RESEARCH PAPER

Assessment of recurrent flood impact on crop health and phenology using EOSDA modelling for Seraikela Kharsawan and Atreyee River basin of India

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ABSTRACT

The physical and chemical properties of drug molecules including their solid-state properties and their ability to dissolve and their mechanical behavior and their capacity to maintain their form determine how well drugs can be absorbed and how effectively they treat medical conditions but these properties create significant obstacles for developing product formulations particularly in agriculture. Cocrystallization creates a new method for solving these difficulties through its ability to produce crystalline material that contains Active Pharmaceutical Ingredients together with specially chosen Generally Recognized as Safe compounds at specific ratios. Cocrystals establish their stability through noncovalent bonds which include van der Waals interactions and hydrogen bonds and π-π stacking bonds, which permit scientists to control essential drug characteristics which include solubility and permeability and dissolution and compressibility and stability. The use of nutraceuticals as conformers allows them to change the physicochemical properties of API while providing antioxidant and anti-inflammatory benefits. The present research has investigated the impact of crystallization process in the post-flood crop phonological status in Sarikela Kharsawan and Atreeye river basin of India. The research demonstrates how drug-nutraceutical cocrystals will help personalized medicine through its study of current product development work and approved market items.

Keywords: *Cocrystals, Nutraceuticals, Noncovalent Bonds, Agriculture, Cocrystallization*

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1.0 INTRODUCTION

In order to analyze and predict floodwater movement in various circumstances, flood simulation uses a variety of techniques in conjunction with computational models [1-6]. According to research by Lindström et al. (1997), Horritt and Bates (2002), Hunter et al. (2007), Neal et al. (2012), Sampson et al. (2015), Shirvani et al. (2020), Li et al. (2020), and numerous other authors, flood risk management must employ disaster preparedness urban design and climate resilience techniques. Accurate flood simulation is necessary due to the rising frequency of catastrophic weather events brought on by climate change. By simulating water movement and accumulation during flood events, flood simulations offer vital support for evaluating and managing flood risk [7-11]. The simulations will be used by planners and legislators to identify locations that are vulnerable to flooding, construct storm water drainage systems, evaluate flood prevention strategies, and create emergency response plans. In order to create more effective plans, the simulations can pinpoint crucial scenarios for changes in land cover, sea level rise, and rainfall intensity. Important flood prevention measures

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**Author for Correspondence: bubumajumder21@gmail.com* can be put into place by using flood simulations to identify regions that are at risk of flooding. Flood modeling, which creates inundation maps and risk assessments, is useful for emergency planning [12-25]. Because the modeling approach integrates the consequences of land-use change and climate change, it produces realistic future scenarios that aid in the development of successful policies. In order to forecast future flood scenarios and inform planning and policy development, current flood risk management necessitates modeling [21]. Climate scenarios and hydrological models will help the land use planning process by allowing stakeholders to create efficient adaptive solutions that reduce flood risks and increase protective capacity. Using a variety of indicators, the current study determines particular flood characteristics for the study area. The building of the dam altered every aspect of the region's runoff and floods. When transboundary rivers pass the border area, the water distribution patterns of the transboundary river system will alter. The likelihood that a given flood magnitude will occur at a specific site within a given time frame is described by an estimate of flood probability. Flood probability estimation is crucial to the flood simulation process because it offers components that make it possible to comprehend and model flood behavior in various scenarios. In order to simulate scenarios, flood models employ rainfall or flow estimates that follow a "probability-and-frequency" naming approach (e.g., 10-year flood, 50-year flood, 100-year flood, etc.). Rather than evaluating extreme flood circumstances that do not reflect real flood hazard assessment, the flood modeler uses the software to test actual flood scenarios with real flood dangers. In order to verify the hydrologic model's calibration procedure, which must match actual flood patterns from historical data while forecasting future flood scenarios, probability estimate is needed. Because it illustrates which flood protection structures must endure severe flood conditions, the application of flood probability scenarios aids in engineering decisions about the building of levees, culverts, and retention basins. The probability-based flood models assist stakeholders and governments in evaluating their long-term climate resilience plans, implementing mitigation measures, and making investment decisions. Because it guarantees that flood simulation satisfies both theoretical criteria and practical requirements for actual planning, risk assessment, and infrastructure protection, flood probability estimation is an essential part of flood risk management. The flood density index, the stress degree day index, the moisture balance algorithm following dam construction, the topographical behavior of floods, and the vegetation influence on floods are five different indices that have been used to assess the likelihood of flooding.

