# Evaluation of Physical Expansion of Built Environment in District Sargodha (Pakistan)

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*Abstract*

*The current research delves into a comprehensive evaluation of the built-up area change within District Sargodha, Pakistan. This research evaluated the expansion of built-up area infrastructure in the study area and the contributing physical features. The expansion is evaluated through satellite imageries of the last three decades, focusing on 1993, 2003, 2013, and 2023 as study years. To avoid irregular and uneven expansion of built-up areas, monitoring of such growth is inevitable. The physical growth of the built environment in Sargodha district has exhibited remarkable trends from 1993 to 2023. Various factors contributing to urbanization, including industrial units, commercial zones, transportation networks, and health and educational institutions, have witnessed significant expansion during the study period in the study area. In 1993, the built-up area comprised 308.2 km$^2$, representing 5% of the district's total area. Subsequent years saw substantial growth as by 2003, the built-up area reached 453.6 km$^2$ (8% of the total area). By 2013, it expanded to 541.3 km$^2$ (9%) and by 2023, the built-up area also accelerated to 765 km$^2$ (13%). This growth was accompanied by a noticeable shift in population dynamics, signifying a noteworthy trend of urbanization. Conversely, the rural population decreased, likely driven by enhanced economic prospects and improved urban living conditions.*
**Keywords:** Built Environment, Built-up Area, Expansion, Satellite Images

## Introduction

The built environment refers to the human-made structures and spaces where people live, work, and engage in various activities (Lepers, 2005; Alfred et al., 2016). It encompasses everything from buildings and infrastructure to parks, streets, and transportation systems (Sathya et al., 2017). The built environment plays a crucial role in shaping our lives and significantly impacts our well-being, quality of life, and sustainability (Raza & Shirazi., 2014). The expansion of the built environment physically relies on enhancement and increase in urban population and the management to accommodate the growing population (Raddad et al., 2010; Peijun, 2010). The physical expansion of settlements, transportation networks, health institutes, higher educational institutes, industrial units, and population characteristics play a vital role in evaluating the built environment (Hassan et al., 2016).

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The spatial contributions to built-up area expansion encompass zoning regulations, urban planning policies, infrastructure development, natural features, and economic dynamics (Karwariya et al., 2012). These factors collectively determine where and how cities grow, influencing their physical layout and patterns of urban expansion. Effective urban planning and land management strategies are essential to ensure that spatial contributions align with goals of sustainability, livability, and equitable development (Braimoh & Onishi, 2007; Briassoulis, 2008).

How land is utilized within the built environment affects the distribution of activities, including residential, commercial, and industrial zones (Jaafari, 2016; Jabeen et al., 2017). Land-use planning and zoning regulation are crucial in creating sustainable and balanced communities (Cheng, 2003; Chen, 2009). Land utilization is of utmost importance for the urban environment as it directly impacts cities' functionality, sustainability, and quality of life. Land in urban areas is limited and valuable. Effective land utilization ensures optimal use of available space, preventing wastage and maximizing the urban environment's capacity (Shabir et al., 2020; Hashim et al., 2023). It includes considerations such as compact development, mixed land use, and infill development, which help reduce urban sprawl and preserve valuable natural areas. Urban areas are home to various residential, commercial, industrial, recreational, and institutional activities. Efficient land utilization allows for the allocation of suitable areas for these activities, ensuring that the population's needs are met. Proper zoning and land-use planning help create functional and balanced communities (Adams & Cavill, 2015; Zaka, 2004).

## Literature Review

Residential, commercial, industrial, and institutional structures form the core of the built environment. They can vary in size, shape, design, and purpose, ranging from single-family homes to skyscrapers (Hersperger et al., 2010; Gohain et al., 2021). It includes transportation systems (roads, bridges, railways, airports), utilities (water supply, sewage systems, electrical grids), and communication networks (telecommunications, internet infrastructure). It directly influences the quality of life and social dynamics within urban areas (Idrus et al., 2010; Goldblum & Wong, 2000). Well-planned communities with access to green spaces, public amenities, and mixed-income housing promote social interaction, community engagement (Farooq et al., 2023), and a sense of belonging. Affordable housing, social infrastructure, and public gathering spaces create livable and inclusive urban environments (Fazal, 2000; Ghosh & Maji, 2011).

Parks, plazas, squares, and other outdoor areas provide recreation, social interaction, and community engagement spaces. These areas contribute to the aesthetics of the built environment and improve the overall livability of cities and towns. Streets, sidewalks, and bike lanes are essential components of the built environment (Haregeweyen et al., 2012). They facilitate transportation pedestrian movement and provide access to various destinations. Well-designed streetscapes can enhance safety, accessibility, and urban vitality (Arshad et al., 2002; Bihamta et al., 2015).

