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Mapping and Analysis of Landfilling Change Using Remote Sensing and GIS: A Case Study on the Goran Chatbari Ponding Area in Bangladesh

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Abstract: *This study uses satellite imagery to illustrate the landfilling and urban development in Greater Dhaka in the Goran Chatbari Ponding Area in Bangladesh from 2012 to 2018. One of the cities with the greatest rate of growth is Dhaka. This city has a lot of unplanned areas. The main objective of this study is to evaluate how landfilling has changed in one area of Dhaka City in order to foresee what the city's future may hold. Megacity Dhaka has faced several challenges, including unexpected urbanization, congested traffic, water sorting, etc. With the utilization of Geographic Information Systems (GIS) and remote sensing techniques, the computation and analysis of land-filling area is carried out. Time series (2012, 2014, 2016, 2017, and 2018) The Google Earth platform has been used to detect the dynamics of landfills and the changes in land use and land cover, and its adjacent areas. The results of the study indicate that the growth of the population significantly influences the practice of landfilling. There is no landfilling area found in the year 2012 and 2014. The development works and the landfilling area was observed in 2016. The landfill area was about 18 acres, meaning the ponding area was reduced to 597 acres. The ponding area was reduced in the subsequent year by increasing the landfilling area. 27 acres of land have been filled in the research area observed in the satellite image of the year 2017. This indicates the reduction of the ponding area to 588 acres. In 2018, the ponding area decreased by 584 acres which indicates an increase in the landfilling area to 31 acres. The practice of landfilling, as well as changes in land use and land cover, are important issues that damage biodiversity and have an effect on human life. This type of investigative inquiry has the potential to transform Dhaka into a far more civilized and intentional metropolis in the near future.*

Keywords: Biodiversity, GIS, Landfilling, Remote Sensing, Satellite Images, Unplanned Urbanization

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1. Introduction

Dhaka, the capital city of Bangladesh, is recognized as one of the ten megacities globally accommodating over 15 million people in an area of 1624 square kilometers. It is predicted that the population may increase to about 26 million by 2035. Being the administrative and commercial center, Dhaka is getting crowded from all over the country. The loss of farmland due to urbanization is a major "anthropogenic cause"(Lopez, et.al, 2001), habitat destruction (Alphan, 2003), and the decrease of natural vegetation coverage. Development is turning rural areas are experiencing a significant influx of population migrating to urban centers at a rapid pace. that has never been seen before in the context of contemporary human history. The phenomenon described is significantly influencing the natural functioning of ecosystems (Turner, 1994). Urban areas only make up 3% of the geographical area on Earth, yet they have a significant impact on local and global environmental conditions, including climate change (Herold, Goldstein, and Clarke, 2003; Liu and Lathrop, 2002, Grimm, et.al. 2000). Since human actions have a big effect on ecosystems in urban areas, a lot more attention is now being paid to keeping monitoring and documenting alterations in land use and land cover within urban areas (Stow and Chen, 2002). The significance of such studies is in their ability to elucidate the impact of diverse human activities on the ecological well-being of urban environments through the analysis of spatial characteristics pertaining to land use and land cover (Yeh and Li, 1999). The alteration of existing land uses and the emergence of new land covers as a direct result of human activities is now moving at a faster pace in emerging countries than in industrialized nations, and it is anticipated that by the year 2020, the majority of the world's megacities is going to be located in emerging countries and regions (World Bank, 2007). Growing urban populations in emerging countries have accelerated environmental degradation by causing fast alterations in land utilization and coverage. (Holdgate, 1993). Considering the projected global

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urban population growth, it is anticipated that the number of individuals residing in urban areas will nearly double by the year 2050, the impact of the population is very important (UN, 2008).