2.0 MATERIALS AND METHODS

2.1 Flood density index

Google Earth Engine data is used to calculate the flood density index. The project looks on measuring water depth using microwave bands over various seasons. Groundwater and surface water bodies, as well as water table levels, change throughout the pre-monsoon season. While the exceptionally high water level patterns display erratic behavior that leads to significant water loss, the average soil moisture level decreases. The pre-monsoon season is characterized by dry weather and high evaporation rates, which expose soil surfaces and cause the soil to dry up, making these conditions unsuitable for vegetative and agricultural growth. This is completely at odds with the post-monsoon phase (Fig. 1-bottom). Higher water levels are seen in post-monsoon water depth maps as a result of the arrival of monsoon rains, which significantly replenish groundwater and surface water systems. The spatial dispersion of the recently identified heavy rainfalls was demonstrated by widespread heavy rain that spanned several different locations. This region's unique soil properties have a significant impact on the conversion process. After enough rainfall, the soil in this area gains the capacity to hold moisture for long stretches of time. After heavy rainfall, the soil holds onto moisture at ideal levels for several days, helping to maintain competitive moisture conditions that support plant development and agricultural operations until the conclusion of the post-monsoon period.

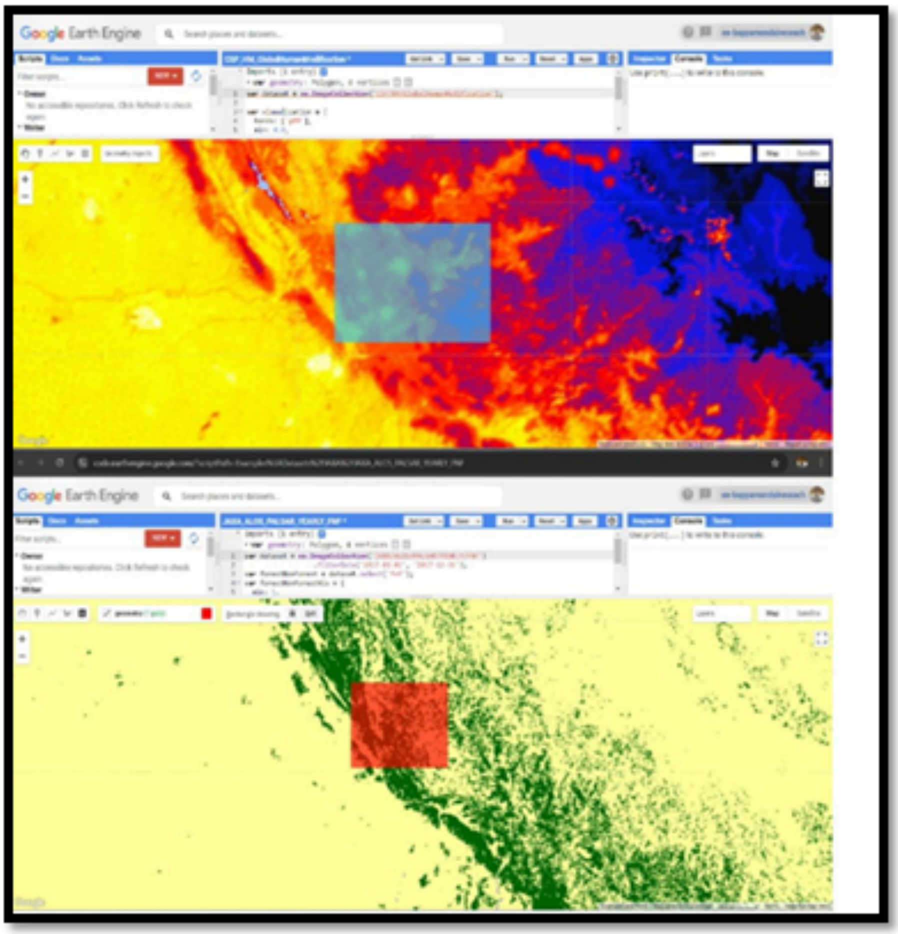

Fig. 1 Flood density index

2.2 Post dam construction moisture balance algorithm

The result is a Google Earth Engine (GEE) display that presents information about moisture balance following dam construction using satellite data. Because precipitation minus evapotranspiration is used to estimate water resources, agricultural production, vegetation health, and regional climatic patterns, the research looks at variations in moisture balance. Because dam-related causes induce discrete or limited moisture balance shifts, the surrounding areas exhibit varied patterns of moisture balance. The downstream region from the dam produces an opposite gradient that generates and sustains moisture under ideal circumstances, causing the gradient to change from brown to green. Even though there are more effective ways to visualize it, the NDVI or land categorization is assessed using the red AOI (area of interest) in the overlay and a unique base layer. Because post-dam moisture retention will enhance vegetation development, the red rectangle is located near green vegetation. The availability of moisture downstream has increased due to the dam. The procedure will lessen drought stress, which will encourage the growth of plants and the advancement of agriculture. The maps monitor elevated moisture levels and show the changes brought about by land cover modification. Google Earth Engine's output shows how the construction of dams has improved regional moisture balance. The researchers examine the moisture balance during different seasons using satellite data. In order to provide a definitive understanding of how climatological phenomena like monsoon rain affect moisture availability, the data offer a picture of both temporal dynamics (changes occurring over time) and spatial patterns (changes occurring across different areas).

3.0 RESULTS AND DISCUSSIONS

3.1 Pre-monsoon moisture distribution

The algorithm's map shows a wide range of moisture distribution patterns, from widely diffused to fully clustered. Because some locations have minimal rainfall while others dry out rapidly, the fluctuation illustrates how different geographic areas disperse their water resources. While some areas have materials that encourage rapid moisture loss due to low infiltration and high evaporation rates, other regions exhibit better moisture retention due to their soils, vegetation, and landscape features (Fig. 2-top). Because severe temperatures produce rapid moisture evaporation when the region receives inadequate rainfall, the pre-monsoon season exhibits a delicate moisture equilibrium. Due to differences in soil texture, land usage, and elevation, different land parcels have varying water-holding capacities. Disjunctive moisture patterns in dryland agricultural systems demonstrate ecological harm and diminish their farming capability.