The built environment's sustainability involves incorporating environmentally friendly practices into design, construction, and operation. It includes energy-efficient buildings, green spaces, renewable energy sources, and water management systems (White & Engelen, 2000; Deng et al., 2009). Ensuring the built environment is accessible to people of all abilities is essential. It involves designing inclusive buildings, streets, and public spaces that accommodate individuals with disabilities (Waddell, 2002; Cohen, 2006). Well-planned land utilization enhances accessibility and mobility within urban areas. Locating residential areas near commercial centers, schools, and public transportation makes it easier for people to access essential services and amenities (Dewan

& Yamaguchi, 2009; Cervero, 2013). Efficient land use also supports the development of transportation infrastructure, such as roads, sidewalks, bike lanes, and public transit systems, contributing to improved connectivity and reduced congestion (Waddell et al., 2003).

Urban design focuses on cities' and towns' aesthetics, functionality, and spatial organization. It considers factors such as building placement, street layouts, and the overall character of the urban environment (Codjoe, 200; Sajjad et al., 2015). Designing and managing the built environment is a complex task that requires collaboration among urban planners, architects, engineers, policymakers, and community members. By creating well-designed, sustainable, and inclusive built environments, the quality of life for individuals can be improved and promote thriving communities (Sajid, 2022; Hashim et al., 2023).

In District Sargodha, proper and timely evaluation of built-up expansion may help minimize the negative impacts of the built environment on agricultural land and the surrounding environment.

## Research Methodology
### Study Area: District Sargodha
The district is bounded on the North by the Jhelum River, on the East by the Chenab River, beyond which lies the districts of Mandi Bahauddin and Hafizabad, on the South by the Jhang district, on the West by the Khushab district. The whole area is part of Chaj Doab (The land between the two rivers of Chenab and Jhelum). The district's total area is approximately 5854 square kilometers (2,264 sq miles) and has an average elevation of 607 feet above sea level. The district's population is about 3.7 million more than the urban population of 1.0 million, which constitutes 37% of the district population (GoP, 2017).

**Figure 1: Location Map of the Study Area**
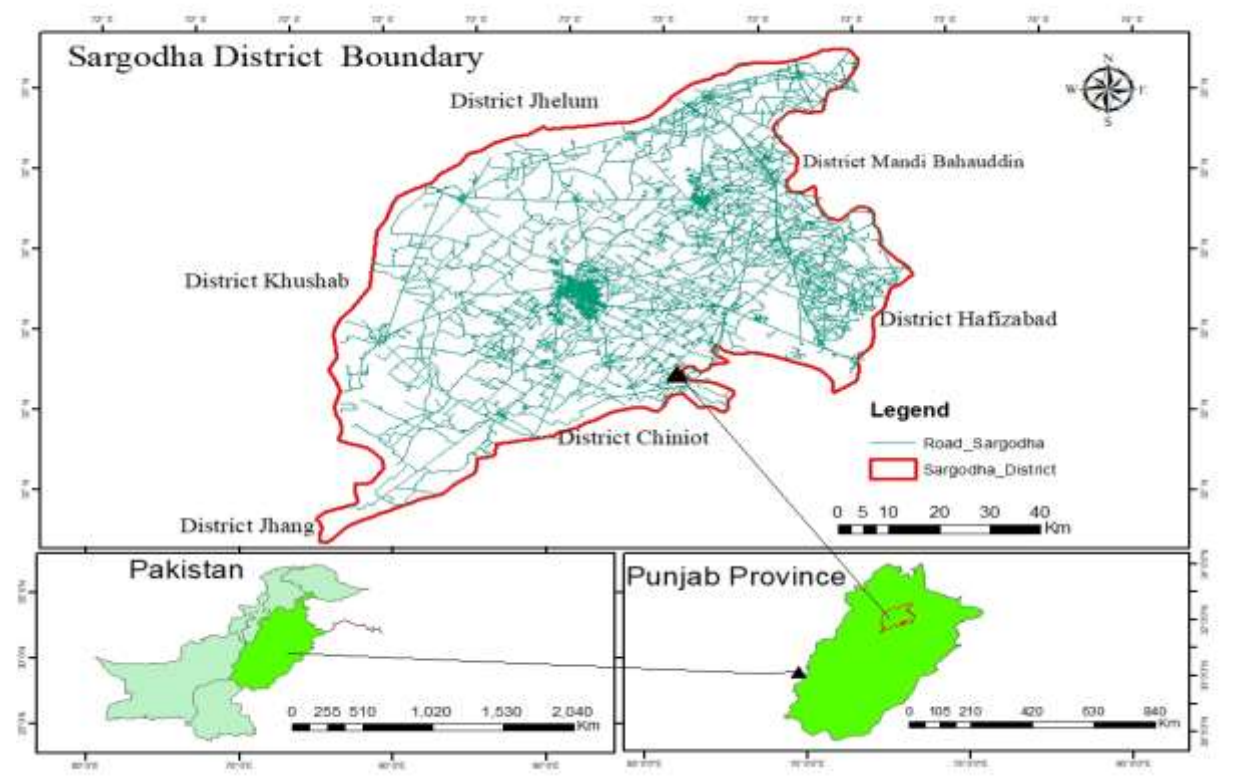
## Data Sources

This study is based on spatial analysis of satellite-based images. The United States Geological Survey's (USGS) open source is used for temporal Landsat satellite imageries of 1993, 2003, 2013, and 2023 to determine the evolving pattern of the built-up area in district Sargodha. Geographic Information System (GIS) and Remote Sensing (RS) techniques are used to process the temporal Landsat images. The transportation network is digitized from the topographic sheets after necessary geo-referencing and re-projection. Open-source Google Earth images create digital data for roads and public services like health care infrastructure, educational institutes, police stations, shopping centers, industries, transportation networks, etc.

