

Analyzing the Spatial Trend of Urban Sprawl in the Secondary Cities of Pakistan: A Case Study of Hyderabad

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Abstract

As land and soils are limited resources, they can only be destroyed so many times in human lifetimes. At the beginning of 21st century since 2008, half of the global population dwells in the cities. However, urban sprawl mainly promotes social, economic, and environmental issues internationally and also obstacles in achieving Sustainable Development Goals (SDGs). This research aimed to study the spatial trend of urban sprawl and its mitigation in secondary cities of Pakistan. Hyderabad city was taken as study area. Geographical Information System (GIS) concerning Spatial Predictive Model (SPM) was employed to project Hyderabad's urban sprawl spatially. All three patterns' trends of urban sprawl including past, present and future were determined by applying Linear Regression based on SPM. To do so, yearly code and the rate of urban expansion variables were put in Spatial Predictive Model and calculated the trend of urban sprawl during 2007-2017, also projected up to 2030. Additionally, policy guidelines are suggested to curb the urban sprawl particularly in the secondary cities of Pakistan.

Keywords: Sustainable Development; Urban Sprawl; Spatial Predictive Model; Environment Degradation; Hyderabad

Introduction

Land and soils are finite, and their devastation is irretrievable within human life spans. Urban sprawl eventually transforms traditional and semi-natural ecosystems into synthetic ecosystems, which creates numerous environmental and ecological challenges, such as heat island effects (Yuan & Bauer, 2007), changes in local climate (Gennaio et al. 2009), arable land losses (Habibi & Asadi, 2011), and water contamination (Lagarias, 2007; Yin et al. 2005). These practices have been an enormous impacting on the surrounding environment including natural resources and landscapes' depletion, and environmental pollution and its degradation (Lu et al. 2011; Terzi & Kaya, 2008). Therefore, more significant effort is required to protect forests, agricultural areas, and other green spaces from urban development (Tanguay et al. 2010; Jaeger et al. 2010).

Moreover, according to Bhatta et al. (2010), the process of haphazard or chaotic growth of urban areas is counted as urban sprawl. It occurs mainly by informal, uncontrolled, and unorganized growth (Zali et al. 2016). Meanwhile, urban sprawl is a stage that takes place after urbanization. It is one of the low-density settlements which takes up a lot of space that was once used for farming, vacant land, or natural habitat (Rosni et al. 2017). In the past, urban areas had defined specific vicinities, however they have vanished their actual lands' status by unprecedented developmental growth in these days (Zali et al. 2016).

More importantly, the relevant meaning of the word "urban sprawl" is more growth than actual. This differs from pure urban growth due to excessive growth. When excessive growth generates more pollution than it consumes, it puts pressure on city limits, which results in environmental degradation (Habibi & Asadi, 2011). The demand for and price of housing and infrastructure will also increase (Kaya & Curran, 2006).

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However, Hyderabad city as one of the secondary cities of Sindh province, Pakistan is experiencing the same issues. Uncontrolled urban settlements are growing across the Hyderabad city. Mainly urban sprawl occurs over the fertile agriculture land uses (Mangi et al. 2018). Hyderabad's development sprawl often caused by increased in usage of private mobility, less affordability among dwellers, monopoly of real estate developers, and not following the governmental authorities bylaws by responsible stakeholders, etc. (Peerzado, Magsi and Sheikh, 2019; Mangi et al. 2018).

Therefore, this study has conducted to find out the spatial trend of urban sprawl and its mitigation in Hyderabad city, Sindh, Pakistan. The city's spatial growth was measured from 2007 to 2017 and predicted up to 2030 using geo-information systems (GIS) tools. Also, suggested policy guidelines to curb the urban sprawl at secondary cities level. Hyderabad is the gateway of all secondary cities of Sindh Province. Most public prefer to live in Hyderabad (i.e., secondary city) after metropolitan Karachi (i.e., primary city). Resultantly, rapid urban sprawl has emerged. However, this study will assist urban planners, city administrators, and other stakeholders while decision making to curb urban sprawl at the secondary city level particularly in Hyderabad city of Pakistan.

Most significantly, as Master Plan of Hyderabad has outdated, governmental authorities are looking for new Master Plan. Hence, this study will benefit to responsible authorities to expose the existing situation of urban developmental growth and improper land conversion in Hyderabad city, and to propose future urban development.

Literature Review

Increased income inequality, job insecurity, ageing urban cores, rising housing costs, lengthy commutes, environmental problems, the loss of farmland and biodiversity, traffic congestion, feelings of vulnerability, high blood pressure, rigid muscles, bigotry, and even murder and mayhem are all effects of urban sprawl (DeSalvo & Su, 2017; Bhatta et al. 2010).

The sprawl is a phenomenon characteristic of the American lifestyle. The fast growths of population and global urbanization have sprawl an international development form (Hamidi & Ewing, 2014). Over the past three decades, urban sprawl has become a widespread problem in developing nations. Sprawl has an adverse impact on the environment and socioeconomic conditions. The causes and effects of sprawl have caught the attention of policymakers worldwide (Kalwar et al. 2019). They are hard at work calculating the precise amount of urban sprawl and developing an environmentally friendly strategy to stop it (Yue et al. 2013; Sahito et al. 2020b).

