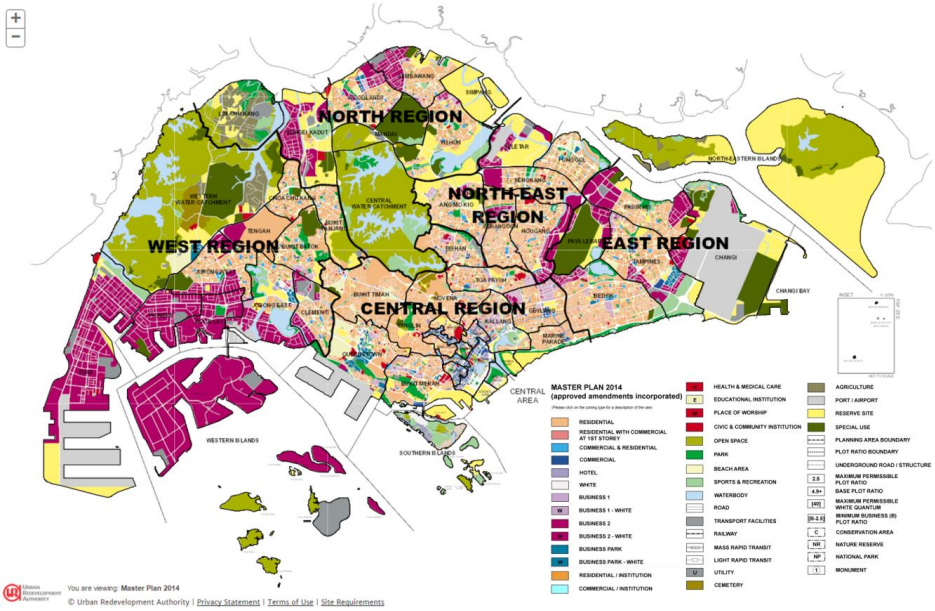

Figure 19: Masterplan of Singapore 2014.
Source: urban redevelopment authority.

2.2. Sustainable City Goals:

One of Singapore's main sustainable city goals is to reduce its carbon emissions intensity by 36% below 2005 levels by 2030 and to achieve net-zero emissions as soon as possible in the second half of the century. The city-state also aims to increase the use of renewable energy sources, such as solar and wind power, and to improve resource efficiency by reducing waste and increasing water conservation.

2.3. Innovative Technologies used:

The most developed smart services in Singapore is within the Transportation and urban mobility sector; the development of Intelligent Transport System (ITS) has been going on for more than 10 years. Singapore also has a strong e-governance foundation, which they have been incubating since the early 80s. There is a broad spectrum of smart services that Singaporean Government wish to provide for the public, but their journey is still at an early stage as most of the services have been launched (many of them as trials) recently in the early 2010s, and many service are on their planning stage, to be implemented along with cross-cutting efforts of the Smart Nation initiatives. Singapore has implemented various innovative technologies to promote sustainability in urban planning, such as:

2.3.1. Intelligent Transport System (ITS):

Singapore has implemented a sophisticated ITS to enhance traffic flow and to keep road traffic running safety. The strength of the ITS in Singapore originates from its holistic approach towards traffic management; ITS work together with other transport initiatives such as free public transportation in pre-morning peak hours, a vehicle quota system, well-functioning public transport system and congestion charge, to enhance overall transport system in the city. Utilizing ITS components, Singapore provides several smart transport services for citizens.

2.3.2. ONE MOTORING

ONE.MOTORING is the comprehensive portal serving all drivers and vehicle owners in Singapore. On this web portal, citizens can access traffic information collected from surveillance cameras installed on roads and taxi vehicles with GPS. Through Traffic Smart, drivers are able to see snapshots of roadways that is taken at every 5-minute interval. Due to security reasons, real-time moving video or close-up shots are not provided online.

It also provides information on current ERP rates (Electrical Road Pricing), sections where road works are in progress, traffic images of major expressways, traffic news, travel time calculator, road maps and street directions, and parking information. This useful portal can also be accessed on mobile devices. One motoring, not only provides traffic information but also offers information and guidance for citizens regarding buying, selling, and maintaining their vehicles.

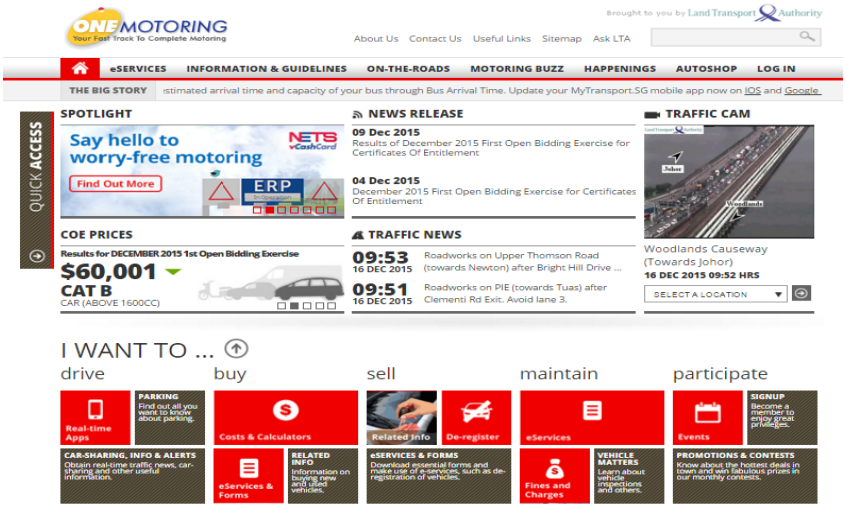

Figure 20: OneMotoring Website main page.
Source: www.onemotoring.com.sg

Figure 21: One Motoring traffic cameras.
Source: OneMotoring website

2.3.3. Parking guidance service:

LTA has launched the Parking Guidance System since 2008 and this provide drivers with real-time information on parking availability. This reduces the amount of circulating traffic searching for available spaces and promotes a more efficient use of existing parking facilities. Information is displayed on electronic sign board or online on One Motoring Portal, or on mobile application such as MyTransport.SG.

Next step in transportation sector under the Smart Nation Vision is anticipated to bring something more advanced and newer. Public buses may be unmanned in a near future as autonomous vehicles or self-driving cars have become a reality. Autonomous driving may be applied to other things, for example cargo trucks operating only at night, reducing road congestions during the day.

2.3.4. Bus information system:

MyTransport.SG smartphone application provides real-time information for commuters. It updates its features regularly to improve commuters' travelling experience.

Over the past year, LTA has been working with SBS Transit and SMRT to install and test a new centralized system, which determines real-time bus location, and hence provide more accurate bus arrival information for more than 4,700 public buses over 360 routes. Bus loading information is also available for selected bus services. Commuters are able to see colour-coded space availability information to help them decide whether to board the arriving bus or choose to get on the next bus. The colour green indicates available seats, yellow indicates available standing spaces, and red indicates limited standing.

Various applications developed by My Transport Singapore, brought to citizens by the LTA are available to enhance commuters' and drivers' convenient urban mobility.

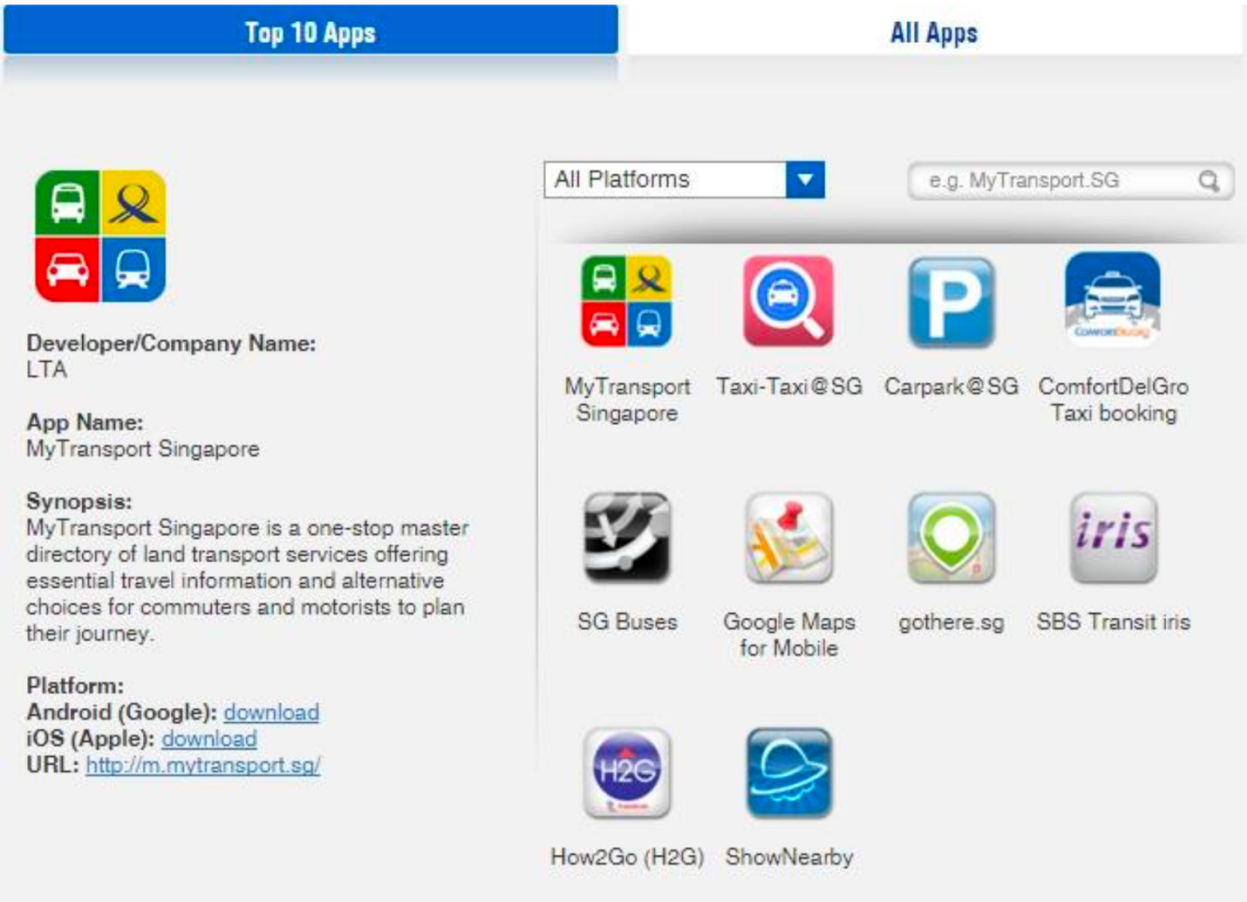

Figure 22: Available applications, Top 10.
Source: MyTransport official website

2.3.5. Emergency and response :

The Singapore Civil Defence Force (SCDF) is a uniformed organization, overseen by the Ministry of Home Affairs of Singapore Government that provide fire-fighting, rescue and emergency medical services; relieve hazardous materials incidents, as well as formulate, implement and enforce regulations on fire safety.

Emergency Medical Service (EMS) is operated by the SCDF and it can be reached through three-digit dial '995'. The 995 Operations Centre can also be reached through mobile application that SCDF provides in collaboration with iDA, which has been designed to increase survival rate from incidents such as out-of-hospital cardiac arrest. The application so-called myResponders has been launched recently in April 2015 which alerts users to nearby cases of suspected cardiac arrest, guiding them to respond before the SCDF arrives. Since the application was launched, there have been more than 2,000 downloads, although the number of registrations to become responders did not reach the similar level so far.

Figure 23: myResponder App.
Source: Singapore Civil Defence Force official website.

'mySCDF' allows citizens to provide feedback to SCDF, instructions for use of fire extinguisher, how to perform CPR and AED, as well as access for SCDF annual reports.

Other applications that allow the public with access to critical emergency information are 'Biological Threats', 'Decontamination Procedures', 'Exposure to Biological Agents', 'Fire Safety', and 'If An Explosion Occurs'.

Some e-services are also available on SCDF's main website. These services include: i) online payment for SCDF's services; ii) apply for courses at SCDF for public education programmes; iii) purchase fire and ambulance reports; and iv) SCDF facilities locator.

Another major aspect of Smart Nation initiative that is on its way is tele-medicine. Singapore aim to promote the widespread use of wearable technologies such as fitness trackers, smart watches and even smart clothing which can monitor the well-being of a patient. The idea is not only to record of vital signs such as blood pressure, heart rate and body temperature and but also transmit the data via Internet to designated healthcare professionals or family members.

IDA established its plan for Smart Health-Assist pilot project in the Jurong Lake District in late 2015 to support the needs of the aging population of Singapore. It is designed to record data from user-friendly sensors in the houses of the elderly and the patients suffering from chronic diseases to be sent securely online to healthcare providers, allowing them to monitor individuals, receive alerts, and respond to any emergencies.

2.3.6. The Smart Nation Vision:

The Smart Nation Vision comprises urban sectors (such as urban mobility, environment, healthcare, logistics, etc), supporting ecosystem such as industry and manpower, and Smart Nation Platform. Smart Nation Platform is divided into two layers: Smart Nation Operating System (SN-OS) and Communications & Sensor Network.

Communications & sensor Network is foundational infrastructure for deploying essential field facilities such as smart meters, CCTVs, flood sensors, etc. As shown in figure 17 field facilities installed around the city are linked both by wired and wireless connections to form communication and sensor network as a whole. Information gathered from the devices are then shared among agencies for appropriate responses.

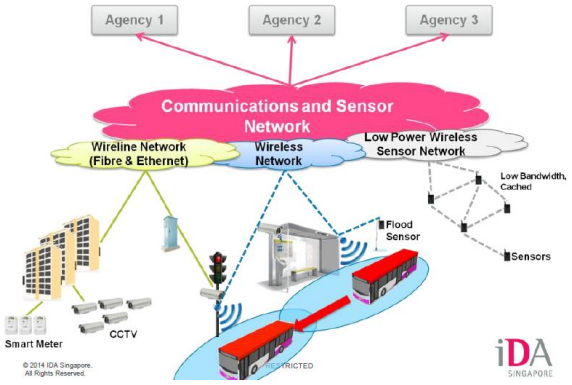

Figure 24: Communication and sensor network.
Source: iDA Smart Nation platform Industry Briefing, 2014

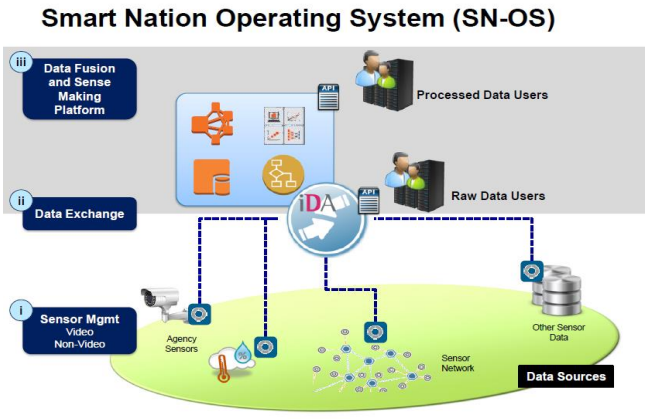

Figure 25: SN-OS platform.Source: iDA Smart Nation platform Industry Briefing, 2014

Based on communication & sensor network, Smart Nation Operating System operates in three layers; I) sensor management, II) data exchange, and III) sense-making platform.

I) Sensor management:

Through sensor management, for both video and non-video sensors, field facilities should be regularly monitored for their well-functioning (state of charge, gateway status, sensor network performance, etc.) and be checked upon their remote controls (activation, de-activation, sensing mode, sensor-specific configuration, etc.).

II) Data exchange:

A unified platform where reliable, secure, timely data sharing is facilitated is extremely important for effective use of human and machine-centric sensor data. Within SN-OS, open standards, protocols, and data security policies are established and applied to harmonize Government agencies and private enterprises in the use of data.

III) Sense-making platform:

Data are processed, integrated, and analyzed for relevant information to be delivered for end users in this sense-making platform.

2.3.7. Green link Determining (GLIDE) system:

Within the ITS, all traffic signals are controlled by the Green Link DEtermining (GLIDE) system. Under the system, the green light is allocated based on real-time traffic demands and traffic signals at neighbouring junctions along major corridors are linked, minimizing the drivers' stops while they travel from one junction to another (this is known as a green wave). Presence of pedestrians are detected through push button that they press at crossings.

GLIDE automatically detects the traffic flow, traffic light faults and pedestrians and for such system thin metal wire detector loops are installed below the road surface and before signal junctions.