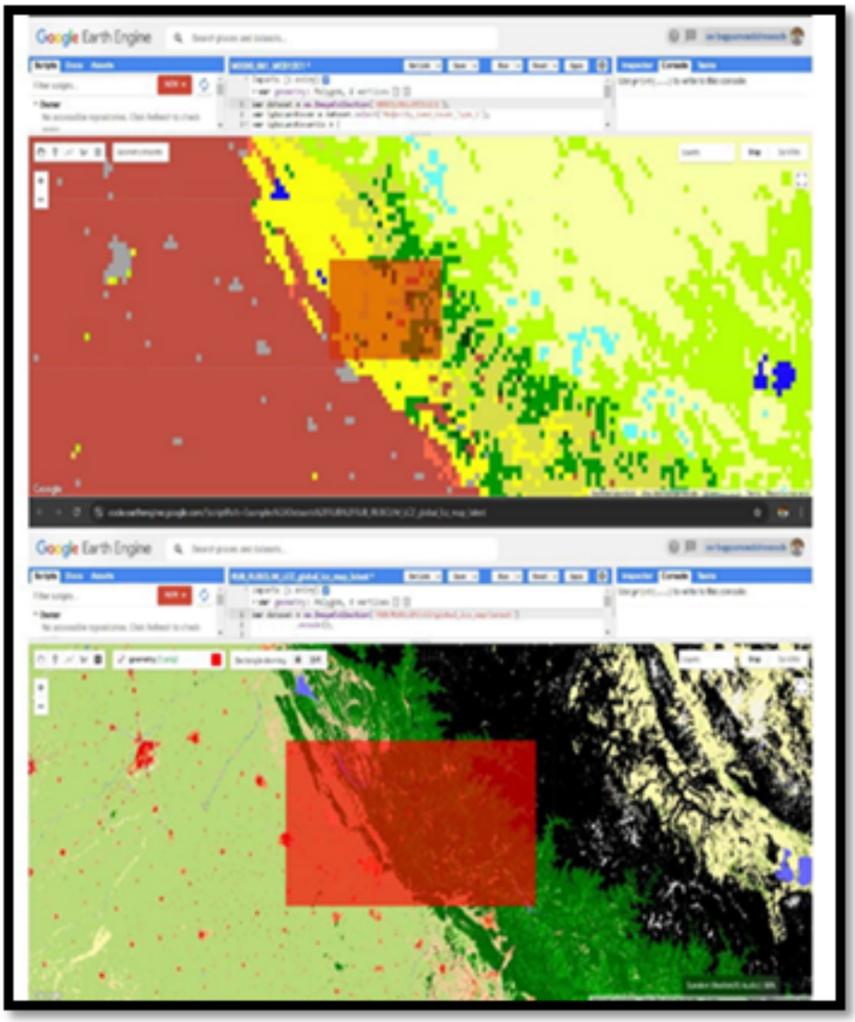

Fig. 2 Post dam construction moisture balance algorithm

3.2 Post-monsoon moisture accumulation

The information presented in Figure 2 (bottom) indicates that the post-monsoon moisture map, which depicts the distribution of moisture over the landscape, has a steady pattern. The two months of monsoon rainfall that fell during this period provided enough moisture to replenish soil and groundwater systems. The method shows that during post-monsoon periods, the moisture balance ratio improves as regional soil achieves its saturation point. The regional imbalance that existed prior to the start of the monsoon period decreases as a result of increased stability in the moisture balance between two regions. Improved moisture conditions in the area boost groundwater recharge, vegetation growth, and agricultural productivity. The findings show that when conducting research, scientists need to take into account both soil types and rainfall intensity. The area's main source of water is rainfall, but the soil's capacity to hold water determines how long moisture is retained following a rainstorm. Higher capacity soils, like clay loams, can hold