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Monitoring spatiotemporal changes of urban surface water based on satellite imagery and Google Earth Engine platform in Dhaka City from 1990 to 2021

Md. Jakir Hossain^{1*} , Md. Munir Mahmud¹ and Sheikh Tawhidul Islam¹

Abstract

Background This study focuses on Dhaka City and its impact on urban surface water. Cities, ecosystems, and agriculture need surface water. It is crucial for water resource planning and environmental preservation. The primary aim is to study how urbanization has affected surface water in Dhaka City over 30 years using satellite imagery.

Methods The study analyzed three decades of urban surface water shifts using Landsat 5 TM and Landsat 8 OLI/TIRS satellite imagery and Google Earth Engine (GEE) with JavaScript code for water ratio index detection. To investigate water level changes, field observation surveys and secondary data analysis were conducted. This integrated methodology simplified surface water data extraction and analysis, making remote sensing easier and allowing cloud-based satellite data processing.

Results The study demonstrates that the amount of surface water in cities is going down, from 36.23 km² in 1990 to 5.83 km² in 2021, which is an enormous decrease. This means that about 20 square kilometers, or 45 percent of the water's surface, have been lost in the last 30 years. The main reasons for the drop are unplanned expansion of cities, accelerated real estate development, and more trade and economic activities in the study area.

Conclusions The GEE algorithms provide useful insights into surface water's maximum and minimum extent, enabling appropriate planning and management. These findings aid Dhaka City's water resource management and environmental protection.

Keywords Urban surface water, Spatiotemporal changes, Satellite imagery, Google Earth Engine (GEE)

Background

The escalating requirements for water utilization, the equilibrium of surface energy, the functioning of ecosystems, the replenishment of groundwater, and the pursuit of economic advancement collectively underscore the imperative of achieving water sustainability within the

framework of human civilization (Water and Ecosystems 2023; Abbass et al. 2022). The contemporary challenges faced by numerous nations include rapid urbanization, the depletion of fresh water supplies, and the scarcity of other natural resources. These issues exhibit a higher prevalence in developing nations such as Bangladesh (Hayashi and Rosenberry 2022; Amani et al. 2020).

This study highlights the importance of water resources management in the development of a sustainable and livable urban environment. It acknowledges that surface water patterns are influenced by urbanization, climate change, and seasonal variations. There exists a

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correlation between urban sprawl and ineffective water management, which in turn contributes to the issues of water scarcity, biodiversity depletion, and the occurrence of flood hazards. This study aims to overcome a common limitation observed in research pertaining to changes in urban surface water: seasons, urbanization, land cover changes, and topographical factors are generally overlooked (Padowski and Gorelick 2014). These components' intricate interactions are assessed using multi-year satellite images, powerful geostatistical methods, and the Google Earth Engine Platform to close this gap (Acharya et al. 2019). A comparison of Dhaka and Hong Kong, two very different cities, shows how seasonal fluctuations, urbanization, and terrain affect surface water dynamics. Dhaka's flat topography allows for more horizontal expansion and water body infiltration than Hong Kong's mountainous terrain, which strengthens surface water (Faridatul et al. 2019). This research illuminates the complex dynamics that define urban surface water systems, guiding watershed management and urban development.

Due to uncontrolled urbanization and population increase in recent decades, Dhaka has rapidly become a metropolis. Unfortunately, this uncontrolled expansion has degraded the environment, notably climate and water quality and availability (Li et al. 2009). Potable water shortages are already a result of uncontrolled growth. Lakes and ponds were part of the city's ecosystem and culture in the past. These water bodies helped drain the city, move people, and provide agricultural water. Given this, annual water body assessments are essential for urban environmental planning (Amani et al. 2020; Kandekar et al. 2021). This study uses Google Earth Engine to locate and quantify urban surface water coverage during the past 30 years.

Water resources assessments in the field are laborious and expensive due to the harsh natural environment, and consistent long-term data series are hard to find. Satellite remote sensing can easily and accurately monitor water bodies on a vast scale (Arikan and Yildiz 2023). The utilization of remote sensing satellite technology offers effective solutions to various challenges related to water resources, earth science, and irrigation planning. Several water removal indices have been developed based on the spectral features of the water system in order to facilitate the removal of water from remote sensing images.

Furthermore, this research applies an innovative methodology to investigate surface water, providing a novel viewpoint on the allocation and movement of water resources. The results of this study will be utilized to create instruments within the Google Earth Engine platform that may be employed for the assessment and surveillance of water resources. Furthermore, the research offers valuable suggestions for the preservation and sustainable

administration of water resources within the designated geographical region.

Aims and objectives

The primary aim of this study is to evaluate the spatiotemporal dynamics of urban surface water in Dhaka City between 1990 and 2021 using satellite imagery and the Google Earth Engine (GEE) platform. The utilization of historical imagery data enables the evaluation of surface water extent over a span of thirty years, facilitating the identification of trends pertaining to water loss or gain within the designated research region. The Geospatial Extraction Engine (GEE) will employ sophisticated algorithms and machine learning techniques to efficiently and precisely extract surface water data from satellite imagery, enabling the evaluation of dynamics in urban water bodies. This study also investigates the causes and factors contributing to alterations in urban surface water, encompassing unanticipated urban growth, real estate development, heightened industrial operations, and climate change. The aforementioned findings hold significant importance in the formulation of water management strategies and sustainable urban development policies for Dhaka City.

Methods

Study area

Dhaka city which is shown on Fig. 1, the bustling capital of Bangladesh, is a densely populated urban hub with a staggering population of over 21 million, encompassing an area of 306.38 square kilometers (118.29 sq mi). Positioned at 23° 42' N 90° 22' E in central Bangladesh, the city lies along the eastern banks of the Buriganga river, southern banks of Turag, western bank of Balu, and north-western bank of Shitalakshya rivers. Dhaka is strategically situated in the fertile region of the Ganges Delta, teeming with agricultural potential (Yin et al. 2021; Islam et al. 2014).

