Land Use Land Cover and Population Changes in Bhaktapur District

Raghu Nath Prajapati[1, 2]

[1]Associate Professor, Nepal Engineering College, Changunarayan, Bhaktapur, Nepal
[2]PhD Scholar, Infrastructure Univeristy Kuala Lumpur, Malaysia

Corresponding Author
Raghu Nath Prajapati
Email: 082101900006@s.iukl.edu.my, raghunp@nec.edu.np
https://orcid.org/0000-0001-9222-1043

Received Date 05 July 2024 **Accepted Date** 14 August 2024 **Published Date** 1 September 2024

ABSTRACT

Bhaktapur District, renowned for its cultural heritage, has undergone substantial land use and population changes from 2001 to 2019 and 2001 to 2021, respectively, driven by rapid urbanization and economic growth. This study employs Geographic Information System (GIS) tools and demographic data from the Central Bureau of Statistics (CBS) to examine these changes. Findings highlight a significant rise in built-up areas, especially around Bhaktapur city and neighboring municipalities like Madhyapur Thimi and Suryabinayak, which has led to a notable decrease in agricultural land. Specifically, built-up areas expanded by 5.56 m² in Changunarayan from 2001 to 2011 and by 4.155 m² in Suryabinayak from 2011 to 2019. While forested areas remained stable until 2011, they saw a substantial decline, notably a decrease of 21.683 m² in Madhyapur. Cropland has also diminished across all municipalities, with Changunarayan and Madhyapur experiencing the highest reductions of 36.89 m² and 33.23 m², respectively. Population growth has been particularly pronounced in Madhyapur and Suryabinayak, with Madhyapur experiencing a 5.8% increase in 2011 and Suryabinayak a 5.7% increase in 2021, whereas Bhaktapur city saw a slight decrease. These trends emphasize the impact of urban expansion on agricultural land and highlight the necessity for strategic urban planning. The study advocates for sustainable development practices that reconcile urban growth with the preservation of agricultural land and natural resources. It urges policymakers and urban planners to implement strategies that safeguard remaining farmland, promote sustainable urban agriculture, and protect the district's cultural and environmental assets for long-term ecological and economic stability.

KEYWORDS

Bhaktapur District, LULC change, Population change

INTRODUCTION

Bhaktapur District, one of the three historical cities in the Kathmandu Valley of Nepal, is renowned for its rich cultural heritage, exquisite traditional architecture, and significant historical legacy. Known as the "City of Devotees," Bhaktapur's well-preserved palaces, temples, and courtyards reflect centuries-old artistry and craftsmanship (Silva, 2015). However, like many regions worldwide, Bhaktapur has undergone substantial changes in land use and population dynamics over the past few decades (Thapa chhetri & Moriwaki, 2017).

These transformations are largely driven by rapid urbanization, economic development, and shifts in demographic patterns (Costa et al., 2023; Wang & Yang, 2020).

In recent decades, Bhaktapur has experienced a remarkable shift from a predominantly agrarian society to an increasingly urbanized area (Timsina, 2020). The expansion of residential areas, commercial zones, and infrastructure has led to significant alterations in land use patterns. Agricultural lands and open spaces have been converted into urban settlements, leading to a reduction in green cover and changes in the local ecosystem. This urban sprawl, while indicative of economic growth, poses challenges for sustainable development and environmental conservation (Hassan & Lee, 2015; Shao et al., 2021). The population dynamics of Bhaktapur District have also undergone significant changes. The district has experienced a steady population increase, driven by natural growth and migration from rural areas seeking better economic opportunities and improved living standards (Ishtiaque et al., 2017). This population growth has intensified the demand for housing, infrastructure, and services, further accelerating land use changes. Understanding these population trends is crucial for devising effective urban planning and management strategies to accommodate the growing population while ensuring the district's sustainability (Puchol-Salort et al., 2021).

This study aims to explore and analyze the changes in land use and population within Bhaktapur District, shedding light on the underlying factors driving these changes and their broader implications. The study provides a comprehensive understanding of how urban expansion, agricultural decline, and infrastructural development are reshaping the district's landscape and demographic structure. By examining historical data, satellite imagery, and contemporary trends, the study seeks to highlight the critical interactions between human activities and land use changes. The findings of this research are intended to guide the formulation of sustainable urban planning strategies that accommodate population growth while safeguarding the district's cultural and environmental assets.

Study Area

Bhaktapur District, located in the eastern part of the Kathmandu Valley in Nepal, is a region steeped in history and culture. Covering an area of 119 square kilometers, it is bordered by Kavrepalanchok District to the east, Kathmandu District to the west, and Lalitpur District to the south. The district is situated at an average elevation of 1,401 meters above sea level, providing a picturesque landscape that blends urban and rural characteristics.

