湖南大学学报（自然科学版）
Journal of Hunan University (Natural Sciences)

第 50 卷 第 5 期
2023 年 5 月

Available online at http://jonuns.com/index.php/journal/index

Vol. 50 No. 5
May 2023

Open Access Article https://doi.org/10.55463/issn.1674-2974.50.5.13

Urban Growth Studies for the Holy City of Makkah, Saudi Arabia, through Literature Synthesis

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Received: February 14, 2023 / Revised: March 8, 2023 / Accepted: April 5, 2023 / Published: May 31, 2023

Abstract: Urban growth in the Holy City of Makkah witnessed many changes from the beginning of the city, led by religious, economic, and political factors. The study aims to evaluate the trend of urban growth in Makkah, Saudi Arabia; it employed a systematic literature approach categorized into three for evaluating previous studies in this study for urban growth and expansion studies in Makkah. The first category covers the body of literature on the Kingdom of Saudi Arabia with a connection to the Arab nations and receives 27% of the scholars' contributions. The second category covers the literature related to the Kingdom of Saudi Arabia cities and depicts 41% of the scholars' contributions. The third category demonstrates literature specially conducted on the Holy City of Makkah and depicts 32% of the scholars' contributions. The study handles 20 years of urban growth in Makkah from 1998 to 2013 with four study periods 1998, 2003, 2008, and 2013. The study indicates that scholars are making great efforts to study urban growth in Makkah. This study strongly recommends further studies on Makkah's urban growth using GIS and remote sensing technologies that will provide the information needed for future rational decision-making on urban growth management in Makkah.

Keywords: Holy City of Makkah, Kingdom of Saudi Arabia, land use change, literature synthesis, urban growth.

通过文献综合对沙特阿拉伯圣城麦加进行城市增长研究

摘要：聖城麥加的城市發展見證了從建城之初起的許多變化，受宗教、經濟和政治因素的影響。該研究旨在評估沙特阿拉伯麥加的城市增長趨勢；它採用系統的文獻方法分為三類，以評估本研究中以前對麥加城市增長和擴張研究的研究。第一類涵蓋了與阿拉伯國家有關的沙特阿拉伯王國的文獻主體，佔學者貢獻的27%。第二類涵蓋與沙特阿拉伯王國城市相關

的文獻，描述了41%的學者貢獻。第三類是專門針對聖城麥加進行的文學創作，描繪了32%的學者貢獻。該研究處理了麥加從1998年到2013年20年的城市增長，分為1998、2003、2008和2013年四個研究期。該研究表明學者們正在努力研究麥加的城市增長。本研究強烈建議使用地理信息系統和遙感技術進一步研究麥加的城市增長，這將為未來麥加城市增長管理的理性決策提供所需的信息。

关键词：沙特阿拉伯王国麦加圣城，土地利用变化，文献综合，城市发展。

1. Introduction

The Holy City of Makkah is one of the oldest human settlements and the most venerated holy place in Islam and the world and also one of the prominent Saudi cities and the capital of the western region of the Kingdom [56]. Urban growth in the HCOM is contributed by [30]; Prophet Ibrahim (peace be upon him) formed the first nuclei of the Holy City of Makkah about 3,700 years ago. Urban growth of the HCOM involves two phases between 1955 and 2030. The phase of very slow growth was before 1955 and indicated the Makkah built-up area in 711 Ha, while the phase of very rapid growth was 1955-1985 with an area of 4721.4 Ha. The phase of moderate growth is 1986-2011, with an area of 24946.1 Ha, and the projected 2020 area is 41051.4 Ha. [12] stated that the stated history of urban growth covers years 661,1612,1924 and 1983, respectively. [38] categorized urban cover changes directionally into northeast, southeast, southwest, and northwest. The topography/mountain range within the city determines all directions of growth. Moreover, urban growth in the Arab world has received scholarly contributions from scholars, among which [6] commented that Arab nations witnessed dramatic urban growth and expansion in the last 30 years, mainly in countries that geographically are in the Arabian Gulf Regions. For example, Dammam City in the KSA is rapidly urbanizing with a significant economic base and advantages. Urbanization in the Arab world nearly doubled from its initial population of 151 million in 2001 to 260 million in 2020 [6]. Urbanization in the Arab world is in [35], which views the Arab region through (a) Urbanization and development with emphasis on its demography and urbanization, conflict and displacement, urbanization, and migration. It also looks at housing and lands with informal organic settlements, among others. (b) Urbanization and the economy, with emphasis on its policies, are part of the report. (c) Urbanization and social equity cover social protection and food security, women in urban development and social, economic, and political inclusion of disabilities. (d) Urbanization and environment, on the other hand, treat climate change, the natural environment, and policies. (e) Urbanization and governance are with the following considerations: metropolitan governance, public participation, spatial planning, and national urban policies, among others. Factors affecting urban growth received a contribution of [1] as factors affecting urban growth globally are common indicators. Therefore, urban growth requires proper management for its suitability, but improper and weak management could result in urban challenges. [9] contributes urbanization and climate change effects concerning heat islands; urbanization environmental impacts on climate changes have numerous indicators, such as urban heat island. This generates much interest in changes in land surface temperature among scholars globally. Emission in urban centers is within the context of the study [49], the defense meteorological satellite program, and the operational line-sean system sense emission of the city through light, gas flaring, and significant natural fires. According to [44], urban centers globally have emissions of nitrogen oxides and hydrocarbons from automobiles that affect the ozone creating the need for environmental regulations. This study evaluates urban growth studies concerning HCOM through literature synthesis. This research relates to the chair's goal for developing The HCOM and the Holy Places through enhancing the scientific and research field concerning literature documentation.

2. Methods

The study is qualitative and reviewed the existing established body of literature. It employed a systematic literature approach in this study of urban growth studies in the HCOM in the Kingdom of Saudi Arabia. The study literature includes three categories within the theme and subject matter of urban growth and expansion studies. Category 1 covers the body of literature on KSA with a connection to the Arab nations. Category 2 covers the literature related to Saudi Arabian cities, while the third category demonstrates literature specifically conducted on the Holy City of Makkah Al-Mukkaramah. Arguments of scholars, opinions, findings, and recommendations form an integral part of this study's findings and recommendations. Digitally generated maps in the scholarly literature apply to elaborate and demonstrate the extent of urban growth in HCOM. This study

consists of six sections: a general introduction, a literature review that views urban growth studies in KSA as a whole, urban growth in some cities in the Kingdom, and urban growth and area studies in the Holy City of Makkah Al-Mukkaramah. Other sections include the study area, methodology, and findings, which elaborate on the statistical contributions based on the three categories above, conclusion, and recommendations. Fig. 1 shows a schematic representation of the steps involved in conducting the research.

