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Spatial Analysis for identification of suitable areas to promote dense settlements in the case of Kageshwori Manohara Municipality

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Abstract
This research looks out for the identification of a suitable area to deploy optimum density in human settlement and planning in Kageshwori Manohara Municipality. Analyzing the global, national, and regional trend of urban population growth, this research also seeks for optimum density required for the case area. To address the problem of rapid urbanization in Municipality this research looks for the interventions in development approach based on sustainable and economical ways. For this spatial analysis is done for determining the suitable area for dense settlement development. GIS based; MCA is used for suitability analysis. Literature and discussion helped in determining restriction and development criteria for selection of suitable area for dense settlements. Final maps from both criteria are developed in GIS as maps. A final map was created based on the restriction criteria. Each development criterion was initially transformed into a GIS map and then standardized into raster maps, using a scale where values of 5,4,3,2 and represent highly suitable, moderately suitable, low suitability, very low suitability, and unsuitability, respectively. Final Raster weighted overlay was done in GIS using multiple layers of developable and restricted criteria, which gave the final suitable area in the form of map. Further required density for this suitable area is studied with future population projection. Area required for the future is calculated maintaining the desired density. Thus, divided area with various degree of suitability, are recommended for priority development and order. Various policy interventions, incentive distribution, tax exemption could be deployed to encourage people to follow the guided development plan, which maximizes profitability for people and the country.

Keywords
Densification, Spatial Analysis Compact settlements, Land Suitability, Density, GIS based MCA

1. Introduction

A human way of living could be urban or rural. Urban areas consist of more secondary and tertiary activities rather than an agricultural economy. A surplus economy, dense urban dwellings and services, more infrastructural services, and high people density are common characteristics of urban areas. In the context where the world urban population exceeds half, Nepal also recorded an urban population of more than 66% [1]. The formation of more municipalities resulted in growth in urban areas and population in many parts of the country. Urbanization is gaining pace in other cities of Nepal. However, Kathmandu Valley continues to be the “hub” of urban development in Nepal [2]. Unplanned urbanization in the valley continued engulfing the agricultural lands, adding several physical, social, and environmental problems in the Kathmandu Valley, and significantly increasing vulnerability to disasters, including earthquakes [1]. The increase in urban hazards is directly proportional to the increase in populations and is more hazardous when there are fewer or no preparations. So, population growth has challenged new and developing towns to accommodate the population with additional infrastructure and services.

Similarly, unplanned, and non-uniform urban density has created gaps in development for developing areas. Less or high density creates an imbalance in urban ecosystems. So, there is a need to balance urban density and available resources. The concept of densification of settlements comes up when there is a limited resource available and it must be shared with maximum economic benefit [1].

Urban densification is a way to create cities compact to use land more intensively. It comes as a major strategy for sustainable and resilient planning consisting of compact settlements, walkability, TOD, and more. As per [1] densification process can be observed through increase in population/ jobs and through increase of built floor area. These two 2 variables are obviously related but may present divergences over time and space. Urban densification can bring disastrous effects when not regulated or monitored overtime.

With the rise in urban population throughout the country, Kathmandu valley still contributing to 9 percent of total population of Nepal [1] which was 10 percent in 2011. The urban area in the valley is expanding along with fringe development. The case for the study is taken among 18 local administrations inside the valley contributing to accommodate the high increase of population and demands. The case area for the study is Kageshwori Manohara located in the northeast part of the valley. This area can represent a similar case and scenario which is occurring in the valley.

Kageshwori Manohara Municipality has an administrative boundary of 27.38 sq.km formed through the merge of 6 former VDC of the area. (Kageshwori Manohara Municipality,2018) and municipal boundary differentiated by Manohara River on East and Bagmati on the west. Currently there are 9 wards with a total population of 1,30,433. [1]

It is seen that the municipality is facing population growth of

more than 100 percent in just a decade. The trend has been the same for more than two decades. This growth trend has resulted in huge changes in landcover and an increase in fringe development. The high land price in central Kathmandu has pushed huge population to shift towards the outskirts of the valley, because of which a major number of outskirt municipality have faced the consequences for more than two decades. Therefore, the population of Kathmandu Metro is decreasing where other outer areas are getting populated. The study area consists of a substantial volume of virgin land and resources which are used for farming and agriculture. But due to unplanned land management and preparation, the population growth has resulted sprawl development with rise in urban hazards and loss of natural resources. Optimum use of resources and proper planning could be achieved if the population is managed within the designated area.

1.1 Statement of Problem

In Nepal, rapid urbanization is driving a significant increase in the urban population, reaching 62.2 percentage due to the government's declaration of municipalities as urban areas. Kageshwori Manohara Municipality in the Kathmandu Valley is grappling with the challenge of balancing development and environmental concerns. A decade ago, this area was predominantly rural with ample agricultural land, green vegetation, and forests. However, Kageshwori Manohara Municipality now faces an annual population growth rate of 9.57 percentage, resulting in a doubling of the population over the past decade, with further increases projected. This population surge has led to extensive changes in land use, environmental degradation, and socio-cultural issues, characterized by haphazard and uncontrolled urban growth. Despite various planning efforts, implementation has proven largely ineffective [3]. The influx of people to Kageshwori Manohara Municipality is likely driven by the shortage of space and services in Kathmandu's city center. Consequently, the land cover in Kageshwori Manohara Municipality is rapidly transforming due to this migration, necessitating urgent attention to sustainable urban planning and development. The main problems can be listed as.

