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# Google Earth Engine Based Approach for Assessment and Management of Flood in Ganga Sub Basin – Ghaghra Confluence to Gomti Confluence

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**Abstract:** Floods are an intense and frequent disaster happening in numerous portions of the world. Flood is a excess of water that submerges surroundings that is normally dry. It is the sever problem in Ganga Sub Basin - Ghaghra Confluence to Gomti Confluence of Uttar Pradesh. Near real time mapping of inundated areas is very important for figuring out the flood extent, deployment of emergency reaction teams, and evaluation of damages and casualties. In this thesis work, a real time flood mapping and monitoring online WEB based application using Sentinel-1 time-series data has been developed on Google Earth Engine (GEE) platform. The SAR Data has Capability to see through the cloud and during the flood the major problem with optical data is, it can not see through the cloud. In this thesis work the SAR data has been used to identify the inundated pixels before and during flood to identify the extent and calamities due to flood. Flood is a hazardous natural phenomenon which severely affect lives, goods and services. Monitoring of flood affected area becomes compulsory for emergency responses but due to damage of network and risk for lives in going such areas it becomes a very typical task. Google Earth Engine (GEE) is an open-source cloud based online platform which reduces this problem. In this thesis work the GEE platform has been used for Near-Real time flood mapping in the study area. The GEE based app "FLOOD MONITORING SYSTEM: GANGA SUB BASIN – GHAGHRA CONFLUENCE TO GOMTI CONFLUENCE" has been developed for Near-Real time flood Mapping.

**Keywords:** Flood, Google Earth Engine, SAR Image, Disaster

## 1. Introduction

India is possibly the most flood skewed nations on earth. India, because of its topographical area, environment, geography and huge individuals, has a more huge effect of flood fiascos. 23 of the 36 states and alliance districts in the nation are mindful to floods [10].

Almost 75% of the absolute Indian precipitation is concentrated throughout a short rainstorm season of four months (June-September). Thusly the streams eyewitness a significant conveyance during these months, inciting extensive floods in Uttar Pradesh, Bihar, West Bengal and Assam. (Srinivasa Rao G, 10 July 2018) [8, 9].

Remote sensing and GIS data can provide a better platform to detect Flood affected areas to mitigate and make prevention measures. This research was based on the open source Google Earth Engine Platform to assess the Near-Real-Time flood affected areas [20]. In this research work the study area (Ganga Sub Basin – Ghaghra Confluence to Gomti Confluence) has been taken situated in Uttar Pradesh and Bihar. Both of the states face flood almost every year which causes huge damage of lives and goods [11].

The geographical level of the Ghaghara Confluence to Gomti crossroads sub-bowl lies between 81° 34' to 84° 47' east longitudes and 24° 34' to 26° 48' north extents of the country. In this sub-bowl the Gomti and Ghaghara to its essential Ganga stream. Various streams that are exhausting in this sub-bowl are the Banas Nadi, the Chhoti Sarju, the Durgauti Nadi, the Gomati, the Kao Nadi, the Karamnasa and the Majhoi to give some examples. The Ghaghara sub-bowl of Ganga bowl has an outright catchment space of 26,254 Sq.km. It channels into the regions of Uttar Pradesh and Bihar. The sub bowl map is showed up underneath (Figure 1):

In this research work Sentinel-1data on GEE platform has been used to plan Near-Real time flood observing App. Microwave information has capacity to infiltrate through cloud though optical information can not. During the flood the sky is covered with cloud because of which optical information can not gather any data while microwave information gathers practically all data [1, 2, 3, 20].

Satellite image of SENTINEL-1 in Google Earth Engine Platform has been used for flooded area identification [5, 6, 7, 21, 22] whereas satellite image of Sentinel-2A and 2B of the year 2015 and 2020 has been used for preparing Base-Map and Land Use Land Cover Map [4]. The details of Satellite Data which has been used and its specification with purpose given in the table 1;

