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Seasonal Distribution Of Surface Waterbodies And Its Role On Horticulture Production In Baruipur Sub-Division In South 24 Parganas (West Bengal, India)

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Abstract

There is much evidence linking human activity to global climate change, and the anticipated changes in climate may have a significant effect on horticulture output. In the Baruipur subdivision, irrigation is essential to meeting the rising demand for food brought on by population growth. Groundwater irrigation serves as agriculture's primary supply of water throughout the dry season. On the other hand, excessive groundwater abstraction for irrigation results in groundwater level depletion. Present study evaluates the seasonal disyribution of surface water and its impact on horticulture production in Baruipur sub-division. Landsat8-Operational Land Imager satellite data were used during the period between 2016 and 2019. Surface waterbodies were extracted from the satellite data using Normalized Difference Water Index. Results showed that the most of the surface waterbodies are observed in the east, north-east and north of the Baruipur sub-division. The extent of surface waterbodies is very less in west of the Baruipur sub-division. In the study area, permanent waterbodies are mostly observed in west and north east of Bhangar block, east of Sonarpur block and some small pockets of Kultali block. Seasonal waterbodies are mostly observed in Jaynagar I and II block, Baruipur block and south of Bhangar-I block. The findings indicated that while there was a consistent pattern of declining groundwater levels during the study duration, there was an increase in the usage of groundwater for irrigation. In the studied area, irrigation plays a major role in groundwater recharging during the dry season. Therefore, for sustainable groundwater resource management in this area, accurate irrigation water monitoring and management are essential.

Keywords: Water distribution, Satellite data, Normalized Difference Water Index, Baruipur sub-division, change analysis

Introduction

The majority of scientists concur that the rate of global climate change is frightening and that these changes will probably have an impact on how much water is used in agriculture, horticulture, and natural ecosystems (Snyder, 2017). Climate change may be able to boost agricultural production in some regions, but it is generally thought that broad negative effects on agricultural production are more likely to occur in most of the world. Increasing air temperature is the current tendency in climate change, especially at night and during the winter, and more near the poles than in lower latitudes (Hochachka, 2019). Higher water temperatures have caused sea levels to rise as a result of water expansion and extra heat storage, primarily in the seas, as a result of global warming. Energy storage in water has increased tremendously (much more than in the air). A greater air temperature also raises the saturation water vapour pressure, or the volume of water vapour maintained in the atmosphere at saturation, which further promotes evaporation.

Due to its distinct qualities, water is allocated and used by agriculture as a resource in different ways. Water used for irrigation in agriculture is dependent on the availability of land resources. Re-evaluating sectoral water allocations is unavoidable in a climate of increasing water scarcity and rising demands for non-agricultural (household and industrial) use of water (Mancosu et al., 2015). Irrigated agriculture makes a significant contribution to domestic food security and the reduction of poverty in emerging nations (Evans and Sadler, 2008). Therefore, ensuring that agriculture receives sufficient water allocations is necessary for the attainment of these goals. In order to use irrigation water and current irrigation infrastructure more effectively, the agriculture sectors of emerging countries need to better allocate irrigation water. For developing nations' agricultural sectors to utilise irrigation water and existing irrigation infrastructure more efficiently, better irrigation water allocation is necessary (Koech and Langat, 2018). Additionally, reallocation is necessary to lessen irrigation's externalities, such as the salinization and waterlogging of irrigated land, as well as the harm to the ecosystem (caused by overextraction of groundwater and depletion and pollution of surface water).