Urban sprawl is a land-use change from an uninhabited area to an area used for a living (Linard et al. 2013). Urbanization entails two procedures; firstly, the scattering of an urban region by the formation of young urban fragments that arise in the proximity of the existing metropolitan area, and the accumulation or agglomeration of these urban fragments, leading to urban landscape concentration (Aguilera-Benavente et al. 2014), and secondly, city is a dynamically changing social and economic and spatial entity with a divergent hierarchy center for human activities (Wu, 2006). Cities are formed by several types of development factors, including cultural, political, and socioeconomic forces that later influence a city's physical form (Lagarias, 2007; Sahito et al. 2020a).

Urban sprawl is a repercussion of diversity in income levels and growing populations, and improved transportation systems. Also caused by the factors mentioned earlier, such as rising taxation, homicide, infrastructure damage, and educational center presence in the city, also confirm sprawl (Wang et al. 2016; Jaeger & Schwick, 2014).

Unlike rural areas, urban sprawl poses a significant challenge for urban development and planning (Gennaio et al. 2009). Bearing in mind the sprawl's socioeconomic and environmental impact, the solution cannot be found currently (Haase & Nuissl, 2007). Additionally, various urban management practices for sustainable development, including the metropolitan area, smart growth, and green city principles, are inadequate and have not effectively slowed sprawl (Lagarias, 2007).

This phenomenon, which has become a problem for many emerging regions, is the unplanned or weak urbanization that resulted in the unregulated growth of an urban area (Noor & Rosni, 2013; UN Habitat, 2013).

Several authors reported that the most significant considerations behind the prevalence of urban sprawl are population and capital formation, reduced land cost, and provision of appropriate housing. Some benefits include inadequate transportation infrastructure, a commuting network, innovative facilities for a career in suburban areas, utilizing infrastructures, subsidies, and urban

facilities. These factors will cause utilities to grow and encourage urban sprawl growth (Kaya & Curran, 2006; Zhang et al. 2013).

Additionally, this study has focused on the urban sprawl of secondary cities of Pakistan particularly Hyderabad city. However, According to World Bank, secondary cities would be counted as the second tier or level in the cities' hierarchy after primary urban areas.

Lastly, mainly three research questions were raised by reviewing literature such as what is the spatial trend of urban sprawl at Hyderabad city? What will be the futuristic condition of urban sprawl up to 2030? how we mitigate the urban sprawl issues from Hyderabad city, Pakistan?. However, based on these research questions, a detailed research methodology was designed to collect and analyze the spatial data as presented in next section.

Material and Methods

Study Area

Hyderabad, Sindh, Pakistan was taken as a study area. It is situated at latitudes of 25.23 and longitudes of 68.21. Hyderabad has a diverse population from various cultures, casts, languages, religions, and so on. Hyderabad City is administratively divided into three Talukas having mixed communities, such as Latifabad Taluka, Qasimabad Taluka, and Hyderabad City Taluka (Mangi et al. 2018), as depicted in Fig.1.

Rapid economic growth, population, and urbanization have resulted in an increased demand for housing infrastructure. The country currently has a housing backlog of over 4 million units (Lagarias, 2007). Hyderabad's urban population is projected to increase from 1.024 million people in 1998, or 79% of the total population, to 2.320 million people by 2030, or 83% of the entire population (Greater Hyderabad Master Plan, 2007-2027), as pointed out in Table 1.

Table 1 Various Taluka and District Population in Hyderabad (Figures in thousands)

| Name of Taluka | 1998 | 2017 | 2020* | 2030* |
|------------------------------|------|-------|-------|-------|
| Latifabad | 564 | 672 | 922* | 1069* |
| Qasimabad | 115 | 304 | 284* | 347* |
| Hyderabad (City) Taluka | 525 | 755 | 793* | 904* |
| Hyderabad (Rural) Taluka | 290 | 466 | 426* | 491* |
| Hyderabad Urban | 1204 | 1,834 | 1999* | 2320* |
| Hyderabad District | | | | |
| District urban + rural total | 1494 | 2,199 | 2425* | 2811* |

In Hyderabad, it is anticipated that the urban population will increase by 2.41 percent in a calendar year while the rural population will increase by 1.96 percent annually. The city's real estate and housing sectors are under a great deal of stress due to the high pace of urbanization. As a result, the environment has become worse, leading to appalling living situations, increased health hazards, and the quick expansion of slums and squatter communities.



Fig.1. District Map of Hyderabad, Sindh, Pakistan (Planning & Development, Hyderabad Development Authority, Government of Sindh)

Methods

Urban growth modeling and prediction began during the 1950s. It began growing again during the 1970s and 1980s. The continuing availability and advancement of spatial data combined with Geographical Information System (GIS) and computer technologies have increased geographic operations rate since the 1990s (Webber & Longley, 2003; Allen & Lu, 2003). However, there are still relatively few methodologies that have been developed for assessing the extent of urban sprawl in areas undergoing development. Thus, there is a need for such a technique to be used with field and geospatial databases (Crabtree et al. 2009; Sun et al. 2007).