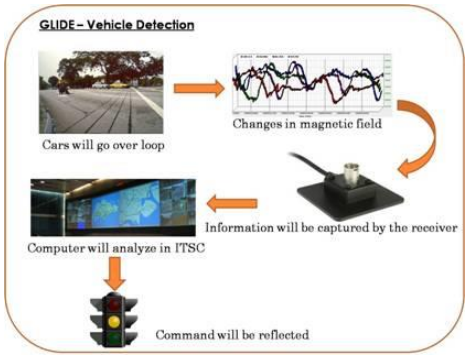

Figure 26: GLIDE vehicle detection.
Source: SMU School of Information System

Figure 27: GLIDE vehicle detection.
Source: SMU School of Information System

2.3.8. J-Eyes:

Surveillance cameras installed on special poles, street lamp posts and traffic light poles at road junctions monitor traffic conditions and to send video images to the traffic control centre. The information gathered are monitored by the Operations Executives who decide on appropriate implement actions when any problems occur.

Figure 28: J-Eyes surveillance camera.
Source: ITA website

2.3.9. Expressway monitoring & advisory system (EMAS) :

EMS monitors traffic on expressways using surveillance cameras and alerts motorists of any traffic incidents and make sure swift response is made to these incidents. EMAS Arterial capabilities have been fitted to 10 major arterial road corridors in early 2014, helping to manage traffic and guiding drivers more effectively.

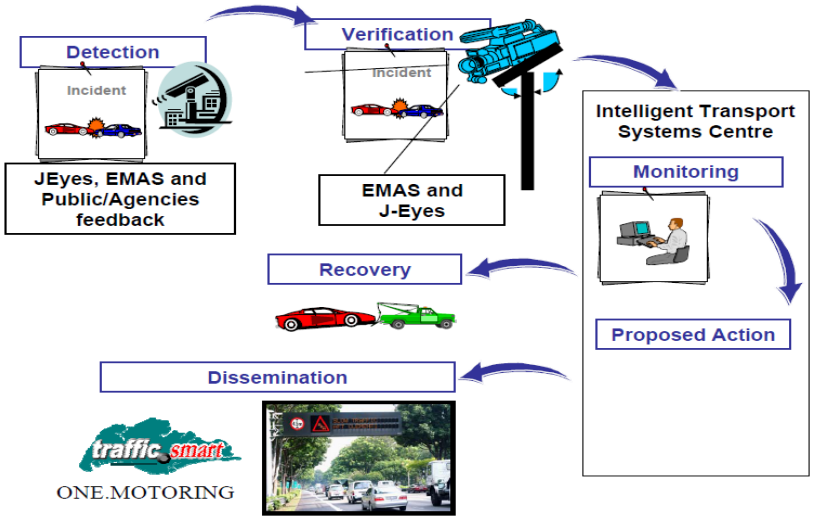

Figure 29: 24 EMAS workflow.
Source: SMU School of Information System

2.3.10. E-TrafficScan:

LTA works in cooperation with city taxi companies. All taxi vehicles in the city are equipped with the GPS that tracks their locations and speed as they probe on the road network. Taxies act as a form of moving sensor and data

collected are returned to drivers to provide travel information on both expressways and arterial roads, improving the time-efficiency of their journey route. The information can be found on the One Motoring Portal, along with other ITS such as EMAS and GLIDE.

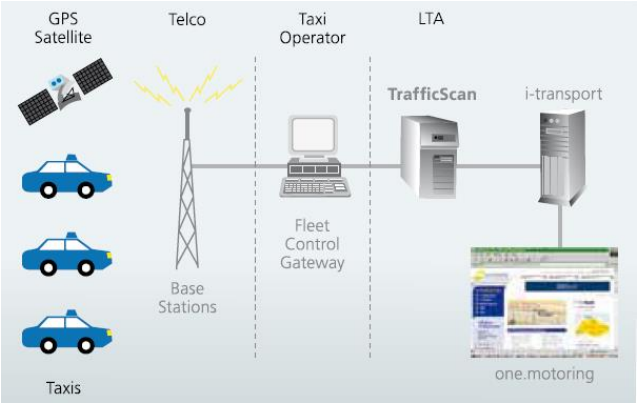

Figure 30: Information flow in TrafficScan.
Source: TraffricScan-Bringing Real-time Travel Information to Motorists, CHIN Kian Kong and LEE Chin Wai (2009)

2.3.11. Traffic message channel (TMC)

The traffic message channel is a standard for delivering real-time traffic information to drivers through TMC-compliant devices. TMC message that carries location code and an event code is transmitted to the device in vehicle.

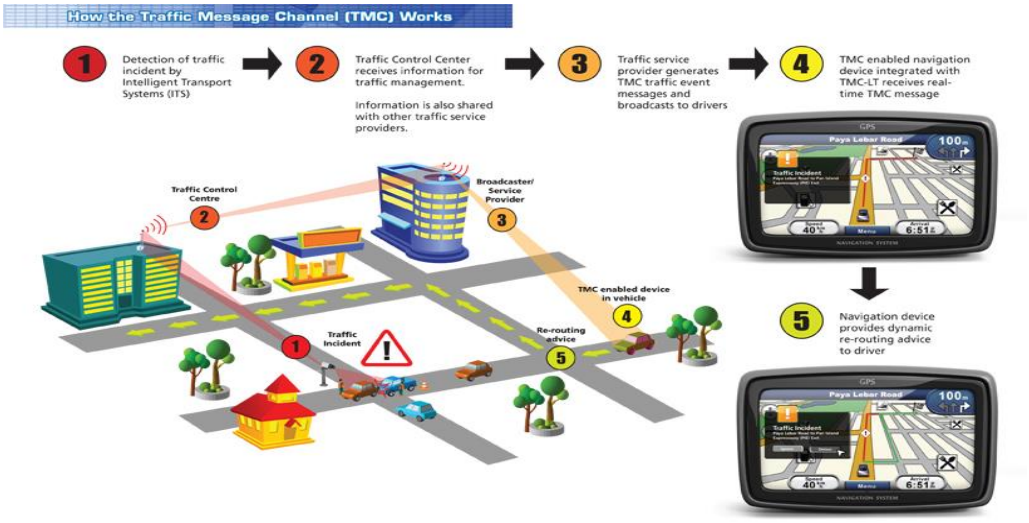

Figure 31: How TMC works.
Source: Land Transport Authority official website

2.3.12. Intelligent Energy System (IES):

Intelligent Energy System (IES), launched in 2009, is a smart grid system that provides real- time information on how electricity is used. IES attempts to improve efficiency of network operations and facilitate active participation among consumers by connecting intelligent homes, vehicles, communities, electricity network sensors and sources of green generation.

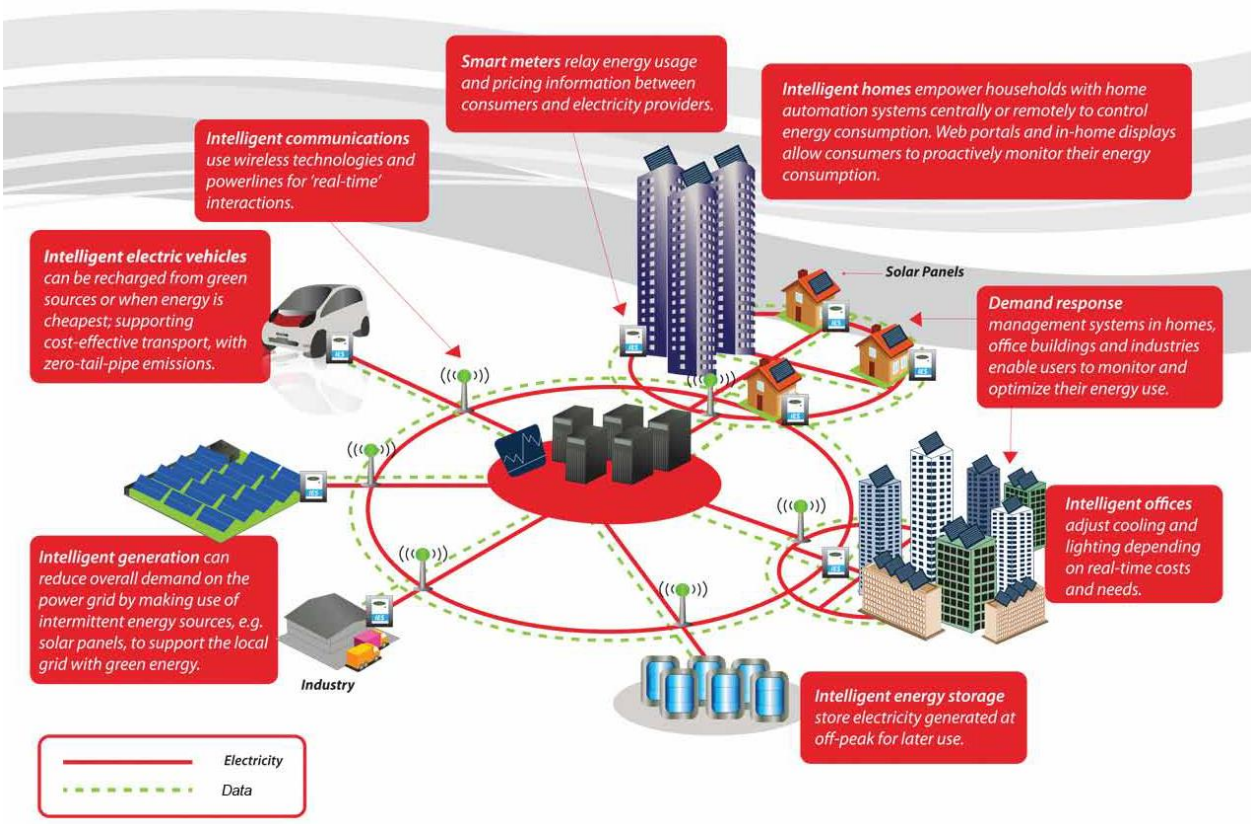

Figure 32: Nationwide Intelligent Energy System (IS).
source: NEI

2.4. Citizen interaction and communication mechanisms:

As a connected nation with extremely impressive wireless broadband connection rate and smart phone penetration rate, Singapore has emphasized the importance of connectivity between the Government, industries and its people. Most of Singapore Government's main websites have developed more citizen-central contents and much of information are transferred to citizens through social media and mobile applications.

Plan	Objectives
e-Government Action Plan (2000–2003)	To provide as many public services online as possible
e-Government Action Plan II (2003–2006)	Improvement of the service experience of customers
iGov Masterplan (2006-2010)	Focus on creating an integrated Government that works behind the scenes to serve users better. Mobile services were introduced to work with the high mobile phone penetration rate, providing citizens with an additional channel for accessing public services.
eGov2015 Masterplan (2011–2015)	Aim to become a collaborative Government that facilitates greater co-creation and interaction between the Government, the citizens, and the private sector to bring greater value for Singapore. This plan aim to shift from a "Government-to-You" approach to a "Government-with-You" approach in delivery of the online services. The goal is to encourage for more interactions.

Table 4: e-Gov in Singapore.
Source: Singapore eGov official website

2.5. Impact on Sustainability:

The innovative technologies implemented in Singapore have had a significant impact on the city's sustainability. For example, the city-state has reduced its carbon emissions intensity by 22% below 2005 levels as of 2020 and is on track to meet its 2030 target. Singapore has also made significant progress in reducing water consumption and improving water quality, with water recycling technologies contributing to about 40% of the city's water supply. Additionally, Singapore's public transportation system is widely regarded as one of the most efficient and sustainable in the world.

2.6. Lessons learned and best practices for other cities:

Singapore's success in integrating technology with sustainability provides several valuable lessons for other cities. One lesson is the importance of a comprehensive and long-term sustainability plan that sets clear goals and targets for environmental protection and resource efficiency. Another lesson is the need for innovative technologies that can improve energy efficiency, reduce carbon emissions, and increase resource resilience. Finally, collaboration between the public and private sectors is crucial for the successful implementation and maintenance of these technologies.

Chapter 4

The Case study:

The new town of Hassi Messaoud

Introduction:

In this chapter, we will apply the theoretical knowledge gathered from the previous chapters to conduct a comprehensive urban planning analysis of the new city of Hassi Messaoud. Our objective is to understand the unique characteristics and environment of Hassi Messaoud in order to develop a project that is responsive to its needs and aligned with sustainable principles. Additionally, we will explore the potential integration of technological innovation to enhance the city's functionality, efficiency, and overall sustainability.

By analyzing the available data and conducting an in-depth examination of the urban fabric of Hassi Messaoud, we aim to gain insights into the city's infrastructure, land use patterns, transportation networks, and environmental considerations. This analysis will enable us to identify the challenges and opportunities associated with urban planning in the area, paving the way for informed decision-making in the design and development process.

Moreover, as we delve into the urban planning analysis, we will also explore the potential integration of technological innovation in Hassi Messaoud. We recognize that technological advancements have the capacity to revolutionize urban environments, making them more sustainable, efficient, and livable.

By integrating technological innovation into the urban planning analysis of Hassi Messaoud, we aspire to create a blueprint for a city that not only addresses its present challenges but also prepares for the future. We recognize that a forward-thinking approach to urban development can position Hassi Messaoud as a model for sustainable and technologically advanced cities in Algeria.

Through this chapter, we aim to provide policymakers, urban planners, and stakeholders with valuable insights and recommendations. By combining a comprehensive urban planning analysis with the integration of technological innovation, we strive to present a vision for Hassi Messaoud that embraces sustainability, efficiency, and a high quality of life. By doing so, we contribute to the discourse on urban planning in Algeria and inspire the realization of a new town that embodies the principles of sustainable development and technological advancement.

1. Presentation of the new town of Hassi Messaoud:

1.1. Technical sheet:

Technical sheet		
Situation		Hassi Messaoud–Ouargla-Algeria
Total area		4 483 hectares
Urbanization area		2 053 ha
Future extension area		1 152 ha
Surface of the Logistics Activity Zone «ZAL»		965 ha
Population		80000 inhabitants
Density		17.84 inhabitant/hectare
Project owner		Public power at the Ministry of Energy and Mining
Project manager		DONGMYEONG Group
Decree of establishment		n° 06-321 of 01/09/2006 under the supervision of the Ministry of Energy; Placed under the supervision of the Ministry of Habitat and Urban Planning and the City, following executive decree n°20-298 of 12 October 2020
Decree approving of the layout plan		no. 16/150 of 23 May 2016
Projected Programs	Collective housing	10 299
	Semi-collective housing	3 658
	Individual housing	3 854
	Mixed housing	2 773
	Public facilities	450 facilities

Table 5: Technical sheet of the new town of Hassi Messaoud.
Source: Author's creation

Figure 33: The new town of Hasssi Messaoud.
Source : Algerie presse service

1.2. Location of the new town of Hassi Messaoud: (1)

1.2.1. Territorial location:

The commune of Hassi Messaoud is part of the Wilaya of Ouargla, one of the largest wilaya in the country. The « New town » project is located about 86 km southeast of Ouargla, capital of the wilaya.

The project site is located approximately 900km southeast of Algiers.

The wilaya of Ouargla is limited to:

- North by the wilaya of El-Oued, Touggourt and El M'Ghair.
- East by Tunisia.
- West by the wilaya of Ghardaïa and El Meniaa.
- South by the wilayas of Illizi and In Salah.

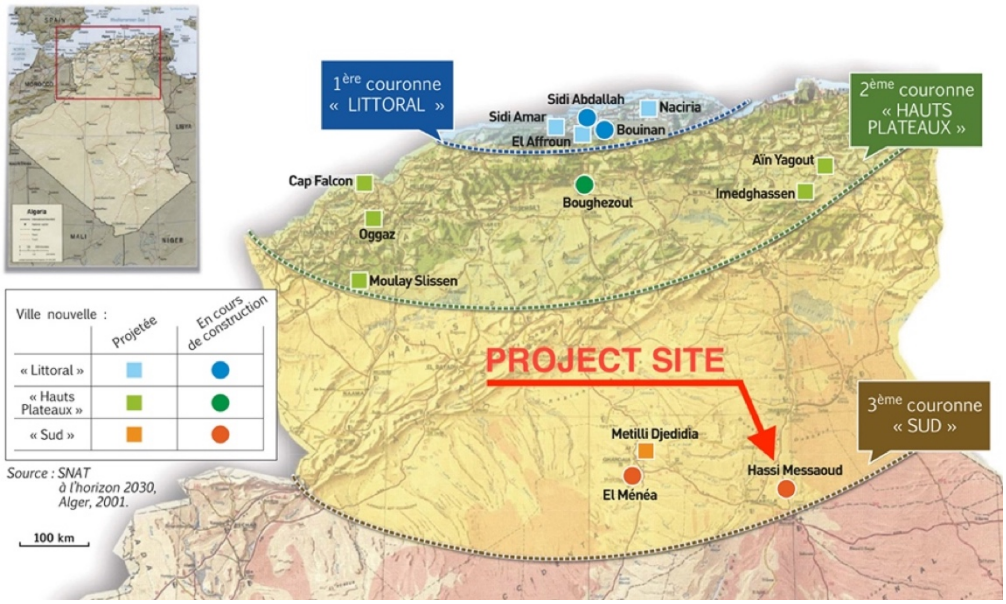

Figure 34: Location of the project site on the national plan.
Source : Schéma national de l'aménagement du territoire à l'horizon 2030, Alger, 2001. + Author's creation

1.2.2. Regional situation:

Located in the region of Oued El Maraa, the new city is equidistant (about 80 Km) from the three surrounding towns, Ouargla, Touggourt and the present city of Hassi Messaoud.