Over the past few decades, Bangladesh's urban population has grown significantly. In 1981, there were 14.1 million people living in Bangladesh's cities; in 1991, there were 22.5 million; in 2001, there were 31.1 million; and in 2005 (BBS, 2001), there were 35 million (CUS, NIPORT, and MEASURE, 2006). Rapid urbanization has turned rural areas into built-up areas, and it is thought that more than 809 km square of farmland is turned into towns, roads, and other infrastructure every year (BBS, 1996). The biggest part of Bangladesh's economy is agriculture. When that part of the economy shrinks, so does the amount of land that can be farmed. The aforementioned circumstances may result in the occurrence of land deprivation, insufficiency in food supply, as well as economic challenges. (Ahmad, 2005). According to World Bank estimates from 2007, According to their projections, Dhaka, the capital of Bangladesh, is expected to attain the status of the third-largest metropolis globally by the year 2020. It has also experienced one of the most significant transformations globally rapid rates of urban growth (World Bank, 2007, Islam, 1999, 2005). A significant portion of the city can now be flooded with just one hour of rain due to the state of the drainage system. City dwellers are at risk as the monsoon season approaches. The government entities involved are still striving to tackle the capital's biggest drainage challenges. Though sufficient areas such as a water retention pond are necessary for reducing drainage congestion, the retention areas of the western part of Dhaka are reducing fast due to unavoidable circumstances. The 1950s saw moderate urban growth in Dhaka, but the 1971 declaration of Bangladesh's independence was followed by rapid growth. (Chowdhury and Faruqui, 1989). The phenomenon of rural-to-urban migration on a significant scale has resulted in a notable increase in the pace of urbanization and is thought to have caused significant growth in Dhaka's population (Islam, 1996). To yet, relatively little attention has been paid to Dhaka's sustainability of the social and economic environment, which is critical for coordinating development. This has resulted in numerous environmental concerns throughout the city, primarily as a result of unplanned urbanization, widespread urban poverty, recurring bouts of flooding, the significant increase of slums, resource exploitation, and mismanagement of limited land resources. (Hasan and Mulamoottil, 1994).

To reduce the drainage congestion in Dhaka City, the government of Bangladesh has taken initiatives over time and constructed three retention ponds in Kallyanpur, Goran Chatbari, and Dholaikhal. It is important to assess the condition of those retention ponds as many development works are going on which may affect the size of the retention ponds. The government of Bangladesh has taken an initiative, 40 acres of land used for the construction of the Dhaka Elevated Expressway at Goran Chatbari ponding area. The government will use this land for the construction of buildings and relevant resettlement facilities.

Applications of remote sensing (RS) and geographic information system (GIS) technologies include the detection and monitoring of dynamic changes in the physical environment. (Andrea et at., 2001; Ahmed, 2002; Stabel and Loffler, 2004; Twumasi and Merem, 2006; Islam, 2009a). GIS and RS are excellent and powerful tools for studying the geographical and temporal dynamics of LULC. (Hathout, 2002; Herold et al., 2003; Lambin, Geist, and Lepers, 2003; Serrea et al., 2008). Remote sensing data provides extensive multi-temporal information regarding land use and land cover (LULC) change processes and patterns. Geographic Information Systems (GIS) offer valuable advantages in terms of mapping and analyzing these changes. (Zhang et al., 2002). Remote Sensing is highly excellent at depicting the relationships between people and their urban environment (Gatrell and Jensen, 2008). The utilization of space-borne satellite data is particularly advantageous for impoverished countries due to the cost and time constraints associated with traditional survey methods (Dong, Forster, and Ticehurst, 1997). These tools have emerged as viable alternatives to conventional survey methodologies and terrestrial approaches for urban cartography. (Jensen, et.al., 2004). Multiple research studies have demonstrated the potential of remote sensing (RS) in enhancing information acquisition and facilitating decision-making processes across various urban contexts. (Gatrell and Jensen, 2008; Jensen and Cowen, 1999; Zeilhofer and Topanotti, 2008).