While the exact count of water bodies within Dhaka city remains unknown, estimates suggest that there are more than 400 water bodies within its boundaries. However, the rapid pace of urbanization and human activities have put these water bodies under significant threats, including pollution, encroachment, and reduced water flow (Sultana et al. 2009). The importance of water-related issues in Dhaka metropolis makes it necessary to investigate and monitor surface water resource spatiotemporal variations. Therefore, the water ratio measure (WRI) is a useful spectral measure for detecting and monitoring surface water bodies using satellite data. Calculating the WRI provides vital information on surface water dynamics in the research area, which aids water

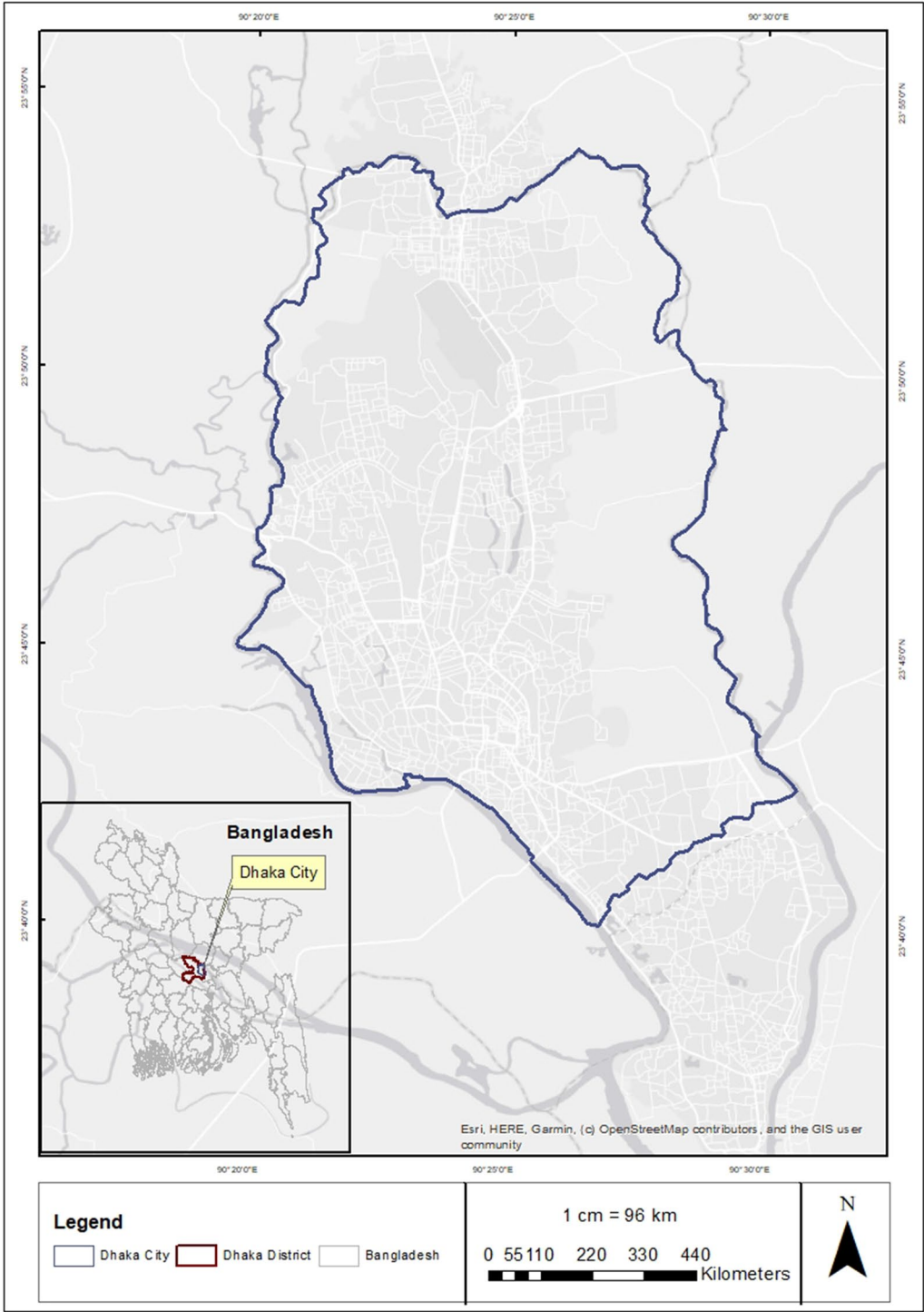


Fig. 1 Location of the study area

resource management and environmental protection (Kandekar et al. 2021; Ahsan et al. 2023).

Growing urbanization and development constraints on Dhaka make such investigations urgent. Understanding

surface water resource changes can help make informed decisions and execute successful measures to protect these precious natural resources (Azharul Haq 2006; Yang et al. 2022). To maintain the sustainable growth and

well-being of Dhaka's residents, development and water conservation must be balanced.

Dhaka, one of the world's densest cities, has seen significant urbanization, changing land use. Urbanization has reduced green and blue spaces. Land is converted for residential, commercial, and industrial use, destroying vegetation and waterways. Urbanization has added 7500 hectares of land and lost 6600 hectares of vegetation between 1988 and 2020 (Rahman and Szabó 2021). This tendency threatens the region's environment and biodiversity. The Köppen classification classifies Dhaka as a tropical wet and dry climate with hot, wet, and humid conditions. The city has diverse seasons, including a monsoon. With an annual average of 25 °C (77 °F), monthly temperatures range from 18 °C (64 °F) in January to 29 °C (84 °F) in August. These conditions are uncomfortable year-round due to extreme humidity. Between May and September, the monsoon season produces about 80% of the annual average 1854 mm (73.0 inches) of rainfall. Flooding and waterlogging can disrupt daily living and urban infrastructure due to excessive rainfall (Govind and Alam 2022).

Data acquisition and processing using GEE platform

Google Earth Engine (GEE) is a powerful cloud-based tool for geoscientists to handle and analyze data. It includes online programming tools and interactive displays, removing the requirement to download remote sensing photographs for analysis (Amani et al. 2020). GEE is ideal for large-scale, long-term research projects using PB (petabyte) amounts of remote sensing data due to its powerful computational capabilities and extensive API documentation. (Yang et al. 2022). GEE excels in its API library, which incorporates many complex remote sensing image processing methods. This makes the

platform convenient for non-programmers who value efficient data processing (Annala et al. 2018). GEE code was used to show Landsat 5 TM data from 1990, 2000, and 2010, and Landsat 8 OLI/TIRS data from 2021. Satellite photographs from the dry season, which occurs in the study area from December to February, were analyzed. GEE preprocessed these pictures to find cloud-free or low-cloud images. Clipping the image set to the study area's boundary followed (Abbass et al. 2022; Kandekar et al. 2021; Arikan and Yildiz 2023; Yin et al. 2021; Annala et al. 2018).

