

Relationship between New Spatial Patterns and Green Architecture Transformations – Focusing Urban Dynamics in UAE

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ABSTRACT

For decades, green architecture transformations have been a factor in the design of urban areas. The urbanization process is associated with a burgeoning population, increasing economic activities, and the rise of various socioeconomic engagements. Therefore, there is a need to explore green space, motivating the city's socio-ecological practices. This study aims to evaluate the relationship between spatial patterns and urbanization. It discusses the role of spatial patterns in the process of urbanization. More specifically, the elements of the network of transportation and alteration in land usage were discussed as two spatial patterns. Further, the study examines the factors that led the Arabian region, mainly, the UAE to transform their industry towards green architecture, since the year 1990 was marked as the initiation of the change in the construction industry in the Arabian region. The urban greenbelt strategy was used in this study to limit the physical spread of urban sprawl, avoid environmental deterioration, and preserve green space. The study analysed that despite efforts taken to transform the construction industry towards green architecture entirely.

Keywords: Economic growth, green architecture, population, spatial patterns, UAE transformation, urbanisation.

Mathematics Subject Classification: 86A60,

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1. INTRODUCTION

The structure of urbanisation in the contemporary era reflects the transformation of cities based on more intricate mechanisms where there is an abundance of interrelating and networking. Subsequently, such entangled mechanisms bring about the eruption of unprecedented approaches worldwide. Such practices cannot be construed from the limited course of knowledge possessed by the individuals. Amongst those intricate mechanisms, spatial patterns depict the demographic sites of urban outfits such as buildings, amusement sites, pools, and other infrastructure (Batty and Longley 1994). The notion of urbanisation is imperative to unearth the multi-dimensional aspects of its progress and expansion. The transportation network lays the foundation for all the urban regions as it is the indispensable means of maintaining the functionality for the continuation of urban life. Huynh et al. (2016) reviewed 73 different cities' spatial patterns by evaluating the ratio of the distribution of conveyance points. The findings of the study unveiled various distribution points. Further, about the visual retrospection, it was examined that the cities that had proper distribution patterns were lagging in terms of having appropriate centres.

Moreover, the findings revealed the presence of two urban systems, i.e., well-structured and spontaneously grown (Huynh et al. 2016).

Green architecture transformation may reduce the adverse effects of urbanisation and progress the quality of life of urban inhabitants by maintaining biodiversity and providing ecosystem services and constitute an important element of sustainable urban development. Air purification, noise reduction, flood, biodiversity protection, temperature mitigation, carbon storage, and recreational services regulation are just a few of the important ecosystem services provided by green areas (Nielsen et al. 2014, He et al. 2016, Margaritis and Kang, 2017, Rahman et al. 2017, Zölch et al. 2017). Furthermore, green transformations serve important cultural functions, such as gathering places for local inhabitants and increasing a population's perception of security (Bijker and Sijtsma 2017).

Although there is evidence in the literature that public green transformations have risen with urban expansion in some situations, this has been chiefly due to an expansion in the total city size and successful greening programmes (Zhao et al. 2013). Previous research has primarily focused on the city level, leaving a comprehensive examination of the effects of various development patterns and urban subtleties on the availability of green transformations at the regional level lacking. Green transformations can help urban people cope with the adverse effects of urbanisation and improve their general quality of life, but urban dynamics heavily impact their availability. The goal of this research is to see how spatial patterns and urbanisation interact in the urbanisation process.

2. LITERATURE REVIEW

In the past few years, technological accessibility, different nature of data, and advanced mapping techniques regarding urban structures have been increased. The availability of data has facilitated the researchers to have insights regarding the spatial patterns that are the parts of urban systems. Among them, one of the data sets is related to the street and road networks, which establishes the urban system's fundamental structure. Thus, it provides a plethora of information about organising the city (Huynh et al. 2016, Jiang, 2007, Louf and Barthelemy, 2014).

