



GIS-Based Assessment of Urban Land Regulation and Environmental Change in Shahbad City

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Abstract

The rapid urban growth has led to a continuous land-use change in Shahbad City, growth of built-up areas and pressure on environmental resources and urban infrastructure. In the present study, the management of urban growth in Shahbad has been discussed focusing on sustainable land-use regulation, control of pollution, environmental protection and spatio-temporal analysis using satellite data. The study emphasizes the problems of distribution of infrastructure, traffic congestion, environmental degradation and loss of green spaces due to unregulated expansion, ribbon development along the main transport corridors, conversion of agricultural land and the development of unauthorized settlements. Therefore a proper and effective land-use control system based on zoning, implementation of master-plans, building bylaws, urban growth boundaries and GIS based monitoring is vital to provide organised guidance on land-use development.

Other environmental issues highlighted in the study include air pollution, water pollution, solid waste, noise pollution, vegetation loss and the urban heat-island effect. There has been a significant rise in land resource pressure, and a decrease in agriculture and open land, along with a loss of vegetation and green cover, between 2000 and 2020. Environmental stress was further exacerbated by vehicular emissions, construction activities, untreated wastewater, and waste disposal and encroachment on natural drainage areas in an unscientific manner. Satellite images offer valuable insight into the small city centre, the linear development, the mixed use pattern and the incremental spreading outward into the surrounding farmland of Shahbad. The study suggests that zoning enforcement should be promoted, environmentally sensitive areas should be protected, public transport should be improved, sewage and solid waste management should be improved, green infrastructure, rainwater harvesting and community participation should be promoted. Shahabad City requires sustainable urban growth management to achieve an appropriate synergy between the economic development, the environment, social inclusion and infrastructure capacity.

Keywords: Urban Growth Management; Shahbad City; Sustainable Development; Land-Use Regulation; Pollution Control; Environmental Safeguards; Satellite Imagery



Introduction

Urban growth is one of the most important processes affecting the physical form, economic activities, social composition and environmental quality of towns and cities. Urban expansion can provide job opportunities, infrastructure, education, health and commercial services, but can also lead to land use disputes, destruction of agricultural land and ecological systems, traffic jams, strain on public facilities and services, and more. Hence, the urban growth has to be managed in a way that it becomes orderly, inclusive and environmentally friendly. Spatial and functional changes in Shahbad City have been rapid due to population growth, enhanced mobility, expansion of commercial activities and constant urbanization of land used for agricultural activities. In the process, the city has developed incrementally to encroach on the surrounding farmland. This has been significantly influenced by major road and railway routes, creating ribbon development and a clustering of residential, commercial and service facilities around transport corridors. The satellite imagery clearly shows a dense central settlement, with a surrounding area of agricultural land, open spaces, and dispersed built-up areas.

Due to rapid growth in the city of Shahbad, there is a need for effective city land use regulation. Agricultural land has been increasingly turned into residential colonies, commercial establishments and industrial pockets and the unauthorized construction and informal land subdivision have added to fragmented development. Therefore, zoning controls, master-plan provisions and even building bylaws and urban growth boundaries are crucial to manage unplanned growth. The appropriate zoning can help to keep incompatible land uses separated, provide more efficient distribution of public services and provide the proper placement of residential, commercial, industrial, institutional, and recreational uses. Urban development has also brought environmental degradation as a major effect of Shahbad. Poor air quality has been influenced by vehicular emissions, road dust, construction activity, and small industrial units and open burning of waste. The use of groundwater, untreated sewage, agricultural runoff and improper domestic wastewater disposal are stressors on water resources. As the population and commercial activities have grown, so has the amount of solid waste produced, and unscientific garbage disposal and burning have posed extra health and environmental hazards. Environmental quality has further deteriorated by noise pollution, loss of green spaces and the urban heat-island effect.

Between 2000 and 2020, the impact of urban sprawl on environmental impacts became more visible. The built-up area grew, putting pressure on land resources, while agricultural and open areas decreased and vegetation cover decreased. The trends show that protecting the environment must be an integral part of urban planning. The use of Green belts, parks, roadside plantations, ecological buffers, sewage-treatment systems and rainwater-harvesting structures, along with scientific solid-waste management will help minimize environmental stress.



New geospatial technologies offer powerful resources to track and analyse these changes. Land-use mapping, satellite-image interpretation, digital land records, environmental monitoring and monitoring systems, can aid in identifying unauthorized development, pollution hotspots, encroachments, and future growth corridors using GIS. The present study therefore investigates how urban growth management is being handled in Shahbad City with regard to land-use management, pollution control measures, environmental protection measures and the use of satellite imagery. It seeks to recommend sustainable planning strategies which can reconcile urban development and environmental protection, with infrastructure provision and enhanced quality of life.