Figure 2 illustrates the methodology flow diagram of this study. This research used the GEE platform visualized the water ratio index (WRI) generated using a formula to detect water bodies in the picture. WRI can detect even small amounts of water due to its great sensitivity to water content changes. WRI is better at distinguishing water bodies from non-water features like bare soil, metropolitan areas, and barren countryside (Amani et al. 2020). When identifying water bodies in complicated landscapes with mixed land cover, this better discriminating can be helpful. By using reflectance disparities between green, red, near-infrared, and medium-infrared bands, the WRI index may identify water bodies. Waterbodies reflect more in the green and red bands than the near- and medium-infrared frequencies. Water absorbs near- and medium-infrared light but reflects more green and red light, explaining this behavior (Khalid et al. 2021).

Landsat 5 TM and Landsat 8 OLI/TIRS data were used to analyze the impact of urbanization on surface water bodies in Dhaka using the water ratio index (WRI). Water extraction band indices for multispectral data are available now, WRI is one (Kandekar et al. 2021). This approach detected water bodies and determined threshold values

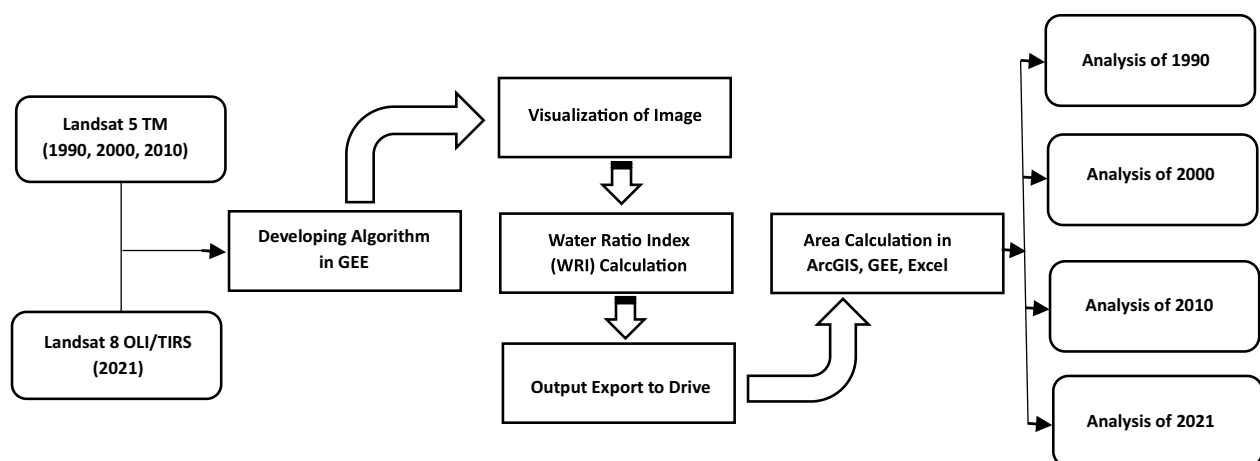


Fig. 2 Methodology flow diagram

using reflectance values in Blue, Green, Red, NIR, MIR, and SWIR electromagnetic spectrum bands. Landsat 8 outperformed Landsat 5 in spatial resolution, radiometric sensitivity, and dynamic range for Earth observation (Abbass et al. 2022; Amani et al. 2020; Islam et al. 2014; Verpoorter et al. 2012). The WRI method quantified Dhaka's urbanization's influence on water bodies.

The formula for calculating WRI is:

$$\text{WRI} = (\text{Green} + \text{Red}) / (\text{NIR} + \text{MIR})$$

$$\text{for Landsat 5,} \quad \text{WRI} = (\text{Band 2} + \text{Band 3}) / (\text{Band 4} + \text{Band 5})$$

$$\text{for Landsat 8,} \quad \text{WRI} = (\text{Band 3} + \text{Band 4}) / (\text{Band 5} + \text{Band 6})$$

Typically, water bodies exhibit WRI values exceeding 1, while features like vegetation and bare soil tend to have lower WRI values. This distinction arises from the differing reflectance properties of water, vegetation, and soil across various spectral bands. Vegetation and soil typically reflect more light in the near-infrared and medium-infrared bands compared to the green and red bands (Laonamsai et al. 2023).

The water ratio index uses water's spectral properties to highlight the contrast between water and other objects. The index separates water bodies from pictures by setting a threshold (Verpoorter et al. 2012). The GEE platform's water extraction algorithm makes this operation easy and efficient. GEE code, especially VB and JavaScript, has advanced water resources management (Liu et al. 1678). Water resource management and analysis are enhanced by GEE's water ratio index and coding. By quickly identifying and extracting huge areas of surface water, researchers and decision-makers can understand water dynamics and availability. Advances in remote sensing and algorithm development help sustain water resource management and conservation. The seamless integration of GEE's programming and spectral analysis tools helps academics make informed judgments and solve water-related problems, improving communities and ecosystems (Li et al. 2809).

The raster data were subjected to categorization in order to ascertain the precise magnitude of water distribution within the city of Dhaka. The classed raster data were subsequently transformed into polygon features using the Arc toolkit. This facilitated the computation of the extent of water surface coverage within the designated study area. The aforementioned procedure was iterated for the calendar years 1990, 2000, 2010, and 2021. Following that, the surface areas of the water bodies were measured, and a thorough examination was carried out utilizing ArcGIS and MS Excel to acquire more profound understanding and successfully interpret the findings.

The study incorporates field observation surveys to verify the precision of the real-time output. Furthermore, it involves conducting targeted group conversations with community members in order to identify the reasons that are leading to the depletion of urban surface water resources. In addition, the collection of expert viewpoints is undertaken to elicit suggestions for the sustainable governance of urban surface water resources.

Results: urban inland surface water identification and quantification

Google Earth Engine (GEE) revolutionizes remote sensing processing with a cloud-based platform and many algorithms for geoscience data collecting and analysis. GEE saves time by removing image downloading and lowers work cycles with its extensive interaction and computational capabilities. Remote sensing scientists can concentrate on analysis rather than tedious processing. (Amani et al. 2020; Yin et al. 2021; Tamiminia et al. 2020).

GEE's simple remote sensing image processing extracts vector information from water bodies for hydrological element analysis. This study analyzed Dhaka for 30 years using Landsat 5 and 8 data. Water body index reduces irrelevant ground information and improves water body recognition with numerous bands. This study used the coding and GEE-produced water ratio index (WRI). The WRI index directly eliminated water bodies from other features, providing actual water surface coverage area data. The WRI index for each decade was generated using 1990–2021 December Landsat 5 and 8 data. WRI index was exported to disk and downloaded for processing using Java. These raster data were classified using ArcGIS and transformed into polygons to determine the study area's annual water coverage.

