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Evaluating the Quality of Life for Sustainable Peri-Urban Development Planning: A Case of Imphal City, Manipur Northeastern State, India

Adinarayanane Ramamurthy [1], Ningthoujam Kingson Singh [2], Faiz Ahmed Chundeli [3]
[1,2,3] School of Planning & Architecture Vijayawada, Government of India, Andhra Pradesh, India.
[1] Corresponding author: adinarayanane@spav.ac.in

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Abstract: Urban Sprawl, as a low-density, unplanned, unlimited, and sporadic physical expansion towards suburban area is one of the worldwide challenges facing spatial land management and development planning in recent years. Indian cities have been faced with the urban sprawl phenomenon, especially since the 1970s. More recently, scientific studies have been proved the impact of urban sprawl in peri-urban areas poses a significant challenge to optimal land use management in India. While existing research on urban sprawl in the country tends to focus on larger metropolitan areas, the dynamics of smaller cities and towns, especially in the context of infrastructure needs and quality of life, have been largely overlooked. This research gap becomes particularly evident in the case of smaller cities like Imphal City of North-Eastern India, where rapid urbanization is accompanied by distinct socio-cultural and geographic factors. Keeping the aforesaid knowledge in mind, the Greater Imphal Planning Region, Manipur State, India has been chosen as the study region, which is not exempted from the impacts of urban sprawl on peri-urban development and for making further detailed investigation. In the Imphal study region, urban expansion has led to challenges such as haphazard land development, encroachments, inadequate infrastructure provisions, and inadequate land use planning, which end up with negative consequences on quality of life. The demographic landscape of Manipur, with 10% valley and 90% hilly terrain, sees 57% of its population residing in the valley and 43% in the hills, where 41% of the Scheduled Tribe (ST) population predominates, leading to significant land management challenges due to restrictions on non-ST individuals' land ownership in hilly areas under the Manipur Land Revenue and Land Reform Act of 1960, particularly affecting the valley region. This legal framework underscores the necessity for meticulous urban planning for optimal use of land resource management. This research study aims to assess the impact of Urban sprawl over Peri-urban Development planning and to evolve the spatial interaction model to achieve better Quality of life and sustainable peri-urban development in the study region. The Research study analyses the spatial growth using spatial metrics, quantified demand and supply gaps in infrastructure services and assesses the quality of life in the peri-urban system also evolving a spatial interaction model using the Gravity model tool by employing ArcGIS Pro. The scope involves studying urban expansion in the peri-urban area of the Greater Imphal Boundary, with a focus on spatial aspects and a mix of qualitative and quantitative analysis. The study made the comparison between unorganized development in peri-urban areas and the overall quality of Life by residents in those areas, with urban areas, in respect of LULC and associated population. The Quality of Life (QOL) assessment, domains like, Facilities, Safety and Security, Environment, Physical Health, Psychological Health, and social linkages were judged. Further, the study unveil insights into spatial growth dynamics, and informed urban planning for sustainable development. Based on the findings, the study continues with the evolving spatial interaction model and recommends location-specific planning strategies through planning intervention to promote sustainable peri-urban development planning.

Keywords*:* Land management; Quality of life; Sustainable Peri-Urban Development; Urban Sprawl; Urban Growth Dynamics;

Introduction

The expansion of urban activity outside of defined administrative borders within urban zones gives rise to peri-urban areas. Peri-urbanization is the process by which rural regions on the edges of developed cities change into more urbanized environments in terms of physicality, economy, and society; this development frequently happens gradually. Peri-urbanization is characterized by a number of important factors, such as the move from agricultural to industry in local economic and employment structures, fast migration and population increase, rising property values, and mixed land use patterns.

Even though peri-urbanization processes seem to vary throughout, both industrialized and developing nations have certain commonalities with them. Peri-urbanization in emerging nations is characterized by natural population growth, migration from rural to urban regions, and the establishment of peri-urban zones that combine non-agricultural and agricultural uses.

Developing nations, especially those in Asia, are seeing a strong peri-urbanization, as seen by the outflow of urban people towards new towns and peripheral areas, and a decline in population growth inside urban centers (Firman, 2004). Chinese cities serve as prime examples of this tendency, since suburban housing and industrial expansion are shifting in these directions (Pengjun et al., 2009). Peri-urbanization is viewed in the Asian setting as a change from rural to urban living (Hudalah et al., 2007).

Peri-urbanization in Europe is defined as the movement from isolated cities to larger urban areas. As more and more interactions between businesses, housing markets, and migration patterns are seen at the regional level, metropolitan coordination becomes even more crucial for comprehending and preparing for peri-urban transformation (Salet and Woltjer, 2009). In the same way, metropolitan areas receive attention in the US, with a special emphasis on controlling urban sprawl and containment.

Taking into account the distinctions in the urbanization processes of established and developing nations, a number of reasons contribute to the wider disparities in peri-urban growth around the globe. These include the evolution of urbanization over time, the degree of urban-rural separation, the function of information technology, communication, and transportation, and the general state of economic development (McGee, 1991; Aguilar, 2008). The many global circumstances that are reflected in the dynamics of peri-urban development underscore the necessity of employing region-specific methodologies to comprehend and oversee these dynamic environments.

T.L. Smith's original definition in 1992 described peri-urban regions as "built-up areas just outside the corporate limits of the city," but consensus on a universal definition remains elusive. Attempts at defining peri-urban areas can be categorized into three conceptual approaches: location-based, idea-based, and method-oriented. These definitions often emerge when rural regions undergo changes in land use or highway construction, signifying a phase known as "peri-urbanization" as rural areas transition into urban spaces relative to urban characteristics.

Peri-urban areas are developing as a result of the increasing pressure on inner cities to expand, which is mostly caused by the increase in urban population and the rising demand for space. Census towns have grown at a faster rate than statutory towns in India's urbanization trajectory between 2001 and 2011, suggesting development beyond administrative borders. Economic progress is credited with this expansion, especially following the economic reforms of 1991 that drew foreign direct investment into technology-driven businesses. Due to high land costs and a lack of available land within cities, investments were made in regions immediately outside of them, which caused peri-urban areas to expand faster than their parent metropolitan districts.

The growth of urban centers into their surrounding settings, which not only changes rural to urban landscapes but also has an effect on the socioeconomic makeup of the area, is what defines the spatial development of peri-urban regions. Urban and regional planners in India face significant problems due to the conversion of agricultural land into urban areas and the horizontal and vertical expansion of cities.

Peri urban development of Cities in Develop Countries

In developed countries, peri-urban development of cities is characterized by a transition from distinctive urban centers towards broader urban regions. Interactions between businesses, housing markets, and regional mobility patterns characterize this transformation, highlighting metropolitan coordination as a crucial level for comprehending peri-urban planning and development. Peri-urban locations frequently see mixed urban and rural economic functions as a result of economic shifts from agriculture to industry or higher productivity enterprises. Urban containment and sprawl management are unique features observed in the United States, highlighting the complexities of balancing urban growth with environmental and social considerations.

Peri urban development of Cities in Developing Countries

In developing countries, peri-urban development of cities presents a different set of challenges and opportunities. The urban-rural interplay is a significant focus, with a notable shift in economic activities towards higher productivity sectors while retaining agricultural functions. In emerging nations, peri-urban zones can act as hubs for middle-class to affluent residential expansion, industry, and regional economic growth. Rapid and unchecked land conversion from rural to urban uses, however, can negatively impact rural economies and cause problems like job losses in agriculture and decreased food production. Inequalities and conflicts can also arise from social and functional breakdown in peri-urban areas, especially in locations like Asia, Latin America, and Africa.

Peri urban development of Cities in Under develop Countries

In underdeveloped countries, peri-urban development of cities faces additional complexities due to limited resources and infrastructure. The urbanization process in these regions may be characterized by informal settlements, inadequate access to basic services, and challenges in land use planning. The lack of coordinated development strategies across local authority boundaries can hinder effective governance and sustainable growth in peri-urban areas. Addressing issues such as poverty, land fragmentation, and social disparities becomes crucial in underdeveloped countries to ensure inclusive and equitable peri-urban development.

Case Area Profile and Data Analysis

Case Area Profile

Manipur, situated in the north-eastern region of India, is a landlocked state sharing a 352 km international boundary with Myanmar to the southeast. Bordered by Nagaland to the north, Assam to the west, and Mizoram to the south, Manipur spans a total area of 22,327 sq.km, It lies between 230 49' 45.530" N to 25o 42' 1.456" N latitude and 920 58' 23.422" E to 94o 43' 35.553" E longitude. Geographically, Manipur is characterized by a central valley surrounded by hills, dividing its terrain into distinct landscapes. Imphal, the capital city, derived its name from the combination of "Yum" meaning house and "Phal" signifying plenty or beauty, and it encompasses parts of both Imphal East and Imphal West districts, serving as the sole Class I city in Manipur.

Manipur exhibits a clear geographical division into two main regions: the hilly area and the valley region, each characterized by unique physical attributes, flora, and fauna. The capital city is situated within an oval-shaped valley spanning around 700 square miles (2,000 sq.km), encircled by mountain ranges and positioned at an elevation of approximately 790 meters (2,590 ft.) above sea level. The valley slopes gently from north to south, contributing to its distinct topography and landscape features.

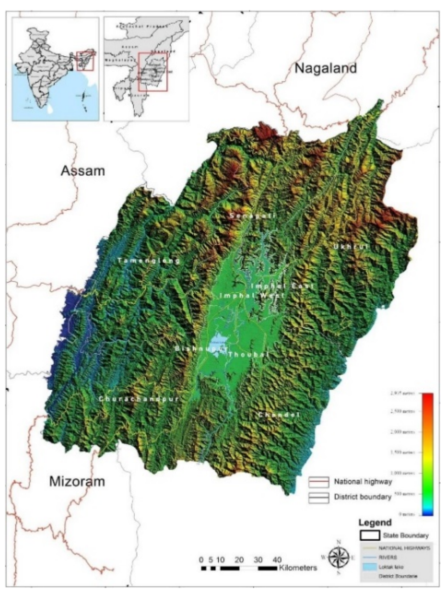

Figure 1: Physiographic map of Manipur Study Region.