moisture for longer periods of time, allowing water levels from post-monsoon periods to remain stable until the monsoon precipitation has almost completely stopped. The application makes use of satellite data, which offers both time and spatial information.

3.3 Topographic behaviour of flood

Light rain falls in irregular patterns during the pre-monsoon season, producing little surface runoff while water collects in low-lying places. Because the rainfall is insufficient to produce significant water movement events like bank overflow, water accumulation, or abrupt flash floods, the drier and semi-dry circumstances make it challenging to see how the topography responds to flood situations. The way the landscape carries out hydrodynamic processes is entirely different during the post-monsoon season. High water levels that follow intense monsoon rainstorms have caused severe flooding in regions inland from the shore. Because they are dependent on three primary factors—their initiation places, current status, and geographic area—floods in this region follow topographical patterns.

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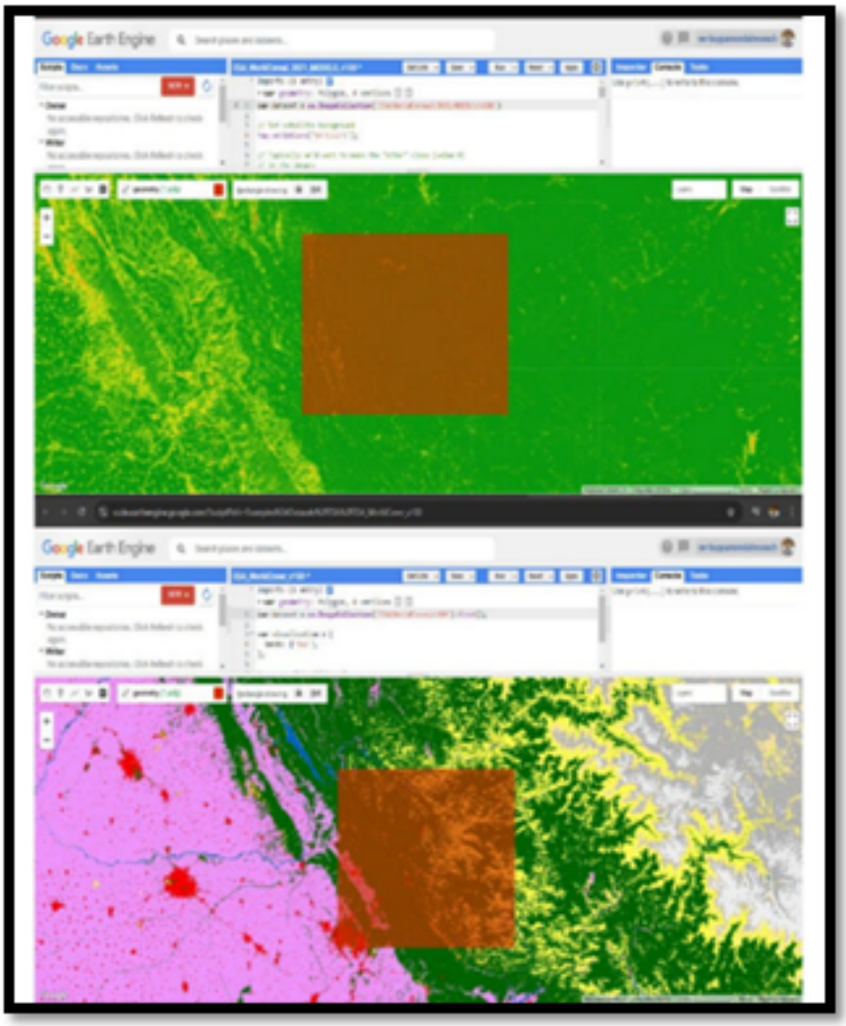