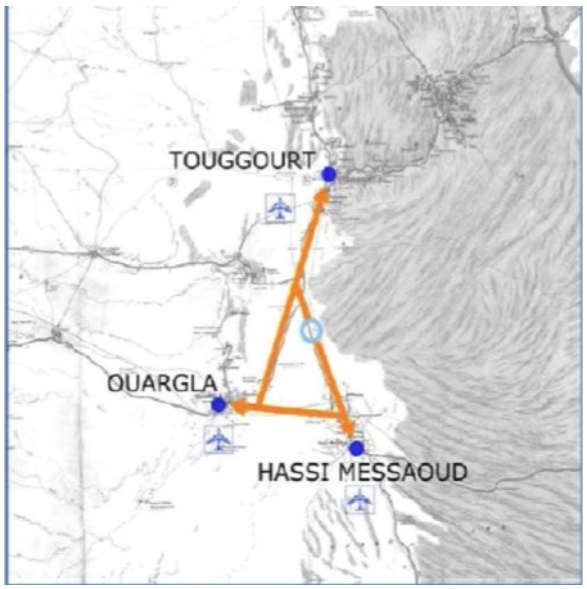

Figure 35: Location of the project site on the regional plan.
Source : Rapport des études hydrogéologiques, GROUPEMENT DONGMYEONG

1.3. Perimeter of the new town of Hassi Messaoud: (2)

The perimeter of the New City covers an area of 4,483 hectares divided into 4 zones of which: 2,044 hectares included in the New City's urbanization and development perimeter, 1,161 hectares included in the future extension perimeter. 313 hectares constitute the perimeter of protection of the new city and 965 hectares are included in the area of logistic activities.

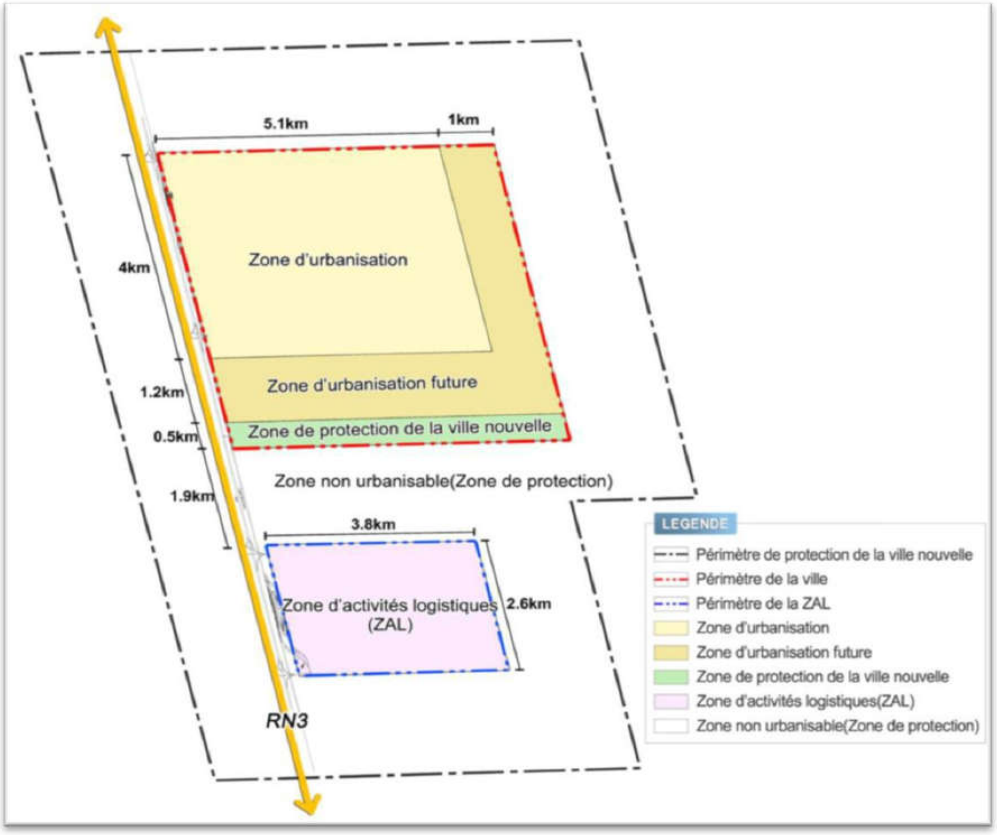

Figure 36: Perimeter of the new town

.Source: Ministère d'habitat, finalisations des études de la ville nouvelle Hassi Messaoud

1.4. Historical overview of the present city of Hassi:

The present city of Hassi Messaoud represents a very important economic pole whose Algerian revenues are basically based on hydrocarbons, that's the main reason for the creation and development of the city of Hassi Messaoud.

Hassi Messaoud is the name of an ancient water well that became the city's first oil source, in 1956 French colonization classified HMD as an oil city of the country.

From the year 1957 the 2 big oil companies have established near the field of exploitation (Haoud el Hamra) their base of life; base of 24 February and base Irara (prefabricated districts). (3)

Figure 37: Hassi Messaoud in 1960.
Source: LE CŒUR DE L'ALGÉRIE PÉTROLIÈRE.
https://heh08com.wordpress.com/2008/06/24/le-coeur-de-l'algerie-petroliere/

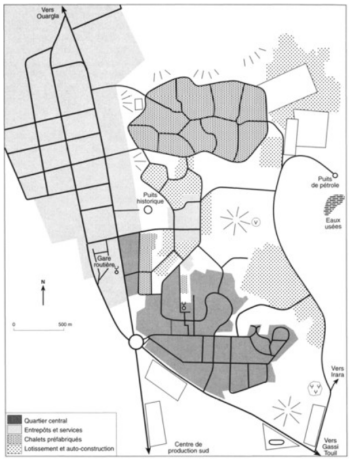

Figure 38: Map of the city of Hassi Messaoud in 1960.
Source: LE CŒUR DE L'ALGÉRIE PÉTROLIÈRE

Hassi Messaoud is a city of oil, the city was born as a city of male workers during all the 1960s Hassi Messaoud still had only 614 inhabitants (a population from the whole of the national territory: executives from the north, workers from all over the Sahara) and for this reason it has retained the character of an oil mining city that was intended only for male workers. (4)

At the administrative division of 1984, HMD was erected as a commune, benefiting from industrial taxes that allow it to have a more urban face like commercial axis, large projects, administrative and residential centers and annexes of accompaniment, an airport located in the hydrocarbon zone. The very high rate of demographic increase observed led to a dynamic and anarchic urban development spread over an oil field. Homes built near pipes, industrial facilities and wells pose a threat to the safety of residents and property. (5)

1.5. The creation of the new city Hassi Messaoud: (6)

The creation of the new city results from the direct application of the law n°04-20 of 25 December 2004 on the prevention of major risks and disaster management. The Project was issued by a presidential decree, DE no. 06-321 dated September 18, 2006. The public authorities have transformed this necessity into a development opportunity perfectly in line with the directives of

the National Land Use Planning Scheme 2025 (SNAT 2030) which requires any action which refers to it to take into account four guidelines which are:

- The sustainability of resources.
- The rebalancing of the territory.
- Social and territorial equity.
- The attractiveness and competitiveness of the territories.

1.6. The choice and the implementation arguments:

Through preliminary studies on the site of settlements and its surroundings (studies on the different geographical contexts, the exploitation of hydrocarbons, the socio-economic life of the population...) several factors contributed to the choice of location of the new city.

1.7. Classification of the current city of Hassi Messaoud as a technological risk zone: (5)

A new town outside the oil fields. Results from studies carried out on the city in various fields of activity, in relation to oil and gas exploitation in relation to environmental protection.

Hassi Messaoud is the most important oil field in the country has a worrying extension of its urban fabric, that's due to the search for habitat and jobs in the hydrocarbons sector.

The population is thus exposed to the omnipresent risk of major accidents:

- The wild dumps.
- The used oil.
- Air emissions.
- Water resources and waste liquids.
- Illicit construction.

These major accidents involve the gradual relocation of this city to the new city outside the hydrocarbon field.

1.8. Project objectives:

This new city will have as essential functions:

- The development of new and renewable energies and fossil fuels.
- To consolidate the balance of regional urban infrastructure.

- The creation of a new center for dynamic and sustainable urbanization and development and an urban living environment of excellence.

1.9. Vocation of the new city Hassi Messaoud:

The new city of Hassi Messaoud is designed and programmed in complementarity with the three neighbouring cities Ouargla, Touggourt and the current city of Hassi messaoud. The new city is a city that supports sustainable development in the region's economic fabric and ensures the creation of approximately 40,000 jobs. The diagram below represents the main vocations of this new city. The dominant functions of the city and its logistics area:

- Renewable energy.
- Research and development.
- Agricultural sciences.
- Medical and well-being.
- Culture, Sport, and Recreation.
- Support for the oil and gas.
- Logistics and Distribution.
- Industry (Food, ICT and building materials).

1.10. Strategic vision of the new city of Hassi Messaoud:

The new city of Hassi Messaoud aims to create a dynamic ensemble to support and promote the economic and social development in a sustainable way of the southern regions of the country, the creation of a living environment and activity of unique excellence in a dry environment and consolidate the balance of the regional and national urban framework through the assurance of:

- Economic Sustainability: «Hassi Messaoud, a new city focused on the development of the energy sector».
- Socio-cultural sustainability: «Hassi Messaoud, a new city offering an attractive living environment. »
- Environmental sustainability: «Hassi Messaoud, new ecological city of life and harmonious devolution of man and nature».

1.11. Concepts for the creation of the new city: (5)

The design of this city is based on new and creative concepts that can play an attractive role in a sustainable way. As such, the new city has four main objectives: economic efficiency, social progress, environmental comfort, and quality of life. Each axis developed in sub-objectives aims to establish the sustainable development approach and ensure territorial balance.

Economic efficiency	Social progress	Environmental comfort	Quality of life
•Provide efficient infrastructure networks for intercity and intraurban movement of people and goods. •Ensure the economic growth of the city and region. •Promote renewable solar and wind energy.	•Create the development conditions adapted to the needs of the inhabitants. Harmonize between tradition and modernity. •Promoting social diversity in housing. •Provide access to culture and recreation for all. •Provide full access to training and education	•Recycling and treatment of waste and wastewater. Reducing greenhouse gas emissions. •Ensure energy saving and energy efficiency, especially in buildings.	•Designing living spaces on a human scale. •Adapt the urban composition to the particularities of the Saharan climate. •Ensure the diversity of urban functions. •Promote public transit modes.

Table 6: Concepts and objectives of the new Hassi Messaoud.
Source: Author's creation

2. Analysis of the new town of Hassi Messaoud:

2.1. Accessibility to the new town of Hassi Messaoud: (7)

Road and transport conditions at the project site are relatively favorable and several projects have already started, including railway lines from Touggourt to Hassi Messaoud and from the new town of Hassi Messaoud to Ouargla.

The project site is located at the intersection of the N-S road linking Biskra, Touggourt, El Oued, Tamanrasset, Illizi. and the O-E road linking Ouargla, Ghardaïa. Construction of the motorway between Hassi Messaoud and Ouargla (20km) and the road linking Ouargla to El Goléa over a length of 274km planned in the SRAT will improve the road conditions of the new city.

The new city of Hassi Messaoud will be served by the airport of Touggourt, that of Ouargla and the present city of Hassi Messaoud.

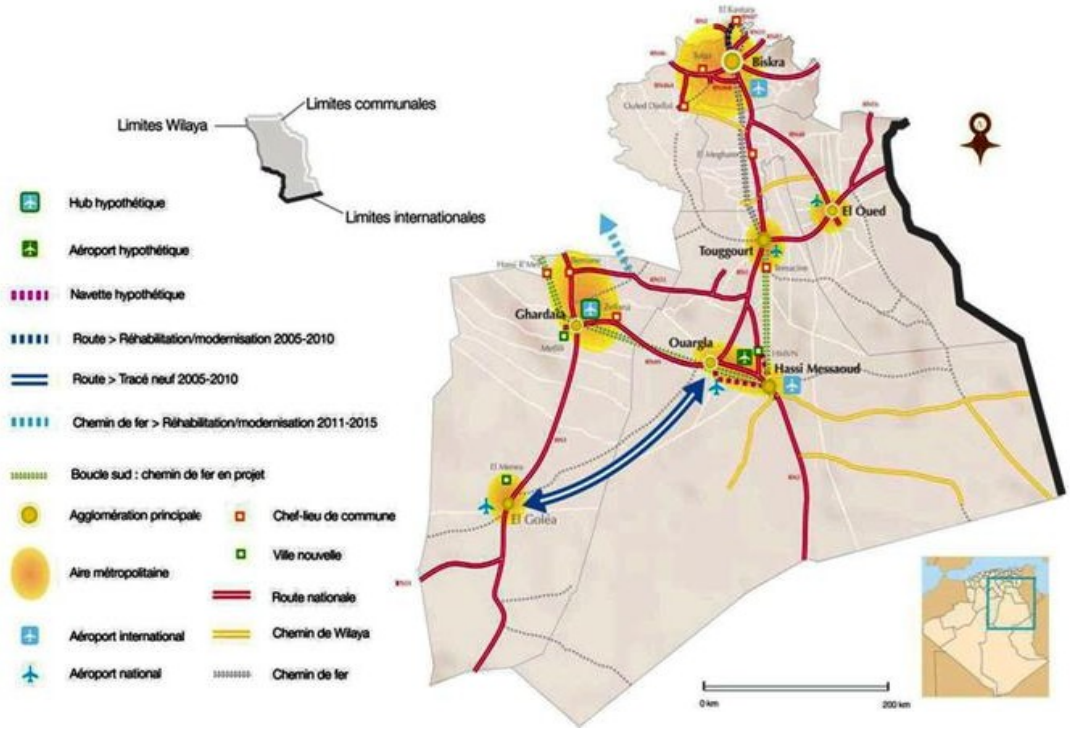

Figure 39: The various transport networks in the south-eastern region of Algeria.
Source : Ministère d'habitat, finalisations des études de la ville nouvelle Hassi Messaoud

➢ **The role of doors in accessibility to the new city:** (8)

Access to the city is through "doors". The symbolism of the "door" refers to city systems traditional.

A. Accessibility to the city (urbanization zone):

Three doors designed as an interface between the city and its territory:

- Two doors that connect the city to RN3.
- A door from the railway station.

B. Accessibility to the ZAL (Zone logistics):

- Two doors that connect the ZAL with RN3.
- A door from the train station.

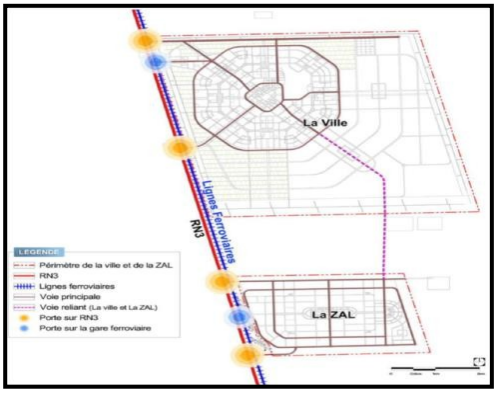

Figure 40: The doors of the new city.

Source : Règlement d'urbanisme tache 5.3.5 p : 05

2.2. The geographical context of the new city of Hassi Messaoud:

2.2.1. Climate: (9)

The project for the new town of Hassi Messaoud is located in an arid desert area of the Great Eastern Erg, in the region of Maraa (in the 445 block) without housing and equipment.

The project site for the new town is located in the Hassi Messaoud region, and the weather stations (observation sites) of Touggourt, Ouargla and Hassi Messaoud are located at approximately 83.72 km , 107.89 km and 109.22 km, respectively.