Huynh et al. (2016) asserted that public transport points were well-described and could measure the extent of the social and technical progression in urban cities. Additionally, the transport network is administered to assist the citizens in making their life activities feasible, from going to schools to social work and shopping. Resultantly, it can be delineated as an indicator of favourable distribution for the residents. Through the interchange of these elements, spatial pattern regarding transport in an urban setting can lead us towards a comprehensive understanding of the morphogenesis and morphology of an urban mechanism (Huynh et al. 2016).

The more advanced spatial form of the integrated cities is urban agglomeration, which is consequent to establishing the interconnection among cities in the form of competition and cooperation. An urban agglomeration is associated with increased integration, an indispensable factor in economic progress across the world (Fang and Yu, 2017). The spatial patterns regarding distribution are significant

elements for environmental dynamics, including population genetics, mating systems, predation and swift prevalence of illnesses. The process of urbanising is dynamic that extends with increasing demography, boost to industrial activities and other socio-economic factors. This emphasises that proper knowledge about spatial patterns is necessary for devising better decisions (Ramachandra, et al. 2012).

Expanding urban communities takes place directly in the form of alteration in land being used and its patterns and modification in the distribution of urban space under the economic and social burdens (Alphan, et al. 2009). As a result, urbanisation usually extends unpredictably, i.e., sprawl also referred to as “geography of nowhere” (Kunstler, 1993). The emergence of sprawl is based on location, time, spaciousness, and gradual increase of population, where better planning and policy making also increase. Three parameters are involved in an urban sprawling, such as; scattered population in limited density developments, disintegrated construction and further development without considering the urban core (Ewing, et al. 2002, Moghadam and Helbich, 2013), which can be assessed through land use analysis and land cover analysis. Land cover terms the apparent physical cover on the exterior of the Earth (Di Gregorio and Jansen, 1998, Codjoe, 2004), i.e., plantation, snow cover, water reservoirs (USDA Forest Service, 1989), environmental and physical conditions of land (Codjoe, 2004; Turner and Meyer, 1994). On the other hand, land use alludes to the socio-economic usability of land and seizing the site for another purpose (Ramachandra, et al. 2012, USDA Forest Service, 1989). Conspicuously, grasping the dynamics mentioned above assist in understanding the predicaments that the region has faced, along with appropriate spatial monitoring of urban dynamics (Bhatta, 2010).

2.1. Spatial cycle and urban dynamics

Since the era of Malthus, the alterations in economy and demography based on time and location were studied. Malthus recommended regularising the relation of land fertility, wage and population density. Urbanisation is the process likewise the regional economic progression while assimilation of the rural population and the usage of natural resources. Spatial cycles, which are related to the transition of urbanisation, are observed in the societies of advanced countries. They witness a lesser degree of aggregation and have progressed at the levels of moderate local bodies. In addition to it, the population expansion in the suburb areas doesn't exceed the core population. The altering distribution of people is the leading factor to change in the industrial distribution and organisation.

The development in an urbanised community is going through the ascending movement of spatial cycles connected spatially and visible during progress in urban and other communities. Figure 1 exhibits the spatial cycle where the horizontal axis represents the population of urban society, and the prices of land are shown on the vertical axis. The process comprises four quadrants that delineate movement anti-clockwise (Orishimo, 1987).