. **Fig. 3** Topographic behaviour of flood

Water building up in hollows or depressions, little surface drainage, and comparatively light, sporadic rainfall are the hallmarks of the pre-monsoon season. Because the amount of rainfall does not create enough hydrological activity to trigger over-stream bankflow, pooling, or flash flooding events, the drier or semi-dry conditions restrict terrain visibility for flood behavior studies. All of the hydrodynamic movements that take place throughout the landscape are completely reversed during the post-monsoon season. High water tables and nearly flooded conditions are experienced in inland locations after periods of heavy monsoon rains. The primary cause of flood events in this region is topographical factors, which dictate their origin, present condition, and impact area.

3.4 Stress degree day index

The Stress Degree Day Index (SDDI) is a numerical indicator of heat stress in plants, which is employed in agriculture and environmental science. It can be computed as:

$$SDDI = (Tc-Ta)$$

Where, Tc = Canopy temperature, Ta = Ambient temperature.

The temperature differential between the air and the canopy is shown by the index. The higher the SDDI, the more heat stress the plant undergoes, usually due to decreased transpiration caused by factors like high atmospheric demand or water scarcity. In South Asia, intense solar radiation during the pre-monsoon months of March through May raises air temperatures and evapotranspiration rates. Due to insufficient rainfall and inadequate irrigation, which are unable to replenish the moisture lost from the soil, plants suffer from soil moisture stress. In order to reduce water loss, plants usually seal their stomata, which lowers transpiration rates. Figure 4-top indicates that the canopy temperature will rise above the average air temperature. Rainfall will replenish soil moisture during the post-monsoon months, enabling plants to absorb enough water. Because plants can keep their stomata open, transpiration can continue, cooling the canopy while maintaining temperatures close to or lower than those of the surrounding air.