Source: Physiographic Map prepared by the authors 2024, based on DEM downloaded from USGS Earth Explorer.

As the capital of Manipur, Imphal has a well-developed road transportation network, vital for the state's connectivity and development. With no inland waterways, road transport has historically been the primary mode of communication, supported by key national highways like NH 2, NH 37, and NH 102, linking Imphal with Nagaland, Assam, and Mizoram respectively. The Asian Highway, part of NH 2, extends Imphal's connectivity to Myanmar via the border town Moreh. Additionally, Imphal Airport, the region's second-largest, ensures air connectivity to major cities like Aizawl, Guwahati, and New Delhi. While the newly established Jiribam Railway Station marks the inception of rail infrastructure in Manipur, plans for extension towards Greater Imphal area aim to enhance accessibility in the near future.

Imphal serves as a hub for cultural traditions, festivals, and commerce. The Imphal Municipal Corporation spans 34.75 sq. km, with a population of 2,68,243 (Census 2011) and 27 wards. The city, located at 93.57o E longitude and 24.500 N latitude. This capital, is central in Manipur's valley region, constituting 42.13% of the state's urban population. Imphal is a low-rise city.

The site area for this study will be the present Greater Imphal planning boundary with 151 sq.km area, which was already delineated in the Preparation of the master plan of 2021 -2041.The study area was already delineated with 7 Zones and 51 Subzones. So, the study will be conducted withing these zones and Subzones of the Greater Imphal Planning Boundary.

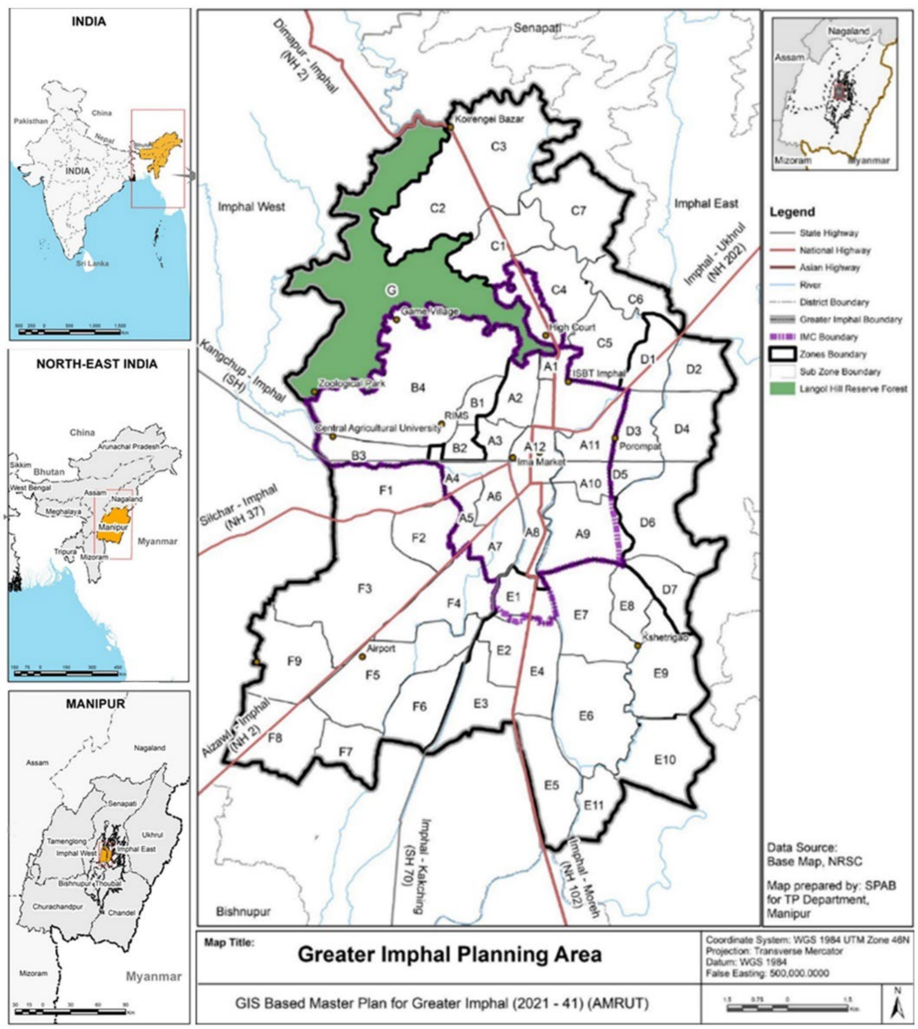

Figure 2: Administrative Boundary of Manipur and Greater Imphal Planning Area

Source: Generated by Authors, 2024, based on the Administrative Atlas, Census of India, Master plan of Manipur: 2021-2041

Imphal's climate is pleasant. The valley has a mild, pleasant climate even if Imphal's height of 2,600 feet makes it hotter than that of the surrounding mountains owing to heat reflection. The Summer averages are between 20 and 30 degrees Celsius, and winter averages are between 5 and 23 degrees Celsius. Rainfall falls from April until October. There are 1413 mm of rain on average every year.

Infrastructure

The livability of Greater Imphal hinges on the presence and ease of access to essential social infrastructure, including healthcare, education, sports facilities, and cultural amenities. Educational facilities in Greater Imphal, according to the URDPFI guidelines, currently meet the required standards based on the 2011 census data, providing adequate infrastructure for pre-schools, schools, technical institutes, and universities. Healthcare facilities are also sufficient to cater to the current population, though gaps exist in certain areas across various hierarchies. Recreational spaces, however, are significantly lacking, with a notable scarcity of parks and open areas across all zones except Zone A, which hosts a city-level exhibition ground, an open-air theatre, and a stadium. The proportion of recreational space in Greater Imphal is far below the URDPFI guidelines' recommended range of 10-12%, highlighting a critical deficiency in recreational amenities.

In terms of physical infrastructure, Greater Imphal faces several challenges. The water supply system, established around 108 years ago, has not kept pace with population growth, leading to inadequate distribution infrastructure. The sewerage network primarily covers zones A and B within the Imphal Municipal Corporation, with other areas relying on on-site systems. The Imphal Sewerage Project, completed in 2020, features a sewage treatment plant and an extensive sewer network. The region's urban sprawl is influenced by the Manipur Land Revenue and Land Reform Act of 1960, which restricts land transfer based on caste affiliations, necessitating meticulous urban planning and resource management to mitigate challenges arising from disparate land-use patterns and ownership regulations.

Data Collection and Analysis

Secondary survey

A secondary survey involves collecting and analyzing data from existing sources. The secondary data was collected from various departments like the Town Planning Department of Manipur (Masterplan 2021-2041), PHED office, Imphal Municipal Corporation.

The secondary data collected for the spatial Metrics analysis in the study region includes Landsat 4–5 TM (2001, 2011), 30 m resolution Multispectral 7 Bands, Landsat 8 (2021), 30 m resolution Multispectral 11 Bands, Boundary shape file of the study area. For the demand and gap assessment of infrastructure and composite mapping of infrastructures, various Secondary data were referred from the Masterplan 2021-2041 of Greater Imphal planning area in terms of Education, Healthcare, Recreational space, Water supply, Sewerage and Road Infrastructure. The focus of the study we along the lines of assessing the basic infrastructure since they are the vital parameter while studying the Quality of Life in the study area. To evolve the spatial interaction model the point location of the Major attracting locations were obtained from the Town planning office of Manipur. As for the Generation of the Land urban development suitability map, various secondary data like the Slope (Open Topography), Soil type (European Soil Data center), Soil depth (Food and Agricultural Organization) and Geomorphology (Bhukosh) were used.

Primary Survey

A primary survey involves collecting original data directly from sources or respondents to address a specific research objective. This method is crucial in planning as it yields firsthand, current information that guides informed decision-making. By obtaining up-to-date insights, primary surveys ensure that planners can accurately assess and address the needs and preferences of the target population. Primary data was collected using a Stratified random sampling technique with a total of 280 samples. The primary data collection was stratified into different zones (A, B, C, D, E, and F) based on population size. The sample size for each zone was calculated using Cochran's formula (1977) for finite population, with a 95% confidence level and a 6% margin of error, assuming a population size of 560,000. The Cochran's formula used for calculating the sample size is provided below in Eq (1) and Eq (2).

$$n = \frac{n_o}{1+\frac{n_o}{N}} \qquad (1)$$

$$n_o = \frac{z^2 p(1-p)}{e^2} \qquad (2)$$

Where, n =number of samples for Finite population, e= margin of error, p=Population proportion, z= Z score. The corresponding number of samples required for identified and Zone-A had a sample size of 118, Zone-B had a sample size of 19, Zone-C had a sample size of 20, Zone-D had a sample size of 33, Zone-E had a sample size of 44, and Zone-F had a sample size of 30.

For studying the Quality of Life in the peri-urban and the urban area, the parameters are organized into several domains. These include Infrastructure Services (Mobility, Availability of Public Transport), Environment (Noise pollution level, Air quality), Physical Health (How satisfied are you with the conditions of your living place?), Psychological Health (How much do you enjoy life? How satisfied are you with your capacity for work?), and Social Relationship (If you were in trouble, do you have relatives or friends you can count on to help you whenever you need them? Have you contributed money in the past 6 months in your locality for the betterment of your locality? How well do you know your Neighbor's?). These parameters are assessed using a Likert scale ranging from 1 (Not at all) to 5 (An extreme amount) for the Environment domain, and 1 (Very dissatisfied) to 5 (Very satisfied) for the Physical Health, Psychological Health, and Social Relationship domains. The data sources for these parameters include the Zone of living index 2019, World Health Organization, and Quality of Living (Mercer)2020.