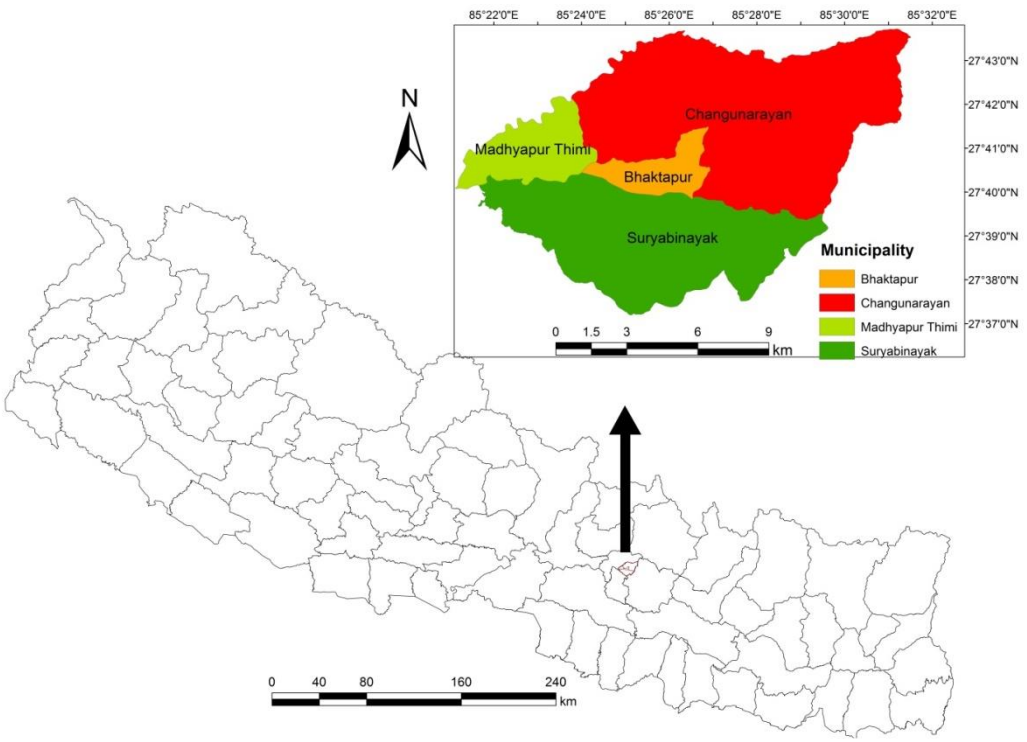

Figure 1: Study Area

The district administrative center, Bhaktapur city, is one of Nepal most well-preserved medieval cities, renowned for its intricate wood carvings, ancient temples, and historical monuments (Nepal, 2024). Bhaktapur geography is characterized by its diverse topography, including flat plains, rolling hills, and river valleys. The Hanumante River, which flows through the district, is a vital water source for agriculture and local communities (Prajapati et al., 2020; Sada, 2012). The fertile soil and favorable climate make Bhaktapur an ideal region for traditional agriculture, with rice, wheat, and vegetables being the main crops cultivated in the area.

Despite its rich agricultural heritage, Bhaktapur has undergone significant urbanization over the past few decades. The district's proximity to the capital city of Kathmandu has made it an attractive location for residential and commercial development. As a result, agricultural lands are increasingly being converted into urban settlements, altering the district's land use patterns and contributing to a dynamic urban landscape.

METHODOLOGY

This research, titled "Land Use Land Cover and Population Change in Bhaktapur District," utilizes a methodical approach to collect, analyze, and interpret data to grasp the spatial and temporal shifts in land use and population. Data layers from Geographic Information Systems (GIS), including land use maps, administrative boundaries, and topographical features, were sourced from institutions such as the Survey Department of Nepal and ICIMOD (https://www.icimod.org/country/nepal/). Additionally, population statistics were collected from the Central Bureau of Statistics (CBS) of Nepal for the census years 2001, 2011, and 2021, supplemented by local government records and other pertinent sources to ensure thoroughness and precision.

The study employed ArcGIS tools to process and analyzes land use land cover (LULC) data from ICIMOD, categorizing land into types such as residential, commercial, agricultural, forest, and barren. Change detection in LULC was conducted to identify and measure shifts in land use patterns over the period from 2001 to 2019, shedding light on the extent and nature of these changes. Population data were scrutinized to identify trends, growth rates, and spatial distribution. The research explored how population growth correlates with changes in land use, investigating the interplay between demographic shifts and urbanization. GIS tools facilitated spatial analysis, generating thematic maps that illustrate patterns of urban expansion, agricultural decline, and other land use transformations. By overlaying population data with land use maps, the study examined the spatial relationship between population density and land use dynamics.

