Jute Crop Information System: Application of geospatial technology in Jute sector

Technical Report · March 2023

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Jute Crop Information System: Application of geospatial technology in Jute sector

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1. Introduction

Jute is an important fibre crop of India which provides gainful employment to farmers and industries. Jute crop needs to be monitored periodically as this is one of the high input oriented and long duration crops. Any failure of the crop due to vagaries of monsoon, pest/ disease results in eroding the resources of farmers resulting in socio-economic distress. Hence there is a need to develop techniques for mapping and frequent updation of area and condition of these crops using latest available technology. Geospatial technologies aid in the monitoring of this important crop and its spatial distribution that leads to efficient regional and local monitoring, especially during periods of surplus or deficit and also during periods of disasters or episodic events. In addition to inventory, transport of raw produce with various processing industries needs geo-tagging for efficient monitoring. Satellite remote sensing by virtue of its varied advantages, mainly the capability to provide an unbiased and synoptic view of the natural resources with better repeativity in a timely and cost effective manner has become one of the sought after techniques to provide thematic information for developmental planning on a sustainable basis.

Keeping this background in mind, Indian Space Research Organization(ISRO) through its technology centre i.e. National Remote Sensing Centre (NRSC), along with and Ministry of Textile through The Jute Corporation of India Ltd.(JCIL) and National Jute Board (NJB) started a pilot level study in developing a monitoring system of jute crop based on space and ground information. Subsequently, a tailored-made mobile app for the jute crop has been designed and used for field data collection. These geo-tagged data were hosted in BHUVAN geo-portal for visualization and further analysis. A data analytics were conceptualize to use these ground based information to monitor and assess the progression of jute crop growth and development. Satellite based jute crop maps were also prepared over the selected districts. A smart sampling technique based on the satellite-based yield proxy was also implemented to locate the Crop Cutting Experiment (CCE) jute field. A systematic measurement of the jute biomass and fibre yield was done through CCE following the recommended protocol. These CCE data is being further utilized to model the jute yield based on weather, soil and satellite data to upscale it at district level. It is proposed to build a fully operational Jute Crop Information System towards seamless integration of it in the JCIL/NJMB's operation.

2. Approach /Methodology:

A brief approach of the Jute Crop Information System is presented in Fig1. Overall objective of the effort is to develop and deploy of a centralised Jute crop information system for monitoring and assessment of jute crop prospects and production in the country using

ground and space-based observations. It is intended to cover major jute growing districts over four states *i.e.* West Bengal, Assam, Bihar and Odisha.
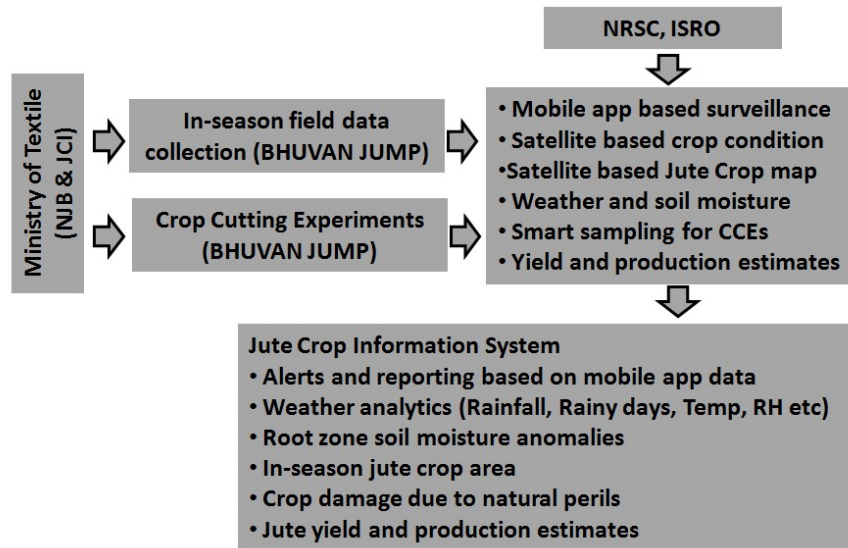

Fig. 1. Schematic diagram of the methodology for Jute crop information system.

