Public Space and Solid Waste Facilities in Makkah

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Abstract
Rapid urban development and modernization in Makkah have led to an increase in urban infrastructure needs. The city of Makkah is a main destination for the global Islamic pilgrimage and is highly utilized for major infrastructure and building expansion including processes of densification. As a consequence of Hajj and Umrah activities, the city experiences a major annual upward trajectory of public space usage and solid waste production which caters to the needs of temporary activities targeted to foreign visitors. These circumstances lead to issues of inefficiencies in the management of public services in the city, particularly in the provision of public space and solid waste management for residents. Within this context, the aim of this paper is to understand the development of public space in Makkah and the level of services delivered to local residents based on residents’ perspectives on services provided in formal and informal settlements in Makkah. The study contributes to the gap in research on public space and waste handling in Makkah. Interviews addressing resident characteristics and public space with the quality of solid waste provision in Makkah are presented. An explanation of residents’ preferences for public space was also presented. At different times of the day, in the year 2018, the observations were carried out to identify usage patterns by the residents. The paper accomplishes this by presenting significant points for developments in community space and solid waste management.

Keywords Public space · Solid waste · Access · Formal · Informal settlement

Introduction
Public space plays an important role in sustaining a healthy urban environment. Public space functions not only as a physical conduit for human interaction (Radywyl and Biggs 2013) but reflects the cultural production of built and un-built spaces in terms of socio-economics, culture, and environment (Roggema 2009; Alberti 2008). Public space is necessary to maintain a balanced urban environment, including aesthetic, economic, and social-cultural aspects of the city. Importantly, public space is a form of common goods also facing Hardin’s tragedy of the commons (Hardin 1968).

In strategic locations of the city such as city centers, public space is highly utilized by the residents as well as visited by tourists. Making public spaces attractive for urban residents and foreigners is necessary as it provides multiple activities such as shopping and cultural festivals, and facilities including supporting local economies. On the other hand, public spaces are in high competition with other functions that may be considered more economical as compared to private facilities. In many cases, the provision of adding

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more public space is cost-effective compared to other private and public uses when considering the “free access” it provides to all types of residents.

With increasing densification and pressures for urban renewal, public spaces are facing issues caused by overcrowding and inadequate provision of supporting facilities and activities (Radywyl and Biggs 2013). Public spaces in central locations are subject to increasing risks of safety and declining amenity, while others located in remote and “edge” locations are abandoned and turn into informal dumping grounds. Public spaces including built and unbuilt spaces which function as seasonal tourist attractions often experience user congestion in peak periods while being virtually empty at other times. In this setting, management of public services such as handling significant gaps in waste production, electricity, and water distracts from providing a regular level of services (Alkhalidy 2009; Imam 2017).

Public spaces in the Global South face more diverse challenges as towns and cities experience different modes of urbanization. They have enhanced ways of existing and prolonged community prospects of reconstruction. It is observed that they are unsuccessful to convert urban surroundings to reflect resident principles that mutually form residential and community places (Suhartini and Jones 2020). The provision of formal public space and other basic infrastructure is provided in designated plans and often does not cover the needs of the population in informal settlements (Suhartini and Jones 2019). Using minimum standards for public service provision, public space in these cities is often not properly designed and built to accommodate residents’ needs. In many cases, public space functions mainly as a green space and is not available for other community uses such as children’s play areas and sanitation facilities. Dysfunctional public space also results from land being ‘space leftovers’ (Lee and Maheswaran 2011) leading to unsafe environments which are linked to residents’ needs (Neal 2009). Properly planned public space provision in informal settlements is almost rare and usually evolves from the self-built actions of the local community using vacant space or abandoned private land (Suhartini and Jones 2020). As settlements densify, residents encroach onto roads and sidewalks for use as “public spaces” for playing, gathering, and holding ceremonies (Osra and Jones 2018). Furthermore, these incidental “public spaces” do not comply with mainstream planning and design standards and often lack supporting basic infrastructures such as clean water, proper drainage, solid waste facilities, and toilets. Subsequently, public spaces become places to leave household and human waste which then impacts the overall quality of the neighborhood.