2. Aim and Objectives

The primary goal of this study is to use time series satellite imagery from 2012 to 2018 to track the dynamics of the Goran Chatbari Ponding area's landfilling area. In order to fulfill the general goal of this study, a specific objective is:

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- Using remote sensing techniques, the primary goal of this study is to evaluate and estimate the size of the Goran Chatbari retention pond area in light of landfilling.

3. Study Area

The study area, which includes four mouzas (small administrative units) named Baunia, Boro Kakor, Degun, and Goran Chatbari, is situated on the northwest side of Dhaka North City Corporation (Figure 1).

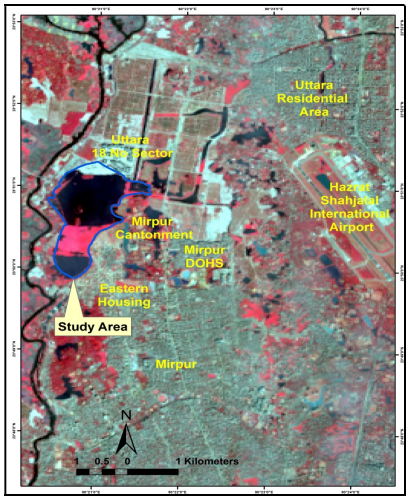


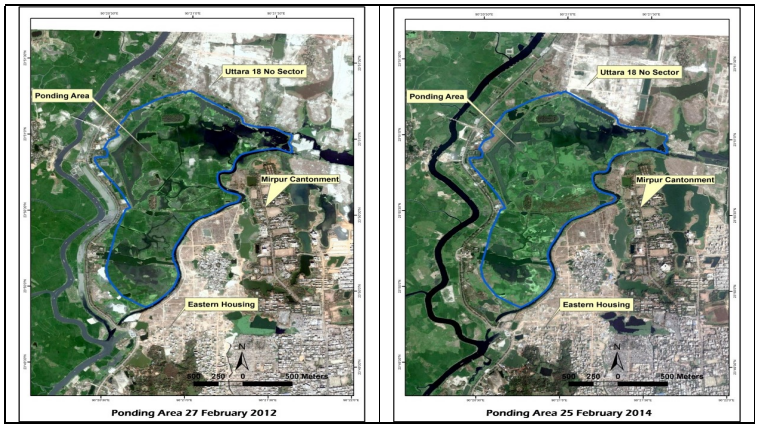
Figure 1: The Location of the Research Area

4. Data and Methods

The primary data source for this study is a Google Earth platform image. Time series (2012, 2014, 2016, 2017, and 2018). Images from the Google Earth platform have been utilized to analyze landfill dynamics, land use, and cover change in the surrounding areas (figure. 2). The information and data obtained from many sources are subjected to analysis utilizing various methodologies through the utilization of Geographic Information Systems (GIS) and Remote Sensing (RS) software. Subsequently, the images underwent a process of geo-referencing in order to establish a uniform projection system. Additionally, geo-referenced images were co-registered using Ground Control Points (GCPs) to avoid distortion from one image to another. Then, the ponding area and landfilling were delineated using the ArcGIS tool for the years 2012, 2014, 2016, 2017, and 2018. In addition, the effect of construction on the study area was evaluated by analyzing the shift in the ponding area. Simultaneously, the landfilling area was estimated.

5. Results and Discussion

It was observed from the satellite image of 2012 that the total ponding area is 615 acres when there were no visible development works for land development within the study area (Figure 2). A similar condition was found in 2014 when no landfilling works started (Figure 3).



