Entrepreneurial Innovation in Smart Cities: The Role of Urban Living Labs for Driving Sustainable Urban Solutions

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Abstract: By 2050, more than 50 percent of the world's population will live in urban areas. **Objective:** This study aims to explore the concept of Urban Living Labs (URLs) and their role in achieving smart city aspirations and innovation. Methodology: The research used a descriptive-inductive methodology, including case studies of selected cities, a comparison between two smart cities, Dubai and Barcelona, and a qualitative analysis using expert interviews. **Main Results:** Living Labs proved effective as a tool for achieving smart city goals. The results demonstrated the importance of collaboration between the public and private sectors. The study also revealed implementation challenges in some cities and differences in the application of the URL concept between Dubai and Barcelona, where a top-down approach prevailed in Dubai, and a bottom-up approach prevailed in Barcelona. **Conclusions:** Living Labs are a vital framework for integrating innovations into smart cities, with the need for better strategic planning that achieves sustainability, social justice, and preserves citizens' privacy. The study shows urban living labs promote innovation, entrepreneurship, and sustainability in smart cities. **Recommendations:** By examining Barcelona and Dubai, the research provides insights into the design, implementation, and outcomes of these labs, offering valuable lessons for other cities. However, addressing the challenges associated with urban living labs is crucial for their long-term viability and scalability.

Keywords: Living Labs, Smart Cities, Urban Innovation, Sustainability.

الابتكار الريادي في المدن الذكية: دور مختبرات المعيشة الحضرية في دفع عجلة الحلول الحضرية المستدامة

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ملخص: بحلول عام 2050، سيعيش أكثر من خمسين بالمئة من سكان العالم في مناطق حضرية. **الهدف:** تهدف هذه الدراسة الى استكشاف مفهوم المختبرات الحضرية الحية ودورها في تحقيق تطلعات المدن الذكية وتفعيل الابتكار فيها. **المنهج :** استخدم البحث منهجية وصفية استقرائية مع تحليل حالات دراسية لمدن مختارة واجراء مقارنة بين مدينتين ذكيتين دبي و برشلونة اضافة لعمل تحليل نوعي باستخدام اسلوب المقابلة للخبراء. **أهم النتائج:** أثبتت المختبرات الحية فعاليتها كأداة لتحقيق أهداف المدن الذكية، أظهرت النتائج أهمية التعاون بين القطاعين العام والخاص، كما كشفت الدراسة عن تحديات تنفيذية في بعض المدن واختلافات في تطبيق مفهوم المختبرات الحضرية الحية بين مدينتي دبي وبرشلونة حيث كان اسلوب من اعلى لاسفل يسود في مدينة دبي، واسلوب من اسفل لاعلى يسود في برشلونة. **الاستنتاجات:** تعد المختبرات الحية إطاراً حيوياً لدمج الابتكارات في المدن الذكية، مع الحاجة إلى تخطيط استراتيجي أفضل يحقق الاستدامة و العدالة الاجتماعية ويحفظ الخصوصية للمواطنين. توضح الدراسة أن المختبرات الحضرية الحية تعزز الابتكار وريادة الأعمال والاستدامة في المدن الذكية. **التوصيات:** من خلال تحليل نموذجي برشلونة ودبي، تقدم البحث رؤى حول تصميم وتنفيذ ونتائج هذه المختبرات، مقدمة دروساً قيمة للمدن الأخرى. مع ذلك، فإن معالجة التحديات المرتبطة بالمختبرات الحضرية الحية أمر بالغ الأهمية لضمان استدامتها وقابليتها للتوسع على المدى الطويل.

الكلمات المفتاحية: المختبرات الحية، المدن الذكية، الابتكار الحضري، الاستدامة.

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Introduction

World Bank statistics show that 54% of the global population lives in urban areas, expected to rise to 80% by 2045 (World Bank, 2024). Cities with over 10 million residents increased from 10 in 1990 to 28 in 2014, projected to reach 41 by 2030 (World Bank, 2024). Urbanization in Europe, the Middle East, and Arab nations will exceed 85% in five years, straining infrastructure. Cities must transform into smart systems for survival, acting as catalysts for socio-technical change, according to the World's Cities Report (2016). Johannes Hahn (2011) noted cities as arenas for solutions, driving innovation and cultural vibrancy while addressing unemployment and poverty. Information and Communication Technology (ICT) boosts urban service efficiency (Abu Drabi, A., 2023), sparking optimism for innovative technologies despite challenges in valuing new ICT. The 'Smart Cities' concept integrates technology solutions for urban issues, emphasizing citizen involvement alongside governance, as highlighted by Van Timmeren, Pimentel, and Reynolds (2015). Innovative processes in smart cities are vital for sustainable job creation amid limited research. The current decade sees rapid urban transformation focusing on innovation for sustainability (Allam & Dhunny, 2021). Urban living labs (ULLs) serve as platforms for testing technologies in cities (Voytenko et al., 2022). They enable collaboration among governments, businesses, researchers, and citizens to address sustainable challenges, promoting inclusive development through real-time feedback. A study (Yigitcanlar et al., 2022) found that 73% of successful smart city projects originated from community engagement startups, like London's FixMyStreet (Anthopoulos et al., 2021). A comparative study by Nesti (2021) on Europe's largest urban labs showed that 89% utilized the Urban Labs approach.

Research Problem

The concept of smart cities emerged in the 21st century, driven by urban growth and technology. Smart cities improve urban life by integrating information and communication technology (ICT), innovation, and sustainability. With 68% of the global population projected to live in urban areas (United Nations, 2018), innovative solutions are needed for challenges like quality of life and resource management. This research examines whether smart cities can foster innovations and serve as entrepreneurial innovation hubs.

Interest in smart cities aims to enhance entrepreneurial innovation within ecosystems. Urban living labs provide innovation frameworks through realistic testing environments that encourage collaboration among public and private sectors, residents, and researchers (Bulkeley et al., 2016). They integrate research, innovation, and experimentation, engaging users (Leminen et al., 2012). These labs address urban issues involving various stakeholders. The research highlights gaps: Lack of a coherent framework and clear definition for urban living labs, resulting in inconsistent applications (Steen & van Bueren, 2017). The unclear potential of urban living labs to enhance innovation and entrepreneurship (Schuurman et al., 2016). Implementation barriers such as financing and stakeholder alignment challenge smart city urban living labs (Voytenko et al., 2016). A significant research gap exists in balancing economic, environmental, and social goals alongside UULs' role in sustainable urban development (Nesti, 2018). This study aims to explore UULs and their impact on promoting entrepreneurial innovation in smart cities in the Middle East and Europe. It will evaluate their role in addressing urban challenges and

fostering sustainable development using case study methodologies and theoretical frameworks. The research seeks to enhance understanding of the design and implementation of ULLs.