## Results and Discussion

### Built Environment in District Sargodha

The evaluation of the built environment in Sargodha District from 1993 to 2023 involves assessing industrial units, transportation networks, educational institutions, and healthcare units. Over this three-decade period, significant changes and developments have occurred in these sectors, impacting the overall built environment of the district.

### Industrial Units

The evaluation of industrial units in Sargodha District from 1993 to 2023 would involve examining the growth and transformation of the industrial sector. It includes analyzing the establishment of new industries, expansion of existing ones, and the types of industries that have emerged. Factors such as employment generation, economic contribution, environmental impact, and land use patterns associated with industrial units must be considered. The evaluation would highlight the industrial growth trends, the diversification of industries, and the overall impact on the built environment, including infrastructure demands and urban sprawl.

### Transportation Networks

Assessing the transportation networks in Sargodha District over the study period would involve analyzing the expansion and improvement of road networks, public transportation systems, and connectivity within and to other regions. Evaluating transportation networks would also include studying the impact of transportation infrastructure on mobility patterns, accessibility to different areas, and the integration of sustainable transportation modes. This evaluation would consider the development of new roads, bridges, highways and expanding public transit services. It would also analyze the challenges and opportunities related to traffic congestion, air pollution, and adopting sustainable transportation practices.

### Educational Institutions and Health Care Units

Evaluating educational institutions and healthcare units in Sargodha District from 1993 to 2023 would involve examining these facilities' growth, distribution, and quality. It includes assessing the establishing of new schools, colleges, universities, hospitals, clinics, and healthcare centers in the district. The evaluation would consider factors such as educational and healthcare access, infrastructure development, quality of services, and the impact on the district's socio-economic development. It would also analyze the alignment between the growth of educational and healthcare facilities with the district's population needs and demographic changes.

Overall, evaluating the built environment in Sargodha District in terms of industrial units, transportation networks, educational institutions, and healthcare units over the study period would

provide insights into these sectors' development, challenges, and impacts. It would help understand the evolution of the district's economic, social, and physical landscape and provide valuable information for future planning, policy-making, and sustainable development initiatives.