Analytical hierarchy process (AHP) was used for further analysis of the Primary data. It is a structured decision-making technique developed by Thomas L. Saaty in the 1970s. AHP helps in dealing with complex decisions by breaking them down into smaller, more manageable components and then evaluating those components based on their relative importance. AHP is used to determine the relative weights or importance of different QOL domains (e.g., physical health, psychological, social relationships, safety and security environment, access to facilities).

The AHP provides a systematic way to incorporate local experts' judgments and derive weights for each QOL domain, which can then be used to compute an overall QOL score. AHP is well-suited for this research as it allows the incorporation of local context and perceptions, which is essential because the perception and importance of QOL indicators can vary across different regions and cultures.

A questionnaire survey is conducted to collect data on various QOL domains from local residents. The survey data provides a quantitative assessment of different QOL domains from the perspective of local residents.

Collecting primary data through surveys is essential for QOL studies as it captures the subjective perceptions and experiences of the local population, which are crucial for accurately assessing QOL. The Quality-of-Life score map that is generated from the data is used for the Pearson's correlation of Quality of life with LULC and also Population density map to interpreted the relation between them.

Spatial growth patterns and dynamics through Spatial metrics analysis

Decadal LULC analysis for the Years 2001, 2011 and 2021

The multi-spectral satellite imagery from the Landsat 4-5 TM and Landsat 8 sensors were used to generate the LULC maps for 2001, 2011, and 2021. The process began with the acquisition of the Landsat 4-5 TM data for 2001 and 2011. A supervised classification was used to assign specific land cover classes, such as built-up areas, vegetation, dense vegetation, Agricultural land and water bodies, to each pixel in the imagery. This process was repeated using the more recent Landsat 8 data from 2021 to create the LULC map for that year. The accuracy of the processed images was checked using Kappa coefficients and the results were 0.83, 0.86, 0.82. 80 percent is the minimum required accuracy for LULC classification. After generating these LULC maps for the different time periods, the change in LULC were analyzed and a comparative statement of Decadal LULC for the Years 2001, 2011 and 2021 were calculated.

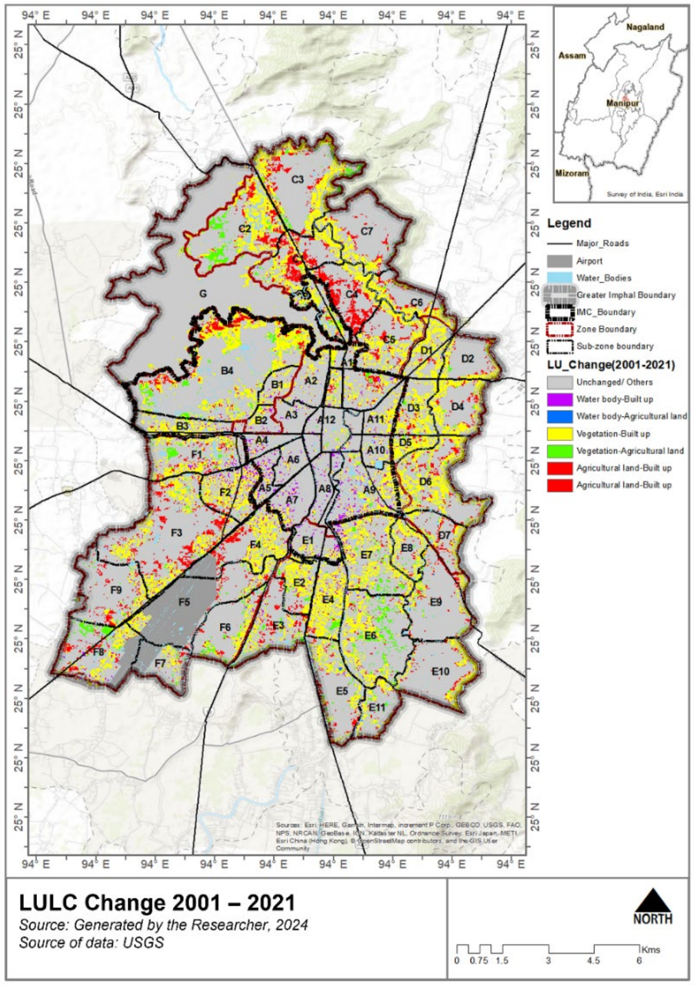

Figure 3: LULC change detection analysis for years 2001- 2021 in Study Region.

Source: Generated by Authors, 2024

Table 1: Decadal LULC analysis for the Years 2001, 2011 and 2021

Sl.no	Description	2001		2011		2001-2011		2021		2011-2021	
		Actual area (Sq.km)	% to Total	Actual area	% to Total	Area change (sq.km)	% shift	Actual area (Sq.km)	% to Total	Area change	% shift
1	Built up	30	20	54	36	24	16	72	48	18	12
2	Water body	5	3	25	16	20	13	20	13	-5	-3
3	Dense Vegetation	5	3	6	4	1	1	5	3	-1	-1
4	Vegetation	62	41	18	12	-44	-29	18	12	0	0
5	Agricultural Land	48	32	48	32	0	0	36	24	-12	-8
	TOTAL	151	100	151	100			151	100		

Source: Generated by Authors, 2024

Urban expansion Intensity Index (UEI)

The urban Expansion Intensity Index was carried out using the formula given below in Eq (3). It analyzes the preference direction of Urban development and Peri urban growth. It was studied in 8 cardinal directions of Growth.

$$\text{Urban expansion Intensity index (UEI)} = \frac{(BUAn{+}i - BUAn)}{i} X \frac{1}{TLA} X100 \quad (3)$$

where BUAn+i and BUAn represent the starting and ending built-up area of the ith spatial zone, and UEI represents the yearly average expansion intensity index of the ith spatial zone for the time period t. zone in sq.km, while TLA stands for the spatial zone's total land area in sq.km.

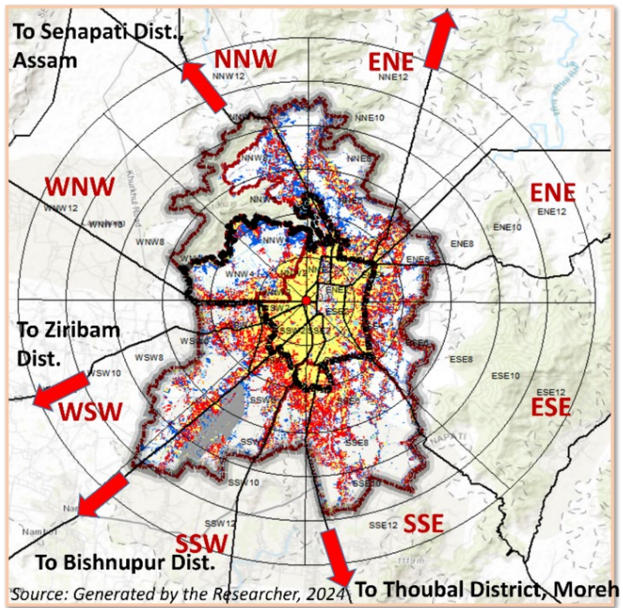

Figure 4: Urban Expansion Intensity (UEI) Index for the decades 2001-2011 and 2011-2021

Source: Generated by Authors, 2024

The Urban Expansion Intensity Index legends classify areas based on development pace: "High Speed development (>1.92)" signifies rapid urban growth, "Fast speed development (1.05-1.92)" denotes quick expansion, and "Medium speed development (0.59-1.05)" indicates a moderate rate of urban development, “Low speed development (0.28-0.59)” and Slow development (0-0.28).

Table 2: Urban Expansion Intensity (UEI) Index and directions (2001-2011 and 2011-2021)

Direction	NNE	ENE	ESE	SSE	SSW	WSW	WNW	NNW
2001-2011	1.25	1.86	1.80	2.10	1.90	1.74	0.81	0.89
2011-2021	1.40	1.03	0.90	0.90	1.30	1.08	1.10	1.60

Source: Generated by Authors, 2024

Urban expansion speed index

The status of the Urban expansion speed which can also be defined as the average area developed per year was analyzed. The Eq (4) was used for the calculation of the Urban Expansion Speed Index (UES).

$$\text{Urban expansion Speed index (UES)} = \frac{(BUAn{+}i - BUAn)}{i} \quad (4)$$

The unit is km2, and i is the total number of years. BUAn and BUAn+i represent the total area of urban built-up areas in n years and n+ i years, respectively. +ve value means the settlement is expanding and -ve means the settlement is shrinking.

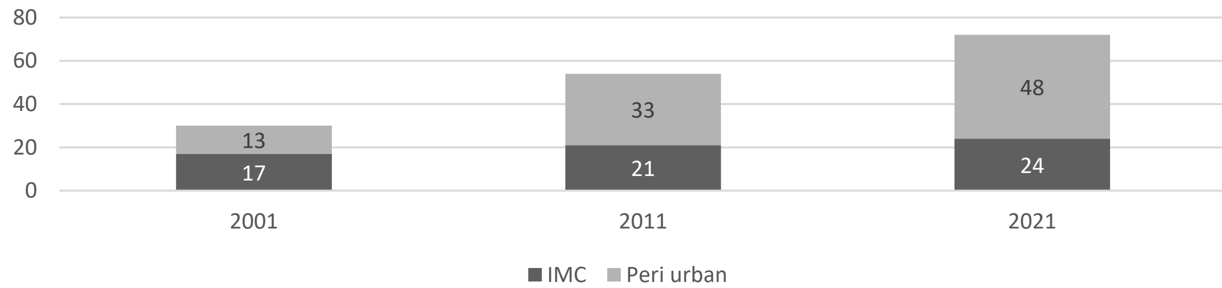

Figure 5: Built up Growth in Imphal Municipal Corporation (IMC) & Peri Urban area.

