

URBAN SPRAWL AND ITS IMPACT ON AGRICULTURAL LAND, VEGETATION AND WATER BODIES: A GIS AND REMOTE SENSING BASED ANALYSIS OF MULTAN TEHSIL, PAKISTAN (2000-2020)

Muhammad Mazhar¹, Noor Hussain², Ubaidullah Machhi³, Naveed Noor⁴

¹Senior Staff Lecturer, F.F.C Grammer School & College Mirpur Mathelo

²Department of Geography, Shah Abdul Latif University, Khairpur

³Assistant Professor, Government Boys Degree College Nawabshah

⁴PhD research Scholar, Department of Geography, Shah Abdul Latif University, Khairpur

Corresponding Author: *

Muhammad Mazhar

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ABSTRACT

Urban sprawl is a significant driver of agricultural land loss and environmental degradation in rapidly growing cities. This study evaluates the impact of urban expansion on mango orchards, vegetation cover and water bodies in Multan Tehsil, Pakistan, between 2000 and 2020, using Geographic Information Systems (GIS), remote sensing and socio-economic surveys. Multi temporal Landsat imagery was analyzed through supervised classification and post classification comparison to quantify land use and land cover (LULC) changes, while structured questionnaires and interviews captured socio economic drivers of orchard conversion. Results indicate that mango orchards declined from 301.68 km² in 2000 to 158.61 km² in 2020, while built-up areas expanded from 59.73 km² to 207.10 km². Survey findings show that 51% of orchard owners sold land due to lucrative economic offers and 37% cited the desire for improved residential environments. Other factors driving urban expansion include infrastructure development, low land prices and employment opportunities. Despite awareness of orchard loss, 66% of respondents expressed satisfaction with urban development, highlighting a socio environmental trade off. Declines in water bodies and vegetation cover further indicate ecological pressures associated with unplanned urbanization. The study demonstrates that urban sprawl in Multan is largely economically and spatially driven, with market incentives outweighing agricultural considerations. Although mango production initially remained stable due to intensification, continued orchard loss poses long term risks to food security, rural livelihoods and environmental sustainability. These findings underscore the need for integrated urban planning, regulatory enforcement and sustainable orchard management to balance development with agricultural preservation, providing evidence-based guidance for policymakers in similar developing regions.

Keywords: Urban sprawl, Mango orchards, Land use change, GIS, Multan, Agricultural sustainability

1. INTRODUCTION

Urban sprawl has emerged as one of the most critical challenges associated with contemporary urbanization. Unlike compact and planned urban growth, sprawl is characterized by low density, dispersed and often unregulated expansion of urban areas into surrounding rural landscapes (Chin, 2002; Ewing, 2008; Pendall, 1999). This form of growth places immense pressure on natural

and agricultural resources, leading to long term environmental and socio-economic consequences. As cities expand outward, productive agricultural land, vegetation cover and water bodies are increasingly converted into built up areas, threatening food security, ecological balance and sustainable development (Habibi et al., 2011; McKinney et al., 2002). Globally, urban sprawl has

intensified with rapid population growth, rising incomes, improved transportation systems and changing lifestyle preferences (Roser, 2018; Ritchie, 2019). While urbanization can generate economic opportunities and improve access to services, uncontrolled sprawl often results in inefficient land use, environmental degradation and loss of ecosystem services (Gordon et al., 2020). The pace of land consumption in many cities has exceeded population growth, leading to low density expansion and fragmented landscapes (Glaser et al., 2021). In developing countries, where agriculture remains central to livelihoods and national economies, the conversion of fertile agricultural land and natural vegetation is particularly concerning.

Agricultural land plays a crucial role in ensuring food security and sustaining rural economies. However, urban sprawl frequently targets peri urban areas that are naturally fertile and well irrigated (Habibi et al., 2011). Similarly, vegetation cover and water bodies are essential for regulating microclimates, supporting biodiversity and maintaining hydrological cycles. The loss of these resources due to urban expansion can exacerbate environmental problems such as urban heat islands, water scarcity, flooding and ecological degradation (McKinney et al., 2002). Studies from rapidly growing cities such as Beijing demonstrate how urban expansion leads to large scale transformation of rural land into industrial, commercial and residential uses (Lei, 2017). Such patterns are increasingly visible in South Asian cities.

Pakistan is experiencing rapid urban growth accompanied by widespread urban sprawl. According to the Population Census, 38.82% of the population resides in urban areas, and this proportion is expected to increase significantly (Census, 2023). Weak enforcement of land use regulations, speculative real estate development and population pressure have accelerated the conversion of non-urban land into residential and commercial uses. Theoretical perspectives such as *The Limits to Growth* highlight how rapid population expansion and economic growth place pressure on natural resources, including fertile land and food production systems (Meadows, 2017). Despite the significance of this issue, empirical studies quantifying the environmental impacts of urban sprawl in Pakistan remain limited.