- High Population growth with low density settlements.
- Huge change in land cover: Loss of agricultural lands and natural environment.
- Rise in sprawl and development which makes infrastructure costlier and ineffective.

1.2 Objective of the study

Analyzing the problems of the case area, the study has a main objective which is:

- To conduct comprehensive spatial analysis to identify suitable areas for promoting optimum dense settlements, carrying out required policy interventions in the case of Kageshwori Manohara Municipality.

To address the study objective, further research questions are developed which are listed below:

- How do we identify suitable areas for promoting dense settlements?
- What is the optimum density for such a developing area?
- What policy interventions can be done to encourage desired density in suitable identified area?

1.3 Rationale of Research

Increasing the density of cities, especially in places like Nepal, is essential for making cities more sustainable. It has its challenges, but if we do it right, it can help protect nature, boost the economy, and make cities stronger. We need to find a balance between what's good for individuals and what's good for everyone. Planning cities in a compact way can be cost-effective and better for the environment. In Kageshwori Manohara where more people are moving in, we really need to plan how we build things carefully. This idea of denser cities is recognized worldwide because it helps save land, protect nature, reduce pollution, and create more housing. According to [4], policymakers are starting to focus on making housing denser to use land wisely and create diverse and vibrant cities.

Need of the study

- Kageshwori Manohara is a swiftly growing urban center among the valley's 18 municipalities.
- Protecting open spaces and optimizing natural resources is crucial.
- Tackling sprawl and fringe development in the municipality is vital.

Importance of the study

- Identification of Area that needs to be promoted or discouraged.
- Regulating optimum density could help in resource optimization.
- To recommend concerned authority/organization conduct/invest in potential development area.

1.4 Scope and limitation

This research primarily focuses on Kageshwori Manohara municipality, and the criteria used for spatial analysis are tailored to its specific context. However, it's worth noting that the insights gained from this study could potentially be valuable for similar regions facing similar challenges and sharing comparable characteristics. Therefore, while the analysis is context-specific, its findings and methodology could potentially have broader applicability to other areas with analogous conditions.

2. Conceptual framework and Methodology

This research delves into the intricacies of urban development and population growth in Kageshwori Manohara, a rapidly expanding town. The study approach follows a pragmatic paradigm, emphasizing practical problem-solving within the context of urban densification. The research paradigm selection considers three key factors: assumptions regarding reality and knowledge, theoretical frameworks, literature, and

research practices, as well as ethical principles and value systems. This research adopts the Pragmatic paradigm, focusing on the application of research findings to address urban densification challenges effectively.

Ontological Position Kageshwori Manohara has witnessed substantial, unplanned urban growth, primarily driven by an influx of people from neighboring areas seeking improved living conditions. This has resulted in the conversion of agricultural land into urban areas, depleting natural resources. Our study concentrates on the well-planned management of this growing population.

Epistemology To gain insights into the area, this study employs comprehensive surveys, establish communication with key stakeholders, and utilize Geographic Information Systems (GIS) to analyze historical spatial patterns. These steps guide data gathering and knowledge acquisition.

Research Paradigm This research aligns with the Pragmatic paradigm, emphasizing practical solutions and real-world problem-solving in the realm of urban densification. It aims to offer actionable recommendations that bridge the gap between theory and practice, addressing the actual challenges faced by Kageshwori Manohara Municipality. This paradigm prioritizes tangible enhancements in suitable space identification for densification practices, finding optimal density and urban development. In summary, this research methodology combines the pragmatic paradigm with robust data collection and analysis techniques to effectively address space identification for urban densification practice and challenges in Kageshwori Manohara while maintaining originality and integrity in natural and social ecosystems.

Methodological approach The main aim is to produce a suitable area map eligible for optimum density development and contribute to local level planning policy. This will be carried out with major steps such as

- Literature Review for Contextual study of applicable criteria for optimum density development.
- Data Collection in the form of primary or secondary to work in software for analysis of the quantitate and qualitative collected data.
- Spatial analysis using Raster Overlay for identification of most suitable raster which represents developable or non-developable area.

3. Literature Review

Urban densification is a way to create compact city development with optimum utilization of space and resources. Densification can be done where it is beforehand or after. The concentration of people inside the CBD, or the less density out the fringe area, both are not acceptable in terms of sustainability, resource optimization and durability. Densification observed through two variables: increase in population and increases in built up area which may not align overtime. Monitoring the divergence between built and occupational densification is crucial to understand urbanization dynamics. These indicators should be compared with variables like quality of life and economic development to assess the effectiveness of compact city/in-fill development policies implemented by cities and regions [5].