Source: Google earth platform, compiled by the author. Figures 2 and 3: Ponding area in the study area in 2012 and 2014

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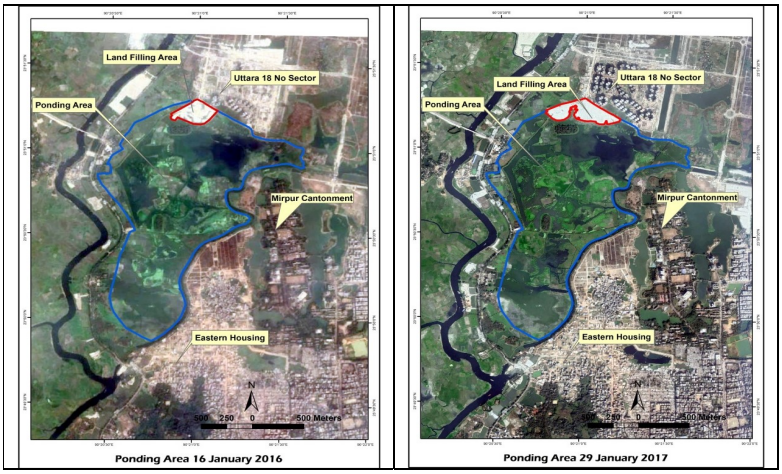
However, the development works/landfilling area was observed in 2016. The landfill area was about 18 acres, meaning the ponding area was reduced to 597 acres (Figure 4).

The ponding was reduced in the subsequent year by increasing the landfilling area. The land filled in the study area is 27 acres which was observed in the satellite image of the year 2017 (27 January 2017). This indicates the reduction of the ponding area to 588 acres (Figure 5). In 2018, the ponding area decreased by 584 acres which indicates that the increase in landfilling area was 31 acres (Figure 6). The reduction of the ponding area as well as the increase of the development works is presented in Figure 7.



Source: Google earth platform, compiled by the author.
Figures 4 and 5: The status of the land development in early 2016 and 2017

One of the world's biggest megacities is Dhaka. Population pressures are increasing day by day in this city. Water bodies and other bare landfilling day by day. Urbanization also increases year after year in an unplanned way. A parcel of land is typically modified when its usage changes. This shift is driven by needs, which not just changing the land need cover but also its intensity and management (Verburg *et al*. 2000). Changes in land use and cover are important factors that affect human lives and harm biodiversity. One of the megacities with the fastest population growth today is Dhaka. Dhaka has faced numerous challenges in recent years, including unplanned urbanization, pervasive urban poverty, water logging, the growth of squatter settlements and urban slums, traffic congestion, environmental pollution, and other socioeconomic issues.

Source: Google earth platform, compiled by author. Figure 6: The status of land development in early 2018.

Ecosystem services support human well-being. In this study, it was observed that the ponding area of the study area is decreasing year after year which is very dangerous for the local biodiversity.

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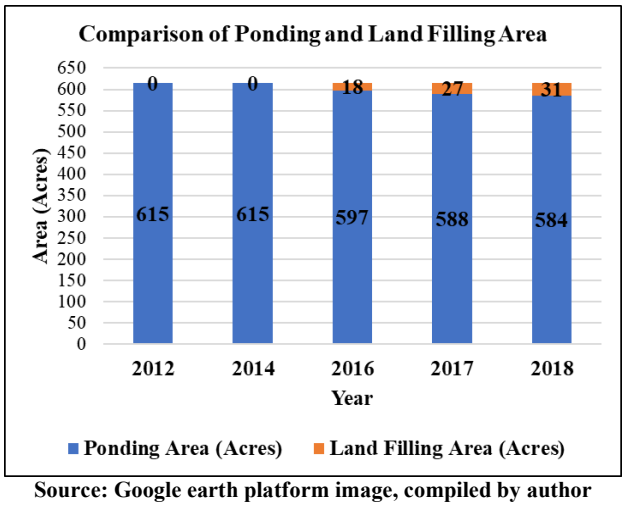

Source: Google earth platform image, compiled by author

Figure 7: Change of ponding and landfill area in the last 6 years in the Goran Chatbari area

Rapid urbanization is primarily caused by population expansion, yet other reasons including economic progress and environmental changes also play a role in this ambiguous situation.

