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Smart cities and communities in the GCC region: from top-down city development to more local approaches

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City planners are seeking ways to incorporate human-centric urban projects that combine smart technology, good infrastructure and people's perception as well as their participation. Smart city developments are increasingly being applied to smaller scales at which communities can co-design hard infrastructure and the resulting services. Experiences from city projects at this level have produced a plethora of designs, challenges and success factors, particularly from cases in countries with long legacies in city development. In the Gulf Cooperation Council region, young cities and new planned cities house the bulk of the population and face environmental challenges related to urban segregation, urban sprawl and large consumption footprints. The political-economy of this region in terms of central urban planning and government-led economic development offers valuable insights on the limits and challenges in implementing projects related to smart and connected communities (SCC). SCC as a label for smart urban interventions towards more connectedness between hard and soft (human-related) infrastructure can provide opportunities for participatory and sustainable urban planning in the region. This paper analyzes the role of community-level interventions within the smart city policies of Gulf countries. It shows that only few local-level projects exist, while the barriers to large-scale SCC initiatives are related to demographics, community characteristics, technological sophistication, lack of conducive regulations, and the prevalence of central urban planning. The success of local smart city approaches in the Gulf is dependent on public leadership in terms of clearing obstacles, designing broader strategies, and expanding projects to include the residential sector. Considering the potential of SCC projects to enhance the transition to sustainability in the predominantly urban Gulf societies, broader engagement of local governments, utilities, and community-level developers can result in tangible benefits in terms of more sustainable, smart and tailored local services.

KEYWORDS

connected communities, smart cities, urban policy, connected buildings, low-carbon growth, Gulf Cooperation Council

1 Introduction

City planners have sought to readjust smart city interventions in order to incorporate more human centric designs that encourage more interactions between citizens, technologies and institutional solutions (Siokas et al., 2021). Therefore, cities have encouraged the utilization of more modern technologies related to telecommunications, real-time processing, and the sharing of physical assets in order improve services or encourage citizens' participation (Garau et al., 2020; Raghava Rao and Kumar 2022). Smart city developments have also been applied to smaller scales such as campuses or compounds in which more interactions between people and hard infrastructure can be expected (Dameri et al., 2016). In this context, the idea of smart and connected communities (SCC) has emerged as a label for urban interventions towards achieving more connectedness and better services in urban communities (Al-Saidi and Zaidan, 2023). The SCC concept emphasizes the development of synergies through the use of technology, infrastructure, and local community participation (Damiani et al., 2017; Shaw and Sui, 2018; Sui and Shaw, 2018). However, SCC projects have shown a degree of variation with most cases on the challenges of implementing the SCC concept stemming from high-income countries in the Global North (Al-Saidi and Zaidan, 2023). So far, there is a lack of knowledge on the feasibility of SCC interventions in other political-economic contexts such as that of the Gulf Cooperation Council (GCC) region. City developments in the GCC region are dominated by top-down and state-centric urban planning as well as public investments. For this region, the SCC concept can offer valuable contributions towards more local and demand-driven urban development.

GCC countries are experiencing a technology-driven transformation towards a low-carbon and energy-efficient built environment (Al-Saidi and Elagib, 2018; Zaidan et al., 2019). This is reflected in region-wide efforts to adopt renewables, encourage the development of low-carbon smart cities (e.g., Masdar city in the United Arab Emirates and Lusail city in Qatar), and invest in ICT-based solutions for infrastructure (Saxena and Al-Tamimi, 2018; Al-Saidi and Zaidan, 2020). This push is a part of the highly publicized and controversial efforts of GCC governments to reshape urban development through mega-projects, centralized master planning, and westernized approaches conveying modernism and global affluence (Acuto, 2010; Aoun and Teller, 2016; Rizzo, 2017b; Zaidan, 2019). This is often contrasted with the conservative societies of the region, the large consumption footprints, and the preferences of local people for large and isolated residential houses rather than high-rise buildings or congested high-tech cities (Zaidan, 2019; Ansari et al., 2020). The GCC countries have a recent history of independence and modernization through the use of oil and gas revenues for economic growth that is dominated by the involvement of state companies. In order to encourage more urban sustainability in the Gulf and other parts of the world, it is important to rethink future directions for urban planning with the aim of achieving more participation and less environmental damage. The COVID-19 pandemic has not only been a global health crisis but also a time to rethink sustainability and the living spaces of communities (Rosa-Jimenez and Jaime-Segura, 2021). From empty streets to disruption of traffic patterns, it has been a living experiment about how cities may work in a different way, and a time to reflect on our place on Earth. Urban resilience has been, more than ever, a key factor in the way we conceive our urban future.

The SCC idea raises several questions with regard to the premise of "community" and its associated social aspects such as coherence, privacy, acceptability, and affordability. While forms of connected communities already exist in the region (e.g., through district cooling and centralized waste management), these technologies are often analyzed in terms of beneficial smart city applications that are provided via commercial (monopolistic) service providers at a district level (Mohasses, 2018; Al-Saidi and Zaidan, 2020; Zaidan and Abulibdeh, 2021). The benefits of connected communities in the region demand a broader discussion in terms of the scale and feasible/desirable directions. This can aid policymakers in designing city plans that combine prudent investment, smart technology, and community participation.

This paper analyzes the development of connected communities by focusing on the social context of urban planning in the Gulf region. Using interviews with experts and data on prominent case studies highlighted in the recent academic literature, it aims to localize community-level developments within smart city initiatives in the GCC region. The paper presents challenges for the implementation of SCC projects in city developments in the Gulf and critically reflects on the relevance of the SCC concept for this region. By studying these cases, the question arises as to whether the underlying urban development model in the GCC region can allow more local-level developments. In doing so, the paper highlights critical elements for the development of SCC projects in the region and connectedness aspects in major urban mega-projects. These critical elements include the leading applications and sectors of connection (e.g., energy, waste, cooling), the scale of the developments (e.g., commercial buildings, compact communities, or large smart cities), and organizational aspects (e.g., community cooperatives or centralized control).

2 Methodology

In order to contextualize the urban planning model of the smart city development in the region and assess the feasibility of more locally led approaches, this paper relies on a mixed method approach by using recent academic literature, expert interviews, and data from projects. Firstly, a literature review was conducted in order to assess the trend towards smart cities in the GCC region and identify prominent cases (See Sections 3 and 4.1). In this literature review, conducted in August 2021 using the Scopus database, we searched for all publications with any of the following words in the abstract, keywords, or title: smart cities, smart city, smart communities, smart community, connected communities, connected community. In addition, publications had to include any of the following country names: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, or the UAE. The resulting dataset of 155 entries was then sorted to exclude purely or predominantly technical papers, inaccessible papers (9 cases not available on common online platforms), or papers irrelevant to the region or topic (e.g., with only a peripheral relation to the topic or

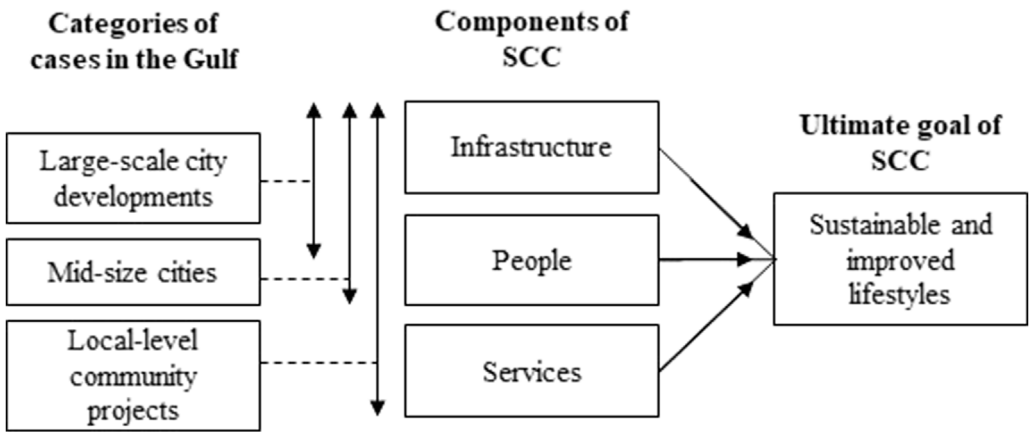

FIGURE 1
Layout of the analysis steps.

the region). The final dataset of 23 publications was then qualitatively analyzed using the software MAXQDA in order to code parts of the publications that may identify prominent cases and particular challenges (see Section 3.)