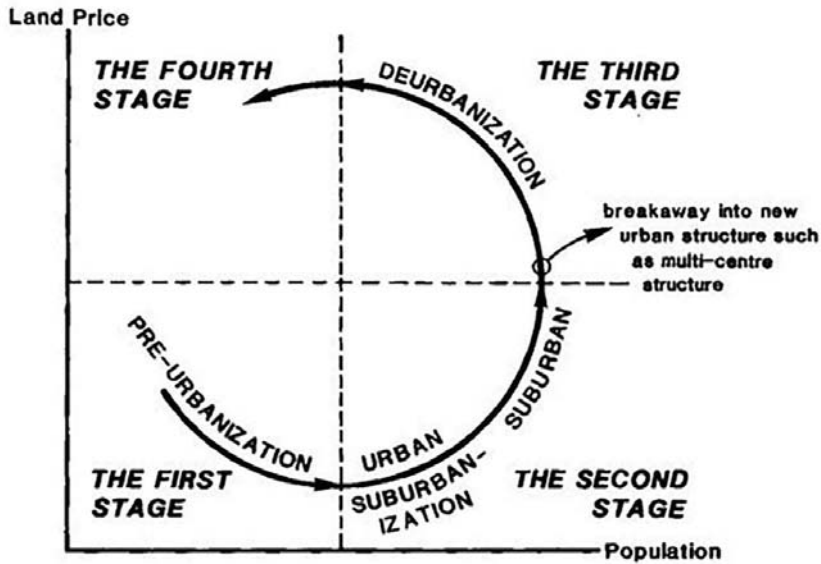


Figure 1. Process of urbanisation (Orishimo, 1987)

Initially, there is an increase in population while there is no hike in the prices of land during the same time. During the process of suburbanisation, the sub-urban have development footprints of urbanisation. While the third and fourth phases go in a similar manner (Orishimo, 1987).

2.2. Building Green Infrastructure

Green architecture is developing an architecture that is not environmentally harmful (Tasci, 2015). Some of the prominent features of green building are summarised below:

- Green building has efficient ventilation systems for heat and cooling.
- It encompasses energy conservative lighting arrangements and household machines.
- It has proper solar energy generation settings.
- It comprises the fixture of plumbing for water conservation.
- The substitute sources of power, i.e., wind power or solar energy, are available in green buildings.
- The building materials that are used in green buildings are natural and non-hazardous compounds.
- The construction residue can be recycled.
- Effective use of space (Ragheb, et al. 2016).

The concept of sustainable development was taking its roots three decades ago when it was introduced by the report of Brundtland in 1987 (Sabbagh, et al. 2019). Following the same concept, the first sustainability assessment was done under the auspicious of a UK based institution, the Building Research Establishment, in 1990. The period was marked with the initiation of various sustainability standards, rating mechanism and codes that were useful to design, build, sustain, and rate and mark the building with ratings to make them up to the mark. However, even the situation in 2019 depicts that

regardless of much directed efforts and investments for resource conservation, it requires more steps and determination to transform the entire region from traditional building to green building (Sabbagh, et al. 2019).

Remarkable advantages and outcomes are associated with green building built-in environment. The construction of green architecture is based on some principles for diminishing the heat island effect, saving natural resources and curbing carbon emissions. The geographical location of the Arab region is favourable and abundant to generate renewable energy resources, i.e., wind power energy and solar energy. Figures 2 and 3 show the wind power density and photovoltaic power potentials of the Arab world (Sabbagh, et al. 2019).

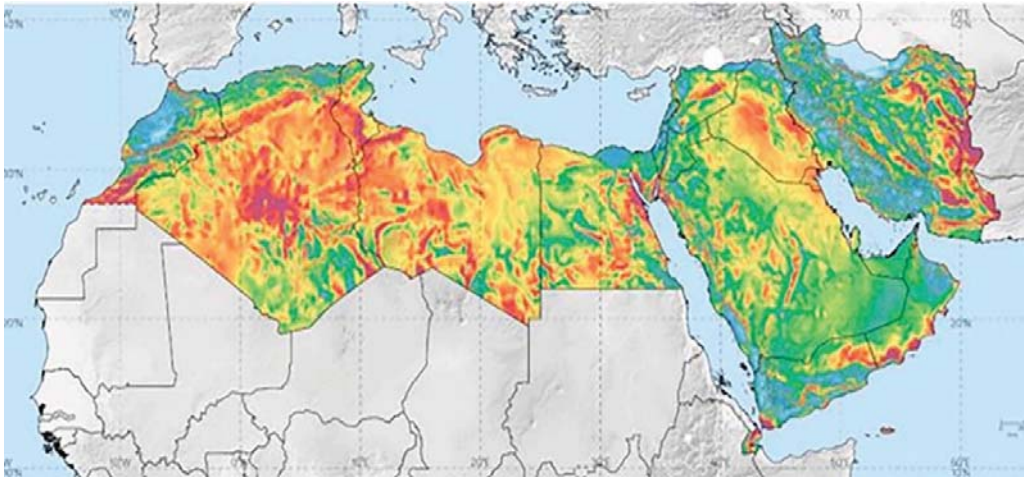


Figure 2. Density of wind power in Arab countries (Sabbagh, Mansour and Banawi, 2019)