Multan Tehsil provides a compelling case for examining the impacts of urban sprawl on land resources. Known as the “City of Mango,” Multan is situated on a fertile alluvial plain along the Chenab River and is supported by an extensive irrigation network. The region is renowned for its agricultural productivity, particularly mango orchards, which contribute significantly to local livelihoods and export earnings (Raza et al., 2023). However, recent reports indicate that thousands of acres of mango orchards have been cleared for housing schemes and infrastructure development. This rapid land transformation reflects broader patterns of peri urban expansion driven by housing demand, private residential schemes and road network development.

Remote Sensing and Geographic Information Systems (GIS) provide effective tools for assessing the impacts of urban sprawl on environmental resources over time. Multi temporal satellite imagery allows the identification and quantification of land use and land cover changes, offering objective and spatially explicit evidence of land transformation. Such spatial analysis is essential for understanding the magnitude, pattern and spatial distribution of sprawl induced impacts. This study aims to evaluate the impact of urban sprawl on agricultural land, vegetation cover and water bodies in Multan Tehsil between 2000 and 2020 using GIS and Remote Sensing techniques. By analyzing land cover changes across multiple time periods, the study quantifies resource loss and examines the relationship between urban expansion and environmental degradation. The research highlights how unplanned urban growth has reshaped the landscape and reduced critical natural and agricultural assets.

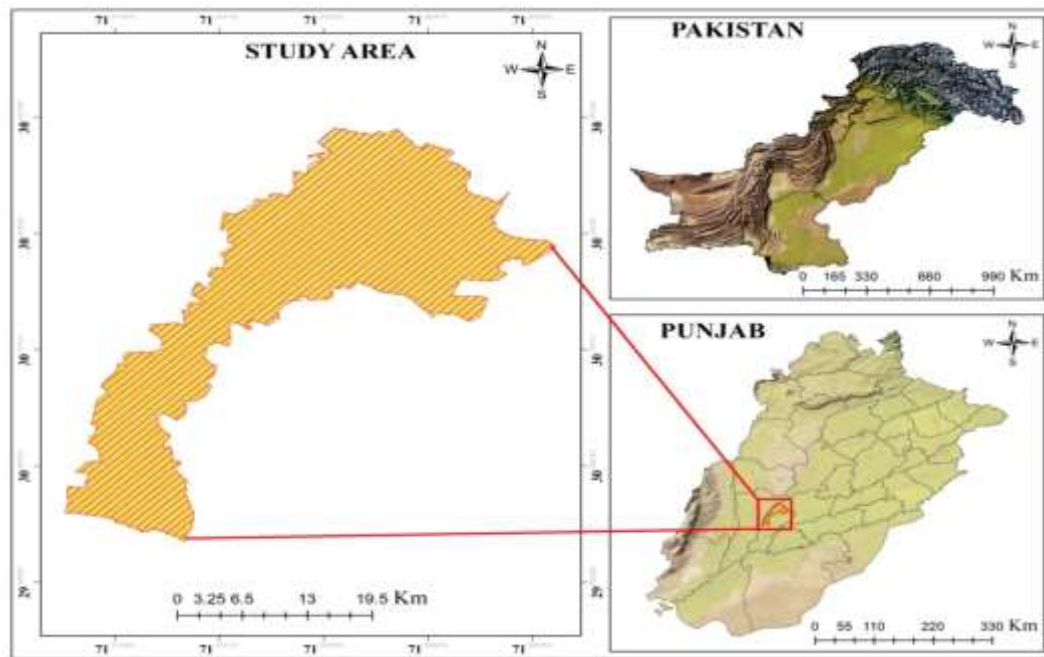


Figure 1 Location Map of Study Area

Aims and Objectives

To assess the impact of urban sprawl on agricultural land, vegetation cover and water bodies in Multan Tehsil between 2000 and 2020 using GIS and Remote Sensing techniques.

1. To quantify changes in agricultural land, vegetation cover and water bodies in Multan Tehsil over the period 2000-2020.
2. To examine the spatial and temporal relationship between urban sprawl and environmental resource conversion, identifying high impact zones where urban expansion has significantly reduced productive agricultural land and natural resources.
3. To analyze the spatial relationship between urban sprawl and the conversion of agricultural and natural land resources.