Urban Growth Management for Sustainable Development

Due to rapid urbanization, population growth and constant land use changes, environmental balance, infrastructure capacity and sustainability issues are emerging as a big challenge for urban growth management in Shahbad city. Urban growth management is an effort that seeks to ensure development is orderly, efficient and in accordance with Sustainable Development Goals (SDGs), with SDG-11 being the ones that focus on the creation of inclusive, safe and resilient cities. Control of the growth in Shahbad is done by regulating land-use patterns through zoning, enforcing master plan guidelines, protecting environmentally sensitive areas, and promoting compact development to reduce urban sprawl. Preserving green spaces, upgrading public transit, fostering mixed-use planning and providing sufficient water, sanitation and waste management services are key strategies that help mitigate the effects of growth. Furthermore, sustainable urban development needs to include solutions for the integration of renewable energy, rainwater harvesting and the use of sustainable building materials, which will minimize ecological footprints. Building institutional capacity is also crucial, as are improving governance and ensuring participation of community members to tackle issues of unplanned construction, encroachment, and inefficient use of resources. Smart planning techniques such as GIS-based land monitoring, environmental impact assessment and growth forecasting models can help identify future challenges and support a balanced approach to development as Shahbad continues to expand outwards. In essence, sustainable urban growth management aims to reconcile economic growth with the conservation of natural environment, social inclusion and infrastructure provision for Shahbad's transformation to become a modern urban centre, while being both environmentally responsible and socio-economically viable.

Regulation of Urban Land Use

In Shahbad city, due to fast population growth, urbanization, and transformation of the agricultural land and growth of commercial activities, there is a growing demand for systematic allocation of land and controlled urban development, which is the foundation of sustainable growth management in urban areas. The unplanned growth of cities brings in more problems like settlement in unplanned areas, encroachment on public land, mismanagement in the infrastructure



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distribution system, congestion, decreasing green cover and degradation. Specific attention is given to the regulating land use in Shahbad, as the city is bound between rural and urban development and the agricultural landscapes are continuously changing into residential colonies, commercial corridors and industrial pockets. Preserving the balance, order and environmental care in this transformation is the key to land-use regulation. The key purpose is to direct the use of land for residential, commercial, industrial, institutional, transportation, recreational or ecological purposes to ensure efficient use of land yet ecological stability and socio-economic equity.

A good urban land-use regulation needs a clear framework of urban zones, enforcement of the provisions of the master plan, building bylaws and environmental norms and monitoring systems which would prevent unauthorized building. The importance of implementing the master plan in Shahbad is to prevent the development of the city in an irregular manner, particularly in the vicinity of the main transport corridors, where ribbon development has gained momentum over the last 20 years. One of the most important aspects of regulating the use of urban land is zoning, which divides land into different zones for various uses, including residential, commercial, industrial, institutional, agricultural and recreational uses. Appropriate zoning avoids inappropriate uses of land, such as incompatible industrial uses in residential areas or any pressure for commercial use in environmentally sensitive areas. Zoning controls the proliferation of unplanned colonies in and around Shahbad at its northern and southern limits where the rate of land conversion is highest. The demarcation of zones for planned residential development can guarantee provision of basic services like drainage, water supply, electricity and road connections. Commercial zoning also helps to structure markets, steer clear of "mixed use clusters", and control building heights and commercial density. Industrial zoning helps ensure polluting factories and processing units are located in designated industrial zones with suitable waste-management facility and transportation access, which helps to decrease pollution and protect public health. Institutional zoning for schools, colleges, hospitals and administrative offices promotes a more equitable distribution of public services and well-planned development around the institution.

Controlling urban sprawl, which has become a significant challenge in Shahbad, has been incorporated in the regulation, due to the lack of a proper structure in peri-urban areas. Sprawl leads to less efficient service delivery, increased commuting distance, increased infrastructure costs and loss of agricultural land. Urban growth boundaries, compact development and development in low-density areas are methods that can limit sprawl and promote efficiency in land use. Compact development promotes mixed land use, development density, walkability and utilization of existing infrastructure. In Shahbad, it is essential to have compact growth, especially around the city centre, where commercial activity is growing and space is limited. Well-designed land-use control can encourage vertical growth rather than out-of-control horizontal growth and help to minimize land use and maintain agricultural and green spaces. Protection of the environment is also a vital part of the regulation of land use. Natural resources of Shahbad are



under stress due to urbanization as farming was the main activity, there is a good amount of fertile land, canal systems, groundwater resources and vegetative cover. Regulation of encroachment is a way of protecting environmentally sensitive areas like low-lying drainage areas, water bodies, canal banks and green belts. Pollution from construction can be avoided by placing buffer zones around water bodies. The green setbacks, open space reservation and the mandatory tree plantation are a part of the regulations in the interest of ecological balance.