The results, presented in Figs. 3 and 4, showcase the year-wise water coverage area of Dhaka city. This research harnesses the power of GEE and integrates various tools and technologies, enabling a comprehensive understanding of the changing trends in water bodies within Dhaka city over the past three decades. The combination of GEE and ArcGIS facilitates efficient data analysis, providing valuable insights for decision-makers and researchers working on water resource management and urban development in the study area.

Figure 3 in the study focused on water bodies in Dhaka city, the capital of Bangladesh, showcases false color composite (FCC) maps obtained from Landsat 5 and 8 satellite imagery. These maps were created for four

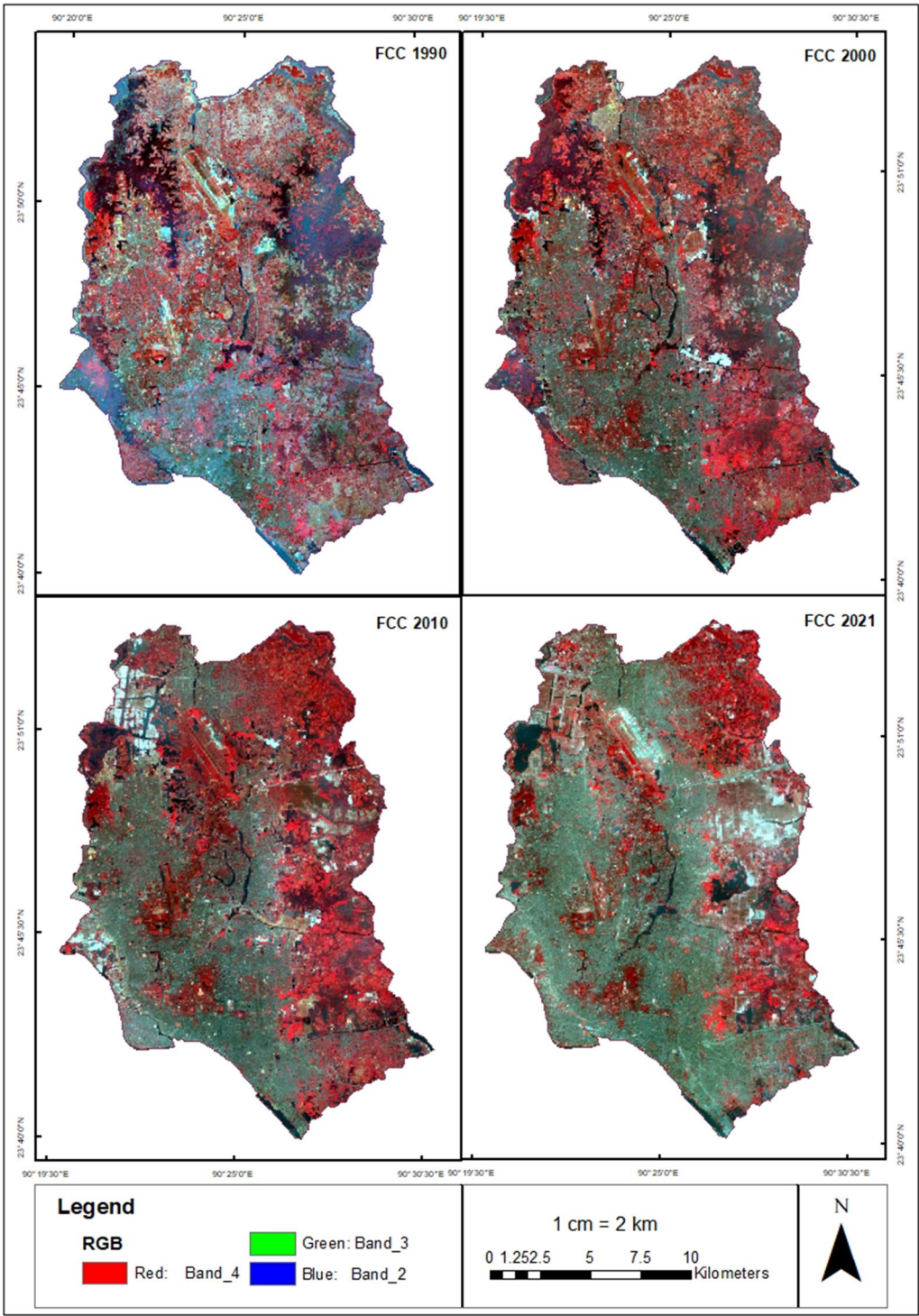


Fig. 3 Water bodies identified using false color composite from 1990 to 2021

specific years: 1990, 2000, 2010, and 2021. The color scheme utilized in the maps effectively highlighted water bodies, represented by shades of blue or dark blue. To generate these maps, a specific combination of bands was

chosen, with the near-infrared band represented as red, the shortwave infrared band as green, and the visible blue band as blue. This selection of bands enabled the identification of healthy vegetation in vibrant red, while water