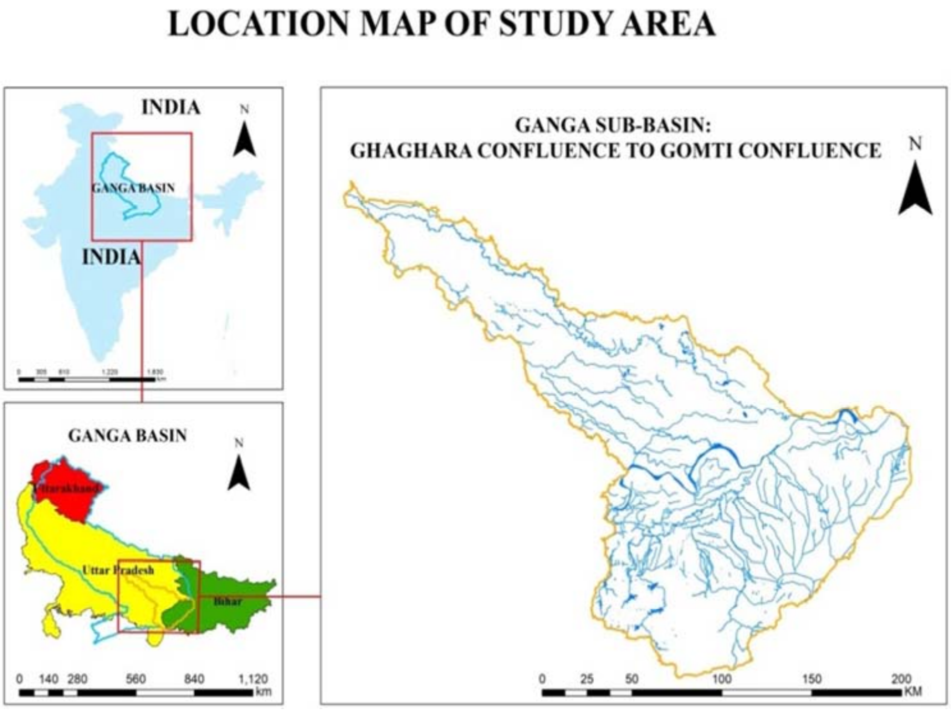


***Figure 1.*** *Study area.*

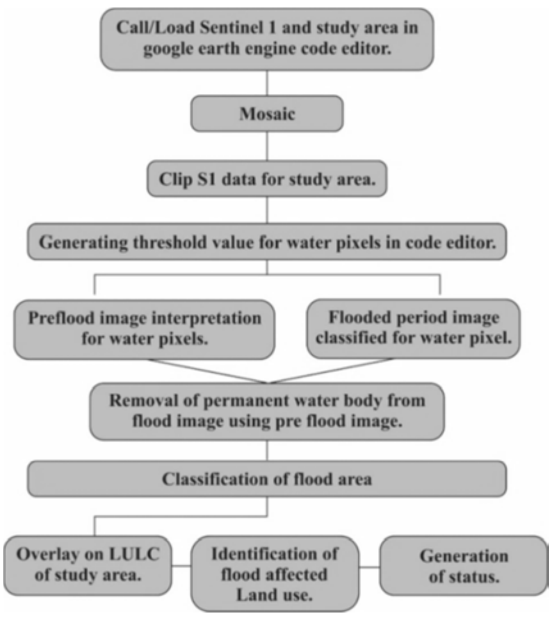


***Figure 2.*** *Methodology flow chart.*

***Table 1.*** *Description of satellite data used.*

| S. No. | Satellite | Spatial Resolution | Source | Year | Purpose |
|---|---|---|---|---|---|
| 1. | Sentinel-1 | 20 m | https://scihub.copernicus.eu | 2015 to till date | Identify the flooded area |
| 2. | Sentinel-2B | 30 m | https://earthexplorer.usgs.gov | 2015 and 2020 | Prepare LULC and Base Map |

## 2. Methodology

The research work conducted in Uttar Pradesh and Bihar state of India by The methodology adopted in this research work has been given in figure 2 and described in following 2.1 to 2.4 subheads [12-15, 18 19].

### *2.1. Call/Load Sentinel 1 and Study Area in Google Earth Engine Code Editor*

The Sentinel 1 data and study area shape file has been called or loaded for the analysis in GEE code editor Platform.

### *2.2. Mosaic AND Clip S1 Data for Study Area*

The study area S-1 data has been mosaiced and then clipped for the study area in GEE code editor platform.