The analysis of LULC and population data provided valuable insights into the forces driving and consequences of land use changes in Bhaktapur District. This comprehensive study highlights how urban growth, agricultural reduction, and infrastructure development are altering the district's landscape and demographic profile. The integration of GIS and demographic data offers a robust framework for analyzing and visualizing these changes, with findings aimed at guiding sustainable urban planning and heritage conservation strategies.

RESULTS AND DISCUSSIONS

Land Use Changes (2001-2019)

The land use changes in Bhaktapur District between 2001 and 2019, as illustrated in Figure 2-3, highlight significant urban expansion and a corresponding decrease in agricultural land. Various colors represent different land use types: dark blue for water bodies, dark green for forests, red for built-up areas, light green for cropland, gray for bare rock, and purple for other wooded lands.

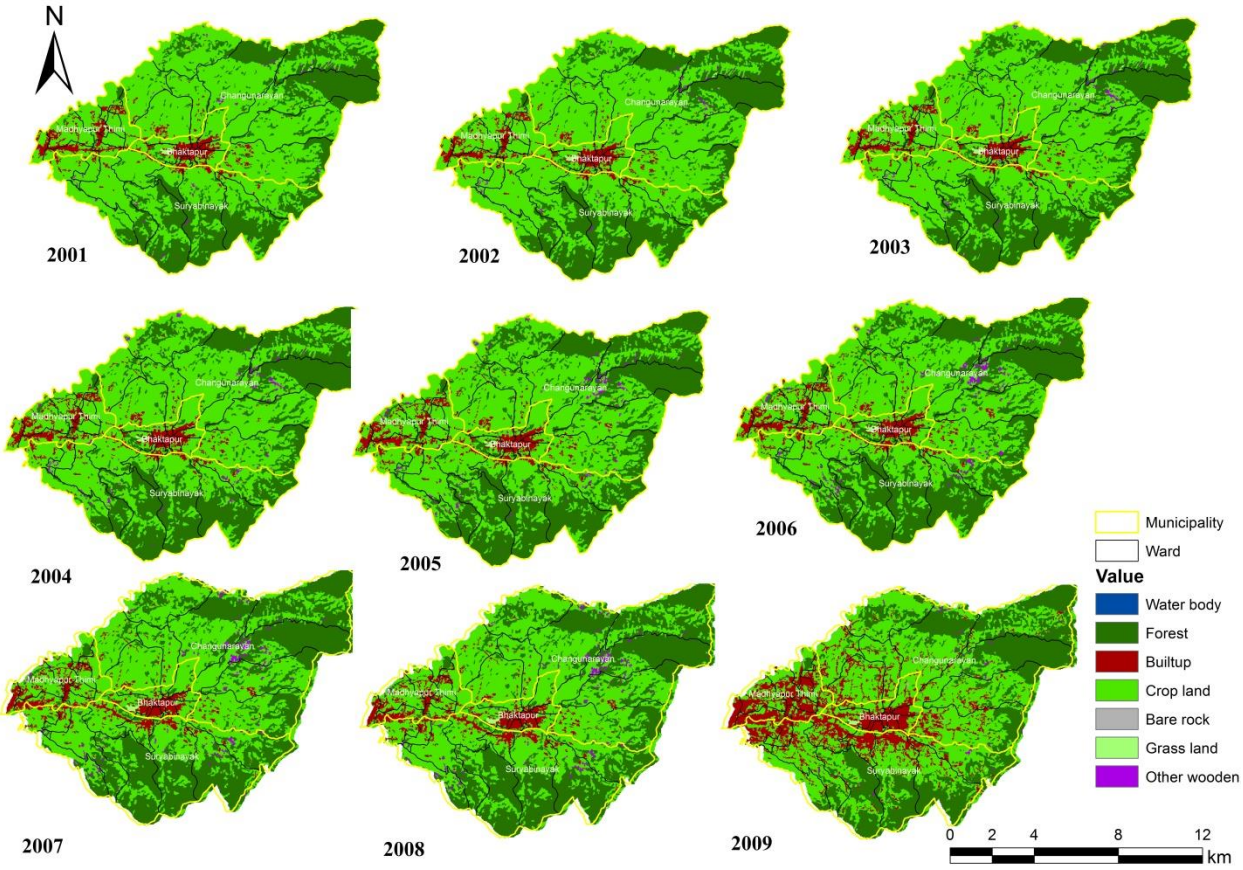

Figure 2: Land Use Land Cover (2001 to 2009) of Different Municipality in Bhaktapur District

Over the 18-year period, there is a noticeable increase in built-up areas, particularly around Bhaktapur city and the surrounding municipalities of Madhyapur Thimi and Suryabinayak. This indicates substantial urban growth driven by the rising population and the need for more housing and infrastructure. As urban areas have expanded, cropland has notably decreased, especially in regions adjacent to these growing urban zones. This suggests that agricultural land is being converted into urban land to meet the demands of the increasing population. In contrast, forested areas have remained relatively stable, indicating limited deforestation in the district. Other land uses, such as bare rock and other wooded lands, have shown minimal changes, suggesting they have been less impacted by urbanization.