The total field activities have been undertaken under the project Jute ICARE of National Jute Board and The Jute Corporation of India Ltd. It is a synergistic effort between Ministry of Textile (JCIL/NJB) and National Remote Sensing Centre, ISRO, Hyderabad with defined role, responsibilities and deliverables as under;

2.1 Role of Ministry of Textile (JCIL/NJB)

- In-season collection of the ground truth information using the mobile apps via identified nodal agencies and focal points.
- Conduct Crop Cutting Experiments over the jute growing areas following the smart sampling scheme.
- Integration/utilization of the decision support system.
- Provide feed-back mechanism for further improvement of the information system

2.2 Role of National Remote Sensing Centre (ISRO)

- Ensuring mobile app based objective field data collection of Jute crop and hosting it over BHUVAN geo-portal for visualization and reanalysis.
- Organising awareness programme on the collection of field observations and CCE using mobile apps.
- Providing CCE locations using smart sampling technique
- Augmenting Crop Cutting module in the existing BHUVAN JUMP app
- Providing data analytics and automated reporting of jute crop prospect based on field data collected using mobile app.

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- Modelling of crop biomass and yield estimate of jute crop
- Crop damage assessment due to climatic perils
- Development of Jute crop Information System towards informed decision making.

2.3 Deliverables / Outputs

- Mobile apps based total solution for field data collection, asset mapping and CCE of Jute crop
- Geo-tagging of the offices / establishments / centres of The Jute Corporation of India Ltd.
- Dedicated module for data hosting, visualization, downloading and analysis.
- Data analytics/automatic report generation of the Jute crop based on information collected using BHUVAN JUMP mobile app.
- Weather and soil moisture information over the jute growing areas.
- Jute crop area map and yield estimation.
- Monthly/fortnightly reporting of Jute crop status based on the field and space based observations.

3. Jute crop information system:

It is a crop information system in a geo-portal to host, analyze and support the mobile based field observations, satellite and weather data sets towards centralised monitoring and assessment of jute crop for informed decision making. A schematic diagram of the proposed information system is presented in Fig. 2
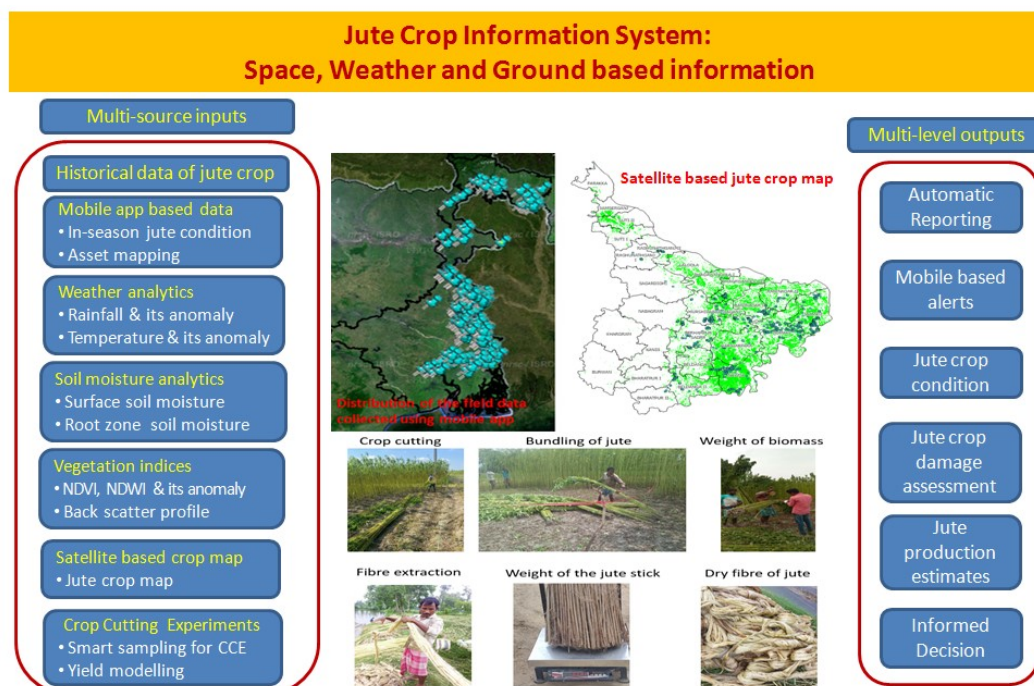

Fig. 2. Proposed dash board of the Jute crop information system.