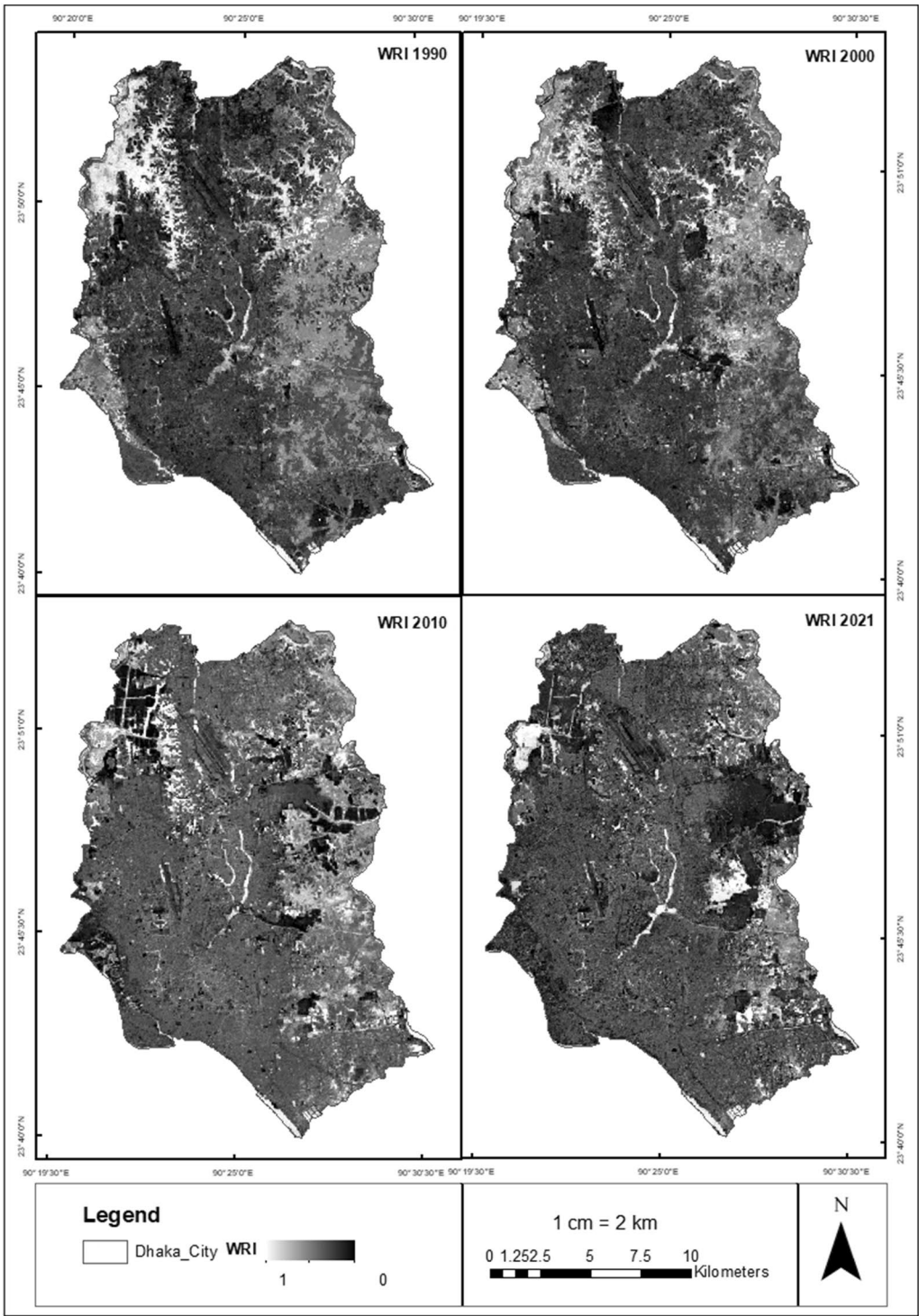


Fig. 4 The water bodies of identified using water ratio index (WRI) from 1990 to 2021

bodies appeared as distinctive shades of blue or black. Urban areas, depending on their level of development and vegetation presence, were depicted as varying shades of gray or white.

Moving on to Fig. 4, it illustrates the results of the water ratio index (WRI) analysis, which serves as a key metric derived from remote sensing data, particularly Landsat satellite 5 and 8 imagery, to identify and emphasize water

areas on the earth's surface. In this case, the WRI output was generated with a threshold value of 1. As a result, pixels with a WRI value greater than 1 were classified as water, whereas those with lower WRI values were designated as other features like vegetation, roads, or cloud shadows. By utilizing this threshold, the WRI output offers valuable insights into the extent of water bodies in Dhaka city over a span of three decades. This information becomes instrumental in monitoring changes and trends in surface water resources, a critical aspect of water resource management, particularly in rapidly developing urban areas like Dhaka. The city's fast-paced urbanization and the ever-evolving climate scenario significantly impact water availability and quality, necessitating a proactive approach to water resource management.

Through Figs. 3 and 4, the study effectively visualizes the dynamic changes in water bodies within Dhaka city over the past forty years, exposing a notable decline in surface water resources. The rapid urbanization and associated development activities have emerged as the principal drivers of this decline. The information derived from these figures provides valuable data for policymakers and researchers to understand and address the challenges posed by diminishing water resources. It underscores the urgency to adopt sustainable water management strategies, considering the city's ongoing growth and the potential impacts of climate change. By utilizing remote sensing data and innovative indices like the WRI, this study offers a powerful tool for analyzing and addressing water-related issues in Dhaka city and other similar urban environments facing similar challenges.

Figure 5 depicts the alterations in the extent of surface water covering throughout the dry season in Dhaka city, spanning the years 1990 to 2021. The surface water map from 1990 revealed the presence of several minor aquatic features, including ponds, tiny lakes, and river-side wetlands, inside the municipal limits of the city. The water bodies were primarily positioned in the periphery of the city and dispersed across the center regions, with a predominant concentration on the eastern and northern perimeters of the city limits. The blue color on the map is indicative of the water bodies located within the study region. The field observation survey additionally validates the presence of these waterbodies within the study region. Nevertheless, even in this nascent phase, the quantity and dimensions of these aquatic formations had already commenced a fall as a result of the swift proliferation of metropolitan regions and the erection of novel edifices and infrastructure.

Many smaller ponds and lakes vanished by 2000 as water levels dropped. The city's agricultural borders had the last water features. Few large lakes and reservoirs were visible in the city by 2010, especially in the east and

north, where urbanization was lower. The 2021 surface water map shows few public water bodies in Dhaka, with only a few minor ponds and lakes on the outskirts and surrounded by thick urbanization (Islam et al. 2014). This loss of aquatic bodies was largely caused by low-lying urbanization and real estate development. Despite preservation efforts, urbanization and development threaten surviving water bodies.

Discussion

Over the past few decades, Dhaka city has undergone significant growth in population and economic prosperity. However, this rapid increase in population has posed a threat to the city's surface water coverage, leading to an ecological imbalance. The total area of Dhaka city stands at 306.4 sq. km (Amani et al. 2020; Ahsan et al. 2023; Dewan et al. 2012), and this study utilized the water ratio index (WRI) to determine the extent of urban land surface and water surface.

Table 1 describes the details information of surface coverage area. In 1990, the total land surface covered 270.17 sq. km, with the water surface area spanning 26.23 sq. km. A decade later, in 2000, the land surface coverage expanded slightly to 273.41 sq. km, while the water surface area decreased to 32.99 sq. km. By 2010, the total land surface increased to 277.73 sq. km, while the water surface further decreased to 28.67 sq. km. Finally, in 2021, the land surface coverage reached 290.58 sq. km, whereas the water surface coverage dwindled to 15.82 sq. km.

Over the course of the past thirty years, the data indicate a discernible pattern: there has been a steady and notable increase in land surface coverage, which may be attributed to the city's rapid urbanization and developmental activities. In contrast, there has been a consistent decrease in the extent of water surface covering in Dhaka during the aforementioned timeframe, thereby underscoring the urgent concern regarding the reduction of surface water resources in the region.

The provided bar graph, Fig. 6, presents a comparative analysis of the urban land and water surface percentages from 1990 to 2021, as determined by this study. In 1990, the land surface accounted for 88.18%, while the water surface made up 11.82%. By 2000, the land surface percentage increased to 89.23%, with the water surface percentage decreasing to 10.77%. In 2010, the trend continued, with the land surface occupying 90.64% and the water surface shrinking to 9.36%. Finally, in 2021, the land surface percentage surged to 94.84%, leaving only 5.16% for water surface. The study highlights a notable decline in water surface over the last few decades, signifying a significant shift in the city's landscape.

