Rapid assessment of recent flood episode in Kaziranga National Park, Assam using remotely sensed satellite data

Flooding is considered as the most damaging natural hazard. Continuous population growth associated with changes in land use and climate exacerbates flood hazard, and makes livelihood more precarious. A large part of Assam, a state of northeastern India, experiences devastating flood frequently. The Brahmaputra river, along with its distributaries and tributaries in Assam, causes flood in the monsoon season each year which affects agriculture, human life and properties, wildlife, etc. Kaziranga National Park (KNP), a UNESCO World Heritage Site, is the most flood-affected National Parks of Assam (Figure 1). The park is famous for its great Indian one-horned rhino (*Rhinoceros unicornis*) though other animals such as elephants, tigers, wild buffaloes, ungulates, wild boars, etc. are also found in the park[1]. Hence, predicting and monitoring flood as well as assessment of loss due to flood is essential specifically in flood-prone areas with enriched biodiversity.

Satellite remote sensing has been used as an essential tool for flood assessment and complementary information for flood modelling. One of the advantages of the remote sensing data is that it can provide information on large area with near real time. Moreover, many of these datasets are freely available in the public domain. Landsat 8 OLI (Operational Land Imager) and SARAL/AltiKa (Satellite with Argos and AltiKa) can be considered as good examples. Landsat 8 OLI with moderate spatial resolution and high radiometric quantization can be useful for land surface monitoring. Also, the newly introduced shortwave infrared (SWIR) bands are effective for water body or wetland monitoring. On the other hand, SARAL/AltiKa is one of its own kind of mission conceptualized and implemented by ISRO and CNES. AltiKa is an onboard altimetry system which is useful for inland water study[2,3] along with its oceanographic applications. In this study, we used Landsat 8 OLI (for water extent) and SARAL/AltiKa (for water level) data for a quick assessment of one of the most devastating floods of 2016.

The flood situation in Assam continued to remain grim during the fourth week of July 2016 affecting several districts such as Golaghat, Dhemaji, Lakhimpur, Jorhat, Nowgong, Marigaon, Sonitpur and Sibsagar[4]. The KNP includes parts of Brahmaputra river and areas falling in Nagaon, Golaghat and Sonitpur districts. The KNP is basically situated at flood plain of the Brahmaputra river. In most cases, elevation of this region is less than 75 m (Figure 2). The

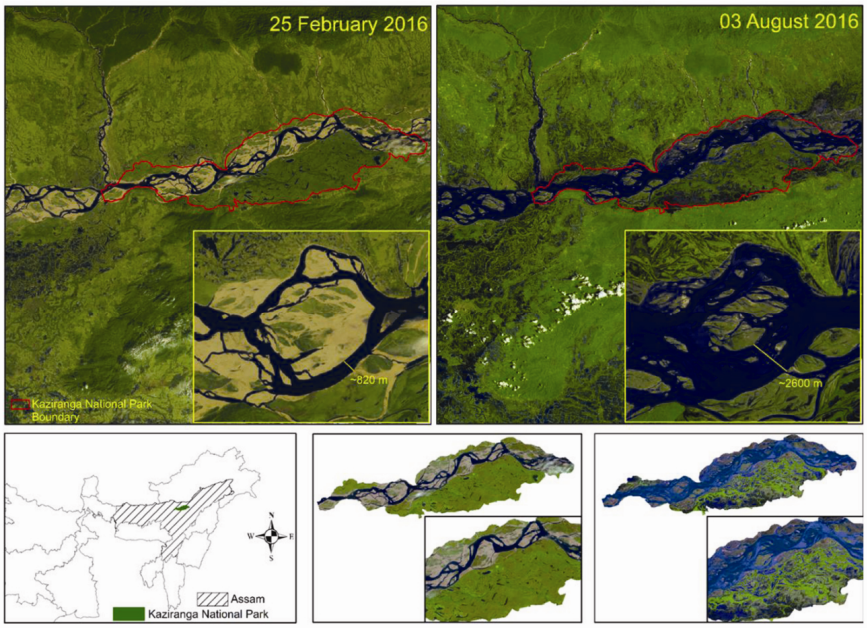

Figure 1. Landsat 8 OLI imagery of dry (February) and flood (August) seasons of KNP.

