Geo-spatial analysis on Socioeconomic mapping between Demographic data and Economic growth: A case study of Mumbai

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Abstract: ***Background: The Industrial Revolution and globalization spurred global economic growth, creating financial hubs like New York and London. India's post-independence focus on industrialization and 1991 liberalization fueled rapid growth in IT, manufacturing, and finance, with Mumbai emerging as a trade and investment hub. Maharashtra's robust industrial base and Mumbai's strategic coastal location, migration, and key institutions like the RBI and BSE cemented its status as India's financial capital.***
Aim: [3][4]To understand and evaluate GIS Mapping of Mumbai concerning economic growth and sustainability.
Objectives: To identify the financial zones in Mumbai using GIS Mapping, to analyze the literature and case studies in Mumbai using GIS, and to develop Maps for demographic data and economic growth of Mumbai.
Research question: RQ 1) What are the demographic characteristics of Mumbai? RQ 2) Why is Mumbai considered the financial capital of India in terms of economic growth?
Methods and results: With the use of ArcGIS Pro and census data (2011) in shape files and table data, we developed a suite of symbology maps to visually represent and analyze data patterns and growth trends.
Conclusion: Through ten literature reviews, the identified research gaps in Mumbai provided valuable insights into the city's financial growth. I utilized GIS tools to create maps that integrate demographic, GDP, and population data. These GIS maps reveal patterns that impact the planning and implementation of economic strategies in Mumbai. This research provides essential insights into spatial planning and financial management within the city, emphasizing how Mumbai's economic growth plays a crucial role in India's overall economic progress, effectively illustrated through the GIS visuals.
Limitations: This study focuses on demographic and economic spatial data due to limitations in data availability and time constraints. Future research on Mumbai could expand to include sustainable indicators such as environmental factors, technological advancements, and governance practices.

Keywords: GIS, geospatial data, mapping, spatial patterns, sustainability, socio-economy, demography, Mumbai, growth

I. Introduction

Mumbai's transformation into India's financial capital is a complex narrative shaped by historical events, geographical advantages, economic reforms, and sociocultural influences. The Industrial Revolution and globalization were crucial in driving global economic growth, which ultimately led to the rise of financial hubs around the world.

A. Historical Context

Colonial Legacy: Mumbai's journey began during the British colonial period, primarily due to its prime location on India's west coast and its deep natural harbor, which made it ideal for maritime trade. The British East India Company developed Mumbai into a major port and a hub for trade and commerce. A significant milestone in the city's financial development was the establishment of the Bombay Stock Exchange (BSE) in 1875, as it is Asia's oldest stock exchange and attracted numerous businesses and investors.

Post-Independence Growth: After India's independence in 1947, Mumbai continued to grow as a financial center, attracting a diverse population and fostering a dynamic, entrepreneurial spirit. In 1960, following the Samyukta Maharashtra Movement, Maharashtra was established with Mumbai as its capital city.

B. Economic Liberalization and Industrialization

Industrial Focus Post-independence, India focused on industrialization, choosing industries that produce basic and heavy industrial goods such as steel, chemicals, machines, tools, and locomotives.

1991 Liberalization The economic liberalization of 1991 catalyzed more comprehensive economic reforms, including liberalization and privatization. [9]These reforms led to rapid growth in the IT, manufacturing, and finance sectors. [5]Reforms in the 1990s and 2000s aimed to increase international competitiveness by reducing import tariffs, deregulating markets, and lowering taxes, which led to increased foreign investment and high economic growth.

II. Aim

This research paper aims to analyze the role of Geographic Information System (GIS) mapping in understanding and evaluating economic growth in Mumbai. As India's financial capital, Mumbai features a dynamic economic landscape shaped by urban expansion, infrastructure development, population density, land use patterns, transportation networks, and industrial growth. This research intends to explore how [7][13]GIS mapping tools can offer spatial insights into these economic factors, thereby facilitating data-driven decision-making for urban planning, policy development, and sustainable growth.

III. Objectives

A. To Identify Financial Zones.
GIS mapping can identify financial zones within Mumbai. These maps utilize data visualization to provide key insights.

B. To Analysis Literature and Case Study.
Geographic Information Systems (GIS) enhance the analysis of literature and case studies in Mumbai by generating base maps from various sources, including Google Earth, existing land use plans, and proposed land use plans. Historical maps and project drawings offer essential data that allow for before-and-after analyses. [8]For instance, when mapping the Vasai Virar region, we contrasted the current Development Plan with earlier topographical maps to understand changes in land use and the effects of planning policies.

C. To Develop Maps for Demographic Data and Economic Growth.

Demographic Data: Datasets from Mumbai can be utilized to map demographic information.

Economic Growth: [11]GIS mapping can analyze economic parameters to understand the distribution of economic growth. This includes mapping major zones, identifying urbanizable and green zones, and representing informal urbanization over time. By supporting key growth sectors and prioritizing infrastructure projects, GIS mapping aids in creating attractive residential environments and attracting a skilled workforce.