In the above context, this paper examines the relationship between the provision of public space and the impact on solid waste management in cities of the Global South. Firstly, the paper discusses the notion of public space and how it relates to the provision of solid waste handling. Secondly, the paper explores a case study of Makkah, Saudi Arabia. This latter city is the main destination for global Islamic pilgrimages of Hajj and Umrah and faces major issues of overcrowded public spaces as well as the peak production of solid waste. During the Hajj season, a mechanism including sustainability also exploited the comprehensive practices to reserve in this region. Due to this, it is required to rely on the value of a circular economy and get high productivity in the exploitation of capital (Osra et al. 2021).

### Material and methodology

This part discusses the methods used to collect and analyze the data to address the research aim. The study’s aim was addressed by investigating urban development in Makkah, namely, the Al-Khalidyah district to understand the development of public space in Makkah and the level of services delivered to local residents based on residents’ perspectives on services provided in formal and informal settlements.

It is important to identify the philosophical background of a research study because it affects the research process and outcomes (Bernard 2013; Berry and Otley 2004; Creswell and Creswell 2018; Neuman and Robson 2014; Thornhill et al. 2009; Wahyuni 2012). This is because the selected research paradigm shapes the procedural framework that is used to understand a specific social phenomenon.

Thus, the case study design provided an acceptable research strategy in the current study since it provides a detailed insight into a phenomenon in its natural setting. (Wahyuni 2012; Woodside 2010; Yin 2012). The case study design, in particular, provides the chance to undertake holistic research in Al-Khalidyah by assessing the public space and the degree of services given to residents at the local level. This design includes the collection of multiple sources of data, which enhances the researcher’s ability to explain certain processes and outcomes.

### Case study design

This section describes the case study design and justifies its use in this study. The case study design is employed in many fields, including sociology and cultural studies. It is used to look into people, organizations, or behaviors at a certain time and location. Case studies might be based solely on qualitative data gathering methods or on a combination of methodologies.

This study adopted Yin’s (2009, p. 18) definition of the approach: “A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between the object of study and context are not evident.”
The contexts of this study are formal and informal settlements in the Al-Khaldiyah district. There are no noticeably established boundaries between these contexts and the objects of study, namely, public spaces, services, and residents’ views. This design allowed the researchers to investigate a real-life phenomenon in its natural context and develop a constructive sense of validity by establishing a chain of evidence from multiple sources.

**Data resources**

To achieve the above, two main methods have been used. Firstly, the structured interviews with residents who live in the Al-Khalidyah district. Thus, 204 people were interviewed to address resident characteristics in the Al-Khalidyah district, and their views on public space as well as the quality of solid waste provision are presented. This includes an explanation of residents’ preferences for public space and solid waste in their neighborhood. Secondly, the site observations. Thus, general observations were carried out at different times of the day (morning and evening) to identify usage patterns of public spaces by the residents. Secondly, in-depth observations and spatial analyses were conducted in Al Khalidyah District in 2018, before the Covid-19 pandemic, when no gathering restrictions were being in place to present key points for improvements to public space and solid waste management. The observations were recorded in the form of field notes, photographs, sketches, and maps to identify the nature of using public spaces, solid-waste types, a form of expression at different urban levels, solid waste disposal methods, public and private interface, and any modifications that residents might have made to public spaces to reflect their desires, views, and aspirations.

**Data analysis**

Firstly, the structured interviews in the form of questionnaires were conducted with the residents in the Al-Khalidyah district to collect data on baseline information about the residents, public space types, the characteristics of public spaces, the nature of usage, the satisfaction of residents with public spaces, and the solid-waste disposal preferences. Both descriptive and correlational analyses were performed using Microsoft Excel software. The items in the survey instrument used a 5-point Likert scale: (5) very good, (4) good, (3) average, (2) poor, and (1) very poor.

Secondly, a systematic analysis of the observational data was performed with a specific focus on the above aspects, to understand the development of public space in Makkah and the level of services delivered to local residents based on residents’ perspectives on services provided in formal and informal settlements. Two main strategies were used to examine the data. First, photos were used to explore residents’ social practices, such as gathering, playing, and running night markets in public spaces. Second, sketches and maps were used to identify how residents start to change the functions of streets, sidewalks, and open spaces according to their activities.