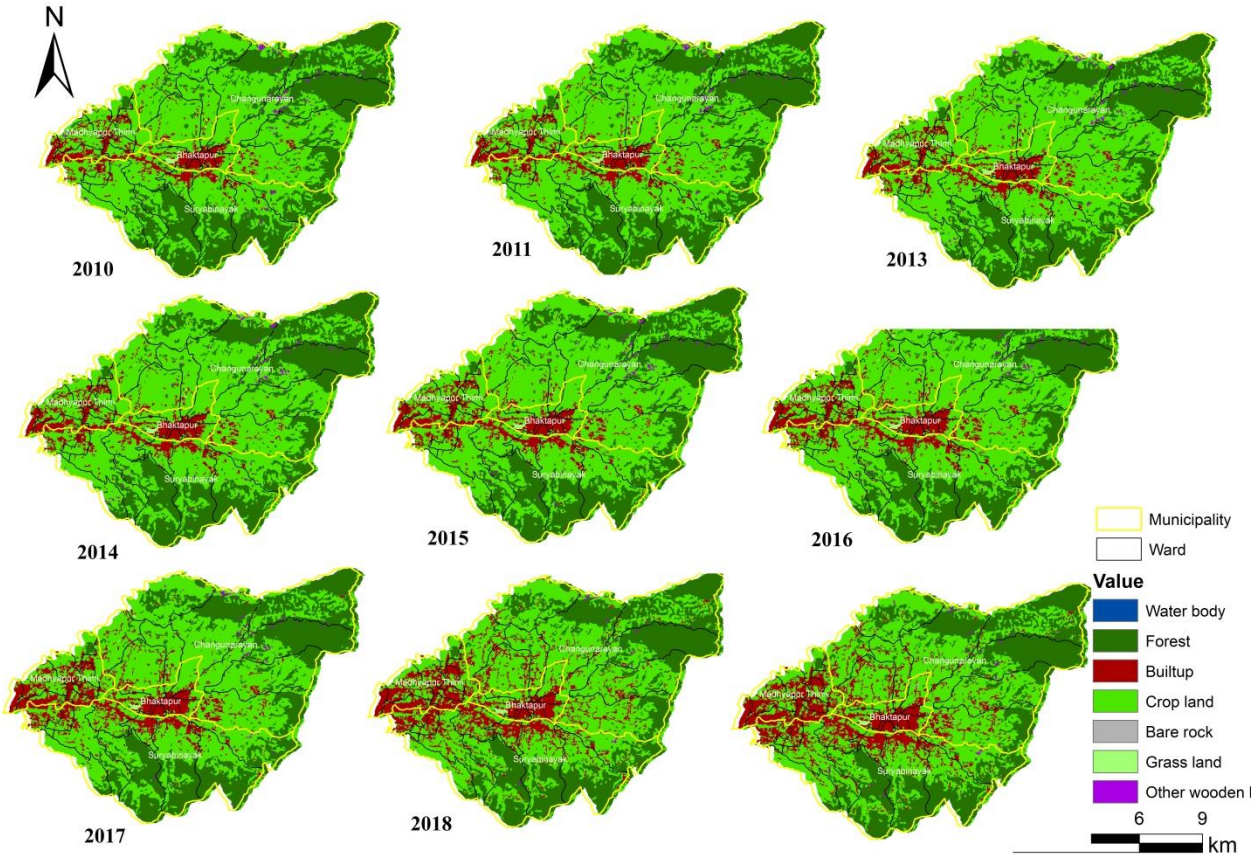

Figure 3: Land Use Land Cover (2010 to 2019) of Different Municipality in Bhaktapur District

The images depicting land use changes in Bhaktapur District from 2001 to 2019 and a comparison between decade maps of 2001 to 2019 (Figure 4) reveal significant trends in urban expansion and agricultural land reduction. Over the nine-year period from 2001 to 2009, the built-up areas (represented in red) steadily increased each year. This growth is particularly noticeable around Bhaktapur city, Madhyapur Thimi, and Suryabinayak, indicating a clear pattern of urban sprawl. The core areas in these municipalities expanded significantly, leading to a gradual reduction in cropland (light green). By 2009, much of the cropland near urban centers had been converted to residential and commercial use. From 2010 to 2013, there is a noticeable increase in built-up areas around Bhaktapur and its surrounding regions. The period from 2013 to 2014 shows a slight reduction in cropland and an increase in urban areas, which persists through 2015. The urban expansion is more pronounced from 2015 to 2016, with more red areas appearing on the map. This trend continues through 2017 and 2018, marking significant urban spread compared to 2010. In the broader comparison between 2001 and 2019 (Figure 4), there is a dramatic increase in built-up areas, showing extensive urban growth over two decades. The urban core around Bhaktapur city has expanded significantly, engulfing areas that were predominantly agricultural land in 2001. This shift indicates that urban development has taken precedence over agricultural activities, resulting in a substantial reduction in cropland. The forest areas (dark green) have remained relatively stable throughout these periods, suggesting effective

conservation efforts, which are crucial for maintaining environmental sustainability amidst urban expansion.