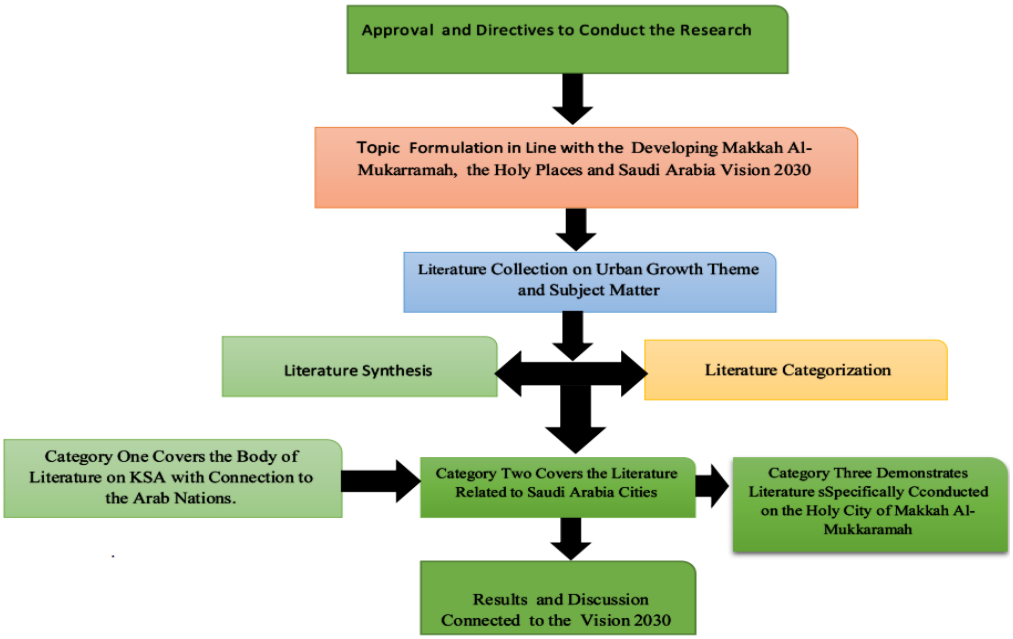

Fig. 1 Schematic representation of steps involved in conducting the research

2.1. Geographical Location of Study Area (Makkah City)

The geographical location of the HCOM has received tremendous scholarly contributions from scholars like [45]; western Saudi Arabia is covered by an enhanced geothermal system of hydrothermal with a historic rock center (Harrat) with very high heat generation. [48] states the geographical location of the HCOM as it is in the southwestern part of the KSA in the western region, and it is called Makkah Al-Mokarmah province. Historically, this area is called Al-Hijaz, an Arabic name that refers to the space between the Sarawat Mountains in the east and the Red Sea in the west. These circumnutated rugged mountains uplift the associated Red Sea rifting. Furthermore, the land between them is called Tiamat Al_Hijaz "coastal plain low laying." It starts from the KSA North border with the Arab Kingdom of Jordan to edges with Tihamat Asir in the south. Mountains in the HCOM are sequentially arranged naturally along the northwest, southeast, and east-west. Some naturally isolated mountains are in HCOM, such as Thour and El-Nour mountains. Fig. 2, as in [48], indicates the location map of HCOM in Saudi Arabia, while Fig. 3, as in [23], demonstrates the location and distribution of bus stops within the Makkah metropolis, which depicts the extent of urban growth.

Fig. 2 Location map of Makkah, Saudi Arabia [48]

Fig. 3 Location and distribution of bus stops in Makkah [23]

Additionally, the geographical location of the Holy City of Makkah is in [20] that depicts the geographical location coordinates of Makkah. It is located on the latitude 20^{o}, 21I N, and longitudes $39^{o}45^{I}$ and $40^{o}00^{I}$. The metropolis is 300 meters above sea level and attracts a large population, and active urban and economic development. The geographical location of Makkah also receives a contribution from [10]. Makkah is in a central part of a region. It is a holy place for Muslims with a population of 1,867,886 and is 70 km from Jeddah city. According to [33] and [30], the HCOM is in the western parts of KSA and has the third population. The Metropolis flood disaster is at increases because of (a) its topography and (b) large population interaction during Hajj (pilgrims). Also, the HCOM is 80 km from the Red Sea; it is the spiritual capital of more than one and a half billion Muslims globally. [30] discussed modern transportation that has greatly transformed the land use of the HCOM. The central business district (CBD) close to the Grand Mosque converted into hotels “Hajj and Umrah.” [11] comments that a million Hajj visitors arrived at the holy centers of Makkah and Al-Madinah for pilgrims’ processes.

3. Results

This section provides a sequential arrangement of the scholarly works employed in this study. It covers literature on KSA "urban growth in major cities of the KSA," and urban growth and expansion in HCOM, the focal point of the study. It also considers urban growth in Makka Al-Mukkaramah. The study employed literature synthesis in its methodology. Established scholarly works in Makka Al-Mukkaramah and related works applied as the basis for the drawn conclusion in this study.

3.1. Urban Growth in Saudi Arabia

Urban growth and urbanization processes in KSA are receiving enormous scholarly contributions. Some of the scholarly contributions in KSA urbanization history are in [6], which clearly states that Saudi Arabia records urbanization historically of urban population from 17.5% in 1955, which significantly rose to 65.9% in 1980. The population sharply rose to 88.5% in 2005, and it is statistically projected to attain 91.1% by the year 2030 [6]. [45] states that KSA is one of the biggest countries for reserving oil and gas and is one of the primary oil-producing countries. Electricity is obtained from power plants mainly based on oil and gas. Clear renewable energy is actively considered following UNFCC to mitigate CO_2 emission effects on climate [45]. [62] considers the KSA in the following ways; (1) Saudi Arabia emerging urban trends, (2) Sustainability toward urban mobility and transportation, (3) Green city development and environmental sustainability, (4) Urban economy dynamism, (5) The roles of urban governance in managing urban transformation in the KSA, and (6) New urban agenda in KSA. [1] evaluates present urban expansion in KSA with specific reference to the Al-Ahsa province of the study area's eastern region. Urban growth has created issues and concerns for stakeholders, urban planners, and the generality of related researchers and scholars. Table 1, as [1], provides urban population dwelling in urban areas. Population growth in the urban area is the primary indicator that leads to rapid urban growth.

Table 1 Urban population in Arab Gulf States and its historical perspective [1]

S/N	Nations	1950 (%)	1975 (%)	2004 (%)	2015 (%)
1	Saudi Arabia	9	58.4	80.8	83.2
2	United Arab Emirates	25	83.6	76.7	77.4
3	Kuwait	51	89	98.3	98.5
4	Nahrain	71	85	96.2	98.2
5	Qatar	50	88.9	95.3	96.2
6	Oman	3	34.1	71.7	72
7	Arab Gulf States	34.8	73.2	86.5	87.6

Additionally, areas of coverage of the Organization of Islamic Cooperation (OIC) countries are captured in detail in [59]; this report covers these nine important areas concerning the OIC countries. The areas are (1) Comprehending and understanding forces responsible for urbanization, (2) Urbanization specifically in OIC nations regarding the assessing the present condition, states its trend analysis, (3) Urbanization and sustainability and the new urban agenda, (4) Evaluation of urbanization social impacts, (5) Promoting urban resilience together with environmental resources, (6) Proactive legislation of urban, (7) Effective planning making for the sustainability of cities, (8) Urban development in OIC countries with references to proactive policies issues for sustainability, and (9) Livability of cities in OIC countries through effective economic planning [59].