### *2.3. Generating Threshold Value for Water Pixels in Code Editor*

To differentiate flooded and non-Flooded areas in the app, it is required to generate the threshold values of inundated pixels and non-inundated pixels. So the threshold was decided on the basis of rice pixels and flooded pixels [3, 14].

### *2.4. Pre flood Image Interpretation for Water Pixels*

The water pixels before flood was identified to saperate the permanent water with flood areas.

### *2.5. Flooded Period Image Classified for Water Pixel*

The water pixels during the flood has been classified for flood inundation mapping.

### *2.6. Removal of Permanent Water Body from Flood Image Using Pre Flood Image*

Using the before flood image the permanent waterbody has been removed from the after-flood image to identify actual flood affected areas.

### *2.7. Classification of Flood Area*

The flooded area has been classified using the flood image after removal of permanent water pixels.

### *2.8. Overlay on LULC of Study Area*

The Land Use Landcover map has been generated for the year 1015 and 2020 using the sentinel-2 image has been overlayed on the flooded area image.

### *2.9. Identification of Flood Affected Land Use*

Using the LULC and flood image the final flood affected LULC maps and its statistics has been generated.

### *2.10. Publishing of Web-Based Application for Flood Monitoring*

The flood monitoring application has been published using Google Earth Engine platform. The link for the app is given below; https://www.spacefun.org/subbasin-flood-monitoring.

## 3. Results & Discussions

The study area is situated between the confluence of two rivers with the main River Ganga. Due to merging of these rivers water in the river Ganga the water table in Ganga River is increased. During the rainy season due to rainfall water table is also increases in both the rivers and their tributaries, a large amount of water merged with the Ganga River water which causes flood condition in the study area.

Flood occurrence in the study area is a common situation for every rainy season. The human beings and landuse is adversely affected due to heavy flood. flooding is responsible for a large number of losses of lives and goods which causes adverse impact on livelihood and economy of the area [8-11].

Flood is a risky normal phenomenon which seriously influence lives, labour and products. Monitoring of flood influenced region gets necessary for crisis reactions however because of harm of organization and hazard for lives in going such regions it turns into an typical task. Remote sensing technique provide a reliable and frequent information for flood affected areas without going to the area through the satellite imagery. The SAR Data has Capability to see through the cloud and during the flood the major problem with optical data is, it can not see through the cloud. In this thesis work the SAR data has been used to identify the inundated pixels before and during flood to identify the extent and calamities due to flood [8-11].

Near-Real-Time monitoring of flood is very important for quick response and recovery of flood affected population and services. Google Earth Engine (GEE) is an open-source cloud based online platform which provide a better platform for near real time satellite data monitoring. In this thesis work the GEE stage has been utilized for Near-Real time flood mapping in the study area. The GEE based application "FLOOD MONITORING SYSTEM: GANGA SUB BASIN – GHAGHRA CONFLUENCE TO GOMTI CONFLUENCE" has been developed for quick response in the flood affected area [20].

The GEE app "FLOOD MONITORING SYSTEM: GANGA SUB BASIN – GHAGHRA CONFLUENCE TO GOMTI CONFLUENCE" has been used to map the flood affected areas from the year 2015 to 2020 and will be used in future. Using this application, the flood affected areas has been mapped as well as the effect of flood in different landuse also monitored, which is given in the following table no 2 and 3 and the graph in the figure 3 and 4. The flood affected map has been shown in the following figure 5 to 10.

***Table 2.*** *TOTAL FLOOD AFFECTED AREA FROM 2015-2020.*

| Year | Flood Affected Area in ha. |
|---|---|
| 2015 | 9,009.72 |
| 2016 | 76,116.37 |
| 2017 | 14,592.13 |
| 2018 | 26,394.71 |
| 2019 | 15,814.38 |
| 2020 | 25,540.03 |