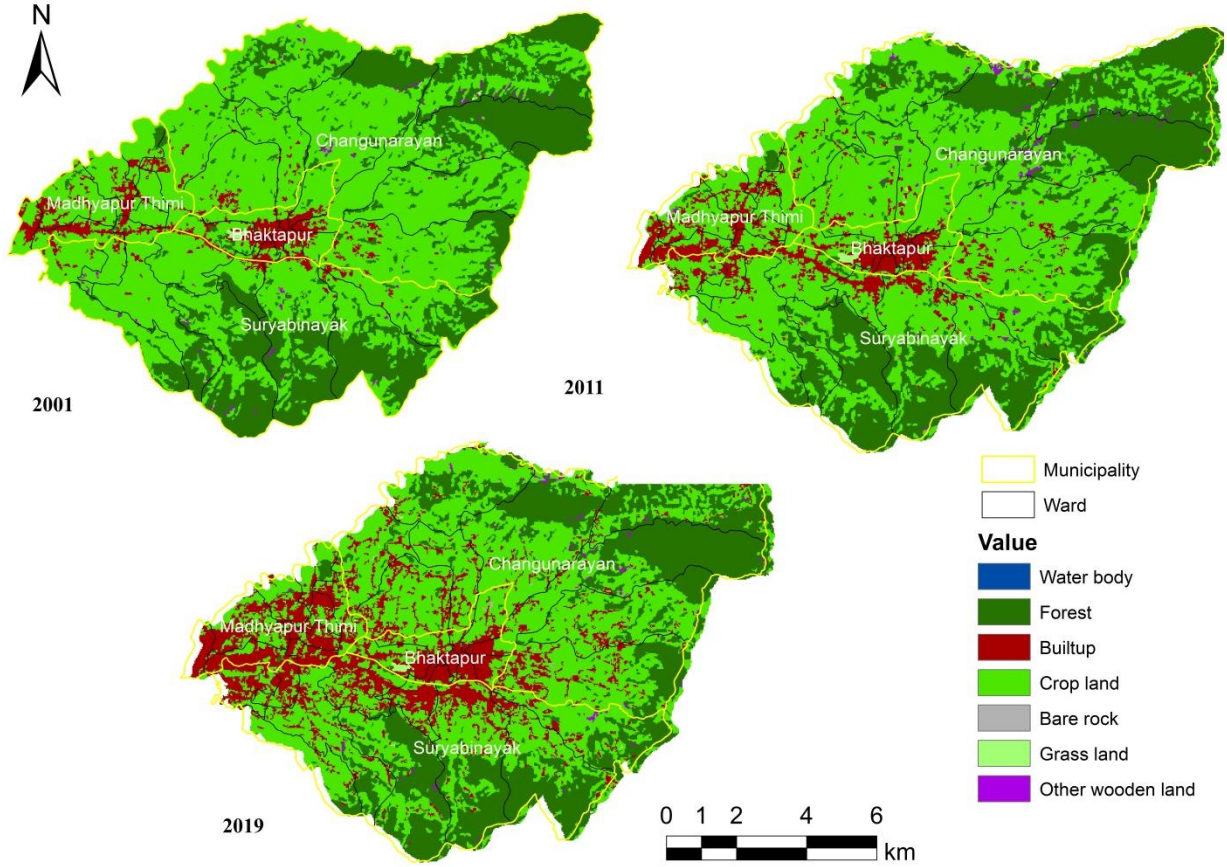

Figure 4: Decade Wise LULC of Bhaktapur District

Spatial analysis shows that Bhaktapur city has experienced considerable urban growth, with built-up areas expanding outward. Madhyapur Thimi and Suryabinayak also show a high rate of urban expansion, reflecting the overall urban growth trend in the district. In contrast, Changunarayan, while experiencing some urban growth, has managed to retain much of its forest cover. This urban growth pattern underscores the challenges of balancing development with agricultural sustainability and environmental conservation. To ensure the district's long-term ecological and economic health, it is essential to implement sustainable urban planning strategies that protect remaining agricultural and forest lands. The expansion of built-up areas reflects a rise in population and urban development, necessitating more housing, infrastructure, and services. While this growth indicates economic development, it poses challenges for sustainable land use and resource management. The decline in agricultural land underscores a shift from traditional farming to urban uses, which could impact local food production and the livelihoods of farmers. Implementing policies that promote sustainable urban agriculture or protect remaining agricultural lands could help mitigate these effects.