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3.1 Legacy data of the Jute crop: All the historical data regarding the Jute crop and its production data can be kept in this module for consultation.

3.1 Mobile app for Field Data Collection.

An android-based GPS enabled mobile application (BHUVAN JUMP) was developed for the field data collection of Jute crop. The mobile app facilitates near-real time field data collection along with field photographs and geo-location of Jute crop. The data have been transferred to ISRO's geoportal (BHUVAN) for visualization, storage and further analysis. Presently, it is having crop surveillance and asset mapping module. In future a separate module on CCE data collection would be augmented. A schematic diagram of different module of BHUVAN JUMP is presented in Fig. 3
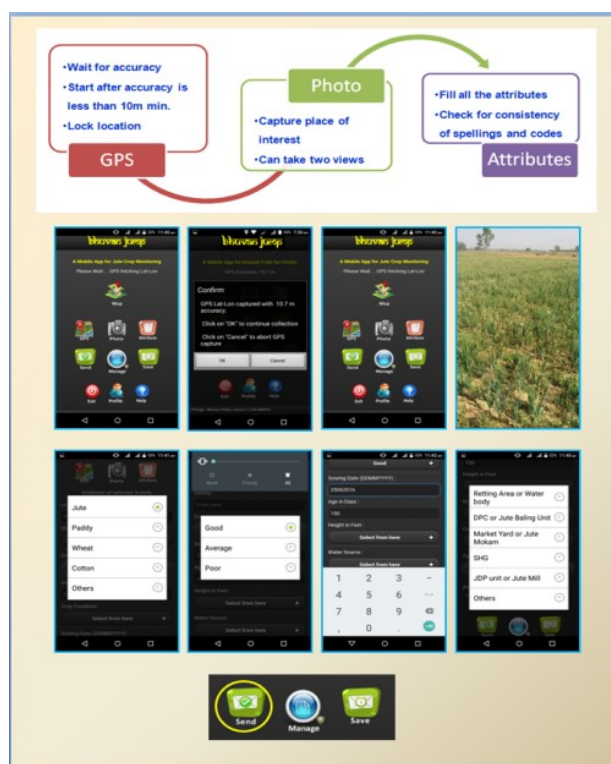

Fig. 3 Different module of BHUVAN JUMP Mobile app

The attributes of the BHUVAN JUMP were iteratively fixed based on several discussion with the JCIL officials and presented as below;

- Village name:
- *Soil type (Loam/Clayey/Red/ Black/Mixed)
- *Current week rainfall (Deficit/Excess/Normal)
- *Previous week rainfall (Deficit/Excess/Normal)
- *Crop types (Tossa (JRO)/White (JRC)/Mesta)
- *Presence of weed: (High/Medium/Low/None)

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- *Sowing : (Broadcasting/Line sowing)
- *Sowing week:(1st week/2nd week/3rd week/4th week)
- *Sowing Month:(Jan/Feb/Mar/Apr/May/Jun/Jul/Aug/Sep/Oct/Nov/Dec)
- *Sowing Year: (2018/2019/..........2030)
- *Crop growth stages (sowing/early vegetative/late vegetative/maturity/others)
- *Crop health condition (Good/Average/Poor)
- *Crop stress : (Pest/Disease/Drought/Flood/No stress)
- *Height of the crop (feet): (0.5/1/1.5/2/2.5/3/3.5/4/4.5/5/6/7/8/9/10/11/12)
- Expected Total *fibre* yield (Qtls/bigha):
- Water source nearby for retting : (Pond/Ditches/river/others/none) :
- any other information:

 * Marked are mandatory; values in () are combo box options. All others are text
Dates are 6 digits DDMMYYYY format
Provide confirmation message to the surveyor

3.2 Collection of field data using mobile apps:

Several training programmes have been conducted to provide awareness to JCI field staff on the use of mobile app for field data collection. A SOP is also prepared to streamline the field data collection. The field staff of JCI provided in-season field observation of the crop condition using the mobile apps, which were further hosted in BHUVAN geo-portal for analysis (https://bhuvan-app1.nrsc.gov.in/fdcviewer/fdcviewer.php). The participation and the enthusiasm of the ground staff of the JCI is really appreciable. The data collected in the last few crop seasons were presented in Fig. 4 mentioning the number of points and its spatial distribution.
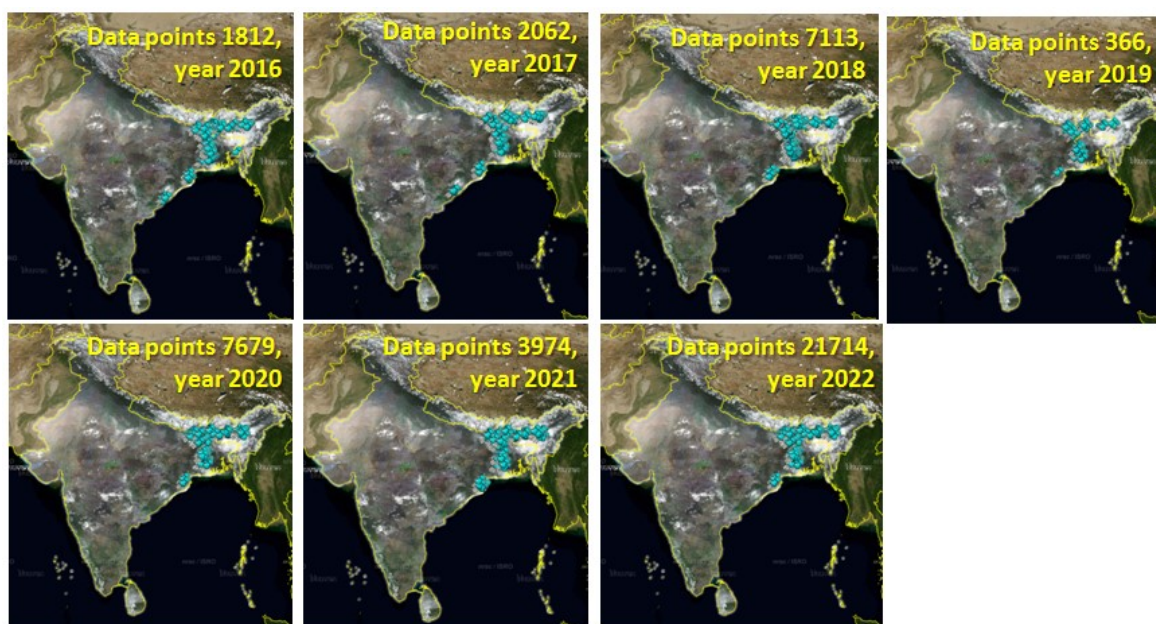
Fig. 4 Distribution of the field data points collected using the mobile app over the different jute crop growing States during crop season 2016-22.

3.3 Automated report generation of jute crop condition based on field data collected

Field data collected by JCIL has further been analysed to generate district level report at desired time interval automatically using BHUVAN interface. A prototype of such interface has already been developed and tested. An alert system would also be developed in due course of time.