**The relationship between public space and public waste**

Public space is defined as a social and physical space that is accessible for all regardless of their socio-economic attributes and backgrounds (UNESCO (Eds) 2017). The use of public space is varied ranging from passive and active recreation space to spaces used for tourist attractions, biodiversity, environmental quality, and the role of the “lungs” of the city (Radywyl and Biggs 2013) as well as space for accommodating political activities (Neal 2009). The benefits of urban open space include improving environmental quality as well as improving local aesthetics (Imam 2017).

Public space has become an inseparable part of the urban form and structure of the city that functions for social and economic uses. Public space connects different urban forms while accommodating cultural and knowledge interactions at different scales (Radywyl and Biggs 2013). Regardless of the scale, public space provision and management are key components of urban management, design, policy, and development. Safety and security features such as lights, ramps, footpaths, and surveillance facilities are key elements of vibrant public spaces to facilitate accessibility for all residents (HABITAT 2015). Adequate basic infrastructure provision in public space such as the provision and servicing of publicly placed bins for the collection of waste and recycling.

Ensures a “comfortable environment” for the users. Well-utilized urban public space increases the users’ desire and interest to maintain public space, especially in terms of maintaining cleanliness and assisting in surveillance to ensure socially acceptable functions. Vice versa, poorly maintained and designed public space often reflects low access and participation from residents to utilize and maintain such facilities.

Notwithstanding its importance in the Global South, public space management is less prioritized in urban planning and policy than urban development needs such as water and sanitation. Policies and strategies for managing public space struggle to keep up with the growing complexity of “on the ground” arising in public space management (Duivenvoorden et al. 2020). Poorly designed public space is often used as refuse areas for waste dumping while facilitating crime caused by poor maintenance (Lee and Maheswaran 2011). Thus, understanding the different functions of public
space at different scales and in their local contexts may provide valuable inputs for innovative solutions in multiscale analysis (Duivenvoorden et al. 2020).

More recently, the discussion on public space has shifted to the role of multifunctional public space responding to increasing needs of space under the pressure of urban expansion. Multifunctional space in the context of urban management and planning comprises open space with different functions at different times such as accommodating economic, social, and cultural interaction (HABITAT 2015). Cities of the Global North have intensively applied models of mix-use of public space in urban management, design, and planning to anticipate over-utilization of public space at peak times. Depending on their role, multifunctional space is designed with a mix of facilities such as waste recycling stations, sanitation facilities, open space, shops, and other amenities and is usually managed by a municipal board, a private company, and a joint venture. This model of integration addresses the challenges of limited public space availability in the city centers as well as the need for maintaining city cleanliness and supporting the wider urban economy. Despite the above, the main attention has been on the quantity of public space rather than focusing on how public space may support the functions of specific user needs while enhancing the quality of urban areas (Zivkovic et al. 2019). This includes public spaces which are subject to intermittent high usage and peak loads, and which generate considerable amounts of waste that must be properly managed to minimize risks to public health and the environment. In this setting, demand for public services such as the timely collection and removal of public waste as well as sanitation facilities are a priority to facilitate a “whole of place” response (Zivkovic et al. 2019; Zorpas et al. 2021; Loizia et al. 2021; Voukkali et al. 2021).

Urban expansion and development pressure in Makkah

Makkah City is positioned in the Kingdom of Saudi Arabia, at a latitude of 20°, 210 N and a longitude of 39° 45′, 400 00′ E. The city is 326 m above sea level in Arabian Peninsula, with a desert climate and average temperature range from 18 to 40 °C. The province of Makkah is the largest in Saudi Arabia comprising an area of 153,148 km² and including 12 municipalities, namely, Al Jumum, Al Kamil, Al Khurmah, Al-Lith, Al Qunfudah, Taif, Jeddah, Khulays, Makkah al Mukarramah, Rabigh, Ranyah, Turubah, and Adham (Majrashi 2017). In 2017, the population of Makkah was 8,557,666 persons with a density of 56 persons/km² in 2017. Makkah has the largest population within productive age groups (see Figs. 1 and 2).