Research Methodology

This research adopts a qualitative approach (Creswell & Poth, 2018) to explore Urban Living Laboratories (ULLs) and their role as hubs of creativity and innovation in smart cities, as well as their impact on stimulating sustainable urban entrepreneurial solutions. Qualitative methodology has the potential to provide in-depth insights into complex phenomena in the context of smart cities. Therefore, this research was chosen to delve deeper into understanding the dynamics of ULLs. Yin (2013) suggests using case studies within government agencies to understand "how" or "why" programs work. The research used a multiple case study approach (Yin, 2018), supplemented by analysis of available official documents and expert interviews to gain a comprehensive and in-depth multifaceted understanding of the research problem (Denzin & Lincoln., 2005, Flick, 2018). Yin (2013) explains that case studies and interviews are used to understand the research point better. Practicing planners will have a clear direction when comparing cities and validate solid understanding for those wishing to employ ULLs as a further outreach/education tool while the qualitative approach provides depth and context, it has limitations, including Potential bias in participant responses, Limited generalizability due to the focus on two case studies, Challenges in accessing certain documents or stakeholders (Creswell & Poth, 2018).

Case Study Design: This case study examines two prominent smart cities: Barcelona and Dubai. The study select these locations due to their advanced adoption of smart city initiatives and their utilization of Urban Living Labs to promote innovation and sustainability. "Although both Dubai and Barcelona are smart cities, their developmental contexts differ. Barcelona, in a developed country, focuses on participatory approaches and sustainable projects supported primarily by public and European funding. In the meantime, Dubai, as a city in a developing country, adopts a rapid technological model relying on massive investments and global partnerships to drive economic growth and enhance competitiveness. This reflects the differences between the two cities in terms of resources and priorities, enriching the research methodology and answering the study's questions about how this concept is applied a concept that is difficult to confine to a single definition or specific practice."

Barcelona is committed to advancing smart city initiatives, and has significantly emphasized citizen engagement in innovative urban living laboratories to address urban challenges, preserve ecosystems, and resolve energy and mobility issues through innovation and public-private partnerships (Barcelona City Council, 2023). This city serves as an exemplary model worthy of study in this domain. Concurrently, Dubai, which is internationally acknowledged as a hub for innovation and technological leadership, has implemented strategies to enhance economic diversity and improve urban sustainability through its distinct approach to urban living laboratories, which contrasts with that of the European city of Barcelona (22 @ Barcelona Innovation District, 2023). The case study approach enables a comprehensive examination of the design, implementation, and outcomes of urban living laboratories in these two selected cities, thereby illuminating their respective successes and challenges (Yin, 2013).

Data Collection Methods: The data collected will undergo thematic analysis, a widely recognized qualitative methodology designed to identify, analyze, and systematically report patterns within the data (Corbin & Strauss, 2015). This methodology includes interviews, transcriptions, and coding processes to elucidate significant themes and patterns (Bowen, 2009).To ensure a robust and comprehensive analysis, the study uses three methods to ensure an in-depth and comprehensive analysis of data collection:

A. **Secondary data**: The documents to be analyzed include policy reports and white papers on smart city initiatives, case studies and project evaluations related to urban living labs, academic literature on urban innovation and sustainability, and official publications from smart city programs. (UN-Habitat, 2022; 2023; 2024), (Marvin & Bulkeley, 2021), (Menny et al., 2021). http://www.openlivinglabs.eu/

B. **Case study data**: Information and data will be collected from available official reports and secondary sources that are reliable regarding the subject of living laboratories in Barcelona and Dubai, examining how this concept is applied and developed in these two cities. Visitdubai.com. https://uia.org/publications Barcelona City Council. (2023). 22 @ Barcelona Innovation District. (2023). Barcelona Regional. (2023). Sustainable Urban Development in Barcelona. Smart Dubai Office. (2025).

C. **Expert interview**: The Researchers interviewed twelve experts (five from Barcelona and seven from Dubai), discussing their experiences and challenges with Urban Living Labs (ULLs). The interviews were for 20-25 minutes in 2024**.** Based on the expert interviews. The interviews will focus on clarifying the role of urban living laboratories in promoting entrepreneurial innovation, the challenges and opportunities associated with their implementation, and the impact of these laboratories on sustainable urban development. This will involve interviewing twelve experts in the design and implementation of living laboratories in Dubai and Barcelona, including urban planners, academics specializing in smart cities and innovation, and founders of start-up companies. During the interviews, we will clarify the role of living laboratories and their capacity to promote entrepreneurship, innovation, and sustainable development in smart cities while also addressing the challenges, opportunities, strengths, and weaknesses related to their implementation.

Data Analysis: These identified themes will subsequently be organized into broader categories aligning with the research objectives, encompassing entrepreneurial opportunities, sustainability outcomes, and challenges about implementation. Following this categorization, triangulation will be conducted; the findings derived from interviews, document analysis, and case studies will be cross verified to ensure consistency and reliability. Ultimately, the identified themes will be interpreted within the context of the research problem, offering valuable insights into the role of ULLs in the development of smart cities. The study will strictly adhere to established ethical standards within qualitative research by acquiring informed consent from interview participants, safeguarding confidentiality and anonymity, and presenting findings transparently and without bias.

By integrating case studies, expert interviews, and document analysis, the research intends to provide actionable insights for policymakers and urban planners, highlight best practices for nurturing entrepreneurial

ecosystems through ULLs, and enhance the academic discourse on smart cities and urban innovation. Bulkeley et al. (2021) examine the role of urban living labs (ULLs) in urban experimentation and governance.