According to United Nations Human Settlement Program (UNHSP) in [1], the global urban-rural dweller ratio could be traced historically considering historical years and population percentages. Table 2, as in [1], demonstrates the urban dweller's rate in Arab nations. The scholar provides past, present, and future projected likely approximate percentages of the urban population in the Arab nation. It is an excellent stricture and information that can apply to the location and distribution of resources, utilities, facilities, and services in nations. It is, therefore, integral for rational

decision-making by stakeholders.

Table 2 Urban rural residence ratio in Arab nations [1]

No.	Years	% of urban population
1	1800	3%
2	1900	10%
3	2000	47%
4	2030	60%

3.2. Urban Growth in Saudi Arabian Cities

Cities in Saudi Arabia are significantly urbanizing with references to rapid urban growth that follows the new concepts of Urban Planning, especially in the bigger cities like the Holy City of Makkah, Holy City of Madinah, Riyadh, and Dammam, to mention a few [1]. Topography, climate, and soil types determine the major natural physical factor influencing urban growth in KSA cities, and the population is considered a social factor [1]. [4] recorded the KSA as the largest in the Arabian Peninsula, with three primary regions. The most densely populated cities in Saudi Arabia include (a) Al-Riyadh, (b) Makkah Al-Mukkaramah, and (c) Eastern Region. KSA has precisely 26,090,555 population and a housing population of approximately 4,655,127. The household size in Saudi Arabia is significant, with six people per household, and housing types are mainly apartments, traditional houses, and villas. [28] investigates the effects of four driving forces: elevation, slope, and distances to the major roads to the drainages on urban expansion in five selected cities of Saudi Arabia (a) Riyadh, (b) Jeddah, (c) Makkah, (d) Al-Taif and (e) Eastern Region. The research adds that 1985-2014 employed relative operating characteristics (ROC) and qualitative urban growth maps. It uncovers that the four indicators are the primary determining factors for site selection in KSA. Urban growth is monitored by (1) biophysical variables, which include climate, topography, and proximity to other neighborhoods; (2) proximity variables, concerned with distances to roads, railways, water sources, and distance to the central business district (CBD) [28]. Urban sprawl in Jeddah is in [32]; the study considered these in evaluating urban sprawl in Jeddah city in the KSA. (a) Migration and its characteristics and peculiarities are looked at through causes of migration, its impacts, and international migration with its reasons. The central business district (CBD) of Jeddah and its capacity are all parts of the study. (b) In Jeddah's Infrastructure, regarding its water supply, sewage, drainages for stormwater, and flood disasters in Jeddah are seen. Flood disaster causes and consequences with communication infrastructure are evaluated. (c) The study also appraises the transportation sector. Car overdependence, its reasons, impacts, traffic congestion, air pollution, and road accidents are the scholarly work [32].

Additionally, urbanization in Dammam is in [6], where the city is rapidly urbanizing as the urban expansion is obvious with a significant economic base and advantages. Dammam metropolitan area (DMA) urban growth is very high compared with other cities of KSA. The scholars summarize the factors that led to the rapid urban growth of Dammam as follows: (1) Economic boom and housing development related to its obesity. (2) Land speculation, value appreciations, and private sector active participation in land development. (3) Dammam urban development (DUPD) limitation in its urban land management. The task of DUPD municipally of the eastern province, 2008 spelled out as follows: (a) land use preparation and design together with updating, (b) private layout subdivision approval and review, (c) planning studio preparation is a task, (d) building permits and controlling and monitoring, (e) planning policies and building regulations within the area of jurisdictions, (f) geo-database developments within the area, and (g) traffic policies and their management strategy development [6]. Table 3, as in [13], demonstrates the urban growth of Dammam from 1930 to 2030.

Table 3 Urban growth of Dammam from 1930 to 2030 [13]

No.	Years	Urban Growth (ha)	Population	Population Densities
1	1934	34.2	5,000	146
2	1956	883.6	98,000	117
3	1980	5023.7	360,000	72
4	2000	19,532.1	1.02 million	52
5	2014	38,760.3	1.66 million	43
6	2030	57,130.0	2.10 million	37

The environmental quality of Dammam concerns its speedy urban expansion and growth within 80 years. According to [13], the scholars handle the research using these stapes: introduction and its historical background, 1932–1956 stage one and as its initial stage, 1956–1980 is the state two, and it is considered as a formative stage, while 1980–2000 is the stage three, and it is considered as the emerging stage. The master plan of Dammam [13] deals principally with (a) Urban growth control of Dammam and its neighboring Al-Khobar and Dhahran urban growths and (b) Development control implementations and enforcement to achieve sustainable development. (c) Promote public transit and an integrated corridor with Al-Khobar and Dammam. (d) Make tourism, commerce, and general business vibrant within the shoreline. [6] comments on the environmental impact of urban growth specifically in DMA to include (a) Marine environment and land deterioration and (b) Unsuitable and nonconforming development processes in DMA, which covers loss of agricultural land and gulf water landfilling. Both have significant ecological challenges; (c) Unsustainable urbanization in DMA is categorized as follows: urban sprawl development, urban legalization of the urban sprawl, enormous scale urban development projects, conflicting and nonconforming land uses, and rapid urbanization together with a dilemma in a rapidly changing environment [6]. Table 4, as in [4], provides the statistical distribution of the

regional population of KSA.

Table 4 Regional population of the Kingdom of Saudi Arabia [4]

No.	Regions	Population	% in Saudi	% in region wise household	People per household
1	Al-Riyadh	6,505,509	69.3	24.5	5.6
2	Makkah Al-Mukarramah	6,662,597	64.2	25.5	5.0
3	Al-Madina Al-Munawwarah	1,694,749	76.5	6.5	5.5
4	Al-Qaseem	1,184,365	80.8	4.5	5.8
5	Eastern Region	3,799,773	78.2	14.2	6.1
6	Aseer	1,847,236	85.7	7.3	5.6
7	Tabouk	777,680	86.5	3.0	5.8
8	Hail	593,308	85.6	2.3	6.3
9	Northern Border	311,473	88.0	1.2	7.3
10	Al-Jouf	428,266	83.7	1.6	6.1
11	Jazan	1,332,262	84.2	5.1	6.6
12	Najran	496,613	82.5	1.9	5.4
13	Al-Baha	406,724	87.2	1.6	5.4

Dammam is the world-leading energy supplier and is ranked as the third major metropolis in the KSA[13]. Municipal water production forecasting is highly essential for a country like Saudi Arabia, and this is because its utility is exorbitant and costly in desalination plants in its water production [10]. KSA vision 2020 is elaborated in [60], which states that Saudi Arabia vision 2030 stipulates these supportive programs geared toward sustainable development;(a) Housing program, (b) Lifestyle improvement, (c) National industrial development, (d) Enhancing Hajj and Umrah, (e) National companies promotion program, (f) National transformation, (g) Fiscal balance program, (h) Strategic partnership program, (I) Saudi characters enrichment program, (J) Public investment program, (K) Privatization program.