The data necessary for the study of the climate of the new city can be summarized as follows:

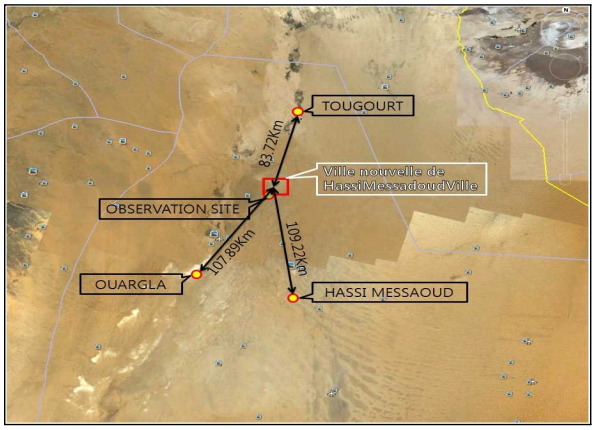

Figure 41: observation sites of Touggourt, Ouargla and Hassi Messaoud.
Source : Author's creation

2.2.1.1. Wind:

Based on the analysis of the result of wind directions observed at the three weather stations in the nearby cities mentioned above:

- The prevailing wind of Hassi Messaoud and Touggourt blows from the east and that of Ouargla from the north.
- The wind direction is mainly from the south for warm winds, north and northeast for moderate winds from January to June and from October to January.
- Relatively frequent winds with high speeds from February to May and from August to November cause sandstorms, which typically blow for 10 days per year maximum.

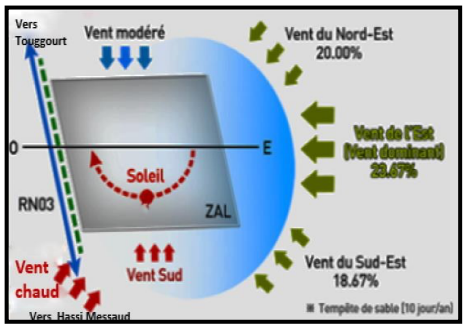

Figure 42: Direction of winds at the project site.

Source : Ministère d'habitat, finalisations des études de la ville nouvelle Hassi Messaoud

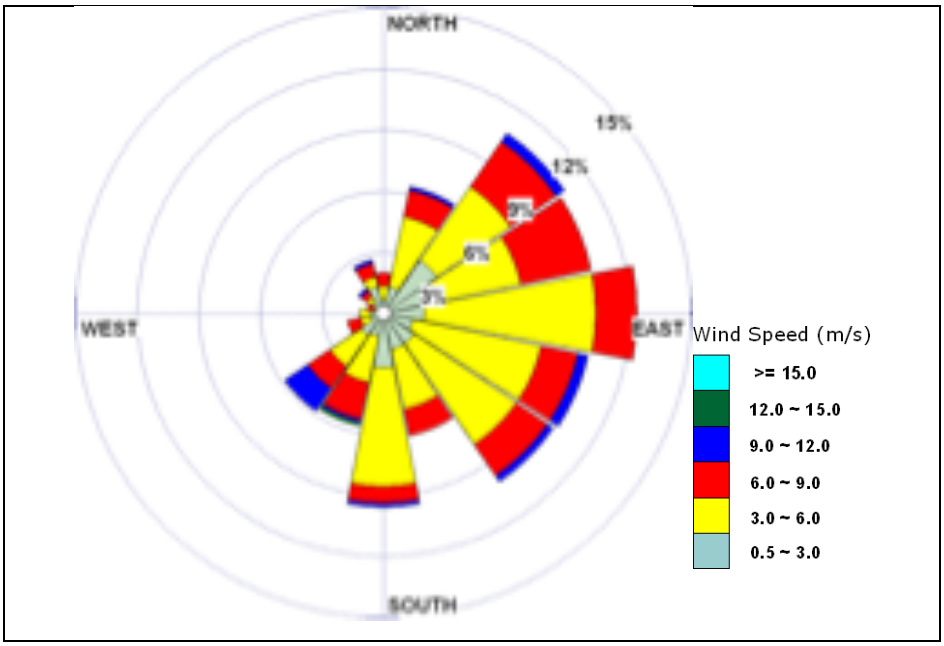

Figure 43: Wind rose on the project site.
Source : livre vie des villes série 5/2014 p : 49

2.2.1.2. Temperature:

Monthly mean temperature ranges from 11.6°C (January) to 35.1°C (July and august) at Hassi Messaoud. The thermal amplitudes between the minima and maxima are large with a significant difference up to 23°C.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly average temperatures in (C°)	11.6	13.8	18.3	22.5	27.9	32.6	35.1	35.1	30.7	24.6	17.2	12.6
Monthly minimum temperatures in (C°)	5	6.9	11.3	15.3	20.5	25.1	27.7	27.6	23.9	17.9	10.6	6.3
Maximum monthly temperatures in (C°)	18.1	20.7	25.2	29.7	35.2	40.1	43.1	42.5	37.5	31.2	23.7	19

Table 7: Descriptive temperature statistics in period: 1992 – 2011.
Source: Rapport des études hydrogéologiques, Tâche 1.2.2, GROUPEMENT DONGMYEONG

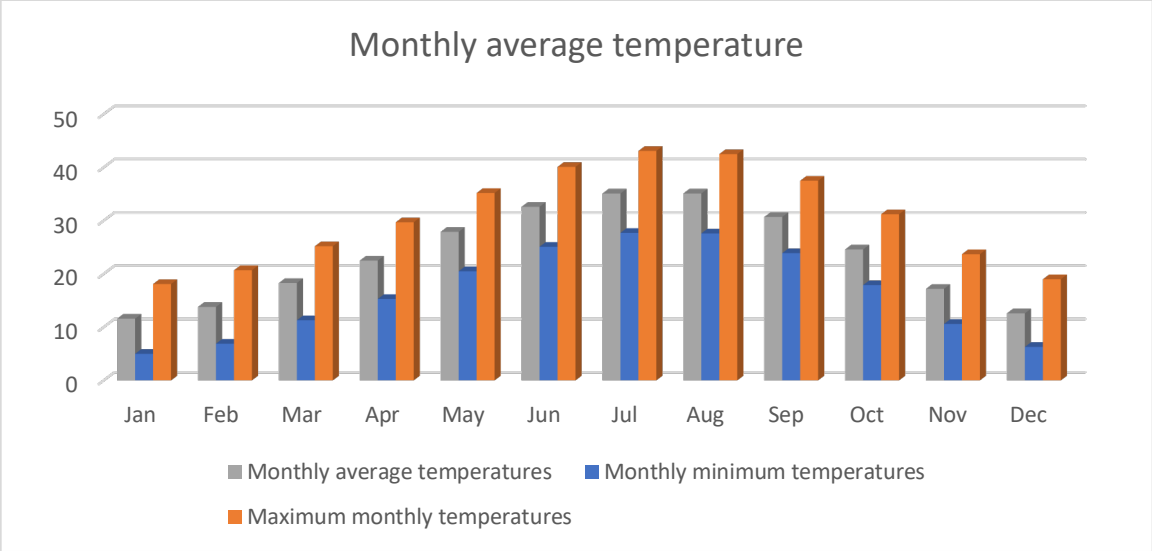

Figure 44: Monthly average temperature.
Source: Author's creation

2.2.1.3. Precipitation:

Monthly rainfall totals ranged from 0.2mm in July to 7.8mm in March. The annual rainfall totals do not exceed 40mm.

The region recorded the lowest rainfall in July, when the temperature was the highest.

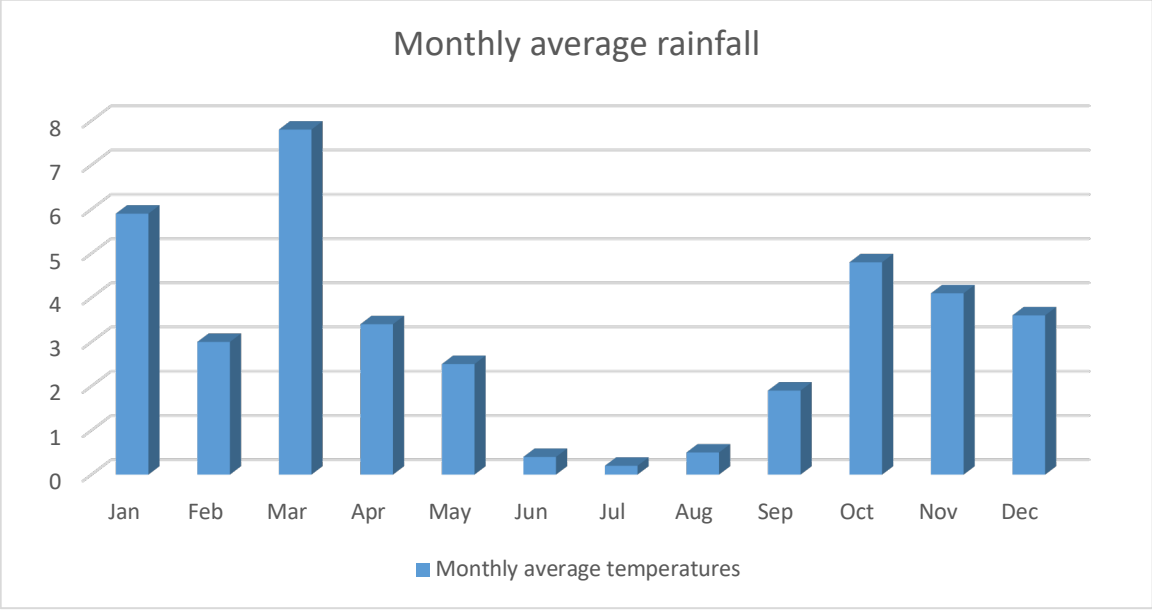

Figure 45: Average monthly rainfall.
Source: Rapport des études hydrogéologiques, Tâche 1.2.2, GROUPEMENT DONGMYEONG + Author's creation

2.2.1.4. Evaporation:

Average monthly evaporation ranges from 106.5mm in December to 486.9mm in July. Highest evaporation recorded in July.

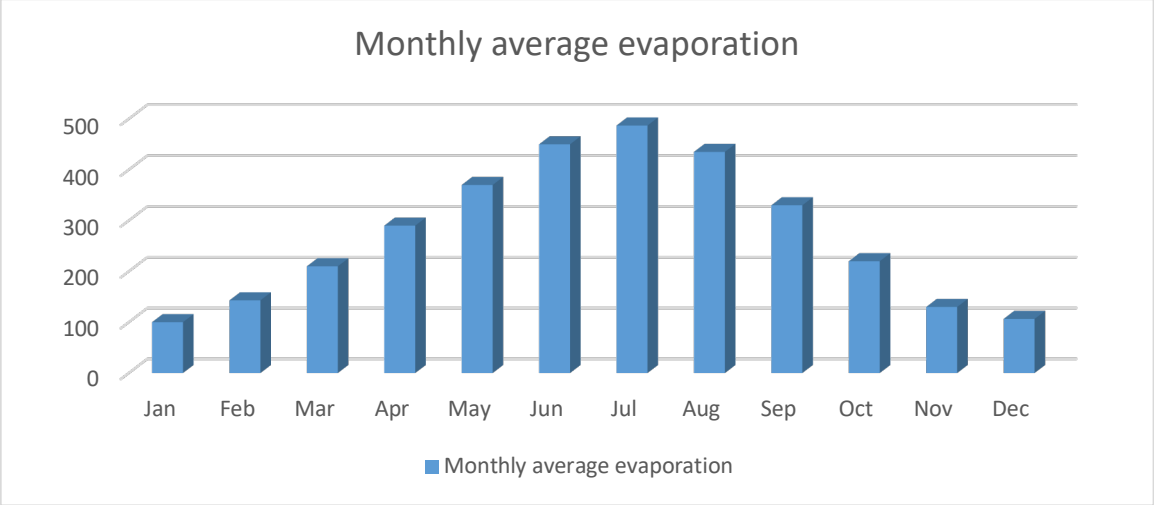

Figure 46: Monthly average evaporation.
Source: Rapport des études hydrogéologiques, Tâche 1.2.2, GROUPEMENT DONGMYEONG + Author's creation

2.2.1.5. Humidity:

Monthly mean humidity ranges from 23% (July) to 60% (December). Monthly mean maximum humidities are generally observed in January (59%) and December (60%) and July (23%) for minimum humidities.

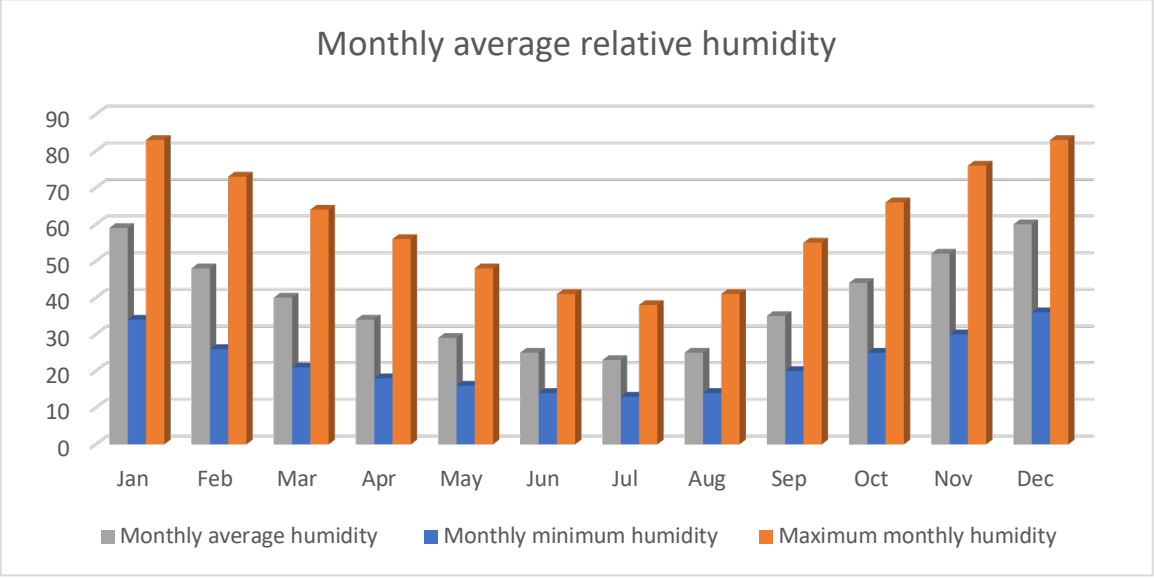

Figure 47: Monthly average relative humidity.
Source: Rapport des études hydrogéologiques, Tâche 1.2.2, GROUPEMENT DONGMYEONG + Author's creation

2.2.2. Topography:

The site configuration is generally flat and located at an altitude of approximately 120 m. There are no OUED tracks on the site. The dunes are formed from the northeast to the southwest of the site. In particular, the dunes in the northeast are higher than those in the southwest.

2.2.3. Seismic activity: (2)

Based on the available information (USGS, CGS, RPA 2003), the study area is subject to the lowest seismic hazard (Zone 0), very low or negligible seismic hazard.

Known geotechnical hazards such as landslides, collapses, cavities, falls and liquefactions are not identified at this site. During geotechnical investigations, no faults are observed on the different project areas.