The data analytic module of the BHUVAN JUMP is presented in fig. 5. It requires selection of State, District, followed by the time of interest to view all the available field points. A report can be generated and downloaded as pdf by just simply clicking the generate report button.
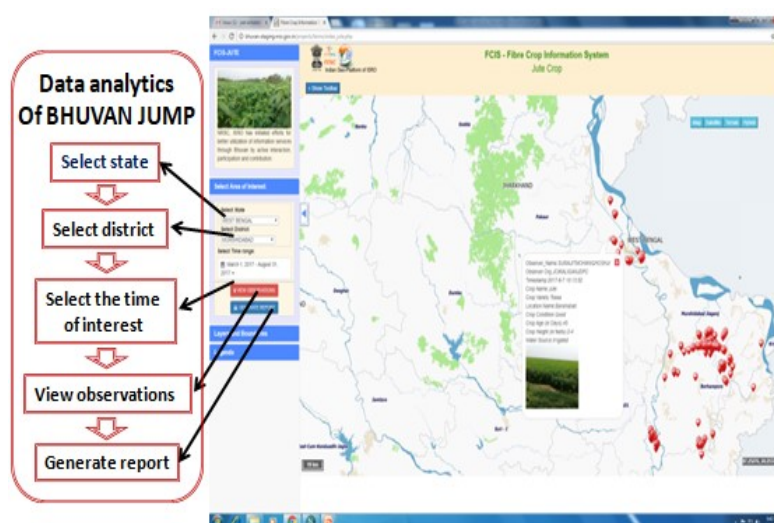

Fig. 5 Data analytic module of BHUVAN JUMP for automated report generation.

Based on the requirements, different crop attributes can be picked up from the BHUVAN JUMP database and time-wise progression of these attributes can also be tabulated and plotted in near-real time basis. These plots are very crucial to assess the crop stress, condition and growth. The field data of jute crop over Murshidabad district during April to August 2022 were analyzed and presented in Fig. 6 . Nearly 20% of the field observations were found to be drought affected throughout the season and it has found to be more in the later part of the season. The pest and disease infestation is also recorded through the time period , which was as high as 30-40% of the field observations. The modal height of the jute crop was found to be increasing steadily from April to July and truncated at 10-12 feet. Such information can be the basis of crop surveillance and decision making.
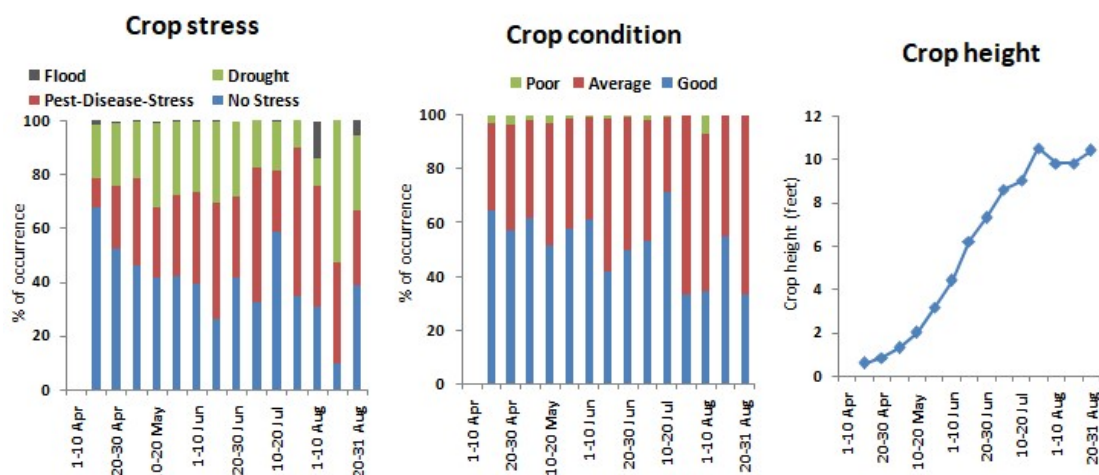
Fig. 6 Jute Crop Stress and crop height reported using BHUVAN JUMP over Murshidabad districts during April – October 2022