The report [61] evaluates Arab cities considering these elements as parameters. The elements include: (a) Population and urbanization, (b) The growing economics, (c) Housing condition and urban growth, (d) Urban mobility, (e) Environmental challenges of urban areas, (f) Governance systems of urban centers, (g) Remittance of migration, and (h) Cooperation and regional corridor. Table 5 depicts Arabs nations' classification by [61]; the report categorized Arab nations into four categories as in Table 5. Each category consists of many countries. It is an excellent indicator that could be used for urban and regional planning and international spatial planning for the distribution and location of urban and regional issues.

Table 5 Arab nation classification [61]

Mashreq (East)	Magrib (West)	Gulf Cooperation Council	Southern Tier nations
Egypt	Algeria	Bahrain	Comoros
Iraq	Libya	Kuwait	Djibouti
Jordan	Morocco	Oman	Somalia
Lebanon	Tunisia	Qatar	Sudan
Palestine	Mauritania	Saudi Arabia	Yemen
Syrian Arab Republic		United Arab Emirates	

The Jeddah CPI Profile [40] includes three main headings. (1) An overview of Jeddah city considers its historical background, geographical location, demography, socioeconomic elements, pattern, and trend of its urban growth and expansion, evaluating the present and current structure plans. (2) City prosperity index (CPI) evaluation that covers overall CPI concerning the infrastructural development index, quality of life assessment, social inclusion, and equity analysis, including environmental sustainability index analysis. It analyzes its urban governance with its legislation SWOT analysis with CPI evaluation. (3) The report also covers local urban observatories with emphasis on urban observation, the local urban observatory of Jeddah, its structures, functionalities, and performances [40]. Urban growth in Jeddah is in [50], and Jeddah is the second largest city in Saudi Arabia, and it is the gateway to the Holy City of Makkah. Urban development in Jeddah historically from 1927 to 1995 has had these periods. The pre-boom period of 1927-1970 is considered the pre-boom period with a peculiarity in its urban growth. The boom period covers 1973-1983 with a high level of urban expansion, and the post-boom era covers 1984-1995. Jeddah plays a vital role in Saudi Arabia. The function and roles of Jeddah city in KSA include; (a) It is the gateway to the Airport/Seaports and lands commercial center, (b) It serves as the business and commercial center, (c) it is the KSA diplomatic center, (d) It is the gateway to both Hajj and Umrah for the global visitors. (e) It is the education center together with health services in the KSA [50]. [21] supports urban growth in Jeddah; Jeddah has been witnessing rapid urban growth in the last four decades. This changes the pattern and mode of travel behavior within the transportation sector of the metropolis. The scholar uses these indicators in

the study: (a) Population density, (b) Car ownership and vehicular population, (c) unemployment, (d) Poverty, and (e) Marital status [21].

Furthermore, [17] shows the urban growth records of Qatif Oasis in Saudi Arabia in Table 6, while Table 7 indicates the loss of agricultural land in Qatif Oasis in the same author's work. Table 6 shows the historical records of urban growth in Qatif Oasis in the KSA, while Table 7 depicts the loss of agricultural land in Qatif Qasis. As built-up increases, agricultural land decreases together with a reduction in water bodies through landfilling and land reclamation. This urban expansion, therefore, required active urban management for sustainable city development.

Table 6 Urban growth records in Qatif Qasis [17]

Years	Urban Area in Ha	Population	Densities Ration Person/Hf
1955	33	12,000	363.6
1965	71	28,200	397.2
1975	90	46,600	517.8
1985	844	98,425	116.6
1995	1,535	174,280	113.5
2005	2,023	247,420	112.3
2015	4,022	310,820	77.3
2040	6,916	712,280	103.0

Table 7 The loss of agricultural land in Qatif Qais [17]

Land use/Years	1975–1985	1985–1995	1995–2015	2015–2040
The loss of agricultural land	308	710	972	1200
Sea shore land is filled with	660	1090	1515	608
Total	968	1860	2487	1808

3.3. Urban Growth in Makka Al-Mukkaramah

Urban growth in the Makkah metropolitan area is a significant scholarly contribution. [19] reported that residential land use in the HCOM sharply increased from 179% in 1990 to 248% in 2010.

[1] reported that cities with more than one million populations in KSA include HCOM, Al-Madinah Munawarrah, and Riyadh. Built-up areas significantly increased in Saudi Arabian cities. The population of HCOM is approximately 2,042,000 [55]. This population is without undocumented residents. [1] highlighted the urban growth history from 1992 to 2004. Table 8 expatriates the urban growth history for 1992-2004.

Table 8 Urban growth history within 1992-2004 [1]

Cities	Increase in built up areas (%)	Increase in the area of the city (%)
Makkah Al-Mukarramah	126.8	0.07
Madina Al-Munawwarah	69.3	64.13
Dammam	80.3	66.11
Al-Riyadh	94.2	59.97
Jeddah	317.8	59.97

[48] states that the urban setting and pattern of HCOM within its metropolitan areas is peculiar with geomorphology control. The Metropolis radiates toward the steep mountain ranges with a complex alluvial channel. It covers an area of approximately 9000 ha. Spatial development expands toward the alluvial corridor. [20] comments that HCOM is the most extraordinary city in the KSA because of its religious and regional significance. This significance attracts and generates very high population influence and rapid urban growth and expansion of the metropolis. Table 9, as in [20], provides an overview of some scholars and their contributions to urban growth studies of Makkah and other cities in Saudi Arabia.

Table 9 Scholars and their contributions to urban growth studies of Makkah and other cities in Saudi Arabia [20]

No.	Scholars	Topics	Years of Study	Case Study	Techniques
1	Muhamad Al-Khuzami	Monitored urban growth	2000	Al-Dariyya	Satellite imagery
2	Al-Asmari, Makkah Al-Mukarramah	Human factors influencing urban growth	2008	Jedda	
3	Abdel Baqi	Extend of urban growth and expansion	1983	Makkah Al-Mukarramah	
4	Al-Mazra	The influence of ecological features on urban expansion	1984	Makkah Al-Mukarramah	
5	Abdel-Baqi	Urban expansion in both ancient and modern Makah	1986	Makkah Al-Mukarramah	
6	Al-Seriany	Makkah urban growth and western theories	1986	Makkah Al-Mukarramah	Western theories
7	Al-Seriany	Land and distribution	1986	Makkah Al-Mukarramah	
8	Al-Sharif	Urban changes using three corridor areas : (a) traditional, (2) transitional and (3) Modern	2002	Makkah Al-Mukarramah	
9	Al-Zhari	Circulation of area of urban spaces	2004	Makkah Al-Mukarramah	Maps of 1947, 1980 and 1989
10	Al-Wizinami	Monitor changes and urban growth	2010	Makkah Al-	Maps of Southern