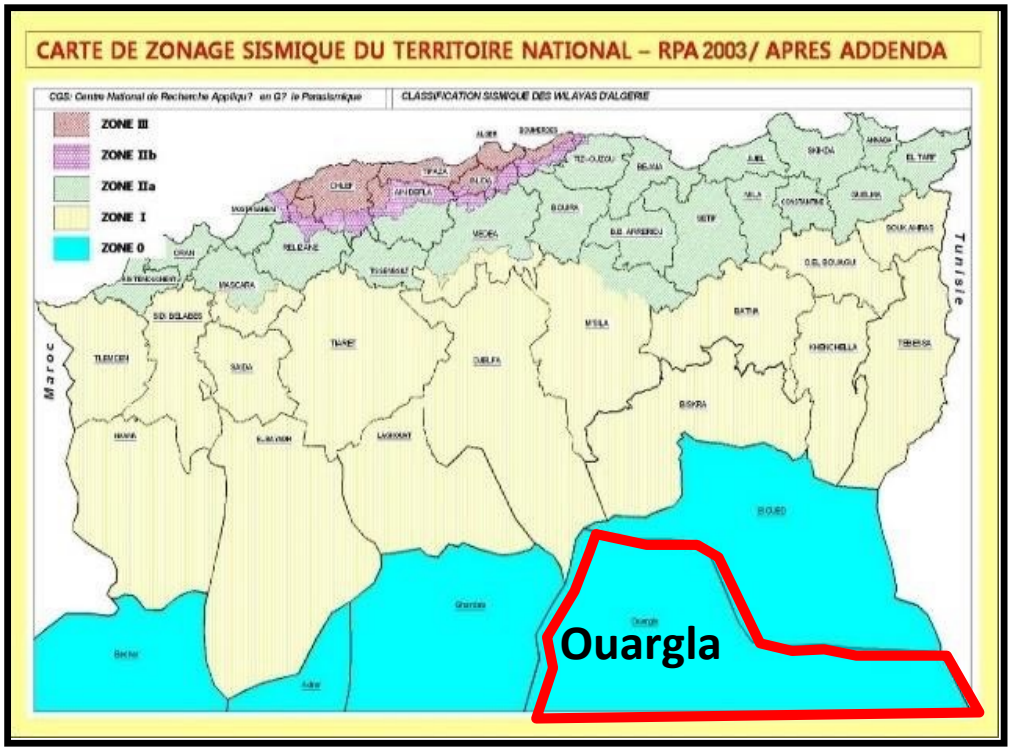

Figure 48: seismic zoning map of the territory national- RPA 2003.
Source : Ministère d'habitat, finalisations des études de la ville nouvelle Hassi Messaoud, p :15

2.2.4. Hydrography: (9)

The territory of the project site contains in its subsurface large quantities of water contained in underground reservoirs, which are part of the Northern Sahara Aquifer System (Système Aquifère du Sahara Septentrional SASS). These water reservoirs, commonly known by the CT-CI aquifers, are fossil because of their negligible refills in comparison with the samples taken.

- The Intercalary Continental (CI): Located at a depth from the ground between 1500 and 1800 m, characterized by the Albian aquifer, and having a high temperature reaching 60°C and a low salinity oscillating between 0.5 and 1.5 g/l.
- Terminal Complex (TC): Located between 100 and 400 m below the ground surface, consisting of two aquifers.

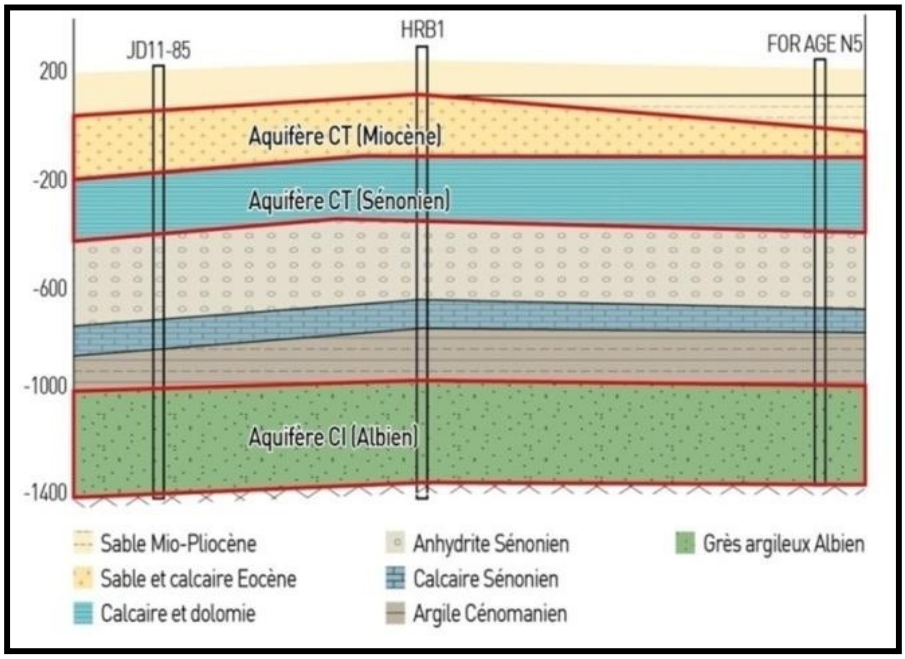

Figure 49: Synthetic correlative cut of the site of the new city of Hassi Messaoud.
Source : Ministère d'habitat, finalisations des études de la ville nouvelle Hassi Messaoud, p :19

2.3. Urban composition:

Urban development in the new city is based on the following principles:

- Traditional urban development: An approach derived from the traditional architecture of medinas closely related to the so-called modern fabric.

- Functional diversity: Encouraging the use of mixed-use land, especially for residential, commercial, business and leisure uses, with gentle pedestrian accessibility.
- Development around public transport: densification of buildings around poles and axes of public transport in order to create new dynamic centralities.
- Structuring of urban spaces: around neighborhood courtyards.
- Promoting special facilities around green spaces: at the level of different neighborhoods reminiscent of family atmospheres

2.3.1. The spatial organization of the new city of Hassi Messaoud: (10)

The new town of Hassi Messaoud is a compact city, structured in four residential districts, and a city center.

The city's concentric-radio model means that the four neighborhoods are organized around a primitive urban center which is the result of the intersection of the two structuring axes one on the North-West/South-East side and the other on the South side-west/north, which is one of the main economic, business, administrative and cultural functions, and it also incorporates a central park that encompasses recreational and recreational attractions.

Figure 50: Plan of the new city Hassi Messaoud.

This urban organization belongs to the conventional urbanism which is organized in three levels: The CBD in the center, the high density habitat in the second position and the last one is the low density habitat.

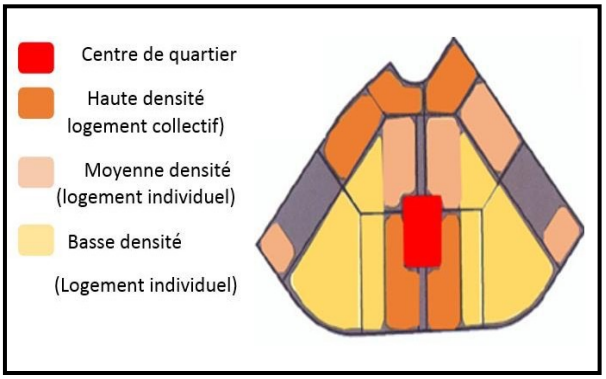

Figure 51: Neighborhood Organization Diagram.
Source : Ministère d'habitat, finalisations des études de la ville nouvelle Hassi Messaoud

2.3.2. Distribution of urban units: (11)

A. Basic principle:

An urban base unit (or neighborhood unit) is designed as a living unit with daily amenities without recourse to mechanical modes of travel. The grouping of more than two living units constitutes the neighborhood.

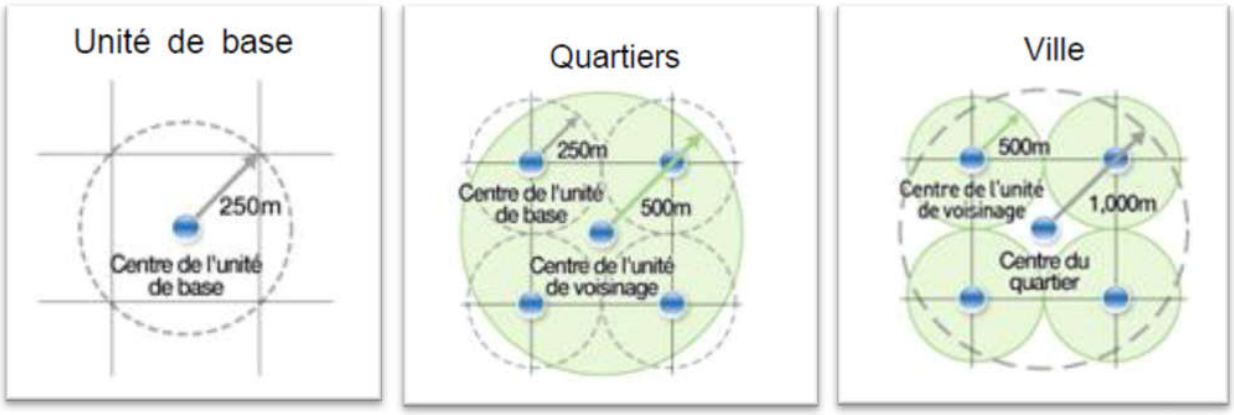

Figure 52: Basic principle.
Source : Ministère d'habitat, finalisations des études de la ville nouvelle Hassi Messaoud

B. Distribution of urban units:

Distribution of urban units considering their size, their spatial composition and the distribution of urban functions, as well as their development by stages. Organization of the city into four districts taking into account the actual shape of the city and the distances to the facilities.

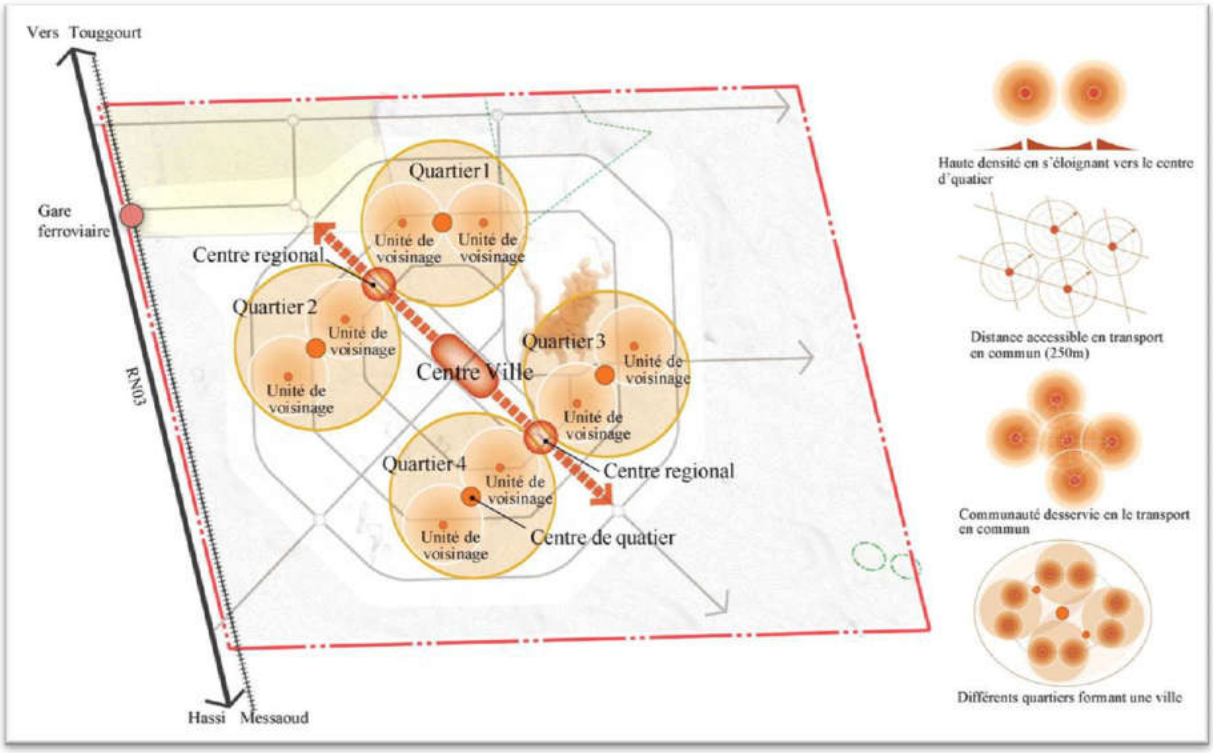

Figure 53: Distribution of urban units.
Source : Ministère d'habitat, finalisations des études de la ville nouvelle Hassi Messaoud

C. Composition and typology of urban tissues:

The principle adopted for the structural plan of the city is the concentric-radiography or the design of commercial and business zones integrates in priority the concerns of accessibility of the users and of service. Residential areas are designed to promote pedestrian, cycling and public transport modes.

The location of public facilities takes into account the hierarchy of urban units, their efficiency, the number of populations to be served and their accessibility to users.

Figure 54: Composition and typology of urban tissues.
Source : Groupement DONGMYEONG

2.3.3. Urban axes:

Creation of a green urban axis and a development axis that intersect perpendicular. The green axis connects the area of sand dunes, located in the central part of the southwest axis.

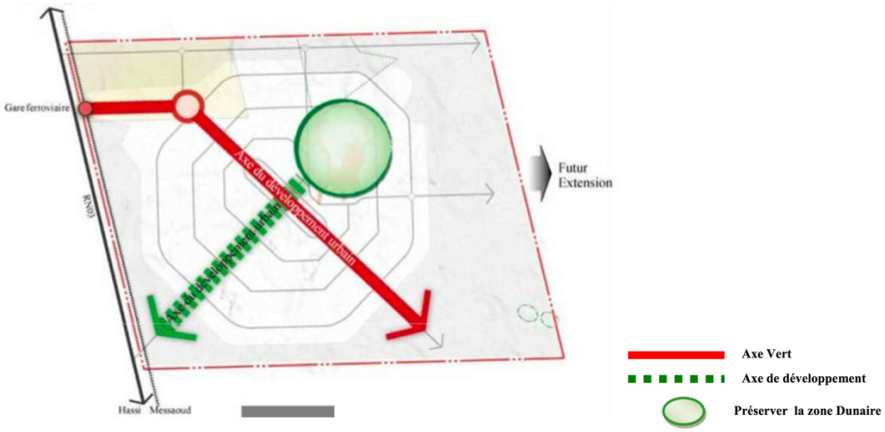

Figure 55: The different urban axes.
Source: Groupement DONGMYEONG.2012

2.3.4. Main road and urban transport:

The structural road axes which intersect perpendicular constitute the urban framework of the new city. They link the main urban functions together.

Organization of the curved, mesh road structure and creation of two points of articulation of the city with the region.