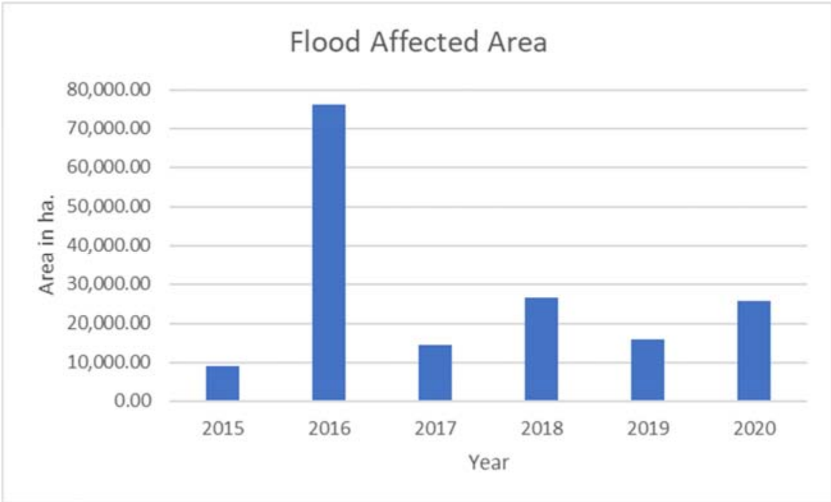


***Figure 3.*** *Graph of Flood Affected Area from 2015-2020.*

***Table 3.*** *Total Flood Affected LULC Area from 2015-2020.*

| Flood Affected Landuse | | | |
|---|---|---|---|
| **Year** | **Agriculture** | **Settlement** | **Other** |
| 2015 | 1,570.38 | 0.225 | 7,439.11 |
| 2016 | 30,414.68 | 18.601 | 45,683.10 |
| 2017 | 1,592.74 | 3.817 | 12,995.57 |
| 2018 | 6,951.14 | 8.903 | 19,434.66 |
| 2019 | 2,663.15 | 4.715 | 13,146.52 |
| 2020 | 5,302.83 | 9.851 | 20,227.35 |