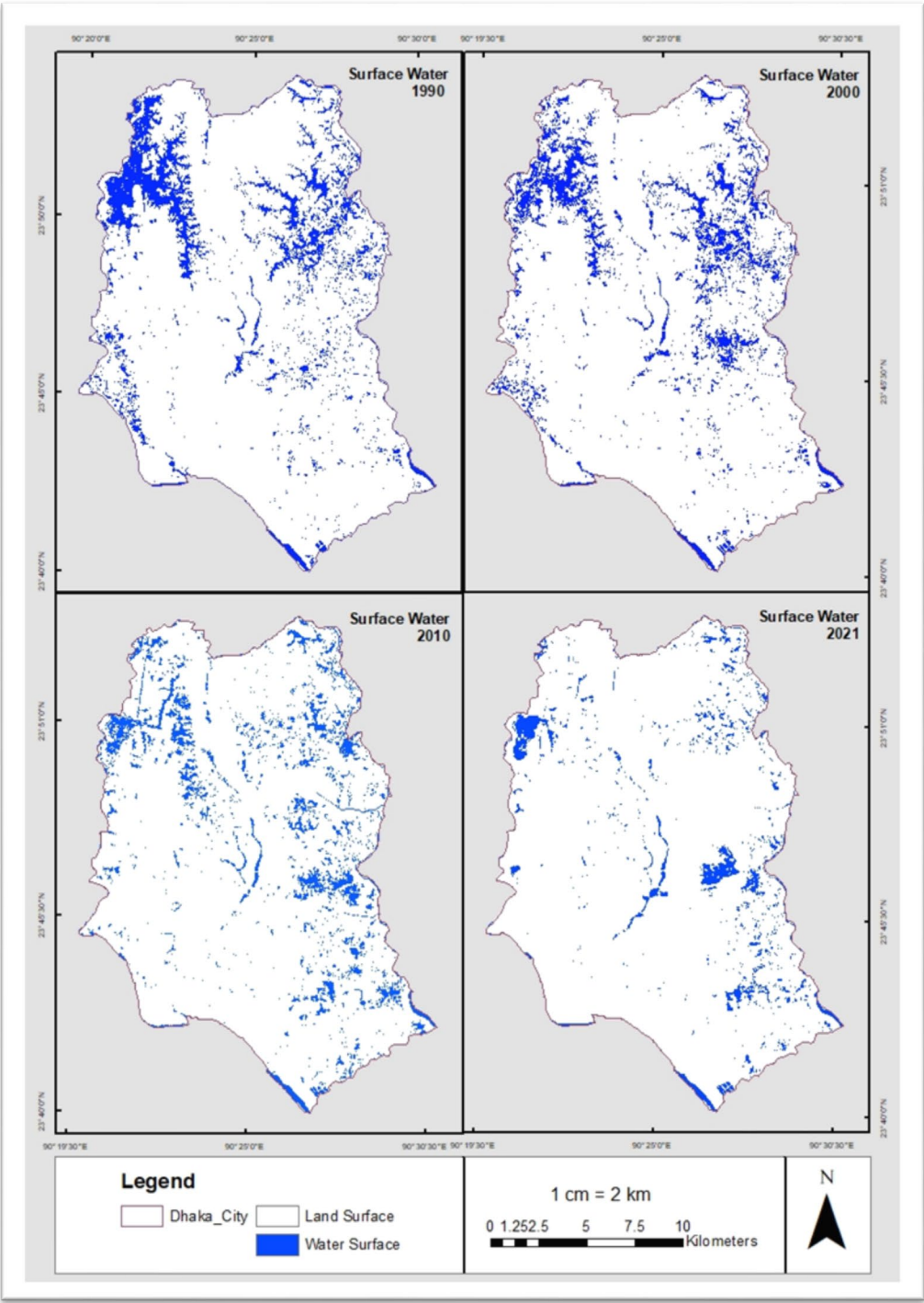


Fig. 5 Inland surface water spread out area (dry season) of Dhaka city from 1990 to 2021

Figure 7 displays a line graph depicting the evolving patterns of urban surface water coverage in Dhaka city from 1990 to 2021. In 1990, approximately 12% of the total coverage area was occupied by water surfaces. Over the next decade, this proportion slightly decreased

to around 10%. Subsequently, in the following decade, it further declined to 9%. However, the most significant change occurred in the last decade, with urban surface water coverage experiencing a rapid and drastic decrease, reaching around 5% by the year 2021. This study’s

Table 1 Details of surface coverage area

Land coverage/year	1990	2000	2010	2021
Land Surface	270.17	273.41	277.73	290.58
Water Surface	36.23	32.99	28.67	15.82
Total	306.4	306.4	306.4	306.4

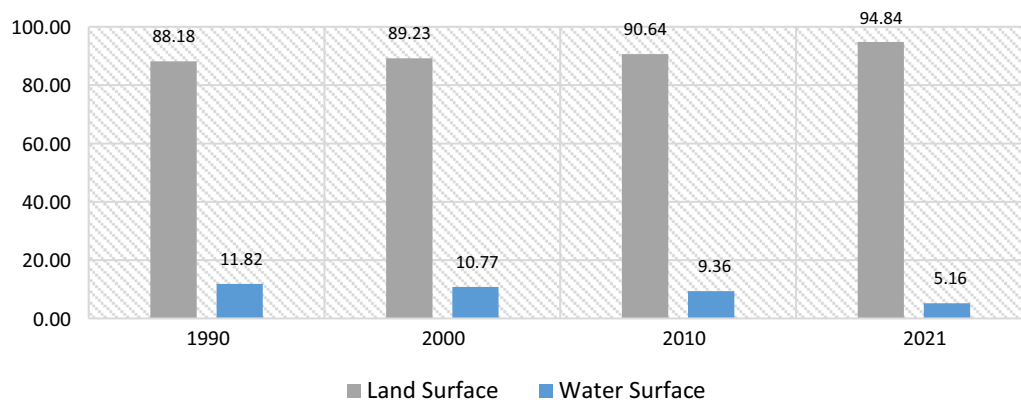
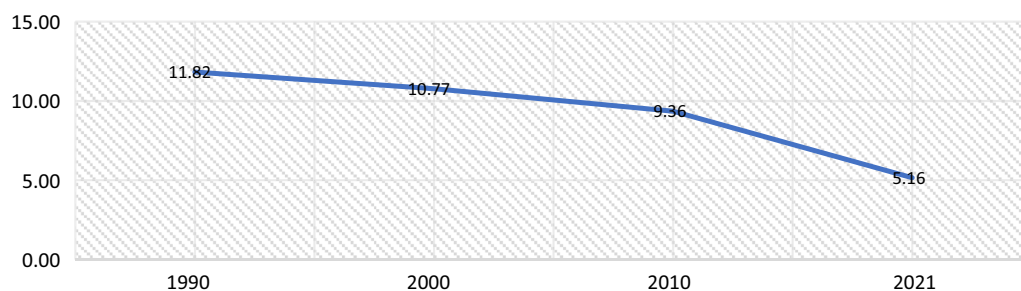
findings indicate that over the course of the last three decades, urban surface water coverage has undergone a substantial transformation, reducing almost by half. Over the past three decades, Dhaka city has witnessed a loss of approximately 20 square kilometers or nearly 44 percent of its surface water.