IV. Literature analysis

#	[1]	[2]	[3]
Title of the paper	Prediction of waterlogged zones under heavy rainfall conditions using machine learning and GIS tools: a case study of Mumbai	Prediction of Land Use and Land Cover Changes in Mumbai City, India, Using Remote Sensing Data and a Multilayer Perceptron Neural Network-Based Markov Chain Model Bhanage Vinayak 1,2 , Han Soo Lee 2,3,* and Shirishkumar Gedem 1	"Vulnerability Mapping for Disaster Assessment using ArcGIS Tools and techniques for Mumbai City, India" RESHMA RASKAR-PHULE1, DEEPANKAR CHOUDHURY
Journal Name and Publisher	Springer Nature link	MDPI	academia.edu
Month and Year of Publication	2023	2020	2015
Objectives of the Study / Research	To identify and map waterlogged zones in Mumbai under heavy rainfall conditions. To develop a predictive model for waterlogging using machine learning and GIS tools. To analyse the relationship between urban infrastructure, rainfall intensity, and waterlogging incidents. To provide insights for urban planning and disaster mitigation strategies.	To analyze the historical patterns of land use and land cover (LULC) changes in Mumbai city. To predict future LULC changes using a Multilayer Perceptron Neural Network (MLP-NN)-based Markov Chain model. To assess the impact of urbanization on Mumbai's ecological balance and infrastructure. To provide insights for sustainable urban planning and environmental management in the city.	To develop a vulnerability map for disaster assessment in Mumbai city using ArcGIS tools. To identify and analyze high-risk zones for natural and man-made disasters. To integrate spatial data with disaster vulnerability factors for effective risk analysis. To assist in planning and implementing disaster mitigation strategies for Mumbai.
Methodology adopted in the Study / Research	Data Collection, Preprocessing, Machine Learning, GIS Analysis	Data Collection, Data Preprocessing, Model Development, Validation	Data Collection, GIS-Based Mapping, Risk Assessment, Map Generation
Results of the Study / Research	Identification of high-risk waterlogging zones in Mumbai. Predictive accuracy of machine learning models achieved (e.g., 85% precision in predicting waterlogged areas). GIS tools visualized spatial patterns of waterlogging hotspots. Proposed preventive measures based on study findings	Significant LULC changes were observed, with increased urban expansion and decreased vegetation cover. The MLP-NN-based Markov Chain model provided accurate predictions for future LULC scenarios. Results highlighted high rates of urban sprawl in Mumbai by 2030, primarily at the expense of natural ecosystems. Spatial patterns of LULC changes were visualized effectively using GIS maps.	High-risk zones for floods, landslides, and infrastructure failures were identified in Mumbai. Vulnerability maps showed a strong correlation between hazard-prone areas and socio-economic factors such as population density and informal settlements. ArcGIS tools were effective in integrating diverse datasets and providing actionable visualizations for disaster risk management. The study recommended specific zones requiring immediate mitigation efforts.
Limitations of the Study / Research	Incomplete or inconsistent historical data on rainfall and waterlogging. Dependence on the quality of available GIS layers and satellite imagery. Limited to the case study area (Mumbai), which may restrict generalization to other regions. Computational limitations in processing large datasets.	Limited availability of high-resolution satellite imagery for historical analysis. Assumption of stationary transition probabilities in the Markov Chain model may oversimplify complex urban dynamics. The model does not account for external socio-economic or policy interventions. Computational complexity in training the MLP-NN for large datasets.	Lack of real-time data integration for dynamic disaster risk assessments. Limited resolution of spatial data, which may not capture micro-level vulnerabilities. Socio-economic and cultural aspects influencing disaster response were not fully incorporated. Dependence on historical data might limit applicability for unprecedented disaster scenarios.
Gaps Identified in the Study / Research	Lack of real-time predictive capability for ongoing rainfall events. Insufficient consideration of socio-economic impacts of waterlogging. Limited exploration of climate change-induced variability in rainfall patterns. Need for integration of IoT-based flood sensors for more accurate predictions.	Insufficient focus on integrating climate change and sea-level rise impacts into LULC predictions. Lack of detailed analysis of the socio-economic consequences of urbanization. Limited exploration of feedback mechanisms between LULC changes and environmental degradation. Need for real-time monitoring systems to complement the predictive model.	Need for incorporating real-time monitoring systems, such as IoT sensors, for continuous risk assessment. Limited focus on climate change-induced disaster risks like sea-level rise and urban heat islands. Insufficient attention to community preparedness and resilience-building measures. Lack of integration of advanced machine learning algorithms to improve predictive capabilities.
Remarks	The study provides a robust framework for predicting waterlogging in urban areas. Integration of IoT and real-time data sources is recommended for future research. Collaboration with urban planning authorities could enhance the applicability of the findings. Additional studies in other metro cities are suggested to validate the model's adaptability.	The study provides a valuable framework for predicting LULC changes in urban areas using advanced modeling techniques. Future studies should incorporate dynamic socio-economic and climate variables for more comprehensive predictions. The integration of high-resolution satellite data and real-time monitoring tools is recommended. The findings can inform policymakers and urban planners to promote sustainable development in Mumbai.	The study provides a valuable GIS-based framework for vulnerability mapping in urban areas. Future studies should focus on integrating real-time data and advanced technologies for more dynamic assessments. Collaboration with local governments and stakeholders can enhance the practical application of the findings. The approach can be replicated in other urban regions facing similar disaster risks for better disaster preparedness.

