

A Comparative Assessment of Orchards Distribution in Urban and Peri-Urban Agriculture Zones in Karachi Through RS/GIS Techniques: (2005-2023)

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Orchard farming plays a crucial role in the urban ecosystem, contributing to biodiversity and offering opportunities for organic waste reprocessing and natural resource conservation. It holds significant economic and cultural value, enhancing the urban environment. This research on orchard distribution in Karachi provides insights that can guide sustainable development, infrastructure planning, environmental protection, and policy-making. The study employs advanced remote sensing and GIS techniques to monitor and analyze changes in orchards over time. Satellite images from Google Earth Pro were utilized to detect temporal changes, with a comparative assessment of agricultural land use between 2005 and 2023. ArcGIS software was used for digitization, revealing that most orchards in Karachi are concentrated in the peripheral areas along the Malir River, predominantly consisting of sapodilla, papaya, and guava trees. These orchards contribute to sustenance, employment, and environmental improvement. However, digitization has uncovered significant changes, including the transformation of some orchard lands into industrial and built-up areas. The data generated from this process can inform sustainable land management decisions for urban agricultural areas in developing nations.

Keywords: Orchard Farming, Population Growth, Temporal Change, Remote Sensing, GIS Techniques.



Introduction:

Urbanization is accelerating globally, with over half of the world's population now residing in cities and towns. By 2030, this figure is expected to reach nearly 5 billion, with substantial urban growth in Asia and Africa contributing to the degradation of natural resources and climate change. [1], [2], [3], [4]. In underdeveloped countries like Pakistan, one of the major challenges is unplanned urban development, which has led to the misuse of valuable land. [5], [6] Karachi, with an estimated population of 20,382,881 in 2023, exemplifies this issue. [7]. To meet the needs of the growing population, urban agriculture has emerged as a crucial source of fresh fruits and vegetables, providing numerous job opportunities across various sectors. [8] Additionally, urban agriculture enhances the aesthetic appeal of cities, [9], [10] offers relaxation, reduces mental fatigue, and fosters positive emotions and self-reflection. It also helps urban residents reconnect with rural methods of food production and contributes to the preservation of natural spaces, which are often essential for self-reflection. [11] Urban agriculture includes diverse production systems, such as vertical farms, hydroponics, aquaponics, aeroponics, backyard and rooftop gardens, urban beekeeping, fisheries, greenhouse farming, and the cultivation of medicinal and decorative plants, as well as orchard farming, all of which play productive roles in cities worldwide. [8]. Orchard farming, in particular, is a vital component of the urban ecosystem, [12] rich in biodiversity and essential for improving, managing, and reinforcing the urban environment [13] through organic waste recycling and natural resource preservation, while also holding significant economic and cultural importance. [14], [15], [16], [17]. In Karachi, most orchards in urban and peri-agricultural areas are located along the periphery of the Malir River, which has historically supported the surrounding agriculture [6].

Table 1: Fruits Area and Production in Karachi (2005-2020)

Fruits	Area in 2005 (Hectares)	Production 2005 (Tons)	Area in 2020 (Hectares)	Production in 2020 (Tons)
Citrus	72	224	Nil	Nil
Mango	211	125	12	74
Banana	110	327	34	165
Guava	63	246	68	487
Dates	42	441	Nil	Nil
Papaya	Nil	Nil	446	2,096

Source: Crop, Area, Production 2005 & 2020, GOP: Ministry of Food, Agriculture and Livestock

Historically, Citrus, Mango, Banana, Guava, Dates, and Papaya have been cultivated in the agricultural lands of Karachi. [18], [19]. Agricultural activities in the peripheral areas of Karachi have a long-standing tradition. Table 1 outlines the overall distribution of orchards in Karachi, highlighting that Citrus, Mango, Banana, Guava, Dates, and Papaya have been key crops. Available data up to 2020 has been included in this study. Notably, Citrus and Dates, which were cultivated in 2005, are no longer found, while Mango plantations have been declining in Karachi. Interestingly, Papaya, which was not grown in 2005, has seen significant expansion, now covering approximately 2,096 acres across Karachi.

This study aims to investigate the temporal changes in orchards along the Malir River in Karachi, where the current orchards primarily consist of Sapodilla, Papaya, and Guava trees. The specific objectives include mapping the orchards in the study area and comparing them between 2005 and 2023. Understanding land-use transformations is crucial for informed decision-making in sustainable land resource management. [20]. This study will also be valuable for assessing changes in urban agricultural areas in developing countries, underscoring the need for sustainable land-use practices that balance urban development with the preservation of agricultural land for future generations.