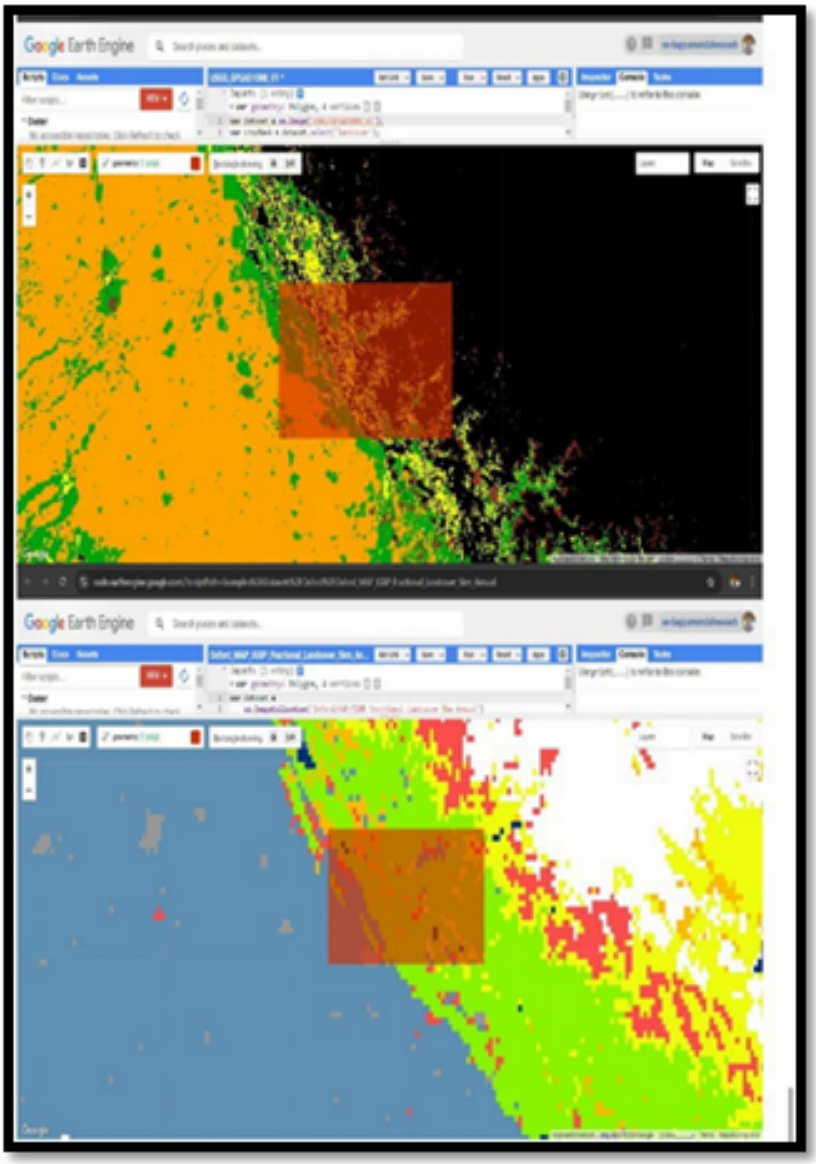

Fig. 4 Stress degree day index

Because there was less heat stress during the post-monsoon period, there was a higher correlation between canopy measures and air temperature, which resulted in lower SDDI values. The SDDI values illustrate how plant physiological activities are impacted by climatic elements including soil moisture and solar radiation, which reveal how these factors affect SDDI movements both before and after the monsoon. Farmers may limit production losses due to heat and moisture stress by managing irrigation schedules and agricultural activities with the help of the SDDI monitoring system, which gives them earlier notification of crop stress.

3.5 Vegetation influence on flood

The control of flood processes depends on vegetation because it helps prevent flooding through its ability to intercept rainfall and enhance water absorption and its ability to strengthen soil roots and its ability to delay water runoff from surfaces.The way plant spreads throughout a terrain determines how efficient these processes are. Large tracts of vegetation with very scant plant cover and soils with very little moisture are covered by dry conditions during the pre-monsoon season. The primary vegetation loss occurs in places with limited plant cover due to subsequent dry spells that exhibit transient soil moisture. As it gathers water from the initial downpour, the plant life can stop soil erosion. A hydraulic barrier that prevents overland water movement is made possible by the regrowth of vegetation in some areas following the initial rains (Fig. 5). During the monsoon season and the times that follow, the vegetation's spatial organization serves as a flood control mechanism. When rainfall levels surpass a particular threshold, the seasonal shift in vegetation strength produces a buffer effect that prevents flooding. Priority access to all necessary parts that keep dam systems functioning should be given to the protection of natural flood control systems. Integrating ecological infrastructure into various locations would create a buffer that increases flood resilience.