The degradation of water quality, which affects stream integrity and utility, is a result of horticultural pollutants being carried into surface streams by runoff or by leaching (Muriithi and Yu, 2015). The separation of effluents from various land processes and land use types is frequently a challenge in the management of horticulture contaminants in watersheds with multiple land uses. Investigations on water quality monitoring frequently evaluate indicators of water quality such as pH, salinity, electrical conductivity, total dissolved substances, phosphate, nitrate, potassium, zinc, copper, cadmium, iron, sulphide, and water temperature (Dippong et al., 2023). These indicators have been used as tracers of anthropogenic processes in environmental research since some of them are rare earth elements that also occur in surface waters. Increasing the use of agrochemicals is a popular strategy to increase productivity per unit of land area that frequently goes hand in hand with agriculture intensification. There is a worldwide concern about heavy metal poisoning of water brought on by industrialization, accelerated urbanisation, and intensive agriculture.

Study Area

The Baruipur is a subdivision of the South 24 Parganas district in West Bengal (India). In the Baruipur subdivision, 29.36% of the district's inhabitants reside. 77.45% of people in South 24 Parganas district were literate, according to the preliminary results of the 2011 Indian census. Like the rest of Gangetic West Bengal, the climate is tropical. The Monsoon, which lasts from early June to mid-September, is another factor that defines it. The winter (mid-November to mid-February) continues to be dry, and the summer (June to mid-August) is humid. Relative humidity varies from 50% in March to 90% in July, with temperatures ranging from 41°C in May to 10°C in January. 1,579 mm of rain falls annually on average. The region is characterised by hot, humid summers, which are typical of a tropical climate. Typically, the monsoon season lasts from July to September. The soil in various wetland regions is often grey to greyish black in colour, silty clay to silty clay loam in texture, and very water retentive. Silt and clay are more common than sand in swampy places. While the subsoil is acidic in brackish water bhelies, the pH of the surface soil is virtually neutral, ranging from 6.5 to 7.5. Groundwater is used for irrigation mostly through shallow and deep tubewells, as well as surface water from rivers through river raising, as well as from canals, ponds, etc.

Materials and Methods

Data Sources

For this study, the entire Baruipur sub-division under the Google Earth Engine (GEE) platform from 2016 to 2023 was covered with Landsat OLI surface reflectance images. The technique used to build the Landsat surface reflectance code produced the Landsat8 Operational Land Imager (OLI) surface reflectance products.

Extraction of surface waterbody

A water body can "stand out" against soil and vegetation owing to the Normalised Difference Water Index (NDWI), which is used to emphasise open water characteristics in satellite images. In 1996, McFeeters first introduced the NDWI index. Today, its main function is to detect and keep track of minute variations in the water content of the bodies of water. The NDWI can improve the water bodies in a satellite picture by using the NIR (near-infrared) and GREEN (visible green) spectral bands. The index's weakness is that it is susceptible to man-made structures, which might cause water bodies to be overestimated. It can be calculated as:

$$NDWI = \frac{Green - NIR}{Green + NIR}$$

The normal water surface reflection is maximised by the visible green wavelengths. The low reflectance of water characteristics is minimised while the strong reflectance of terrestrial plant and soil features is maximised by the near-infrared wavelengths. For water features, the NDWI algorithm generates positive values, but for soil and terrestrial vegetation, it generates negative values (or zero).