As illustrated in Table 1, Bhaktapur Municipality saw water bodies decrease slightly from 0.004 m^2 in 2001 to 0.001 m^2 in 2011, then increase to 0.003 m^2 by 2019. Forest areas consistently declined from 0.153 m^2 in 2001 to 0.041 m^2 in 2019. Built-up areas grew significantly from 2.126 m^2 in 2001 to 3.308 m^2 in 2019, while cropland saw an initial

increase but fell to 3.072 m² by 2019. Grassland areas fluctuated slightly, decreasing to 0.022 m² in 2019. In Changunarayan Municipality, water bodies remained stable. Forest areas rose significantly from 4.11 m² in 2001 to 21.02 m² in 2011 but dropped to 1.57 m² by 2019. Built-up areas expanded initially, then decreased to 1.87 m² by 2019. Cropland increased until 2011, and then sharply declined to 15.64 m² in 2019. Grassland areas showed minor changes, decreasing to 0.01 m² in 2019. In Madhyapur Municipality, water bodies initially decreased but slightly increased to 0.250 m² by 2019. Forest areas saw substantial growth, then decreased to 21.620 m² by 2019. Built-up areas consistently grew, reaching 29.314 m² in 2019, while cropland initially increased but fell to 4.474 m² by 2019. Grassland remained stable. In Suryavinayak Municipality, water bodies and forests decreased significantly from 2001 to 2019. Built-up areas increased significantly to 6.697 m² by 2019, while cropland decreased slightly to 20.216 m². Grassland areas remained stable.

Table 1: LULC Change in Municipalities of Bhaktapur District

LULC change in Bhaktapur Municipality (m2)					
LULC/Year	2001	2011	change than 2001	2019	change than 2011
Waterbody	0.004	0.001	-0.002	0.003	0.002
Forest	0.336	0.153	-0.183	0.041	-0.112
Builtup	2.126	2.289	0.163	3.308	1.018
Cropland	3.972	3.974	0.002	3.072	-0.901
Grassland	0.117	0.129	0.011	0.022	-0.107
Other	0.000	0.005	0.005	0.105	0.100

LULC change in Changunarayan Municipality (m2)					
LULC/Year	2001	2011	change than 2001	2019	change than 2011
Waterbody					
Forest	19.54	40.47	20.93	21.02	-19.45
Builtup	0.82	9.37	8.56	4.85	-4.53
Cropland	42.28	72.29	30.01	35.41	-36.89
Grassland	0.03	0.16	0.12	0.03	-0.13
Other	0.23	0.68	0.46	0.25	-0.43

LULC change in Madhyapur Municipality (m2)					
LULC/Year	2001	2011	change than 2001	2019	change than 2011
Waterbody					
Forest	0.343	21.963	21.620	0.280	-21.683
Builtup	2.346	1.352	-0.994	5.264	3.912
Cropland	8.390	37.704	29.314	4.474	-33.230
Grassland		0.023			
Other		0.525		0.016	-0.510

LULC change in Suryavinayak Municipality (m2)					
LULC/Year	2001	2011	change than 2001	2019	change than 2011
Waterbody					
Forest	17.042	15.937	-1.106	13.698	-2.239

Builtup	0.919	2.803	1.884	6.957	4.155
Cropland	24.232	22.160	-2.072	20.216	-1.944
Grassland	0.005			0.013	0.013
Other	0.190	0.090	-0.100	0.111	0.020

Population Dynamics (2001-2021)

Table 2 provides detailed population data for the years 2001, 2011, and 2021. Bhaktapur's population grew from 72,543 in 2001 to 83,658 in 2011 but then decreased to 79,136 in 2021. Changunarayan's population increased steadily from 58,006 in 2001 to 88,083 in 2021. Madhyapur saw significant growth, with its population rising from 47,751 in 2001 to 119,756 in 2021. Suryabinayak more than doubled its population from 55,744 in 2001 to 140,085 in 2021. Overall, Bhaktapur district's population grew from 225,461 in 2001 to 432,132 in 2021. At the national level, Nepal's population increased from 23,154,123 in 2001 to 29,164,578 in 2021.