Source: Generated by Authors, 2024

Table 3: Urban expansion speed Index in IMC & Peri Urban area

Years	Total Built up area (Sq.km)	Urban Expansion Speed Index
2001	30	-
2011	54	2.4
2021	72	2

Source: Generated by Authors, 2024

Landscape expansion index

The Landscape Expansion Index analyses the type of Development happening in that area. The result will be in three types of Development ie. Infill development, Edge development and Outlying Development. In this study, rather than quantifying it examines the evolution process and relation with spatial distribution. The Landscape Expansion Index is shown in Eq (5)

$$\text{Landscape expansion index (LEI)} = \frac{\text{Ao}}{\text{Ao+Av}} X\ 100 \qquad (5)$$

Where Av is the intersection of the buffer zone with the vacant category and Ao is the intersection of the buffer zone with the occupied feature. LEI has a value between 0 and 100.
0 value means outlying development, 0-50 value means Edge-Expansion and 50-100 value means it is an Infill development.

Table 4: Landscape Expansion Index 2001-2011,2011-2021

LEI interval	2001-2011		2011-2021	
	Area (Ha)	Percentage	Area (Ha)	Percentage
Outlying (0)	245.31	**32.3 %**	210.38	**30 %**
Edge- Expansion (0-50)	513.41	**67.6 %**	407	**58 %**
Infill development (50-100)	0.68	0.1 %	90	13 %

Source: Generated by the Researcher, 2024

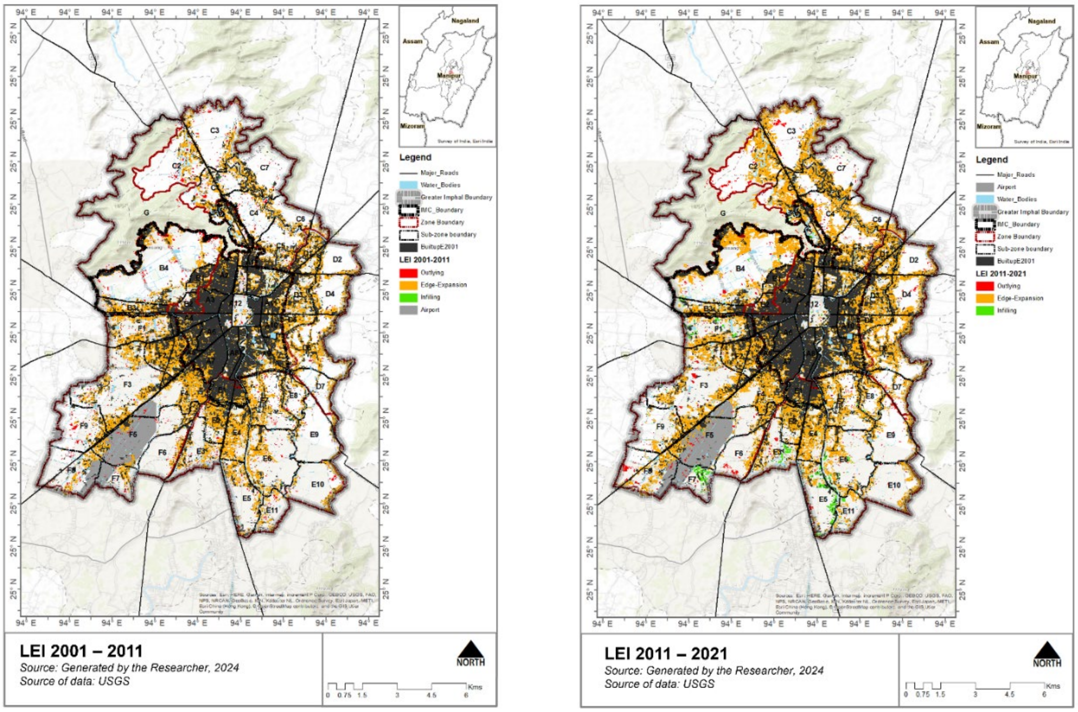

Figure 6: Landscape Expansion Index for the decades 2001-2011 & 2011-2021 in Study Region.

Source: Generated by Authors, 2024

Table 5: Landscape Expansion Index for the decades 2001-2011,2011-2021 in Study Region.

LEI interval	2001-2011		2011-2021	
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Infill development (50-100)	0.68	0.1 %	90	13 %

Source: Generated by Authors, 2024

Demand and supply gap analysis of the infrastructure services

The objective is to quantify the demand and supply gap of the infrastructure services in the Peri urban areas of the study region as per the URDPFI standards and score it in the range of 1-5 where 5 is the best and 1 is the worst score. The existing gaps are normalized to produce individual maps of each domain (Educations, Healthcare, Recreational space, Water supply, Sewerage and Roads). And finally came up with a composite level Infrastructure score map of subzones in the Study region to understand which subzones are performing best and the worst in terms of basic infrastructures.

Education

The parameters used for the scoring of the Educational Infrastructure in the Greater Imphal Boundary area -subzone wise are the Number of Pre-primary schools, Primary schools and Senior Secondary school. They are scored as per the gap identified with standards of URDPFI.

Healthcare

The parameters used for the scoring of the Heath care Infrastructure in the Greater Imphal Boundary area are the Number of Dispensaries in each Subzones. They are scored as per the gap identified with standards of URDPFI.

Recreational space

The parameters used for the scoring of the Recreational Infrastructure in the Greater Imphal Boundary area are the area of Recreational space in each Subzones. They are scored as per the gap identified with standards of URDPFI where it's says that 13 % of the land should be reserved for recreational space. So the area of recreational space required for each subzone is identified in proportion to the population ratio in each subzones.

Water supply

The parameters used for the scoring of the water-supply Infrastructure in the Greater Imphal Boundary area are the percentage of households connected with water supply lines in each Subzones.

Sewerage

The parameters used for the scoring of the sewerage line in the Greater Imphal Boundary area are the percentage connected with sewerage lines in each Subzones.

Road

The parameters used for the scoring of the road Infrastructure in the Greater Imphal Boundary area are the connectivity of the subzones to various hierarchy of roads (Arterial, Sub arterial, collector and Local roads) and the percentage of All-weather roads out of the total roads available.

Composite Index of Infrastructure Services

A composite Index score is the total of all the scores of each domain considered for the scoring of the basic Infrastructure. It shows an overall view of the performance of the subzones in terms of Infrastructure in the Greater Imphal Planning area.

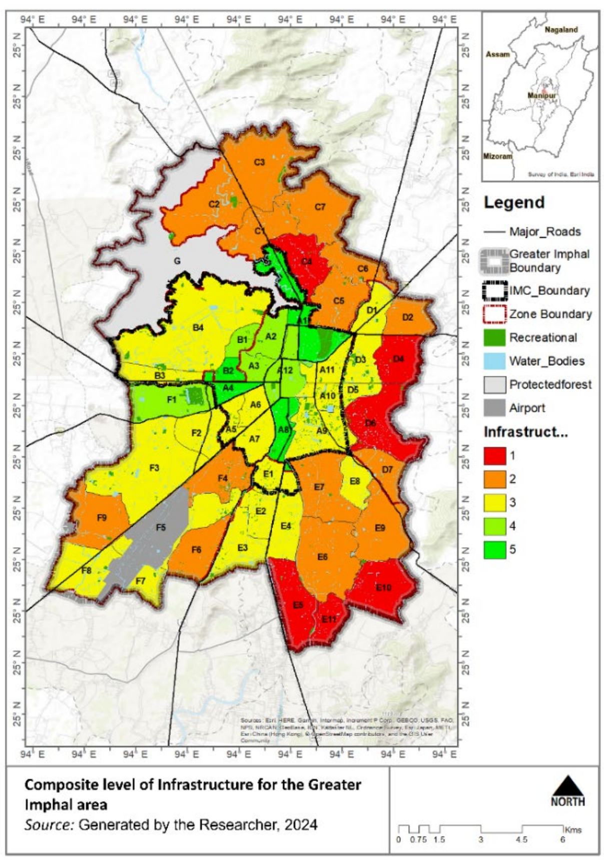

Figure 7: Composite Level of Infrastructure for the Greater Imphal Planning Region.

Source: Generated by Authors, 2024

Quality of life analysis in the study Region

Quality of Life score

The QOL of each subzone were identified by following various steps. First, the QOL domains considered were identified, including Infrastructure services, Physical health, Environment, Psychological health, Safety and security, and social relationships.

Next, the primary survey Likert scale values for each QOL domain were linearly rescaled to a range of 1-20 to enable comparison across domains. The average of these rescaled values was then calculated for the respondents in each subzone.

The QOL data is validated using Cronbach's alpha statistics to guarantee its trustworthiness giving a result of 0.824. Its value is computed by Eq (6)

$$\alpha = \frac{Nc}{v+(N-1)c} \qquad (6)$$

Where N is the number of items being evaluated, c is the average inter-item covariance among the items and v is the average variance. The value of α typically falls between 0 and 1, with values above 0.7 suggesting that the data is reliable (George & Mallery, 2003).

The Saaty's relative relevance scale was then used to compile field specialists' opinions in order to evaluate the relative value of each QOL domain. The Analytic Hierarchy Process was then used to calculate these domain weights (AHP).

Prior to computing the overall QOL score as Low, Moderate, High, or Very High based on the weighted QOL domains, the consistency ratio (CR) was checked to verify the consistency of the experts' assessments, through the consistency index (CI) and random index (RI) using Eq (7) (Saaty 1980).

$$CR = \frac{CI}{RI} \qquad (7)$$

The Consistency Index (CI) is calculated using Eq (8), where λ represents the average value of the consistency vector derived from the pairwise comparison matrix, and n denotes the number of factors being assessed. The value of the Random Index (RI) is constant and depends on the number of domains involved in the decision-making process. For six Quality of Life (QOL) domains, the RI value is 1.24, as determined by the RI table (Saaty, 1980).

$$CI = \frac{\lambda - n}{n-1} \qquad (8)$$

The computations on the pairwise comparison matrix yielded values of 0.1171 for the Consistency Index (CI) and 0.090 for the Consistency Ratio (CR). According to Saaty (1980), a CR value significantly higher than 0.1 indicates inconsistent judgments. However, the computed CR value of 0.090 signifies that the judgments were consistent and can be used for determining the weights of the Quality of Life (QOL) domains.