Secondly, expert interviews with seven academic experts from Qatar (3), Oman (1), the UAE (1) and non-Gulf universities (2) were conducted in 2022 with the aims of validating the selection of prominent cases, contextualizing the urban development model, and assessing the viability of community-level or locally led smart city interventions. These experts are university faculty with publications or academic track records on smart cities in the Gulf. Using these interviews and the mentioned literature review, several cases with varying levels of connectedness and participation were identified and later categorized in three main categories (Section 4.1). These three categories differ in terms of the scale (i.e., large, mid-size and small city developments) and the connectedness (i.e., connectedness increasing in smaller projects). Particularly local-level community projects cover more components of the SCC idea (see Figure 1). Besides, results from these interviews, together with insights from pertinent literature known to the authors (who have expertise on this topic) were used for the comparative contextualization of the smart city model in the GCC region and the assessment of the feasibility of more local approaches (See Sections 4.2 and 5). The assessment is carried out by reflecting on the key three components of SCC interventions (Figure 1). In pertinent academic literature, SCC projects are seen to incorporate both technical interventions related to advanced infrastructure or technologies for better connectedness (e.g., smart communication, energy or transport systems) and people's interaction (i.e., as collaborative users or in designing the community) (Damiani et al., 2017; Shaw and Sui, 2018; Sui and Shaw, 2018). Besides, smart services towards enhanced connectedness (e.g., connected buildings, smart sensors, etc.) have been a constituting component of SCC projects which should ultimately lead to improved lifestyles (e.g., easier access to services or cost savings) and sustainability (e.g., more energy efficiency and a smaller ecological footprint in general) (Al-Saidi and Zaidan, 2023).

3 The push towards smart cities in the Gulf region

GCC states have recently been interested in showcasing modernity and adopting new technologies for their (global) cities (Acuto, 2010; Aoun and Teller, 2016; Al-Saidi, 2020a). This notion is one factor explaining the push towards smart cities, and it is reflected in several megaprojects to construct futuristic planned cities across the region. Most of these cities exhibit modern ICT infrastructure and some smart applications, although not all of them include low-carbon interventions (Al-Saidi and Zaidan, 2020). Self-labeling and competition within and among some GCC countries to build more attractive and extravagant urban developments make the characterization of the smart city movement in the GCC region difficult. For example, many of the urban projects in Saudi Arabia are labeled under the category of industrial or economic cities. This label emphasizes the partnership with the private sector, but these cities do have some smart applications (e.g., smart grids, smart basic services, and high connectivity) (Aina, 2017). Similar developments in Qatar and the UAE are well publicized as smart, and even sustainable, cities. Using the academic literature selected for this paper, we highlighted some prominent cases in GCC countries (with the Kingdom of Saudi Arabia (KSA), Qatar, and the UAE providing most of these cases) and the thematic coverage of papers (Table 1). It is notable that most of the literature adopts a city-wide (and mostly technical) perspective, whereas local or community cases are scarce.

Another explanation for the push towards smart cities lies in environmental and economic considerations. GCC countries see technological updates and low-carbon urban development as a vehicle for economic diversification and ecological modernization (Al-Saidi and Elagib, 2018). In order to achieve this, they rely on ambitious national visions within which smart city initiatives are located. Smart city initiatives are reflected in e-government projects, innovation strategies, or specific smart city programs within the national visions (Saxena and Al-Tamimi, 2018; Asmyatullin et al., 2020). These initiatives are still maturing, and they are challenged by a wide range of contextual issues, as depicted in Table 2 using the selected literature. Although these challenges might be common to GCC countries, we describe them per country and publication since

TABLE 1 Thematic coverage and case studies of selected literature.

Country	Thematic coverage of literature	Prominent cases highlighted
Bahrain	Perceptions on smart urbanism and cities (Mamlook et al. (2019); Al Khalifa, (2021)); electric vehicles (Shareeda et al. (2021)); enterprise architecture and smart systems (Adwan. (2018); Nickahdar and Al Khalifa. (2019)); makerspaces and smart citizens (Almurbati. (2019)); smart cultural heritage (Khalaf. (2019))	No clear and prominent case; several infrastructure-related developments
Kuwait	Digital economy (Balnaves. (2018))	Several satellite smart cities under planning, such as the South Saad Al-Abdullah
Oman	Smart city development as a part of economic and national vision strategies in the GCC (Saxena and Al-Tamimi. (2018); Asmyatullin et al. (2020))	No clear and prominent case so far; Duqm Special Economic Zone mentioned as exhibiting smart digital infrastructure; Madinat Al Irfan as a future smart city
Qatar	End-of-time use of smart parking (Hefnawy et al. (2018)); eco-cities and smart city trends (Sodiq et al. (2019)); smart transportation and communication (Al-Thani et al. (2018))	Education city and Musheireb Downtown as existing smart city developments; Lusail city as a smart city under construction
Saudi Arabia	GeoICT applications (Aina. (2017)); acceptance of smart applications (IoT) (Albesher and Alhomoud. (2020)); assessment of smart city strategies (Doheim et al. (2019))	A range of planned Economic Cities as part of the Saudi smart city initiative; Yanbu and Jubail industrial cities as prominent economic cities; Neom city as a future smart mega-development
UAE	Cyber-physical systems (Khan et al. (2021)); informality and political economy of smart cities (Breslow. (2020)); stakeholder's perceptions of smart campuses (Ahmed et al. (2020)); eco-balance of planned smart cities (Madakam and Ramaswamy. (2016)); finance of infrastructure and industrial assets (Petratos. (2020)); smart government services (Obedait et al. (2019))	Smart Dubai as a "test bed" for smart applications; Masdar City as a prominent smart city; several smart campus initiatives

TABLE 2 Description of smart city challenges and impediments.

Challenge	Description
Demographics	In UAE, constantly changing population due to a high share of expats affecting the quality of smart services (Obedait et al. (2019))
Entrepreneurship	In Kuwait, lack of entrepreneurial skills hindering the development of digital businesses and communities (Balnaves. (2018))
Lack of regulations	In KSA, no legal frameworks for smart city implementation as in some other countries; e.g., India or Singapore, with national standards for projects lacking (Aina. (2017))
Knowledge	In several GCC countries, educational programs and skills related to ICT and smart applications are lacking (Aina. (2017); Mohasses. (2018); Almurbati. (2019); Doheim et al. (2019); Ahmed et al. (2020))
Security	Several issues related to ensuring confidentiality, secure access, and integrity of data reported in cases from the UAE (Ahmed et al. (2020); Khan et al. (2021))
Infrastructure and cost	Lack of infrastructure for electrical vehicles in Bahrain (Shareeda et al. (2021)); cost-recovery of smart application in the UAE (Ahmed et al. (2020)); some projects (including some Economic City projects) falling behind and lacking funds/financial sustainability in KSA (Aina. (2017))
Incentives and governmental support	Fragmented efforts and patchwork development of smart city projects in Dubai (Breslow. (2020)); need for governmental incentives to advance electric vehicles in Bahrain (Shareeda et al. (2021)); need for leadership in smart governance and digitalization of public works in KSA (Doheim et al. (2019))
Awareness, participation, and resistance	Lack of awareness and participation leading to resistance to change towards smart applications reported in several GCC countries (Mohasses. (2018); Ahmed et al. (2020); Albesher and Alhomoud. (2020); Shareeda et al. (2021))

it is difficult to measure their prevalence based on the current literature.