Environmental zoning also deters polluting or over encroaching industries and commercial enterprises on the green space. Enforcing environmental guidelines in land-use planning will help minimize environmental impacts in the long term to the extent possible in Shahbad. The informal and unauthorized development, which is a constant issue in fast-growing towns, also needs to be regulated in relation to urban land use. Illegal colonies and subdivisions of agriculture land and unregulated commercial buildings create significant problems for urban governance. These developments are frequently lacking in basic infrastructure, resulting in issues such as waterlogging, lack of sanitation, lack of good road access and unsafe construction. Formal development can be discouraged via a strengthening of enforcement controls, including regular inspections, penalties for development without permits, and a limitation on the registration of unauthorized plots. Simultaneously, a proper policy of regularization has to be followed with due care being taken to ensure social equity and not fueling the spirit of future violations. Moreover, land-use control is an important dimension of transportation planning, a critical component for orderly urban growth. Shahbad can coordinate land-use patterns with transport corridors, decrease congestion, enhance mobility, and achieve equitable access to public services. The location of roads, bus terminals, cycle paths and pedestrian zones is planned for by land-use planning. Narrow streets or residential neighbourhoods may have regulations to limit commercial activities to avoid congestion; mixed-use areas around the transport hubs can shorten travel times and enhance accessibility.

Pollution Control Measures and Environmental Safeguards

The development of the city of Shahbad has subjected the environment to a heavy burden due to the high density of population, rapid change of land use, increased built-up zones, and the increase of commercial and transportation activity, which has led to a need to implement measures for pollution control and protection of the environment as an integral part of sustainable urban management. The problems of air pollution, water contamination, solid waste accumulation, noise pollution and decreasing green space have all been growing more prominent as the city moves towards becoming more urbanized. Therefore, a critical role of pollution control is not only to comply with a regulatory requirement, but it is also a fundamental requirement to safeguard public health, environmental resilience and sustainability in the long term. The major sources of air pollution in Shahbad are vehicle emissions, road-side commercial establishments, small industrial establishments, and open burning of waste and building construction in the outskirts of Shahbad.



With the rising traffic and especially the highway close to the city the emission of particulate matter, NO_x, CO and dust has risen. Pollution control measures like better traffic control, bypass routes, stricter vehicle emission tests, use of public transport and enforcement of no-idling and no-burning policies are crucial to minimize air pollution. Promoting alternative modes of transportation, such as the use of cycle lanes and pedestrian infrastructure, can help alleviate the reliance on individual cars. Dust and particulate matter can also be trapped by green buffers along the main roads, which will also improve air quality. Another major environmental problem faced by Shahbad is water pollution.

Groundwater has been extracted to meet the ever-growing demand for domestic settlements, and this has put strains on the aquifers. Contamination is caused by untreated sewage, effluents from small industries, agricultural runoff containing pesticides and fertilizers and by the improper disposal of domestic wastewater. Pollution control measures should focus on the construction and operation of sewage treatment systems, storm water drains and decentralized wastewater management systems to address these challenges. Effective measures such as controlling industrial effluent, ensuring effluent treatment standards and implementing monitoring systems for groundwater quality are critical protections. Buffer zones should be implemented and development should be limited around natural drainage channels to prevent sewage from entering canal systems or local ponds. Residential colonies, public structures, commercial complexes may implement rainwater harvesting systems to reduce stress on existing water resources and replenish groundwater. Implementing permeable pavement, detention ponds, and green roofs in urban design also helps to improve the hydrological cycles and decreases runoff pollution.

Solid waste management is another significant field that needs protection from the environment. The population and commercial activities in Shahbad have led to growing amounts of Municipal Waste (HWMP, PWMP, MWMP, and CDW). Unscientific dumping at open sites, along road sides, littering and burning of waste increase air and soil pollution and make the environment unhygienic. To effectively control pollution, it is necessary to set up an integrated solid waste management system comprising door to door collection, segregation of biodegradable and non-biodegradable waste, recycling units, designated waste disposal locations. Awareness initiatives within the community that promote separation at source and reduce the use of single-use plastics play a crucial role in waste management initiatives. Encourage community based composting units and/or composting pits at home. Dumping and burning of waste must be prevented to protect the environment. Further, there are opportunities for strengthening the overall system through partnerships with private organizations for the transport and recycling of waste. The increasing urbanization in the town of Shahbad has made noise pollution one of its less noticed but glaring problems. Road traffic, traffic noise in commercial areas, construction work, industrial equipment in peri-urban regions and noise from loudspeakers at social occasions are all sources of noise. Stronger application of noise regulations, establishment of silence zones in schools, hospitals and