Table 1 Literature analysis table 1

#	[4]	[5]	[6]
Title of the paper	Air quality mapping using GIS and economic evaluation of health impact for Mumbai City, India	Mapping food vulnerability using an analytical hierarchy process (AHP) in the Metropolis of Mumbai	Remote sensing-based assessment of Coastal Regulation Zones in India: a case study of Mumbai, India Pennan Chinnasamy1,2 · Aashni Parikh3
Journal Name and Publisher	Journal of the Air & Waste Management Association	Springer Nature link	Springer Nature link
Month and Year of Publication	11 Apr 2016	2023	01-Sep-20
Objectives of the Study / Research	To assess and map air quality levels across Mumbai city using GIS tools. To identify critical areas with poor air quality and analyse spatial variations. To evaluate the economic impact of air pollution on public health in Mumbai. To provide actionable insights for policymakers to mitigate air pollution and associated health risks.	To identify and map food vulnerability across various regions in the metropolis of Mumbai. To analyse the spatial and socio-economic factors contributing to food insecurity. To prioritize areas for intervention using the Analytical Hierarchy Process (AHP). To provide a decision-making framework for policymakers to mitigate food vulnerability.	To assess Coastal Regulation Zones (CRZ) in Mumbai using remote sensing techniques. To analyse land use and land cover (LULC) changes in coastal areas and their compliance with CRZ regulations. To identify regions vulnerable to ecological degradation and urban encroachments in the coastal zones. To provide data-driven insights for better enforcement of CRZ norms and sustainable coastal management.
Methodology adopted in the Study / Research	Data Collection, GIS-Based Mapping, Health Impact Assessment, Economic Evaluation, Validation	Data Collection, Analytical Hierarchy Process (AHP), GIS-Based Mapping, Validation	Data Collection, Remote Sensing Analysis, GIS-Based Spatial Analysis, Change Detection, Validation
Results of the Study / Research	Air quality maps revealed critical hotspots, particularly in industrial zones and areas with high traffic density. Poor air quality was strongly correlated with increased cases of respiratory and cardiovascular diseases. The economic burden of health impacts due to air pollution was quantified, highlighting significant costs for healthcare and lost productivity. GIS-based mapping effectively visualized spatial variations in air quality and associated risks.	Food vulnerability maps highlighted critical areas with limited access to affordable and nutritious food, particularly in informal settlements. Economic factors like income disparities and unemployment had the highest weightage in contributing to food vulnerability. Geographic constraints, including poor connectivity to food markets, were also identified as significant contributors. The AHP-based mapping approach provided a clear visualization of food-insecure zones and priorities for policy intervention.	Significant LULC changes were observed in CRZ-II zones, primarily due to urban expansion and infrastructure development. Coastal areas designated as CRZ-I (ecologically sensitive zones) showed signs of encroachment and degradation. Mapping revealed a lack of compliance with CRZ regulations in several regions, particularly in areas with high population density and industrial activity. The study provided a visual representation of compliance and non-compliance zones, aiding enforcement efforts.
Limitations of the Study / Research	Lack of real-time air quality data, leading to reliance on historical records. Limited number of air quality monitoring stations, reducing the resolution of the analysis. Socio-economic disparities in health impact assessment were not fully considered. The study did not explore seasonal variations in air pollution levels.	Dependence on secondary data, which may not fully capture real-time dynamics of food access and supply. The accuracy of the AHP method is influenced by subjective weight assignments and expert judgments. Limited focus on temporal changes in food vulnerability, such as seasonal fluctuations in food supply. Socio-cultural factors influencing food access and preferences were not deeply explored.	Dependence on satellite imagery with limited resolution, which may not capture micro-level encroachments. Challenges in validating data due to restricted access to certain coastal areas for ground-truthing. The study did not fully account for the dynamic nature of coastal ecosystems, such as seasonal variations and tidal impacts. Socio-economic factors influencing CRZ violations were not deeply analysed.
Gaps Identified in the Study / Research	Insufficient focus on long-term health impacts and chronic diseases caused by air pollution. Limited exploration of mitigation strategies to reduce air pollution in critical areas. Lack of integration of predictive models to forecast air quality changes. Absence of community-level data on the socio-economic impact of air pollution.	Lack of integration of climate change impacts (e.g., flooding or drought) on food supply chains. Insufficient attention to community-led initiatives and informal food distribution networks. Limited exploration of the role of policy measures in alleviating food insecurity in the identified zones. Absence of predictive modelling to forecast future food vulnerability scenarios.	Limited integration of socio-economic and legal frameworks in the analysis of CRZ violations. Insufficient attention to climate change impacts (e.g., sea-level rise, storm surges) on CRZ zones. Absence of community participation in assessing the impacts of CRZ regulations. Lack of predictive modelling to forecast future trends in CRZ violations and coastal degradation.
Remarks	The study highlights the importance of GIS tools for spatial analysis of air quality and its health impacts. Policymakers should prioritize mitigation efforts in identified hotspots and implement stricter emission controls. Future studies should incorporate real-time air quality monitoring and predictive modelling for better insights. Collaboration with healthcare agencies and urban planners is essential to address air pollution and its health effects holistically.	The study effectively combines AHP and GIS tools to map food vulnerability and prioritize interventions. Policymakers can use these insights to design targeted programs for improving food access and reducing inequalities. Future research should incorporate real-time data, predictive models, and socio-cultural dimensions for a more holistic understanding. Collaboration with local communities and stakeholders is essential to develop sustainable food security solutions for Mumbai.	The study demonstrates the effectiveness of remote sensing and GIS tools for monitoring CRZ compliance and coastal management. Policymakers should use the insights to strengthen enforcement of CRZ regulations and promote sustainable development in coastal areas. Future research should incorporate higher-resolution satellite imagery, climate models, and socio-economic data for a more comprehensive analysis. Collaboration between government, researchers, and local communities is crucial to address CRZ violations and protect coastal ecosystems.