4 Results

4.1 Salient city developments

4.1.1 From city-wide smart city initiatives to large-scale, tech-based cities

The traditional approach to promoting smart city initiatives in the GCC region is highly planned and centralized, and local or bottom-up approaches towards more technology-based connectedness are rather rare. This baseline model is represented by national and city-level smart city initiatives that aim at enhancing the use of modern technologies in urban agglomerations; e.g., the Digital Oman Strategy, the Qatar Smart Program, the Smart Dubai Initiative, and the Saudi Smart City Initiative (Aina, 2017; Saxena and Al-Tamimi, 2018; Doheim et al., 2019). Another approach to smart cities in the GCC region relies on interventions in the built environments in newly planned cities as urban mega-projects (Aoun and Teller, 2016; Al-Saidi and Zaidan, 2020). Using the classification of smart city policies according to Angelidou (2014), the baseline approach is rather central or national, and relies largely on hard

TABLE 3 Levels of connectivity and collaboration in major planned smart cities in the GCC region.

Project	Scale of development (planned)	Connectivity technologies				Participation and collaborative arrangements		
		Smart grids	District cooling	Neighborhood-level controls	Connected buildings	Participatory planning and design	Residents–community interactions	Shared assets and management
NEOM City, KSA*	26,500 km^2	Yes	Yes	Yes	NA	NA	NA	NA
	500 bn USD							
Lusail City, Qatar	38 km^2	Yes	Yes	Yes	No	No	Partly	No
	45 bn USD							
Madinat Al Irfan, Oman*	4.9 km^2	Yes	Yes	Yes	NA	NA	NA	NA
	13 bn USD							
Yanbu Industrial City, KSA	185 km^2	Yes*	Yes	Yes	No	No	No	No
Jubail Industrial City, KSA	1,016 km^2	Yes*	Yes	Yes	No	No	No	No
	20 bn USD							
Musheirab Downtown City, Qatar	0.31 km^2	No	Yes	Yes	No	No	Partly	No
	5.5 bn USD							
Masdar City, UAE	2.3 km^2	Partly (pilots)	Yes	Yes	No	No	Partly	No
	22 bn USD							
Education City, UAE	14 km^2	No	Partly (e.g., Stadium)	Yes	No	No	Yes	No
	15 bn USD							

Source: Al-Saidi and Zaidan (2020), and descriptions from official websites including documents provided by project master planners. Fields with* indicate information based on Aina (2017).
NA: Information not available.

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infrastructure, in contrast to local strategies and those balancing hard and soft (human-centered) infrastructure.

Table 3 compares key hard and soft smart city interventions towards increased connectivity and participation in prominent cases of planned cities in the region. Around the world, connectedness through technologies and participation of communities targeted through smart city initiatives is increasingly popular (Ciasullo et al., 2020; Lung-Amam et al., 2021). While technologies such as smart grids and district cooling represent some of the oldest characteristics of smart communities (Deguchi, 2020; São José et al., 2021), more local smart technologies are now common. These technologies are becoming more accessible and widespread as major new cities in the Gulf region strive to incorporate them. In the case of Yanbu and Jubail, we could not verify the widespread use of smart grids in these large cities, although the use of these technologies is mentioned by Aina (2017). Neighborhood-level controls imply monitoring and optimization at smaller boundaries through smart systems for waste management, parking, traffic, and lighting (e.g., Azgomi and Jamshidi, 2018; Esmaeilian et al., 2018). All of the cities in Table 3 are incorporating some forms of these smart systems and deploying them at more local levels, although they are centrally managed or optimized. Connected buildings through shared assets and management (e.g., for energy optimization and exchange of surplus energy) are rarely used in these projects. For such a high level of connectedness, one would need a participatory design, closer interactions among communities (or between residents and community management), and the availability of shared (and jointly owned) assets (Ciaffi and Saporito, 2017; Damiani et al., 2017). These features are largely absent in large-scale smart cities, which emphasize technologies and hard infrastructure, while mid-sized and innovation-oriented cities have more collaborative features.

4.1.2 Flagship developments: mid-sized research, innovation, and cultural cities

While large-city developments exhibit some connectedness features through city infrastructure, they lack community-level participation, sharing of assets and participation. In contrast, mid-sized urban cities such as Musheirab, Masdar, or Education City exhibit more of these soft community-focused interactions. They represent a special type of urban mega-projects oriented towards the promotion of certain priorities in the region's national visions. As with other large cities, they are designed and planned through a top-down approach implemented by a master developer. As an example of the focus of these cities, Masdar City has largely been promoted as a low-carbon city. Despite being reoriented towards economic entrepreneurship after the 2014 oil price shock, it still incorporates sustainable design and harbors related R&D stakeholders (Griffiths and Sovacool, 2020). Similarly, Education City hosts several campuses of foreign universities and promotes the production, transfer, and preservation of knowledge (including heritage conservation). Musheirab Downtown City incorporates more mixed-use urban planning although it aims at urban revitalization and heritage preservation (e.g., through several museums). Such mid-sized and purpose-oriented developments represent flagship projects which can be oversized or may underperform in terms of some sustainability factors (Rizzo, 2017b). They are rather characterized as "theme cities" (Al-Saidi and Zaidan, 2020). They might not incorporate all the hard connectivity approaches through smart grids or district cooling, but they perform better in terms of human-related factors (see Table 3.) For example, there are more interactions between the community developers (the master planers) and the residents/users receiving services. In the case of Education City in Qatar, due to its vision of being a knowledge community, there are more interactions within the community through a joint identity, regular community-wide events, and stronger collaboration and contacts.

4.1.3 Connected campuses and industrial communities: some scattered developments

Local-level projects related to connected communities are relatively rare in Gulf countries, but they hold the potential for high connectivity and participation. Experts stress that most current developments are rather experimental at the level of homogeneous communities such as industrial hubs or university campuses. They report several research projects in Qatar and other countries experimenting with enhanced connectivity in single buildings (schools, colleges) as a nucleus for larger initiatives focusing on smart or connected educational campuses. A wider framework for a Smart Campus is provided in the UAE and is proposed for the American University in Sharjah based on several applications related to Internet of Things (IoT) and cloud computing platforms (Ahmed et al., 2020). Among the hurdles identified were reluctance to change in academic learning techniques, investment costs, data privacy agreements, a failover system to provide redundancy, and business continuity. In contrast, the primary facilitators were change management, willpower, a clear vision for smart transformation, technological awareness, incentives for faculty and students to deploy Smart Campus applications, adequate training, and motivation of all campus stakeholders (Ahmed et al., 2020).