Over the past three decades, the gradual decrease in water bodies in Dhaka city during the dry season has become evident. Experts suggest that an ideal city should have surface water covering at least 15 percent of its area. However, overcrowded Dhaka falls far short of this benchmark, with bodies of water accounting for only 5.16 percent of its total area, as indicated by this study. Unfortunately, the share of surface water in the capital city of Bangladesh has continued to decline. This downward trend can be attributed to the rapid expansion of urban areas and the relentless construction of new buildings

and infrastructure, which have encroached upon natural water bodies.

Additionally, urbanization and the growth of built-up areas in Dhaka have reduced green spaces and increased impermeable surfaces. This has upset the vegetation-water balance. Dhaka's tropical wet and dry climate, with its unique monsoonal season, affects water dynamics. The city has an average annual temperature of 25 °C and a substantial monsoon season from May to September, when 80% of its precipitation falls (Govind and Alam 2022). Moreover, real estate construction on water bodies undermines natural drainage systems, increasing the risk of flooding. Traffic and industrial pollution worsen existing difficulties, affecting public health and water quality (Rahman and Szabó 2021). The complex linkages between land use, climate, and urbanization are crucial to sustainable urban planning and water resource management in Dhaka.

However, the loss of these water bodies has far-reaching consequences for both the environment and the city's residents. Reduced water availability poses challenges for the local population, while the risk of flooding increases due to the diminishing capacity of natural water reservoirs to absorb excess rainfall. In recent years, Dhaka's dwellers have experienced extreme heat, which

**Fig. 6** Year wise urban surface coverage area of Dhaka city**Fig. 7** Changing trends urban surface water of Dhaka city

environmentalists attribute to the shrinking water bodies. Water surfaces play a crucial role in balancing the urban heat island effect, a function that is also carried out by vegetation. The declining water bodies exacerbate the urban heat island effect, leading to uncomfortable living conditions and potential health hazards for the city's inhabitants (Thiele-Eich et al. 2015).

Finally, Dhaka's urban surface water preservation requires a comprehensive policy based on expert knowledge and local perspectives. To reduce illegal discharge and industrial emissions, environmental rules must be strictly enforced. Urban planning must prioritize green spaces, water bodies, and sustainable water management. Workshops and awareness campaigns can help communities develop a shared responsibility for water conservation. Learning about sustainable water use, waste management, and pollution prevention empowers people. Funding green infrastructure like parks and wetlands helps preserve and diversify ecosystems by functioning as natural filtration systems. Novel wastewater treatment technology and recycling programs reduce water resource strain. Collaborations between authorities, NGOs, communities, and the private sector boost conservation efforts. Collaborations enable resource and expertise sharing. These steps create a framework for protecting Dhaka's metropolitan surface water for future generations.

Given these challenges, it is imperative to prioritize the conservation and restoration of water bodies in Dhaka city. Such efforts are crucial not only for environmental protection but also for the well-being and quality of life of its residents. By safeguarding these valuable natural resources, the city can better mitigate the impacts of climate change, reduce heat stress, and ensure a sustainable and resilient future for Dhaka and its inhabitants.

Conclusions

The alterations in surface water resources have significant implications for climate change, the equilibrium of the ecosystem, and the progress of agricultural activities within the examined region. Anthropogenic activities have been responsible for alterations in surface water, resulting in significant impacts on various aspects such as surface temperature, soil moisture, biodiversity, ecosystem functioning, and human well-being. Hence, the implementation of dynamic surface water monitoring is vital in order to facilitate the strategic development of a thriving ecosystem and promote sustainable economic progress.

While previous research has explored surface water extraction and monitoring using traditional methods, the current study focuses on employing machine learning programming through Google Earth Engine (GEE). By calculating the water ratio index (WRI) based on GEE, the study successfully extracts water body data at appropriate thresholds for different years, such as 1990, 2000, 2010, and 2021, revealing water area coverages of 36.23, 32.99, 28.67, and 5.83 km², respectively. This novel approach proves beneficial in monitoring surface water within the study area.

Trends in urban water surface provide insights on water quantity swings. It helps relevant departments make educated judgements and build conservation and management policies. This study's use of Google Earth Engine gives surface water research a fresh perspective, enabling water resource distribution and dynamics analysis. This work improves surface water dynamics understanding and helps develop sustainable water resource management techniques.