Material and Methods:

Study Area:

This research focuses on Karachi, the capital of Sindh province in Pakistan. Known as the 'Glory of the East,' 'City of Lights,' 'Liverpool of India and Pakistan,' and the 'Bride of the Cities,' Karachi spans an area of 3,527 km² and is situated between 24°45' to 25°15' north latitude and 66°37' to 67°37' east longitude. [21]. The city is administratively divided into six districts: Karachi Central, Karachi East, Karachi South, Karachi West, Korangi, and Malir. [6]. Karachi is home to the country's primary civilian and air force airports, two seaports, a nuclear power plant, fuel storage facilities, and numerous industries.

As one of Pakistan's oldest cities, Karachi holds significant political and commercial importance, largely due to its strategic port. Since independence, it has been the sole port city responsible for handling Pakistan's imports and exports. [22]. Karachi serves as Pakistan's economic and trading hub, contributing approximately 25 percent to the country's Gross Domestic Product (GDP). Since independence, the city's population has surged as people from across the country have migrated here for business opportunities and better income. [20]. Today, Karachi is the world's largest city by population and the seventh-largest urban cluster, with a population of 20,382,881 as of the 2023 census, growing at a rate of 4.10%. [7]

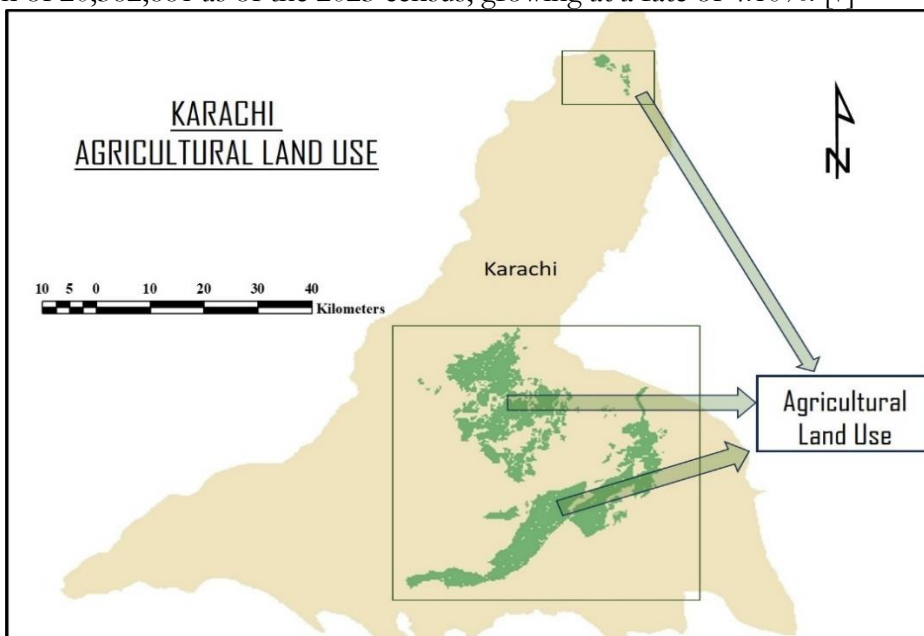


Figure 1: Karachi-Agricultural Land Use

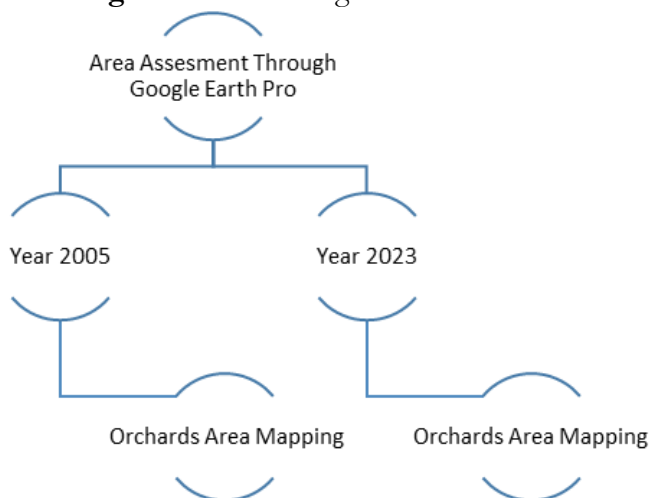


Figure 2: Flow Diagram showing Procedures

However, this rapid growth has led to a significant expansion of Karachi's built-up area over the past 30 years, causing considerable harm to both the community and the natural environment. [23]. Urbanization has disrupted the region's natural features, with suburban areas undergoing rapid changes due to overpopulation. [24]. This highlights the urgent need for urban agriculture planning to curb urban sprawl and promote sustainable land use. [25]. Urban planners and researchers can play a crucial role in identifying suitable areas for farming and infrastructure development. [26]

Material and Methods:

Satellite images from Google Earth Pro have proven to be an excellent tool for detecting temporal changes. [24], [27], [26]. For comparative analysis, historical images of agricultural land use in Karachi from the years 2005 and 2023 were utilized. ArcGIS software was employed for the digitization process.