Overall, the experts interviewed see local connectivity approaches through smart campuses as a viable future option for the Gulf region. Campuses are, in fact, considered to be viable candidates for smart and sustainable transformation due to their heterogeneous and flexible energy demands, available resources, clear asset ownership and management, public participation, and scale. These characteristics enable the framing of a knowledge- and resource-driven system that actively engages people within the system. Furthermore, smart campuses can function as responsive systems integrated into future smart and sustainable cities and societies. In an optimal case, a smart campus as a SCC (Figure 2) is typically equipped with different distributed energy resources (DER), energy storage systems (ESS), and district heating and cooling devices. The end-use loads associated with built environments and mobility can be managed and reshaped in response to the community's total supply and demand (Zaidan et al., 2022).

4.2 Comparative assessment and critical developments

4.2.1 The baseline model: a planned smart city

A recurrent theme in the understanding of urban smart city developments in the Gulf is the focus on top-down planned city

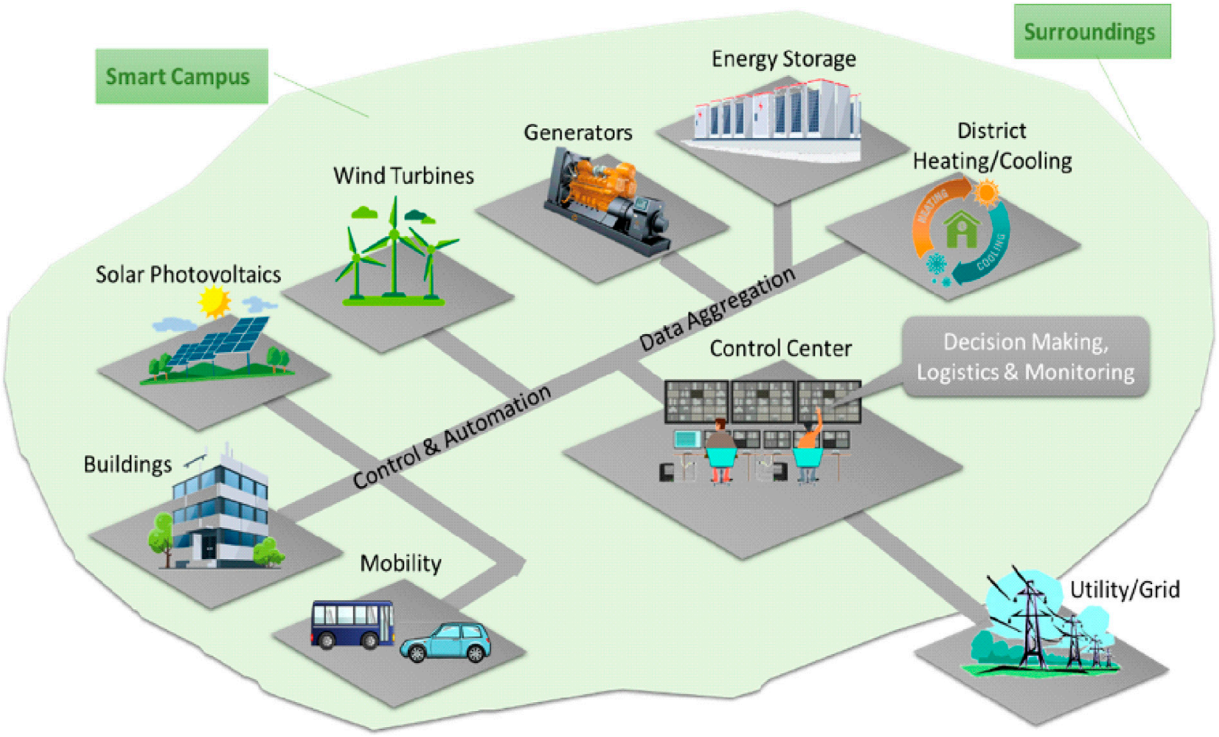

FIGURE 2
Architecture of a smart community as an example for smart campuses (reproduced from Zaidan et al., 2022, licensed under CC BY 4.0).

projects. The planned city model is a stable choice for governments across the region and is often rendered via (semi-)governmental master planners (e.g., property developers with state companies as majority shareholders), who solicit collaboration from other governmental and private stakeholders in realizing the planned city vision (Al-Saidi and Zaidan, 2020). Generally, developing planned cities is believed to accelerate the adoption of smart technologies in order to improve the sustainability of cities and spur innovation (Stace, 2020). Smart cities often establish a basis for investment opportunities from the private sector and coordinated planning among state agencies. Transport, communications, and energy efficiency are all gradually being transformed by new technologies, and planned cities are positioned to take full advantage of this transition. Through the commercialization of smart innovations including connectivity issues, planned cities are geared towards the highly important economic diversification goals of Gulf countries.

The smart planned city model deployed through technologies can fail to engage people in sustainability, which is crucial for making these solutions successful and ultimately accomplishing improvements in urban sustainable performance (Ghofrani et al., 2022). In contrast to top-down planned cities, community-level smart initiatives are largely lacking in the Gulf region despite the multiple benefits attested to them by the experts interviewed; e.g., energy democratization, community building through engagement and participation, improvements in environmental and energy literacy, and the promotion of environmental lifestyles. Smart communities provide important benefits, especially with regard to offering alternatives to existing energy systems while also taking into account citizens' active participation in energy generation, delivery, and consumption, as well as their policy perspectives. Aside from significant savings in energy consumption and lower emissions, the experts interviewed stressed that "energy-smart-connected" buildings and communities can offer new urban models for the Gulf region that are more "citizen-driven".

The prevalence of top-down "smart" planned cities and the lack of a critical mass of bottom-up smart communities was attributed to different reasons. SCC projects require collective action by local communities. The existence of collaborative and homogenous communities can be problematic in the Gulf. Many Gulf countries exhibit large expat communities who often stay for only short periods. While nationals prefer to reside in detached (and often large, multi-family) houses, residential compounds often house short-term tenants from various backgrounds. The outcomes of the connected community mainly depend on different assumptions about processes such as decision-making, participation and ownership, improved social capital, community empowerment, knowledge and skill development, as well as environmental education and attitudes. In the context of the Gulf region, these factors might not be favorable for residential communities engaging in collective ventures, particularly with regard to sharing assets, risks, and costs. Often, the property developer or the master planner introduces new technologies while the community members are required to pay for improved services.

4.2.2 People-centered communities? Connectedness, organization, and cooperation

The SCC idea focuses on both physical and human connections: i.e., among cooperating people and connected buildings or assets. It is represented by people who collaboratively and collectively address and optimize the community's social, environmental and cultural needs (Zaidan et al., 2022). It involves open participatory practices that are built on community members' involvement and their diverse local perspectives (Ghofrani et al., 2022). In particular, the community must address the reduction of fossil fuel usage creating the means (e.g., production) of providing clean energy. In many cases in Europe, for example, the community can invest in and operate community solar or wind farms, energy storage, and other joint assets. Moreover, the community can build smart cooperative controls and management tools to increase energy efficiency, or develop mechanisms to bring about safety, security, and privacy while using the technologies. Often, the same communities would engage in collective action to reduce waste in addition to reducing the need for non-value-added logistical and materials-handling operations, and for developing smart cooperative means for sharing resources, e.g., vehicles, local farming, etc. This wide range of SCC practices is not adequately reflected in the Gulf, according to the experts interviewed and the projects reviewed. SCCs in the Gulf region are rarely understood in terms of people-centered connections through community creation, place-making, or rule-based cooperation among residents.