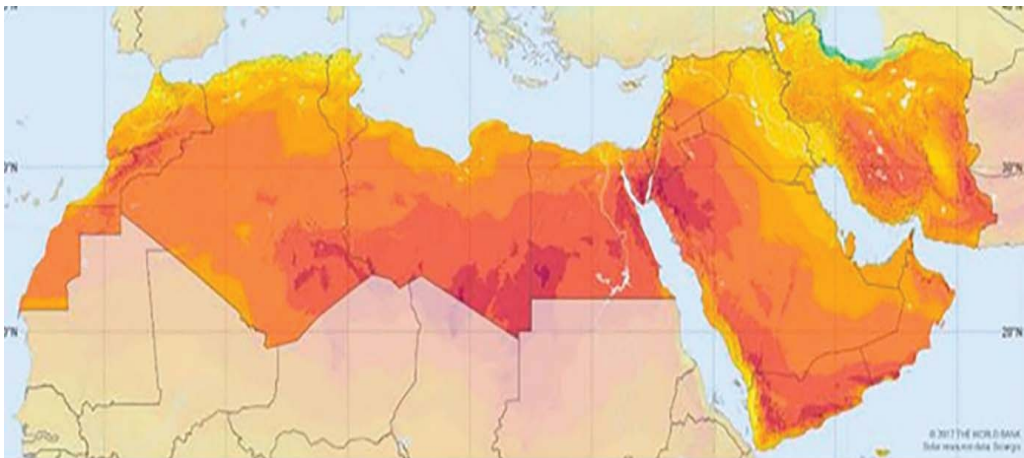


Figure 3. Solar photovoltaic power of the Arabian region (Sabbagh, Mansour and Banawi, 2019)

3. METHODOLOGICAL FRAMEWORK

Dubai metropolitan current development action plan is looked back by the legislation of legal greenbelt in Dubai. The efficiency of the greenbelt is measurement should be based on the data covering of the timings before and after its acceptance. In this respect, remote sensing investigation was conducted for investigating the temporal and spatial dynamics of urban growth in the initial step. The future development, in the second step, of urban development was forecasted at 50% of probabilities and the confidence level of 75%. The greenbelt plans proficiency, along with their local sensitivity, in the third step, were anticipated toward the extension of future settlement. Lastly, the strategies are conducted through SWOT (Strengths, Weaknesses, Opportunities, and Threats) and Quantitative Strategic Planning Matrix (QSPM) analysis related to the greenbelt planning. Internal and external factors are examined via fieldwork observations which were used in SWOT and QSPM. This analysis was carried in the following steps;

- Defining key strategic factors.
- SWOT analysis is performed for objectively weighing the pros and cons of strategic factors.

In this study, the analysis of the relationship between spatial patterns and green architecture transformation in UAE consist of three methodologies; checking integration between the housing survey results with the statistical data, reviewing literature about housing statistics, and surveying housing topologies. First, government reports and census studies are used to perform a statistical data literature analysis relating to housing supply and demand, population growth rates, and maps of housing distribution. This information was used to conclude present and future housing market patterns in both locations, which assist future housing tendencies and housing dynamics. Second, the spatial distribution of homes is studied using maps for residential land uses, and densities lead to findings regarding their typologies and population ethnicity. A brief idea of the methodological approach considered in this study is provided in figure 4.