Additionally, the research involved comparing the Population density and Land use Land cover (LULC) to the QOL. This allowed for the deduction of analytical conclusions on the connection between these variables and the Quality of Life in the studied area.

Table 6: Weights of Quality of Life (QoL) domains computed through AHP

Domains	Overall weightage
Safety And Security	0.10
Environment	0.25
Physical Health	0.14
Psychological Health	0.11
Social Relationship	0.10
Infrastructure Service	0.30

Source: Generated by Authors, 2024

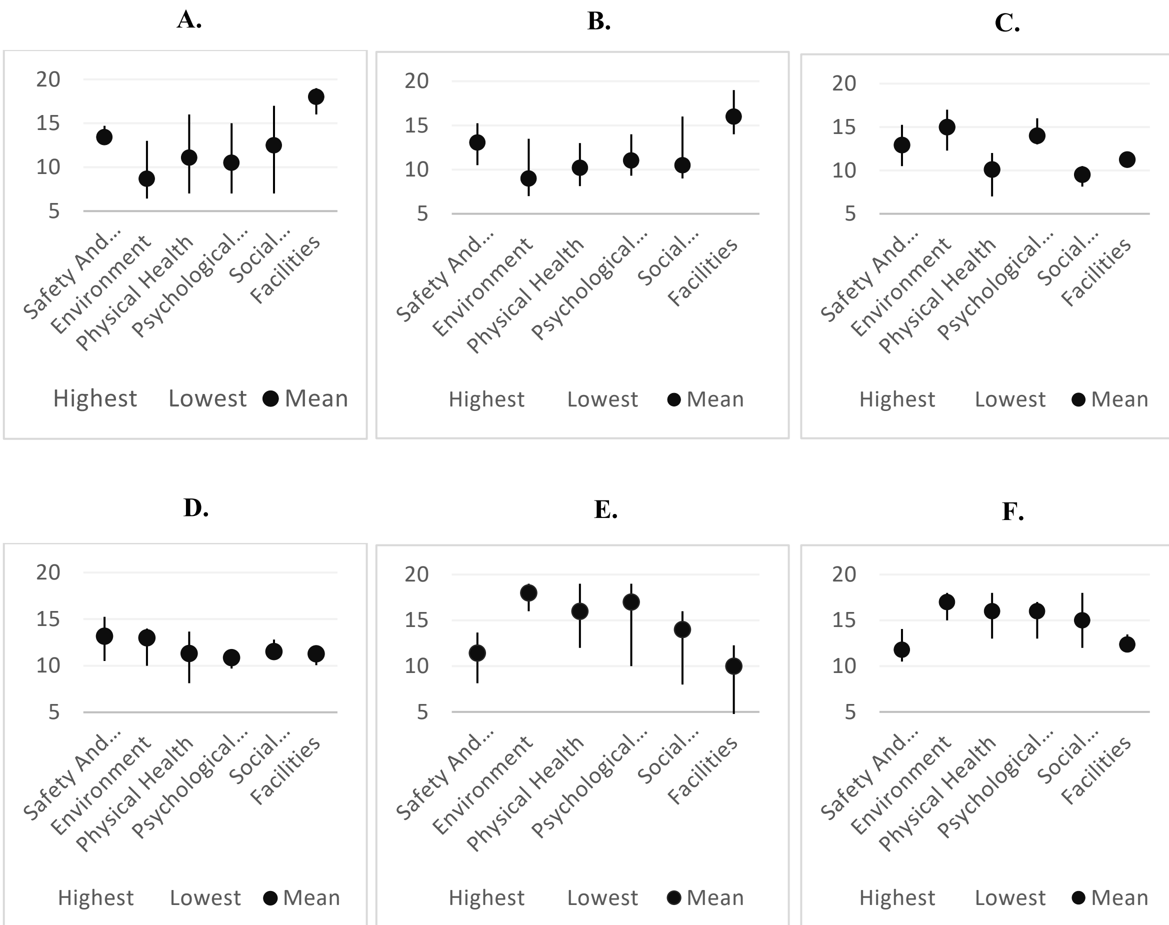

Figure 8: Variability in QoL data of Zone A, B, C, D, E & F

Source: Generated by Authors based on the Primary Survey, 2024

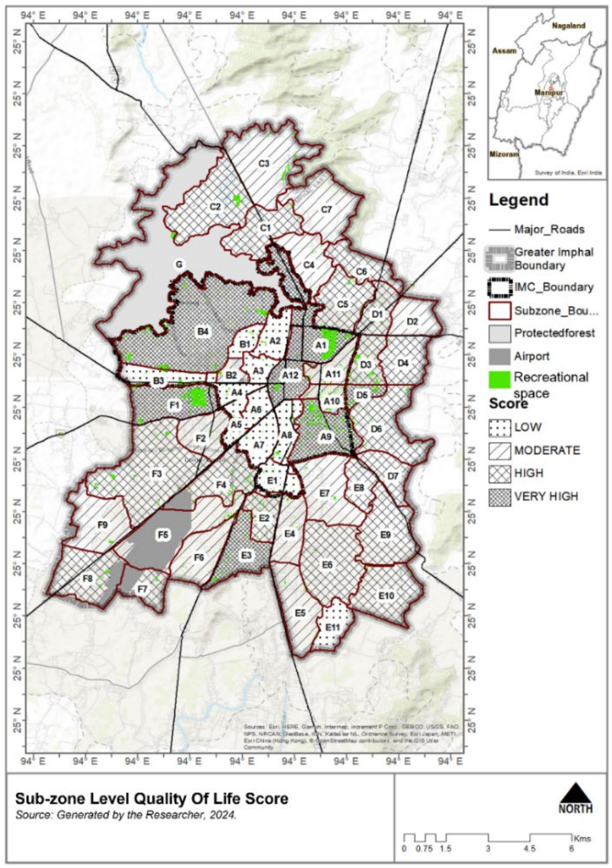

Figure 9: Sub-zone Level Quality of Life Score in the Study Region.
Source: Generated by Authors, 2024

Correlation between QOL and LULC

The Pearson's correlation analysis was carried out with the subzone data of QOL score, built up density, Water body density, Vegetation and Agricultural Land density.

Table 7: Correlation between QoL and Land Use Land Cover Change (LULC)

	QOL score	Built up density	Water body density	Vegetation	Agricultural Land density
QOL score	1				
Built up density	-0.464	1			
Water body density	0.112	-0.431	1		
Vegetation	0.574	-0.358	0.174	1	
Agricultural Land density	0.159	-0.863	-0.027	-0.051	1

Source- Generated by Authors, 2024

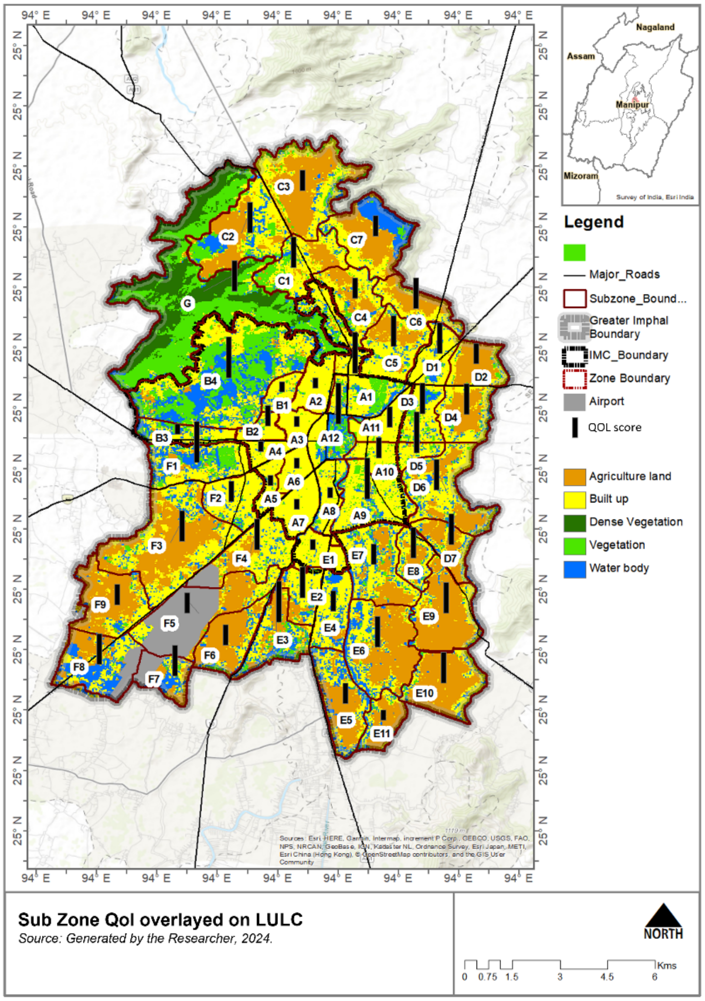

Figure 10: QOL score Overlayed on LULC map (2021) in the Study Region.

Source: Generated by Authors, 2024

Correlation of Recreational space with QoL domains

The Pearson's correlation analysis was carried out with the subzone data of Recreational area and the QOL domains like psychological health, Physical health, Social Relationship to understand the relation with the recreational spaces.