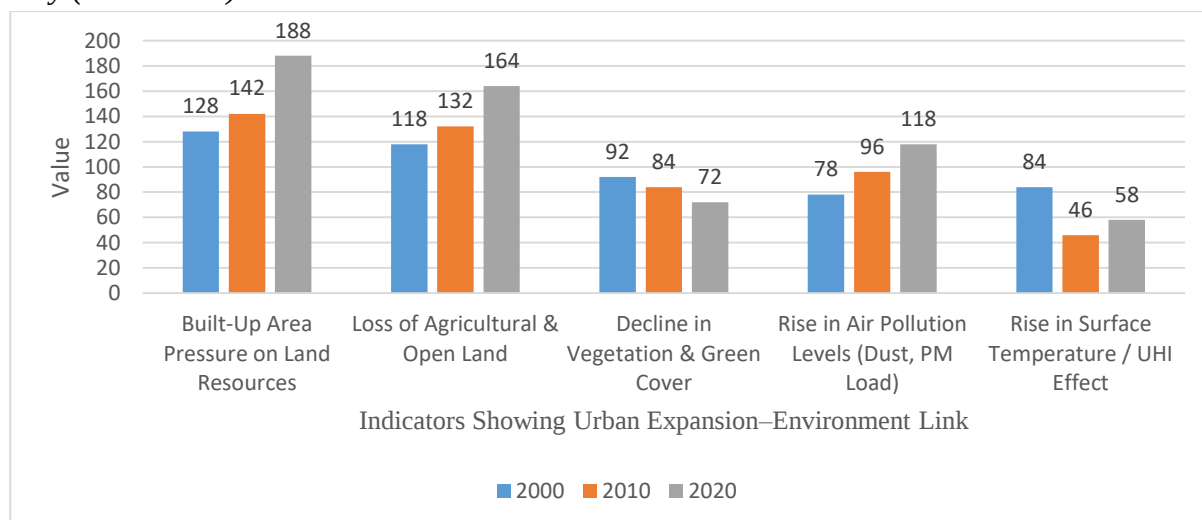
residential areas, and prohibition of unauthorized use of loudspeakers are necessary in order to reduce noise pollution in the environment. Roadside commercial activities workshops, repair shops and transport depots must meet the noise standard by adopting sound absorbing materials or by moving them to designated commercial areas. Urban greenery also helps to absorb noise and decrease acoustic pollution, thus highlighting the importance of protecting and increasing green cover.

Table 1: Relationship Between Urban Expansion and Environmental Degradation in Shahbad City (2000–2020)

Indicators Showing Urban Expansion–Environment Link	2000	2010	2020
Built-Up Area Pressure on Land Resources	128	142	188
Loss of Agricultural & Open Land	118	132	164
Decline in Vegetation & Green Cover	92	84	72
Rise in Air Pollution Levels (Dust, PM Load)	78	96	118
Rise in Surface Temperature / UHI Effect	84	46	58

Source: Primary data

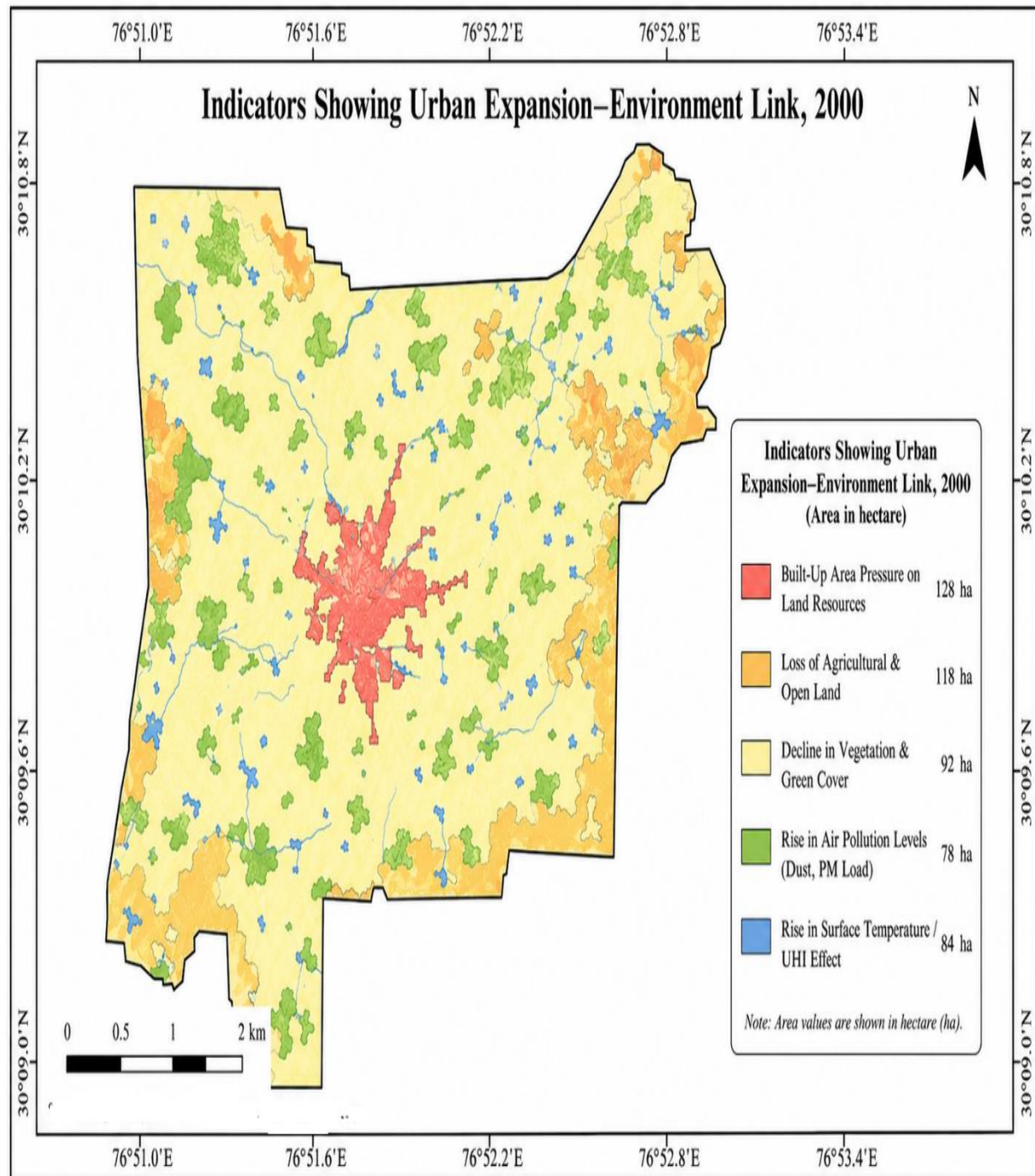
Figure 1: Relationship Between Urban Expansion and Environmental Degradation in Shahbad City (2000–2020)