Change analysis of the surface waterbody

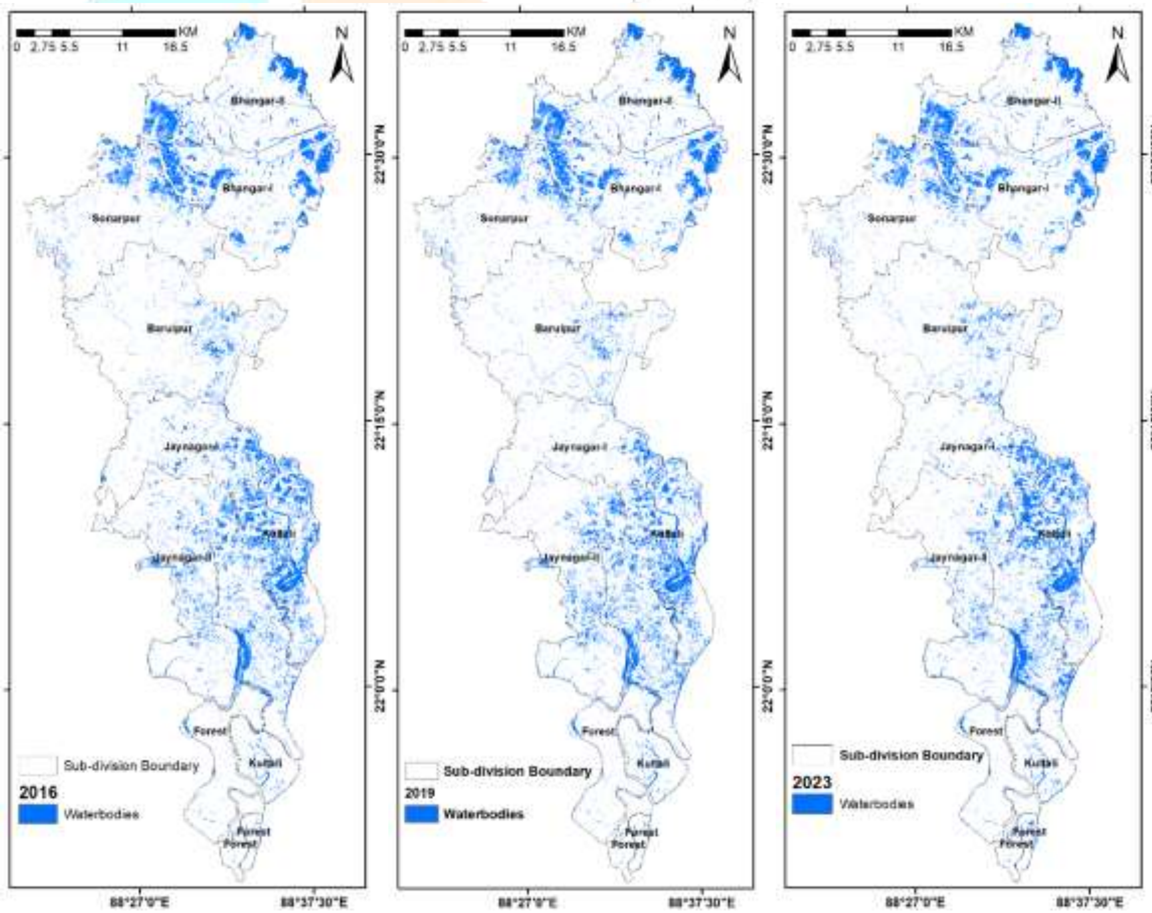
The water frequency (WF, equation 1) for the long-term surface water bodies in the Baruipur sub-division spans from 0% to 100%, In accordance with WF, there are three categories of surface water bodies: seasonal water bodies (WF 25%), seasonal to permanent water bodies (WF 25% WF 50%), permanent to seasonal waterbodies (WF 50% WF 75%) and permanent water bodies (WF 75%).

$$WF = \frac{\sum N_{Water}}{\sum N_{Good}}$$

where , $\sum N_{Water}$ represents the number of times that all images were identified as water bodies during the year, and $\sum N_{Good}$ represents the number of high-quality images during the year.

Results

Figure 1 portrays the spatial distribution of surface waterbodies in 206, 2019 and 2022 respectively. Most of the surface waterbodies are observed in the east, north-east and north of the Baruipur sub-division. The extent of surface waterbodies is very less in west of the Baruipur sub-division. The extent of surface waterbodies in Baruipur and South of Kultali block. Most of the surface waterbodes are observed in Kultali block, Jaynar-II, Sonarpur block and Bhangar block. Moreover, the extent of surface waterbodies is decreasing day-by-day.