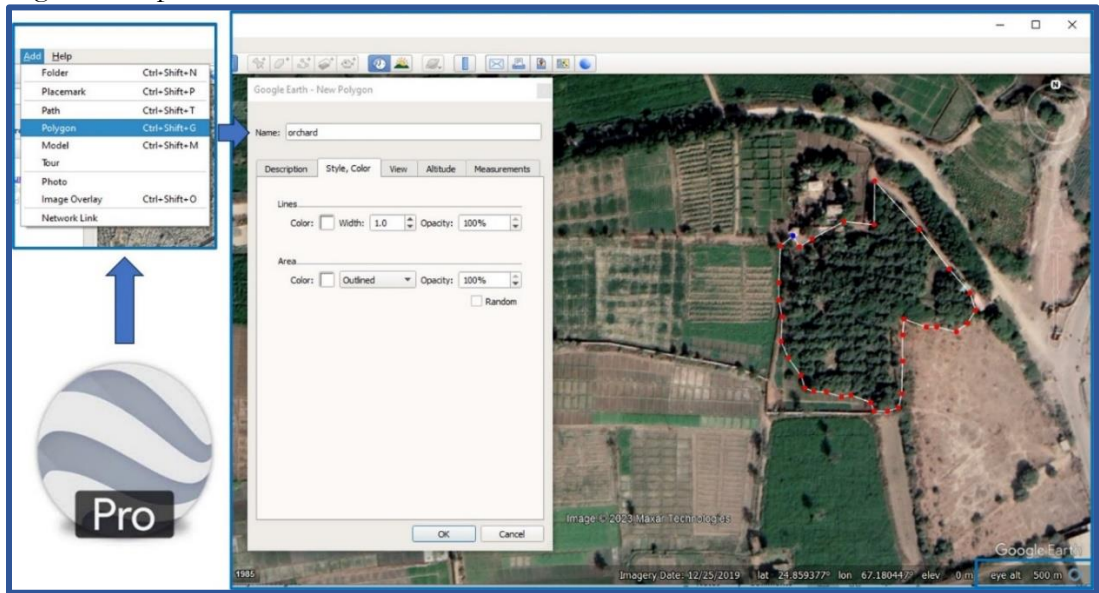


Figure 3: Procedure of Mapping

The area was mapped by identifying objects on the Google Earth Pro image, followed by digitization at an altitude of 500 meters (Figure 3).

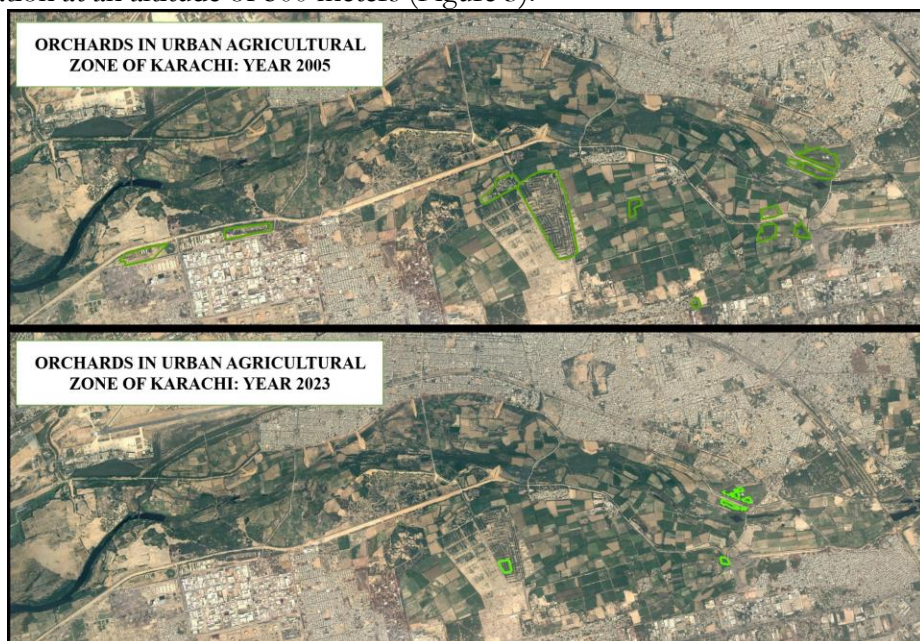


Figure 4: Compare orchard distribution in Agricultural zones of Karachi (2005 and 2023)