As studied by Aina et al. (2013), urban form in Makkah before modernization in Saudi Arabia was characterized by strong Arabic traditional settlement patterns which focused on the importance of private and public space centered on Islamic values. Traditionally, urban space expressed a balance of religious, social, cultural, and environmental values as embedded in urban form and structure. Public space was provided to be sufficient to cover social needs, avoid spatial redundancy, and be designed to adapt to the desert climate and harsh environment. Incremental change, instead of large-scale development, was apparent during the pre-modernization period in the mid-1800s. This vernacular urban pattern is recognized as the heritage of Arabian architecture and design, characterizing the traditional urban settlements of Makkah (Lewis-Lettington et al. 2019).

During the era of the oil boom in Saudi Arabia, the national economy was stimulated along with migration influx to the region. At the same time, the number of pilgrims arriving for Hajj and Umrah increased, pushing further expansion in the key cities and the region generally.

In Makkah, the government anticipated the growing demands of urban growth by establishing formal planning systems and local administration to manage urban development. This occurred noting that urban expansion in Saudi Arabia began replicating western planning systems as early as the 1930s (Majrashi 2017); (Aina et al. 2013), a trend that accelerated throughout the twentieth century (Al Jabri and Alhazmi 2017). There are four major phases of urban development that can be identified in Makkah. In the period of the 1970s–1980s, the economy of the city started to flourish, causing an influx of migrants to Makkah, adding a major increase in population. The population boom increased the demand for land, housing, and services. In the 1980–1990 period, Makkah experienced a further major urban expansion about in extension of Al-Masjid Al-Haram’s capacity to accommodate the Hajj pilgrimage. The expansion was marked by the development of large-scale infrastructure connecting regions in Saudi Arabia plus the construction of inter-district freeway tunnels within cities. In the period of the 1990s to 2000s, the city government changed its development focus by concentrating on improving urban amenities. At the same time, residential areas and urban structures grew irregularly along transport lines and local center nodes. Since the beginning of the new millennium, the government of Makkah carried out major redevelopment with massive investment directed into housing and basic infrastructure to reorganize the city form. Current city planning imposes land-use zoning systems while unifying

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1. https://www.maag-recycling.ch/ueber-uns/leitbild/ and https://www.watermangroup.com/au/project/battersea-cringe-dock-london/

2. https://www.stats.gov.sa/en/5723
urban form and structure. This policy is considered a threat to heritage buildings as well as the embedded local cultures (Lewis-Lettington et al. 2019). As a general observation, development now has less priority in improving local basic infrastructure, with the focus on supporting interregional
infrastructure development which has led to increasing urban sprawl (Fig. 3).

Urban densification in central Makkah has seen formal public open spaces replaced with housing and infrastructure (Jabri and Alhazmi 2017). High demand for land as generated by Hajj and Umrah activities has led to increasing pressure on basic infrastructures such as water, electricity, and waste handling (Majrashi 2017). The city welcomed approximately 3 million pilgrims in 2019, with most being overseas visitors. Pilgrims in Makkah only stay several weeks for Hajj rituals, but visitors require upscaling of infrastructure and amenities to accommodate their needs. Limited suitable land for development has pushed the government to promote developer-led high-rise vertical housing for development, with some converting land used for public open space and local services (Alkhaldy 2009).

Urban densification projects in Makkah have not stopped the emergence of unplanned settlements. Approximately 40% of the urban population in Makkah or some 3.4 million residents live in informal settlements, such settlements underpinned by settlers renting land from local landowners (Kadhim 2016). The residents of such settlements include those who overseas illegal migrants who have overstayed their visas after the Hajj season as well as residents displaced by urban development including the expansion of the Al-Masjid Al-Haram (Majrashi 2017). Informal settlements in Makkah play an important role in that they offer residents affordable housing and proximity to the city and local centers, plus they are well served by some basic infrastructure such as water and electricity (Kadhim 2016). Notwithstanding these challenges, poor access to basic facilities such as health clinics and schools as well as rising crime rates have become major issues pervading informal settlements (Fig. 4).