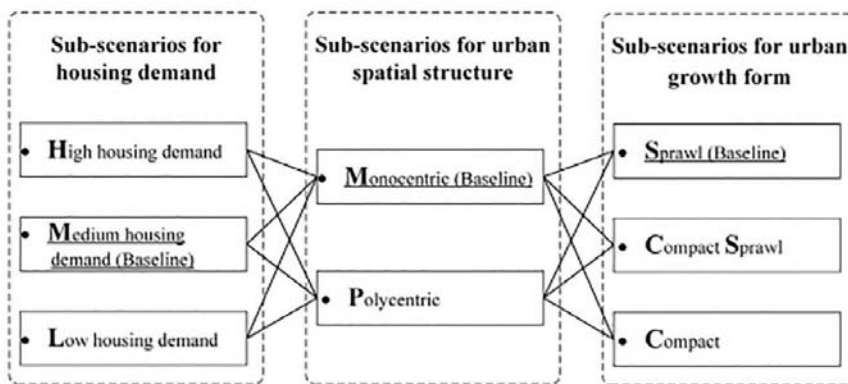


Figure 4. Methodological Approach

3.1. Remote sensing data

Geo-statistical techniques of remote sensing and GIS are utilised, respectively, for determining dynamic quantification of the sprawl in urban growth research. In remote sensing electromagnetic radiation

detection sensors are used. The radiation can come from machines (active remote sensing) or sun (passive remote sensing), and it can be reflected off the Earth's surface. Landsat sensors were considered for achieving four imageries throughout 1998, 2008, and 2018 at equal intervals. The United States Geological Survey host Landsat archive of satellite remote sensing data which gathered satellite imageries, through a web-based Earth-Explorer program with the valid format of radiometric and geometric errors. All images of the study area were selected in driest month for removing the error caused by cloudiness. Table 1 show the information and specifications of the satellite imageries mentioned above. To show the layout of maps GIS software was used, while to prepare the images ENVI software was utilised. The maximum likelihood classifier was integrated for the cover classification or land use, according to ten pixel-group samples. A visualised comparison method was used to conduct an accuracy assessment. One hundred pixels were randomly selected from both the classified and original images for each land-use class.

Table 1: Landsat Imageries Specification

Date	Satellite	Sensor
1998	Landsat 4	TM
2008	Landsat 5	TM
2018	Landsat 7	ETM+

3.2. Forecasting settlement extension data

It is essential for predicting urban sprawl development in the probabilistic future for planning an exact boundary of greenbelt in the past, besides examining urban sprawl development. Global Human Built-up and Settlement Extent (HBASE) were used to collect forecasting settlement extension data with the help of socio-economic applications and the data centre of the National Aeronautics and Space Administration. The HBASE dataset for the target year 2015 are derived by using the global land survey of the Landsat dataset and comprises a probabilistic classification of built-up and settlement extension prospectively. Two levels of settlement extensions are utilised for predicting the potential sprawl effect on the greenbelt plans in the future time windows at a confidence level of 50% and 70% of probabilities. The most frequent confidence level is 95% ranging from 80% to 99%. Often, the confidence level is determined on the basis field of study or the publication where the findings will be published.

3.3. Environmental change index

Local environmental sensitivity determines the environmental change index. Therefore, the change index can be integrated for evaluating ecological changes and sensitivity.

4. RESULTS AND DISCUSSION

It is well understood that green architectural transformations affect urban dynamics. However, green architectural changes current studies mostly ignored zoning within urban regions and stimulates the urban spatial patterns beyond the city level (de la Barrera et al. 2016, Haase, 2016, Kabisch et al. 2016,

Richards et al. 2017). Therefore, green architecture transformation needs to be measured at the urban regional scale to better interpret for the complexity of land development in light of the increasingly powerful interactions between urban and rural areas and the constant high pressure on open spaces caused by urban growth in the majorly all regions in UAE.