Table 2: Population in Different Municipality in Bhaktapur district

Municipality\Year	**2001**	**2011**	**2021**
Bhaktapur	72543	83658	79136
Changunarayan		58006	88083
Madhyapur	47751	84142	119756
Suryabinayak	55744	78845	140085
Bhaktapur district	225461	304651	432132
Nepal	23151423	26494504	29164578

This data indicates that while Bhaktapur municipality has seen a slight decrease in population density and annual growth rate, other municipalities in the district, particularly Madhyapur and Suryabinayak, have experienced significant population increases. This could be due to urban expansion, migration patterns, and developmental changes in these areas. The overall growth in Bhaktapur district reflects a trend of urbanization and population concentration in certain municipalities, likely driven by economic opportunities and infrastructure development. The annual population change graph shows that Bhaktapur experienced a slight positive growth in 2011, which turned into a slight decline by 2021. In contrast, in Figure 5, Changunarayan exhibited a consistent increase in annual population change from around 2.5% in 2011 to approximately 3.5% in 2021. Madhyapur had the highest annual population change in 2011 at about 6%, but this rate decreased to roughly 3% in 2021. Suryabinayak, on the other hand, saw an increase in its annual population change from around 4% in 2011 to approximately 5.5% in 2021, indicating significant growth.

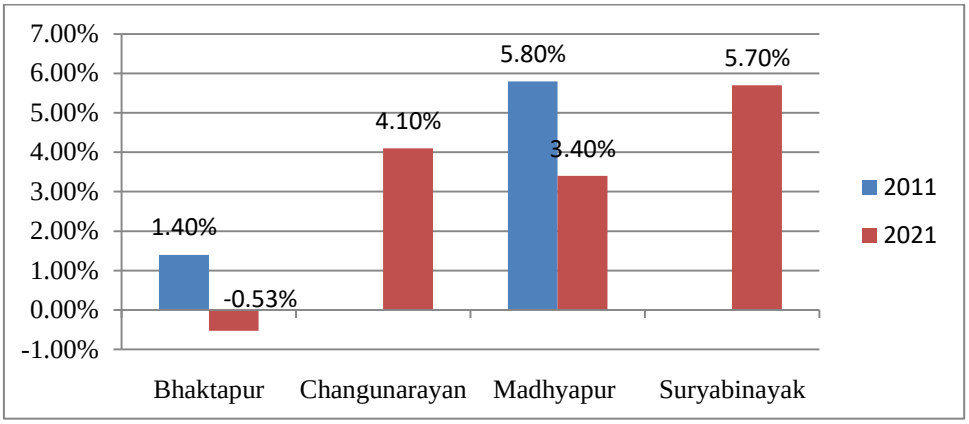

Figure 5: Annual Population Change (for 2011 to 2021)

Figure 6, depicting population density per square kilometer, shows that in Bhaktapur, the density decreased from about 12,000 persons per square kilometer in 2011 to just below 11,000 in 2021. Changunarayan had a low population density in both years, with a slight increase from approximately 1,500 to just over 2,000 persons per square kilometer. Population density in Madhuapur increased significantly from around 7,500 in 2011 to approximately 12,000 in 2021. Similarly, Suryabinayak experienced a notable rise in population density from about 3,000 to over 4,000 persons per square kilometer.

The increasing built-up areas and decreasing forests and water bodies reflect the impact of urbanization and land use changes. To ensure the district long-term ecological and economic health, it is essential to implement sustainable urban planning strategies that protect remaining agricultural and forest lands. The decline in agricultural land underscores a shift from traditional farming to urban uses, which could impact local food production and the livelihoods of farmers. Implementing policies that promote sustainable urban agriculture or protect remaining agricultural lands could help mitigate these effects.

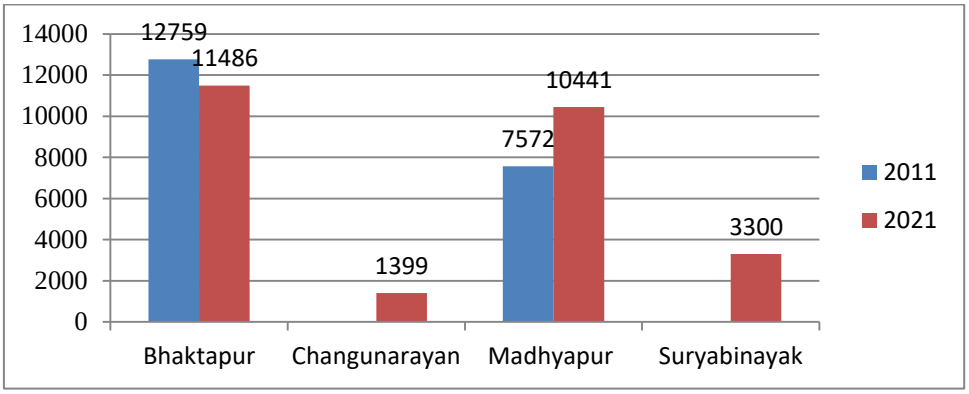

Figure 6: Population Density Per Square Kilometer Area

CONCLUSION

The analysis of land use and population changes in Bhaktapur District from 2001 to 2019 reveals significant trends and implications for urban planning and sustainable development. Over this period, Bhaktapur has experienced substantial urban expansion, driven by population growth and economic development. This has led to a notable increase in built-up