2. LITERATURE REVIEW

Urban sprawl is widely recognized as one of the most significant drivers of agricultural land conversion and environmental degradation worldwide. The term refers to the unplanned and often chaotic outward expansion of urban areas into surrounding rural and peri urban landscapes. According to the Oxford English Dictionary, urban sprawl is defined as the uncontrolled and unpleasant extension of urban development into the countryside. Scholars such as Jan Brueckner (2000) describe sprawl as excessive spatial growth of cities, while Anthony Downs (2008) characterizes it by low density settlements, leapfrog

development, automobile dependency and fragmented land use governance. Similarly, Reid Ewing (2008) links urban sprawl to population growth, income rise, declining land values at urban fringes and transport accessibility.

The outward expansion of cities often results in the irreversible loss of fertile agricultural land, natural vegetation and surface water resources. According to Eko A.J (2012) projected that between 1.8% and 2.4% of global arable land would be lost to urban growth by 2030, with nearly 80% of this loss occurring in Asia and Africa. In these regions, rapid urbanization threatens long term food production systems by reducing cultivable land and intensifying pressure on remaining agricultural resources. In China, where food security concerns are prominent, Zhong T. Y. et al. (2022) found that agricultural land and orchard losses were more pronounced in regions with higher economic activity and approved Special Economic Zones (SEZs). Although the total percentage loss appeared modest, the rate of conversion has steadily increased since 2005, signaling long term risks to agricultural sustainability. Urban sprawl has particularly severe implications for high value agricultural lands such as orchards. Pro rural perspectives argue that conversion of fertile farmland and fruit orchards reduces agricultural employment, weakens irrigation investment and increases food insecurity (Husnain, 2018). Once agricultural land is converted into built up areas, the transformation is largely irreversible

(Rosenberger et al., 2002). Studies in South Asia indicate that agricultural land conversion is accelerating in response to demographic pressure and economic transformation (Magsi & Torre, 2014; Mazhar & Jamal, 2009).

Vegetation loss represents another critical environmental consequence of urban expansion. Land use changes significantly alter ecosystem functions and services, including biodiversity conservation, carbon sequestration and microclimate regulation (Lindenmayer & Fischer, 2006).

In Pakistan, agriculture remains a cornerstone of the national economy, contributing approximately 21% to GDP and employing nearly 45% of the labor force (GoP, 2012). The country possesses approximately 24.44% of its land under cultivation, underscoring the strategic importance of preserving fertile land. Nevertheless, rapid urbanization driven by population growth and rural-to-urban migration has intensified pressure on agricultural areas (PBS, 2017). The urban population increased from 32.5% in 1998 to 36.38% in 2017 and 38.82% in 2023, with major cities experiencing substantial expansion.

Multan, located in southern Punjab, represents a critical case study due to its extensive mango orchards and fertile alluvial plains. Mango (*Mangifera indica* L.), commonly known as the “king of fruits,” is among Pakistan’s most important horticultural crops and export commodities (Rajwana et al., 2010; Reddy et al., 2018). Southern Punjab districts including Multan, Rahim Yar Khan, and Bahawalpur are central to national mango production. However, urban expansion in Multan has significantly reduced vegetation cover and agricultural land. Akram M. et al. (2018) documented substantial urban growth in Multan between 1987 and 2013, resulting in nearly 97 km² reduction in vegetation cover. Population growth has been identified as a primary driver of this expansion (PBS, 2017). The shift of labor from agriculture to industrial and service sectors further accelerates farmland conversion (Deng et al., 2015). As agricultural profitability declines relative to urban land value, farmers are increasingly inclined to sell land for residential colonies and commercial developments (Ghaffar, 2016). This process not only undermines local food production but also threatens rural livelihoods and increases dependency on external food sources.

Remote Sensing and Geographic Information Systems (GIS) have emerged as powerful tools for assessing land use and land cover dynamics associated with urban sprawl. Multi temporal satellite imagery enables accurate quantification of changes in agricultural land, vegetation cover and water bodies over time. Such spatial analyses are essential for identifying high impact zones and guiding sustainable land use planning (Netzband et al., 2015). Studies conducted in Iran and other regions have demonstrated the effectiveness of GIS based approaches in measuring sprawl intensity and environmental impacts (Ibrahim et al., 2011). Despite growing awareness of these issues, empirical studies focusing on the environmental impacts of urban sprawl in medium sized Pakistani cities remain limited. There is a particular lack of research addressing orchard loss and water resource degradation in rapidly expanding urban areas. This study addresses these gaps by examining the impact of urban sprawl on agricultural land, vegetation and water bodies in Multan Tehsil from 2000 to 2020, providing evidence-based insights for sustainable land-use planning and environmental conservation.

3. RESEARCH METHODOLOGY

3.1 RESEARCH DESIGN

This study employs a mixed methods approach integrating quantitative geospatial analysis with primary socio-economic data to assess the impact of urban sprawl on agricultural land, vegetation particularly mango orchards and water bodies in Multan Tehsil from 2000 to 2020. The quantitative component measures land use/land cover (LULC) change using multi-temporal satellite imagery, while the qualitative component examines socio-economic drivers of orchard conversion and peri urban expansion.