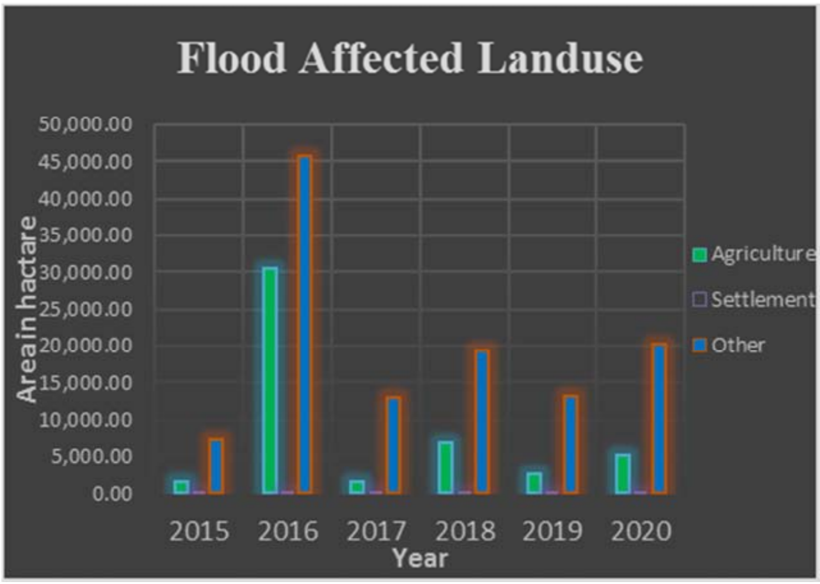


***Figure 4.*** *Graph of Total Flood Affected LULC Area from 2015-2020.*

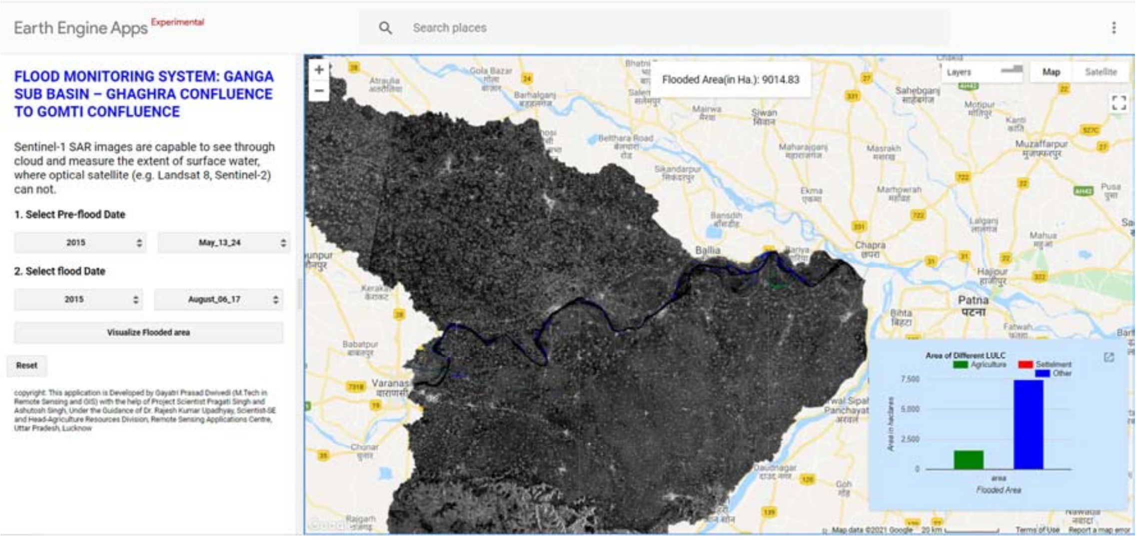


*Figure 5. Visualisation of Total Flood Affected Area and LULC in GEE App for the Year 2015.*

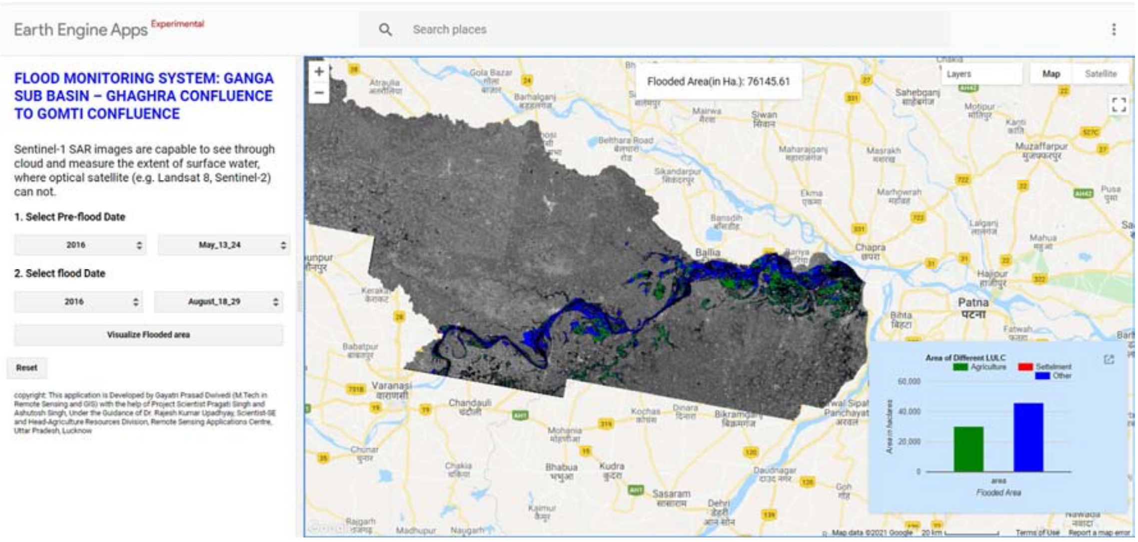


*Figure 6. Visualisation of Total Flood Affected Area and LULC in GEE App for the Year 2016.*