Gaps have been emerging over time in terms of public space and municipal solid waste (MSW) provision in Makkah. The local governments of Makkah are confronted with problems of dealing with daily solid waste production plus the demand for multifunctional public space for residents. Solid waste in both private and public premises is managed...
According to Galaly and van Oost (2017), the proportion of total solid waste production in Makkah comprises plastics (39%), paper (19%), food waste (17%), rubber (12%), and the remainder (13%) comprising small amounts of assorted aluminum, textiles, and non-biodegradable items such as nappies. The challenges are not only in dealing with the lack of public open space and mixed MSW management systems to meet normal weekly demands but also how to manage the impacts generated by a wide gap of resident versus visitor needs between the Hajj on and off-season. Public space in main pilgrimage locations outside of the Hajj season is underutilized, abandoned, and vacant, causing issues in terms of general maintenance and security throughout the rest of the year (Imam 2017). This major variability in demand challenges the government of Makkah in balancing service between peak and low seasons, including covering expenses to maintain the facilities for residents and visitors. A similar situation occurs for solid waste handling as waste facilities such as permanent and portable public toilets are mainly used over a short period and remain idle for the rest of the year (Imam 2017) (Fig. 5).

Public space and public waste in Makkah: a case of formal and informal settlements

The case study in Makkah is the Al-Khalidyah District, a dense newly planned area of 2.83 km² with an average of 19,156 persons/km² and a balanced proportion of formal and informal settlements. Al-Khalidyah District comprises sixteen neighborhoods with main uses comprising residential, commercial, health, religious, and educational uses. Under spatial plans, districts are supposed to be planned and comprise a range of public spaces including parks, playgrounds, sports fields, social centers, health clinics, and prayer spaces. The eastern part of Al-Khalidyah remains most dense, being resided by both citizens and foreigners. The district suffers from a lack of essential services and infrastructure including adequate public spaces for the residents. Furthermore, steep slopes make it difficult to build high standard infrastructure which results in an irregular mix of local houses and narrow alleyways causing traffic and pedestrian congestion.

The field surveys included in-depth observations in formal and informal settlements in Makkah as well as conducting questionnaires. Questionnaires were distributed to 204 respondents from different districts around Makkah. Questions comprising inquiries regarding baseline data on socio-economic characteristics and their views on current usage of public space and waste facilities and recommendations for further improvement were asked. The district reflects a majority of urban characters in Saudi Arabia which are less influenced by Hajj and Umrah activities. Descriptive quantitative and spatial analyses were deployed to examine the results of questionnaires and observations (Fig. 6).

Based on the field surveys, the Al Khalidyah District has approximately 53 of public open space, or approximately 19% of the total area. Three main types of public open space can be identified: formal parks and gardens, government unused land, and streets with multifunctional uses. If unused and abandoned private lands are included, then there are four types of open space. As a general observation, formal parks are well designed and provide a variety of different functions for residents and visitors, including connecting footpaths, seating and shade areas, child playgrounds, vendor carts selling drinks and ice-creams, and non-formalized “open spaces” which are used for general relaxation, exercise, car-washing, and general sociality. Formal parks as can be seen in Fig. 7 are accessible 24 h a day and have different uses at different times. In terms of solid waste in parks, solid waste comprises cans, food boxes, and plastics, with collection bins full in the
mornings and require regular cleaning. There are rubbish bins, but these are not sufficient for the waste deposited as bins are overflowing and waste is on the ground.

In some parts of the Al Khalidyah district, abandoned and unused private and government lands are used informally as public spaces for parking and children’s play areas. There are no waste collection facilities provided in these areas. Some abandoned private land is also utilized for selling food by mobile vendors (Fig. 8).

Dumping sites are more frequent in informal settlements, occupying vacant land with good access to residential buildings and open space. Residents, who are mostly overseas migrants, use this space for meeting, a child playing, and general socializing. Rubbish is disposed of and littered throughout (Fig. 9).