				Mukarramah	Makkah
Land Use Changes in Saudi Arabian Cities					
1	Al-Nagri	Change in land use in cities	1989	Unaiza	1976-1983, 1977
2	Al-Gekhaida	Urban expansion	1994	Riyadh	1950–1983
3	Al-Ghamdi	Changes affecting the city of Makkah	2001		Satellite sensor digital (SPOTXS)
4	Al-Najar	Urban expansion	2002		Satellite data 1978–2000

[37] views the historical perspectives of holy cities under sequential and logical development periods: (a) Urban development pre-Islamic era, (b) The development and rise of the Islam era, (c) Post-Islamic era, and (d) Two cities and their regions. Housing sector challenges in the HCOM are in [12]. The housing sector in HCOM poses countless obstacles to not only its residents but also visitors. Urban growth in the HCOM, as in [12], gives a long history of urban growth and expansion. The stated history covers years 661, 1612, 1924, and 1983, respectively, and is a spectacular contribution to the urban growth and expansion of the HCOM. Figs. 1 and 2, as in [12], demonstrate the long historic urban expansion of the HCOM.

In addition, the urban expansion processes of the two cities, Makkah and Al-Madinah, are within the context of [37]. The scholar explains the urban expansion between the two cities concerning pilgrimages. Besides, the connections between the holy cities are systematically considered HCOM the first center for pilgrims, while Al-Madinah is the second center for pilgrims. The scholar also demonstrates three main points of pilgrimage to Makkah. The routes developed for pilgrims included railways, roads, and air routes. Population statistics of both Makkah and Al-Madinah of 1950 and post-1950 were detailed in the research. The scholar also handled populations, and urban centers' ranking of the two holy cities, population structure, distributions, and population origin are all depicted in [37]. Fig. 4, as in [37], provides pre-Islamic and early Islamic built-up areas in the Holy City of Makkah, while Fig. 5 also depicts urban growth in HCOM between 661AD and 1983 AD.

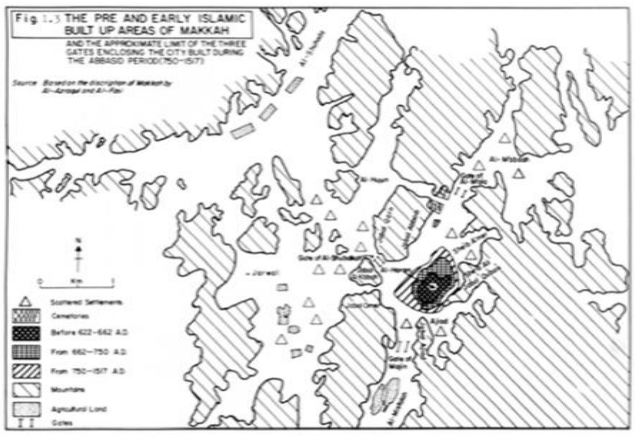

Fig. 4 Pre-Islamic (622AD) and early Islamic (750–1517 AD) era built-up area distribution in Makkah [37]

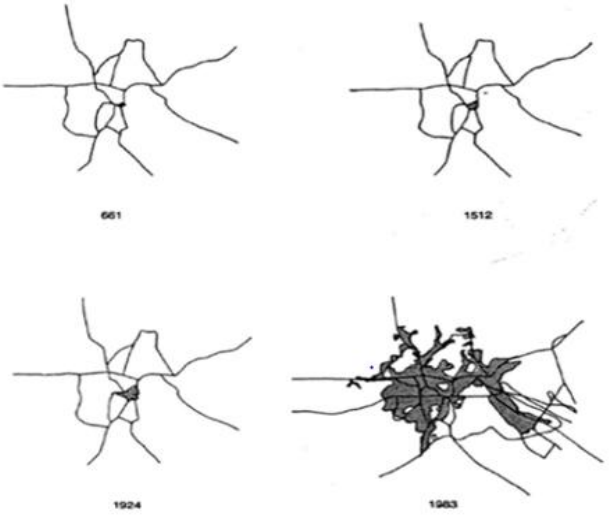

Fig. 5 Urban growth in Makkah from 661 to 1983 AD [12]

Figs. 4 and 5 above demonstrate the two millenniums of urban growth and expansion in the HCOM. Both scholars started with 622-662 AD and 750-1517 AD as in [37], while [12] started from 661 to 1983 AD. This millennium record relates to the spiritual functions of the HCOM. Additionally, population distribution in KSA is in [12], where the scholar summarizes population distribution between Saudis and Non-Saudis in HCOM past, present, and current together with projected future population. Table 10, as in [12], provides information on Saudis and non-Saudis population distribution in Saudi Arabia, while Table 11 explains housing population housing units, households, and individuals by types of housing units in HCOM.

Table 10 Indigene and non-indigene population distribution in Saudi Arabia [12]

Years	Saudis	Non-Saudis
1993	550,196	415,501
1999	800,000	475,000
2009	1,225,000	570,000
2019	1,675,000	670,000
2030	2,250,000	760,000
2040	2,925,000	855,00
2050	3,675,000	954,495

Table 11, as in [12], demonstrates a parameter helpful in effective urban management within the Makkah metropolis; it could provide information regarding the demography elements, such as the age group of the population, as each age group has specific social requirements. [12] explained housing units, households, and individuals by types of housing units in HCOM that can apply for the determination of

population densities and distribution within the holy city metropolis and also for determining housing conditions within a metropolis, and it could be a superb source of housing planning data acquisition.

Table 11 Housing units, households and individuals by types of housing units in Makkah [12]

Units	Traditional houses	Villa	A Floor in a villa/traditional	Apartment	Others	Total
Housing Units	63454	13908	15932	160282	9398	262974
Households	63493	13911	15933	160331	9399	263067
Individuals	368768	87046	968024	768024	289003	1345088

Fig. 6, as in [28], provides urbanization and urban expansion probability maps of the HCOM 1985 and 2014 AD. The scholar provides essential data for urban growth in the holy city. The probability maps indicate the changes that occurred within the study period. Fig. 7 demonstrates the urban growth and expansion of HCOM, which depicts the urbanization processes within the Holy Mosque of Kaaba, indicating the conglomeration of skyscrapers that accommodate a large population during Hajj and Umrah.