Literature Review

Concept of Smart City

Smart cities integrate sustainability, citizen welfare, competitiveness and ICT (Caragliu et al., 2012; Chourabi et al., 2012; Hollands, 2008), coordinating technology across sectors through IoT. Urban migration strains resources (UNPD, 2010), driving smart city development amid budget constraints and digital labor shifts. Research spans spatial planning (Freeman, 1977; Morandi et al., 2015), economic geography (Bunnell & Coe, 2001), and urban technology (Allwinkle & Cruickshank, 2011). While definitions vary, participatory governance and ICT-enabled services are key (Caragliu et al., 2009). Smart cities combine innovation systems with local talent (Richter et al., 2015), transforming urban living through technology (Alcatel, 2012; California Institute, 2001).
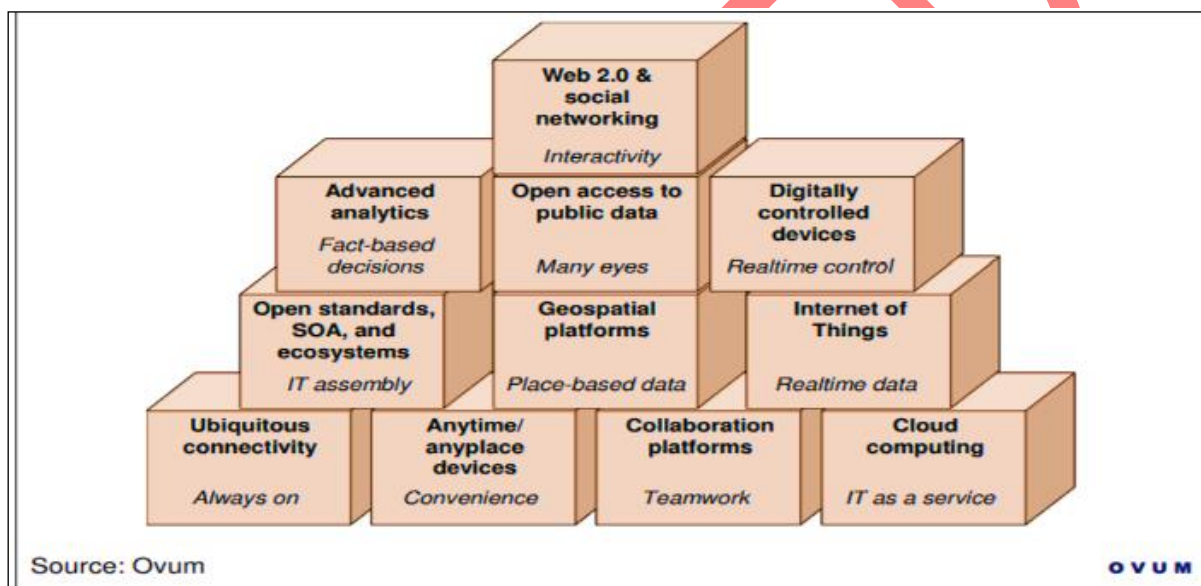

Figure (1): IT is building blocks of digitally enabled cities, Ovum, 2018.

Competitiveness Between Cities

Cities provide superior job opportunities, services, and accessibility through advanced infrastructure, boosting living standards and economic growth (Hodgkinson, 2011). Smart city technologies like Google Maps and adaptive traffic systems are now widespread (Al-baharat et al., 2024), with 3,000-5,000 cities implementing solutions (Kittrabal, Cisco). As urban competition intensifies (UN, 2008), high-performing cities attract talent, investment, and businesses (Richter et al., 2015)

Smart Cities and the Quadruple Helix Innovation Systems

MIT's Triple Helix model (Etzkowitz, 2008; Arnkil et al., 2010; Dubina, 2015) connects research, business, and cities (Leydesdorff et al., 2011). European adaptations added citizens as a fourth dimension, creating the Quadruple Helix model (ARUP, 2016; Selada, 2017). This approach fosters open innovation through collaboration between universities, industry, government, and citizens (Paskaleva et al., 2015; Arnkil, 2015), enhancing smart city development and Urban Living Labs via participatory innovation.
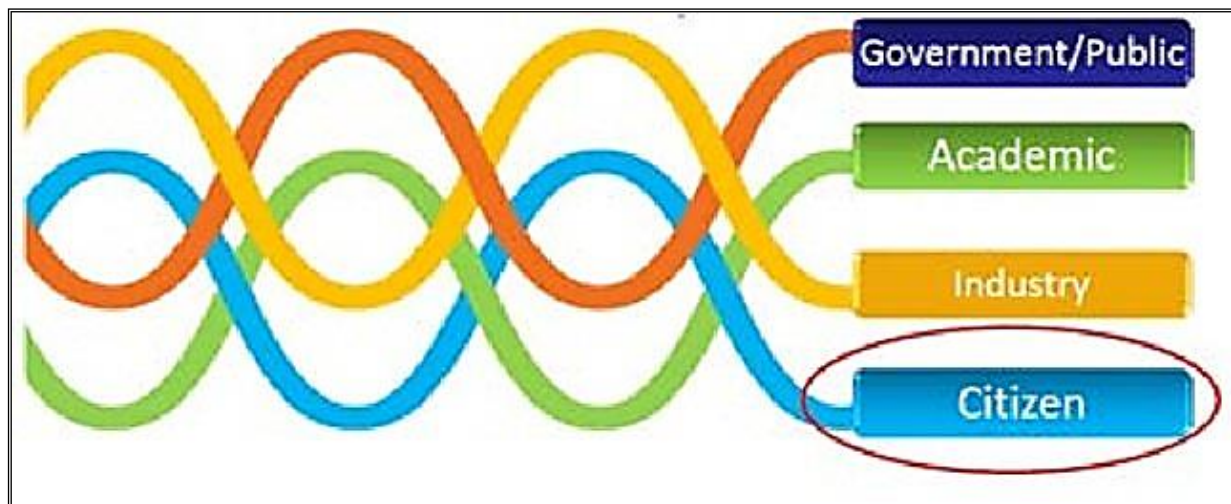
Figure (2): Quadruple helix Model.

Examples of this quadrilateral spiral model include the Technology Parks in Helsinki's Arabianranta district, the Cambridge Science Park, and the @22 district in Barcelona, all of which are examples of creative zones and collaboration between the four partners to produce innovations and place them within cities rather than suburb**s.**

The Concept of living labs (LL)

MIT's William Mitchell pioneered Living Labs (LL) as real-world innovation testbeds (Mitchell, 2007), building on earlier work by Bajgier et al. (Almirall et al., 2012). These labs unite stakeholders to solve complex urban challenges (Sevtsuk & Beinart, 2005; Pego et al., 2019), evolving from small-scale home monitoring to city-wide smart projects. Their flexible framework allows participants to set parameters (Bergvall-Kåreborn et al., 2009) and operate across scales - from households to entire industries. Research shows decentralized networks foster broader innovation than centralized approaches (JPI Urban Europe, 2020). Core features include real-world testing, user involvement, and multi-actor collaboration. Leminen (2015) identifies four governance types (user/utilizer/enabler/provider-driven), while Bergvall-Kåreborn & Ståhlbröst (2020) emphasize context-embedded experimentation.

Figure (3): the steps in the living lab way of working.