For this purpose, the rapid urbanized city as Hyderabad, Pakistan was selected the study area. To attain the research objectives, a detailed methodology was designed. Data were extracted by published articles, master plan, census reports, and existing and previous Hyderabad growth trends from satellite imagery (Nguyen et al. 2019). Geographical Information System tools (Sun et al. 2007; Fenta et al. 2017) and Linear Regression model (Maldonado et al. 2015; Zhang et al. 2015; Mangi et al. 2018) were employed to assess the urban developmental growth trends of Hyderabad. Afterward, to validate urban growth trends or sprawl, Spatial Predictive Model (SPM) was used considering the Linear Regression statistical technique (Maldonado et al. 2015; Zhang et al. 2015; Mangi et al. 2018) in SPSS software. The process, by which Hyderabad's developmental growth was assessed through GIS, is shown in Fig.2.

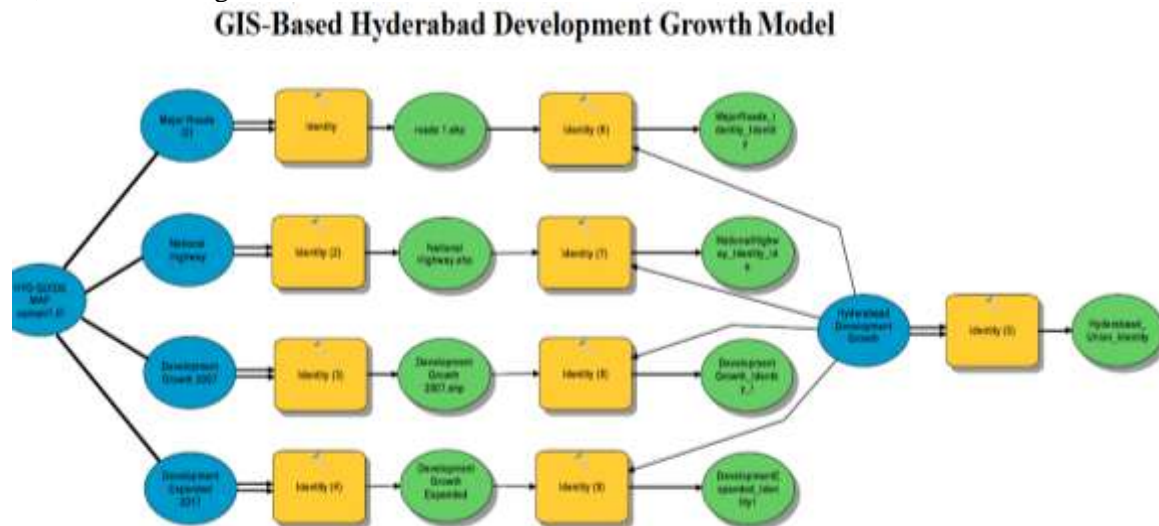


Fig.2. GIS-Based Hyderabad's Developmental Growth Model

In the context of spatial predictive model (Mangi et al. 2018), the increasing land conversion rate and future sprawl rate of Hyderabad city was identified through yearly code and urban expansion trend measuring the relationship between these variables. The detailed process of statistical model is elucidated as follows:

(i) Urban Sprawl (US) = rate of growth + constant factor (Yearly Code) (1)

(ii) using the following formulas for regression parameters: rate of growth and constant factor.

$$\text{Rate of growth (a)} = \frac{n \sum x_i \cdot y_i - \sum x_i \cdot y_i}{n \sum x_i^2 - (\sum x_i)^2} \quad (2)$$

and

$$\text{Constant factor (b)} = \bar{y} - a \bar{x} \quad (3)$$

where,
x = yearly code
y = US

(iii) using equation (2) and (3) and data in Table.1. we have;

$$a = 0.921 \text{ and } b = 1.525$$

Therefore, by entering the numbers for the rate of growth (a) and constant factor (b) in equation (1), we obtain the results corresponding to the yearly code;

(iv) $US = 0.921 YC + 1.525$
 where, $YC = \dots, -1, 0, 1, \dots$ ($-1 YC = 2006$ and $+1 YC = 2008$) and $YC = 0$ corresponds to 2007 as shown in Table.1.

Whereas, US (y) is counted as a dependent variable and yearly code (x) is highlighted as an independent variable. Similar to this, the constant factor denoted by " b " denotes the slope of the line, while the rate of increase of y (or intercept of the regression line) is denoted by " a ", as shown in Fig.3.

Results

For predicting urban sprawl, two distinct indicators were carried out, as pointed out in Table 2. However, data were measured to observe the current and future urban growth trends or urban sprawl. Hence, Hyderabad's urban expansion was calculated by 2030.