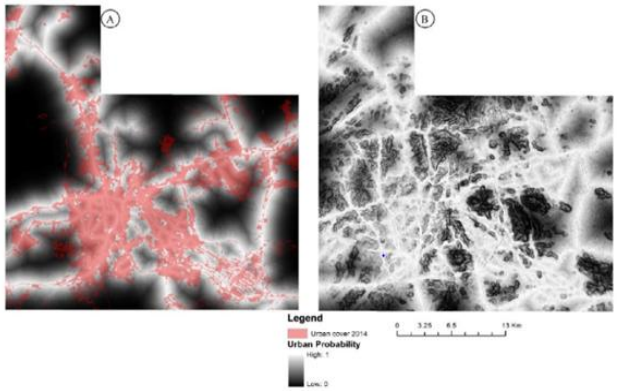

Fig. 6 Urbanization probability maps of Makkah from 1985 to 2014 [29]

Fig. 7 Urban growth and expansion of Makkah [28]

Urban growth in HCOM from [39] showed that urban cover changes were directionally in the Northeast, Southeast, Southwest, and Northwest. The topography/mountain range within the HCOM determines all directions of growth. The study handles 20 years of urban growth in the HCOM from 1998 to 2013 AD with four study periods 1998, 2003, 2008, and 2013. Millions of visitors come to the HCOM annually. [33] found that the urban extent of HCOM extends to 37 km in the northern part and 43 km in the eastern part of the metropolis, and its total urban area is 1,600 km^2. The latitude of Makkah is 21^o 35I E to 40^o E. Figs. 8 and 9 as in [33] generality of its topography and built-up residential within HCOM and urban growth. Besides, it shows residential land use past status of the residential area, and its present stage, with is projected by 2040.

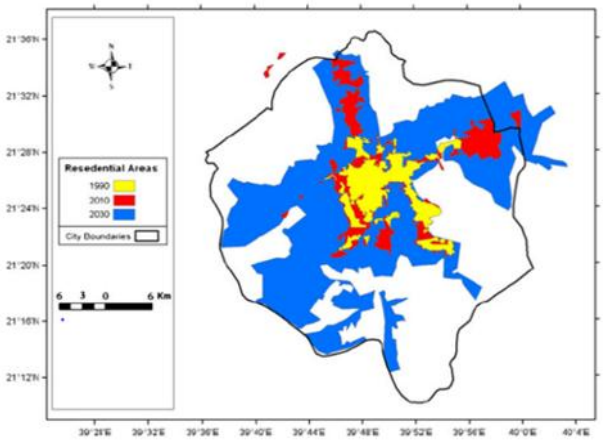

Fig. 8 Topography and built-up residential area map [33]

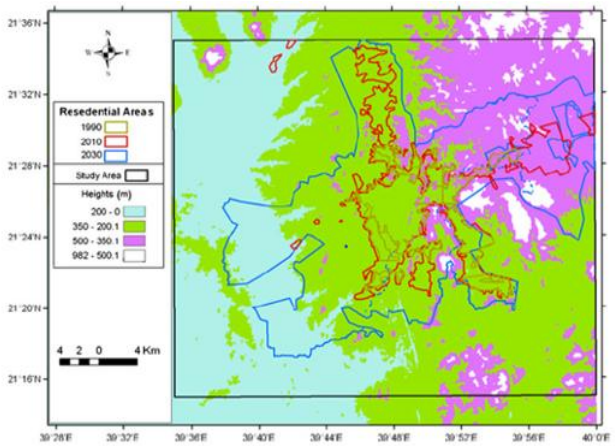

Fig. 9 Urban residential land use3 past and projected [33]

[30] contributed to urban growth in the HCOM: the first nuclei of HCOM were formed by Prophet Ibrahim “Peace be upon him” (AS) about 3,700 years ago. It relates to the Zamzam well and the Holy Kaaba. At present, the HCOM annually accommodates more than three million pilgrims globally. Table 12, as in [30], demonstrates the historic, present, and future urban growth phases of the HCOM within the years 1955 to 2030.

Table 12 Urban growth phases of Makkah Al-Mukarramah between 1955 and 2030 [30]

No.	Phases of urban growth	Area, ha	Annual growth (%)	Total growth during phases
1	The phase of very slow growth before 1955	711	-	-
2	A phase of very rapid growth (1955-1985)	4721.4	11.3	664
3	The phase of moderate growth (1986-2011)	24946.1	8.12	528.4
4	Projected 2020	41051.4	8.07	164.6
5	Projected 2030	74179.8	8.07	180.7

The land cover classification of Makkah is covered by [39]; the land cover classification employed in the study includes (a) an Urban built-up area, which covers residential, commercial, industrial, and recreational land use. (b) Transportation land use, which covers streets, all roads, and connectivity. (c) Soil as land depicts bare soil, sand, open, and desert. (d) Vegetation land use handles agricultural land, vegetal area, trees, and related land use. (e) Mountain land use covers hills, large rocks, and rugged terrain. Figs. 10 and 11 in [39] show land use and land cover changes during the study period and directions of urban growth in HCOM.

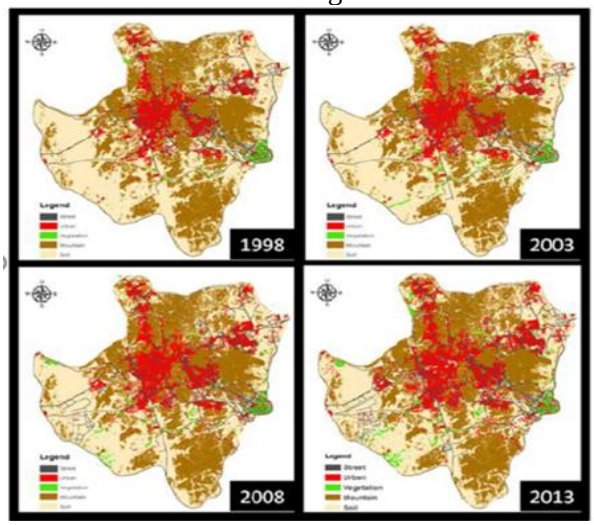

Fig. 10 Land use: land cover changes during the study [38]

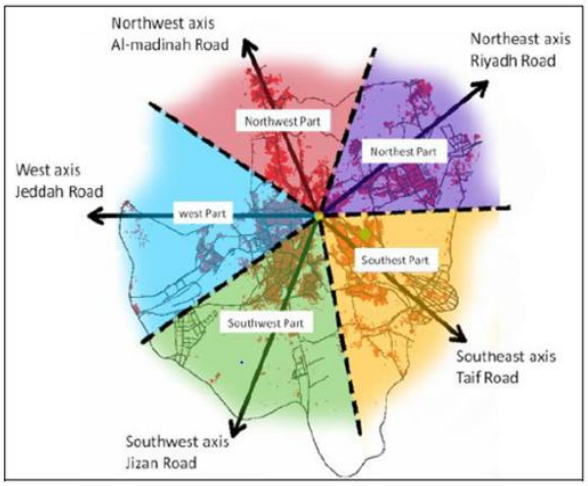

Fig. 11 Direction of urban growth in Makkah [38]

Moreover, urban growth in the HCOM and the relation to the Hajj sites expansion is in [23], the study summarizes urban growth in the holy city through these under-listing stages. (a) Holy Mosque expansion, (b) Improvement of Zam Zam well, (c) The Tent City in Minna, (d) Al-Jamrat project, (e) Transportation in the holy city with particular emphasis on the public transit and tunnels, and (f) Hazards in the HCOM with emphasis on the crowd management, security services together with health services. Fig. 10 as [23] demonstrates the locations and distributions of bus stations in the city. Holy sites in Makkah include the Holy Mosque, which relates to the wells of Zam Zam, Safa, Al-Marwa, and A/Mataf. Other sacred places in HCOM are Arafat, Muzdalifah, Mina, and Jamarat [23].