Urban Living Labs: The Quadruple Helix and Living Labs share collaborative approaches for smart city innovation. Living Labs are real-world innovation ecosystems engaging stakeholders through iterative processes (Niitamo & Kulkki, 2006). Originating in smart homes (Eriksson et al., 2005), they were formalized by ENOLL in 2006. ULLs combine digital interaction, research, and public-private-people partnerships (Molinari, 2011; Mirijamdotter et al., 2006), enabling cities to co-create solutions with citizens (Steen & Van Bueren, 2017). Examples include Helsinki's Living Labs, which are developing urban methodologies (Paskaleva, 2011), and Pasila's community planning initiatives. They serve as innovation hubs where stakeholders collaborate using technology to solve urban challenges (Juujarvi & Pesso, 2013), aligning with smart city goals, such as those related to Euro 2020 (Hossain et al.,2020).
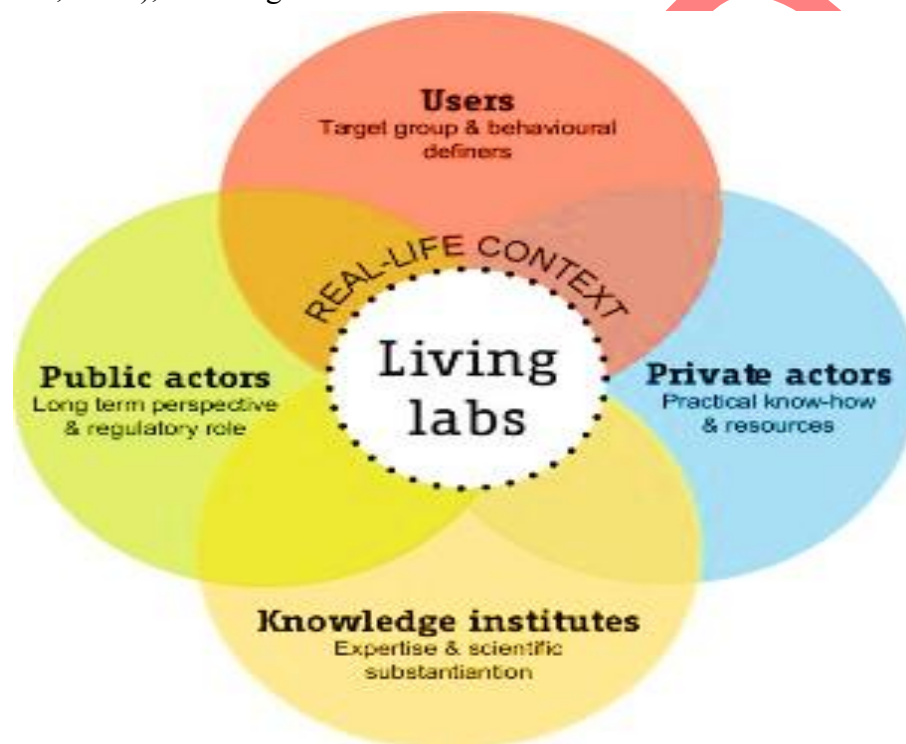

Figure (4): The living lab stakeholders.

Urban living labs drive 'urban' or 'civic' innovation, while most labs engage with the private sector. They focus on urban challenges, boost community engagement, and foster connections between local authorities and citizens. Urban Living Labs emphasize social value and civic engagement, working closely with governments. (Gonzalez, 2015). This approach resolves the tension between top-down governance and bottom-up initiatives (Almirall, 2008). A key feature of Urban Living Labs is enhancing transparency and governance, empowering citizens to address critical issues like energy and climate change. (Bernardo, 2017).

How Do Living Labs Work?

Urban Living Labs (ULLs) serve as real-world testbeds for social and technical innovation (Carvalho et al., 2019), yet their mechanisms remain understudied (Nesti, 2016). They enable stakeholders to co-create and evaluate urban solutions through experimentation, promoting social change. Effective ULLs require stakeholder identification and participation, as Well as Context-Aware design tailored to local needs. Adaptive implementation Leadership models vary (Townsend, 2015b): Grassroots (civil society-led); Civic (university/municipal-led);

Strategic (corporate/government-led). Smart City ULLs engage diverse actors (Albino et al., 2015; Bason, 2013) through activities including: Citizen participation; Digital solutions; Sustainable mobility; E-learning/tourism

Examples of ULL Applications in Smart Cities

The following paragraphs discuss five empirical cases of ULLs to identify and understand how they are used.

Belgian Living Lab, December 2017: Urban Mining-2: The meeting was held for the third Belgian district urban laboratory in Mechelen on December 18, and the second for urban mining (FISSAC, 2019). The experts discussed several issues of importance and priority, such as demolition issues and how to distribute to sites, in addition to economic challenges and cooperation between various supply chains, and also focused attention on how to move urban mining to a new level better through organization, management and making correct decisions, and site testing, monitoring and analysis and what are the future challenges.

Germany Living Lab: To develop a methodology and software platform that facilitates the exchange of information, the project engages stakeholders at all stages of the production and distribution value chain, supporting industrial symbiosis networks and replicating pilot systems at local and regional levels. The pillars of the model are Environmental (with a life-cycle approach), economic, and social. Their model goal can be replicated in other districts and value chain scenarios. FISSAC seeks to reveal the efficiency of the processes and services FISSAC, 2019).

Nordic Urban Living Labs projects: An ongoing collaboration exists among the Smart Cities Network in northern Norway, where each municipality oversees an innovative and pioneering project. These projects are evaluated within the context of the city's living urban laboratories, resulting in the implementation of five distinct initiatives (Open Living Labs, 2019). Smart cities in Scandinavia attract global investments, facilitated by the presence of living urban laboratories that enhance their viability, sustainability, and intelligence. Consequently, this environment becomes increasingly appealing for start-ups and small enterprises. Companies within these smart cities are positioned to expand their business and devise practical solutions through these live laboratories. Living urban laboratories have been established in fourteen cities in Northern Scandinavia to foster and promote sustainable urban development while achieving cooperation and integration among the municipalities, funded by Nordic Innovation. According to the Intelligent Community Forum (2015), living urban laboratories are vital for identifying solutions and accelerating business operations, attracting investments and enterprises to these locales. Businesses are tailored to meet the needs of residents and customers, facilitating their entry into new markets. Recently, five innovative projects have been sanctioned across five cities in Northern Scandinavia, prominently featuring the Urban Flow Management Project in Copenhagen, the Mobility Centers Project in Bergen, and the Y Finding Project in Helsinki, which focuses on road navigation (Fig. 5).
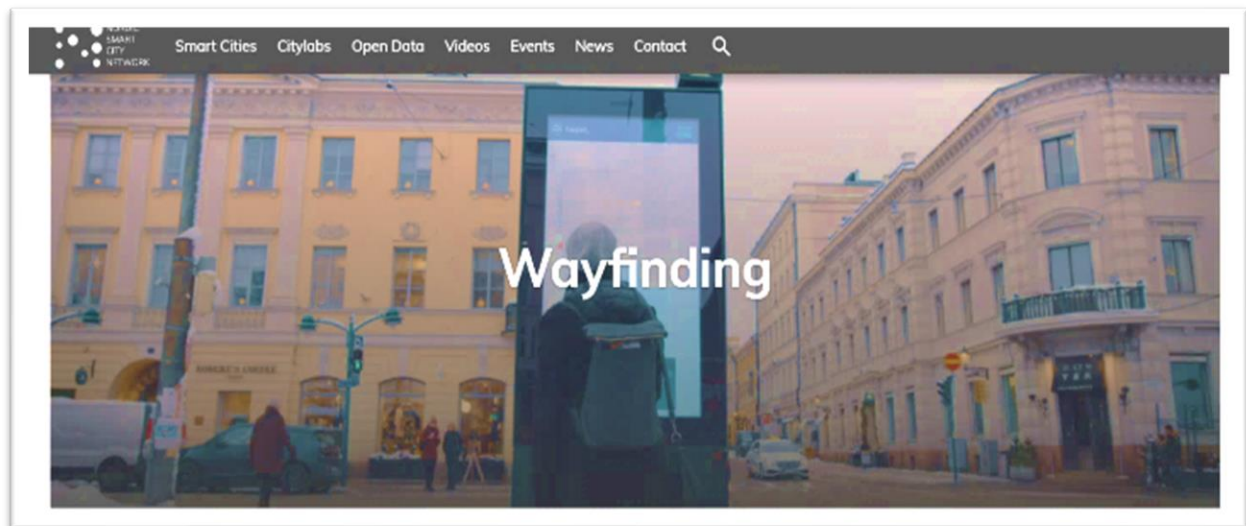
Figure (5): Wayfinding project in Helsinki Picture at the project page.