3.4 Weather analytics: This module primarily involves in the analysis of spatio-temporal distribution of rainfall, number of dry days and wet days. It will also include the temperature profile of the respective areas. IMD district wise rainfall data and the IMD AWS data are utilized in this respect. This module will provide the weather condition and its dynamics over the jute growing areas of India. As an example the monthly gridded rainfall data of 2022 over West Bengal is shown in Fig. 7.
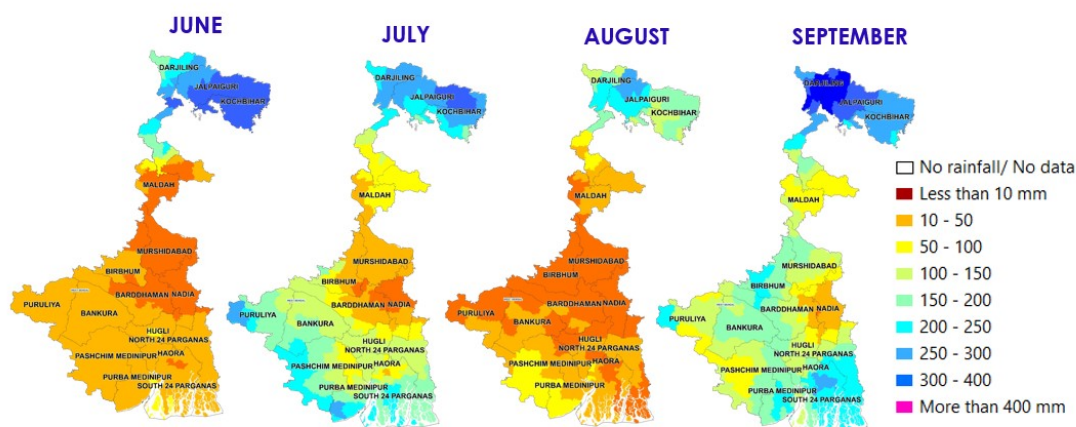

Fig. 7 Monthly cumulative rainfall of 2022 over West Bengal

3.6 Soil moisture status: This module primarily involves in monitoring the soil moisture condition at the surface and root zone level and can act as an early indicator of moisture stress. The SMAP soil moisture data and soil moisture product of mass soil water balance would be utilized in this respect. Further optical based wetness index would also be incorporated in this module if cloud free data are available. The root zone soil moisture over the jute growing region of West Bengal during June- July 2022 presented Fig. 8 showing persistence soil dryness.
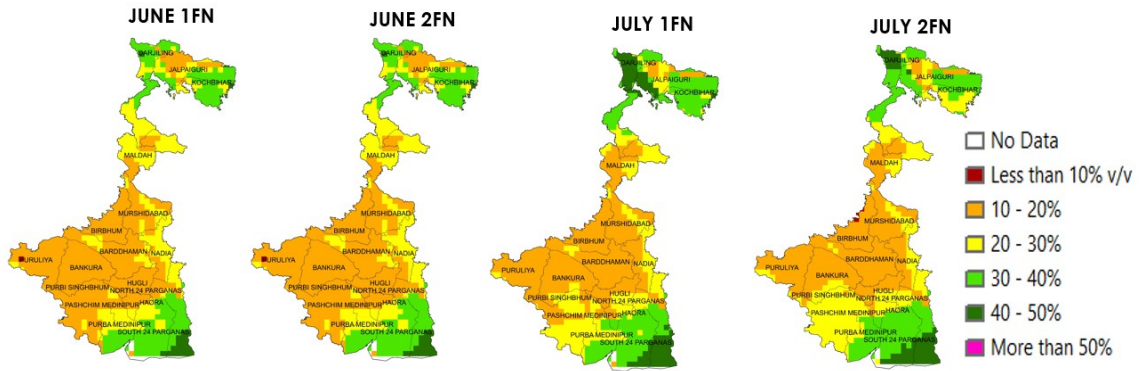
Fig. 8 Root zone soil moisture during June – July 2002 over West Bengal