Source: Table 4.3



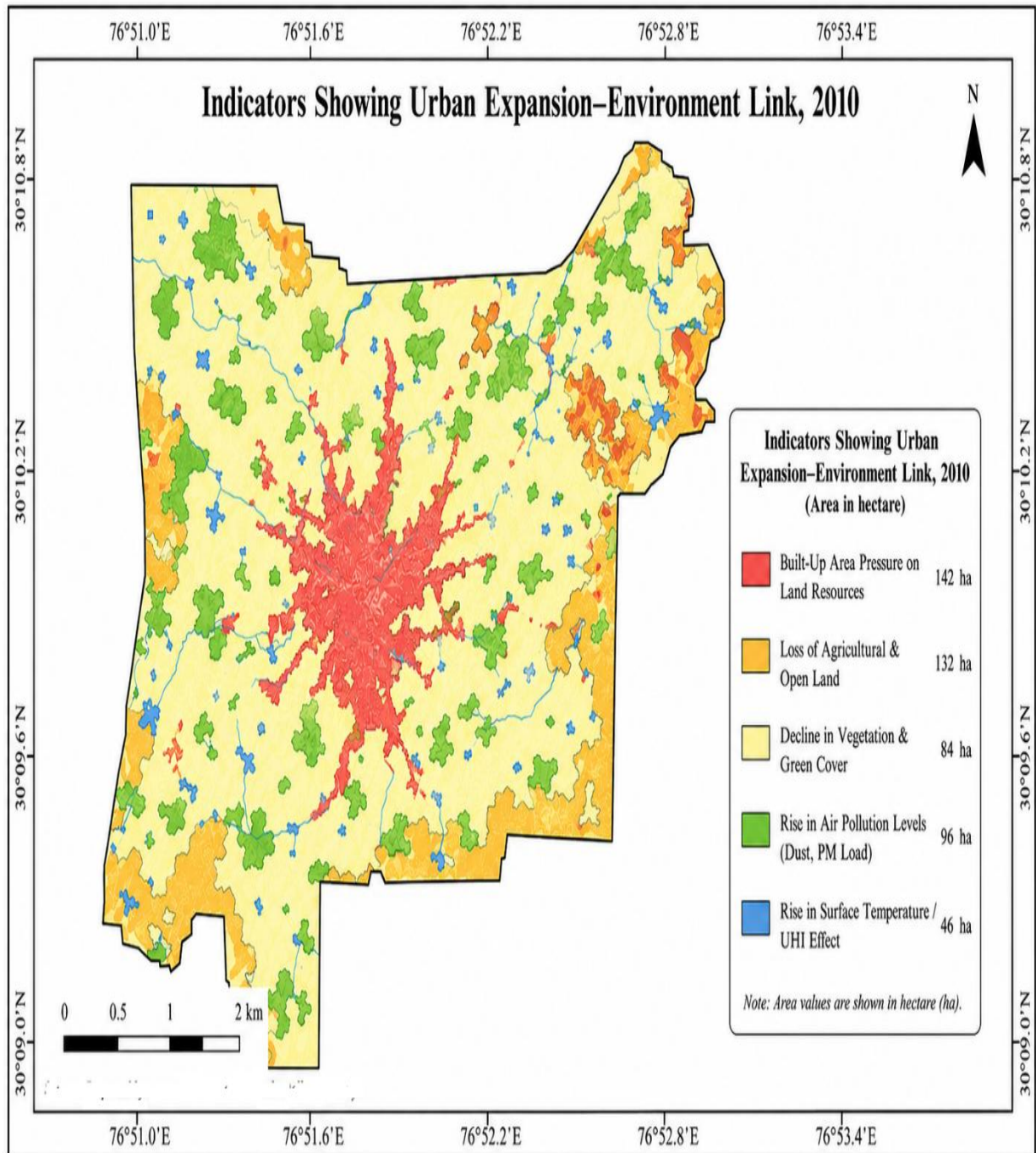
Map 4.7: Relationship Between Urban Expansion and Environmental Degradation in Shahbad City 2000.