Table 2 Urban growth and yearly code variables for the linear regression model

| S. No. | Variables | |
|--------|-------------------|-----------------------|
| | X (Yearly code) | Y (Urban Sprawl in %) |
| 01 | 2007 ($x = 0$) | 0.00 |
| 02 | 2010 ($x = 3$) | 7.21 |
| 03 | 2014 ($x = 7$) | 6.23 |
| 04 | 2017 ($x = 10$) | 11.07 |

Table 2 describes different parameters of yearly code and urban expansion variables. To determine past, present, and future urban sprawl trends for the computation of yearly code and urban growth variables, a Spatial Predictive Model considering Linear Regression was applied. However, this study paradigm can be helpful in a number of relevant future studies that may be done.

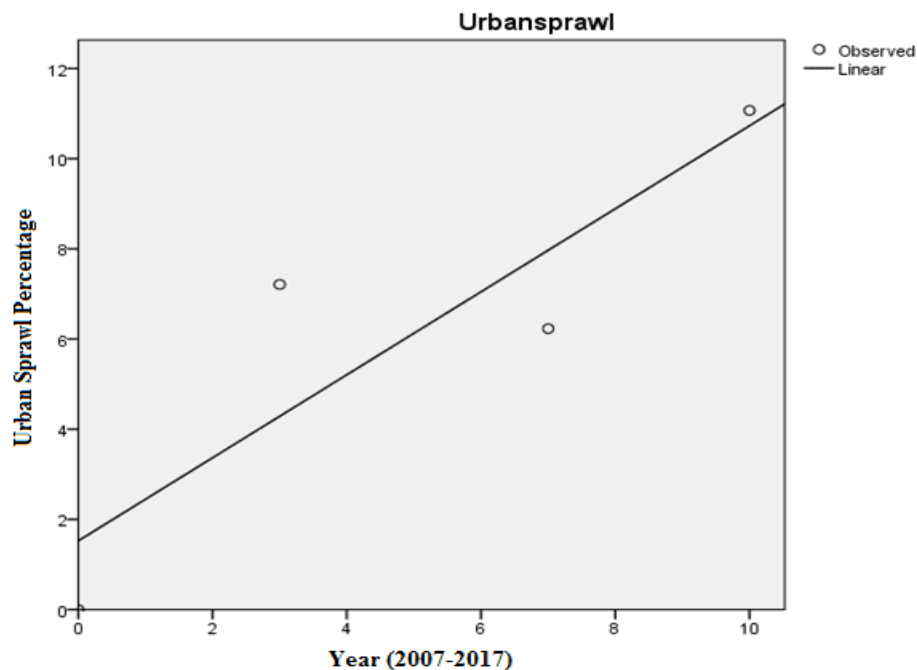


Fig.3. An Assessment of Spatial Predictive Model (2007-2017)

Figure 3 shows the year-by-year urban sprawl in the research area from 2007 to 2017. Line slope depicts the various trends of urban sprawl in percentage, as also expressed in Table 2.

Table 3 Existing and predicted situation of urban sprawl of Hyderabad

| Variables | | Projected Urban Sprawl (%) | | |
|-----------|-----------------------|----------------------------|--------|--------|
| X (Year) | Y (Urban Sprawl in %) | 2020* | 2025* | 2030* |
| 2007 | 0.00 | | | |
| 2010 | 7.21 | | | |
| 2014 | 6.23 | 13.49* | 18.10* | 22.70* |
| 2017 | 11.07 | | | |

The urban sprawl that is already occurring and is expected to happen in the future, as expressed in Table 3. In this study, authors projected urban sprawl (US) patterns from 2007 to 2017 using historical and recent spatial data. The built-up area's yearly percentage is widely discussed.

However, Greater Hyderabad Master Plan (2007-2027) keeps about 140 km² of the city's built-up area. Currently, 77.95 km² of Hyderabad city are covered with built-up, as shown in Fig.7. In 2007, while making a master plan, Hyderabad city's built-up area of 43.62 km² was noted. The plan's proportions for different land uses are shown in Table 4 and illustrated on a map in Fig.4. Whereas, more built-up areas were added with 10.10 km² (7.21%) in 2010, 8.73 km² (6.23%) in 2014, and 15.50 km² (11.07%) built-up areas increased up to 2017, as indicated in Table 3. More importantly, the built-up area was predicted up to 2030 in three phases, namely 2020, 2025, and 2030, in order to investigate the future urban developmental growth conditions. However, as widely estimated in Table 3, Hyderabad city's future development may expand and reach up to 13.49% in 2020, 18.10% in 2025, and may be noticed at around 22.70% in 2030. As a result, it shows that Hyderabad's boundaries have been rapidly and radically expanding.

Table 4 Built-up land use proportion of Hyderabad as on 2007 (Greater Hyderabad Master Plan, 2007-2027)

| Land-uses | Area (km ²) | Proportion (%) |
|---|-------------------------|----------------|
| Residential | 20.218 | 43.78 |
| Travel or Movement | 10.698 | 23.16 |
| Social, Institutional or Infrastructure | 3.804 | 8.23 |
| Restricted Areas (Special Purpose) | 3.729 | 8.07 |
| Industrial Manufacturing and Waste | 3.358 | 7.27 |
| Shopping, Business and Trade | 1.865 | 4.03 |
| Mass Assembly of People | 1.451 | 3.14 |
| Leisure | 0.590 | 1.27 |
| Mixed Land Use | 0.458 | 0.99 |
| Total Area | 46.176 | 100 |

The different trends of urban sprawl were examined by using the Geographical Information System (GIS) tools. Spatial data were extracted from existing master plan and satellite imagery software (i.e., SAS Planet and Google Earth Pro, etc.), and made various maps to investigate Hyderabad city's growth trends between 2007 and 2017, as illustrated in Fig.4-9.