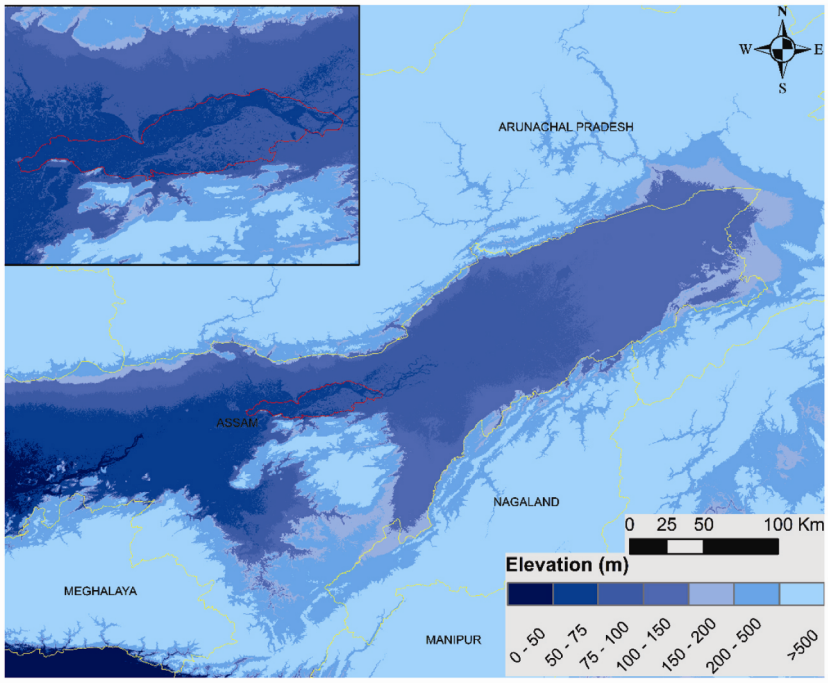

Figure 2. SRTM DEM showing the topographic condition of KNP and its surroundings.

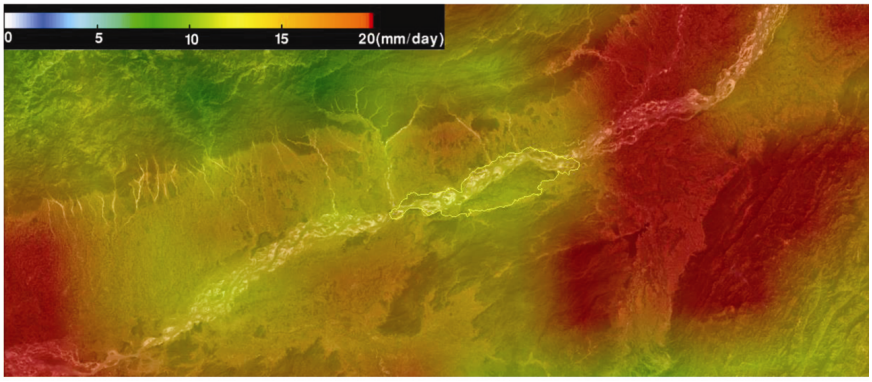

Figure 3. Mean daily rainfall from 5 July to 4 August 2016 in part of northeast India overlaid on Google Earth (Source: https://pmm.nasa.gov/data-access).

Figure 4. SARAL/AltiKa footprints of pass #810 over the Brahmaputra river in KNP.