To identify suitable area for compact settlement, there must be some suitability features and criteria that allows for an easy and economical development practice. It is also important to note the pattern and hierarchy of settlements that people are willing to adopt. From the historic to modern era, it is found that humans are social animals which form society and groups to live together sharing and caring for each other. Modern urban areas are more engaged in-service industry rather than physical good production. Here industries are located far away from the settlements and working area. The main concept is to optimum use of space and resource which can be done through proximity design of space within a walkable distance or less time consuming. Urban growth follows some theoretical patterns such as Sector Model, Concentric Model and Axial Growth model based on the natural setting of human population, economy, socio-cultural aspects, and environment. These models are studied and observed in the case area while searching for the appropriate pattern of development. In Nepal, the developing area is mostly following Axial pattern. The axial growth model, developed around the same time as the sectoral growth model, proposes that urban development occurs primarily along the transportation lines leading out from the city center[5].

3.1 Spatial Analysis using MCDM

GIS-Based Spatial Analysis and Multiple-Criteria Decision Making (MCDA) is a way to use maps and data to help make smart decisions about places [5]. It looks at things like where things are, what they're like, and how they're connected to each other. By using maps and numbers, it helps people decide what's best, considering many different things [5]. This is useful for picking the right spot for something or making choices about the environment or transportation. It also makes sure that people work together and understand why a decision was made.

3.2 Criteria Development for Spatial Analysis.

Urban densification means making cities more crowded in a smart and sustainable way because cities are getting bigger, and land is limited. This involves things like using land efficiently, having good transportation, green spaces, and friendly places to walk. It also means making sure everyone can easily access things like healthcare and education, and that cities are safe from natural disasters. Densification plans should be based on factors like making areas more compact, having green spaces, good transportation, and promoting parks and sports areas. These are some heading the for criteria development.

Selecting the right criteria is essential when identifying suitable areas for urban expansion. These criteria depend on factors like geography, climate, and human preferences. The specific choice of criteria should match the location and available data. In general, criteria can be grouped into four categories: accessibility, physical characteristics, socioeconomic factors, and environmental considerations. For residential development, typical criteria include proximity to roads, land use, distance from rivers, slope, and population density [6].

Different studies adopt various criteria depending on their research focus and location. It's important that these criteria align with the specific context. For example, when assessing suitability for urban development in Bajura district, Nepal, factors like slope rating, land cover, elevation rating, drainage, and geological conditions are considered [6]. Likewise, a study in Shaanxi Province, China, looked at criteria such as slope, demographics, infrastructure proximity, and buffer zones from rivers and roads to identify suitable areas for settlements [6]. These diverse approaches can help determine appropriate criteria for urban densification. Moreover, criteria can be categorized into two groups of constraints and development factors. Development factors can be proximity to transportation, health, education, water supply, market centers and administration whereas constraints can be Forest and conserved area, river, and water bodies, site slope and other constraints.

3.3 Desired Density of a City

Urban areas have their own unique approaches to development and population density. There's no global standard, but it's important for each place to find an optimal density that balances economic growth, infrastructure, and environmental sustainability. This research explores how different cities worldwide have determined suitable population densities based on their available resources and development goals.

Globally it is found that cities around the world hold varied population densities based on their planning and development policy or it could be the natural growth of people. According to (Philippine Statics Authority,2023). Manila, Philippines has the largest population density of more than 42,857 person per sq.km Many south Asian country has their gross density of around 500 Person per sq.km, while the net density of core urban area exceeds 20000 persons per sq.km (World Population Review,2023)

In India, many development plans have adopted a density of around 400-500 PPHa. Despite this, the Housing Plan for Low-income group includes 500 DU per hectare which is high and could be planned in minimum dwelling unit size and vertical expansion is required. For In Situ upgradation of slums, guidelines propose a maximum of 250 PPHa [7].

In Nepal, some places are very crowded, like Kathmandu, while others, especially in the countryside, are less crowded because of the tough terrain. On average, there are about 204 people living in each square kilometer in Nepal as of 2021. Kathmandu is the most crowded, with around 5,169 people in each square kilometer, while places like Manang have only 2.51 people in the same space. Some other cities, like Bhaktapur, Pokhara, and Biratnagar, are also moderately crowded, and some areas might be even more crowded.

In 2021, Kathmandu had about 9.1 percentage of Nepal's population, and it's getting even more crowded by 2035, with a projected population density of 367 people per hectare. Across Nepal, cities and towns are becoming more densely populated, with most places expected to have over 100 people per hectare. This shows a trend toward more concentrated urban living. A report by JICA sets guidelines for urban planning, suggesting a gross population density of 300 people per hectare and a net density of 600 people per hectare to manage urban growth. Within Kathmandu's Ring Road, the central core will be very crowded with around 1000 people per hectare, while the surrounding areas will be a bit less crowded at 600 people per hectare.