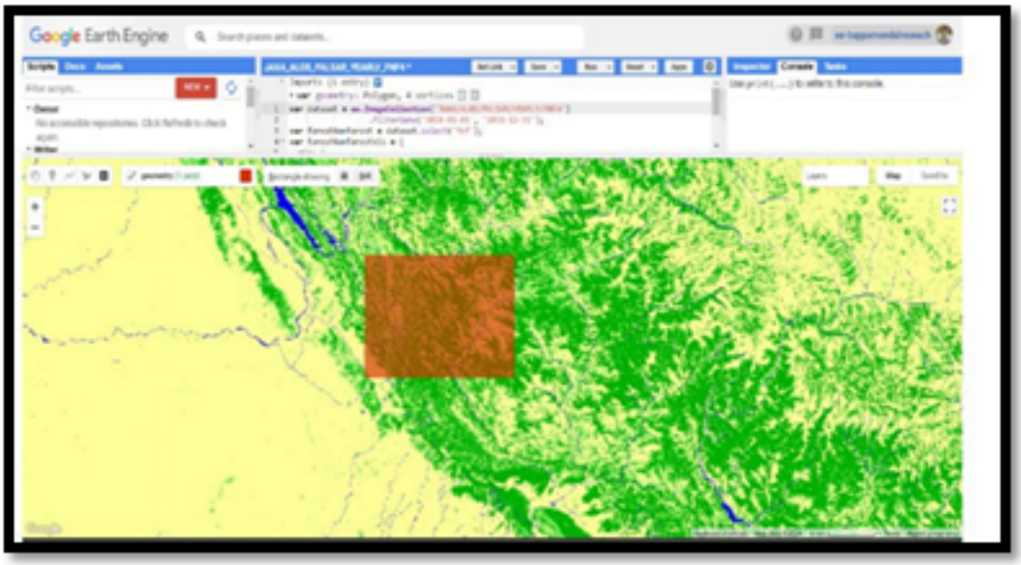

Fig. 5 Vegetation influence on flood

3.6 Flood simulating factors

According to hydrologists, flooding models have three functions: flood effect mitigation, flood management, and flood prediction. The geographic and meteorological distribution of all factors that influence flood behavior is part of the study of flood hydrology and flood simulation. Slope, the sediment transport index (STI), focal flow, the stream power index (SPI), and flow accumulation are the main topographic features. These factors aid in illustrating the water flow patterns and topographic features that influence flood behavior. Because slope indicates how steep the terrain is, it is a crucial aspect for hydraulic investigations. The volume of flood discharge increases along with the overland flow speed to downstream regions as the slope rises. Slower flow on the lower slope side leads to more infiltration, which lessens the effects of flooding. Slope parameterization is used in flood modeling to pinpoint regions with fast flow and track such areas to evaluate erosion potential and flash flood dangers. The sediment transport index is a measurement instrument that assesses the ability of sediment to flow throughout the environment by combining slope and area sources. High STI values indicate possible storm conditions during floods, which enhance overland flow and promote sediment movement and erosion. Focal flow is a technique that employs digital elevation models (DEMs) to compute the density of water flowing toward a specific location in the landscape. The places where water passes through its sensor system are displayed by focal flow. Because the focused flow pattern indicates where water will gather, the results of this parameter display the flood threat area. Potential locations for water to collect are indicated by areas with significant focused flow movement. The high focal flow areas indicate possible places where water will flow to build gully formation areas and erosion sites. The stream power index uses slope and a particular catchment area as its basis measurement to gauge the severity of water erosion. The system's capacity to move and transport sediment on channels allows it to detect sediment energy. SPI makes it possible for flood simulations to find water routes with enough force to either enlarge or deepen them, resulting in significant geomorphic changes.

SPI finds unstable channels that become high-risk during floods, making places downstream more vulnerable to flooding. In a digital elevation model, flow accumulation is defined as the number of cells upstream that contribute to a single cell. The system displays the amount of water that could get to a particular place. Channelized flow and depressions that will gather significant amounts of water during storms are the two primary patterns found in high flow accumulation areas. The first prerequisite for identifying possible flood locations is the system. In addition to land use data and raindrop readings, flow accumulation data is required for the full forecast of flood extent and intensity. Slope, STI, focal flow, SPI, and flow accumulation are some of the criteria needed to determine flooding conditions in a given location. Researchers can create flood models to forecast when and where floods will occur by using an area's relief features to estimate how water moves through the terrain, how sediments move through the environment, and how energy is distributed.

4.0 CONCLUSION

Important information about hydrological performance, flood patterns, and the spatial distribution of flooding in the border floodplains between northern West Bengal and neighboring Bangladesh was obtained by flood modeling of the Atreyee and Punarbhaba river systems. The study evaluated the degree of flooding as well as the variations in runoff patterns over time using remote sensing, GIS technology, hydraulic modeling, and hydrologic modeling. Due to their proximity to one another and similar catchment area, the two rivers experienced simultaneous flood peaks. Flood length and flood breadth increased as a result of poor channel slopes, siltation, and floodplain encroachment. The flood scenarios show that there is a high chance of flooding in the areas around Balurghat, Gangarampur, and Thakurgaon, endangering infrastructure, agriculture, and livelihoods. Because the model validation demonstrated the model's dependability by matching actual recorded data, the flood modeling simulations are a useful tool for organizing flood preparedness and response actions. In order to improve data exchange, water resource management, and the creation of sustainable flood control solutions, Bangladesh and India must collaborate at the basin level through transboundary partnerships.

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