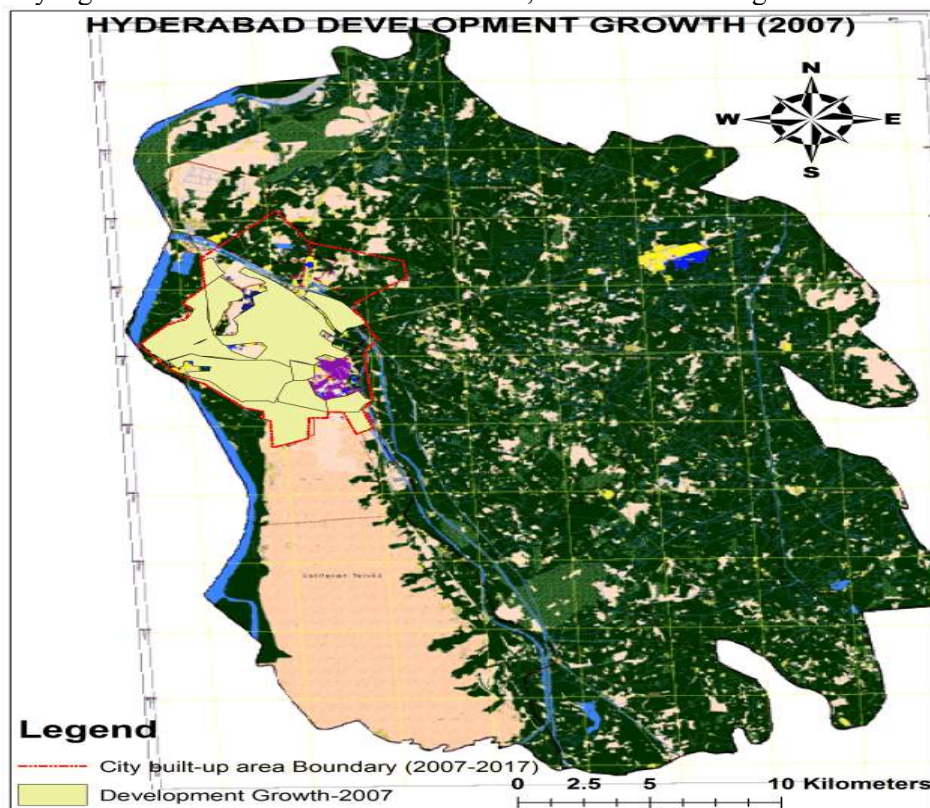


Fig.4. The Extracted Built-up Land of Hyderabad (2007)