Table 2 Literature analysis table 2

#	[7]	[8]	[9]	[10]
Title of the paper	GIS-Based Multi-Objective Urban Land Allocation Approach for Optimal Allocation of Urban Land Uses Sarika Bodhankar1 • Kshama Gupta2 • Pramod Kumar2 • S. K. Srivastav2	Geospatial Analysis to Understand the Linkage Between Urban Sprawl and Temperature of a Region: Micro- and Meso-Scale Study of Mumbai City	Land use change mapping and its impact on storm water runoff using Remote sensing and GIS: a case study of Mumbai, India	Contentions of affordability in the habitat planning of a new town: a case of Navi Mumbai, India Bhagyasshree Ramakrishna and Shruthi Ramesh
Journal Name and Publisher	Springer Nature link	Springer Nature link	Purpose Led Publishing	Open Edition Journals
Month and Year of Publication	16-Jan-22	27-Apr-21	2020	2023
Objectives of the Study / Research	To develop a GIS-based multi-objective approach for optimal allocation of urban land uses. To address competing demands for land resources, balancing socio-economic and environmental priorities. To design an urban land allocation framework that maximizes efficiency while minimizing conflicts among different land uses. To provide a decision-making tool for urban planners to allocate land uses in a sustainable and data-driven manner.	To analyse the relationship between urban sprawl and temperature variations in Mumbai at micro- and meso-scales. To study the impact of urban expansion on local and regional temperature patterns using geospatial tools. To identify areas most affected by urban sprawl-induced temperature rise, commonly referred to as the Urban Heat Island (UHI) effect. To provide actionable insights for urban planners to mitigate the adverse thermal impacts of urban sprawl.	To map and analyse land use and land cover (LULC) changes in Mumbai over time using remote sensing data. To assess the impact of LULC changes on stormwater runoff patterns and flooding risks. To identify high-risk areas prone to stormwater runoff-related flooding. To propose sustainable urban planning and land management strategies to mitigate flooding risks.	To examine the affordability challenges in habitat planning for Navi Mumbai as a new town. To analyse how habitat planning impacts housing affordability for diverse socio-economic groups. To evaluate the effectiveness of current planning strategies in achieving affordable housing goals. To provide recommendations for sustainable and inclusive urban planning in Navi Mumbai.
Methodology adopted in the Study / Research	Data Collection, Multi-Objective Decision Making, GIS Integration, Optimization Approach, Validation	Data Collection, Geospatial Analysis, Micro- and Meso-Scale Study, Urban Sprawl Assessment, Validation	Data Collection, LULC Mapping, Runoff Estimation, Impact Assessment, Validation	Data Collection, Affordability Analysis, Stakeholder Engagement, Comparative Study, Spatial Analysis
Results of the Study / Research	The GIS-based multi-objective approach successfully allocated urban land uses based on predefined priorities. The model reduced conflicts among land uses by integrating environmental, economic, and social factors. Spatial outputs highlighted areas suitable for specific land uses, such as high-density housing, commercial hubs, and green spaces. The approach provided planners with a practical tool for sustainable urban development.	Urban sprawl in Mumbai significantly contributes to the Urban Heat Island (UHI) effect, with higher temperatures observed in densely built-up areas. Vegetated and water-covered regions showed relatively lower temperatures, emphasizing the role of green and blue spaces in mitigating heat. Micro-scale analysis revealed hotspots within central urban areas, while meso-scale analysis indicated a regional temperature gradient influenced by urbanization. Findings highlighted the rapid urban expansion in Mumbai and its adverse impact on thermal comfort and local climate.	Significant increase in impervious surfaces (e.g., built-up areas) due to rapid urbanization in Mumbai over the study period. Reduction in vegetative cover and natural water infiltration zones led to increased stormwater runoff. High-risk flooding zones were identified in areas with dense urban development and inadequate drainage infrastructure. The study demonstrated a strong correlation between LULC changes and stormwater runoff intensification.	Navi Mumbai's habitat planning has led to the creation of modern infrastructure but failed to address affordability for lower-income groups effectively. A mismatch exists between the supply of affordable housing and the demand from economically weaker sections (EWS) and low-income groups (LIG). High land costs and development policies favouring middle- and high-income housing exacerbate affordability issues. Affordable housing projects are often located in peripheral areas, resulting in limited accessibility to jobs and amenities for lower-income residents.
Limitations of the Study / Research	The optimization framework relies heavily on the accuracy and availability of input data, which may be incomplete or outdated. Socio-political factors influencing land allocation decisions were not included in the model. Computational intensity of the multi-objective optimization algorithms may limit their applicability for large datasets or regions. The approach does not account for dynamic changes in land use demand over time.	Dependence on satellite imagery with limited temporal resolution may not capture short-term temperature variations. Micro-scale temperature variations within individual neighbourhoods or streets may be underestimated due to spatial resolution constraints. The study did not factor in other contributors to temperature rise, such as industrial emissions and vehicular pollution. Lack of consideration of socio-economic factors influencing urban sprawl and temperature dynamics.	Reliance on satellite imagery with moderate spatial resolution may not capture detailed changes in smaller land parcels. The study assumes uniform rainfall distribution, which may not reflect localized rainfall variability. Lack of integration of socio-economic factors such as population density and urban growth projections. Limited temporal scope of the analysis may not account for long-term trends in LULC changes and their impacts.	Limited primary data collection due to time and resource constraints; the study relied heavily on secondary data. Focused primarily on housing affordability, without addressing affordability in transportation or other essential services. Lack of long-term evaluation of the outcomes of affordable housing policies in Navi Mumbai. Did not account for the informal housing sector, which plays a significant role in meeting housing needs for lower-income groups.
Gaps Identified in the Study / Research	Insufficient exploration of real-time urban dynamics, such as migration patterns and economic shifts, in land use allocation. Limited focus on integrating public participation in the decision-making process. Absence of predictive modelling to forecast long-term implications of land allocation decisions. Need for further testing of the model across different urban contexts to assess its scalability and adaptability.	Insufficient exploration of mitigation strategies for reducing the UHI effect in urban areas. Limited integration of real-time monitoring systems for dynamic temperature assessments. Lack of focus on the role of urban design elements (e.g., building orientation, materials) in influencing temperature variations. Absence of long-term predictive modelling to assess future temperature impacts due to urban sprawl.	Insufficient exploration of climate change effects on rainfall intensity and its impact on stormwater runoff. Lack of focus on sustainable urban drainage systems (SUDS) or green infrastructure solutions to mitigate flooding. Limited consideration of real-time monitoring tools for stormwater management. Absence of community engagement in identifying and addressing urban flooding challenges.	Insufficient analysis of the environmental sustainability of affordable housing projects. Lack of integration of community participation in planning and decision-making processes. Limited exploration of public-private partnerships and innovative financing models for affordable housing. Absence of detailed studies on the role of rental housing in addressing affordability issues.
Remarks	The study demonstrates the potential of GIS-based tools for solving complex urban planning challenges through multi-objective optimization. Policymakers can use the framework to make informed decisions and ensure equitable and sustainable urban growth. Future research should include dynamic models, public engagement, and advanced computational techniques to enhance the robustness of the approach. Collaboration between urban planners, data scientists, and policymakers is critical for practical implementation.	The study effectively highlights the linkage between urban sprawl and temperature variations, providing valuable insights for urban planning. Policymakers should prioritize green infrastructure and sustainable urban development to mitigate UHI effects. Future research should incorporate high-resolution data, real-time monitoring, and predictive models for more comprehensive analysis. A multidisciplinary approach involving urban planners, climatologists, and ecologists is crucial for addressing urban thermal challenges.	The study provides valuable insights into the relationship between land use changes and stormwater runoff, aiding urban planning and flood risk management. Policymakers should prioritize sustainable land use planning, green infrastructure, and improved drainage systems to mitigate flooding risks. Future research should include climate models, real-time monitoring, and community-based solutions for more comprehensive flood management strategies. Collaboration among urban planners, hydrologists, and policymakers is essential to address Mumbai's flooding challenges effectively.	The study provides critical insights into the affordability challenges in Navi Mumbai's habitat planning, highlighting the need for more inclusive strategies. Policymakers must focus on balancing affordability with accessibility to ensure that lower-income groups are not marginalized. Future research should explore innovative models for affordable housing, including rental housing and community-led housing solutions. Collaboration between the government, private developers, and civil society is essential to create sustainable and affordable urban environments.