Appendix

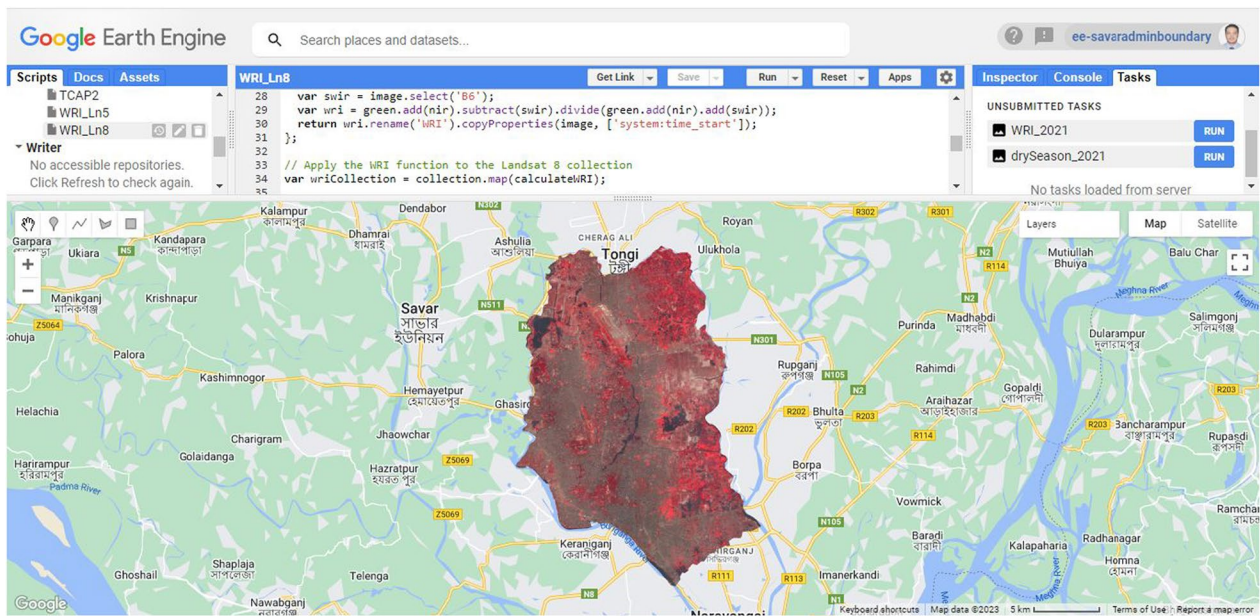
GEE Code for Assessing Satellite Image:

```

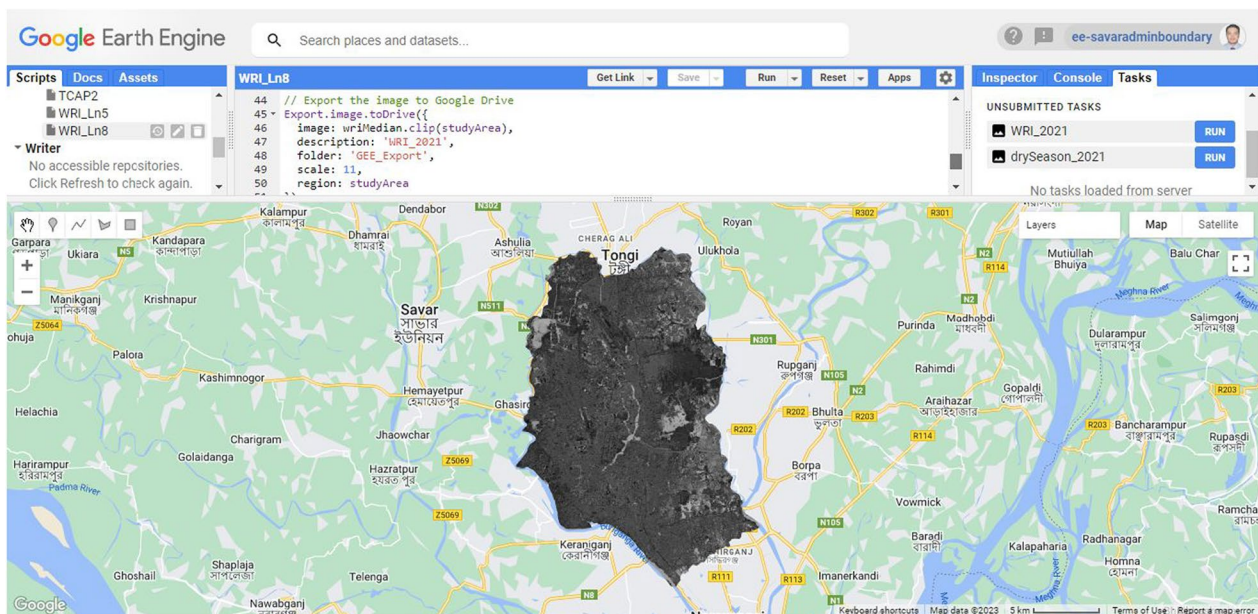
WRI_Ln8
Imports (1 entry)
var studyArea: Table projects/ee-savaradminboundary/assets/Dhaka_City
1 // Define the date range and study area
2 var startDate = '2020-11-01';
3 var endDate = '2021-02-28';
4
5 // Load the Landsat 8 SR image collection
6 var collection = ee.ImageCollection('LANDSAT/LC08/C01/T1_SR')
7   .filterDate(startDate, endDate)
8   .filterBounds(studyArea)
9   .select(['B2', 'B3', 'B4', 'B5', 'B6', 'B7']);
10
11
12 //Code for Visualizing Image
13
14 var visParams = { bands: ['B5', 'B4', 'B3'],
15 min: 0,
16 max: 3000};
17
18 Map.setCenter(90.4125, 23.8103, 11);
19 Map.addLayer(collection.median().clip(studyArea), visParams, 'drySeason');
20
21
22
23 // Define the Water Ratio Index (WRI) function
24 var calculateWRI = function(image) {
25   var green = image.select('B3');
26   var red = image.select('B4');
27   var nir = image.select('B5');
28   var swir = image.select('B6');
29   var wri = green.add(nir).subtract(swir).divide(green.add(nir).add(swir));
30   return wri.rename('WRI').copyProperties(image, ['system:time_start']);
31 };
32
33 // Apply the WRI function to the Landsat 8 collection
34 var wriCollection = collection.map(calculateWRI);
35
36 // Create a median WRI image
37 var wriMedian = wriCollection.median();
38
39
40 // Add the water mask to the map
41 Map.centerObject(studyArea, 11);
42 Map.addLayer(wriMedian.clip(studyArea), {}, 'WRI');
43
44 // Export the image to Google Drive
45 Export.image.toDrive({
46   image: wriMedian.clip(studyArea),
47   description: 'WRI_2021',
48   folder: 'GEE_Export',
49   scale: 11,
50   region: studyArea
51 });
52
53 Export.image.toDrive({
54   image: collection.median().clip(studyArea),
55   description: 'drySeason_2021',
56   folder: 'GEE_Export',
57   scale: 11,
58   region: studyArea
59 });
60

```

Output-01



Output-02



Abbreviations

GEE	Google Earth Engine
OLI	Operational Land Imager
TIRS	Thermal Infrared Sensor
WRI	Water ratio index
FCC	False color composite
NIR	Near infrared

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Author contributions

“MdJH conceived the study, designed the experiments, analyzed the data, and drafted the manuscript. MdMM carried out the experiments and helped draft the manuscript. Dr. STI provided essential reagents and materials. All authors read and approved the final manuscript.”

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Availability of data and materials

Data will be made available upon request from anyone.

Declarations

Ethics approval and consent to participate

Not applicable. The present study did not involve human participants, human data, or animals.

Consent for publication

The manuscript does not contain any individual's data in any form (including individual details, images, or videos). Therefore, consent for publication is not applicable.

Competing interests

The authors declare that they have no conflict of interest.

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