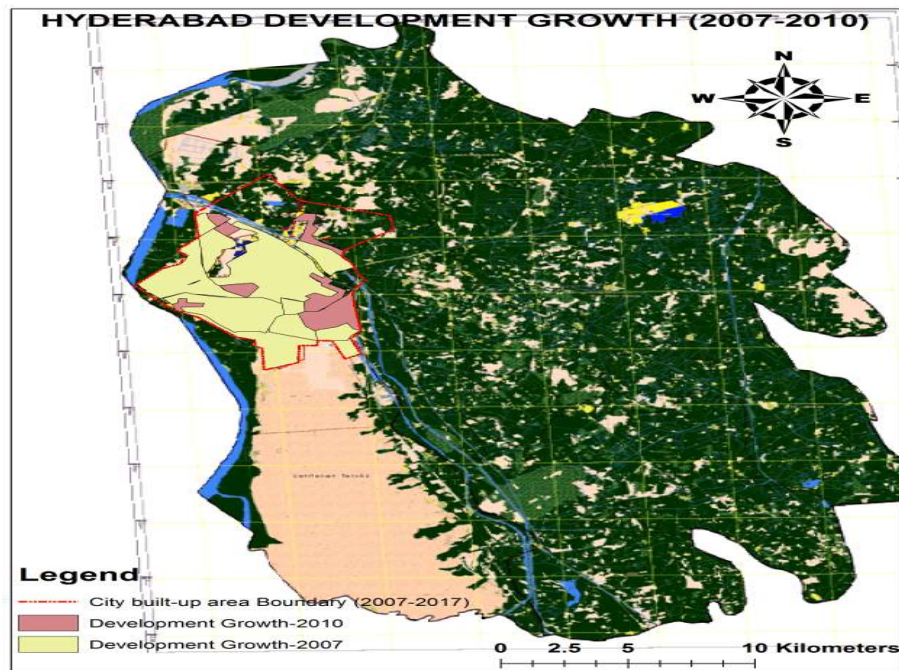


Fig.5. Hyderabad's Urban Developmental Growth 2007-2010

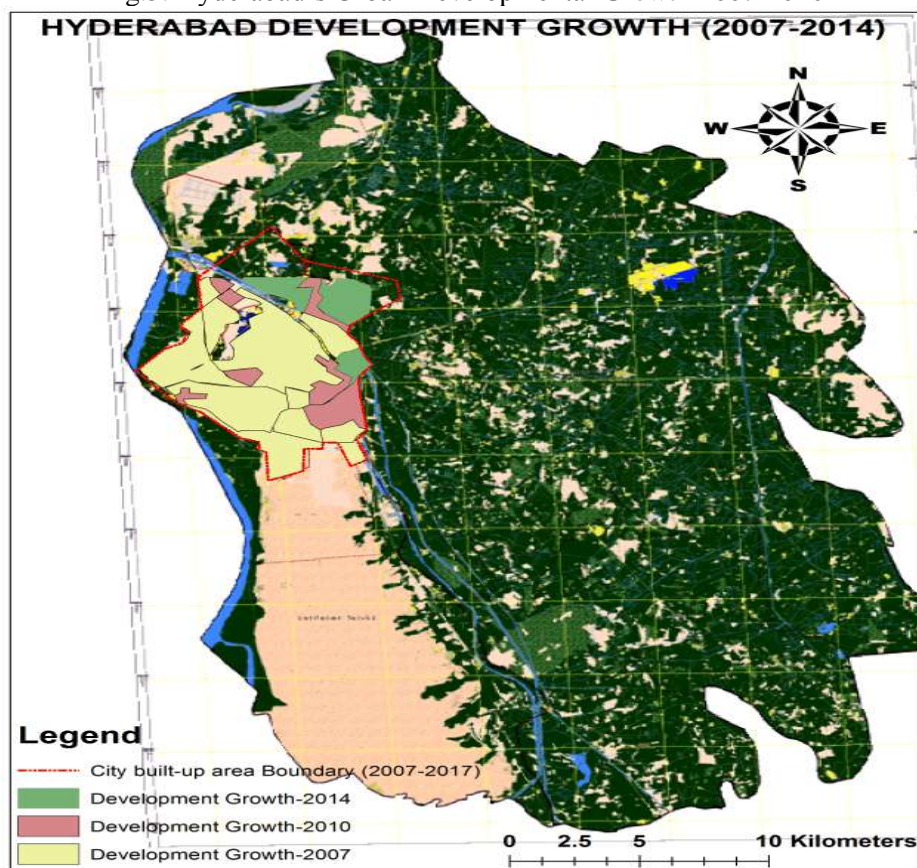


Fig.6. Hyderabad Urban Development Growth (2007-2014)

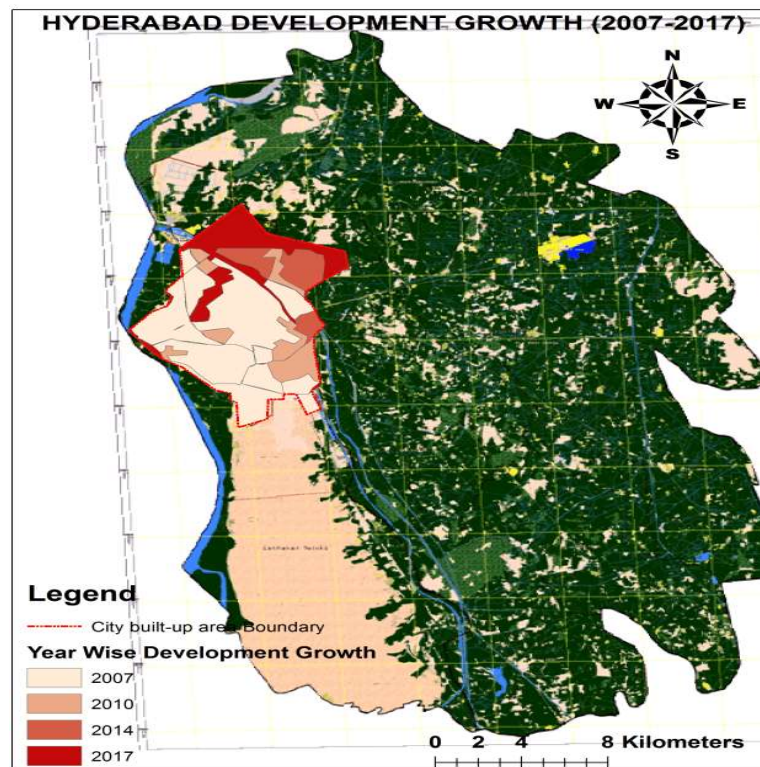


Fig.7. Hyderabad's Urban Developmental Growth (2007-2017)