3.2 Data Collection

Primary Data

Primary data were collected through a structured questionnaire survey and semi-structured interviews. A random sampling technique was applied in mango orchard dominated peri-urban mouzas of Multan Tehsil. A total of 207 questionnaires were completed in areas including Kachor, Sultanpur Hamar, Muhammad Pur, Tara Garh, Baqir Abad, Band Bosan and Buch Villas.

The questionnaire focused on:

- a) Causes of orchard conversion

- b) Land ownership transitions
- c) Economic motivations
- d) Perceptions of urban expansion

Survey responses were analyzed using descriptive statistics in SPSS.

Secondary Data

Secondary data were obtained from:

- a) District Agriculture Department
- b) Mango Research Institute Multan
- c) Land Revenue Department
- d) Pakistan Agriculture Statistics
- e) Multan Development Authority (MDA)

Multi-temporal Landsat satellite imagery (30 m spatial resolution) for the years 2000, 2005, 2010, 2015 and 2020 was acquired from the USGS database.

3.3 Geospatial Data Processing

Image Pre processing

Satellite images were subjected to radiometric and atmospheric correction in ERDAS IMAGINE to enhance spectral consistency across years. Cloud-free images with comparable seasonal timing were selected to minimize phenological variation. The Area of Interest (AOI) was delineated using administrative boundaries of Multan Tehsil, and images were subset accordingly.

Land Use/Land Cover Classification

A supervised classification approach was employed to generate LULC maps for each study year. Training samples were selected using field knowledge and high-resolution visual interpretation. The following land-use classes were identified:

1. Built up area
2. Agriculture (Mango Orchards)
3. Vegetation cover
4. Water bodies
5. Barren land

Supervised classification was adopted to ensure higher thematic accuracy in distinguishing orchard land from other vegetation types.

Change Detection and Impact Assessment

Post classification comparison was used to quantify temporal changes between 2000 and 2020. Area

statistics (km²) and percentage change were calculated in ArcGIS to determine:

- a) Expansion of built-up area
- b) Loss of mango orchards and agricultural land
- c) Reduction in vegetation cover
- d) Changes in water bodies

Overlay analysis was conducted to examine the spatial relationship between urban expansion and environmental resource conversion, identifying high-impact zones.

3.4 Software and Analytical Tools

- a) ERDAS IMAGINE – Image pre-processing and classification
- b) ArcGIS 10.3.1 – Spatial analysis and area computation
- c) SPSS – Survey data analysis
- d) Google Earth Pro – Ground verification

3.5 Methodological Justification and Limitations

The integration of Remote Sensing and GIS with primary survey data enables a comprehensive assessment linking spatial land transformation with socio-economic drivers of urban sprawl. Satellite-based analysis provides an objective and efficient approach for evaluating long-term land-use dynamics over large geographic areas where field-based quantification is impractical.

Although 30 m spatial resolution limits precise estimation of individual tree loss, it remains suitable for detecting multi-decadal land-use trends. Minor limitations related to cloud cover and image seasonality were mitigated through careful image selection and preprocessing.

4. RESULTS

The population of Multan has increased steadily over the decades. In 1951, the population was about 190,000, which rose to 358,000 in 1961 and 539,000 in 1972. By 1998, it had crossed 1.19 million. In recent years, rapid urbanization and economic development have further boosted growth, reaching around 1.82 million in 2017 and approximately 2.55 million in 2023. This continuous rise reflects Multan's importance as a major cultural, commercial and educational center of southern Punjab.