Table 4 Literature analysis table 3

SNo	Title of the Paper	GIS mapping	Spatial patterns	Socio-Economy	Demography	Uderstanding of Mumbai	Smart Cities
[1]	Prediction of waterlogged zones under heavy rainfall conditions using machine learning and GIS tools: a case study of Mumbai	✓					
[2]	Prediction of Land Use and Land Cover Changes in Mumbai City, India, Using Remote Sensing Data and a Multilayer Perceptron Neural Network-Based Markov Chain Model Bhanage Vinayak 1,2 , Han Soo Lee 2,3,* and Shirishkumar Gedem 1		✓		✓		✓
[3]	"Vulnerability Mapping for Disaster Assessment using ArcGIS Tools and techniques for Mumbai City, India" RESHMA RASKAR-PHULE1, DEEPANKAR CHOUDHURY	✓				✓	
[4]	Air quality mapping using GIS and economic evaluation of health impact for Mumbai City, India	✓				✓	
[5]	Mapping food vulnerability using an analytical hierarchy process (AHP) in the Metropolis of Mumbai	✓				✓	
[6]	Remote sensing-based assessment of Coastal Regulation Zones in India: a case study of Mumbai, India Pennan Chinnasamy1,2 · Aashni Parikh3					✓	✓
[7]	GIS-Based Multi-Objective Urban Land Allocation Approach for Optimal Allocation of Urban Land Uses Sarika Bodhankar1 • Kshama Gupta2 • Pramod Kumar2 • S. K. Srivastav2	✓					
[8]	Geospatial Analysis to Understand the Linkage Between Urban Sprawl and Temperature of a Region: Micro- and Meso-Scale Study of Mumbai City		✓			✓	
[9]	Land use change mapping and its impact on storm water runoff using Remote sensing and GIS: a case study of Mumbai, India		✓				
[10]	Contentions of affordability in the habitat planning of a new town: a case of Navi Mumbai, India Bhagyasshree Ramakrishna and Shruthi Ramesh				✓	✓	✓
[11]	Linking remotely sensed Urban Green Space (UGS) distribution patterns and Socio-Economic Status (SES)- A multi-scale probabilistic analysis based in Mumbai, India		✓	✓		✓	

Table 5 Taxonomy of literature analysis

V. Research questions

RQ 1) What are the demographic characteristics of Mumbai?

Mumbai, the capital of Maharashtra, is India's most populous city, with an estimated population of over 20 million. It is a highly diverse metropolis with a mix of ethnicities, languages, and religious communities. [6]The city's

population density is among the highest in the world, and it continues to grow due to migration from various parts of India. Mumbai's literacy rate is above 85%, and its workforce is engaged in a wide range of industries, including finance, entertainment, manufacturing, and services.

RQ 2) Why is Mumbai considered the financial capital of India in terms of economic growth?