Pilots in Helsinki on Wayfinding: Existing services offer capabilities for enhancing city experiences, facilitating real-time data sharing, and gathering feedback. In the best-case scenario, services and street furniture can foster a more efficient and transparent relationship between city managers and citizens. A project in Helsinki, based on the concept of living urban laboratories and titled "Innovative Digital Solutions for the City," aims to enhance marketing services using smart street furniture, which delivers essential information to city visitors, tourists, and citizens through collaboration between the public and private sectors and the utilization of big and open data. This approach enables the city to adopt methods of transparency and efficiency in managing temporary data, providing a live experience for its residents and allowing them to comment on events without compromising their privacy. Urban smart furniture can allow users to peek around walls and display background and hyper-local information in addition to broader, citywide content. Previous experiences from the Helsinki pilots with urban screens demonstrate their ability to simultaneously serve a wide range of uses while being locally focused. City Guidance and Beyond is a collaborative project involving Helsinki (Lead), Tromsø, Tampere, and Stavanger (Open Living Labs, 2019). Fortunately, these companies are also preparing to offer their smart urban solutions in other countries such as China, India, and North America.

ULLs in the South of Paris: In the south of Paris, the Smart Cities ULLs were created (Figure 6), which accompanied the regional development of the CIU in Paris. Cité International is the largest campus in the French capital region. To address the competition and attractiveness of Campus ULLs, a strategy designed for the digital valuation of the area was intended (Open Living Labs, 2019). In this perspective, activities and practical experience have been produced to produce about 30 innovative services in the urban area, such as innovative editorial platforms for thematic content; services for visits, discoveries, and knowledge; innovative interfaces for browsing and viewing the public; Internet; Digital services for technical and cultural education; Playful services for cultural content and others.

Figure (6): ULL of South Paris.

Findings

Cases Analyzed: Dubai and Barcelona

Here is a detailed overview of Dubai's and Barcelona's Smart City experiences in ULLs, highlighting their goals, key projects, governance models, and outcomes. This comparison provides insights into how these two cities leverage technology and inventions to become global leaders in urban development.

Dubai aims to become the "smartest and happiest city in the world" by leveraging technology to enhance quality of life, sustainability, and economic growth. Its main initiative goal is to achieve 100% paperless government services by 2023, transition to 75% clean energy by 2050 (Dubai Clean Energy Strategy), enhance urban mobility, reduce traffic congestion, and foster innovation and entrepreneurship through smart technologies (Smart Dubai Office ,2025). As applied in expert interviews, the Governance Model declares a top-down, government-led approach with strong private sector collaboration (visitdubai.com).

In contrast, Barcelona's Smart City Initiatives aim to be a worldwide model for sustainable and inclusive urban growth through smart technologies (www.BarcelonaRegional, 2023). These efforts concentrate on enhancing energy efficiency and reducing carbon emissions, increasing citizen engagement and quality of life, fostering innovation and supporting local start-ups, and encouraging sustainable mobility and effective public space usage. The initiative emphasizes citizen involvement by adopting a bottom-up, participatory governance model that strongly incorporates public participation (www.Barcelona.cat).

The Case of Barcelona: In 2011, the Smart City Expo & World Congress was held. In this international exhibition, Barcelona was recognized as a smart and leading city globally (Batlle et al., 2011). The beginning was when Barcelona was chosen as the venue for the 1992 Olympic Games. In the 1980s, the city suffered from a marked lack of infrastructure, a real obstacle to the World Olympics (Leon, 2008; Mazzoleni, 2010).

Experts from different disciplines met to transform Barcelona into a smart and modern city and a model to be followed, especially in the areas of smart Economy, smart governance, water, energy, and smart life issues, as well as projects in the field of infrastructure and open data initiative, which helps the population for easy, safe and fast access to information(Garcia-López & Muñiz, 2010). It can be said that Barcelona took care of several aspects of smart cities and was not limited to one side (Marshall, 2000). The urban strategy of Barcelona considered the environment and

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housing, as well as employment and economic knowledge. Universities, as well as the public and private sectors, have established an innovation cluster. These clusters have recently transitioned into living labs, incorporating citizens who are pivotal to this type of entrepreneurial direction (Bakici et al., 2012). The Barcelona Association offers training programs and applied competitions that engage intellectually skilled individuals within the designated Barcelona 22 area. This region is a preferred location for numerous projects aimed at enhancing citizens' quality of life through the intensive deployment of modern technologies. Such technologies are instrumental in facilitating the digital transformation of the city. This area, formerly the industrial sector of Poblenou during the nineteenth century in the Sant Martí district, underwent a significant transition towards digitization, necessitating the implementation of optical fiber projects, Wi-Fi networks, and remote sensing.