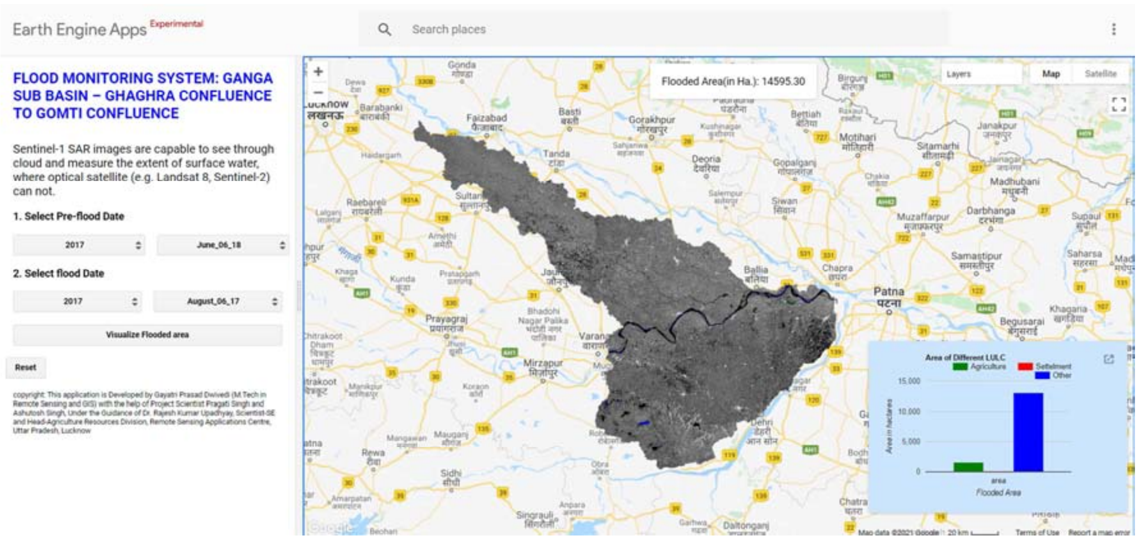


*Figure 7. Visualisation of Total Flood Affected Area and LULC in GEE App for the Year 2017.*