3.7 Satellite based jute crop condition and damage assessment: Satellite based vegetation indices are very sensitive to the growth the condition of the crop, such as Normalized Difference Vegetation Index (NDVI) represent the crop vigour, whereas Land Surface Water Index (LSWI) represent the moisture condition of the crop. These indices can be generated in near-real time under clear sky condition to assess the progression of the crop growth/ condition and how much it is deviating from normal year. LSWI map of West Bengal in July 2021 and July 2022 is presented in Fig.9. The deviation of LSWI of 2022 in comparison to 2021 is showing intense dry condition (drought) over Murshidabad, Bankura, Burdwan and Hooghli districts.
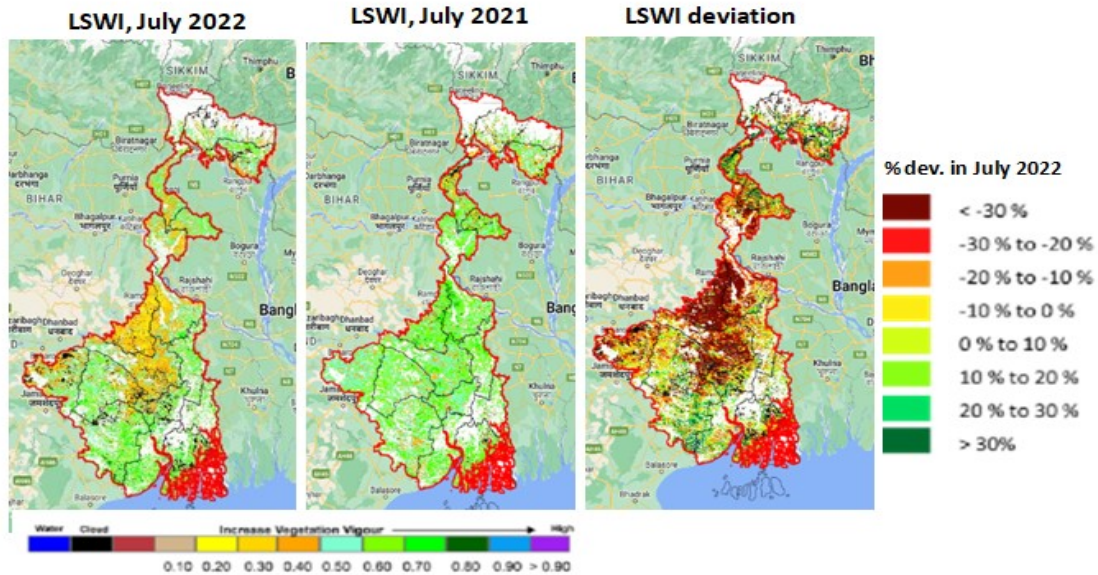

Fig. 9 Land Surface Water Index (LSWI) over West Bengal during July 2021(normal year) and 2022 (drought year). LSWI deviation from normal shows intense dry condition over parts of West Bengal.