SCC experiences in the Gulf region tend not to strengthen community participation and are less associated with bottom-up cooperation (citizen engagement and diversity of community actors); rather, they are based on top-down approaches. They are introduced by a top-down agency; e.g., state actors for government property, university management for smart campuses, or the property owners for industrial or residential compounds. In the Gulf region, the transformation to SCC is particularly difficult given the human involvement and the general population's attitude toward adapting to transformational changes. The whole idea of SCC is to collaborate and communicate for the betterment of the community and the city or region housing that community. As a result, due to the specifics of the Gulf region's social characteristics, this transformation requires public education and the raising of social awareness of environmental challenges. According to the experts' opinions, a possible way forward for the Gulf region is to start with implementing the SCC concept in the industrial and governmental sectors while gradually improving awareness and collaboration with the private sector to expand SCC projects to the residential urban sector. Consequently, a serious public effort to address the challenge of emission reduction at the community level and increased adoption of non-carbon energy sources in the Gulf region must acknowledge the community members' participation and consider their socio-economic factors.

4.2.3 Service myths: technological characterization and sophistication

From a technological and service perspective, the current applications deployed for the connected buildings and SCC in the Gulf region exhibit a rather low level of sophistication, mainly focusing on the deployment of smart appliances and sensors with little exchange among buildings. The case studies on SCC show the use of applications based on ICT, cyber-physical systems (CPS), IoT, and geoformation and communication technologies (GeoICT) (Aina, 2017; Adwan, 2018; Khan et al., 2021) For example, SCC applications mentioned by interviewees include smart meters and thermostats for optimizing energy use through learning of human preferences, occupancy patterns, building properties, and outside weather conditions. Moreover, soft collaborative controls between buildings are used in some new projects as an enabler for an online brokerage platform whereby building prosumers participate in daily or hourly auctions to sell or buy energy capacity. However, these collaborative controls are reported as not yet widely used in SCC projects in the Gulf region. While Gulf countries seek to integrate smart technologies in the procurement phase of their urban projects according to the cherished BAT (Best Available Technologies) rule, there is little local innovation with regard to smart appliances, and the technologies deployed might seem outdated on the commission of projects.

Opportunities to better connect buildings through clustering based on load profile to increase operational performance are not common in the Gulf region, despite being used elsewhere within the framework of smart building clusters (SBC) (Jafari-Marandi et al., 2016; Ma et al., 2016). Moreover, distributed energy systems are largely not used in the Gulf region, so that the idea of buildings or residents being "prosumers" of energy has yet to be disseminated. New SCC applications moving towards zero-energy systems are also in the initial phase, with many opportunities for them to be incorporated into newer projects. With the advent of new technologies, building operation performance can be enhanced by adopting smart control strategies, which, in turn, save a considerable portion of energy to transform the building into a zero-energy system (Li and Wen, 2014). Furthermore, recent advances in battery technology and the declining cost of electric vehicles (EVs) are reshaping roadway transportation, and more than ever before, the nexus between mobility and energy has become apparent. In the near future, buildings must also provide venues for timely charging of occupants' vehicles. With a growing number of EVs on the road and the ability to charge them at home or at public and private charging stations, demand for electricity is increasing, with a concomitant increase in load unpredictability. Considering these developments, local-level approaches such as SCC are quite relevant for countries in both the Global North and South.

4.2.4 Common appearance: extravagance, "worlding" and sustainability mirages

Many of the urban projects in the Gulf region have been characterized as "spectacular" urban endeavors where sometimes the form is more important than the function. The common goal of urban policymakers in the Gulf region is to showcase their cities as modern global cities exhibiting the newest technology and luxury lifestyles (Acuto, 2010; Aoun and Teller, 2016). Breslow (2020) explains this trend in the case of Dubai as a part of "worlding" strategies aimed at attracting high-value tourists and residents and integrating the city within the global economy. Smart city projects deliver such worlding, and they are a part of Dubai's "scale-making projects" towards the promotion of architectural imaginaries and attractive lifestyles (Breslow, 2020). In the case of Qatar, spectacular planned urban projects incorporating sustainability elements have

been criticized as being oversized, segregated, and thus always less oriented towards functionality or sustainability (e.g., more energy consumption or longer distances between buildings) (Rizzo, 2017a; 2017b). Similarly, low-carbon cities such as Masdar City in the UAE have indeed incorporated sustainable design, although it not yet clear whether it will ever match the original ambition of delivering a genuinely green or zero-carbon city (Crot, 2013; Griffiths and Sovacool, 2020).

Sustainability benefits of "building big" using high-tech smart applications might be mere "sustainability mirages," since cities will face environmental externalities of a (superfluously) high urban metabolism. With a range of spectacular and high-cost urban projects spreading across the Gulf region (Al-Saidi and Zaidan, 2020), one should question whether certain premises of connected communities are realistic. Commonly, such communities imply a democratization of urban designs based on community needs, assets, and preferences. Moreover, optimal controls within a building and its community can transform design practices from designing for maximum capacity requirements to setting design parameters within constraints bounded by optimal operating conditions. For these premises to succeed, a primacy of function should be practiced, rather than an orientation towards commonly pre-conceived sets of (spectacular) designs.

5 Discussion: co-developing connected and smart communities through public leadership

In this study, we have highlighted the dissemination and relevance of SCC projects within the context of the development of GCC countries. These Gulf countries have had varied SCC experiences, mostly focusing on experimenting with technology-based connectivity within and among buildings. The preferred approach in the Gulf region remains consistent with the planned smart city development through large-scale interventions in the built environment, particularly in new urban mega-projects. These projects are increasingly deploying neighborhood-level controls and a few connectivity technologies that are centrally managed. While this paper shows the current limitations of the wide dissemination of SCC projects in the Gulf, such limitations are not uncommon. SCC experiences worldwide show a large degree of complexity thus emphasizing the need for experimentation with local designs through iterative urban planning processes (Al-Saidi and Zaidan, 2023). This is in line with urban planning literature that recommends testing and evaluating urban designs (Gleye, 2014). Besides, it is important to adequately study the specific context inherent in the environment of SCC projects. For example, Japanese SCC projects have been facilitated by a strong involvement of municipalities, while European projects are embedded within city-wide projects that are often oriented towards EU sustainability policies (Al-Saidi and Zaidan, 2023). In contrast, the Gulf's context in terms of centralized planning, reliance on the governmental sector and the existence of demographically heterogenous communities has hindered the dissemination of local SCC projects, particularly at the residential sectors.

The future development of Gulf cities towards smart and low-carbon living is dependent on investments in the built environment and community development. This paper has already highlighted how SCC projects are slowly co-evolving due to demographic factors, design choices, and urban planning models specific to the context of the Gulf region. For the promotion of more local and community-based smart city development, the participation of government is essential due to its dominant role in urban planning in the Gulf region as policymaker, planner, property developer, and a major employer. The cases presented in the study have shown that the GCC governments are the driving forces of many large- and mid-size city developments. New urban cities in the Gulf are centrally planned and executed through property developers in which the GCC governments often hold the majority of assets (e.g., through sovereign wealth funds). Besides, the public sector also plays a significant role in small-scale SCC cases, e.g., projects implemented in campuses of universities (with large universities being public ones in the Gulf). In the following, we summarize based on previous analyses the directions for public leadership in allowing community-based projects in the Gulf region to co-evolve parallel to city-wide urban programs:

- *Rethinking smart urban development scale and carriers:* A return to greener, denser and more livable urban neighborhoods can reduce sprawl in the urban areas and enhance sustainability in the Gulf region. Urban planners need to encourage projects targeting the minimization of communities' impact on the natural systems while enhancing harmony with the natural surroundings along with human, social, and heritage preservation. People and communities are important elements of smart urban development, and their engagement is important for tackling key goals such as lowering energy efficiency. For example, as building cooling represents one of the largest energy-use sectors in the Gulf region – e.g., more than 60% in Qatar (Zaidan et al., 2022) – it is critical to emphasize behavioral aspects at community and individual levels, particularly in peak demand situations (e.g., the hot summer season).
- *Top-down strategies with bottom-up engagement:* Concepts such as SCC need to be mainstreamed within national- or city-level urban development strategies. SCC represent one conceivable means towards urban sustainability, specifically in the shift towards zero-carbon energy use through increased bottom-up engagement. Globally, this idea has gained increasing attention, particularly in the United States, Australia, Germany, the United Kingdom, and Denmark (MacArthur, 2017). In the Gulf region, there is a need for explicit policies and a purposeful anchoring of SCC into larger top-down strategies, including clear enabling policies and programs to enhance bottom-up urban engagement.
- *Clearing systemic hurdles:* Common systemic hurdles that can derail local approaches such as SCC include the lack of clear regulations, inadequate use of distributed systems, and the subsidies issue. Regulations that can facilitate smart city application or increased connections among buildings are rather vague in the Gulf region; e.g., issues related to co-ownership of assets, cooperatives, privacy, etc. (Badran, 2021). Moreover, most Gulf countries prefer utility-scale renewables

and lack laws or programs for distributed energy; e.g., lack of feed-in-tariff regulations (Almasri and Narayan, 2021). In many Gulf countries, energy is still highly subsidized (or even free for nationals), which can decrease interest in energy efficiency and the financial benefits of SCC (Al-Saidi, 2020b).

- *Promoting SCC pilots and leaders:* In order to encourage SCC projects, public leadership is important for creating pilot programs and leading by example in initiating SCC projects in the public sector; e.g., public universities, schools, or company assets. Special nationwide SCC programs in pioneer countries such as Japan have paved an important path for the dissemination of community-level projects (Graniera and Kudob, 2016). This paper has already reported difficulties in implementing increased connectivity in the residential sector. However, considering the importance of this sector within the total energy consumption, it is quite clear that it should be targeted in parallel at the industrial and public sectors. Certain residential areas in Gulf countries can exhibit a fair degree of social organization and community identity or engagement. Thus, they can function as good SCC pilots; e.g., long-standing downtown neighborhoods, tribally organized residential communities, or tight-knit compounds or districts.
- *Providing supporting infrastructure:* There is a range of supporting services to encourage SCC dissemination related to issues such as the infrastructure for distributed energy, district cooling infrastructure, or adequate transport systems through the promotion of pedestrian walkways and bicycle networks. In the GCC region, the built environment is still dominated by the car. Urban planners and designers need to incorporate more effective pedestrian and public transport systems to avoid sprawl and reduce gas emissions (Ghofrani et al., 2022).
- *Engagement of local governments and public service providers:* Leadership from local governments and public service providers is important, as many of current SCC projects involve these actors; e.g., municipalities for projects involving industrial areas or school complexes, and water and electricity utilities for all SCC projects. These actors need to understand urban environments as ecologically complex systems that are sensitive to the impacts of production and consumptions models. Commitments from local governments are important for tackling environmental impacts and building robust frameworks of global action. Local governments and actors are becoming leaders in testing, advancing, and demonstrating available technologies. City-level sectors such as energy, water, or transportation have a huge impact on our global footprint, and smart technologies are accelerating the adoption of more efficient and sustainable local solutions (Stace, 2020).

6 Conclusion: are more local smart and connected initiatives feasible?

Local approaches to smart and connected urban development capitalize on community participation in constructing demand-driven and tailored projects that result in improved services and better sustainability outcomes. A wide range of smart services can be locally developed and commonly managed, including electricity and cooling, waste management, transport solutions, or communication technologies. Cases on the implementation of community-level smart interventions have largely stemmed from the liberal democracies in the Global North where bottom-up community building is more feasible. This study reiterates the relevance of the political-economic context for the shape of feasible SCC interventions. It demonstrates only few applications of local SCC projects in the Gulf that incorporate connected and smart infrastructure, participatory planning and users' participation, as well as services utilizing shared assets. Largely, the SCC applications in the Gulf are oriented towards technological and infrastructure solutions related to resource use efficiency and sustainability in large- to midsize cities. As such, this paper contributes to academic literature emphasizing the need for experimentation with context-specific designs in implementing successful SCC interventions. In the Gulf, SCC understandings are co-evolving with the political economy and the shape of institutions governing the external context of smart urban projects.

Local projects emphasizing connectivity and smart applications are still possible in the Gulf, with an increasing number of projects focusing on public and industrial areas. For example, smart educational campuses represent important pilot projects for the SCC concept and are supported through utilities and governmental stakeholders. The expansion of these projects to the residential sector is important in order to capitalize on the benefits of SCC, particularly with regard to energy efficiency as a paramount concern for Gulf countries. However, the model of top-down planned smart cities rather than bottom-up-initiated SCC is encouraged by demographic and regulatory factors related to the relatively large communities of short-term expat workers, energy subsidies, lack of community organization, low environmental awareness, unclear privacy and security regulations, and co-ownership barriers. As a result, current local-level projects are rarely perceived as connecting people in terms of place-making or community-building. In this sense, it is important to consider these soft factors related to the characteristics of communities in different political-economic and cultural contexts. Communities without legacies of cooperation or a common identity can be challenging for a bottom-up development of SCC projects. Smart city developments need to consider long-term aspects related to community-building and place-making ahead of designing local interventions.

Policymakers and urban planners in the Gulf can support SCC projects through clearing obstacles, piloting projects, and establishing broader SCC strategies. As this study demonstrates, in centrally planned urban development, public leadership in encouraging local smart city projects plays a large role, e.g., in initiating projects at public universities, governmental compounds, or selected residential areas in new cities. The SCC concept holds important promises for both policymakers and communities in the Gulf region. SCC offers many built-in analytics that can help decision makers address paramount issues concerning low-carbon living. On the technology front, there are already many forms of promising technologies such as soft or smart thermostats and advanced controls for buildings. Together with technologies for smart vehicles, transport alternatives, and waste management, SCC can provide important sustainability and financial gains for cities. Moreover, flexibility in commercial or manufacturing settings and in local farms can benefit the community and aid in the development of

a transactional market for clean energy and demand reduction. For SCC in residential units to work, occupancy and usage patterns along with behavioral norms and variations need to be understood. Understanding the social elements of the community's private and commercial residents is critical to a successful implementation of SCC projects.

Smart and connected cities and communities are a part of a larger transition to zero-carbon societies. This study is limited by its regional scope that does not allow for detailed analysis of those community characteristics that can be conducive for certain SCC projects. Besides, the number of successful SCC projects at local levels is limited to few pilot projects that have not matured yet. Additional research is needed to examine the societal attitudes that facilitate the adoption of new technologies aimed at achieving zero-carbon societies in Gulf countries. Further research may focus on the bottom-up approaches to realizing the local community's shift towards a zero-carbon energy system and thus to energy sustainability from a social science perspective. For a city or a society to plan and implement the transformation process, there must be a set of initial options, which may grow over time. For this reason, a set of well-defined ideas and critical factors that are relevant for the success of zero-carbon transition projects at the local level should be identified in the context of the Gulf countries. The further development of local-level approaches to smart and connected urban developments in the Gulf is highly needed through the engagement of urban planners while involving actors from industry, academia and the targeted communities.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

Author contributions

MA-S: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Validation, Visualization, Writing–original draft, Writing–review and editing. EZ: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Validation, Visualization, Writing–original draft, Writing–review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Acuto, M. (2010). High-rise Dubai urban entrepreneurialism and the technology of symbolic power. *Cities* 27, 272–284. doi:10.1016/j.cities.2010.01.003

Adwan, E. J. (2018). "Towards a technological reference model of Bahraini smart city," in Smart Cities Symposium, Bahrain, April, 2018, 1–9.