Landfilling Impact on Surrounding Environment

Environmental, biological, and social effects of landfilling can be felt in nearby wetlands and other locations. Wetlands are important ecosystems that offer a variety of ecological services, such as carbon sequestration, water purification, habitat for wildlife, and flood control. The following negative consequences may result from landfilling in certain areas:

- **Destruction of Habitat:** The practice of dumping waste in landfills causes the natural habitat of wetland species, such as plants, animals, and microorganisms, to be lost. Because many species found in wetland ecosystems are unique and adapted to their particular environment, the variety of wetland ecosystems is in danger of being lost.
- **Pollution of Water:** Landfills are a major contributor to water pollution because they produce leachate, which is a poisonous liquid that is created when rainfall percolates through debris. This leachate has the potential to contain a wide variety of potentially toxic elements, including heavy metals, organic contaminants, and poisonous compounds. It has the potential to contaminate groundwater as well as any adjacent bodies of water, which will have an effect on the aquatic life there as well as put the health of the people who rely on these water sources at risk.
- **Air Pollution:** Landfills are a major contributor to air pollution because the anaerobic breakdown of organic waste produces methane gas. The release of methane into the atmosphere is one of the most significant contributors to climate change. In addition to methane, landfills can leak a variety of other noxious and potentially dangerous gases, which can have an effect on the air quality in the areas that are located nearby.
- **Wetland Drainage and Alteration:** Landfill construction frequently necessitates draining and filling portions of the wetland. Altering water flow and perhaps triggering floods in neighboring areas or reducing the wetland's capacity to serve as a storm buffer, might throw off normal hydrological processes.
- **Ecological Disturbance:** The building and maintenance of landfills can cause ecological disturbances by disturbing the soil and introducing species that are not native to the area. This has the additional effect of disrupting the natural balance and functionality of the wetland environment.
- **Land Subsidence and Instability:** As garbage decomposes and settles, land subsidence may occur, resulting in uneven terrain and potentially causing structural damage to neighboring buildings and other nearby infrastructure.

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- **Impact on Culture and Society:** Landfills may have a social impact on the neighborhood. They might experience problems with property prices, possible health hazards, and general societal well-being.
- **Loss of Wetland Services:** Wetlands are important for maintaining ecological functions like carbon sequestration, flood control, and water purification. These essential services are lost when they are filled and damaged, which has an impact on the region's overall ability to adapt to environmental changes.

Prioritizing waste management strategies that concentrate on waste reduction, recycling, and environmentally responsible waste disposal practices away from ecologically sensitive places is essential to reducing the detrimental effects of landfilling in wetlands and the surrounding area. In order to preserve and improve wetland ecosystems for the benefit of the environment and communities that depend on them, conservation and restoration activities can also be extremely important.

6. Conclusion

Existing wetlands transform into concrete structural development which badly impacts on ecological balance and scenic beauty of Dhaka city. Due to unplanned urbanization and industrialization environmental pollution has significantly negatively impacted on ecosystem service of this city. This study presents the changes in the ponding and landfilling area at Goran Chat Bari in the last six years. The results from satellite image analysis indicate that the ponding area has been reduced to 584 acres, which was 615 acres. Simultaneously, the extent of the landfill area was roughly 31 acres for the development works in the last four years. Findings from studies like this will be useful in making strategic decisions about the city's layout. Based on the findings of this study, policymakers and urban planners can implement effective solutions. Dhaka has the potential to become a far more civilized and intentional city with the help of this type of investigative inquiry.

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AUTHORS CONTRIBUTION

In addition to taking the lead in authoring the manuscript, **Mohammad Sujoun Lasker** contributed to the ideation, design, and implementation of the study as well as the outcomes analysis. **Feroze Ahmed Kanak** engaged in the planning of the study, helped collect data, and helped write the report. The final manuscript was read and approved by the authors. **Md. Ariful Alam Qurishi** helped in writing literature review.