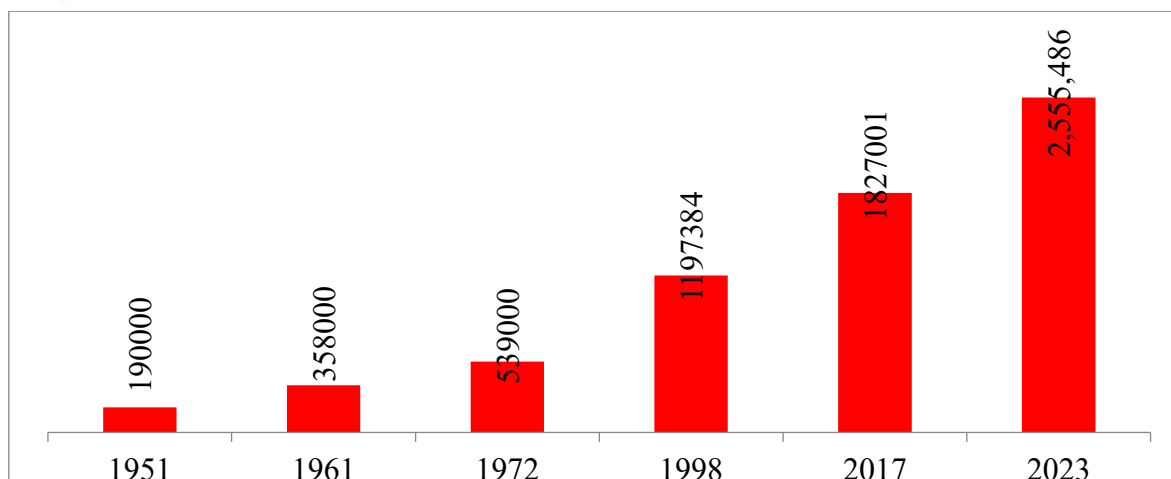


Figure 2 Showing population of Multan Tehsil

Socio Economic Profile of Respondents

A total of 207 respondents were surveyed across mango growing mouzas of Multan. The demographic composition indicates that the majority were male (90%) and within the 40-50 years age group (56%). Approximately 86% were literate. Occupationally, respondents were

primarily private job holders and farmers (60% combined), reflecting direct or indirect dependence on land resources. Most respondents (34%) had resided in the area for 5-10 years, indicating familiarity with recent land-use transitions.

Table 1. Demographic Characteristics of Respondents

Variable	Dominant Category	Percentage
Gender	Male	90%
Age Group	40-50 years	56%
Literacy	Literate	86%
Occupation	Private jobs & farmers	60%
Residency Duration	5-10 years	34%

The socio-economic profile confirms that respondents possess adequate awareness of local land-use transformations.

Perceived Drivers of Urban Sprawl

Survey findings indicate that urban expansion is primarily driven by residential and economic motivations.

Table 2. Main Causes of Urban Sprawl

Cause	Percentage
Better residential environment	37%
Low land prices	30%
Business opportunities	18%
Employment opportunities	15%

The dominant driver (37%) was the demand for an improved residential environment, followed by low land prices (30%). These findings highlight peri-urban land as economically attractive for housing schemes and private development.

Conversion of Mango Orchards: Respondents identified mango orchards as the most affected land category.

Table 3. Land Types Affected by Urban Sprawl

Land Type	Percentage
Mango orchards	50.3%
Barren land	23.8%
Agricultural land	20.0%
Others	6.0%

More than half (50.3%) confirmed that mango orchards were the primary land type converted into built-up area, directly supporting the central research objective.

Reasons for Selling Mango Orchards

Economic incentives were the dominant cause of orchard conversion.

Table 4. Reasons for Selling Orchard Land

Reason	Percentage
Triple market price	51%
Inflation	21.6%
Mango diseases	13.4%
Other reasons	14%

The offer of triple market value (51%) emerged as the strongest motivation, indicating speculative real estate pressure as a key mechanism of land-use change.

Respondents' Perception of Orchard Loss

- 68% confirmed that urban sprawl has destroyed mango orchards over the past two decades.
 - 66% expressed satisfaction with development despite orchard loss.
- This contrast reveals a socio-environmental trade-off, where economic benefits outweigh ecological concerns in public perception.

Satellite Based Evidence of Orchard Decline (2000-2020)

Remote sensing analysis validates survey findings. Land Use/Land Cover (LULC) classification shows a substantial decline in mango orchards between 2000 and 2020.

- Orchard area decreased from 301.68 km² (2000) to 158.61 km² (2020).
- Built-up area increased from 59.73 km² to 207.10 km² during the same period.

The most significant spatial losses occurred along major road corridors and newly developed housing schemes in peri-urban zones of Multan. These findings demonstrate a strong inverse relationship between orchard cover and built-up expansion.