The KVDA Development Plan of 2020 has introduced a target population density of 300 people per hectare (PPHa) to guide urban growth [8]. Specific areas exhibit various population densities, such as Kuleshwor with 159 PPHA and Gongabu with 143 PPHA [8]. The LTDP 2002 recommends a population density of 300 PPHA, with an optimal density of 500 PPHA to balance resident needs and urban sustainability [8]. Harsiddhi Town Development Program is designed with a population density of 210 PPHA. KVDA data from 2020 presents different densities across ward, like Ward 24 with 442 PPHA and Ward 8 with 75 PPHA. Bhaktapur Metropolitan's Ward 9 has a notably high population density of 1039 PPHA, while Ward 17 has 72 PPHA. Madhyapur Thimi shows a density of 76 PPHA. Kritipur's Ward 10 stands out with 919 PPHA, while Ward 19 has a lower density of 12 PPHA. This data pattern underscores the diversity of urban planning approaches and population density trends It emphasizes the importance of balanced strategies to accommodate varying degrees of urbanization while considering livability and sustainable development [8].

Nepal's urban development strategies revolve around sustainable, balanced growth. The 2007 National Urban Policy (NUP) prioritizes densification and local involvement. The 2017 Nepal Urban Development Strategy (NUDS) outlines a 15-year plan focusing on infrastructure and finance. The 2015 Planning Norms and Standards simplify urban development planning. The Land Use Policy of 2015 safeguards land use. The 2019 Land Use Act empowers government intervention. Nepal actively supports SDG 11 for sustainable cities. The Kathmandu Valley Development Authority (KVDA) addresses urbanization challenges, striving for sustainable growth. The "2035 A.D. Scenario of Kathmandu Valley" envisions urban forests, greenery, and cultural preservation. Nepal's urban policies prioritize sustainability, balance, and infrastructure while aligning with global goals.

4. Study Area

Kageshwori Manohara Municipality is a recently established municipality in the Kathmandu Valley, situated in the Bagmati Province of Nepal. It shares borders with Gokarneshwor Municipality to the west, Sindhupalchowk District to the north, Shankharapur Municipality and Bhaktapur District to the east, and Kathmandu Metropolitan City to the south. The municipality was formed by merging six former VDCs (Gothatar, Mulpani, Danchhi, Bhadrawas, Alapot, and Gagalphedi) in December 2014, covering an area of 27.364 sq.km. It is divided into nine wards, with its administrative center located in Danchhi, Ward-5.

Geographically, Kageshwori Manohara connects Kathmandu and Bhaktapur and has road links through Bagmati Corridor, Jadibuti, Chabahil, and Bode. It also shares its boundary with Tribhuvan International Airport. The municipality is home to religious sites like Kageshwori Mahadev Temple and Sali Nadi.

It also attracts tourists with places like Gokarna Forest Resort and the ongoing construction of an International Cricket Stadium in Ward-6.

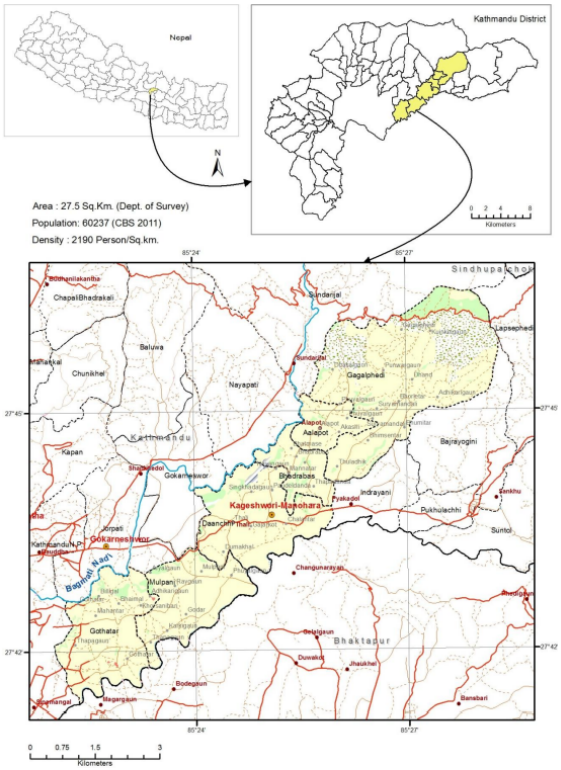

Figure 1: Location Map of Kageshwori Manohara Municipality

Source: The Story of Bhai dega [9]

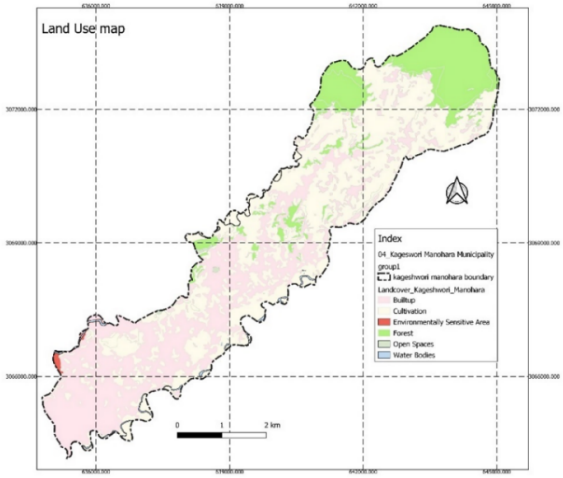

Figure 2: Landcover Map

Source: The Story of Bhai dega [9]

The municipality is rich in natural resources and a green environment. Shivpuri Forest and Gokarna Forest area contribute natural greenery to the municipality. The large flat agricultural area is cultivated through natural streams and mainly by Bagmati and Manohara River. These assets also do provide mines and minerals with them. The municipality has large stream water sources which are drinkable. The north Ground water Zone also lies in this region, where water gets stored in natural form.