**Physical Expansion of Built Environment 1993 – 2023**

**Figure 2: Industrial units in Sargodha district**
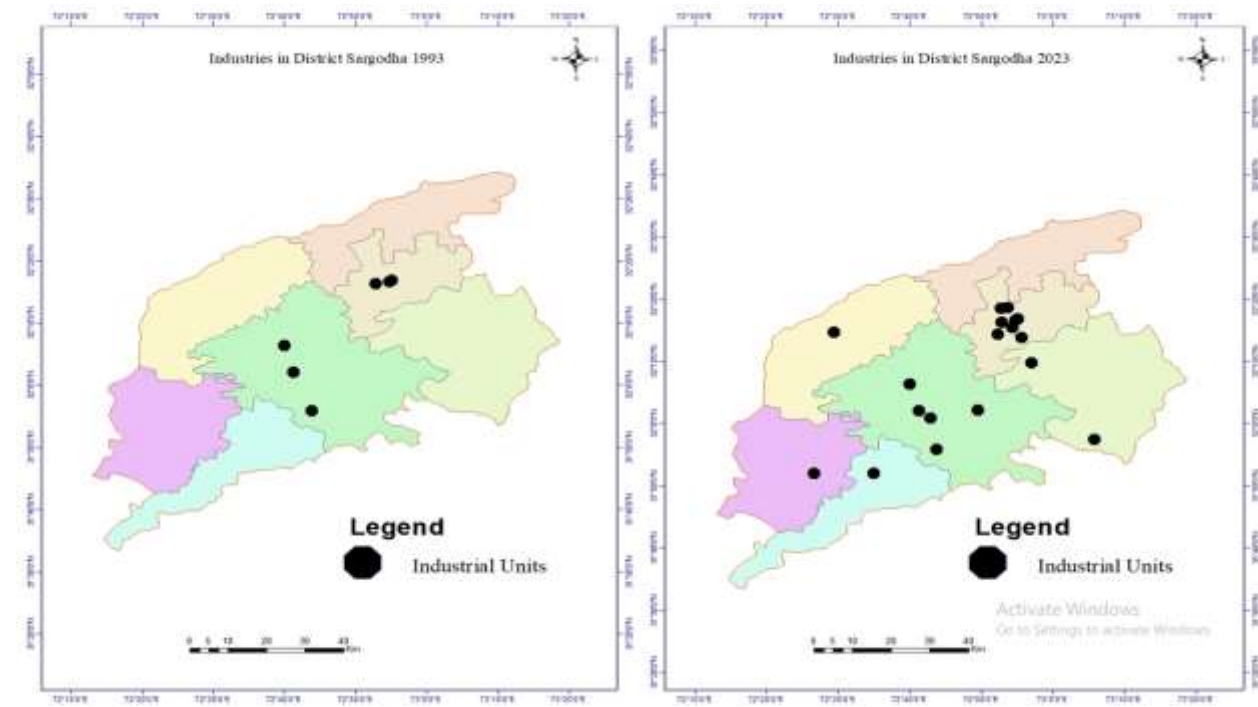


The data provided pertains to the number and distribution of industrial units in the seven tehsils (administrative subdivisions) of Sargodha District: Sargodha Tehsil, Bhalwal Tehsil, Bheera Tehsil, Kot Momin Tehsil, Shahpur Tehsil, Sahiwal Tehsil, and Sillanwali Tehsil. In 1993, the entire district had only five industrial units. Of these, three were in Sargodha Tehsil and two in Bhalwal Tehsil. By 2023, the number of industrial units had increased to 17, indicating substantial growth in the industrial sector.

The distribution of industrial units across the tehsils has also changed over time. In 1993, Sargodha Tehsil had three units, and Bhalwal Tehsil had two. However, in 2023, Bhalwal Tehsil witnessed significant industrial growth, with the number of industrial units increasing to seven. Sargodha Tehsil retained its position as a prominent industrial hub, with five industrial units. Kot Momin Tehsil, Shahpur Tehsil, Sahiwal Tehsil, and Sillanwali Tehsil had one industrial unit in 2023.

Comparing the results for the given years, it is evident that the number of industrial units in the Sargodha District has experienced notable growth. The increase from five units in 1993 to 17 units in 2023 reflects the district's expanding industrial activities and development. The rise in industrial units signifies economic progress, job opportunities, and potential regional investments.

The distribution of industrial units across the tehsils also highlights the shift in industrial development. Bhalwal Tehsil has emerged as a significant industrial center, surpassing Sargodha Tehsil's number of units. It suggests the potential for industrial growth and investment in Bhalwal

Tehsil. The presence of industrial units in other tehsils, such as Kot Momin, Shahpur, Sahiwal, and Sillanwali, indicates a diversification of industrial activities beyond the traditional hubs. This data provides insights into the industrial landscape of Sargodha District, indicating the growth and changing distribution of industrial units over the years. It showcases the expansion of industrial activities, potential economic opportunities, and the need for infrastructure development to support the growing industrial sector in the region.