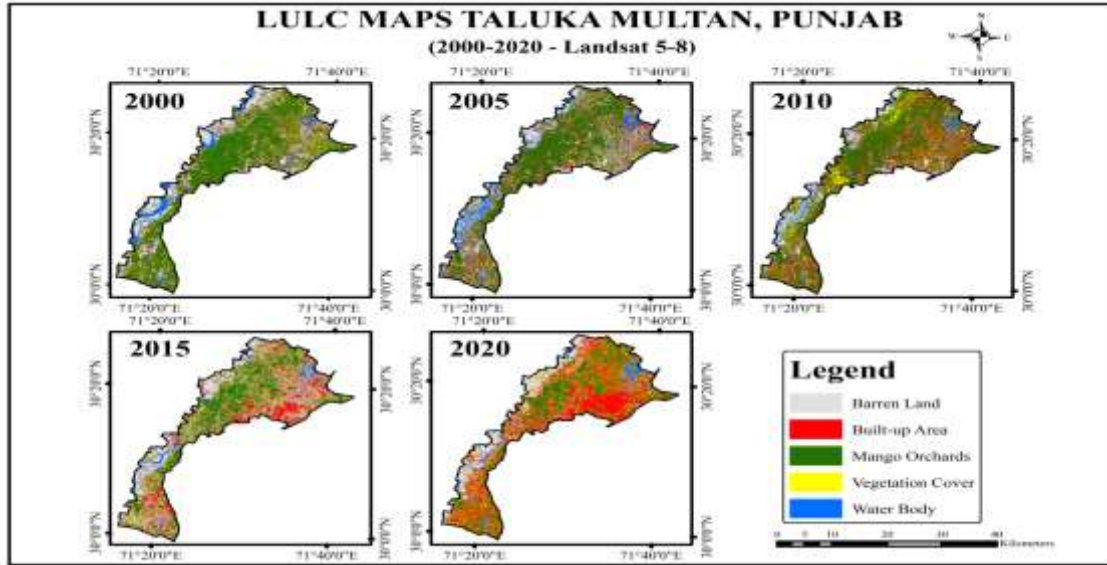


Figure 3 Showing land use land change map of Multan

Table 5 Change in classes from 2000 to 2020.

Class Name	Year 2000 Area (Sq.Km)	Year 2005 Area (Sq.Km)	Year 2010 Area (Sq.Km)	Year 2015 Area (Sq.Km)	Year 2020 Area (Sq.Km)
Built-up Area	59.73	93.1	118.83	120.07	207.1
Mango Orchards	301.68	289.81	287.13	179.78	158.61
Vegetation Cover	42.04	7.43	62.81	63.31	89.76
Water Body	48.14	45.97	37.92	37.9	22.14
Barren Land	129.4	144.68	74.31	179.94	103.38
Total Area	580.99	580.99	580.99	580.99	580.99

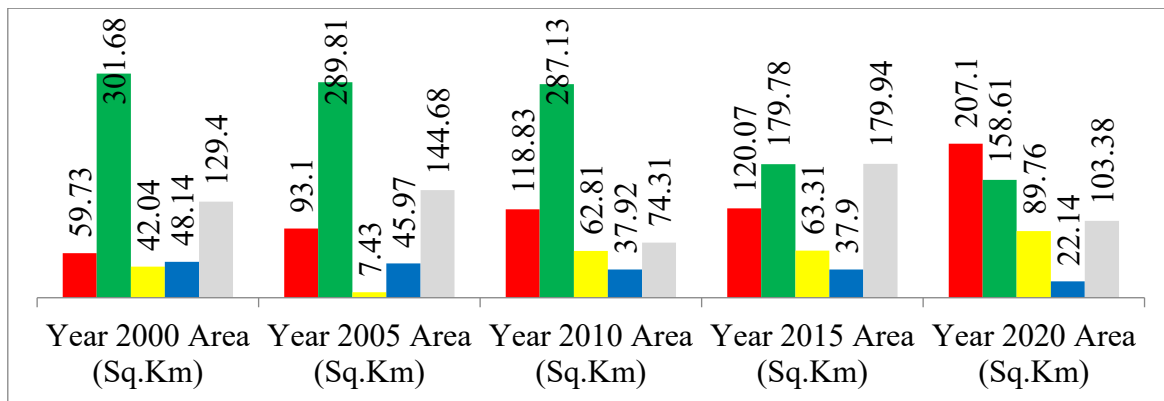
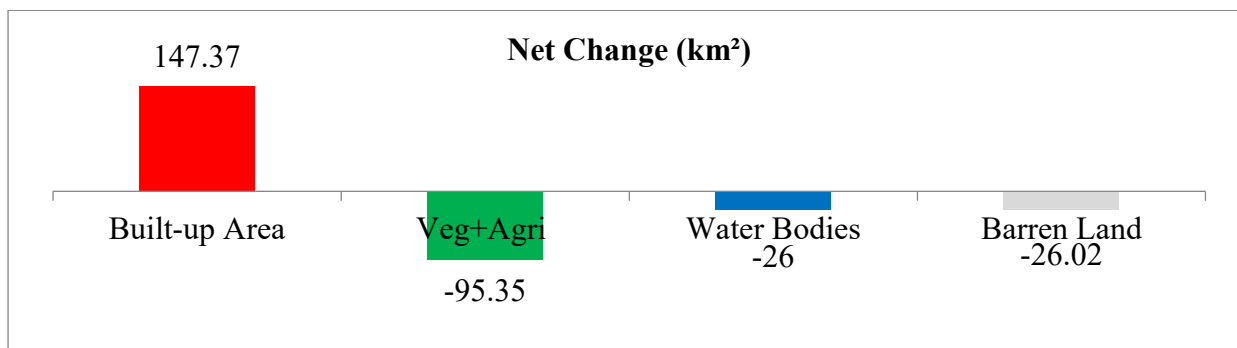


Figure 4 Shows land use land cover overall Class Analysis 2000-2020

Table 6. Showing Overall Change in classes

LULC Class	Total Change in Class	Net Change (km ²)
Built-up Area	147.37	147.37
Mango Orchards	-143.07	Sum of

Vegetation Cover	47.72	Total Change in Classes Other than Built up -147.37
Water Bodies	-26	
Barren Land	-26.02	



Mango Area and Production Trends

Secondary data from the Pakistan Bureau of Statistics and Crop Reporting Services further support spatial findings.