5. Analysis and findings

Existing Urban Expansion and Pattern

Kageshwori Manohara Municipality is growing at a faster rate for human settlements and market area. The market area has been developed in old chowks(nodes) in many parts of the municipality. Ribbon development is seen along the roadside of the maximum area. Infrastructure development is also seen along the different road hierarchy connecting to the major roads. It is found that the municipality has a road network connected to every part of the site. The development is seen wherever there is presence of road. Despite the quality of roads, people are attracted towards the road for either residential or commercial purposes. The settlement along the road is mixed type housing supporting local business and housing demand at the same time.

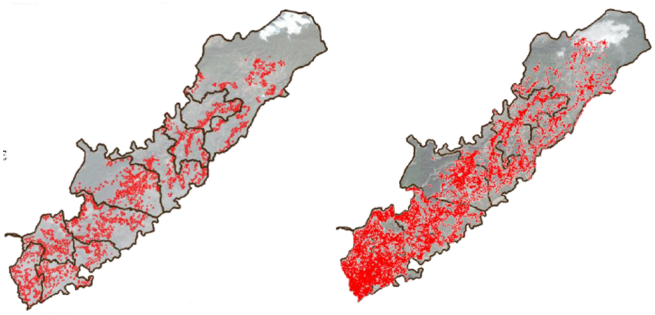

Figure 3: Landcover 2011 AD (left) and Landcover 2021 (right)

Source: Author

In a decade there has been a lot of change in landcovers from open to build areas from 2011 to 2021. Along with growth in population there is a vast increase in built up area for residential and commercial purposes. Similarly, strip/ribbon development patterns can be witnessed along the major roads as well as urban roads. There is loss in Agricultural Land and open space. Population is increasing rapidly such that there is less density at the cost of loss of more precious lands.

5.1 Population Growth and Distribution

In the 2078 B.S. census, Kageshwori Manohara Municipality had a total population of 130,433, accounting for 4.44 percentage of the Kathmandu Valley's population. Kathmandu Metropolitan City had the highest share at 29.35 percentage, while Dakshinkali contributed the least at 0.89 percentage. The municipality saw the highest population growth from 2068 to 2078 among all 18 local bodies in the valley, mainly due to internal migration. The population in Kageshwori Manohara doubled each decade from 2058 to 2078.

figure:

Despite Ward 9 having a large population, Ward 8 had the highest population density at 143.4 people per hectare (PPHA), while Ward 1 had the lowest density at 6.31 PPHA. Ward 9 had the second-highest density, followed by Wards 7, 6, 5, and 4.

The municipality's population distribution reflects a mix of urban and rural settlements typical of the Kathmandu Valley. Urban areas have higher population densities, especially

around economic centers, transport hubs, and government facilities. The outskirts have a more dispersed population due to agriculture and traditional livelihoods. Population density decreases from the southern to the northern part, where forested hills limit human settlement due to land suitability and infrastructure constraints.

5.2 Migration trend

Migration significantly impacts a city's social, economic, and political landscape, requiring a balance between locals and newcomers for sustainable development. In Kageshwori Manohara Municipality, data from 2019 households reveals that 69.4 percentage have moved there. Between April 2073 and November 2076, 3,658 individuals migrated in while 406 left. For every person leaving, nine others chose to settle here. The influx of people from various Nepali districts drives population growth, primarily due to better economic prospects. Migration stages often involve moving from larger cities like Kathmandu to suburban areas with cheaper housing. About 18.9 percentage of households had absent members, with 30 percentage pursuing higher education and 70 percentage seeking foreign employment. This migration trend emphasizes inter-municipal and rural-urban migration, especially in wards close to Kathmandu, indicating ongoing urbanization and potential for more migration.

5.3 Existing Land use and change

Land use in Kageshwori Manohara Municipality has undergone significant changes due to urbanization and growth. The municipality, closely linked to Kathmandu, has attracted people seeking comfortable housing and a peaceful environment. Presently, out of the municipality's 2,735.42 hectares, 34.43 percent is built-up, 46.94 percent is cultivated land, and 11.28 percent is protected area under Shivpuri National Park [10].