Figure 56: Road type.
Source: Groupement DONGMYEONG.2012

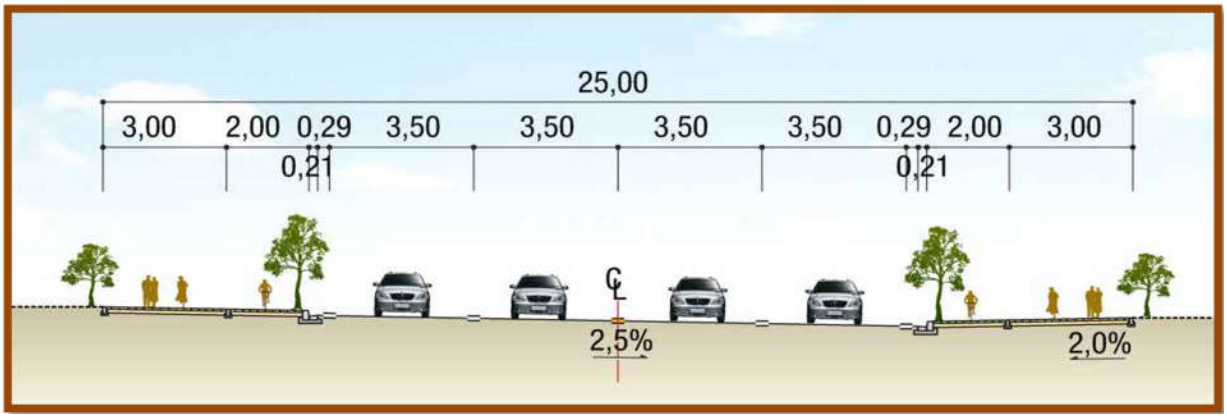

Figure 57: Road type.
Source: Groupement DONGMYEONG.2012

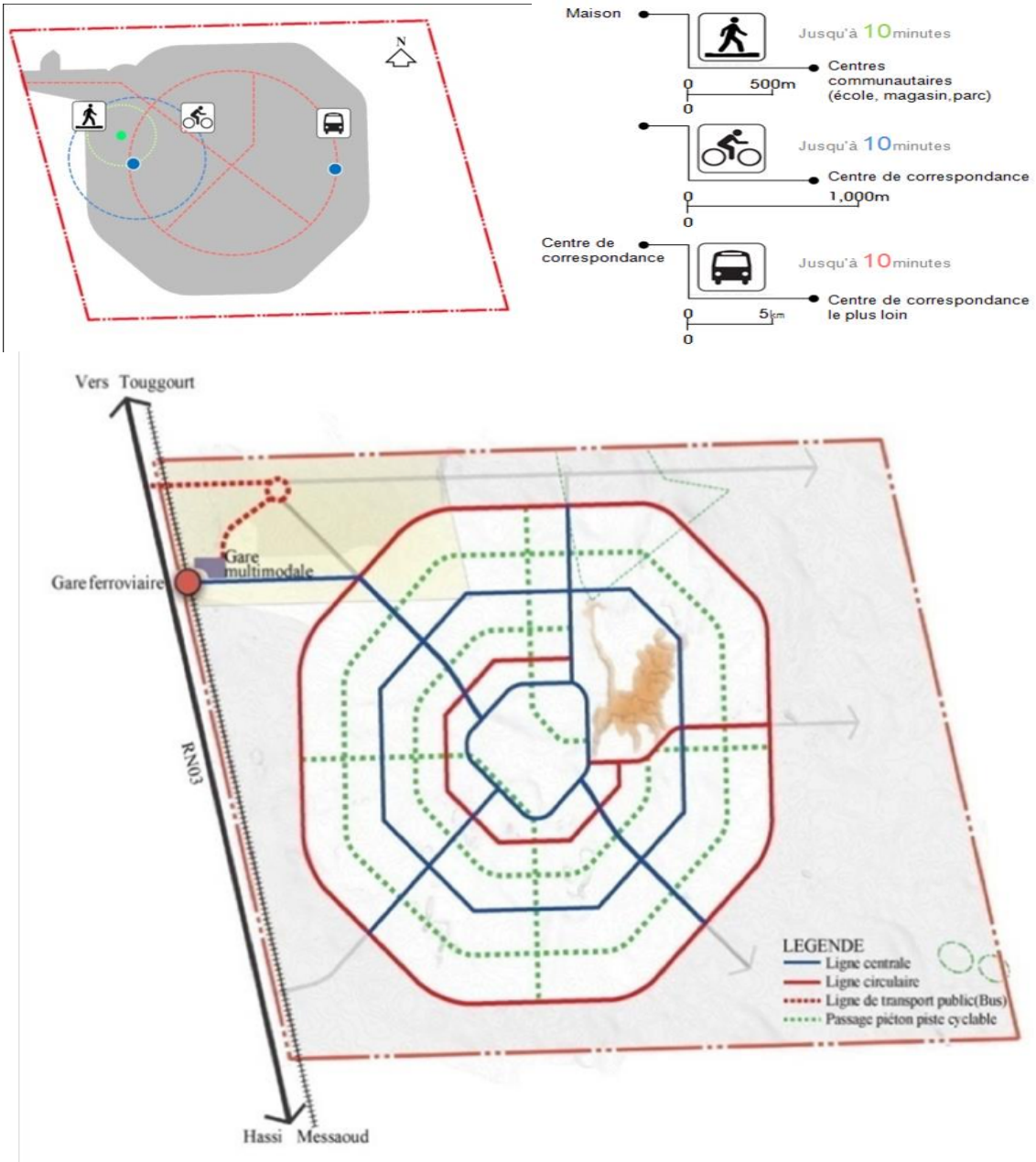

Figure 58: Organization of the transit system.
Source :Groupement DONGMYEONG.2012

2.3.5. Parks and green spaces: (12)

2.3.5.1. Centre park :

This park represents the main translation element of the basic concept of the city "oasis city". It is designed as a space for structuring the center of the new city. It articulates other green spaces including green axes and other parks.

2.3.5.2. Green axes :

Green axes of different dimensions and constitutions are designed in a hierarchical way (primary, secondary, tertiary and others) according to their roles of vegetable screens for the reduction of the speed of warm south-is and channeling fresh northern winds.

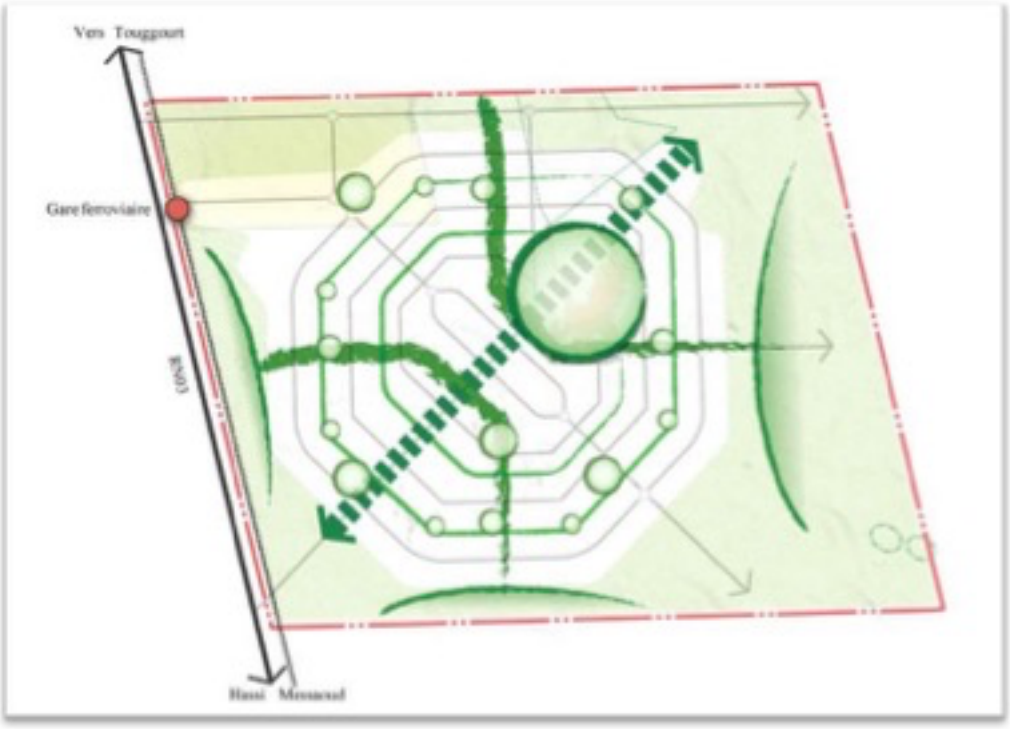

Figure 59: Location of parks and green spaces.
Source : Groupement DONGMYEONG.2012

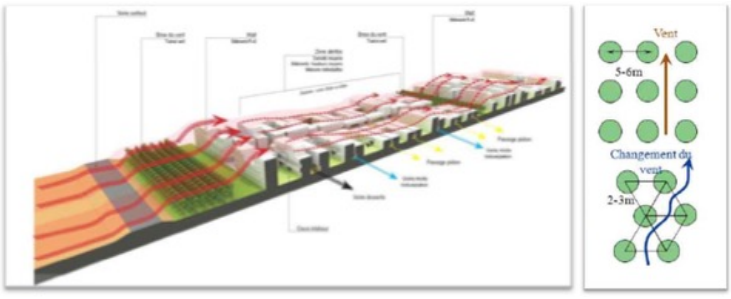

Figure 60: The green strip of the city + Wind speed reduction conceptual diagram.
Source : livre vie des ville

- Agricultural production perimeters are located on the outskirts of the city and integrated into the system for fixing sand dunes.

- Creation of plant hedges, windbreaks, at the points of articulation of the city with the region.
- Wind speed is reduced by high-rise community housing on the outskirts of the city.

2.3.5.3. Plan of water :

- Creation of large aquatic spaces (lake type) at the level of the central park located in the center of the city.
- Design and development of suitable aquatic spaces at the level of open spaces, considering their location, function, importance and the quality of the landscapes.
- Creation of water canals along the green axes and connected to other aquatic spaces for the construction of the blue network of climate regulation.

Figure 61: Types and forms of aquatic spaces.
Source : Groupement DONGMYEONG.2012

2.3.6. Shading compared with the urban axis : (13)

Based on the hourly results of the simulation studies conducted at Hassi Messaoud by the DONGMYEONG group and taking into account the elevation of the buildings and the angle of azimuth of the sun, it emerges that the orientation of the streets 45 degrees in relation to the direction north allows the creation of more than 3 hours of shaded areas per day at the level of these streets.

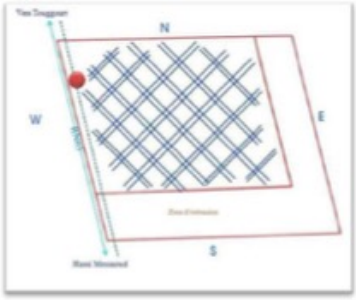

Figure 62: Design of the road network considering sun protection.
Source : Groupement DONGMYEONG

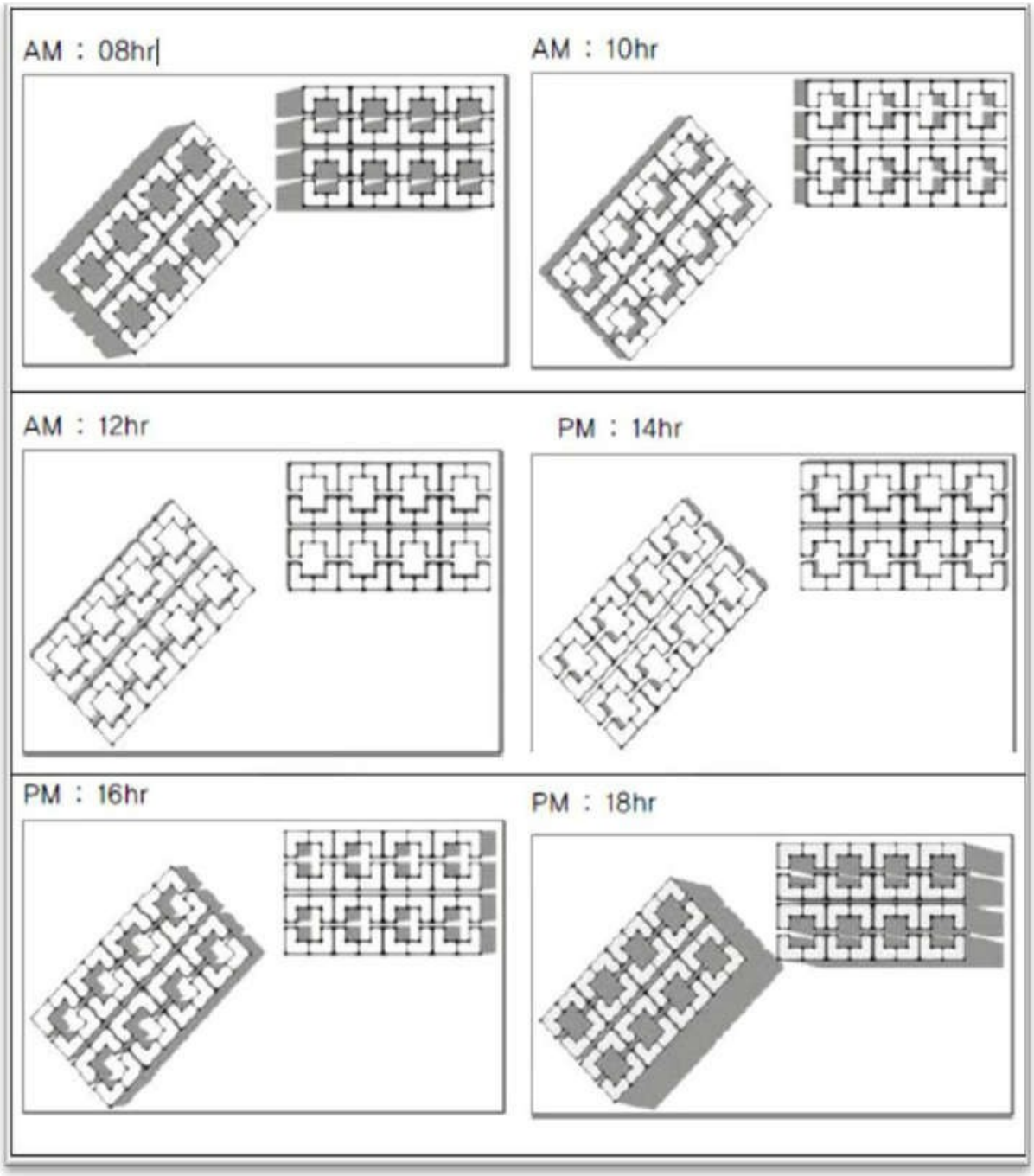

Figure 63: Island orientation due to protection against the sun.
Source : Groupement DONGMYEONG

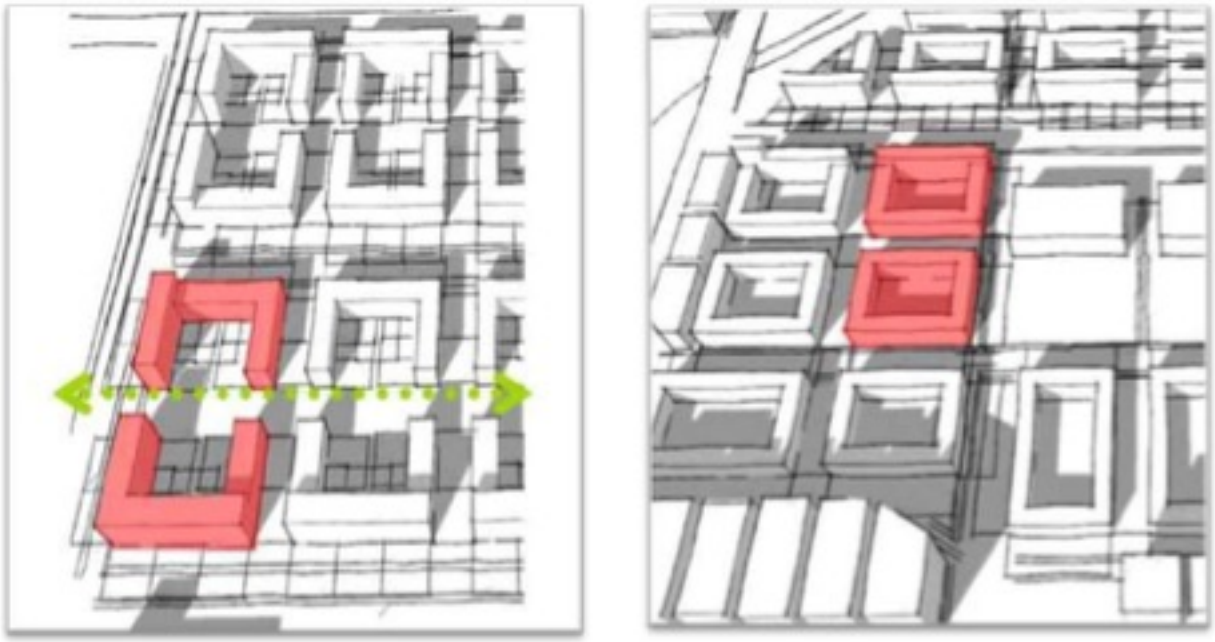

Figure 64: Example of collective housing organization

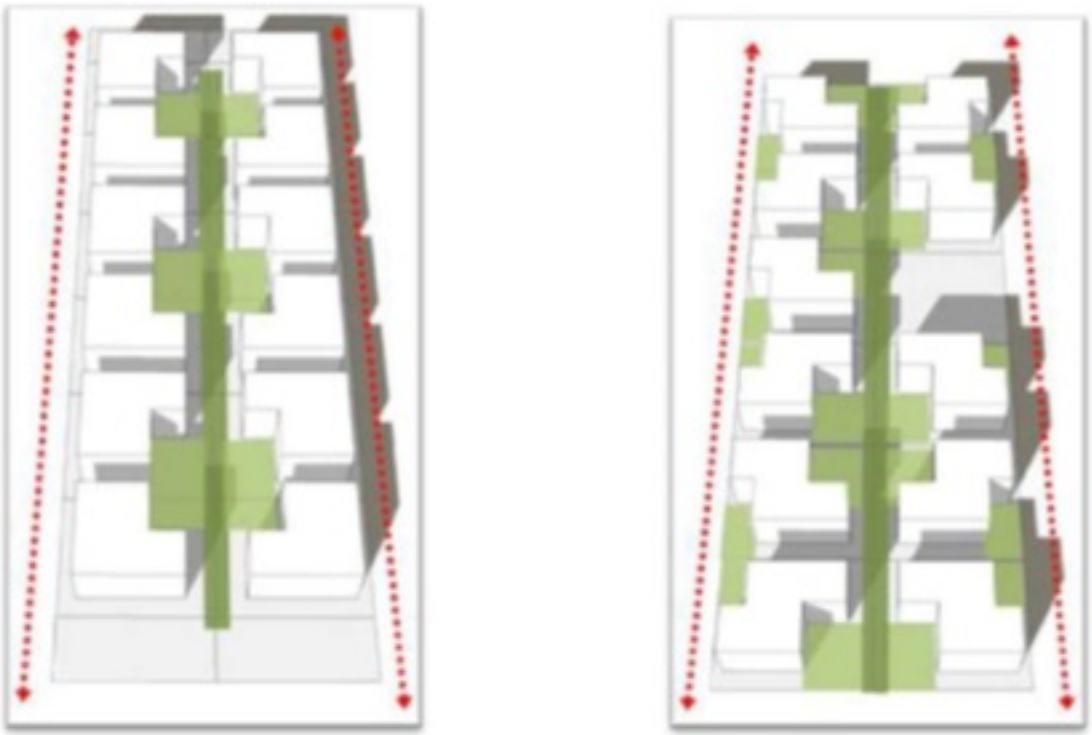

Figure 65: Example of individual habitat organization.
Source : Groupement DONGMYEONG

2.4. Management of wastewater: (14)

Particular attention is paid to the efficiency of the wastewater treatment and recycling system in order to reduce environmental nuisances.