**Figure 3: Transportation Network in Sargodha district**
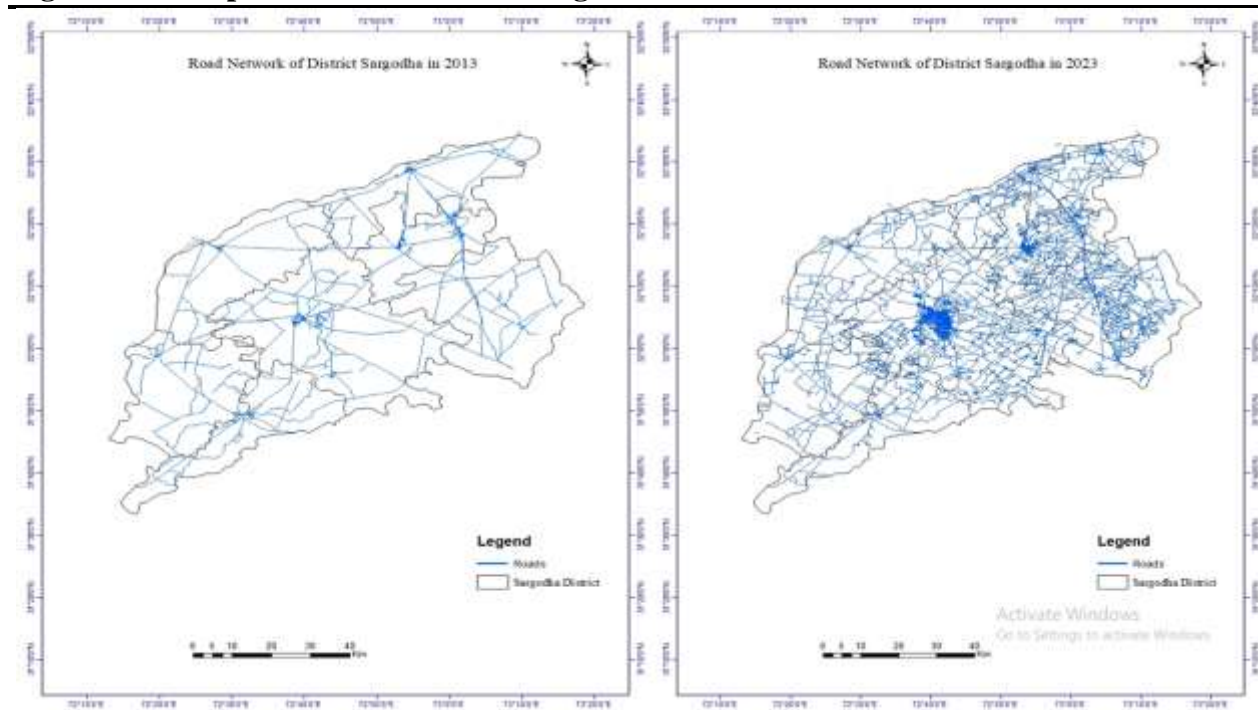


Over time, road networks tend to expand and improve to accommodate population growth, urbanization, and changing transportation needs throughout district Sargodha. Increases in road networks involved the construction of new roads, the widening of existing roads, and the development of highways and expressways. These expansions aim to enhance accessibility, reduce travel times, and improve connectivity between different tehsils and areas within the district, especially the road connection of the seven tehsils with the district headquarters, Sargodha tehsil. It is witnessed that between 1993 and 2023, the road network in the Sargodha district underwent significant changes to meet the increasing demand for transportation.

Currently, the motorway touches the four tehsils of district Sargodha, including Bheera, Bhalwal tehsil, Kot Momin, and Sargodha tehsil. The Sargodha tehsil is connected through the Sial Mor interchange, the Bheera tehsil through the Bheera interchange, the Bhalwal tehsil by the Salam interchange, and the Kot Momin tehsil via the Kot Momin interchange. Due to the connection of these four tehsils with the motorway, the flow of transportation enhanced towards these tehsils, due to which the road network around these tehsils witnessed a dense network compared to the other tehsils of the district.

**Figure 4: Higher Education Institutions in Sargodha district**
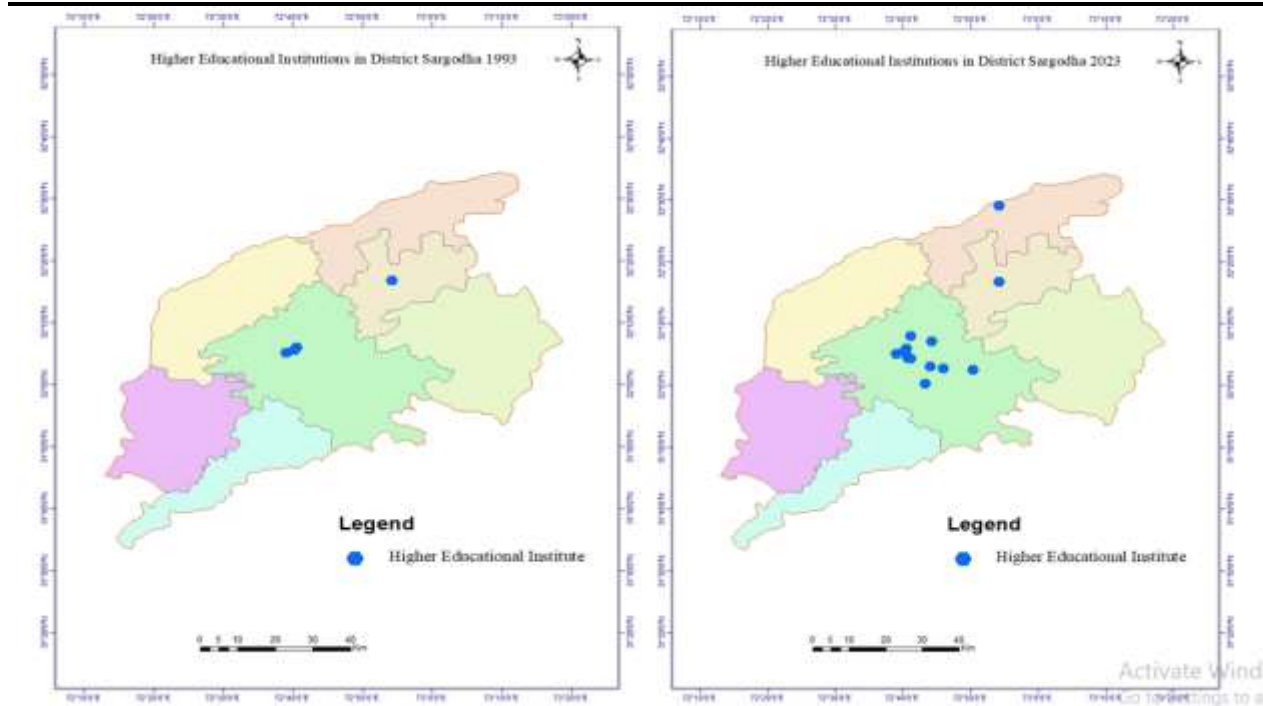


The information provided pertains to the number and distribution of higher educational institutions in the seven tehsils of Sargodha District: Sargodha Tehsil, Bhalwal Tehsil, Bheera Tehsil, Kot Momin Tehsil, Shahpur Tehsil, Sahiwal Tehsil, and Sillanwali Tehsil. In 1993, the district had only three higher educational institutions, with two located in Sargodha Tehsil and one in Bhalwal Tehsil. However, by 2023, the number of higher educational institutions had increased to 11.