(a) (b) (c)

Figure 1: Spatial distribution of surface waterbodies in (a) 2016 (b) 2019 and (c) 2023

In Baranagar block, surface waterbodies are mostly observed in the west and small pockets of north-east. The etent of surface waterbodies are almost nil in north, central and south of the Baranagar Block I and II.

In Sonarpur block, surface waterbodies are mostly observed in north-east of the study area. Most of the water bodies are found in upper part of the Kultali block; whereas, the extent of surface waterbodies is almost nil in south of the Kultali block. In Jaynagar-I block, the surface waterbodies are mostly observed in the south-east; whereas, in Jaynagar-II block, the surface waterbodies are mostly distributed in the south and north of the block. The extent of surface water bodies in Baruipur block is very less

In the study area, permanent waterbodies are mostly observed in west and north east of Bhangar block, east of Sonarpur block and some small pockets of Kultali block. Seasonal waterbodies are mostly observed in Jaynagar I and II block, Baruipur block and south of Bhangar-I block. Most of the surface waterbodies are transformed from seasonal to permanent category in

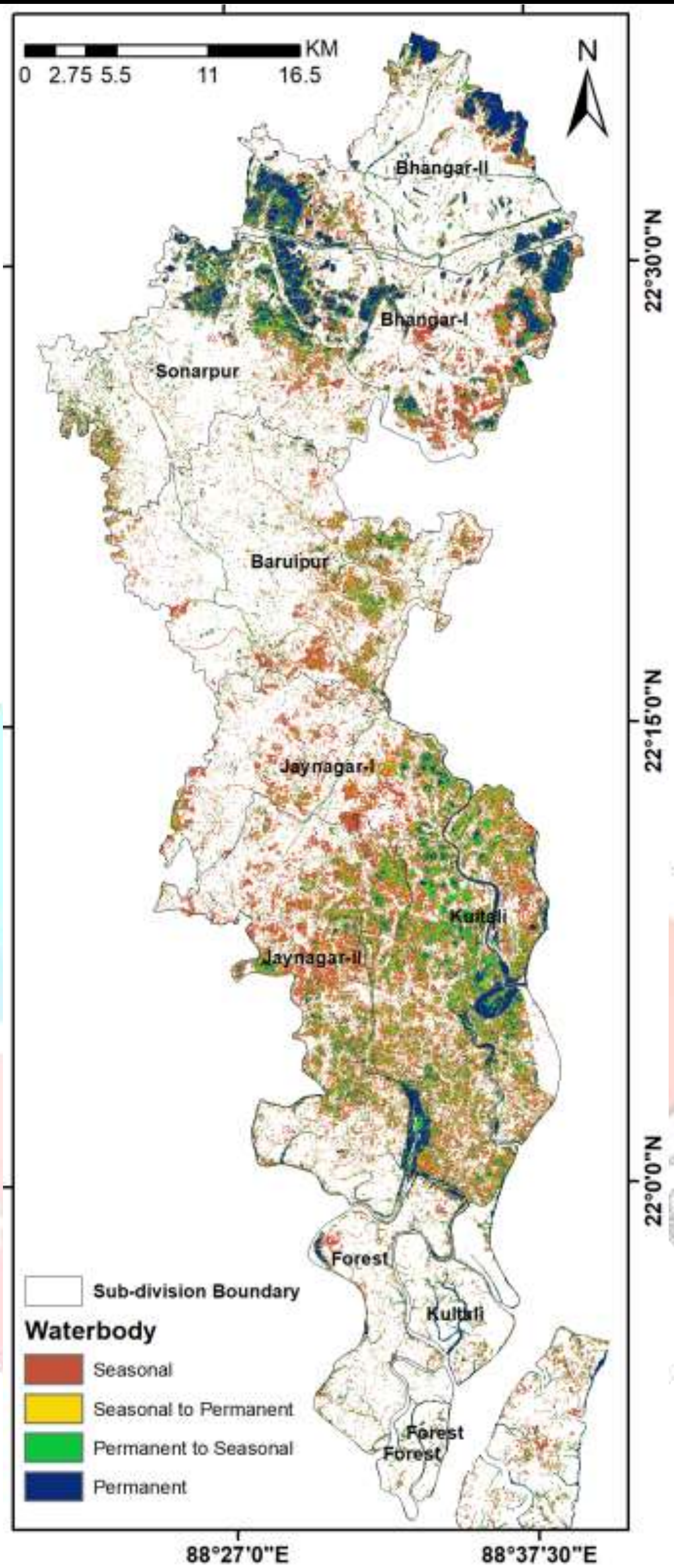


Figure 2: Spatial distribution of water occurrence in Baruipur sub-division

Kultali block. Moreover, the surface waterbodies are transformed from permanent to seasonal category in Kultali block, Baruipur and Sonarpur block. Some small patches are also observed and distributed heterogeneously in the entire study area. This may be attributed to increasing population pressure and construction of built-up area and other infrastructure facilities in the study area. The subterranean watertable in the Baruipur and Sonarpur municipal areas has decreased. More crucially, there are now very few outlets for water to flow out of the metropolitan region due to the loss of water bodies. Due to overcrowding and building, a larger pond on the municipal and town lands has disappeared. Because groundwater levels have dropped due to shrinking natural water basins, people suffer throughout the heat.

Discussion

The Baruipur sub-division is situated at the Ganga's lowest point in the southernmost portion of Gangetic West Bengal. The research area's drainage pattern is significantly influenced by the Bay of Bengal's tidal forces (Alam, 2019). There are several mudflats, coastal marshes, lagoons, creeks, and sizable river estuaries in this region. Numerous rivers and streams are called Khal, and marshy wetlands and wooded swamps are called Bil (also spelt Beel). These channels, which can be man-made or natural, connect most rivers to one another, creating a network of rivers that