[62] elaborated the HCOM Profile, and the report views the city profiles through the following: (a) Spatial regional and national context. These elements include geographical location, socio-economic base, national connectivity, regional development pattern, and regional structure and dynamism of the city. (b) The financial framework of the Holy City and its governance is detailed by evaluating the plan hierarchy, regional plans for the city region, the city plans, layout, land subdivision, and the local context of the city. (c) The reports also view through the mirror of the urbanization pattern for the city development: land uses, open/vacant space, urban densities, and delineated administrative boundaries [62]. Urban growth in the HCOM is in [19]; residential land use in the holy city metropolitan area increased by 197% while flood volume increased by 248%. It increases connection with development in flood-prone areas and the new suburban areas that reduce water permeability in the soil. Table 13, as in [19], shows residential land use records in the HCOM metropolis, which portrays the trend of changes that occurred between 1947, 1990, and 2010.

Table 13 Residential land use records in Makkah Metropolis [18]

Land use	1947	1990	2010
Residential land use changes	5.168	99.234	158.583

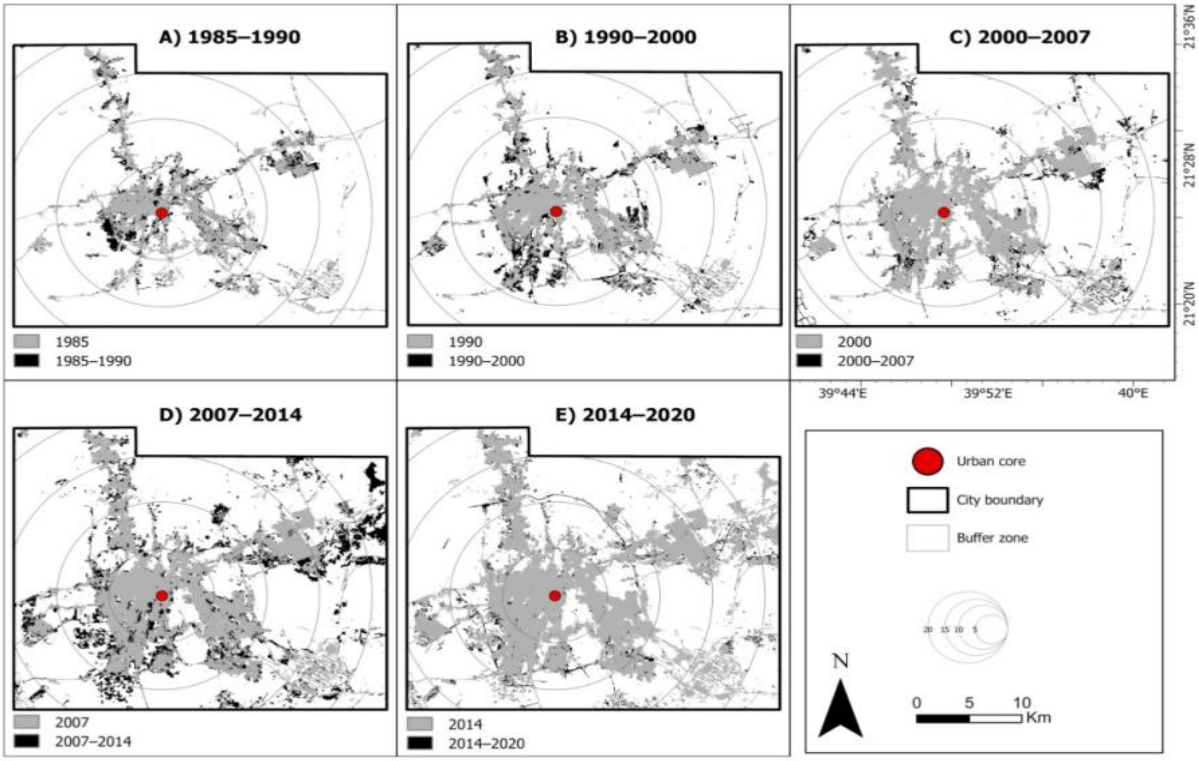

Fig. 12 Urban expansion in Makkah between 1985 and 2020: (a) 1985-1900, (b) 1990-2000, (c) 2000-2007, (d) 2007-2014, (f) 2014-2020 [25]

4. Discussion

This section provides findings of the statistical distribution of the sampled scholarly works employed in the study. It also depicts areas of the coverage of the scholars concerning urban growth and expansion in the study area. Section 5.1 uncovers statistical directions with the area coverage of the contributed scholarly works.

4.1. Statistical Directions and Areas of Coverage of Scholars Works

Scholars and experts in urban growth contributed to the trajectory of the study. The paper employed a literature review of urban growth globally [1]. [6] handles predicaments and challenges directly connected with rapid urbanization in Dammam Saudi Arabia Urbanization. [20] itemized its stated objectives as (a) Evaluating and recording land use and land cover changes in the Holy City of Makkah Al-Mukarramah. This objective has the following sub-themes - assessing urban growth patterns in the HCOM and ascertaining land cover distribution in the Holy City of Makkah. (b) Assessing the factors responsible for the urban growth of the HCOM. This has sub-themes as follows: (1) Digital map generation for the metropolis and (2) Identification of conflicting, incongruous, or incompatible land uses [20]. [7] employed shapefiles of residential land uses integrated and compiled with the aid of GIS and used a digital elevation model (DEM) for geological data sets of soil types on urbanization impacts on flash floor hazards evaluation. [30] evaluates the interconnectivity between the evolution of pilgrims' population and urban growth, emphasizing challenges during Hajj. [29] employed experts' opinions for assessing the sustainability indicator index for the Holy City of Makkah. The scholars formulated ninety-two indicators with 115 primary sets. The indicators are summarized as; (a) Environmental indicator, (b) Socio-economic indicator, (c) institutional indicator, and (d) Spillover indicator. [9] focuses on the spatiotemporal urban heat island influence by land use and land cover types in Riyadh, Saudi Arabia. The scholars employed multi-temporal land sat images of 1985, 1995, 2005, and 2015.