Analyzing the data year-wise, there has been a significant growth in the number of higher educational institutions in Sargodha District over the studied period. This increase from three institutions in 1993 to 11 in 2023 reflects the progress and expansion of the higher education sector. The rise in educational institutions indicates improved access to education, catering to the growing demand for higher education among the district's population.

Examining the data tehsil-wise, Sargodha Tehsil witnessed substantial growth in higher educational institutions, increasing from two in 1993 to nine in 2023. It indicates a focus on educational development in the tehsil, making it a significant center for higher education. Bhalwal Tehsil maintained one higher educational institution throughout the years, showcasing consistent educational opportunities.

In contrast, the remaining tehsils, including Kot Momin, Shahpur, Sahiwal, Sillanwali, and Bheera, had limited or no higher educational institutions as of 2023. It highlights a disparity in educational infrastructure and access to higher education across the district. It suggests a need for focused efforts to promote educational development in these tehsils, ensuring equitable access to higher education opportunities for students in those areas.

The data reveals a positive trend of increasing higher educational institutions in Sargodha District, particularly in Sargodha Tehsil. However, there is room for further development, especially in the tehsils where higher educational institutions are currently lacking or limited. Bridging the educational gap across tehsils would contribute to the district's overall educational advancement and human capital development.

**Figure 5: Health Institutions in Sargodha District**
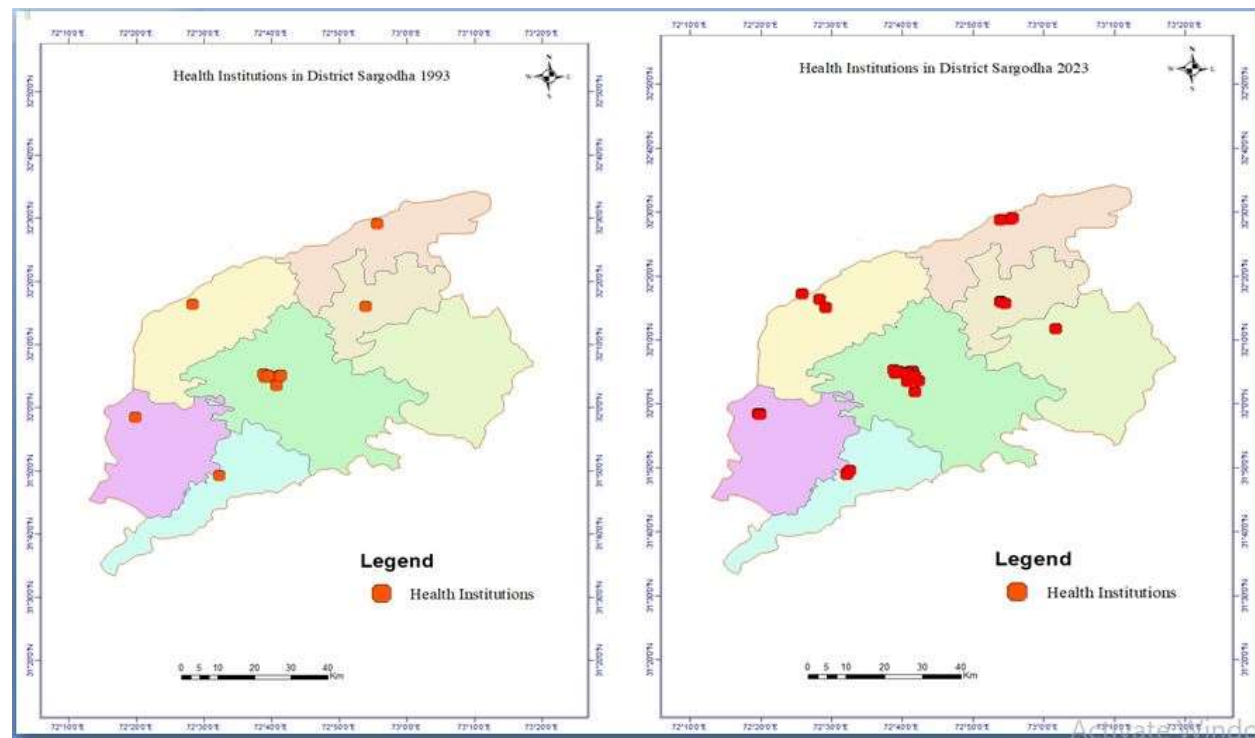


The provided statistics relate to the number and distribution of healthcare institutions in the seven tehsils of Sargodha District: Sargodha Tehsil, Bhalwal Tehsil, Bheera Tehsil, Kot Momin Tehsil, Shahpur Tehsil, Sahiwal Tehsil, and Sillanwali Tehsil. In 1993, the entire district had a total of nine healthcare institutions, with four located in Sargodha Tehsil, one each in Bhalwal Tehsil, Shahpur Tehsil, Sahiwal Tehsil, and Sillanwali Tehsil. However, by 2023, the number of healthcare institutions had increased to 19.