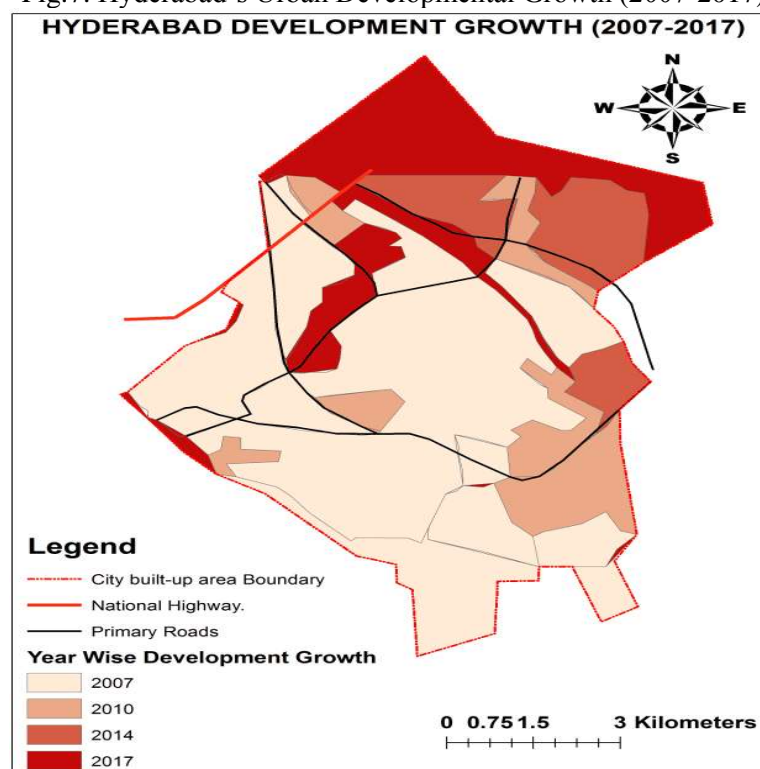


Fig.8. Hyderabad's Built-up Area (2017)

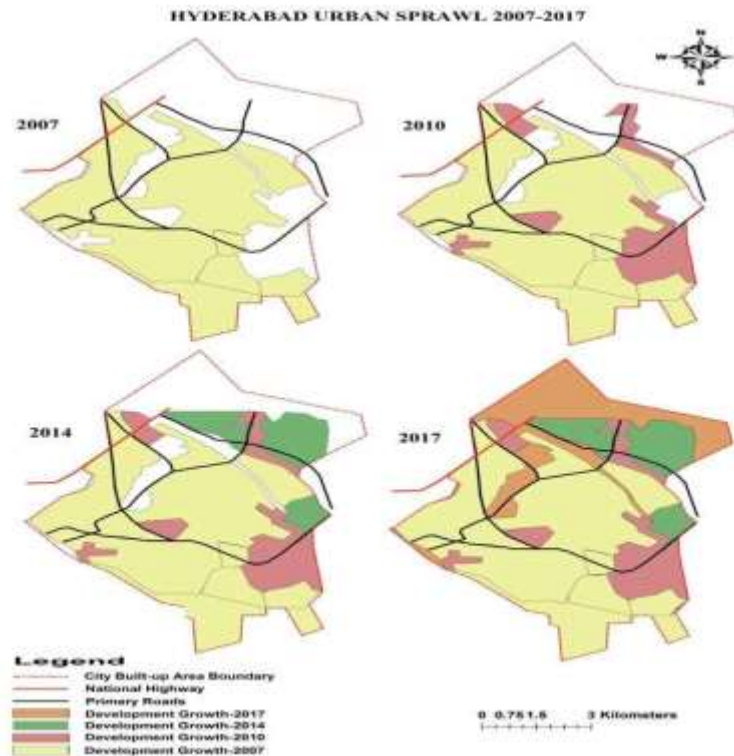


Fig.9. Urban Sprawl of Hyderabad (2007-2017)

Meanwhile, Hyderabad's population is also increasing rapidly with time that creates mushroom growth of new abadies or settlements, causing overburden on existing infrastructure and facilities. The rate of infrastructure development has not kept up with the actual demand in the city. However, it is urgently necessary to concentrate the efforts of all organisations interested in and contributing to the development of Hyderabad city, Pakistan, in order to tackle the immense challenge of Hyderabad's urban growth.

Discussion

The spatial pattern of urban sprawl and its prevention in Hyderabad, Sindh, Pakistan, were the primary focus of this study. To examine the spatial trends of Hyderabad's urban sprawl, the Geographical Information System (GIS) with Spatial Predictive Model (SPM) was used. Finding the Hyderabad city's past, present, and future urban sprawl trends, a Linear Regression based on Spatial Predictive Model was applied.

However, study results revealed that the existing built-up area of Hyderabad city is laid at 77.95 km², which had expanded up to 43.62 km² in 2007. While, in 2010, after three years, the built-up area further increased by 10.10 km² (7.21%). It was added more about 8.73 km² (6.23%) in 2014. Later, in the recent past three years (2014-2017), approximately 15.50 km² (11.07%) built-up area was also increased in Hyderabad city.

More importantly, Hyderabad's urban sprawl may grow up to 13.49 % in 2020. It could expand more up to 18.10 % in 2025. Urban sprawl could spread over 22.70 % in 2030. In conclusion, Hyderabad city boundaries have been dramatically expanded at an alarming rate.