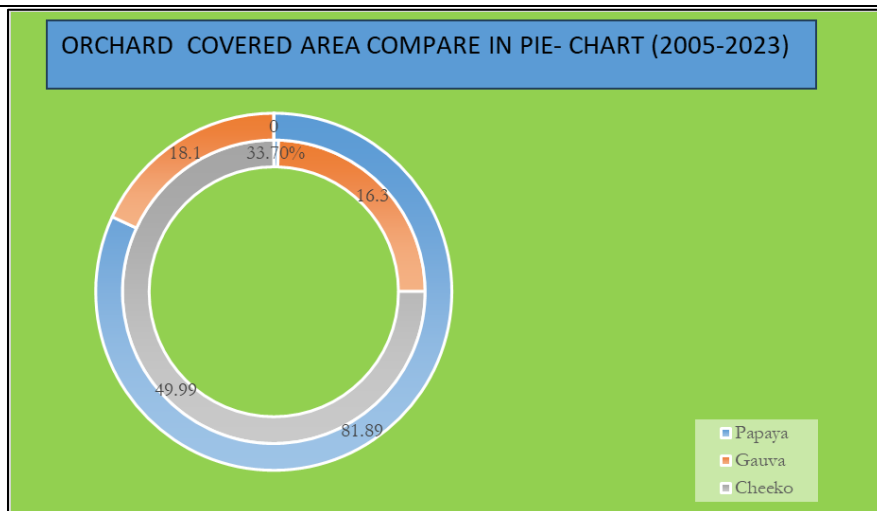
Result and Discussion:

Results:

The primary goals of the study are to establish orchards in the designated study area and to analyze and compare their growth and development from early 2005 to 2023. Figure 4 illustrates the comparison of orchard distribution in Karachi's urban agriculture zone for the years 2005 and 2023. Significant changes are evident, with many orchards having disappeared and been replaced by buildings and industries. These transformations are attributed to rapid urbanization and unplanned city development. [28]

Table 2: Urban Agriculture-Orchards for the Years 2005 and 2023:

Farms Areas (2005)	Farm Area Transformation (2023)	Latitude	Longitude	Covered Area 2005-June (Sq. meters)	Covered Area 2023-June (Sq. meters)
Papaya	Industry	24.856	67.1127	51180	0
Guava	Industry	24.858	67.1236	45431	0
Guava	Graveyard	24.82651	67.1497	51859	0
Papaya	Cropland	24.8583	67.17781	26627	0
Papaya	Cropland	24.8603	67.17787	20098	0
Papaya	Open land	24.86498	67.18083	8359	0
Guava	Guava	24.85185	67.17018	6594	6594
Papaya	Papaya and cultivable waste	24.86433	67.18276	27425	6484
Papaya	Papaya and cultivable waste	24.85867	67.18101	15637	9833
Papaya	Built-up	24.86135	67.16378	15795	0
Sapodilla	Fallow land and built-up area	24.85988	67.15548	318444	0
Papaya	Papaya and cropland	24.86629	67.18293	49538	13506
Total Orchard Area				636987	36417



1. **Figure 5:** Statistical graph represents orchard comparison (2005-2023)

Figure 5 presents a comparative analysis of the orchard-covered areas for Papaya, Guava, and Sapodilla, highlighting major changes through the statistical graph. This research examines changes in agricultural land use over the past 18 years, specifically between 2005 and 2023. Table 2 and Figure 5 detail the farms used for various fruit plantations. In 2005, Papaya, Guava, and Sapodilla were cultivated in the urban agricultural zones of the study area, covering a total area of 636,987 square meters. At that time, Papaya was grown on 21,465 square meters, Guava on

103,884 square meters, and Sapodilla on 318,444 square meters. Since then, 96,611 square meters have been converted into industrial use, and 15,795 square meters have been transformed into built-up land. A significant portion of the Sapodilla farms, totaling 318,444 square meters, has been entirely converted into fallow and built-up land. Additionally, some Papaya farms have degraded to the point of becoming cultivable wastelands. Overall, the total orchard area has declined dramatically from 636,987 square meters in 2005 to just 36,417 square meters, reflecting a reduction of 600,570 square meters in urban agricultural land.