A local sewage treatment plant (depending on the direction of the prevailing winds) in the low zone and at the perennial of the green strip of the city.

Wastewater treated at "STEP" will be reused for irrigation of perennial verete strips.

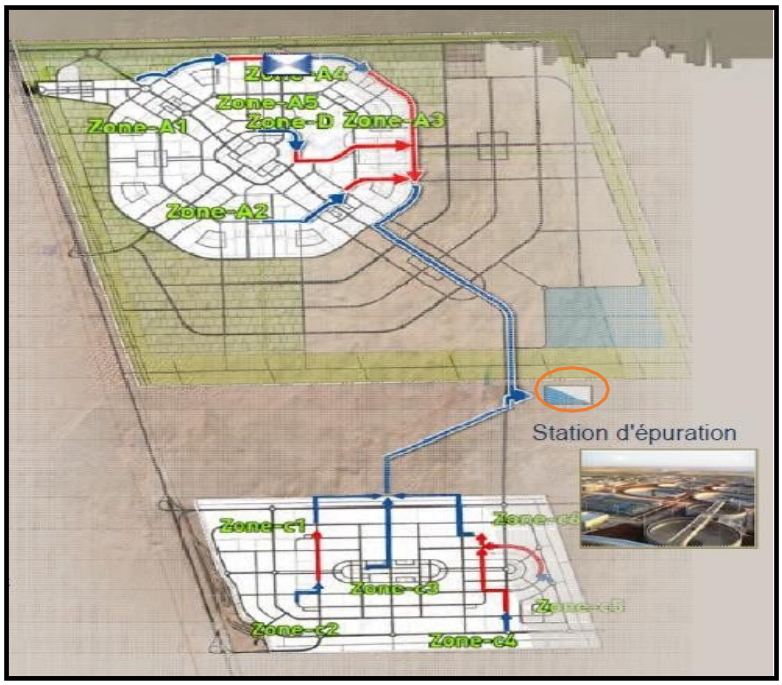

Figure 66: system of wastewater management.
Source: international fair for renewable, clean energies and sustainable development, NP: 25 /Oran28-10-2014

2.5. Renewable energy and energy efficiency: (14)

With the aim of responding to the program of renewable energies and energy efficiency set by the public authorities for 2030. The project for the new town of Hassi Messaoud aims to constitute an exemplary field of application of the most advances in the field of renewable energies and solar energy.

- Promoting high energy performance housing.
- The use of solar energy for air conditioning.
- The application of energy performance in public lighting
- The application of energy management measures for the agricultural sector.

3. SWOT analysis:

Strength	Weakness
• Strategic location between three major cities in the south: Ouargla, Hassi Messaoud, and Touggourt. • Presence and commitment of major internationally renowned oil and gas companies such as SONELGAZ. • The government has shown a strong commitment to the development of the new town, providing financial resources and policy support to foster its growth and sustainability. • High potential for solar energy.	• Harsh desert environment: sandstorms, intense sunlight, long periods of heat, large temperature variations throughout the day, and low precipitation. • Limited water resources: The desert environment presents a challenge in terms of water scarcity and the need for sustainable water management strategies to meet the growing demands of the population and industries. • Limited development of industries beyond oil and natural gas. • Skills and knowledge gap: Developing a culture of technological innovation requires a skilled workforce and expertise in emerging technologies. Ensuring access to relevant training and education programs will be essential to address any skills gaps and foster a culture of innovation.
Opportunity	**Threats**
• Renewable energy potential: The region's high solar irradiation presents an opportunity to harness solar power for renewable energy generation, reducing reliance on fossil fuels and promoting sustainable development. • Economic diversification: By fostering the growth of industries beyond oil and gas, such as renewable energy, manufacturing, and tourism, Hassi Messaoud can diversify its economy, create new job opportunities, and enhance long-term sustainability. • Technological leapfrogging: As a new town, Hassi Messaoud has the advantage of leapfrogging outdated technologies and embracing state-of-the-art solutions from the outset, positioning itself as a leader in technological innovation in the region. • Knowledge and innovation hub: The establishment of research and	• Climate change and environmental risks: The desert environment is susceptible to the impacts of climate change, including increased temperatures, water scarcity, and desertification, which may affect the city's long-term sustainability and livability. • Infrastructure challenges: The rapid development of the new town may put pressure on existing infrastructure systems, leading to potential bottlenecks in transportation, utilities, and public services, necessitating effective planning and infrastructure management. • The industrial nature of the oil and gas sector may deter population growth due to concerns about the quality of life.

development centers, educational institutions, and innovation clusters can position Hassi Messaoud as a hub for knowledge exchange, technological advancements, and fostering entrepreneurship. • The new town's infrastructure provides favorable connectivity and opportunities for the development of other road infrastructure projects.	

4. Implementing of Technological Innovations in the New Town of Hassi Messaoud:

After conducting a comprehensive analysis of the new town of Hassi Messaoud, it has become evident that the integration of technological innovations is crucial for its sustainable development and long-term success. This part presents a set of recommendations for implementing these innovations, derived from the thorough examination of the town's characteristics, challenges, and potential. By incorporating mobility, infrastructure, environment, public safety, government, and smart energy solutions, Hassi Messaoud can unlock its full potential as a modern and sustainable city. These recommendations are tailored to address the specific needs and conditions of the town, ensuring a seamless and effective integration of technological advancements.

4.1. Mobility:

The goals of implementing smart mobility innovations in the new town are to:

Enhance transportation efficiency and connectivity.

Reduce traffic congestion and improve traffic flow.

Promote sustainable and eco-friendly modes of transportation.

4.1.1. Intelligent Traffic Management System:

- Implementation of smart traffic signals and real-time traffic monitoring.
- Integration of smart parking systems and congestion management.
- Deployment of smart transportation apps for route optimization and real-time information.

4.1.2. Electric and Autonomous Vehicles:

- Establishment of electric vehicle charging infrastructure.

- Promotion of electric and autonomous vehicle adoption through incentives.
- Integration of autonomous shuttle services for public transportation within the city.

4.1.3. Smart Transportation Infrastructure:

- Installation of smart street lighting with energy-efficient and adaptive lighting features.
- Implementation of intelligent transportation systems for efficient traffic flow.
- Deployment of smart public transportation options, such as bus rapid transit or light rail systems.

4.2. Infrastructure

The goals of implementing smart infrastructure innovations in the new town are to:

Improve the efficiency and sustainability of essential services like water, waste management, and energy.

Enhance the functionality and reliability of infrastructure systems.

Optimize resource utilization and reduce environmental impact.

4.2.1. Smart Water Management:

- Implementation of smart water meters for accurate monitoring and efficient water usage.
- Integration of smart irrigation systems for green spaces using weather data and soil moisture sensors.
- Adoption of leak detection and water quality monitoring systems for early detection of issues.

4.2.2. Smart Waste Management:

- Implementation of smart waste bins with sensors for optimized waste collection routes.
- Adoption of waste sorting and recycling systems to reduce landfill waste.
- Deployment of smart waste tracking systems to monitor waste disposal and promote sustainable practices.

4.2.3. Smart Building Technology:

- Integration of energy-efficient building designs with smart HVAC and lighting systems.
- Implementation of smart grid infrastructure for energy management and demand response.
- Adoption of building automation systems for improved energy efficiency and occupant comfort.

4.3. Environment:

The goals of implementing smart environment innovations in the new town are to:

Preserve and enhance the natural environment.

Promote sustainable practices and reduce ecological footprint.

Ensure a clean and healthy living environment for residents.

4.3.1. Smart Green Spaces:

- Utilization of IoT sensors for monitoring soil moisture and plant health in green areas.
- Integration of automated irrigation systems based on real-time weather and plant needs.
- Implementation of smart landscaping practices to minimize water consumption and promote native plant species.

4.3.2. Air Quality Monitoring:

- Deployment of air quality sensors across the city to monitor pollutant levels.
- Integration of real-time air quality data into urban planning and health management systems.
- Implementation of measures to reduce air pollution, such as promoting electric vehicles and enforcing emission standards.

4.3.3. Renewable Energy Integration:

- Installation of solar power systems for street lighting and public buildings.
- Integration of rooftop solar panels in residential and commercial areas.
- Exploration of other renewable energy sources like wind or geothermal energy for sustainable power generation.

4.4. Public Safety:

The goals of implementing smart public safety innovations in the new town are to:

Enhance public safety and security.

Improve emergency response times and effectiveness.

Empower citizens with tools and technologies for personal safety.

4.4.1. Smart Surveillance and Monitoring:

- Implementation of intelligent video surveillance systems for enhanced security.
- Integration of facial recognition and license plate recognition technologies for law enforcement.

- Adoption of smart sensors for early detection of fire, floods, or other safety hazards.

4.4.2. Emergency Response Systems:

- Establishment of a centralized emergency response system with real-time incident reporting.
- Integration of mobile applications for citizen reporting and emergency notifications.
- Deployment of smart emergency vehicles equipped with advanced communication and navigation systems.

4.4.3. Community Safety Applications:

- Development of mobile applications for personal safety, crime reporting, and neighborhood watch.
- Integration of smart street lighting with motion sensors and emergency call buttons.
- Implementation of public safety analytics tools to identify crime patterns and optimize resource allocation.

4.5. Government:

The goals of implementing smart government innovations in the new town are to:

Enhance citizen engagement and participation in governance.

Improve access to government services and information.

Foster transparency, efficiency, and accountability in public administration.

4.5.1. Digital Infrastructure and Services:

- Implementation of an e-government platform for online services and transactions.
- Adoption of digital identity and authentication systems for secure access to government services.
- Integration of digital platforms for citizen engagement and participation in decision-making processes.

4.5.2. Open Data and Data Analytics:

- Establishment of an open data portal for transparent access to government data.
- Utilization of data analytics tools for evidence-based policymaking and urban planning.
- Integration of data-driven smart city dashboards for monitoring and reporting city performance.

4.5.3. Smart Citizen Services:

- Implementation of smart city apps for residents to access services, report issues, and provide feedback.
- Integration of digital platforms for citizen collaboration and co-creation of urban initiatives.
- Adoption of smart payment systems for efficient and secure transactions with government agencies.

4.6. Energy:

The goals of implementing smart energy innovations in the new town are to:

Promote energy efficiency and conservation.

Increase the use of renewable energy sources.

Optimize energy management and reduce carbon emissions.

4.6.1. Energy Efficiency Measures:

- Implementation of smart meters and real-time energy monitoring systems for households and businesses.
- Promotion of energy-saving practices and incentives for energy-efficient appliances.
- Integration of smart grid technologies for optimized energy distribution and demand management.

4.6.2. Demand Response and Energy Storage:

- Deployment of demand response programs to manage peak energy demand and reduce strain on the grid.
- Adoption of energy storage systems, such as batteries or pumped hydro storage, for renewable energy integration.
- Integration of smart appliances and home energy management systems to enable demand flexibility.

4.6.3. Energy Harvesting and Microgrids:

- Exploration of energy harvesting technologies, such as solar or kinetic energy, to power small-scale devices.
- Establishment of microgrids to enhance energy resilience and promote local energy generation.
- Integration of peer-to-peer energy trading platforms to facilitate energy sharing and local energy markets.

5. Conclusion:

Based on the analytical study conducted on the new town of Hassi Messaoud, it is evident that the integration of technological innovations has the potential to significantly enhance the city's sustainability and quality of life. The planners of the town have already demonstrated their commitment to integrating climate considerations and drawing inspiration from traditional practices to create a comfortable and environmentally friendly urban environment.

By adopting smart mobility solutions, such as intelligent traffic management systems and electric and autonomous vehicles, the city can improve transportation efficiency, reduce congestion, and promote cleaner modes of transport. Implementing smart infrastructure, including water and waste management systems, as well as energy-efficient building technologies, will optimize resource usage and contribute to a more sustainable and resilient city.

Furthermore, embracing smart environmental practices, such as monitoring air quality, integrating renewable energy sources, and promoting green spaces, will ensure a healthier and more environmentally conscious city. Enhancing public safety through smart surveillance systems, emergency response mechanisms, and community safety applications will contribute to a secure and protected urban environment.

Additionally, incorporating smart government initiatives, including digital infrastructure, open data, and citizen services, will improve governance processes, enhance public participation, and provide efficient and transparent services to residents. Finally, integrating smart energy solutions, such as energy efficiency measures, demand response programs, and renewable energy integration, will support the city's transition to a sustainable and low-carbon energy system.

In conclusion, the integration of technological innovations in the new town of Hassi Messaoud offers a transformative opportunity to create a sustainable, efficient, and technologically advanced urban environment. By implementing the recommended innovations across various categories, the city can improve its livability, resource management, and overall quality of life for its residents while also promoting environmental sustainability.

CONCLUSION

Conclusion:

In conclusion, this thesis has embarked on a comprehensive exploration of the concept of sustainable cities and the pivotal role of technological innovation in their development. By examining the new town of Hassi Messaoud as a case study, it has become evident that the integration of technological innovations holds remarkable potential for enhancing the sustainability, efficiency, and livability of urban environments.

Throughout this study, the fundamental principles and goals of sustainable cities have been elucidated, emphasizing the need to holistically address environmental, social, and economic aspects. The advantages of sustainable cities have been underscored, ranging from improved resource management, and reduced ecological footprint to enhanced quality of life and economic prosperity. These benefits not only contribute to the well-being of residents but also help create a resilient and harmonious relationship between human beings and the environment.

Technological innovation has emerged as a powerful tool in the realm of urban planning and development, as showcased through various examples across different facets of urban life. From energy and circularity to water management, mobility, and safety, innovative technologies have demonstrated their capacity to revolutionize urban environments. The positive impacts of technological innovation on sustainability have been explored in detail, emphasizing how they can lead to resource efficiency, reduced emissions, enhanced urban connectivity, and improved quality of services and infrastructure.

However, it is crucial to acknowledge the challenges and considerations that accompany the adoption of technological innovations. Affordability, equity, data privacy, cybersecurity, and social acceptance are among the key factors that require careful attention and appropriate measures to ensure that technological advancements are inclusive, transparent, and ethically sound.

By drawing inspiration from successful sustainable cities such as Masdar City in the United Arab Emirates and Singapore, valuable insights have been gleaned regarding effective strategies and innovative technologies that can be harnessed in the development of Hassi Messaoud. These cities have demonstrated exemplary practices in areas such as renewable energy integration, smart infrastructure, citizen engagement, and sustainable urban planning, offering valuable lessons for other urban centers striving to embrace sustainability and technological innovation.

Through the analysis of the new town of Hassi Messaoud, its unique characteristics, challenges, and potential have been thoroughly examined. A SWOT analysis has shed light on the town's strengths, weaknesses, opportunities, and threats in terms of sustainable development and the integration of technological innovation. Recommendations have been formulated to capitalize on its strengths, address weaknesses, and leverage opportunities for further sustainable development and technological integration. These recommendations encompass various aspects, including urban planning, renewable energy adoption, smart infrastructure deployment, citizen engagement, and policy implementation.

In conclusion, this thesis underscores the immense potential of technological innovation in fostering sustainable urban development. By embracing technological advancements and integrating them into urban planning processes, cities like Hassi Messaoud can pave the way for a future that is not only environmentally friendly but also socially inclusive and economically prosperous. The implementation of recommended innovations can contribute to the creation of a sustainable, efficient, and technologically advanced urban environment, ultimately enhancing the well-being and quality of life for its residents.

By merging the principles of sustainability and technological innovation, cities can become powerful catalysts for positive change, setting the stage for a more sustainable and prosperous future for generations to come. As the world continues to face pressing challenges such as climate change, rapid urbanization, and resource scarcity, the importance of sustainable cities and the role of technological innovation in their development cannot be overstated. It is through dedicated efforts, collaborative partnerships, and the relentless pursuit of innovative solutions that cities can strive towards a more sustainable and resilient future, where urban environments harmoniously coexist with nature, and the well-being of residents is at the forefront of every decision.