Strategies to Curb Urban Sprawl

Urban sprawl has negative effects and implications for the environment and way of life. When there is urban sprawl, it is difficult to meet sustainable development goals. Therefore, solutions for reducing urban sprawl in Pakistan's secondary cities particularly Hyderabad, must be developed. The following sustainable methods should be promoted and put into practice by officials in the cities:

- (a) It is important to plan the limits of urban areas. To restrain city growth, the green belt should be granted. It should be strictly forbidden to build infrastructure or start new development projects on the city's periphery. Construction is only permitted inside the city's boundaries as defined by the development plan. As a result, Hyderabad city will be constrained (Mojarrad & Hosenifar, 2011; Jaeger et al. 2010).

- (b) The sprawl is facilitated by the transportation infrastructure. The city will grow as more public transport options become accessible. The primary reason for the city's haphazard growth is the rise in the number of private vehicles (Crawford, 2007; Maya, 2008). According to the surveys, fewer people owning private cars and using public transport can assist to reduce sprawl. However, in order to lessen the use of private vehicles and overly intensive local transportation, Hyderabad must boost its mass transit system.
- (c) To live better lives, the majority of low-income people in developing nations move from rural or tertiary/small cities to secondary/primary urban areas (Mangi et al. 2020). Low-income individuals should be given more work options in rural, tertiary/small cities, or suburban areas. These places should be provided with the absolute essentials of life in order to stop the migration that fuels urban sprawl.
- (d) Sprawl development occurs because landowners can capitalize on increased urban land prices. The policy seeks to increase housing provision through the use of land areas and industrial, abandoned properties, public transportation spaces, reintegration of derelict buildings, and heritage landmarks (Irwin & Bockstael, 2007). If present in Hyderabad, the types mentioned earlier of land-uses must observe and rehabilitate or redevelop with effective planning policies.
- (e) Urban consolidation has been proposed to provide adequate land and infrastructural facilities in the integrated metropolis. It seeks to protect urban green spaces, reduce infrastructure costs, and promote public transportation (Nazarnia et al. 2016). Hyderabad city administration has to be strictly followed such guidelines tackling the land-use/land-cover challenges.
- (f) Compact development and urban revitalization are the main focuses of smart growth (Han et al. 2019). However, Hyderabad city development should promote and execute considering smart growth concepts in order to meet sustainable development goals.
- (g) Innovative and effective management: putting out innovative urban policies will lead to the right kind of development. Town planners should therefore be able to estimate the value, direction, and costs of development.
- (h) We may be able to better comprehend future development trends and their effects with the aid of spatial modelling for urban sprawl. An improved method for exploring and changing historical data regarding urban growth into various matrices is spatial modelling. Planning and management must be optimized, monitoring and model construction approaches must be employed, and policies must be developed to ensure the best response (Crabtree et al. 2009).
- (i) Relevant laws and rules must be developed to control urban sprawl. These should go beyond simply stopping the encroachment of non-urban land onto urban territory and include an understanding of the causes of rapid population expansion.

Conclusion

In Hyderabad, a secondary city in Pakistan, this study sought to assess the spatial pattern of urban sprawl and its mitigating factors. Spatial Predictive Model (SPM)-equipped Geographical Information System (GIS) was used to forecast the expansion of urban sprawl in Hyderabad. For the purpose of identifying past, present, and potential future trends in urban sprawl, a spatial predictive model was created using Linear Regression. In this case, the trend of urban sprawl from 2007 to 2017 was calculated as well as anticipated up to 2030 using yearly code and urban expansion variables entered into SPM. The harmful effect of urban sprawl ruins the aesthetic appeal of cities. The emerging causes-based policies are provided after a thorough analysis. The results show that built-up land has increased and spread over different city fringes.

Contrarily, urban sprawl in Pakistan's secondary cities, particularly Hyderabad, is mostly caused by increased population, high land values, economic growth, a rise in the amount of space needed per person, and rising motorized (transport) development. However, by offering services to rural areas, the rate of rural-urban migration could be reduced. Cultivated land has been lost as a result of Hyderabad's rapid development. Urban sprawl is additionally encouraged by the socioeconomic situation of the metropolis. However, spatial modelling for urban sprawl might help us comprehend current development trends and their effects better. A sophisticated method for investigating and translating prior knowledge about urban growth into different matrices is spatial modelling.

On the other hand, in order to achieve the idea of sustainable development and restrain urban sprawl, pertinent policies and regulations must be created and put into place. These should encompass

more than just stopping the spread of non-urban land into urban areas; they should also take into account the causes of rapid population expansion. In order to create lively and sustainable urban expansion, monitoring and innovative technologies must be adopted, planning and management must be streamlined, and policies in response must be devised.

Lastly, this research was only focused on identifying the spatial patterns of urban sprawl of secondary cities of Pakistan particularly Hyderabad city, however, research may further conduct on different urban scales including tertiary cities of Pakistan to know the condition of urban sprawl. Also, research may be carried out to find the acute causes behind such uncontrolled urban development patterns at primary, secondary and tertiary cities of Pakistan as well as developing world.

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