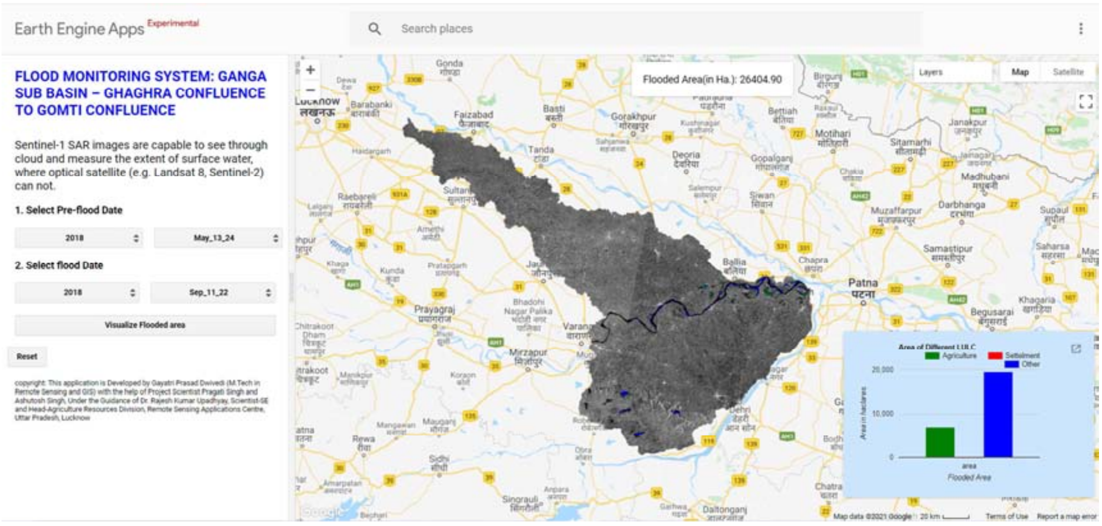


***Figure 8.*** *Visualisation of Total Flood Affected Area and LULC in GEE App for the Year 2018.*

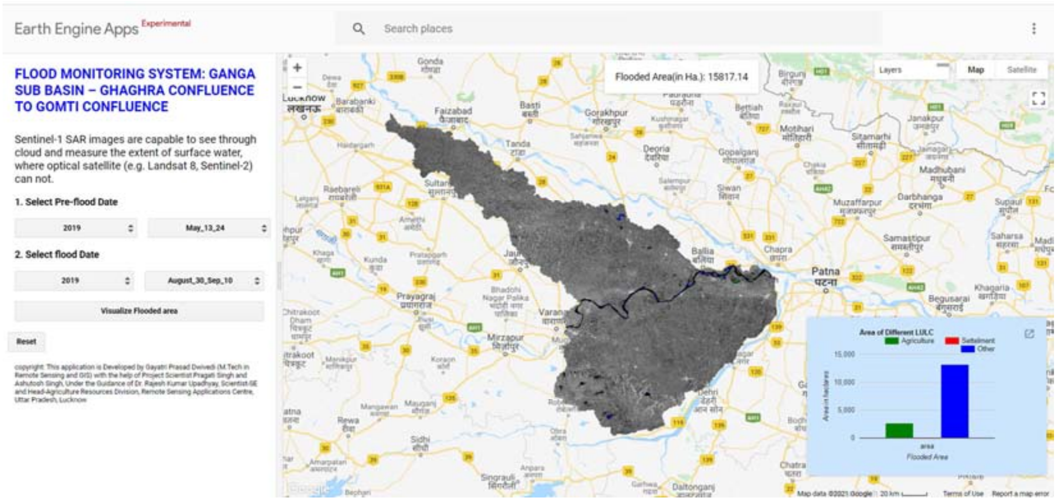


***Figure 9.*** *Visualisation of Total Flood Affected Area and LULC in GEE App for the Year 2019.*

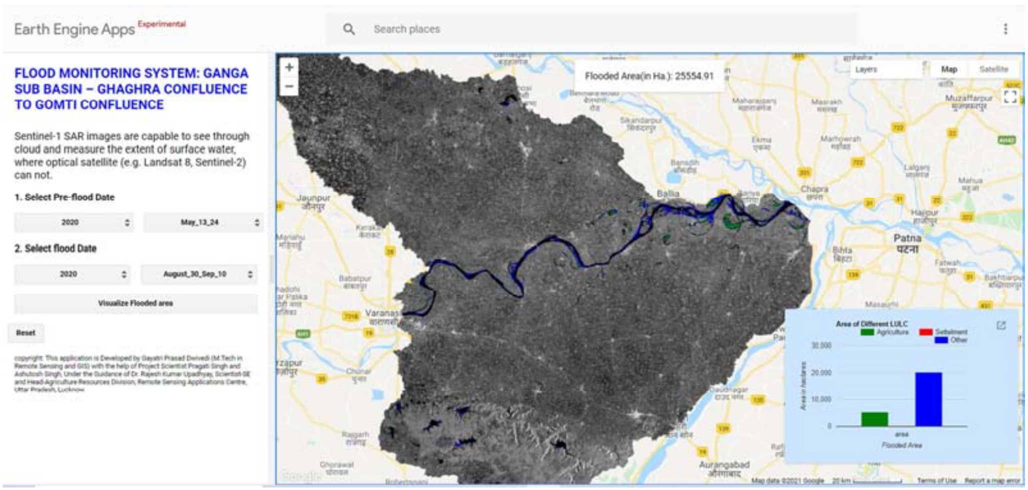


***Figure 10.*** *Visualisation of Total Flood Affected Area and LULC in GEE App for the Year 2020.*

By the above given Graphs, tables and Maps visualized in GEE app, it can be seen that the 2016 was the highly flood affected whereas 2015 was the lowest one. Among the whole flood affected Landuse and Landcover the Sand bars, fellow land, shrublands etc was the highest then the agricultural Landuse is affected after that the settlement area is affected with the flood.

## 4. Conclusion

In this study, it is concluded that the flood is a major disaster in the study area. Monitoring of Near-Real-Time is very necessary for Mitigation and recovery for flood. Optical Data does not have capacity to penetrate through cloud. So, the conclusions made in the study can be summarized as

1) Optical Data can not penetrate through cloud
2) Sentinel-1 freely available Microwave satellite data provide better information regarding flooded area because of its cloud penetration capacity
3) Every year flood occurrence can be seen in the study area either on a large or small scale
4) Near-Real-Time monitoring of flood is necessary for Mitigation and recovery and providing help and support
5) Earlier SAR image processing and interpretation was not easy
6) Google Earth Engine Provide an Open-Source better platform to process, analyze and prepare an app for Near-Real-Time flood mapping and monitoring

By this research work it is recommended that flood management is required in the study area for reducing the severe impact of flood. The settlements should be shift from flood affected areas to low frequency flood affected areas.

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