Furthermore, the adoption of e-government within the public sphere has significantly enhanced public service delivery, making it more effective, adaptable, and accessible (Leon, 2018). Figure 8 summarizes Barcelona's Smart City Experience. Barcelona is among the first major cities to adopt a smart city designation. The successful and innovative application of intelligent technology systems has yielded significant energy savings and reduced CO2 emissions. Implementing intelligent systems in Barcelona has demonstrated that a sustainable environment can coexist harmoniously with economic prosperity across various sectors, particularly tourism. As the quality of life for individuals, notably older people, has seen marked improvement, this reflects the essence of sustainability. Cisco Systems, a multinational company that has collaborated on the Barcelona Smart City model, states that it has targeted 12

key areas, including water, energy, ICT, and others. It is managed by 22 major programs that combine the city's departments to provide coordinated services. It also has a system for quickly gathering and analyzing information from the network. Barcelona has launched an innovative smart application for its elderly citizens (Finkels VCN), designed to keep them in touch with their children and family members. It alerts them to the times when they need to take their medicines and, if necessary, to contact doctors and hospitals related to their health problems. A report by Philips Lighting, a leading lighting company, in partnership with Smart Cities World, highlighted that Barcelona is one of the most intelligent cities, having created approximately 47,000 jobs by implementing Iota systems. It has also saved €42.5 million in water spending and generated an additional €36.5 million in revenue through smart car parks.

Barcelona has launched several living urban laboratories to address its urban challenges, including Hanger, Fablab, i2Cat ULLs, the Build Development Program, and the Barcelona Urban Innovation Lab, most of which are affiliated with universities and research centers. These laboratories provide technological solutions in vital sectors, including security, energy, health, and mobility. Examples that have been applied in the city include installing 12 lighting points for public streets with a digital system that measures humidity, heat, and pollution, as well as detects vibrations for sound. (Bakici et al., 2013).

One of the most important technological centers recently established by the city of Barcelona, Digital 4, aims to stimulate innovation for applications in society and business (Baccarne, 2014). In these ULLs, the latest digital technologies are discussed and developed worldwide, published in periodic

conferences, and awarded to innovators who create applications that improve urban management. Nevertheless, Experts from Barcelona Municipality identified in phone call interviews (2019) several challenges for the city of Barcelona to convert into a new smart city generation. Among them is that Barcelona has an average level of entrepreneurship compared to developed countries. That expert capital is less than required, in addition to the limited number of large companies that can guide innovation, although the Internet of Things platform has now improved this situation. One of the most important challenges is that communication with the world is not at the required level, and Barcelona suffers from insufficient capital funding to attract new projects.
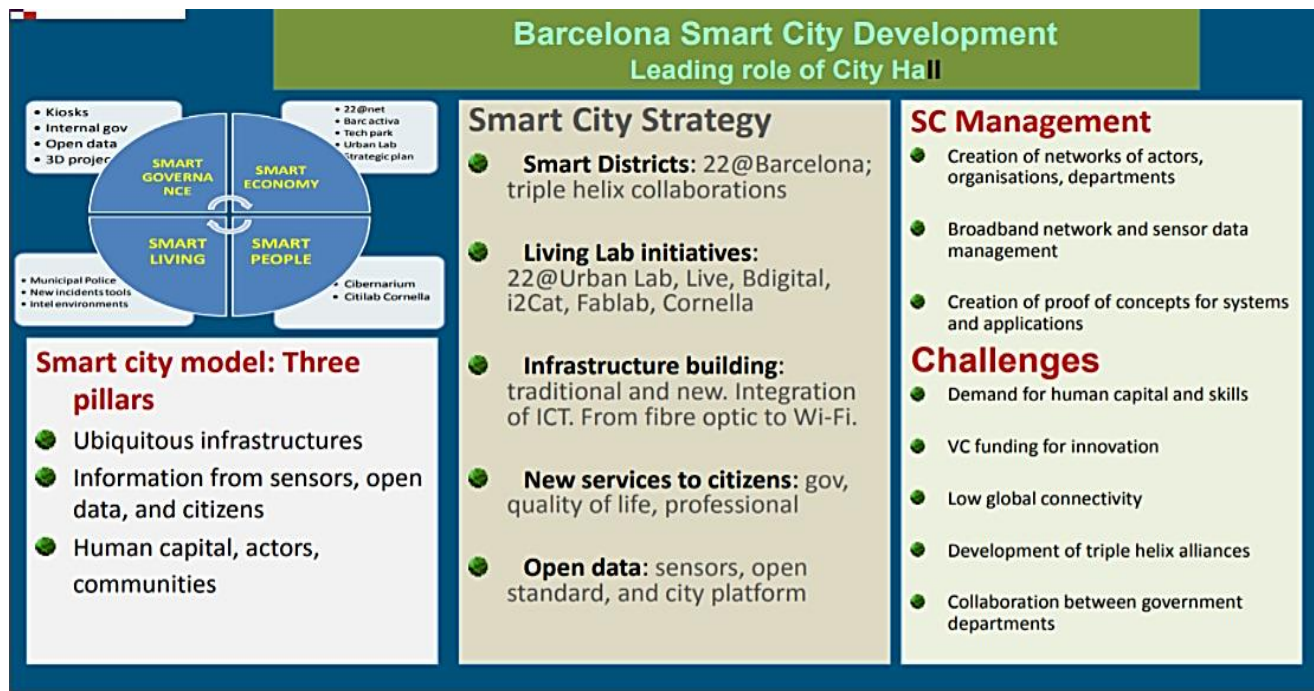
Figure (7): Barcelona smart city development.

The Case of Dubai: While London was at the top of the Aiden Strategic Institute's list of the best 50 smart cities in the world, specializing in social innovation, Dubai is the only Arab city mentioned in the classification and came in at 40th, ahead of global cities such as Paris (46th). In 2013, Dubai declared its goal of becoming the smartest and happiest city on Earth, relying on a smart city strategy that focuses on increasing efficiency in utilizing city resources (Khane et al., 2017). On the other hand, Economy, living, governance, environment, people, and mobility are the components that direct the new strategy (Alawadhi & Schupp, 2021).

Dubai RTA has adopted this strategy to make Dubai the happiest city in the world. In 2015, the Dubai RTA launched the smart transport plan, which relied on understanding the population's needs and requirements, as well as predicting their trips. It also relied on analyzing big data from the sensors to solve the problem of congestion, long trips, and pedestrian paths, which affect the population (Fig. 8.). In addition to Innovative and modern infrastructure (Khane et al., 2017). The strategy implements Sustainable and non-motorized modes of public transport (Smart Dubai, 2015) (Smart Dubai, 2025).

There are many smart systems in the city of Dubai uses in the field of transportation such as driverless transport and the field of smart energy through the application of organic solar

energy in villas and public places in Dubai based on thin films, which generate solar energy as it uses a Vertical farming has spread in the company with the French company Agricool producing crops of fruits such as almonds, pomegranates, mangoes and dates, in addition to leafy and non-leafy vegetables, and this requires the participation of community groups within an ecosystem of urban agriculture (UN-Habitat ,2022). As for smart transport solutions, there are smart meters that turn on streetlights according to movement, in addition to Dubai Municipality's announcement that 25% of transport trips will be based on intelligence and without a driver by 2030, and the streets in the city are designed to accommodate more electric cars (EVs). (Smart Dubai, 2025).