Mumbai is regarded as India's financial capital due to its strong economic foundation, hosting key financial institutions such as the Reserve Bank of India (RBI), the Bombay Stock Exchange (BSE), and the National Stock Exchange (NSE). The city contributes significantly to India's GDP, with thriving industries in banking, finance, trade, real estate, and entertainment. [10]Additionally, Mumbai is home to the headquarters of numerous multinational corporations and leading Indian business conglomerates, driving investment and economic expansion. Its well-established infrastructure and global connectivity further solidify its status as an economic powerhouse.

VI. Methodology

A. Data Collection

Gathered census data (2011) in tabular format.
Obtained shapefiles for Mumbai’s administrative boundaries.

B. Data Processing in ArcGIS Pro

Imported shapefiles and table data into ArcGIS Pro.
Geospatial joins were used to link census data with spatial boundaries.

C. Map Creation and Visualization

Developed symbology maps using various visualization techniques:

- Choropleth maps (color-coded representations of population density, literacy rate, etc.)
- Graduated symbols (for economic activity, employment rates, etc.)
- Heat-maps ([1]to identify high-density and low-density areas)

D. Analysis and Interpretation

- [2]Identified spatial patterns of population growth and migration trends.
- Assessed the correlation between demographic data and urban expansion.
- Compared to different wards/localities for insights into infrastructure development needs.

E. Results

- The analysis revealed growth trends in suburban regions.
- High-density clusters were found in specific areas due to migration.
- Uneven distribution of resources and amenities was noted across different zones.