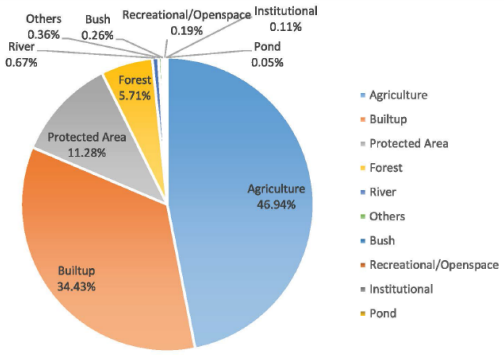

Figure 4: Existing Land use Chart
Source: IUDP 2018, NEST

Analysis of land use change focuses on the expansion of the built-up area since 1990. Rural-urban migration, driven by economic opportunities and push factors from rural regions, has led to rapid urbanization. From 1990 to 2018, the built-up area increased 26 times, while agricultural land decreased significantly, dropping from 80% to 47% of the total area. This shift highlights the municipality's transformation from predominantly rural to urban, with significant implications for its landscape and development.

5.4 Land and housing

Housing provision in Nepal involves informal private, public, organized private, and institutional sectors, with limited development in the formal private housing sector. The government focuses on three housing models: Site and Services, Guided Land Development, and Land Pooling. Twelve land pooling projects have been completed, and ten are ongoing in partnership with private landowners (JICA, 2017). In Kathmandu Valley, the shift from ownership to renting is noticeable, with owner households declining from 62.5 percent to 48.1 percent, and rental households increasing from 33.1 percent to 49.5 percent between 2004 and 2010/11 (CBS 2004, CBS 2010). The average dwelling size is 555 sq. ft, and housing plots average 1223.7 sq. ft (NLSS 2010). Kageshwori Manohara Municipality, an extension of Kathmandu, primarily relies on the informal private sector for housing, with some input from the formal private sector. Sixteen private sector projects, covering 27.05 hectares, provide around 2751 units, mainly in Gothatar and Mulpani. Land development projects are concentrated in wards 9, 8, 7, and 6, with emerging land pooling initiatives in rural wards like 1 and 3. Government intervention involves land pooling schemes, encouraging private sector participation [8].

5.5 Population Projection and Housing Demand

For housing demand calculation, we'll need to consider population projections for specific years, such as 2078, 2088, and 2098. Additional population growth is anticipated for 2088 and 2098. We'll also need to account for various factors like minimum lot size area, maximum coverage (65percent), floor area (FAR=3), and the number of tenants per house (20 sq.m per person).

First gathering population data for different years, such as 2078 (130,433), 2088 (301,845), and 2098 (734,487). Calculating additional population growth for 2088 (171,412) and 2098 (432,642). Considering the minimum lot size area (143.08 sq.m per house), maximum coverage (65percent), floor area ratio (FAR=3), and the number of tenants per house (20 sq.m per person). Calculating the number of houses needed for each year: 2088: 7986.77 houses 2098: 20,158.51 houses Determining additional development areas required for 2088 (114.27 hectares) and 2098 (288.43 hectares). To maintain a desirable population density of 300 people per hectare, we need calculate the area needed for future populations: For 2088: 171,412 / 300 = 571.37 hectares for 2098: 432,642 / 300 = 1,443 hectares. Looking at the situation, if these rational calculations claim for more built-up area, the target density could reach 500 person per hectare. These calculations aim to strike a balance between accommodating population growth and maintaining a sustainable and manageable density, considering the policies and plans of the government and local authorities.

5.6 Final criteria for dense settlement Development

To identify the suitable area for dense settlements, it is important to finalize the criteria that is relevant to site and context. These parameters should be determined from various spatial, non-spatial, qualitative, and quantitative data. These criteria will guide where the suitability of urban dense

settlement can be prioritized. First relevant data is collected, and maps are generated based on the information collected. The data is divided into two major parts such as restriction and development factors. The restricted factors restrict the development, and the development factors are further analyzed deeply for the suitability with degree of suitability with respect to others. The parameters and criteria are developed from the study of various literature studies. The criteria are then expressed and consulted with academicians, experts' governmental bodies, related individuals, and stakeholders. With some addition and subtraction in criteria, A list of final criteria for study is made and detailed out. Before injecting the criteria, it is important to mention the governing planning criteria from government and experts, The planning criteria are derived and discussed from literature part of this report. The frame in which criteria would remain at are listed below:

1. Dense and Compact Area
2. Promoting clean Urban Greenery and Forest.
3. Effective connectivity for all. (Transportation, communication)
4. Easy access to basic health and education for all.
5. Geographically, naturally, safe from disasters and Hazards.
6. Promoting open parks, recreational area, Sports arena etc.

The core criteria were derived from a mix of literature, expert interviews, and professional input. Suitability ranges for these criteria were determined using sources like (Rushemuka, 2020)[17], (Guragain & Bajracharya, 2022)[10], (Pokhrel et al., 2018)[18], and (Rashid, 2021)[19].To ensure consistency, all maps were adjusted to have uniform pixel values during GIS analysis, allowing for a standardized scale. After processing and layer overlay, pixel values were combined, ranging from 5 (high suitability) to 1(restricted suitability).

Analysis Criteria selected are:

Constraints factors: Site Slope, Conserved Forest, Conserved Water Sources and Rivers, Landslide and Soil erosion Area and Flooding area.

Development Factors: Proximity to Major Roads, Water Supply, Sanitation, Electricity, Telecommunications, Public Administration, Health Services, Education and Market Centers.