Analyzing the data year-wise, there has been a significant growth in the number of healthcare institutions in Sargodha District over the study period. The increase from nine institutions in 1993 to 19 in 2023 indicates the development and expansion of the healthcare sector to meet the growing healthcare needs of the population.

Examining the data tehsil-wise, Sargodha Tehsil continued to have the highest number of healthcare institutions over the years, with seven in 2023. Bhalwal Tehsil saw an increase from one institution in 1993 to two in 2023. Other tehsils such as Kot Momin, Shahpur, Sahiwal, Sillanwali, and Bheera had varying numbers of healthcare institutions in 2023, ranging from one to three.

Comparing the data tehsil-wise, it is evident that Sargodha Tehsil and Bhalwal Tehsil have consistently been centers of healthcare provision, with the highest number of institutions. The other tehsils have shown varying levels of healthcare infrastructure development, with some having fewer institutions than others.

The data reflects an overall improvement in healthcare infrastructure in Sargodha District. The increase in healthcare institutions indicates efforts to expand access to healthcare services and improve the healthcare system. However, there may still be variations in the distribution of healthcare institutions across tehsils, with certain tehsils having fewer healthcare facilities. It

highlights the need for equitable healthcare infrastructure development across all tehsils, ensuring that residents can access quality healthcare services regardless of location.

It is essential to continue monitoring and addressing the healthcare needs of the district, considering factors such as population growth, healthcare demand, and geographical distribution to ensure effective and accessible healthcare services for all residents of Sargodha District.

## Built-up Area Expansion and Built Environment

The role of built-up area expansion in the built environment is crucial and multifaceted. As urbanization continues and populations grow, the expansion of built-up areas plays a vital role in accommodating the increasing demand for housing, infrastructure, and services. It provides space for residential, commercial, and industrial developments, shaping the physical landscape and urban fabric. Built-up area expansion drives economic development by attracting investments, creating employment opportunities, and fostering business activities. It becomes a hub for economic transactions and contributes to the local and regional economy. Developing commercial zones and industrial estates within built-up areas supports various industries and services, promoting economic growth.

Infrastructure development is closely linked to built-up area expansion. Transportation networks, utilities, and public facilities are essential components of the built environment. The expansion of built-up areas necessitates the planning and developing of efficient transportation systems, utility networks, and public amenities to meet the needs of the growing population. Proper infrastructure planning ensures the smooth functioning and connectivity of urban areas. Built-up area expansion often involves the transformation of land use. Agricultural or undeveloped land may be converted into built-up areas, leading to changes in land productivity and farming practices. Careful land use planning is necessary to balance built-up expansion with preserving agricultural land and natural resources, ensuring sustainable development and minimizing the loss of valuable farmland.

The environmental impact of built-up area expansion is a significant consideration. The potential consequences are the loss of green spaces, increased energy consumption, and higher carbon emissions. However, sustainable urban planning and design strategies can mitigate these impacts. Incorporating green infrastructure, promoting energy efficiency, and preserving natural areas within built-up environments can enhance sustainability and mitigate environmental harm.

Built-up areas shape social dynamics and influence the quality of life for residents. Well-designed built environments provide community interaction, cultural activities, and access to amenities. They foster vibrant and inclusive communities by offering a mix of housing options, public spaces, recreational facilities, and services that contribute to residents' well-being and social cohesion. In summary, the expansion of built-up areas plays a vital role in urbanization, economic growth, infrastructure development, land use transformation, environmental sustainability, and social dynamics. It is essential to manage this expansion effectively through sustainable urban planning, preserving agricultural land, promoting environmental stewardship, and fostering inclusive communities to create livable and resilient built environments.

## Built-up Area Expansion in District Sargodha

Sargodha is a rapidly growing city and district in Pakistan. Over the years, it has experienced urbanization and increased built-up areas due to population growth, economic development, and infrastructure expansion. The city is known for its agricultural significance and has seen the establishment of various residential, commercial, and industrial areas to cater to the growing needs of its residents and businesses.