Ahmed, V., Abu Alnaaj, K., and Saboor, S. (2020). An investigation into stakeholders' perception of smart campus criteria: the American university of Sharjah as a case study. *Sustainability* 12, 5187. doi:10.3390/su12125187

Aina, Y. A. (2017). Achieving smart sustainable cities with GeoICT support: the Saudi evolving smart cities. *Cities* 71, 49–58. doi:10.1016/j.cities.2017.07.007

Albesher, A. A., and Alhomoud, A. (2020). Determinants towards a better acceptance model of IoT in KSA and eradication of distrust in omnipresent environments. *IJACSA* 11. doi:10.14569/ijacsa.2020.0111264

Al Khalifa, F. (2021). An approach to define smart sustainable urbanism locally through expert's perspective. *Int. J. Sustain. Build. Technol. Urban Dev.* 12, 14–26. doi:10.22712/susb.20210003

Almasri, R. A., and Narayan, S. (2021). A recent review of energy efficiency and renewable energy in the Gulf Cooperation Council (GCC) region. *Int. J. Green Energy* 18, 1441–1468. doi:10.1080/15435075.2021.1904941

Almurbati, N. A. (2019). "The role of makerspaces and smart citizens in shaping Bahrain as a smart city," in 2nd Smart Cities Symposium (SCS 2019). Institution of Engineering and Technology, Bahrain, Bahrain, March, 2019.

Al-Saidi, M. (2020a). From economic to extrinsic values of sustainable energy: prestige, neo-rentierism, and geopolitics of the energy transition in the arabian peninsula. *Energies* 13, 5545. doi:10.3390/en13215545

Al-Saidi, M. (2020b). Instruments of energy subsidy reforms in Arab countries — the case of the Gulf Cooperation Council (GCC) countries. *Energy Rep.* 6, 68–73. doi:10.1016/j.egyr.2019.08.020

Al-Saidi, M., and Elagib, N. A. (2018). Ecological modernization and responses for a low-carbon future in the Gulf Cooperation Council countries. *WIREs Clim. Change* 9, e528. doi:10.1002/wcc.528

Al-Saidi, M., and Zaidan, E. (2020). Gulf futuristic cities beyond the headlines: understanding the planned cities megatrend. *Energy Rep.* 6, 114–121. doi:10.1016/j.egyr.2020.10.061

Al-Saidi, M., and Zaidan, E. (2023). Understanding and enabling "communities" within smart cities: a literature review. *J. Plan. Literature*, 08854122231202739. doi:10.1177/08854122231202739

Al-Thani, S. K., Skelhorn, C. P., Amato, A., Koc, M., and Al-Ghamdi, S. G. (2018). Smart technology impact on neighborhood form for a sustainable doha. *Sustainability* 10, 4764. doi:10.3390/su10124764

Angelidou, M. (2014). Smart city policies: a spatial approach. *Cities* 41, S3–S11. doi:10.1016/j.cities.2014.06.007

Ansari, M. A., Ahmad, M. R., Siddique, S., and Mansoor, K. (2020). An environment Kuznets curve for ecological footprint: evidence from GCC countries. *Carbon Manag.* 11, 355–368. doi:10.1080/17583004.2020.1790242

Aoun, O., and Teller, J. (2016). Planning urban megaprojects in the Gulf: the international consultancy firms in urban planning between global and contingent. *Front. Archit. Res.* 5, 254–264. doi:10.1016/j.foar.2016.01.003

Asmyatullin, R. R., Tyrkba, K. V., and Ruzina, E. I. (2020). Smart cities in GCC: comparative study of economic dimension. *IOP Conf. Ser. Earth Environ. Sci.* 459, 062045. doi:10.1088/1755-1315/459/6/062045

Azgomi, H. F., and Jamshidi, M. (2018). "A brief survey on smart community and smart transportation," in 2018 IEEE 30th International Conference on Tools with Artificial Intelligence (ICTAI), Volos, Greece, November, 2018, 932–939.

Badran, A. (2021). Developing smart cities: regulatory and policy implications for the state of Qatar. *Int. J. Public Adm.* 46, 519–532. doi:10.1080/01900692.2021.2003811

Balnaves, M. (2018). "Digital economy planning in Kuwait," in 2018 11th CMI International Conference: Prospects and Challenges Towards Developing a Digital Economy within the EU, Copenhagen, Denmark, November, 2018, 32–37.

Breslow, H. (2020). The smart city and the containment of informality: the case of Dubai. *Urban Stud.* 58, 471–486. doi:10.1177/0042098020903233

Ciaffi, D., and Saporito, E. (2017). "Shared administration for smart cities," in *Smart cities atlas: western and eastern intelligent communities*. Editors E. Riva Sanseverino, R. Riva Sanseverino, and V. Vaccaro (Cham, Germany: Springer International Publishing), 243–248.

Ciasullo, M. V., Troisi, O., Grimaldi, M., and Leone, D. (2020). Multi-level governance for sustainable innovation in smart communities: an ecosystems approach. *Int. Entrepreneursh. Manag. J.* 16, 1167–1195. doi:10.1007/s11365-020-00641-6

Crot, L. (2013). Planning for sustainability in non-democratic polities: the case of masdar city. *Urban Stud.* 50, 2809–2825. doi:10.1177/0042098012474697

Dameri, R. P., Negre, E., and Rosenthal-Sabroux, C. (2016). "Triple helix in smart cities: a literature review about the vision of public bodies, universities, and private companies," in 2016 49th Hawaii International Conference on System Sciences (HICSS), Koloa, HI, USA, January, 2016, 2974–2982.

Damiani, E., Kowalczyk, R., and Parr, G. (2017). Extending the outreach: from smart cities to connected communities. *ACM Trans. Internet Technol.* 18, 1–7. doi:10.1145/3140543

Deguchi, A. (2020). "From smart city to society 5.0," in *Society 5.0. A people-centric super-smart society/hitachi-UTokyo laboratory (H-UTokyo lab.)*. Editor Hitachi-UTokyo Laboratory (Singapore: Springer Open), 43–65.

Doheim, R. M., Farag, A. A., and Badawi, S. (2019). "Chapter 17 - smart city vision and practices across the Kingdom of Saudi Arabia—a review," in *Smart cities: issues and challenges*. Editors A. Visvizi, and M. D. Lytras (Amsterdam, Netherlands: Elsevier), 309–332.

Esmaeilian, B., Wang, B., Lewis, K., Duarte, F., Ratti, C., and Behdad, S. (2018). The future of waste management in smart and sustainable cities: a review and concept paper. *Waste Manag.* 81, 177–195. doi:10.1016/j.wasman.2018.09.047

Garau, C., Desogus, G., and Zamperlin, P. (2020). "Governing technology-based urbanism: technocratic governance or progressive planning?," in *The Routledge companion to smart cities*. Editors K. S. Willis, and A. Aurigi (Abingdon, Oxon, New York, NY: Routledge Routledge international handbooks), 157–174.