4.1. Satellite imageries

At different spatial and spectral resolutions, the remote sensing process has been broadly utilised in detecting environmental changes. Therefore, three temporal sequences of satellite imageries were extracted for 1998, 2008, and 2018 from Landsat 5, 7, and 8 imageries. The outcomes of the accuracy evaluation were attained with an overall Kappa coefficient of 70%, and mean accuracy of 75% which represent the standard ranges for urban land cover classification. As a whole accuracy is measured of the sample pixels depend on corrected classification outcomes and Kappa coefficient depend on the anticipated classification outcomes as a random-based measure. ENVI are characterised satellite imageries for built-up expansion and discriminating real estate, representing actual natural colour. Table 2 shows the statistical outcomes, which showed a rapid urban increase from 123.15 km² (1998) to 437.94 km² (2018) with a mean alteration pace of 46% and a growth rate of 1.76. Examination of the city's population growth showed elevating population with a mean alteration pace of 29% and a growth rate of 1.30 in synchronised time intervals (Table 3). This evidence indicated a faster development of physical land development alongside that the urban population in Dubai city is more rapid compared to its growing population.

Table 2: The Study Area of Urban Expansion

Date	Expansion (km ²)	Alteration (%)	Growth rate
1998	130.15	-	
2008	195.91	40%	1.85
2018	294.49	44%	1.29

Table 3: The Study Urban Population

Date	Expansion (km ²)	Alteration (%)	Growth rate
1998	1,400,208	-	
2008	1,778,450	25%	1.23
2018	3,001,148	24%	1.10

In the northern and western parts, a leading trend of sprawl development was observed throughout 30 years because of their ability to leapfrog the development of the new settlements. The new settlement trend in this scenario is observed to outskirts real estates and occupied brownfields, which encompassed elevating urban sprawl. On the contrary, the increasing heights have comparatively controlled the sprawl extension throughout the last three decades, specifically in the eastern and

southern cities. Thereby, the pre-requisite need for a greenbelt is considered in the western and northern parts of Dubai.

To emphasise effective procedure for controlling the urban development around the city, the legal greenbelt initial plan was initiated. The legal greenbelt plan failed due to greenbelt status in 2018 because of the approximate occupation rate over 20% by spatial overlapping and the legal greenbelt plan regarding the urban expansion (Table 4). It is possible to make the legal greenbelt plan work by keeping the land in a natural state and the forest land clause. One also required an approved preservation plan, provide the necessary documentation, and have the application notarised.

Table 4: Occupation Rate of Sprawl Expansion

Time	Greenbelt plans			
	Legal		Proposed	
	Km2	Percentage	Km2	Percentage
2008	2.25	8.50	0.11	0.05
2018	5.58	20.49	1.41	0.95

4.2. Sprawl probabilities

In future the probabilistic classifications of settlement extension and built-up were used (Wang, et al. 2017). The total settlement area and the connectome index of green-blue infrastructure were calculated as indicators for different scenarios. The scenarios should be examined individually, with two of the three sub-scenarios remaining the same. At the same time, the other is varied to assess the effects of various urban dynamics on availability of green space. In this situation, two settlement extension levels were used to predict the possible sprawl effect on the greenbelt plans in the future time windows at a confidence level of 50% and 75% probabilities. The spatial expansion of the city was computed in GIS equal to 450 and 650 km² based on both possibilities. The probabilistic classifications settlement extension of and built-up can be modified for time intervals of 2030 and 2050 prospectively after the increasing rate of urban expansion and mean alteration pace throughout the past decades. In particular, the settlement extension on the proposed and legal greenbelt plans was conducted in Table 4 based on GIS-based spatial overlaying.

Thereby, the settlement extension occupation rates within greenbelt plans were estimated in Table 5 based on two intervals in future time. The legal greenbelt would be encompassed by settlement extension approximately 69% up to 2030 and 99% up to 2050 as indicated by outcome. Thereby, the better outcomes of 10-50% efficiencies in the future will be explained by the proposed greenbelt plan. Classification of the environmental change index was conducted to identify the local sensitivity in the future proposed and legal greenbelt plans. At the time of legal greenbelt formation the urban boundary generally resulted effective throughout the inner side of the belt. However, the efficiency of the legal greenbelt converted unspecific in the urban sprawl light as a city stretched in the recent decade. Based on this, a new greenbelt plan was suggested in this study for defining a new equilibrium related to the spatial growth of the study area. The planners must set new greenbelts for accomplishing general balance via new urban development.