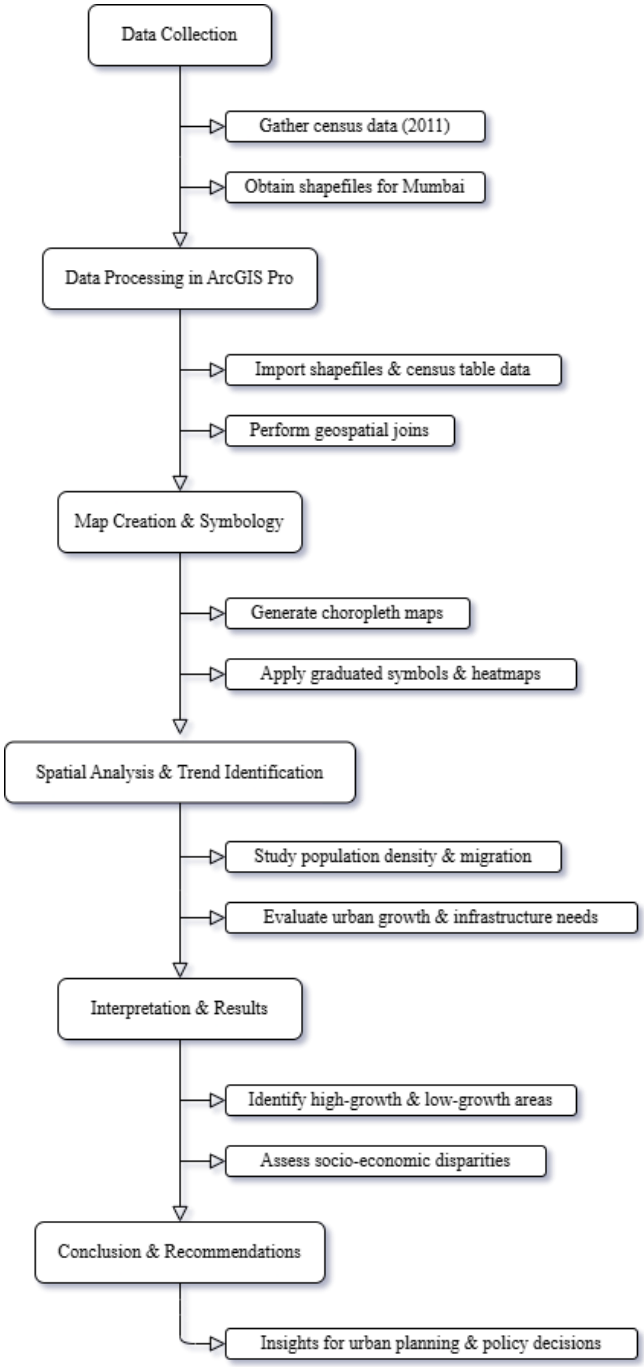

Figure 1 methodology chart

VII. Spatial Understanding

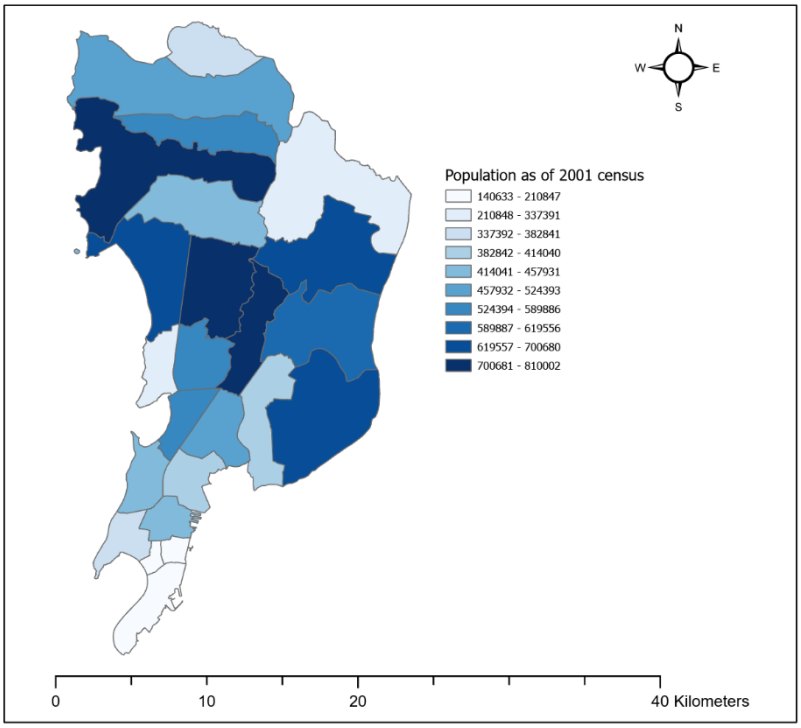

Figure 3 Ward wise population as of 2001

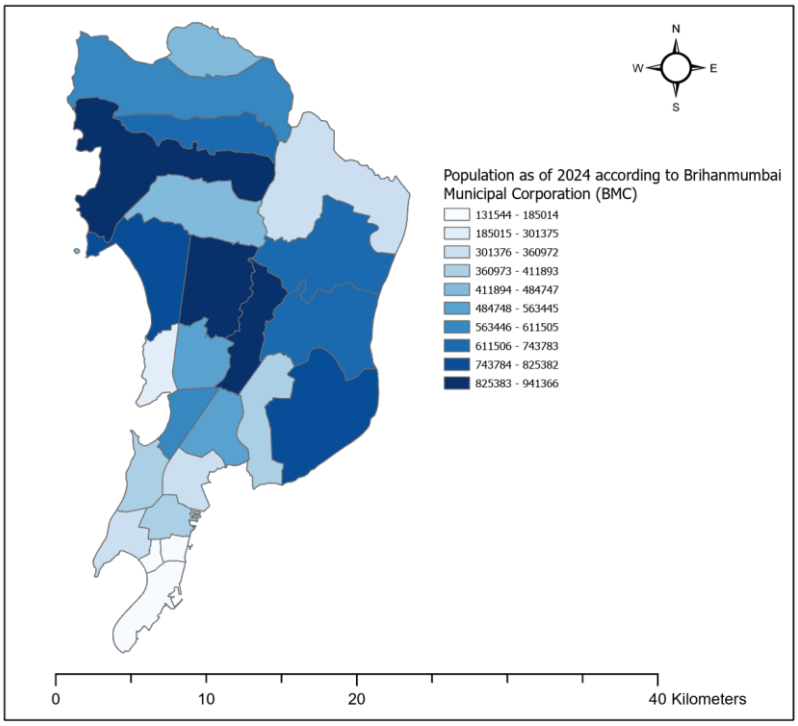

Figure 2 Population as of 2024 according to Brihanmumbai Municipal Corporation (BMC)