Table 8: Correlation of Recreational space with QoL domains

	Recreational space	Psychological health	Physical health	Social Relationship
Recreational space	1			
Psychological health	0.581	1		
Physical health	0.514	0.751	1	
Social Relationship	0.63	0.577	0.523	1

Source: Generated by Authors, 2024

Correlation between QoL and Population density

Similarly, Pearson's correlation analysis was carried out with the QoL with Population density and Built-up density in order to understand the relation between them.

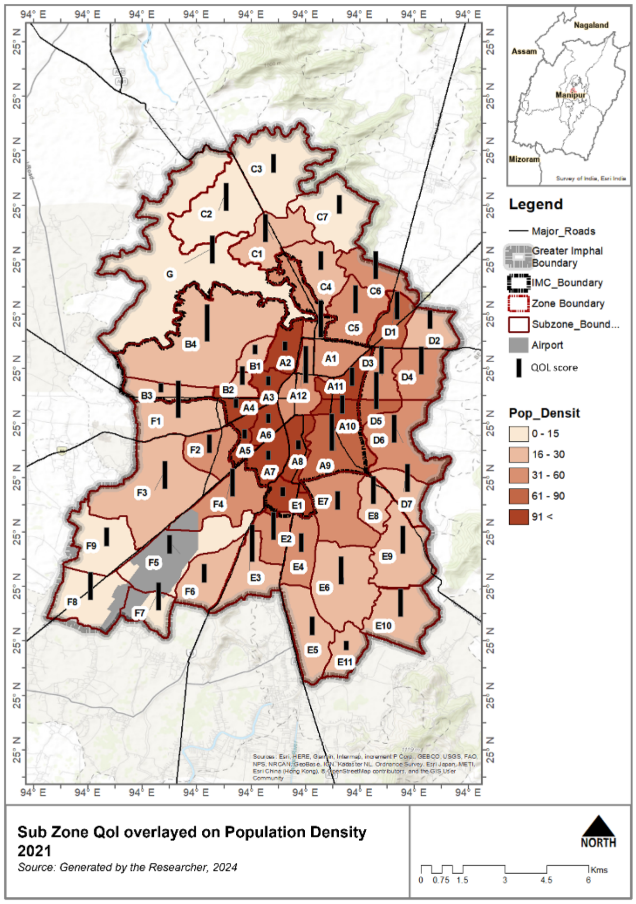

Figure 11: QoL score Overlayed on Population density map (2021) in the Study Region.

Source: Generated by Authors, 2024

Table 9: Correlation between QoL and Population density

	QOL score	Built-up density	Population density
QOL score	1		
Built up density	-0.464	1	
Population density	-0.470	0.827	1

Source: Generated by Authors, 2024

Spatial Interaction Model Analysis

Here the objective is to evolve spatial interaction model to understand the major attracting locations or locations which have future interacting potential.

Gravity model

Gravity model states the interaction or flow between two locations is directly proportional to the product of their sizes (or masses/ attracting factors) and inversely proportional to the square of the distance between them. It is the multi-step approach to mapping spatial interaction and influence. It begins with defining the "Subzones" of the area being analyzed, and the "Trip Attracting Locations" such as educational centers, recreational areas, tourist sites, healthcare facilities, transportation hubs, and work/market centers which are already identified (Master plan of 2021-2041) and weighted using AHP technique. Experts in the area were consulted to determine the relative relevance of each attractive element, and the pairwise comparison matrix was prepared using Saaty's relative importance scale. The "Population size" of these locations is then factored in, as it influences the weightage or pull of these attracting sites. Next, the "Weightage of the Trip Attracting Location factors" is determined, which is then linearly rescaled to a range of 1-10. This rescaled weightage is combined into a "Total Normalized score" that represents the overall gravitational pull or interaction potential of each location. The "Distance" between these locations are also calculated and the distance are calculated from the attracting points to each subzones centroid points, as it is a key factor in the gravity model. The "Gravity model Tool (Arc GIS Pro)" is used to generate "Gravity Influence ". After this a Gravity model map is generated.

Table 10: Weightage of the trip attracting factors

Attracting factors	Overall weightage
Educational centres	0.14
Recreational centres	0.06
Tourist activity centre	0.06
Healthcare centres	0.15
Transportation centres	0.34
Work centres/ Market	0.26

Source: Generated by the Researcher, 2024

This structured process allows for a systematic and data-driven approach to mapping the gravitational forces and spatial interdependencies between different activity centers, which is valuable for urban planning, transportation modeling, and regional development analysis.

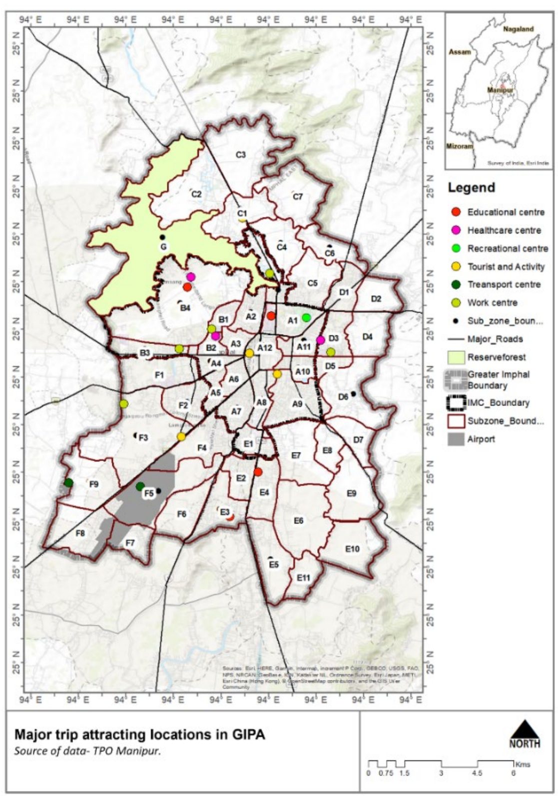

Figure 12: Major Trip attracting locations in Greater Imphal Planning area.

Source: Generated by Authors, 2024, based on the report of Town & Country Planning Office, Manipur.

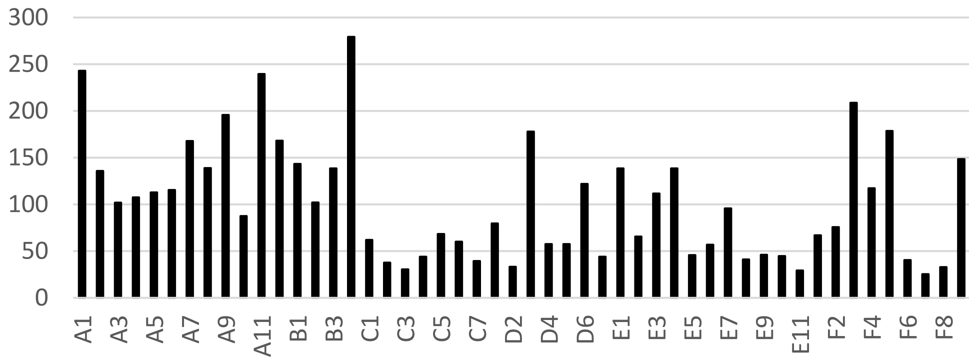

Figure 13: Gravity Value (spatial interaction/influence)

Source: Generated by Authors, 2024

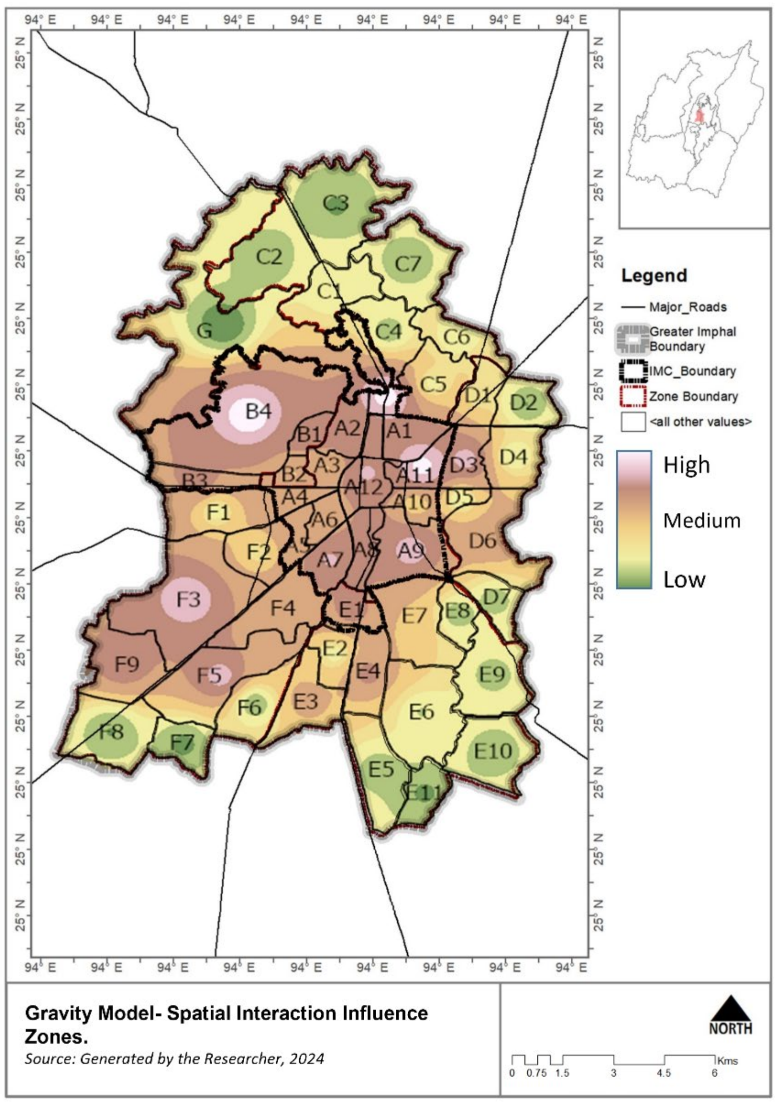

Figure 14: Gravity Model Interaction influence zones of the Study Region.