Table 5: Settlement Extension Occupation Rate

Time	Greenbelt plans			
	Legal		Proposed	
	Km2	%	Km2	%
2030	19.61	58.85	121.52	70.12
2050	28.65	89.46	110.65	65.56

4.3. Key strategies development for greenbelt planning in Dubai

A series of three weakness and strengths were surveyed as proposed greenbelt plan internal factors. 0.50 and 0.40, were anticipated as the total weighting for strength and weakness factors respectively. Correspondingly, the total scores for weakness and strength factors were expected nearly 0.80 and 0.90, respectively. The internal factor's matrix total sum score was computed as 1.80, which is less than 2.5 and thus presented the greenbelt planning strengths as compared to weaknesses in the study area. This issue predominantly relies on the deficiency of a legal mechanism for conserving the greenbelt restrictions in Dubai city. In addition, a series of three opportunities and threats were surveyed as external factors. 0.70 and 0.30, were anticipated to the total weighting values, for opportunity and threat factors, respectively. Correspondingly the full scores were expected to 1.80 and 0.80, respectively, for opportunity and threat factors. A total sum score of the external factor's matrix was computed as 2.60, which is more than 2.5 and explained that greenbelt planning opportunities were more influential than threats in this study area. This promising aspect can be associated with the appropriate pattern of the proposed greenbelt plan for covering the city against all sprawl expansions.

These tactics will reveal substantial effects on the prospect of the greenbelt. The effectiveness of a greenbelt strategy is controversial because of its different effects (Kim, et al. 2019). Some scholars have argued that the appropriate system can result in sprawl restriction, specifically in greenbelt planning, whereas other researchers have identified that the inappropriate greenbelt strategies can support leapfrog development (Jun and Hur, 2001, Dawkins and Nelson, 2002, Bae and Jun, 2003, Ogura, 2010). The present study, in any way, has proposed appropriate strategies for defining an optimal plan of greenbelt based on past changes and the future likelihoods. Several studies refer sustainability to the urban planning offered by a greenbelt concept (Yokohari, et al. 2000, Lindsey, 2003, Brown, et al. 2004, Yang and Jinxing, 2007), the finding of the study has as significant implications for both urban and regional planners. It helps them to better understand the spatially varied impact of urbanisation on availability of green space and suggested targeted planning strategies for different sub-regional zones based on their unique spatial characteristics availability green space and population density.

5. CONCLUSION

Urbanisation takes place due to the assimilation of rural communities into urban where the progression of socio-economic activities takes place to a greater extent. The structure of urbanised cities is based on intricate mechanisms. Spatial patterns are one of those complicated mechanisms that exhibit and

determine the distribution and use of land in urbanised communities. An urban agglomeration is another advanced spatial pattern that creates interconnectedness among the urban communities due to an enhanced level of integration.

The present study has assessed green architecture transformation under various and divergent urban dynamic scenarios at regional and sub-regional levels. Selected situation were mostly related to the green architecture transformation in the light of new construction during urban expansion with effective greening policies.

The current study has operated the urban greenbelt approach to restricting urban sprawl's physical expansion, preventing environmental degradation, and preserving green space. The findings allowed urban planners and policymakers to make and take effective decisions about plans of greenbelt in other urbanised regions. Therefore, the suggested method and its environmental index can be undertaken as an ecological instrument for the instant assessment of greenbelt potentials via other urbanised areas in the UAE and neighbour countries having the same-sized population or environment.

The indicators used in this study, especially when combined, offered broad information on green space availability, notably in comparison analyses, using just a limited amount of input data. It is suggested that distinct urban processes might impact, if not quasi-predetermine, the geographic disparity of green space distribution, which should be investigated further in future research.

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