Table 7. Mango Area and Production (2000–2020)

Year	Area (Acres)	Production (Tons)
2000	59,220	398,310
2005	77,700	440,818
2010	73,900	439,234
2015	71,000	435,603
2020	64,000	431,507

Although production fluctuated due to technological and climatic factors, the overall decline in orchard area after 2005 signals long-term sustainability risks. The reduction in cultivated area aligns with satellite-detected land conversion patterns.

5. CONCLUSION

The research confirms that urban sprawl has severely affected mango orchards, reducing their area by nearly 50% over twenty years. Survey data indicate that the primary driver of orchard loss was economic 51% of landowners sold orchards due to lucrative real estate offers, while 37% cited the desire for better residential environments. Infrastructure development, low land prices, and employment opportunities further encouraged urban expansion.

Remote sensing analysis corroborates these perceptions, showing that mango orchards declined from 301.68 km² in 2000 to 158.61 km² in 2020, while built-up areas increased from 59.73 km² to 207.10 km². Importantly, mango production remained relatively stable initially due to intensification, but the continuing decline in orchard area raises long-term sustainability concerns.

A key insight is the coexistence of high public awareness with general acceptance of urban expansion; despite orchard loss, 65.7% of respondents were satisfied with urban development, highlighting a socio-economic trade-off. Moreover, 82% reported weak government action, revealing gaps in regulatory enforcement. Overall, the study emphasizes that urban growth in Multan is not only spatial but socio-economically driven, resulting in the transformation of high-

value agricultural land. These findings underscore the urgent need for policy interventions, smart urban planning, and sustainable orchard management to preserve the city's identity as a mango-growing region.

REFERENCES

- Akram, M., et al. (2018). Urban growth and vegetation change in Multan (1987–2013). *Journal of Environmental Studies*, 45(2), 123–135.
- Akram, S., & Siddique, S. (2018). Remote sensing analysis of urban expansion and loss of agricultural land in Tehsil Multan City, Pakistan. *Pakistan Geographical Review*, 73(1), 52–55.
- Brueckner, J. K. (2000). Urban sprawl: Diagnosis and remedies. *International Regional Science Review*, 23(2), 160–171. <https://doi.org/10.1177/016001700761012710>
- Brueckner, J. K. (2000). Urban sprawl: Diagnosis and remedies. *International Regional Science Review*, 23, 160–161.
- Census of Pakistan. (2017). Population census report 2017. Pakistan Bureau of Statistics. <https://www.pbs.gov.pk>
- Chin, N. (2002). Urban sprawl and the loss of agricultural land. *Land Use Policy*, 19(2), 123–135. [https://doi.org/10.1016/S0264-8377\(02\)00010-6](https://doi.org/10.1016/S0264-8377(02)00010-6)
- Deng, X., Huang, J., Rozelle, S., & Uchida, E. (2015). Growth, population, and agricultural land conversion in China. *Land Use Policy*, 42, 12–20. <https://doi.org/10.1016/j.landusepol.2014.06.004>
- Downs, A. (2008). *New visions for metropolitan America*. Brookings Institution Press.
- Eko, A. J. (2012). The Effects of Urban Sprawl on Peripheral Agricultural Lands in Calabar, Nigeria. *International Review of Social Sciences and Humanities*, 2, 68–76.
- Ewing, R. (2008). Characteristics, causes, and effects of urban sprawl: A literature review. *Environmental and Urban Studies*, 25(1), 1–15. <https://doi.org/10.1177/0042098008093609>
- Ghaffar, A. (2016). Land conversion and peri-urban development in Punjab, Pakistan. *Pakistan Journal of Geography*, 28(1), 45–60.
- Glaeser, E. L., Kim, H., & Luca, M. (2021). Urban expansion and spatial inequality. *Journal of Economic Geography*, 21(5), 853–874. <https://doi.org/10.1093/jeg/lbab012>
- GoP. (2012). *Pakistan economic survey 2011–12*. Ministry of Finance, Government of Pakistan.
- GoP. (2016). *Economic Survey of Pakistan 2015–16, Population, Labor Force and Employment*. Economic Advisor's Wing, Islamabad, Pakistan, Ch. 12, 1–19.
- GoP. (2017). *Economic Survey of Pakistan, Education*. Economic Advisor's Wing, Islamabad, Pakistan, 15.
- Gordon P, Richardson H. Critiquing (2020). *Sprawl's critics*. *Policy Analysis*, 365: 18. <https://doi.org/10.1146/annurev.ecolsys.39.110707.173401>
- Habibi, A., Hashemi, H., & Darvishi, A. (2011). Urban sprawl and agricultural land loss: Evidence from Iran. *Journal of Land Use Science*, 6(3), 189–204. <https://doi.org/10.1080/1747423X.2010.504340>
- Husnain, M. (2018). Economic drivers of orchard land conversion in Pakistan. *Journal of Rural Studies*, 60, 47–55. <https://doi.org/10.1016/j.jrurstud.2018.03.007>
- Ibrahim, M., Marzloff, I., & Ries, J. B. (2011). Remote sensing and GIS applications in urban sprawl assessment. *Applied Geography*, 31(1), 120–133. <https://doi.org/10.1016/j.apgeog.2010.05.007>
- Lei, Y. (2017). Urban expansion and rural land transformation in Beijing, China. *Cities*, 60, 1–11. <https://doi.org/10.1016/j.cities.2016.09.002>
- Lindenmayer, D. B., & Fischer, J. (2006). *Habitat fragmentation and landscape change: An ecological and conservation synthesis*. Island Press.