Ghofrani, A., Zaidan, E., and Abulibdeh, A. (2022). Simulation and impact analysis of behavioral and socioeconomic dimensions of energy consumption. *Energy* 240, 122502. doi:10.1016/j.energy.2021.122502

Gleye, P. H. (2014). City Planning Versus Urban Planning: Resolving a Profession's Bifurcated Heritage. *J. Plan. Lit.* 30, 3–17. doi:10.1177/0885412214554088

Graniera, B., and Kudob, H. (2016). How are citizens involved in smart cities? Analysing citizen participation in Japanese ``Smart Communities. *Inf. Polity* 21, 61–76. doi:10.3233/ip-150367

Griffiths, S., and Sovacool, B. K. (2020). Rethinking the future low-carbon city: carbon neutrality, green design, and sustainability tensions in the making of Masdar City. *Energy Res. Soc. Sci.* 62, 101368. doi:10.1016/j.erss.2019.101368

Hefnawy, A., Bouras, A., and Cherifi, C. (2018). "Does end of life matter in smart cities?," in 15th IFIP International Conference on Product Lifecycle Management (PLM), Turin, Italy, July, 2018, 442–452.

Jafari-Marandi, R., Hu, M., and Omitaomu, O. A. (2016). A distributed decision framework for building clusters with different heterogeneity settings. *Appl. Energy* 165, 393–404. doi:10.1016/j.apenergy.2015.12.088

Khalaf, M. (2019). "Smart cultural heritage: technologies and applications," in 2nd Smart Cities Symposium (SCS 2019), Bahrain, Bahrain, March, 2019, 1–6.

Khan, F., Kumar, R. L., Kadry, S., Nam, Y., and Meqdad, M. N. (2021). Cyber physical systems: a smart city perspective. *IJECE* 11, 3609. doi:10.11591/ijece.v11i4.pp3609-3616

Li, X., and Wen, J. (2014). Review of building energy modeling for control and operation. *Renew. Sustain. Energy Rev.* 37, 517–537. doi:10.1016/j.rser.2014.05.056

Lung-Amam, W., Bierbaum, A. H., Parks, S., Knaap, G.-J., Sunderman, G., and Stamm, L. (2021). Toward engaged, equitable, and smart communities: lessons from west baltimore. *Hous. Policy Debate* 31, 93–111. doi:10.1080/10511482.2019.1672082

Ma, L., Liu, N., Wang, L., Zhang, J., Lei, J., Zeng, Z., et al. (2016). Multi-party energy management for smart building cluster with PV systems using automatic demand response. *Energy Build.* 121, 11–21. doi:10.1016/j.enbuild.2016.03.072

MacArthur, J. L. (2017). Trade, tarsands and treaties: the political economy context of community energy in Canada. *Sustainability* 9, 464. doi:10.3390/su9030464

Madakam, S., and Ramaswamy, R. (2016). Sustainable smart city: masdar (UAE) (A city: ecologically balanced). *Indian J. Sci. Technol.* 9, 1–8. doi:10.17485/ijst/2016/v9i6/87669

Mamlook, R., Al-Jayyousi, O., Alabyooki, S., and Attallah, S. A. A. (2019). "Smart city and technology transfer: towards sustainable infrastructure in Bahrain," in *Research and innovation forum 2019*. Editors A. Visvizi, and M. D. Lytras (Cham, Germany: Springer International Publishing), 255–268.

Mohasses, M. (2018). "How Dubai is becoming a smart city?," in 2019 International Workshop on Fiber Optics in Access Networks (FOAN), Sarajevo, Bosnia and Herzegovina, September, 2019.

Nickahdar, F. A., and Al Khalifa, F. A. (2019). "Smart sustainable neighborhood design: a prototype for Bahrain," in 2nd Smart Cities Symposium (SCS 2019). Institution of Engineering and Technology, Bahrain, Bahrain, March, 2019.

Obedait, A. A., Youssef, M., and Ljepava, N. (2019). "Citizen-centric approach in delivery of smart government services," in *Smart technologies and innovation for a sustainable future*. Editors A. Al-Masri, and K. Curran (Cham, Germany: Springer International Publishing), 73–80.

Petratos, P. (2020). "Sustainability and financing project: the UAE paradigm," in *Sustainable development and social responsibility—volume 1*. Editors M. Mateev, and J. Nightingale (Cham: Springer International Publishing), 163–170.

Raghava Rao, K., and Kumar, D. S. (2022). "Smart city governance using big data technologies," in *Advanced analytics and deep learning models* (Hoboken, New Jersey, United States: Wiley), 311–324.

Rizzo, A. (2017a). Sustainable urban development and green megaprojects in the Arab states of the Gulf Region: limitations, covert aims, and unintended outcomes in Doha, Qatar. *Int. Plan. Stud.* 22, 85–98. doi:10.1080/13563475.2016.1182896

Rizzo, A. (2017b). Why knowledge megaprojects will fail to transform Gulf countries in post-carbon economies: the case of Qatar. *J. Urban Technol.* 24, 85–98. doi:10.1080/10630732.2017.1311569

Rosa-Jimenez, C., and Jaime-Segura, C. (2021). Living space needs of small housing in the post-pandemic era: malaga as a case study. *JCUA* 6 (1), 51–58. doi:10.25034/ijcua.2022.v6n1-5

São José, D. de, Faria, P., and Vale, Z. (2021). Smart energy community: a systematic review with metanalysis. *Energy Strategy Rev.* 36, 100678. doi:10.1016/j.esr.2021.100678

Saxena, S., and Al-Tamimi, T. A. S. M. (2018). Visioning "smart city" across the Gulf cooperation Council (GCC) countries. *foresight* 20, 237–251. doi:10.1108/fs-11-2017-0068

Shareeda, A., Al-Hashimi, M., and Hamdan, A. (2021). Smart cities and electric vehicles adoption in Bahrain. *J. Decis. Syst.* 30, 321–343. doi:10.1080/12460125.2021.1911024

Shaw, S.-L., and Sui, D. (2018). *Human dynamics research in smart and connected communities*. Cham: Springer International Publishing.

Siokas, G., Tsakanikas, A., and Siokas, E. (2021). Implementing smart city strategies in Greece: appetite for success. *Cities* 108, 102938. doi:10.1016/j.cities.2020.102938

Sodiq, A., Baloch, A. A., Khan, S. A., Sezer, N., Mahmoud, S., Jama, M., et al. (2019). Towards modern sustainable cities: review of sustainability principles and trends. *J. Clean. Prod.* 227, 972–1001. doi:10.1016/j.jclepro.2019.04.106

Stace, S. (2020). "Australian NUP—lessons to Be learnt," in *Developing national urban policies: ways forward to green and smart cities*. Editors D. Kundu, R. Sietchiping, and M. Kinyanjui (Singapore: Springer Singapore), 377–405.

Sui, D., and Shaw, S.-L. (2018). "Outlook and next steps: from human dynamics to smart and connected communities," in *Human dynamics research in smart and connected communities*. Editors S.-L. Shaw, and D. Sui (Cham: Springer International Publishing), 235–245.

Zaidan, E. (2019). Cultural-based challenges of the westernised approach to development in newly developed societies. *Dev. Pract.* 29, 570–581. doi:10.1080/09614524.2019.1598935

Zaidan, E., and Abulibdeh, A. (2021). Master planning and the evolving urban model in the Gulf cities: principles, policies, and practices for the transition to sustainable urbanism. *Plan. Pract. Res.* 36, 193–215. doi:10.1080/02697459.2020.1829278

Zaidan, E., Al-Saidi, M., and Hammad, S. H. (2019). Sustainable development in the Arab world – is the Gulf Cooperation Council (GCC) region fit for the challenge? *Dev. Pract.* 29, 670–681. doi:10.1080/09614524.2019.1628922

Zaidan, E., Ghofrani, A., Abulibdeh, A., and Jafari, M. (2022). Accelerating the change to smart societies-a strategic knowledge-based framework for smart energy transition of urban communities. *Front. Energy Res.* 10. doi:10.3389/fenrg.2022.852092