Table 3: Total Orchard Area of Alfalah society, Awami colony, Bilal colony and Sharafi Goth (2005-2023)

Alfalah Society Orchard Area 2005(SQ Meters)	Alfalah Society Orchard Area 2023(SQ Meters)	Awami Colony Orchard Area 2005(SQ Meters)	Awami Colony Orchard Area 2023(SQ Meters)	Bilal Colony Orchard Area 2005 (SQ Meters)	Bilal Colony Orchard Area 2023 (SQ Meters)	Sharafi Goth Orchard Area 2005(SQ Meters)	Sharafi Goth Orchard Area 2023(SQ Meters)
49540	13505	370288	67866	45403	0	84771	25470

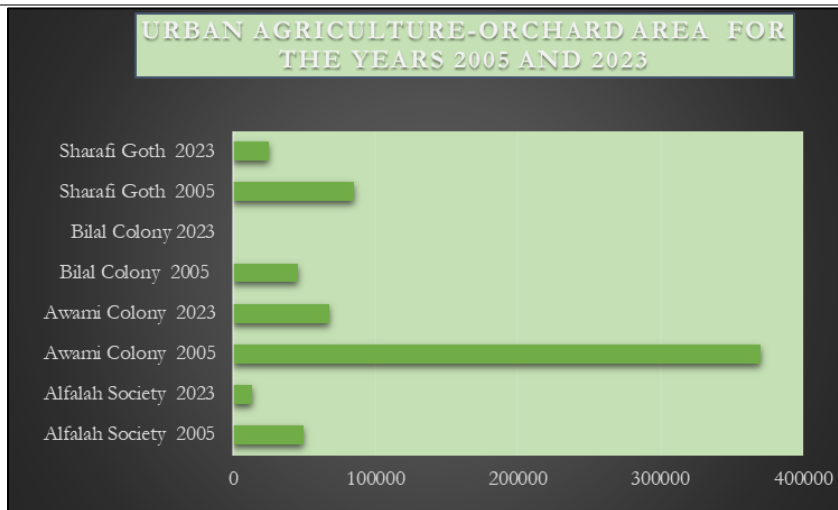


Figure 6: Statistical Bar-graph represents the Urban Agriculture-Orchard Area (2005-2023)

Table 3 and Figure 6 reveal a significant shift in land use, with agricultural land being increasingly converted into built-up areas over time. The construction of dams in several regions, including Alfalah Society, Awami Colony, Bilal Colony, and Sharafi Goth, has also contributed to the reduction of agricultural land. [6]

Rapid urbanization and unplanned city development have further accelerated the conversion of orchard land into residential, commercial, and industrial areas. [29] This widespread transformation has led to the loss of tree cover, decreased biodiversity, diminished livelihoods, and the introduction of pollutants, all of which have negatively impacted environmental quality and human well-being. [30]

Discussion:

The results of this study align with previous research on the transformation of orchard land into urban areas. Our findings reveal a significant decline in orchard land due to urbanization, reflecting trends observed in other regions of Pakistan. Urbanization has increasingly impacted agricultural lands in recent decades, as highlighted by studies in various cities. For example, Multan, known as the 'City of Mangoes,' has experienced a substantial reduction in orchards due to urban expansion. [14]

Similarly, research in Khairpur, Hyderabad, and Larkana Districts has shown a significant increase in urbanization, leading to the widespread conversion of agricultural land

into developed urban areas. [3], [28], [30]. Our research also includes observations of urbanization in Lahore, Karachi, Rawalpindi, Peshawar, Quetta, Faisalabad, Multan, and Hyderabad, where agricultural lands have been increasingly converted into built-up areas. [31]"

Conclusion:

The research findings highlight the temporal changes in urban and peri-urban agriculture in Karachi over the past 18 years. The study employs advanced techniques, including high-resolution satellite imagery and spatial analysis tools, to map and assess the presence and distribution of orchards in both the densely populated urban core and the less developed peri-urban fringes. The observed decline in urban orchards is concerning. To address this, policy efforts must focus on curbing urban sprawl and implementing sustainable land-use planning to protect valuable agricultural land, which is a critical resource for urban residents. The reduction in agricultural land has significant implications for food security, ecological balance, and local climate patterns. Despite its importance, urban and peri-urban agriculture often remains underappreciated. Therefore, it is crucial to monitor these temporal changes to prevent the loss of this essential resource due to urban expansion.

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Author's Contribution:

- **Author1:** Conceptualizations, methodology, data collection, writing original draft.
- **Author2:** Data Analysis, visualization, supervision.
- **Author3:** Review and editing.
- **Author4:** Funding acquisition and editing.

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