**Built-up Area Expansion From 1993 to 2023**
The provided information paints a clear picture of the urbanization and growth trends in Sargodha district from 1993 to 2023. Here is a summary of the key points and implications:
**Steady Urban Growth:** Over the three decades, there has been a consistent increase in the built-up area, indicating urban growth and development in the district.
**Initial Stage 1993:** In 1993, the built-up area covered 308.2 km$^2$, which accounted for 5% of the district's total area. It marked the beginning of urbanization in the district.
**Notable Growth 2003:** By 2003, the built-up area expanded to 453.6 km$^2$, representing 8% of the total area. This decade saw a significant 3% increase, reflecting the growing population and economic activities.
**Continued Expansion 2013:** 2013, the built-up area increased to 541.3 km$^2$, constituting 9% of the district's total area. It showed a 1% increase over the decade, demonstrating ongoing urbanization.
**Rapid Growth (2023):** The most significant growth occurred by 2023, with the built-up area reaching 765 km2, accounting for 13% of the district's total area. It represented a remarkable 4% increase over the last decade.
The ongoing expansion of the built-up area in Sargodha district has both favorable and adverse consequences. It indicates positive economic growth, job prospects, and enhanced infrastructure. However, it also brings concerns such as the depletion of agricultural land, heightened resource demands, and potential environmental issues.
To effectively manage this urban growth and its associated impacts, adopting sustainable land use planning and efficient land management practices is imperative. Striking a harmonious equilibrium between urban development and the conservation of natural resources is essential. This approach is vital for ensuring Sargodha district's enduring sustainability and welfare.

**Figure 6: Built-up Expansions from 1993 – 2023**
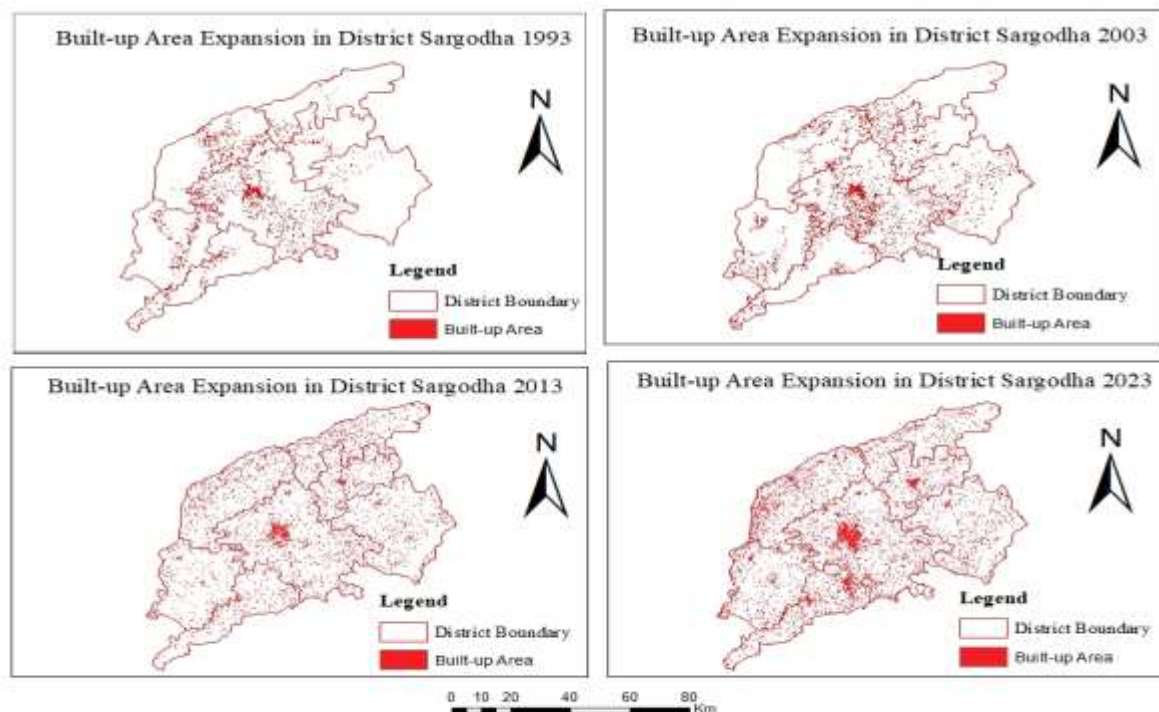
## Conclusion

The findings of this research offer a comprehensive and enlightening assessment of the evolving dynamics of built-up area change within District Sargodha, Pakistan. The intricate relationship between the expansion of built-up areas and their impact on agricultural land emerges as a central theme, providing valuable insights into the complex interplay between urbanization and rural resources. The study's temporal scope, spanning three decades from 1993 to 2023, encapsulates a significant transition period. A striking trend in the district's-built environment's physical growth emerges, characterized by substantial expansion during the study period. The proliferation of industrial units, commercial zones, transportation networks, healthcare, and educational institutions, together with a noticeable shift in population dynamics, underscores the district's trajectory towards urbanization. The expansion of built-up areas, from 308.2 km$^2$ in 1993 to a remarkable 765 km$^2$ in 2023, reflects a transformative process that reshapes the district's landscape and social structure.

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