Source: The researcher has done this research work with the help of QGIS.



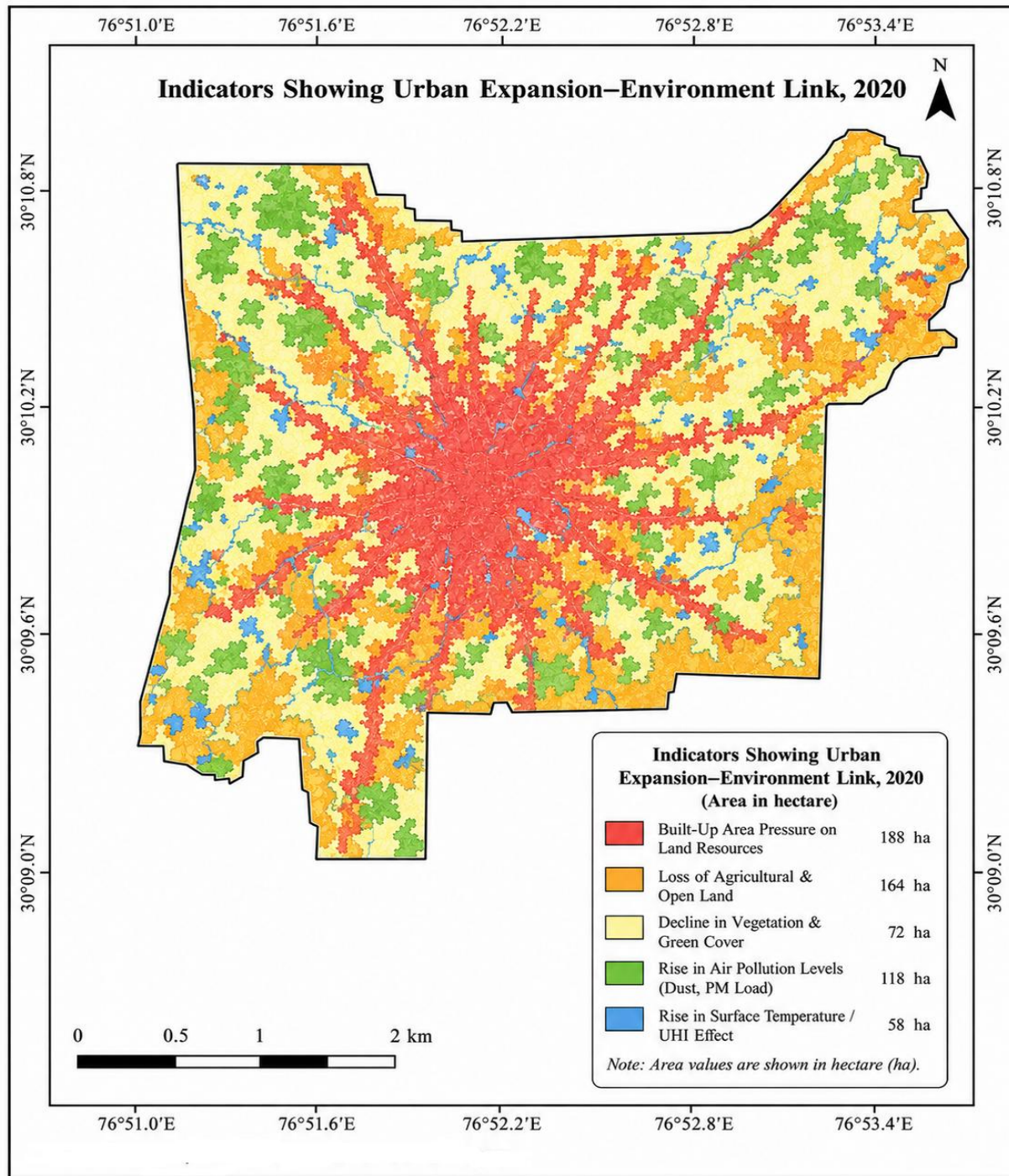
Map 4.8: Relationship Between Urban Expansion and Environmental Degradation in Shahbad City 2010.



Source: The researcher has done this research work with the help of QGIS.



Map 4.9: Relationship Between Urban Expansion and Environmental Degradation in Shahbad City 2020.



Source: The researcher has done this research work with the help of QGIS.