As well, vacant government lands are also used as public spaces including public gatherings, car parking, and “informal” sports fields. In some areas, residents improve the amenity of these spaces by building walls or painting murals, so it is more “engaging” for them to use (Fig. 10). There is no related infrastructure such as lighting, rubbish bins, and sewage found in these areas.

Importantly, streets (Fig. 11) and alleyways (Fig. 12) are actively utilized as public spaces by residents in informal settlements from different age groups for resident gatherings, child play areas, and school-related activities. Several schools in the district do not have adequate open space for outdoor exercise; thus, they utilized abandoned sites and surrounding streets as public spaces. Rubbish is poorly managed as settlements are not seen as a priority for support.
The need for public space is apparent in both planned and informal settlements. Formal planned public spaces such as parks and open spaces are designated in prime locations close to major streets and shopping centers, welcoming residents and visitors from different age groups. On the other hand, informal public spaces used for informal playgrounds, parking lots, sports fields, and meeting points are located in vacant and unused lands in informal settlements. Informal public spaces are mostly used and accessed by residents and rarely used by outsiders. Most formal public space is open for 24 h, while informal public space is used at particular times of the day such as their use as parking lots in the morning and playgrounds and sports fields in the afternoon to evening. Regarding support from basic facilities such as waste bins and sanitation, for example, formal public space is supported by services from the municipal government, while informal settlements are generally devoid of associated, basic facilities. Some areas in informal settlements are served by municipal waste handling, while others in steep areas and inaccessible for dump trucks are not covered by municipal services (Table 1).

**Results**

The results from the questionnaires show that most respondents surveyed lived in Makkah for more than 10 years (39.7%), followed by residents staying 6–10 years (34.8%) and those living up to 5 years (25.5%), with an average length of stay 12 years (Fig. 13a). The proportion of respondents based on their nationality (Saudi and non-Saudi residents) and gender are almost equal. Most of the respondents surveyed lived with 3–7 families in one house (63.2%), with an average number of households in one premise being 4 households (Fig. 13b). A large number of households in one premise are common in Saudi Arabia, and it has been part of traditional culture in Arabic society to have several extended families living in one premise. Additional families will build their rooms on the upper levels of the house as the needs allow. Therefore, it is usual to find multi-story houses in Saudi Arabia, often resided by households of one family. One room on the ground or upper floor of the house is used as a common space for the
Fig. 8 Abandoned and unused private land is used as public space in informal settlements in Al-Khalidyah

Fig. 9 Vacant unused lands in informal settlements in Al-Khalidyah with waste dumped throughout
family; thus, it is rare to find a front yard or backyard of a house used for the family gathering.

Employment by respondents surveyed is distributed almost equally based on their jobs. Most of the respondents work as government employees (27.6%), followed by self-employees (19.7%), housewives (12.3%), students (10.8%), private employees (8.4%), and retired persons (3.9%). Most of the respondents (59.1%) receive a monthly income, followed by those with no income (21.2%), respondents with weekly income (12.3%), and daily income (7.4%). The data shows that most respondents have relatively stable jobs and incomes, despite the status of their residency in formal or informal settlements (Fig. 14a and b).

Gardens built by the government have the most visits (41.9%) followed by sidewalks (30.4%), squares (16.2%), and sports stadiums (11.5%). Meanwhile, respondents mostly visit public space 2–4 times per week, followed by those that never or only visit public space once a week, those who visit public space 5–7 times a week (20.7%), and those who visit public space more than 7 times a week (2%) (Fig. 15).

Respondents’ preferences on particular types of public space are based on proximity to their houses, and easy access (both share 26% of the total responses), followed by those who consider safety (20.7%), cleanliness (14.1%), and various facilities (11.7%). See Fig. 16 for details.

In terms of safety, cleanliness, and general level of services (LOS) provided in public spaces in Makkah, respondents give various views. As can be seen from Fig. 17, most respondents stated that the level of service of public space is very good (73.9%), and less than 20% mention state that the service is good or lower than that. Meanwhile, different responses are shown in questions regarding cleanness and LOS. Most of the respondents agreed that the cleanliness and LOS of public space in Makkah is average (39.9 and 33.35%, respectively). More respondents (23.6%) stated that the LOS of public space is poor compared to cleanliness (15.3%).