References

1. the story behind the goals. *17 Goals.* [Online] http://17goals.org/the-story-behind-the-goals/.
2. Sustainable Development Goals - Goal 11: Sustainable cities and communities. *UNDP.* [Online] https://www.undp.org/content/undp/en/home/sustainable- development-goals/goal-11-sustainable-cities-and- communities.htm.
3. programme, UN-HABITAT Flagship. *Sustainable Development Goals cities.* p. 1.
4. European Commission, Science for Environment Policy. *Indicators for Sustainable Cities.* 2015 (revised March 2018). pp. 5,7,17.
5. ARCADIS. *Citizen Centric Cities - Sustainable Cities Index.* 2018. pp. 8,11.
6. UN-HABITAT. *planning sustainable cities: policy directions.* s.l. : UN-HABITAT, 2009. pp. 27,82,55,67.
7. Department of Economic and Social Affairs, World Economic and Social Survey 2013. *Sustainable Development Challenges.* New York : United Nations, 2013. p. 62.
8. Association, American Planning. *Policy Guide on Planning for Sustainability.* New York : s.n., 2000. pp. 8, 13.
9. Nations, . *Arab Report for Sustainable Development.* 2020. pp. 150-194.
10. Nation, . *Global mobility report 2017.* 2017. p. 24.
11. G.Oleg, . *Sustainable Housing for Sustainable Cities: A Policy Framework for Developing Countries.* s.l. : UN-Habitat, 2012. p. 9.
12. UNDP. Sustainable Development Goals, Goal 8: Decent work and economic growth. *United Nations.* [Online] https://www.un.org/sustainabledevelopment/economic- growth/, Visited on 10/1/2020..
13. —. *The Future We Want Biodiversity and Ecosystems - Driving Sustainable Development Biodiversity and Ecosystems Global Framework 2012-2020.* p. 16.
14. —. Sustainable Development Goals, Goal 9: Industry, innovation, infrastructure. [Online] https://www.sdgfund.org/goal-9-industry-innovation- infrastructure, Visited on 12/1/2020..
15. —. Sustainable Development Goals, Goal 6: Clean water and sanitation. [Online] https://www.sdgfund.org/goal-6-clean-water-and-sanitation, Visited on 12/1/2020..
16. —. Sustainable Development Goals, Goal 7: Affordable and clean energy. [Online] https://www.undp.org/content/undp/en/home/sustainable- development-goals/goal-7-affordable-and-clean-energy.html, Visited on 12/1/2020..
17. EPA, . Recycling Basics. [Online] https://www.epa.gov/recycle/recycling-basics.
18. IUCN. *Common Ground.* 2020. pp. 22,50,53.
19. United States, . Basic Information about Water Reuse. [Online] https://www.epa.gov/waterreuse/basic- information-about-water-reuse#main-content.
20. Smits, . *Innovation studies in the 21st century: Questions from a user's perspective.* Department of Innovation Studies, University of Utrecht, Netherlands. s.l. : Technological Forecasting & Social Change, 2001. p. 865.
21. D, . *The Multidimentional Diffusion of Technology.* s.l. : Technological Forecasting and Social change, 1977. pp. 277-298.
22. L.A, . *Dynamics of Technological Change.* New York : Van Nostrand Reinhold, 1991.
23. Berry M.M.J., Taggart J.H. *Managing Technology and Innovation: A Review.* s.l. : R&D Management, 1994. pp. 341-353.

24. E.B, . *What we've Learned, Managing Invention and Innovation.* s.l. : Research & Technology Management, 1988.
25. AeoLogic. Types of Technological Innovation in the Face of Uncertainty. *AeoLogic.* [Online] 18 January 2023. https://www.aeologic.com/blog/types-of-technological-innovation-in-the-face-of-uncertainty/.
26. OECD. *The OECD Innovation Strategy: Getting a Head Start on Tomorrow.* 2010.
27. Arlington. *Science and Engineering Indicators 2018.* s.l. : National Science Foundation, 2018.
28. JRC. *European Innovation Partnership on Smart Cities and Communities: Strategic Implementation Plan.* s.l. : Brussels: European Commission, 2015.
29. Coudert, . What are the 4 types of innovation ? *Agorize.* [Online] 24 July 2022. https://get.agorize.com/en/resources/what-are-the-4-types-of-innovation/.
30. X, . What is a photovoltaic system and how does it work? *ENEL X.* [Online] https://corporate.enelx.com/en/question-and-answers/how-does-a-photovoltaic-system-work#:~:text=A%20photovoltaic%20system%20is%20a,residential%20and%20industrial%20electricity%20systems..
31. Mohammed Kadhem Abid, M. Vinay Kumar, V. Arun Raj, M. Davidson Kamala Dhas. *Environmental Impacts of the Solar Photovoltaic Systems in the Context of Globalization.* s.l. : Ecological Engineering & Environmental Technology (EEET), 2023.
32. Morrison, . What is wind energy? Definition, types and more. *Power & Beyond.* [Online] 04 04 2022. https://www.power-and-beyond.com/what-is-wind-energy-definition-types-and-more-a-e95f3c16c898e889f0757f62ee91038d/.
33. Agency, International Renewable Energy. *Global Landscape of Renewable Energy Finance 2020.* Abu Dhabi : International Renewable Energy Agency, 2020.
34. Green hydrogen: an alternative that reduces emissions and cares for our planet. *Iberdrola.* [Online] https://www.iberdrola.com/sustainability/green-hydrogen.
35. Trust, Energy Saving. What you need to know about biomass. *Energy Saving Trust.* [Online] https://energysavingtrust.org.uk/advice/biomass/#:~:text=Biomass%20heating%20systems%20burn%20wood,provide%20water%20heating%20as%20well..
36. Network, Sustainable Water and Energy Solutions. *Water, Biomass and Energy Nexus: Electricity Generation from Sugarcane Biomass in Guatemala.* s.l. : Sustainable Water and Energy Solutions Network., 2021.
37. Agency, European Space. AMBROSIA Food traceability . *ESA Business Applications.* [Online] 2018. https://business.esa.int/projects/ambrosia.
38. Harvey J, Smith A, Goulding J and Branco Illodo. *Food sharing, redistribution, and waste reduction via mobile applications: A social network analysis.* Department for Environment, Food, and Rural Affairs. United Kingdom : Industrial Marketing Management, 2020. pp. 437–448.
39. Ultimate Guide to Smart Bins. *Evreka.* [Online] https://evreka.co/blog/ultimate-guide-to-smart-bins/#:~:text=Smart%20bin%20is%20the%20new,of%20your%20smart%20waste%20bins..
40. Viola C, Modak N, Ferguson T. *The future of water: How innovations will advance water sustainability and resilience worldwide.* 2020.
41. Commission, . Improving desalination with nanotechnology . *CORDIS .* [Online] https://cordis.europa.eu/article/id/157580-improving-desalination-with-nanotechnology.

42. —. Digital Opportunity Traineeships initiative exceeds original targets. *digital strategy.* [Online] https://digital-strategy.ec.europa.eu/en/news/digital-opportunity-traineeships-initiative-exceeds-original-targets.
43. Group, C40 CITIES: Climate Leadership. *GOOD PRACTICE GUIDE: Low Emission Vehicles.* s.l. : C40 CITIES, 2016.
44. Base, . ELECTRIC BUSES IN COLOMBIA: PAVING THE WAY FOR E-MOBILITY IN LATIN AMERICA. *Energy Base.* [Online] 30 Jul 2021. https://energy-base.org/news/paving-the-way-for-e-mobility-in-latin-america/.
45. City, . New journey planning app launched. *Aberdeen City.* [Online] 19 Oct 2020. https://www.aberdeencity.gov.uk/News/Press-Archive/Article?title=New%20journey%20planning%20app%20launched.
46. Haiston, . What is a Smart Traffic Management System? *symmetry electronics.* [Online] 20 Feb 2023. https://www.symmetryelectronics.com/blog/what-is-a-smart-traffic-management-system/.
47. Sura Mahmood Abdullah, Muthusamy Periyasamy, Nafees Ahmed Kamaludeen. *Optimizing Traffic Flow in Smart Cities: Soft GRU-Based Recurrent Neural Networks for Enhanced Congestion Prediction Using Deep Learning.* 2023.
48. *Contributions from the Government of the Philippines.*
49. London, Transport for. Contactless and mobile pay as you go. *Transport for London.* [Online] https://tfl.gov.uk/fares/how-to-pay-and-where-to-buy-tickets-and-oyster/pay-as-you-go/contactless-and-mobile-pay-as-you-go.
50. Puhe M, Edelmann M, and Reichenbach M. *Integrated urban e-ticketing for public transport and touristic sites. Science and Technology Options Assessment.* s.l. : European Parliamentary Research Service, 2014.
51. JC, Arias-Molinares D and García-Palomares. *Shared mobility development as key for prompting mobility as a service (MaaS) in urban areas: The case of Madrid. Case Studies on Transport Policy.* 2020. pp. 846–859.
52. Centre for Studies on Risks, the Environment, Mobility and Urban Planning. *MaaS in Europe: Lessons from the Helsinki, Vienna and Hanover experiments.* 2019.
53. United Nations, Department of Economic and Social Affairs. CloQ - Simplifying Financial Inclusion. *United Nations.* [Online] 2021. https://sdgs.un.org/partnerships/cloq-simplifying-financial-inclusion.
54. Y, . *Unlocking the green opportunity for prefabricated buildings and construction in China. Resources, Conservation and Recycling.* 2018.
55. Altman M, Pompei A. 3D Printing For Good: How One Nonprofit Is “Printing” Homes For Families In Need. *United Nations Foundation.* [Online] 2 AUGUST 2018. https://unfoundation.org/blog/post/3d-printing-for-good-how-one-nonprofit-is-printing-homes-for-families-in-need/.
56. Team, Matterport Editorial. Benefits, Challenges & Best Practices for Using Digital Twins in Construction. *Matterport .* [Online] 22 12 2022. https://matterport.com/digital-twin-in-construction.
57. Jeroen Mentens, Dirk Raes, Martin Hermy. *Green Roofs as a Tool for Solving the Rainwater Runoff Problem in the Urbanized 21st Century ?* s.l. : Landscape and Urban Planning, 2006.

58. Kaveh Vessali, Hazem Galal, Dr. Scott Nowson. *How digital twins can make smart cities better.* s.l. : PwC, 2022.
59. Dembski F, Wössner U, Letzgus M, Ruddat M, Yamu C. *Urban Digital Twins for Smart Cities and Citizens: The Case Study of Herrenberg.* Germany : s.n., 2020.
60. Frearson, . Digital twins offer "a very powerful way of developing our cities" say experts. *Dezeen.* [Online] 9 july 2021. https://www.dezeen.com/2021/07/09/digital-twins-develop-cities-digital-design-architecture/.
61. Afzalan N, Muller B. *Online Participatory Technologies: Opportunities and Challenges for Enriching Participatory Planning.* s.l. : Journal of the American Planning Association, 2018. pp. 162–177.
62. Mobasheri A, Deister J, Dieterich H. *Wheelmap: The Wheelchair Accessibility Crowdsourcing Platform. Springer International Publishing.* 2017.
63. Irvin-Erickson Y, La Vigne N, Levine N, Tiry E , Bieler S. *What does Gunshot Detection Technology tell us about gun violence? Applied Geography.* 2017. pp. 262–273.
64. ACOEM. *Brochure: Gunshot and Acoustic Threat Detection: Hear Danger before you See Danger.* Virginia : ACOEM, 2020.
65. Cynthia A. Mamalian, Nancy G. LaVigne,, and the staff of the Crime Mapping Research Center. *The Use of Computerized Crime Mapping by Law Enforcement: Survey Results.* s.l. : National Institute of Justice, 1999.
66. Braga AA, Turchan B, Papachristos AV. *Hot spots policing of small geographic areas effects on crime.* s.l. : Campbell Systematic Reviews, 2019.
67. Garfias Royo M, Parikh P, Belur J. *Using heat maps to identify areas prone to violence against women in the public sphere.* s.l. : Crime Science, 2020.
68. Kemp N, Breetzke GD, Cooper A. *Modeling the risk of robbery in the city of Tshwane.* s.l. : Cartography and Geographic Information Science, 2021.
69. Masdar City: Constructing the world's most sustainable community. [Online] https://ramboll.com/projects/rme/masdar-city.
70. impact, Centre for public. Masdar City in Abu Dhabi. [Online] 2018. https://www.centreforpublicimpact.org/case-study/masdar-city.
71. SUCCESS STORY: Swiss Village for Masdar City. [Online] https://www.esri.com/en-us/arcgis/products/arcgis-cityengine/success-stories/swiss-village.
72. ramboll. Masdar City: Constructing the world's most sustainable community. [Online] https://ramboll.com/projects/rme/masdar-city.
73. Automated and Space Efficient Vehicles: GUIDELINES FOR IMPLEMENTERS OF Personal Rapid Transit (PRT). [Online] https://www.eltis.org/sites/default/files/trainingmaterials/21582_policynoteswg4_2.indd_low.pdf.
74. Personal Rapid Transit. [Online] https://www.2getthere.eu//.
75. website, masdar official. Photovoltaic Power: Deploying solar PV technology in utility-scale and off-grid solar power plants and rooftop systems. [Online] https://masdar.ae/Masdar-Clean-Energy/Technologies/Photovoltaic-Power.
76. —. Concentrated Solar Power: Masdar invests in and develops different types of concentrated solar power systems. [Online] https://masdar.ae/Masdar-Clean-Energy/Technologies/Concentrated-Solar-Power.

77. website, Masdar official. Waste-To-Energy: A proud partner in the UAE's first waste-to-energy power plant. [Online] https://masdar.ae/Masdar-Clean-Energy/Technologies/Waste-to-Energy.
78. Energy Storage: Masdar deploys energy storage solutions to create a more flexible grid system. [Online] https://masdar.ae/Masdar-Clean-Energy/Technologies/Energy-Storage .
79. Masdar City in Abu Dhabi, The public impact. [Online] 2018. https://www.centreforpublicimpact.org/case-study/masdar-city.
80. Ministère d'habitat. *Finalisations des études de la ville nouvelle Hassi Messaoud.* p. 8.
81. —. *finalisations des études de la ville nouvelle Hassi Messaoud.* p. 10.
82. Seghiri Allaoua. *Hassi-Messaoud est-elle une ville ?* s.l. : Méditerranée, tome 99, 3-4-2002. Le sahara, cette «autre Méditerranée» (Fernand Braudel) sous la direction de Marc Côte. pp. 99-102.
83. SeghiriAllaoua. *Hassi-Messaoud est-elle une ville ?*
84. *livre vie des villes numéro spécial-hors série05.* 2014. p. 12.
85. Ministère d'habitat et d'urbanisme et de la ville. *Présentation générale de la ville nouvelle de Hassi Messaoud.* Document Word.
86. Ministère d'habitat. *Finalisations des études de la ville nouvelle Hassi Messaoud.* p. 11.
87. —. *Règlement d'urbanisme de ville nouvelle de Hassi Messaoud,tache 5.3.5.* p. 5.
88. GROUPEMENT DONGMYEONG. *Rapport des études hydrogéologiques, Tâche 1.2.2.*
89. Ministère d'habitat d'urbanisme et de la ville. *Programme urbain de la ville nouvelle de Hasssi Messaoud.* p. 46.
90. Ministère d'habitat d'urbanisme et de la ville,. *Programme urbain de la ville nouvelle de Hasssi Messaoud.*
91. *livre vie des ville N: Hs 05.*
92. *Groupement DONGMYEONG.*
93. *Salon national des énergies renouvelables , propres et de développement durable.* ORAN : s.n., 2014.
94. (EPA), Environmental Protection Agency. Green infrastructure. *epa.* [Online] 2021. https://www.epa.gov/green-infrastructure.
95. (IEA), International Energy Agency. Renewables 2021. *iea.* [Online] 2021. https://www.iea.org/reports/renewables-2021.
96. Bibri, Simon Elias. *The IoT for smart sustainable cities of the future: An analytical framework for sensor-based big data applications for environmental sustainability.* s.l. : Sustainable Cities and Society, 2018. pp. 38, 230-253.
97. GIZ. Developing sustainable transport systems. *giz.* [Online] 2021. https://www.giz.de/en/worldwide/82039.html.
98. PEDRO, . *URBAN STRUCTURES AND MOBILITY, A Case-study in Copenhagen.* FACULDADE DE ENGENHARIA DA UNIVERSIDADE DO PORTO. 2009. Master's thesis.
99. Copenhagen, City of. *City of Copenhagen, CPH 2025 climate plan , Roadmap 2021-2025.*