

Land Use Pattern Alteration Due to Rapid and Unregulated Urbanization: A Geospatial Study of Khulna City and Surroundings

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Abstract: Rapid urbanization in Khulna city and surroundings has significantly changed the land use patterns. Based on remote sensing data and applying the QGIS technique, the present analysis is focused on the comprehensive mapping of the 1991 and 2020 land-use in Khulna to derive information on land-use patterns that change over 30 years to determine the changes in the urban or settlement coverage. This information is very useful for planning and managing future urban expansion and development in the study area.

Keywords: Land use, Khulna, Sentinel-2, QGIS.

Introduction

Khulna is located in the southwestern coastal region of Bangladesh, along the banks of the Rupsha and Bhairab rivers. A lot of people from the surrounding coastal areas of Bangladesh have had to leave their homes and move to adjacent cities including Khulna, due to the combined effects of coastal erosion, salinity intrusion and climate change.

These environmental challenges exert pressure on land resources which leads to rapid and unregulated urbanization. As a result, it becomes necessary to create a land use classification map to monitor the rate or pattern of urban and settlement growth, manage the growing demands on land, water, and the environment, and make geologically sound land-use decisions (Afrin et al., 2022). The overall objective of this analysis is the comprehensive mapping of 1991 and 2020 images of the study area to monitor land-use class change over 30 years and find out the urban or settlement growth patterns.

Methodology

Freely available optical satellite data is used for the mapping of land use. The USGS Landsat TM (level-2) data was downloaded from USGS Earth Explorer (Landsat TM, 1990) and Sentinel-2 data from Copernicus Browser (Sentinel-2 data, 2020). The image processing was done using SNAP and QGIS software and a supervised classification method applied for the

mapping. The SVM (Support Vector Machine) tool was selected to perform the supervised classification. To check the accuracy of the maps from remote sensing data, ground truthing was conducted by waypoint mapping using 'KoBoCollect' mobile app software during field investigations.

The workflow of the classification is visualized in Figure 1. Both Landsat TM and the Sentinel-2 satellite images of 1991 and 2020 classify the land use pattern to assess the spatial coverage and growth pattern of urban or settlement areas.

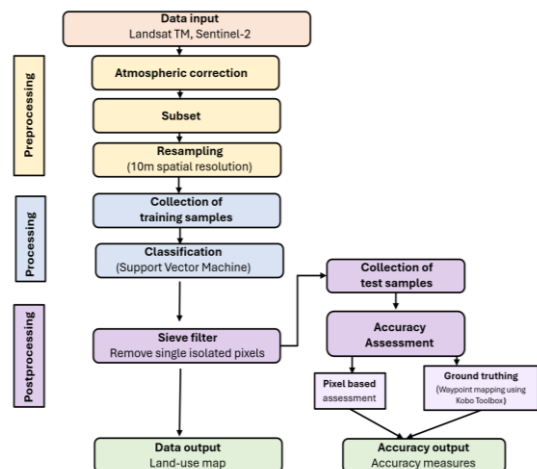


Figure 1, Workflow of the land-use classification.

Results and discussion

Both Sentinel-2 and Landsat TM satellite images classify the whole area into five classes, namely water, urban, agriculture, bare soil and rural settlement (Figure 2).

All types of water are included in the 'water' class (blue). Urban areas (pink) included buildings, roads etc. Rural settlement (deep green) incorporates villages with tree coverage. All the vegetables and croplands are in agriculture class (light green). Open natural or sandbars are considered as bare soil (brownish yellow). Based on the experience gained during fieldwork, all urbanized areas and settlement structures in Khulna are

developed areas that used to address the area directly occupied by a particular physical structure-including building, roads, impervious surfaces and all man-made structures. Therefore, those areas are considered as developed areas, the classes “Urban” and “Rural Settlements” are reclassified to “Developed” and the classes “Water”, “Bare Soil” and “Agriculture” are reclassified to “Natural surface” (Figure 3).

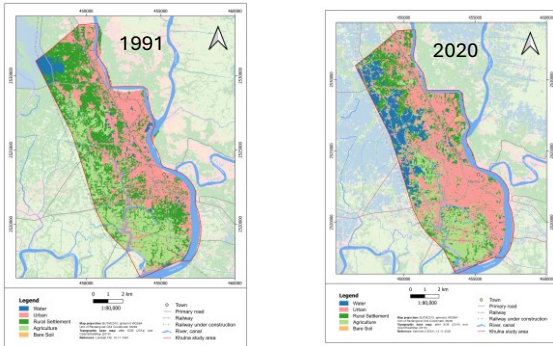


Figure 2, Land use classification maps of 1991 and 2020.

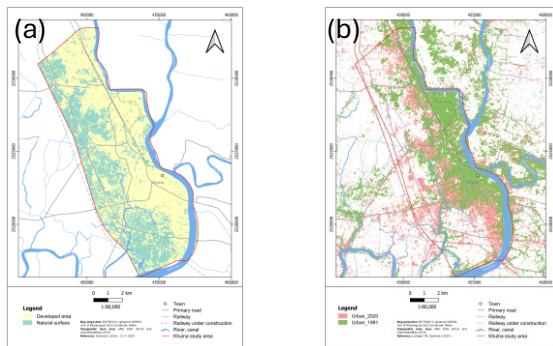


Figure 3, (a) Developed and natural surface areas (b) Urban growth direction of Khulna city and surroundings.

After creating a land use class map of the study area, accuracy was also measured. In the accuracy assessment, the Regions of Interest (ROIs)-representative sample areas selected for each land use class during classification were compared with an independent high-resolution reference dataset using randomly distributed test samples. The procedure will generate a text file containing the accuracy statistics and the error matrix. An error raster from Google Earth satellite pictures, which are freely accessible, was utilized as a high-resolution reference resource. As a result, a clearer understanding of the actual land use was obtained. The overall accuracy of the classification is 83.2%. The Kappa coefficient, a measure for the agreement between classification result and reference shows a good result of 0.8 (Lillesand et al., 2015). Ground truthing using ‘Kobo Collect’ shows similarities in most scenarios.

Conclusion

The analysis of land use classification maps of Khulna city and its surroundings (scale 1:80,000; area 85.15 km²) reveals significant land use changes over time. The

2020 classification map shows an overall accuracy of 83.2% and a Kappa coefficient of 0.8, indicating good reliability and agreement with actual land use conditions (Lillesand et al., 2015). Comparison between the 1991 and 2020 maps highlights rapid urban expansion and settlement growth, especially in the northwestern polder areas. Embankment construction during this period increased waterlogging and expanded water-covered regions. Consequently, by 2020, land use patterns had shifted markedly toward urban and built-up areas, while agricultural and rural lands declined (Figure 3 and Figure 4). These findings are crucial for guiding regional and local planning, disaster risk management, vulnerability assessments, and sustainable land-use strategies from a geological perspective.

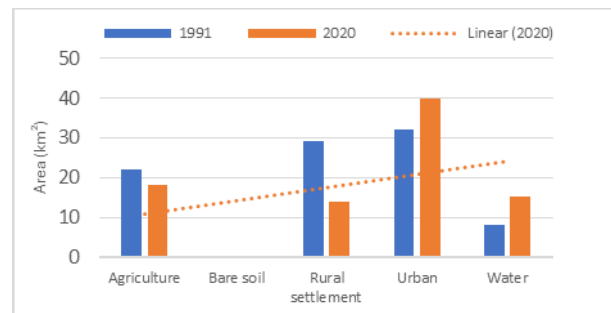


Figure 4, Changes in land use categories in Khulna city and surroundings between 1991 and 2020.

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