Related to questions about the LOS of public space, respondents were asked about the importance of solid waste management and whether they want to participate in further processing of waste in public space. Questionnaires reveal that 98% of the respondents agreed that solid waste
management is important and 88% of the respondents are willing to participate in improved solid waste processing. Approximately 92% of respondents confirmed that current solid waste is collected with no further treatments such as separation, reduction, reuse, and recycling stages. Around 8% of respondents do not want to participate in improved waste management due to a lack of knowledge (40%) and that the current basic service is considered sufficient to collect and manage domestic waste.

As shown in Fig. 18, the majority of respondents prefer to have a general waste container in public spaces (31.7%), followed by those who prefer to have a waste to money machine (25.9%), smart waste container (19.3%), routine cleaning (13.6%), and metro typhoon system (9.6%).

**Discussion**

Public space has a strong relationship with waste management and urban quality in the case of Makkah. The types of public space indicate different types of waste management and reflect the broader quality and socioeconomic status of the precinct. Both formal and informal settlements, when reachable by municipal service, are covered by formal waste handling, while those located in steep areas with narrow streets and lanes are not covered by such service. The case study also confirms the multifunctionality of public space, either created through formal design or naturally created by users. Usage of public space expresses the different needs of users across a range of age groups and can occur regularly or irregularly. Furthermore, public space in both settlements shows that waste management is poorly carried out due to basic types of waste handling (no separation), access to waste sources, and provision of waste facilities.

In both settlements surveyed, proximity to home and access are the main factors influencing respondents in using public spaces. Interestingly, access to public space in formal settlements is significantly different from that in informal settlements. Formal parks are open for all residents and visitors, while public spaces in informal settlements are utilized mostly by residents due to their proximity. Formal parks are located in the city center and some middle ring suburbs.
providing higher access and visibility for all residents, while informal public spaces are located closer to residential areas and or in urban edge settlements and are often attached to houses, commercial or industrial buildings. This shows the importance of public space provision on one hand, and the adaptive nature of public space to respond to different needs of users in different locations.

The analysis shows that residents in formal and informal settlements in Makkah City have access to formal services such as public spaces and means of refuse waste collection. However, waste handling processes are poor in both settlements showing the low capacity of municipal waste management to handle waste in the context of contributing to the circular economy. Despite well-equipped facilities to collect MSW and frequency of collection per week, open dumping, and the absence of 3R methods as not applied in both settlements discourages residents to participate in improved methods of waste handling. Meanwhile, questionnaire results also show that respondents are willing to participate in such treatment as they are concerned with the impact of waste on the environment. This shows that gaps in provision will be well addressed if the government initiates collaboration with residents in improved waste handling and separation measures.

**Conclusion**

This paper presents the relationship between the provision of public space in formal and informal settlements and waste management. The results show that public space provision and waste handling in Makkah deliver basic levels of service regardless of the land status. Furthermore, both provide a safe and convenient space for interactions for residents from different age groups and different activities. In informal settlements, public spaces are often an extension of current uses, such as streets and parking lots, with various uses occurring at different times. Waste in both types of public space are highly reliant on municipal waste management services to provide waste facilities, but also to take the initiative to introduce improved solid waste management outcomes. The paper reveals a strong willingness of residents in Makkah to participate in implementing improved sustainable waste handling mechanisms in both
settlements. Planning and management innovation by the government working with varying community types are key to improving waste collection and management.

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Declarations

Conflict of interest The authors declare no competing interests.

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Fig. 13 Length of stay (a) and the number of households per premise (b)

Fig. 14 Respondents by jobs (a) and types of incomes (b)

Fig. 15 Types of Public Space that are frequently visited (a) and frequency of visits per week (b)
Fig. 16  Reasons to use public space

Fig. 17  Level of safety, cleanliness, and level of service of public space

Fig. 18  Preference for solid waste facilities in public spaces
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