resembles a web that crosses much of the study area. The Baruipur sub-division has a variety of irrigation sources, including river lift irrigation, tanks, tube wells, and government canals. The sub-division's primary irrigation source is government canals, with tanks coming in second. River lift irrigation accounts for 1.87 percent of all irrigated land. Because of this, 88.17 percent of the irrigated area receives its water from surface water sources.

Sediments from freshwater to marine environments, partially accumulated by rivers and partially by the sea, comprise the subdivision. Because to the West Bengal portion of the basin's original south-easterly slope and subsequent growing rate of southerly tilt, the drainage situation in the delta region is currently dire, with most of the rivers dead or near death (Ghosh, 2019). Despite this, the water flow has changed to the east, which has accelerated the deterioration of drainage in western rivers and streams, including those in the study area. The physiographically highest area is formed by the river levees, which divide the adjacent depressed tracts. The terrain is characterised by palaeochannels, khals, bils, marshes, and other characteristics in addition to the deteriorating rivers. Human intervention in the form of embankments has sped up the degradation (Orengo and Petrie, 2017). It shows how the environment and soil have a significant impact on the production of winter vegetables. The production of winter vegetables is influenced by fertilisation to some degree, but the fluctuation in yield is caused by a number of edaphic elements as well as environmental factors as temperature, humidity, rainfall, wind velocity, and cloud cover (Chaudhuri et al., 2022).

Since topography directly affects microclimate and because of related soil parameters like soil temperature that have an impact on germination, tiller production, and crop growth, topography is one of the most obvious causes of variance in field crops. Furthermore, the properties of the soil affect crop development and production. In more complex terrain, the effects of soil forming elements and erosion are not uniform; rather, they vary depending on the location. Soil characteristics are also affected by topographic environments. The orientation of hill slopes where soils form has an impact on the microclimate, which includes north vs. south-facing slopes, and consequently the soils. Different data layers can be created and overlaid using GIS to connect them across location and time. Numerous intricate soil and climate elements affect crop output; these factors can be better understood by utilising the GIS map overlay.

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