- Magsi, H., & Torre, A. (2014). Urban expansion and agricultural land loss in South Asia. *Land Use Policy*, 38, 357–366. <https://doi.org/10.1016/j.landusepol.2013.11.009>
- Mazhar, M., & Jamal, S. (2009). Land use changes and peri-urban development in Pakistan. *Asian Journal of Social Sciences*, 37(3), 412–430.
- McKinney, M. L., et al. (2002). Urbanization, biodiversity, and ecosystem services. *Bioscience*, 52(10), 883–890. [https://doi.org/10.1641/0006-3568\(2002\)052\[0883:UBAES\]2.0.CO;2](https://doi.org/10.1641/0006-3568(2002)052[0883:UBAES]2.0.CO;2)
- Meadows, Donella H; Meadows, Dennis L; Randers, Jørgen; Behrens III, William W.(November, 2017). *The Limits to Growth; A Report for the Club of Rome's Project on the Predicament of Mankind*. New York: Universe Books. ISBN 0876631650.
- Netzband, M., Salge, S., & Schmidt, M. (2015). GIS-based modeling of land-use change in peri-urban areas. *Landscape and Urban Planning*, 135, 1–13. <https://doi.org/10.1016/j.landurbplan.2014.12.010>
- Pendall, R. (1999). Do land-use controls cause sprawl? *Environment and Planning B: Planning and Design*, 26(4), 555–571. <https://doi.org/10.1068/b260555>
- Rajwana, I. A., et al. (2010). Mango cultivation and production in Southern Punjab. *Pakistan Journal of Horticulture*, 40(2), 56–68.
- Rajwana, I. A., Malik, A. U., Khan, A. S., Saleem, B. A., & Malik, S. A. (2010). A new mango hybrid shows better shelf life and fruit quality. *Pakistan Journal of Botany*, 42(4), 2503–2512.
- Raza, S. T., Khan, A. H., Hameed, A., Muhammad, N., Grewal, A. G., Malik, M. T., & Iqbal, A. (2023). A review on white mango scale biology, ecology, distribution, and management. *Agriculture*, 13(9), 1770.
- Reddy, P. V. R., Gundappa, B., & Chakravarthy, A. K. (2018). *Pests of mango: Pests and their management*. Springer Nature Pvt. Ltd., Singapore, 415–440.
- Reddy, S. L., et al. (2018). Global trends in mango production and trade. *Fruit Science Journal*, 12(1), 22–35.
- Ritchie, H. (2019). Population growth and urban expansion. *Our World in Data*. <https://ourworldindata.org/population-growth>
- Rosenberger, R., Loomis, J., & Shogren, J. (2002). The economic impacts of agricultural land conversion. *Land Economics*, 78(3), 345–361. <https://doi.org/10.2307/3147200>
- Roser, M. (2018). Urbanization. *Our World in Data*. <https://ourworldindata.org/urbanization>
- UNDP. (2018, May 16). 68% of the world population projected to live in urban areas by 2050. New York.
- Zhong, T. Y., et al. (2022). Agricultural land loss in China: Urban expansion and orchard conversion. *Land Use Policy*, 116, 106–134. <https://doi.org/10.1016/j.landusepol.2022.106134>
- Zulfiqar, A. (2021). Devastation of mango orchards in Multan. *Dawn News*.