[7] considers calculating the present open spaces in Jeddah per inhabitant with the aid of GIS. The open space of Jeddah is expected to increase per capita from 3.47 m^2 to 3.9 m^2 by 2020. The paper considers evaluating the relationship between imports, exports, and economic growth with particular emphasis on their interrelationship in Saudi Arabia with a study period of 1968 to 2011 with the aid of multivariate co-integration and error correction and techniques [15]. [28] dwells and depicts and investigates the effects of four driving forces: elevation, slope, distances to the major roads, and distance to the drainages on the urban expansion in five selected cities of Saudi Arabia. The selected cities include (a) Riyadh, (b) Jeddah, (c) Makkah, (d) Al-Taif, and (e) Eastern Region. [39] evaluated land use, land cover changes, and urban morphology composition with the aid of multi-temporal satellite images by land sat ETM+. [46] handled flash flood disaster management issues in Riyadh KSA. [2] uses remote sensing (RS) and GIS hydrologic and hydraulic modeling to appraise the consequential impacts of

flood flash hazards on the sustainability of Tabouk City. [16] evaluated economic structure activities in the Makkah region to identify its spatial-economic possibilities. The economic activities evaluated include the agriculture sector, mining sector, manufacturing, power and water sectors, construction, transportation, and communication [16]. [17] considers the environmental consequences of rapid urban growth and expansion transformation of coastal cities, a case of Qatif Oasis within sixty years, to determine its spatial challenges. [49] employed management time-light data to investigate spatial and temporal patterns of urban growth dynamism in KSA from 1992 to 2013 with the aid of the defense meteorological satellite program, operational line-sean system of the stable night time (SNT) data for the time. [38] focuses on exploring the usage potentials of underused urban space within the Hajj sites in the HCOM. [13] employed a 4-dimensional geographical information system (4D GIS) for the accurate mapping of the 3D space urban growth in urban areas. According to [21], spatial analysis of the potential demand for public transportation in the city of Jeddah, Saudi Arabia. [50] demonstrates and appraises the underlining factors responsible for determining urban growth in Jeddah. [13], the study correlates industrial construction flow and economic growth in KSA between 1970 and 2011. Fig. 13 indicates the comparison of urban growth studies scholars' contributions.

Fig. 13 Urban growth studies scholars' effort comparison

Fig. 13 indicates that the sample journals employed include three categories. Category 1 covers the body of literature on KSA with a connection to the Arab nations. This category receives 27% of the scholars, as shown in Fig. 13. Category 2 handles literature related to Saudi Arabia cities. This category depicts 41% of the scholars, indicating that urban growth experts are more interested in studying cities in Saudi Arabia. Madinah Al-Munawarrah, Jeddah, and Dammam are among the popular case studies by scholars in KSA. Category 3 demonstrates the literature conducted on the Holy City of Makkah Al-Mukkarama; it received 32% of the scholars' contribution, indicating the significance of the city of Makkah's role in the KSA.

5. Conclusion

Urban growth in Makkah is fragmented. Makkah had 77.5% sustainability as stated by the United Nations [47]. Makkah also recorded the driving forces of urban growth, academically starting to include distances and proximity to slopes, elevations, drainages, and the main road nearness [28]. [6] states that sustainable urbanization approaches are integrating these elements, policy, principles, and action. Flood management received a contribution from [18]; the flash flood could be on four main well-interconnected phases, (a) Pre-flood phase management, including mitigation and preparedness, and (b) Post-flood phase management, which includes responses and recovery. Mitigation should cover zoning regulation, building codes, public awareness and campaigns, and adequate infrastructure. Additionally, preparedness is to treat plan actions, skills, and drilling, early for casting and warning, and public awareness. On the other hand, the recovery stage is treating organization and aid, medical and housing assistance comes under this, while infrastructure and business restorations are also under it. Responses to the disaster involve relief and rescue operations, dissemination of information, and warning systems [18]. Recommendations on flood disasters in HCOM are in [18]: (a) A decentralized bottom-top approach and management, (b) The need for effective communication, (c) A Shift in the relief-driven response of the flood disaster, (d) National civil disaster management agency (NCDMA) creation and local NCDMA are essential, (e) National and local spatial and non-spatial data collection, storage, management, and analysis for effective decision-making. Project failure in the HCOM recommendations is given by [34] regarding the factors responsible for the mega projects' failure in the city. Project collaboration is highly essential; it needs partnership and teamwork, automation and mechanization in the industry, office development, and expansion outside holy cities to support construction and management framework development. If fully considered and implemented, these recommendations will go a long way in mitigating the rate of mega-construction failure in the holy city metropolis [34].

The study indicates that scholars are making great efforts to research urban growth in Saudi Arabia, in Saudi cities, and specifically in Makkah Al-Mukkaramah. This study strongly recommends further studies on the HCOM. GIS, remote sensing technology, and related technologies should apply for further urban growth studies in the HCOM and other Saudi Arabian cities. If considered, it will provide databases and information for rational decision-making on urban growth issues with references to; effective urban management, development control, future land management, and budgeting and land allocation for various land uses like; residential, commercial,

industrial, and recreational land uses. Additionally, these scholars contribute to the need for GIS and remote sensing applications at an interval for effective urban growth and expansion management. [26] handles estimated land use and land cover changes and their environmental impacts in three selected Saudi Arabian cities, HCOM, Riyadh, and Jeddah. [27] studies the period from 1986 to 2013 concerning LULC. [31] considers open spaces in the HCOM about the rapid population growth. [22] used a critical analysis of five case studies concerning sustainable knowledge parks. [36] evaluates human factors affecting thermal outdoors in Jeddah city. [54] employed multi-temporal satellite data in the studies from 1965 to 2019. According to [5], geographical information systems (GIS) can apply to visualize AMR data using mapping techniques. [8] studied sustainable urban governance in Saudi Arabia with an emphasis on the top-down approach. According to [58], ecological and institutional factors influenced settlement growth and expansion in Saudi Arabia. Additionally, other scholars' work that supports the need for effective urban management in the HCOM metropolis includes [41], which considers the development of a model for the sustainable evaluation of neighborhoods in the Kingdom of Saudi Arabia. [24] evaluated Hajj crowding and its effects with references to Southeast Asian pilgrims. [42] appraised the role of residents of Makkah City roles concerning housing within the HCOM. [43] directed the research to develop a new contextual model in Makkah's hospitality sector to boost and promote the sector. [53] uncovers urban planning predicaments in the HCOM regarding the huge population crowd participating during Hajj. According to [51], the flood disaster of hefty rain in the KSA challenged solutions and the way forward. [52] views smart cities as those that promote the livability, sustainability, and productivity of their inhabitants or dwellers. [56] and [57] consider the effect of the ripe urban development in the central part of the HCOM and the effect of the public open spaces on the user.

In conclusion, the scholars did great work to improve urban life in the KSA cities and the HCOM. But in the last five decades, urban growth in the HCOM has faced an enormous and growing expansion. The new emigration to the Holy City and its religious value are the two main supporting factors for this rapidly growing. For these reasons and others, the Saudi Arabia government encourages and supports research for investigation and finding the best solution for current and future problems. Prince Khalid Al-Faisal Chair for Developing Makkah Al-Mukarramah and the Holy Places and Saudi Arabia Vision 2030 for the HCOM to become one of the best places to live and visit with enhancing the spiritual journey to the Grand Mosque and the sacred places are an example of taking care about the Holy City of Makkah, but still, it needs more work to reach their goals.

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