Source: Generated by Authors, 2024

Results and Discussions

Spatial Matrices analysis

Decadal LULC analysis for the Years 2001, 2011 and 2021

- Highest change from 2001-2011 is 16% Built up Increase and 29% decrease in Vegetation.
- Highest change from 2011-2021 is 12% Built up Increase and 8 % decrease in Agricultural land.

This shows that the Urban sprawl/ Built up growth is increasing at the cost of Vegetation during 2001 to 2011 and Agricultural land during 2011-21

Urban expansion Intensity index

- Only High speed to medium speed development is happening in the Greater Imphal Boundary and there is no low and slow speed taking place.
- From 2001-2011 the High-speed development can be seen in SSE direction and Fast speed development in NNE, ENE, ESE, SSW and WSW.
- From 2011- 2021 The fast speed development- NNE, SSW, WSW, WNW and NNW.

Urban expansion speed index

- The positive value of the Urban expansion speed Index shows that the expansion is happening.
- It's can also be seen that the Peri urban expansion speed is more than the IMC expansion.

Landscape expansion index

- It can be seen that in 2001-2011 and 2011-2021 Majority of Expansion of Built up is happening in Edge expansion manner followed by Outlying manner.
- This shows that the city is expanding in the periphery and may lack infill development.
- The analysis of spatial growth patterns and dynamics using spatial metrics indicates a shift in land use for urban expansion. Between 2001 and 2011, vegetated areas were utilized for urban growth, while from 2011 to 2021, agricultural lands were converted. This highlights the need of improved spatial growth planning without compromising quality of life (QOL). Priority should be given to the peri-urban areas in the southwest (SW) and south-southeast (SSE) directions, as they are experiencing rapid sprawl according to the Urban Expansion Index analysis, with edge expansion constituting 58% of overall growth.

Demand and supply gap analysis of the infrastructure services

Education

- No. of Pre- primary and Primary schools - satisfied as per the URDPFI.
- Senior Secondary Schools – Highest Gap can be seen in Peri urban zone of-F4, F6, E7 and D6.

Healthcare

- In Health care as per URDPFI guideline, no. of Dispensary shortage can be seen only in the Peri-urban area.

Recreational space

- The Recreational space in Greater Imphal area is very less. Recommendation are met only in F1 and A1.

Water supply

- Similarly, the water supply lines are connected totally in Zone-A which is the urban core, whereas the peri urban area not properly connected with water supply lines.

Sewerage

- In sewerage the core Zone-A also does not totally have Sewerage lines. And all the Peri urban area does not have Sewerage lines.

Road

- Road connectivity through Arterial, Sub arterial, Collector and Local roads to all the places are present. But the percentage of All-weather roads to the total road is less in Peri Urban areas.

Quality of life analysis in the study Region

Quality of Life score

- Very high quality of life can be observed in sub- zones A1, A12,A9, B4,F1 and E3 which may be a result of high Recreational space.
- Low quality of life can be observed in sub-zones A2,A3,A4,A5,A6,A7,A8,E1,B3,E11 which majorly falls under the IMC boundary where there is high built up and low vegetation /green space.

Correlation between QOL and LULC

- The QOL indicates and Inverse relation with the Built-up Density, High Built-up density shows Lower QOL and vice-versa.
- The QOL indicates a strong positive relation with vegetation. Higher Vegetation shows higher QOL and vice-versa.
- There is no significant relation between QOL and Agricultural land density. Which means that reduction or increase in Agricultural land does not affect QOL.
- It can be observed that the highest and lowest Quality of Life is present at the Zone-A
- Where QOL is lowest in high Built-up density area, except for the subzones A1, A12 and A9 where the QOL is very high, which may be the result of high vegetation /open space and availability of better Infrastructure services.
- It can also be observed that QOL in Peri urban area remains moderate which may be a result of vegetation area converting to build up area due to urban sprawl.

Correlation of Recreational space with QOL domains

- It can be observed overall that there is significant positive relation between Recreational space with psychological health, Physical health and social relationship.
- Which means that increasing Recreational space will increase the overall score of QOL.

Correlation between QOL and Population density

- It can be observed that the core area of Zone-A where population density is high has low Quality of Life.
- Overall Inverse relation can be seen in QOL and Population density. And correlation between Built up density and Population density shows high positive correlation which means increase in population increases built up density.
- The assessment of quality of life (QOL) in the study region indicates the need for improvement in both urban and peri-urban areas. Enhancing QOL requires well-planned infrastructure in peri-urban areas, including adequate recreational and green spaces. Addressing these shortcomings will positively impact psychological, physical, and social relationship domains, ultimately improving QOL.

Spatial Interaction model analysis

Gravity model

- The core IMC area has the major attracting ZONES A and B, with more Population and higher number of Attracting locations in terms of educational centers, Healthcare centers, Work centers (Office, Market), Tourist activity centers.
- It can be Observed that that the peri Urban Zone F which is Outside the IMC area is also attracting due to its Transport centers like Airport and Upcoming Railway station. Zone-F has the highest possibility among the peri urban zones to have higher urban sprawl/expansion rate.

Discussion

The study on urbanization trends within the Greater Imphal Boundary reveals significant implications for land use and environmental sustainability. Rapid expansion of built-up areas at the expense of vegetation and agriculture underscores the urgency for balanced land management strategies.

Development within the boundary is notably high to medium speed, with peri-urban expansion outpacing that within the Imphal Municipal Corporation, indicating urban sprawl. This concentrated growth, particularly around the city core, highlights challenges in sustainable land use planning and infrastructure provision.

Disparities in overall QOL scores between the urban core and peri-urban areas signify uneven development distribution. While infrastructure is concentrated in the core, both areas suffer from a lack of recreational space due to unplanned growth.

The scarcity of recreational amenities in peri-urban areas reflects challenges in accommodating a growing population within limited land resources. Without proactive measures, this trend is likely to persist, impacting public health and Quality of Life.

Similarly, the importance of planning sewerage lines before dense development cannot be overstated. Inadequate sanitation infrastructure poses health risks and hampers urban livability and environmental sustainability.

Integrated land use planning and infrastructure development are essential to mitigate adverse effects of rapid urbanization and ensure long-term well-being for residents across urban and peri-urban areas and maintain a sustainable development.

Recommendations

Based on the comprehensive analysis and findings of this research study, it is evident that strategic planning interventions and location-specific recommendations are crucial for promoting sustainable peri-urban development within the Greater Imphal Boundary. The following recommendations includes Infrastructure recommendations, Urban development suitable land, and zoning strategies, aimed at optimizing land management, enhancing Quality of Life, and fostering controlled and sustainable urban growth.

Infrastructure recommendation to enhance Quality of Life for 2041

The infrastructure area required for the projected population of 2041 (Master plan for Imphal 2041) is calculated as per the URDPFI standards for the Recreational area, Healthcare area and educational area.

Table 11: Area required for Infrastructure Proposal for 2041

Zones	Recreational area gap in Ha	Healthcare area gap in Ha	Educational facility area gap in Ha	Total area Required in Ha
A	641	10	52.2	863.2
B	160			
C	171	10	13.72	194.72
D	209	50	18.96	277.96
E	286	40	24.76	350.76
F	268	20	7.4	295.4

Source: Generated by Auhtors, 2024

Ideal location suitable for Urban Development

To Identify the Land Suitable for Urban development, various land suitability was carried out like the Agricultural suitability, Landscape suitability, Infrastructure suitability and the Morpho Land use using various literature reviews. And finally, and overall Urban development suitability map was generated using weighted overlay. The map consists classification of Very weak suitability, Weak suitability, Suitable and Highly suitable.

The flowchart for generating the Land Suitable for Urban development is given below,

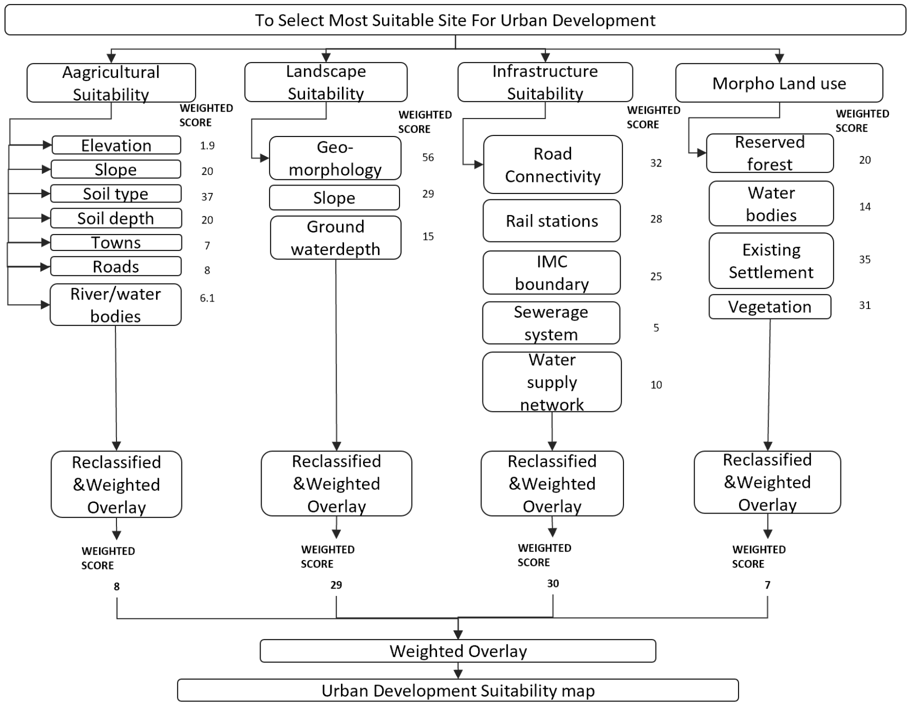

Figure 15: Methodology adopted for generating land suitability map for Urban development
Source: Generated by Authors, 2024