areas, particularly around Bhaktapur city and its neighboring municipalities, Madhyapur Thimi and Suryabinayak, resulting in a corresponding decrease in agricultural land. The shift from agrarian land use to urban development underscores the pressures of urbanization on traditional farming areas. While forest areas have remained relatively stable, indicating effective conservation efforts, the reduction in agricultural land highlights the need for policies that balance urban growth with the preservation of agricultural spaces to ensure local food security and the livelihoods of farmers. Population dynamics further illustrate these trends, with significant growth in municipalities like Madhyapur and Suryabinayak, while Bhaktapur city saw a slight decline. The increase in population density in these areas reflects migration patterns and developmental changes, emphasizing the need for strategic urban planning to accommodate this growth sustainably.

To address these challenges, it is crucial to implement comprehensive urban planning strategies that incorporate sustainable land use practices. Protecting remaining agricultural lands, promoting sustainable urban agriculture, and ensuring the conservation of forest areas are essential steps in maintaining the district's ecological and economic health. Policymakers, urban planners, and conservationists must collaborate to devise and implement strategies that balance development with environmental preservation, safeguarding Bhaktapur cultural and natural heritage for future generations.

REFERENCES

Costa, R. C. A., Santos, R. M. B., Fernandes, L. F. S., Carvalho de Melo, M., Valera, C. A., Valle Junior, R. F. do, Silva, M. M. A. P. de M., Pacheco, F. A. L., & Pissarra, T. C. T. (2023). Hydrologic Response to Land Use and Land Cover Change Scenarios: An Example from the Paraopeba River Basin Based on the SWAT Model. *Water (Switzerland)*, *15*(8), 1–26. https://doi.org/10.3390/w15081451

Hassan, A. M., & Lee, H. (2015). Toward the sustainable development of urban areas: An overview of global trends in trials and policies. *Land Use Policy*, *48*, 199–212. https://doi.org/10.1016/j.landusepol.2015.04.029

Ishtiaque, A., Shrestha, M., & Chhetri, N. (2017). Rapid urban growth in the kathmandu valley, nepal: Monitoring land use land cover dynamics of a himalayan city with landsat imageries. *Environments - MDPI*, *4*(4), 1–16. https://doi.org/10.3390/environments4040072

Nepal, H. (2024). *Nepali Architecture's History: From Pagodas to Palaces*. https://www.hopnepal.com/blog/explore-nepals-architectural-evolution-from-ancient-pagodas-to-majestic-palaces

Prajapati, R. N., Lama, S., Khadka, S., Gauli, S., & Gaire, T. (2020). *A Study of Basic Water Quality in Dry Season in Manohara River in Nepal*. *3*(3), 1–5.

Puchol-Salort, P., O'Keeffe, J., van Reeuwijk, M., & Mijic, A. (2021). An urban planning sustainability framework: Systems approach to blue green urban design. *Sustainable Cities and Society*, *66*(December 2020), 102677. https://doi.org/10.1016/j.scs.2020.102677

Sada, R. (2012). Hanumante River: emerging uses, competition and implications. *Journal of Science and Engineering*, *1*, 17–24. https://doi.org/10.3126/jsce.v1i0.22489

Shao, Z., Sumari, N. S., Portnov, A., Ujoh, F., Musakwa, W., & Mandela, P. J. (2021). Urban sprawl and its impact on sustainable urban development: a combination of remote sensing and social media data. *Geo-Spatial Information Science*, *24*(2), 241–255.

https://doi.org/10.1080/10095020.2020.1787800

Silva, K. D. (2015). The Spirit of Place of Bhaktapur, Nepal. *International Journal of Heritage Studies*, *21*(8), 820–841. https://doi.org/http://dx.doi.org/10.1080/13527258.2015.1028962

Thapa chhetri, D. B., & Moriwaki, R. (2017). Monitoring Urban Growth, Land Use and Land Cover Using Remote Sensing and Gis Techniques: a Case Study of Bhaktapur District,Nepal. *Engineering Science and Technology:An International Journal (ESTIJ)*, *7*(1). https://www.researchgate.net/publication/319554841

Timsina, N. P. (2020). *Trend of urban growth in Nepal with a focus in Kathmandu Valley: A review of processes and drivers of change* (Issue August). www.tomorrowscities.org

Wang, L., & Yang, Z.-L. (2020). Changes in Land Use Influenced by Anthropogenic Activity. In *Oxford Research Encyclopedia of Environmental Science*. Oxford University Press. https://doi.org/10.1093/acrefore/9780199389414.013.37