Table 1: Scoring based of Constraints and Development Factors

	Criteria	Suitability				
		High=1	Moderate=2	Low=3	Very Low=4	Restricted=5
1	Roadway Proximity	0-250	251-500	501-750	751-1000	>1000
2	Water Supply	0-250	251-500	501-750	751-1000	>1000
3	Electricity Line	0-250	251-500	501-750	751-1000	>1000
4	Network/telecom	0-250	251-500	501-750	751-1000	>1000
5	Health Post	0-500	501-1000	1001-1500	1501-2000	2001-2500
6	Hospital	0-700	701-1400	1401-2100	2101-2800	>2800
7	Primary School	0-200	201-400	401-600	601-800	>800
8	Secondary School	0-500	501-1000	1001-1500	1501-2000	>2000
9	College/Univ ersity	0-2000	2000-4000	4000-8000	8000-10000	>10000
10	Administrati ons	0-500	501-1000	1001-1500	1501-2000	>2000
11	Market centers/ BFI	0-2000	2000-4000	4000-8000	8000-10000	>10000
13	Forest/Green	Restricted				
14	Water Bodies	Restricted				
15	Slope	Slope < 30 degree: Suitable			Slope > 30 degree: Restricted	
16	Soil erosion	Restricted				
17	Fault Line	Restricted				

5.7 Final Constraints Map based on Suitability Score

The constraints such as Site Slope, Conserved Forest, Conserved Water Sources and Rivers, Landslide and Soil erosion Area, Flooding areas data is collected and put into frame of maps. All the constraints layers are overlaid in maps to get the final suitability maps which are constraints free.

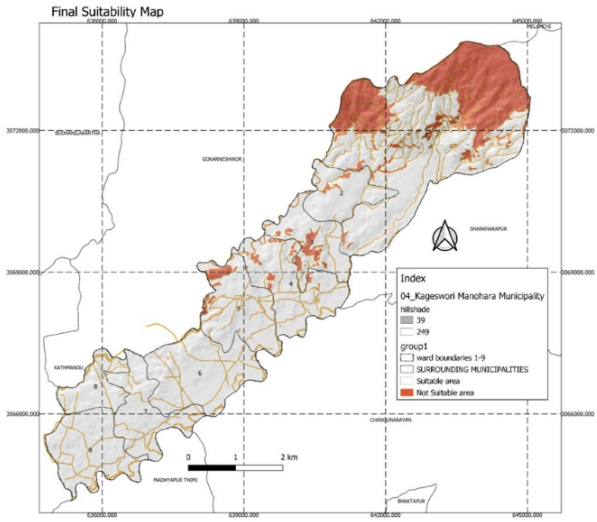

Figure 5: Final constraint Suitability Map
Source: IUDP 2018, NEST

Area	Sq.km	Percent
Suitable Area	20.59	75.23
Unsuitable Area	6.781	24.77
Total	27.371	100

5.8 Maps for Development factors using the scores

Figure 6 shows the individual development factor maps based on proximity and the score provided to them. Individual maps

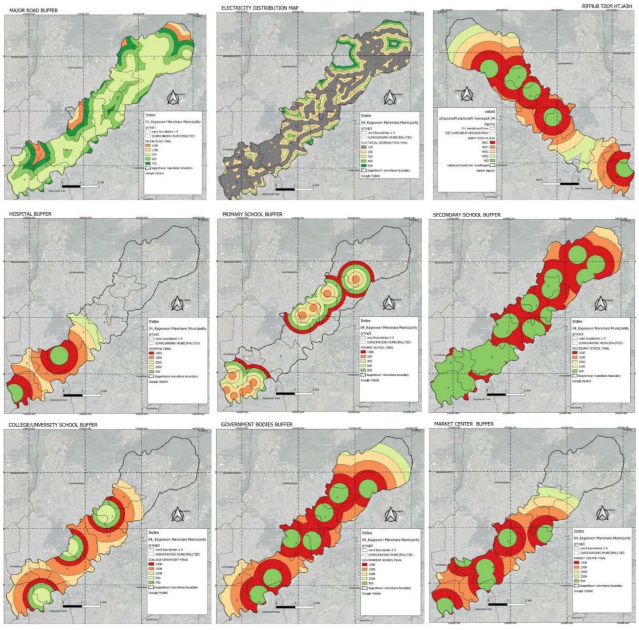

Figure 6: Individual development factor maps based on proximity *Source: Author*

are created based on the criteria scoring, converting them into raster format. These maps are then prepared for the final weighted overlay process, where multiple raster layers are combined to pinpoint the most suitable areas that should take priority for development. Since economic and sustainable development is crucial for developing nation like Nepal, this scoring can add up the priority area to taken into consideration for development.

5.9 Final Suitability Map

The ultimate suitability map is the result of an intricate procedure that amalgamates multiple distinct maps, each focusing on different aspect of suitability like slope and proximity to services like road services. Utilizing Geographic Information System (GIS) technology, these individual maps are harmoniously integrated, giving equal weight to every criterion to ensure an equitable assessment. To facilitate a fair comparison, all values across diverse criteria have been standardized to a consistent scale.