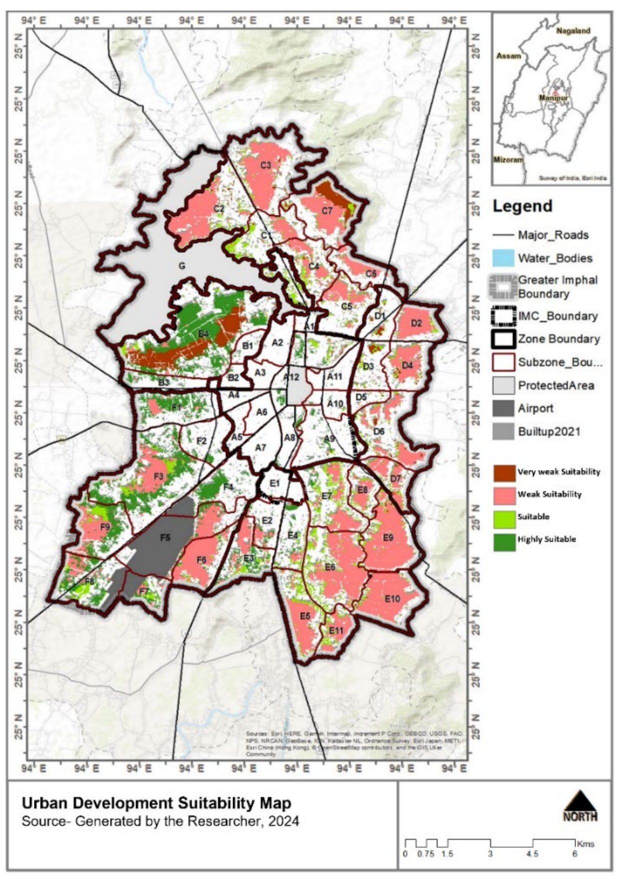

Figure 16: Land suitability map for Urban development in the Study Region.

Source: Generated by Authors, 2024

Table 12: Zone wise area available for Urban suitability in the Study Region.

Zones	Very Weak Suitability	Weak Suitability	Suitable	Highly Suitable	Very Weak + weak Suitability	Suitable + Highly Suitable	Total Area Required In Ha
A	13	12	84	106	25	**1030**	863.2
B	7	27	47	686	34		
C	152	801	313	0	953	**550**	194.7
D	65	398	147	1	463	**210**	277.9
E	15	1226	383	156	1241	**580**	350.7
F	0	794	175	607	794	**950**	295.4

Source: Generated by Authors, 2024

Development Zones Recommendation

Zone-1: Core City Area (Zone-A&B)

- Here the Densification needs to be promoted, keeping in mind the edge expansion that is happening and the growth of the peri urban expansion.

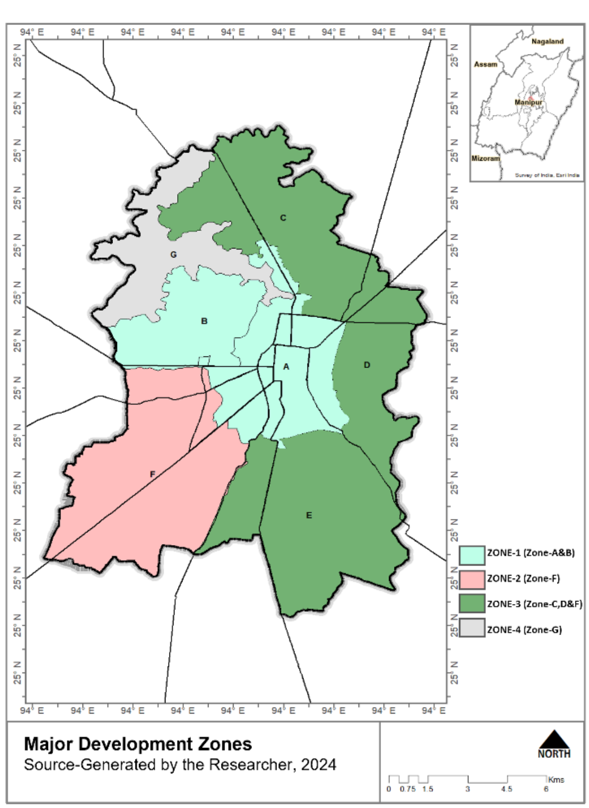

Figure 17: Major Development Zones identified for the Study Region.

Source: Generated by Authors, 2024

Zone-2: Group Development Area (Zone-F)

- In this zone a more compact development needs to be encouraged since the analysis showed that this area has become a new influencing location due to the transport infrastructure and the land suitability analysis showed more suitable area for urban development.
- The development of TOD integrated smart growth Principles with mixed used development will further reduce the uncontrolled edge expansion speed.

Zone-3: Agricultural Zone /Belt Development (Zone-C, D & F)

- Here the primary focus will be on conserving the agricultural land. Since this area is more favorable for agriculture. The restrictions on conversion of agricultural land/weak suitable to Developmental purpose needs to be restricted.
- Agricultural belt needs to be protected towards urban expansion and deferred from development.

Zone-4: Restricted Zone (Zone-G)

- Here the restricted forest area acts as the Physical barrier from further urban expansion on the north west direction. This can act as a green belt to control further expansion.

Recommendation of Greater Imphal Planning Zones

Zone- A

1.Residential area with minimum road width and road density can be selected for densification

2.The plots having potential for densification can have increased FAR.

3. Area suitable for development can be provided with Infrastructures especially the Recreational space as per the gap recommended for each subzone for 2041.

4.Promote conversion to Mixed used residential.

6. Incentives on tax or stamp duty charges can be provided to plots that achieve their maximum FAR.

Zone-B

1.Similar can be followed for this zone as Zone-A.

2.Strict rules must be followed for the people not to encroach into the Zone-G which is a protected forest area and the available wet land.

Zone-C, D & E

These Zones are Predominantly agricultural land.

1.Conversion of agricultural to other land use should be strictly prohibited in this Zones, except for the area with high urban development suitability.

2.Green belts and Agricultural belts can be introduced for controlled urban expansion in this zone.

3.Identified Infrastructure gaps explored through this research should be prioritized /addressed towards navigating to enhance QOL.

Zone- F

This is the rapidly expanding Peri urban zone and Outlying expansion (scattered settlement) is also evident. This zone is where the Airport and Upcoming Railway station is located and the Influence rate is high as per the gravity analysis.

1.Compact settlement should be promoted.

2.Only the land parcel with high suitable for urban development should be used.

3.Agricultural land which is weakly suitable for urban development should strictly not be encroached.

4.Land pooling schemes can be introduced for group development.

Zone-G

This zone should follow strict rules on not encroaching the protected forest area. And this Zone should act as a physical barrier to stop urban expansion on the North west direction.

Conclusion

Location specific planning recommendations and infrastructure strategies tailored to specific area hold the key to elevating the overall QOL within the study region. Simultaneously, they facilitate optimal land use management, allowing for the accommodation of a growing population without sacrificing QOL. Moreover, these strategies aim to safeguard agricultural land, ensuring its preservation and contributing to sustainable peri-urban development characterized by controlled expansion and enhanced liability.

The study has delved into the intricate dynamics of peri-urban development within the Greater Imphal Boundary, offering insights into the interplay between urban sprawl, infrastructure provision, and quality of life (QOL). Through a comprehensive analysis encompassing spatial growth patterns, infrastructure gaps, QOL assessments, and spatial interaction modelling, this study has unveiled critical considerations for sustainable urban planning and land management.

The shift in land-use patterns, with urban expansion initially encroaching upon vegetated areas between 2001 and 2011, followed by a concerning conversion of agricultural lands from 2011 to 2021. This trend underscores the pressing need for proactive planning measures to strike a balance between urban growth and the preservation of valuable natural resources, ensuring long-term environmental sustainability.

The analysis of infrastructure service supply gaps has revealed significant deficiencies in peri-urban areas, particularly concerning recreational spaces, healthcare facilities, and educational institutions. These shortcomings not only impact the overall QOL but also pose challenges in accommodating the growing population's needs. Addressing these gaps through targeted infrastructure development initiatives is crucial for fostering inclusive and equitable urban growth. The assessment of QOL in the study region has further reinforced the importance of well-planned infrastructure and green spaces in both urban and peri-urban areas. The research has established a positive correlation between recreational spaces and domains such as psychological health, physical well-being, and social relationships, emphasizing the vital role of open spaces in enhancing overall QOL. Additionally, the inverse relationship between QOL and population density underscores the need for sustainable urban densification strategies that prioritize liability and residents' well-being. The gravity model analysis has highlighted the urgency of proactive planning in peri-urban Zone-F, where the anticipated surge in urban expansion triggered by the new railway station necessitates immediate attention. Effective management of this influx through strategic interventions, such as compact settlement promotion and land pooling schemes, can mitigate the potential negative impacts of uncontrolled sprawl.

Based on these findings, the research has recommended location-specific planning recommendations and infrastructure strategies tailored to specific areas within the study region. These recommendations encompassing densification initiatives, mixed-use development promotion, agricultural land preservation, and the introduction of green belts and agricultural belts to manage controlled urban expansion. By implementing these strategies, the study aims to elevate the overall QOL while facilitating optimal land-use management and accommodating population growth without compromising sustainability.

This study has contributed to a deeper understanding of the complexities surrounding peri-urban development within the Greater Imphal Boundary. By integrating spatial analysis, infrastructure assessments, QOL evaluations, and spatial interaction modelling, it has provided a strategy for sustainable urban planning and land management strategies. The findings and recommendations presented herein will serve as a valuable resource for policymakers, urban planners, and stakeholders, guiding them towards informed decision-making processes that prioritize the well-being of residents, environmental preservation, and long-term sustainability.

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