Through educational events, including EV test drives and activation of ULLs, residents are taking part in the EV transformation (Khane et al., 2017). Other mobility features in The Sustainable City include car-free clusters and a buggy-sharing program (Khane et al., 2017). The focus of Dubai City is on enhancing the quality of life for its citizens. Individuals have access to smart tools that enable them to inform authorities of any problems, such as digging on roads, air pollution, or noise, within their reach. Sensors placed in waste containers to indicate only those filled and congestion handling have provided drivers with information on vacant parking lots, allowing them to go directly to them without turning and thereby reducing congestion.
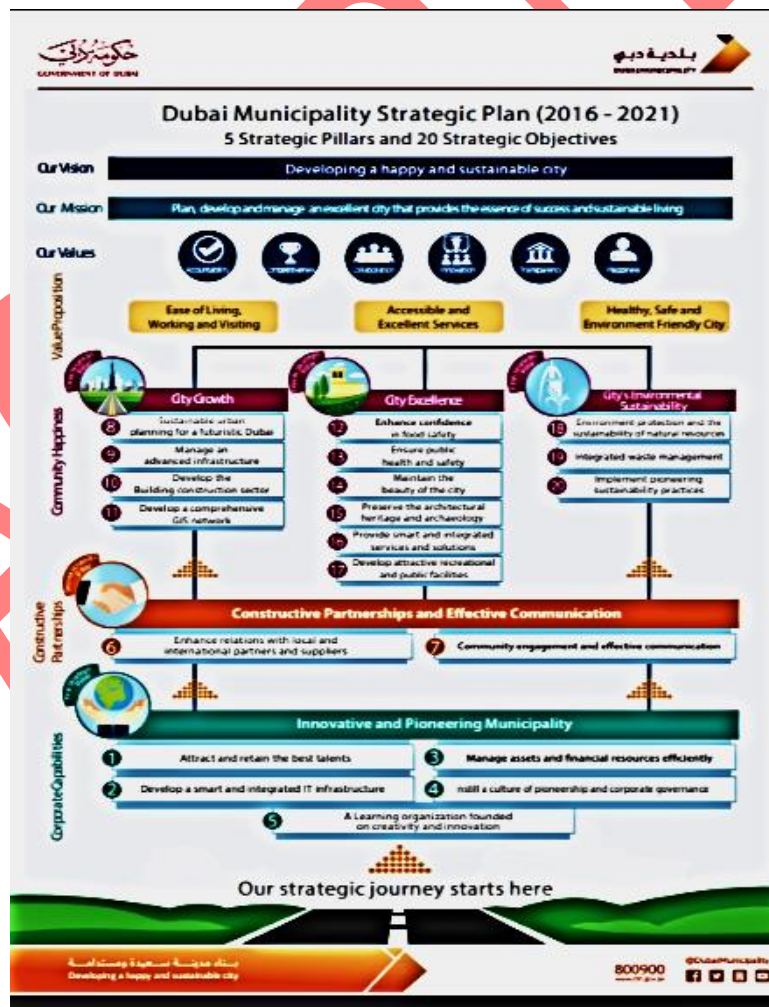

Figure (8): Strategic plan for Dubai Municipality.

Expert Interviews

Barcelona's ULLs excel in citizen engagement and eco-friendly urban design, serving as a benchmark for participatory governance and sustainable innovation. However, scalability and funding challenges must be addressed to maintain its reputation in urban innovation. Dubai's ULLs shine for their rapid implementation and advanced technology integration, bolstered by strong governmental support. Nonetheless, a greater focus on citizen engagement and long-term sustainability is necessary to ensure inclusive and resilient urban development. Both cities can learn from each other: Barcelona could adopt Dubai's approach to large-scale implementation, while Dubai might integrate Barcelona's participatory governance model. Collaboration between the two cities could promote knowledge exchange and joint innovation projects, particularly in the areas of renewable energy and smart mobility. For future directions, Barcelona should concentrate on securing diverse funding sources and scaling

successful projects. Dubai should prioritize citizen engagement and address environmental challenges to ensure sustainable development. Both cities should pursue international partnerships to enhance their urban livability (ULLs) and contribute to global urban sustainability goals. This analysis provides a comprehensive explanation of the ULL experiences in Barcelona and Dubai, highlighting their strengths, weaknesses, opportunities, and threats.

Comparative Analysis: This section compares Urban Living Labs (ULLs) in Barcelona and Dubai, drawing on literature reviews, document analysis, and interviews. It focuses on their objectives, governance models, key initiatives, entrepreneurial opportunities, sustainability contributions, and challenges. The comparison is organized to facilitate a clear understanding of how ULLs function in these two cities and their respective impacts, as illustrated in Table 1.

Table (1): Comparison between Barcelona and Dubai in ULLs Experience.

Aspect	Barcelona	Dubai
Definition of ULLs	User-centered, open, innovative ecosystems that emphasize co-creation and citizen engagement.	Innovation platforms driven by government vision focus on rapidly testing and scaling technologies.
Governance Model	The bottom-up approach emphasizes active citizen participation.	A top-down, government-led approach that includes significant involvement from the private sector.
Primary Focus	Social inclusion, environmental sustainability, and innovation driven by citizens	Technological advancements, economic diversification, and global competitiveness.
Key Stakeholders	Citizens, local government, small and medium-sized enterprises (SMEs), universities, and non-governmental organizations (NGOs).	Government agencies, multinational companies, start-ups, and international investors
Challenges	– Balancing the interests of diverse stakeholders (citizens, businesses, and government). – Limited financial resources for scaling ULL projects. – Many ULL initiatives remain localized and face challenges in scaling up. – High citizen involvement can lead to slower decision-making.	– Aligning government vision with private sector goals. – There is ample funding but high competition for resources. – Rapid scaling but sometimes at the expense of long-term sustainability. – Limited grassroots engagement due to top-down governance.

Source: By authors utilizing literature reviews, document analysis, and interviews.

Barcelona showcases high citizen engagement and social inclusivity while

prioritizing environmental sustainability (Menny, M., et al., 2021). In contrast, Dubai

swiftly implements and scales innovations, drawing global entrepreneurs and investors. However, Barcelona faces limited funding, slower decision-making processes, and challenges in scaling projects. Conversely, Dubai has restricted citizen involvement and must navigate trade-offs between economic growth and environmental sustainability. In Barcelona, opportunities emerge for ULLs by diversifying funding sources to scale projects and strengthen public-private partnerships. In Dubai, enhancing citizen engagement in ULLs helps to balance economic and environmental objectives. However, there is a risk of losing momentum in Barcelona due to funding constraints and overreliance on local stakeholders. In Dubai, there is a risk of prioritizing economic growth over sustainability due to intense competition for resources (Table 2). Show a SWOT summary for comparing the two cities' experiences as smart cities in UULs.