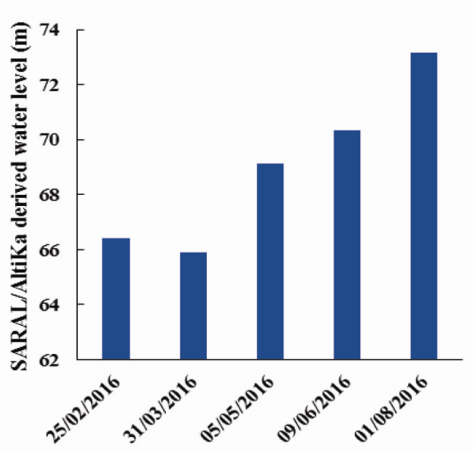

Figure 5. Water level derived (above reference ellipsoid WGS84) from SARAL/AltiKa.

Table 1. Rainfall (mm/day) retrieved from CPC data for July 2015 and 2016 in KNP

Year	Minimum	Maximum	Mean
2016	10.36	21.35	14.70
2015	12.59	14.61	13.38

KNP received ~10% more rainfall in July 2016 compared to July 2015 (Table 1). Climate prediction centre (CPC) data was analysed to get this statistics. The spatial distribution of mean rainfall of 5 July to 4 August 2016 (Global Precipitation Mission (GPM) data) is shown in Figure 1. Both the datasets, viz. CPC and GPM showed similar trend of rainfall (Figure 3 and Table 1). We calculated Modified Normalized Difference Water Index[5] from Landsat 8 OLI data to estimate the total flooded area. Two Landsat 8 OLI imagery dated 25 February 2016 and 3 August 2016 were used in this study. Imagery of 25 February 2016 was used as reference image as February can be considered as dry season. It was found that 70% of the KNP area was still flooded as on 3 August 2016 (Figure 1). Grassland is mostly flooded which is a natural habitat of rhinos and other animals. The width of the Brahmaputra river increased almost three times in some part during this period (February to August 2016) (Figure 1). From SARAL/AltiKa, we studied the variation of water level of Brahmaputra river in KNP. The ground track #810 was processed using ICE-1 retracking method[6] (Figure 4). ICE-1 retracking method is widely used in retrieving water level for inland water, even this method was used for water level retrieval in the Brahmaputra[7]. The water level variation gives an idea about the status of inundation of the flooded area. Water level increased ~6.73 m from February to August 2016 (Figure 5).

The present study highlighted the capabilities of satellite data for a first-hand information of flood in terms of acquiring, processing and reporting information in near real-time for management and conservation of wildlife habitats. A detailed study is needed to assess the vulnerability of wildlife and its habitat to flood, considering the ecological importance of this National Park.

1. Kushwaha, S. P. S., Kalra, M. and Sahi, S., Mapping of Kaziranga Conservation Area, Project Report, IIRS/FED/Kaziranga/36/8026/2008.
2. Ghosh, S. *et al.*, *Mar. Geod.*, 2015, **38**(suppl), 597–613.
3. Sridevi, T., Sharma, R., Mehra, P. and Prasad, K. V. S. R., *Remote Sensing Lett.*, 2016, **7**(4), 348–357.
4. NRSC flood report; http://www.nrsc.gov.in/assam_floods_july_2016 (accessed on 7 August 2016).
5. Xu, H. Q., *Int. J. Remote Sensing*, 2006, **27**, 3025–3033.
6. Frappart, F., Calmant, S., Cauhope, M., Seyler, F. and Cazenave, A., *Remote Sensing Environ.*, 2006, **100**(2), 252–264.
7. Dubey, A. K., Gupta, P. K., Dutta, S. and Singh, R. P., *J. Hydrol.*, 2015, **529**, 1776-1787.

Received 9 August 2016; accepted 17 August 2016

S. GHOSH
S. NANDY*
A. SENTHIL KUMAR

Indian Institute of Remote Sensing (ISRO),
Dehradun 248 001, India
**For correspondence.*
e-mail: subrato.nandy@gmail.com