The figures in Table 4.3 clearly show how fast the urbanization process has taken place in Shahbad City from 2000 to 2020, which has led to an increased rate of environmental degradation in the city. The data shows that with the expansion of the built-up area of the city, the pressure on land resources is constantly rising, from 128 in 2000, 142 in 2010 and 188 in 2020. The rising trend indicates the significant amount of land, particularly at urban fringes, that has been utilised for residential colonies, commercial land use and infrastructure development. Consequently the level of agricultural land and open spaces has steadily reduced, rising from 118 in 2000 to 132 in 2010, and to 164 in 2020. This represents the large scale transformations of land use associated with population growth, development and sprawl along corridors, which has resulted in the decrease in arable areas and natural open spaces that previously helped sustain ecological balance. Reduction in vegetation and green cover is also a serious environmental issue.

In the period 2000-2010-2020, the green cover index has been reduced from 92 to 84 to 72 respectively, which is a significant loss of trees, green belts and natural vegetation due to continuous construction activity. This reduction reduces ecological functions in the city including air purification, temperature control and recharging of groundwater resources, leaving the city more susceptible to environmental stress. Consequently, the dust and particulate matter loading in air quality has increased significantly between 2000 and 2020, from 78 in 2000 to 118 in 2020. This increase is closely correlated with increased traffic volumes, construction dust, more vehicles and a reduction in natural cover that might have buffered against the effects. With the expansion of built-up areas along the main routes, the absence of adequate emission control measures also contributes to worsening air quality.

Surface temperature increase (SIR) as a measure of the Urban Heat Island (UHI) shows a varying but informative trend. It begins at 84 in 2000, dips to 46 in 2010 and then rises again to 58 by 2020. The first drop could be related to a moderate development density or favorable environmental conditions during 2010, while the second rise is due to the increase in the concentration of concrete surfaces, decrease of green surfaces and ongoing built-up area density. These conditions create heat trapping and hamper natural cooling, resulting in easily discernible temperature rises, particularly in central and emerging urban centers.

In conclusion, it is clear that the urban expansion of Shahbad City has impacted the environment negatively and significantly, as presented in Table 4.3. Concomitant to this built up growth, there has been parallel reduction in the land area used for agriculture, in areas of green cover and ecological space, and an increase in air pollution and local temperature increase. The data underlines the need for strategies for sustainable development, green infrastructure planning, pollution mitigations, and land use regulations to bring the environment back into balance, and to prevent further degradation of ecological health by future urban growth.