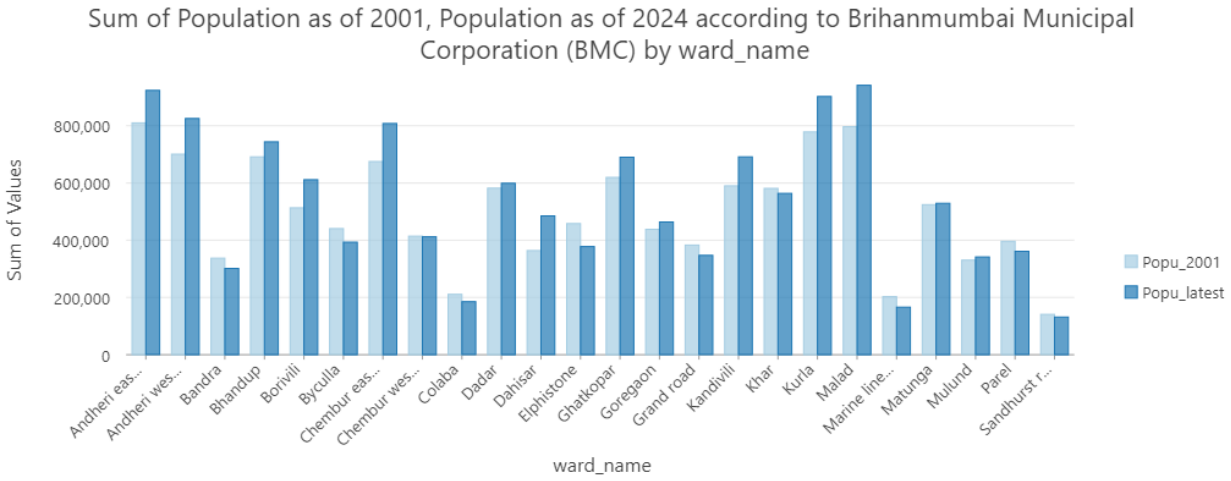

Figure 4 Bar chart showing population data

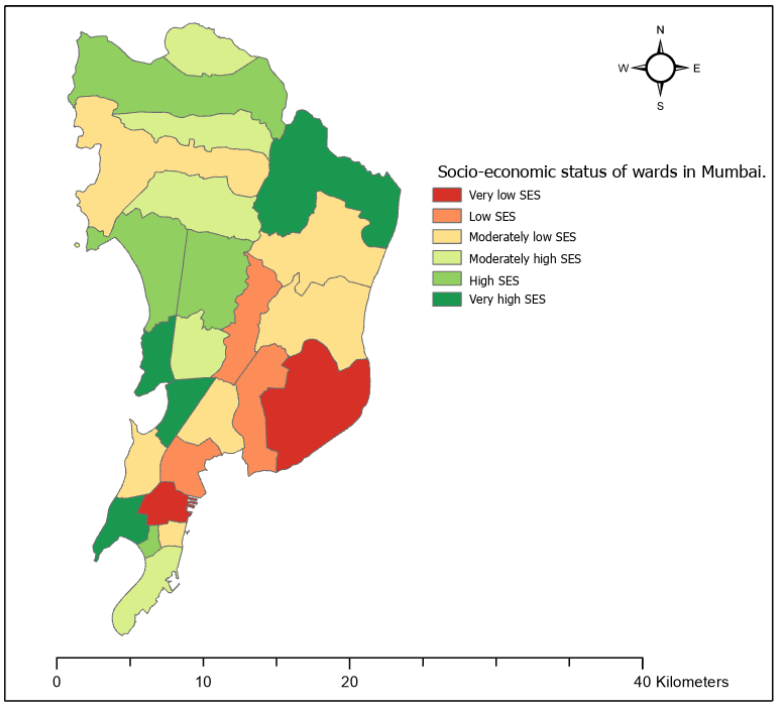

Figure 5 Socio-economic status of wards in Mumbai

VIII. Key Factors Contributing to Mumbai's Status

A. Strategic Location: Mumbai's coastal location on the Arabian Sea has been pivotal in facilitating trade and commerce since the era of the British East India Company.

B. Financial Institutions: The establishment of key financial institutions such as the Reserve Bank of India (RBI) and the Bombay Stock Exchange (BSE) has been instrumental in Mumbai's economic prominence. The BSE, founded in 1875, is Asia's oldest stock exchange and one of the largest globally by market capitalization.

C. Corporate Presence and Skilled Workforce: Mumbai's cosmopolitan culture and skilled workforce have attracted major businesses, banking institutions, and the Bollywood film industry, contributing to its financial prowess.

D. Trade and Investment Hub: Mumbai has emerged as a significant trade and investment hub, attracting merchants, traders, and entrepreneurs. By 1914, almost 50% of private investments in India were being made in Mumbai, and A total of 87% of the capital investment was directed towards the city.

E. Maharashtra's Industrial Base: Maharashtra's robust industrial base has provided a strong foundation for Mumbai's economic success. Mumbai was one of the earliest cities in India to be industrialized and emerged as the centre of a strong organized labor movement.

Mumbai's journey to becoming India's financial capital is a testament to its resilience, adaptability, and entrepreneurial spirit, enabling it to drive the Indian economy. The city's ability to attract investment, talent, and businesses has created a vibrant and dynamic financial ecosystem.

IX. Limitations

This study's focus on demographic and economic spatial data provides a foundation for understanding Mumbai's financial growth, but it acknowledges limitations due to data and time constraints. Here's a breakdown of these limitations and potential avenues for future research:

A. Limitations of the Current Study:

- Limited Scope: The study is restricted to demographic and economic spatial data, which provides a partial view of Mumbai's complex urban dynamics.
- Data Availability: Constraints in data availability limit the scope of the analysis.
- Time Constraints: Time limitations restricted the depth and breadth of the research.

B. Potential Areas for Future Research:

- Sustainable Indicators: Future research could expand to include sustainable indicators such as environmental factors, technological advancements, and governance practices.
    - Environmental Factors: [16]Investigating environmental factors (e.g., pollution levels, green spaces, waste management) can provide insights into the sustainability of Mumbai's growth.
    - Technological Advancements: [14][15]analysing the impact of technological advancements (e.g., digital infrastructure, smart city initiatives) can reveal opportunities for innovation and efficiency.
    - Governance Practices: Examining governance practices (e.g., urban planning, policy implementation, public participation) can help assess the effectiveness of strategies for managing urban growth and promoting equitable development.

By addressing these limitations and exploring these areas for future research, a more comprehensive understanding of Mumbai's financial growth and its implications for sustainable urban development can be achieved.

X. Conclusion

In conclusion, a review of ten sources has identified research gaps in Mumbai, offering valuable insights into the city's financial growth. By utilizing GIS tools and census data, maps were created that incorporate demographic, GDP, and population data. These GIS maps visually illustrate patterns that influence the planning and execution of economic strategies in Mumbai. The research provides key insights into spatial planning and financial

management in the city, effectively demonstrating how Mumbai's economic growth acts as a significant driver of India's overall economic progress through GIS visuals.

Mumbai's status as India's financial center is bolstered by the presence of key institutions such as the Reserve Bank of India and the Bombay Stock Exchange. The city attracts a large influx of talent, industry, and investment, which solidifies its financial position. However, Mumbai also faces challenges that impact its economic growth and competitiveness. High real estate costs—driven by exorbitant premiums and approval charges—create socioeconomic issues like unaffordable housing and talent out-migration. Additionally, these high costs affect commercial real estate, making Mumbai the most expensive city in India for flexible office space. Such factors can deter investment and potentially lead to economic stagnation.

Despite these challenges, Mumbai's economy is substantial, with a GDP exceeding $100 billion, contributing significantly to Maharashtra's overall economic output. The government aims to increase this output to over $300 billion by 2030. Mumbai continues to attract foreign investment in its real estate sector, indicating its ongoing appeal to investors. Furthermore, the World Bank is supporting Maharashtra's efforts to stimulate economic growth across the state, including in Mumbai, by enhancing the capacity of district administrations to identify growth opportunities and facilitate private sector participation. Diversifying Mumbai's economic base and improving the quality of human capital through education are essential for ensuring good employment and entrepreneurial prospects for its citizens.

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