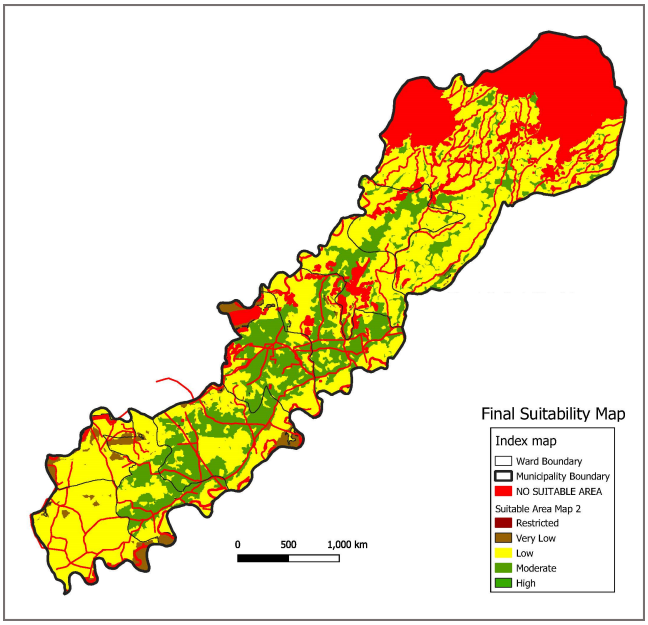

Figure 7: Final Suitability Map
Source: Author

Points	Suitability	Area (Sq. km.)	Percentage
Less than 3	Restricted	6.23	22.65
3 to 4	Very Low	1.3	4.72
4 to 5	Low	9.43	34.29
5 to 6	Moderate	10.29	37.41
6 to 8	High	0.25	0.9
	Total	**27.38**	**100**

Less than 1 percent highly suitable area in wards 4, 5, and 6 for dense settlements. Moderately suitable (9.43 sq.km) in Danchi, Mulpani, and Gothatar, already in development with infrastructure. Low suitability (9.43 sq.km) in wards 1, 2, 8, and 9, with varying population density and infrastructure. Very low suitability (1.3 sq.km), about 4 percent of the total area, mainly comprising protected forests and ecologically vital zones. Approximately 6.23 sq.km restricted for residential development due to ecological importance.

6. Discussion and Conclusion

In the pursuit of identifying ideal areas for urban densification in Kageshwori Manohara Municipality, various criteria were considered. Initially, constraints like water bodies, slopes, and conserved areas were identified, while development factors were assessed. It's evident that areas near main highways and major roads are more suitable due to their resource accessibility. Proximity to roads, utilities, education, healthcare, and markets is attractive to residents, making these areas a priority for habitation. Given the substantial changes in land cover due to population growth, pinpointing suitable spaces becomes crucial to minimize development costs and reduce disaster risks. A significant portion of land is identified as suitable for urban expansion to meet the rising population's housing needs. Over the next decade, approximately 571 hectares will be needed to maintain the desired population density, followed by an additional 1,400 hectares in the second decade. Proper planning is imperative to avoid sprawl-related issues. The study aims to find suitable areas across different wards based on infrastructure, targeting an optimal density of 300 people per hectare. This density encourages low-rise, medium density planning with ample open spaces and urban forests, creating a balance between development and ecology. Challenges arise even after identifying suitable areas. It's a citizen's right to live anywhere, making it crucial for the government to educate and involve citizens in planned development to mitigate hazards and risks. Encouraging proper planning through policies that promote compact settlements and discourage isolated ones is essential. GIS technology has significantly facilitated this study, offering precise and flexible assessment techniques. This analysis has the potential to guide sustainable urban expansion in Kageshwori Manohara Municipality, aiding urban planners and policymakers in decision-making. It monitors urban land development, highlighting the need to align government regulations with market dynamics for effective land management.

7. Policy Intervention and Recommendation

This study explores various criteria to identify the most suitable areas for urban development in Kageshwori Manohara Municipality. It underscores the critical importance of thoughtful space selection, considering factors like water bodies and terrain steepness to minimize unnecessary costs and potential risks. The Municipal policies are a roadmap for shaping the growth of Kageshwori Manohara in a positive direction. They encompass various strategies to ensure the city expands thoughtfully. For instance, there are guidelines dictating where different types of buildings can be constructed, encouraging a mix of businesses, homes, and services in the same area. Additionally, there are incentives in place to encourage developers to build more homes and buildings in smaller spaces, making the city more densely populated. Furthermore, these policies introduce methods like Transfer of Development Rights (TDR), which allow people to move their building rights from less suitable areas to better-suited spots. They aim to involve and educate the local community, explaining why it's crucial to build in specific zones. The plans also focus on providing essential facilities

like roads, schools, and parks in areas where more people live, improving the quality of life for residents. Ensuring affordable housing for everyone is a priority, and these policies are designed to monitor how well they work and adjust if necessary to ensure the city grows sustainably and equitably.

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