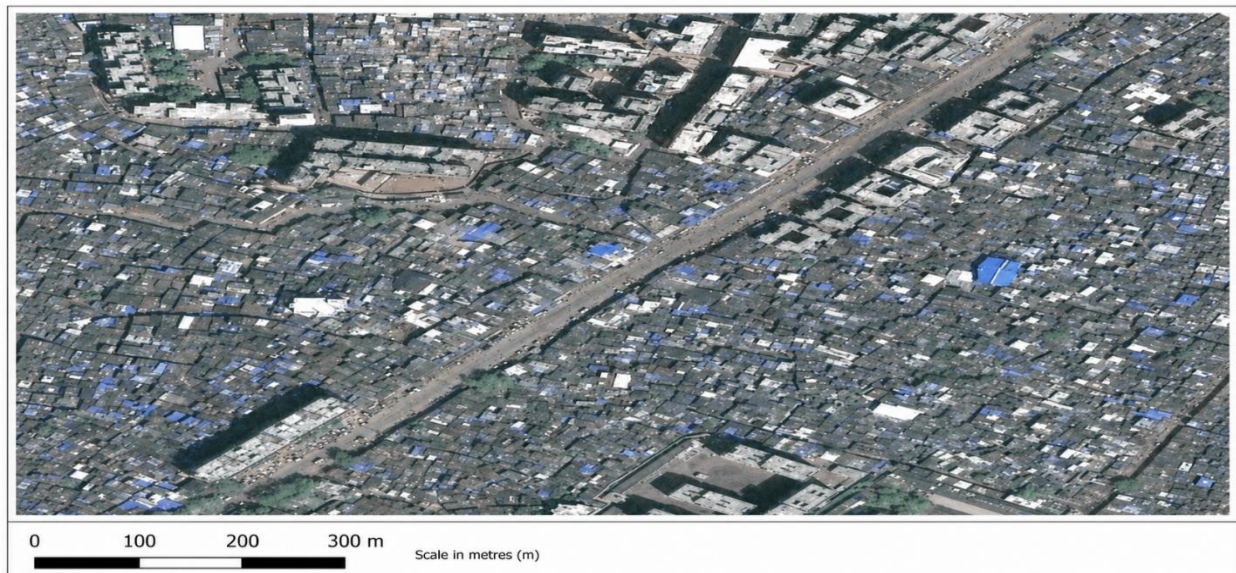


Shahbad satellite

The satellite image of Shahbad gives a good visual understanding about spatial structure, urban expansion and physical environment of the study area. The location, built-up area, agriculture, road network, water bodies and surrounding rural land use of Shahbad can be analysed more accurately by using satellite imagery. Shahbad is an important urban centre of Kurukshetra district of Haryana and the satellite view reveals the predominately agricultural nature of the surroundings of the town. The built-up area is predominantly focused at the central area of the town where the residential colonies, markets, administrative buildings, educational institutions and transport and related activities are concentrated. The satellite image also highlights the importance of transport connectivity in the growth of Shahbad. The town's urban landscape has been influenced by significant roads and railway lines that run through and around the town. Urban development tends to occur along these transport corridors as they make it easier to access and more convenient locations for residential, commercial and service activities. This has led to the gradual expansion of the built-up area of Shahbad away from the older core of the town and into the surrounding villages and agricultural open spaces. The other prominent feature seen in the satellite image is the predominance of agricultural land on the periphery of the urban area. The area around it is a fertile plain, suitable for intensive farming. Large open fields can be seen around the settlement where agriculture used to be carried out. This indicates that the rural-urban dichotomy still exists and urban development is occurring and interacting closely with the rural agriculture sector.

Other features such as water bodies, drainage channels, open space and vegetation patches may be interpreted from images as well. This type of visual information is valuable for research on environmental change, urban growth and stress on natural resources.

Image 4.1: *Shahbad satellite*





The provided satellite image shows an urban area known as Shahbad and indicates a compact urban form. The image shows a dense urban area with buildings and structures in the foreground, indicating a high level of development and urbanization. The rooftops, narrow streets and concentrated buildings suggest that Shahbad has a dense urban centre with high population density and land use. This is a relatively small form of settlement structure, often found in older cities where houses, markets, small-scale commercial businesses and public institutions are clustered together. One of the primary transport routes can be seen going across the image diagonally. This road is an important axis of urban development in Shahbad. This line is well aligned with urban development, highlighting the importance of transport links in the development of the town. Roads make it easier to access and promote shops, services, institutions and residential colonies to both sides of the road. Chances are that this has led to Shahbad's urban sprawl being corridor-like, leaving development to creep out from the core of the main road network.

There is also a combination of 'urban' land use. This density of residential character takes up a significant fraction of the settlement, with some larger building blocks and open compounds suggesting institutional, commercial or service related uses. The blue and white roofs indicate modern building and commercial and/or semi-industrial buildings in parts of the town. There is also some degree of urbanisation in the image with small open spaces between built up patches. Geographically, the satellite image reveals that Shahbad is not just a residential community, but also a developing urban centre that serves as a hub for both services and transportation. The buildings are closely packed, and the road connections and extension of the main road are suggesting continual urban development. This expansion may result in increased land pressure, drainage, traffic flow, loss of open space and basic city facilities. Hence, the satellite image can be helpful to understand the spatial growth, land-use pattern and urban development trend of Shahbad.

Conclusion

The study shows that the fast growing urban sprawl in Shahbad City has changed its spatial structure, environmental conditions and land-use. The population has grown, transportation networks have been extended into the surrounding area, commercial development and a growing need for housing have made it attractive to expand beyond the traditional urban core. Much of this growth has been along major roads and railways, leading to the ribbon development, mixed land use and gradual urbanisation of surrounding agricultural land. Inappropriate land use and fragmentary development have posed some urban-management problems. The lack of planning and regulatory enforcement is reflected in the presence of unauthorised colonies, incompatible land uses, infrastructure gaps and encroachment on agricultural and environmentally sensitive lands. To prevent unplanned sprawl, effective zoning, enforcement of master plan provisions, building bylaws and urban growth boundaries need to be implemented. Where possible, compact



development and vertical growth should be promoted to minimize unnecessary land use, and preserve agricultural and green spaces.

Urban development has also worsened environmental problems in Shahbad. Air pollution has been caused by increased traffic, construction dust and waste burning and by commercial activities. Sewage, groundwater extraction, agricultural runoff and improper disposal of wastewater has impacted water resources. Accumulation of solid waste; noise pollution; reduction of vegetation and the creation of impervious surfaces have added to ecological stress. Loss of agricultural land, open spaces and green cover has led to the decrease in the groundwater recharge, natural cooling and environmental resilience. The integrated pollution-control measures and environmental protection are thus necessary for sustainable urban management. Sewage-treatment systems, scientific solid-waste management, rain water harvesting, monitoring and protection of canals, ponds and drainage channels should be given priority.

Urban parks and ecological buffers, green belts and roadside plantations should be established to enhance air quality, lower surface temperatures, and promote biodiversity. The use of public transportation, cycle tracks and pedestrian facilities can also help to decrease traffic congestion and vehicle emissions. Satellite imagery and GIS based monitoring should be part of the future planning framework of Shahbad. To help monitor land use change, detect encroachments, identify pollution hotspots and predict future urban expansion. However, effective implementation requires the participation of the community, raising awareness, and coordinating between planning authorities, municipal bodies and environmental agencies. In conclusion, the economic and social development of Shahbad has to be balanced with protection of the environment. This will enhance the residents' lifestyle and conserve the natural and agricultural resource environment around Shahbad City.

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