Table (2): SWOT analysis comparison for Barcelona and Dubai UULs.

	Strengthens	Weaknesses	Opportunities	Threats
Barcelona	Promoting strong citizen engagement and social inclusiveness.	Limited funding and delayed decision-making	Broaden funding sources to scale ULL projects.	Potential loss of momentum from funding issues and constraints
Dubai	Swift adoption and expansion of innovations	Restricted citizen participation.	Increase citizen involvement in ULLs.	Potential hazards of placing economic growth above sustainability.

Source: by the Authors.

Discussion

By employing research questions and a qualitative methodology that includes secondary data analysis, case studies, and a comparison between two specific case studies—Barcelona and Dubai—along with expert interviews, the study results were organized. These results underscore the significance of living labs and their role as innovation hubs in smart cities, as well as their ability to promote environmental sustainability and foster sustainable urban development. The strength of living labs is evident in their capacity to cultivate partnerships among stakeholders, including decision-makers, citizens, investors, and researchers, addressing urban challenges such as energy, transportation, water, and waste management, which aligns with the study by Menny et al. (2020) and (2021). One example is the 22 @Barcelona project, which utilizes smart city mechanisms, including technology and the Internet of Things, to develop pioneering and innovative collective solutions. Experts affirm that the success of these solutions greatly depends on strong partnerships among various professionals and their collaboration with citizens.

Dubai's adoption of smart city concepts aligns with its ambition to be a global hub for innovation in AI and blockchain (Smart Dubai, 2025). However, it employs a top-down approach in planning living labs, lacking citizen participation, and is heavily supported by government intervention, a business-friendly climate, and substantial funding. In contrast, Barcelona prioritizes social and environmental sustainability while Dubai focuses on technological growth. Both cities attract global start-ups, investors, and entrepreneurs but differ in their approaches to sustainable urban development through innovation. A key challenge in implementing urban living labs is stakeholder alignment, with both cities struggling to balance public and private interests. Barcelona faces financial constraints in expanding its labs, whereas Dubai enjoys government financial backing but

finds scaling challenging, with many projects remaining localized. Additionally, decision-making delays in Barcelona arise from its bottom-up planning, unlike Dubai, where the central government limits citizen participation and grassroots innovation. Despite notable successes, urban living labs face challenges in aligning stakeholders, securing financing, and achieving scalability—highlighting the need for strategies tailored to each city's governance model. Experts noted that the success of urban living labs hinges on governance and stakeholder engagement. While essential in smart cities, urban living labs encounter significant challenges requiring city-specific solutions related to stakeholder alignment, funding, and scalability.

This comparative study examines how both Barcelona and Dubai utilize Urban Living Labs as engines for innovation and creativity, analyzing the interplay between governance models, sustainability priorities, and stakeholder engagement. Three main themes emerge:

1. Governance Models: The two cities employ distinct approaches; Barcelona adopts a hybrid model aligned with the Quadruple Helix framework, despite facing financial constraints and stakeholder interference that hinder scalability. In contrast, Dubai implements a top-down model that marginalizes community participation, limiting long-term societal transformation and inclusive decision-making.

2. Sustainability vs. Technological Growth: Dubai prioritizes technological leapfrogging, while Barcelona focuses on socio-environmental sustainability through initiatives such as the Superblocks project, aimed at reducing emissions. Experts warn that Dubai's approach risks exacerbating inequalities, whereas Barcelona's model may slow technological deployment.

3. Stakeholder Challenges: Both cities face common obstacles stemming from conflicting interests between investors and government entities, as well as financing gaps. Dubai struggles with unclear funding sources and transparency issues, while Barcelona grapples with reliance on unstable EU grants.

Implications for Policy and Practice

The research suggests a need for adaptable governance frameworks that effectively integrate citizen engagement with operational efficiency. Furthermore, decision-makers must prioritize funding for urban living lab initiatives that offer opportunities for innovative solutions to specific urban challenges. Further research is needed to fully understand the long-term effects of urban living labs on global sustainability. In Barcelona, urban living labs facilitate collaboration among citizens, businesses, researchers, and policymakers to devise urban solutions for energy efficiency and mobility. The 22@Barcelona innovation district uses smart technologies, public-private partnerships, and citizen engagement to identify scalable solutions. Conversely, Dubai adopts a top-down approach, which enables the expedited implementation of projects compared to Barcelona; urban living labs in this context support the objectives of smart city innovation. The Dubai Future Accelerators program plays a crucial role in testing AI and sustainable planning solutions.

Conclusion

Smart cities must be understood within the context of communication technology that integrates urban activities and all associated operational processes, with the participation of the city's citizens in these activities, as stated by Stevenson et al. (2006). The cooperation between the public and private sectors must also foster partnerships based on creative and

innovative strategic relationships rather than focusing solely on profit and loss. Therefore, urban living laboratories must be carefully designed to help engage the target groups. The Barcelona example highlights the importance of citizen participation and participatory governance in promoting inclusive and sustainable smart cities. The Dubai example highlights the importance of effective government leadership and partnerships with the private sector in driving innovation, creativity, and sustainable growth. Both approaches can be combined in a joint approach that helps integrate elements of both models, thereby achieving a balance between rapid technological progress and social inclusion. The research has shed light on the unique approaches and results of urban living laboratories in Barcelona and Dubai, and has formulated visions for policymakers, business leaders, and researchers interested in innovation in smart cities. It is worth noting that each city's model has its strengths and weaknesses, offering valuable lessons for other cities seeking to implement ULLs effectively. While ICT infrastructure is essential in smart cities, achieving smart city goals requires integrating top-down and bottom-up approaches to implement urban living labs (ULLs) effectively. The research finds that ULLs enable IoT policy coherence and meet the needs of local stakeholders. Yigitcanlar, T., & Cugurullo, F. (2023). Gonzalez et al. (2015) and Townsend (2015) suggest the emergence of a second generation of smart cities characterized by active and sustainable participation. They emphasize that achieving smart city goals requires integrating top-down and bottom-up approaches through the effective implementation of Urban Living Labs (ULLs). The research concluded by comparing Barcelona and Dubai. Haque (2011) emphasizes the need for more effective strategies in future urban planning. This study aims to provide a dataset for refining future ULL case studies in developing countries where ULL experiences are still in their early stages of development (Cosgrave et al., 2012). Urban planning decisions must involve all stakeholders, moving away from top-down decision-making. Analyzing various smart city cases can foster tailored approaches and assess the efficiency of urban living laboratories within innovation zones, as discussed by Alawadhi and Schupp (2021).

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