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Satellite data have extensively used to assess the crop affected due to weather extremes particularly for the damage of flood and cyclone. Synthetic Aperture radar (SAR) data has the capability to pick up water (flood) signature quickly and can be used to map the extent of inundated area operationally. Disaster Management Support programme of ISRO regularly map the flood affected area over India. Recently the flood over Naogaon district has also been mapped periodically as presented in Fig. 10
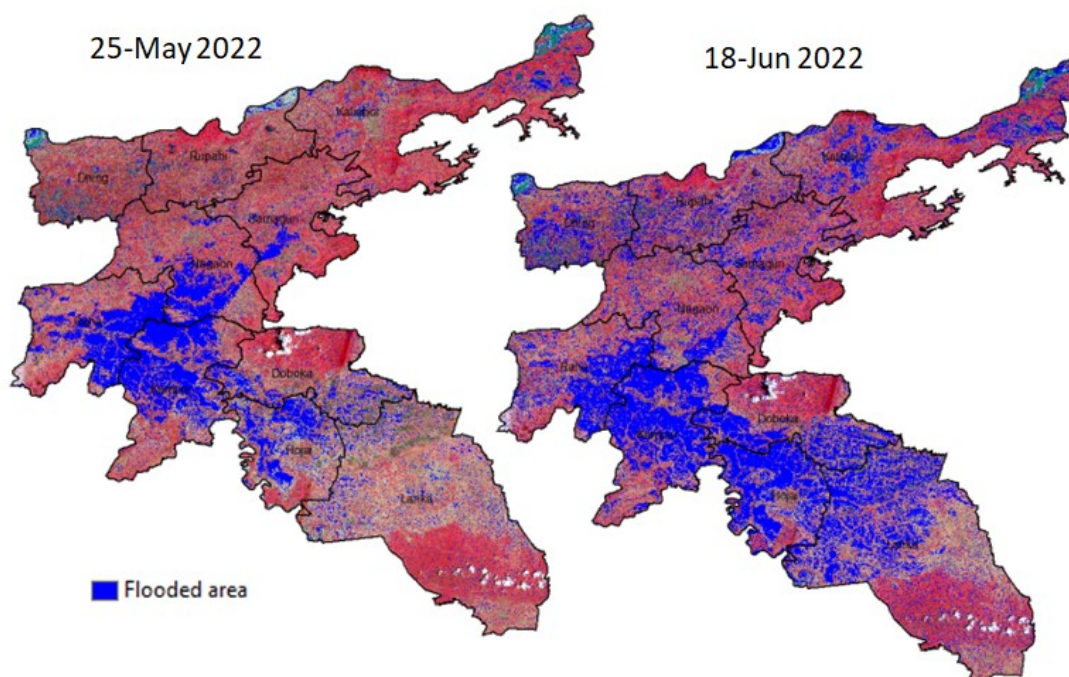

Fig. 10 Flood affected area over Naogaon in two episodic events i.e. 25 May and 18 June 2022

Satellite data has also been used to assess the jute crop lodging and partial inundation due to recent amphan cyclone in 2020 (Chakraborty et al., 2021). An operational methodology has been established using multi-temporal optical and SAR data to assess the jute crop affected due to cyclonic systems like amphan (Fig. 11). These near-real time information can been very help to support insurance claim and relief.
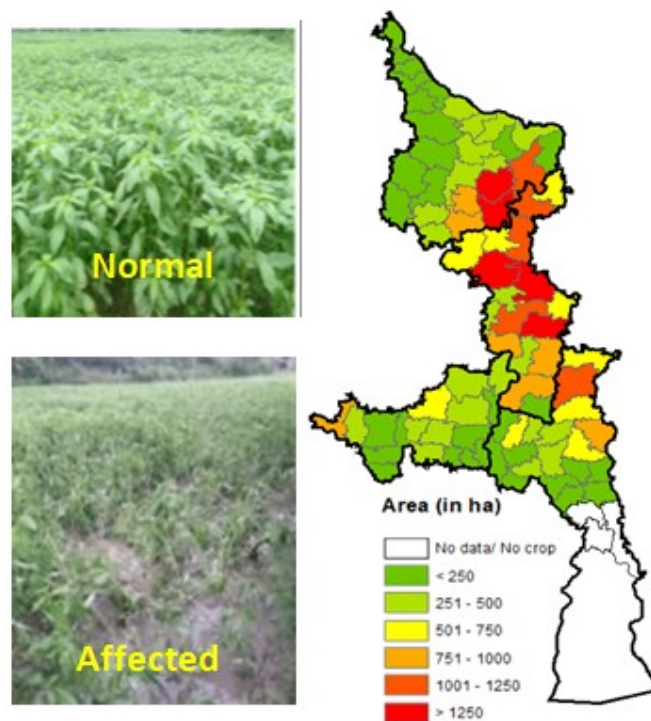
Fig. 11 The Jute growing blocks affected due to recent amphan cyclone, 2020

3.9 Jute crop map, Crop Cutting Experiments and yield estimates:

Multi-temporal satellite data (both optical and microwave) were used to map in-season jute crop and accuracy assessment was done using the BHUVAN JUMP data points. It is found that Jute crop map can be generated using multi-temporal satellite data with 80-85% accuracy depending on the competing crops and associated terrain. The jute crop map of West Bengal of 2022 is presented in Fig12.
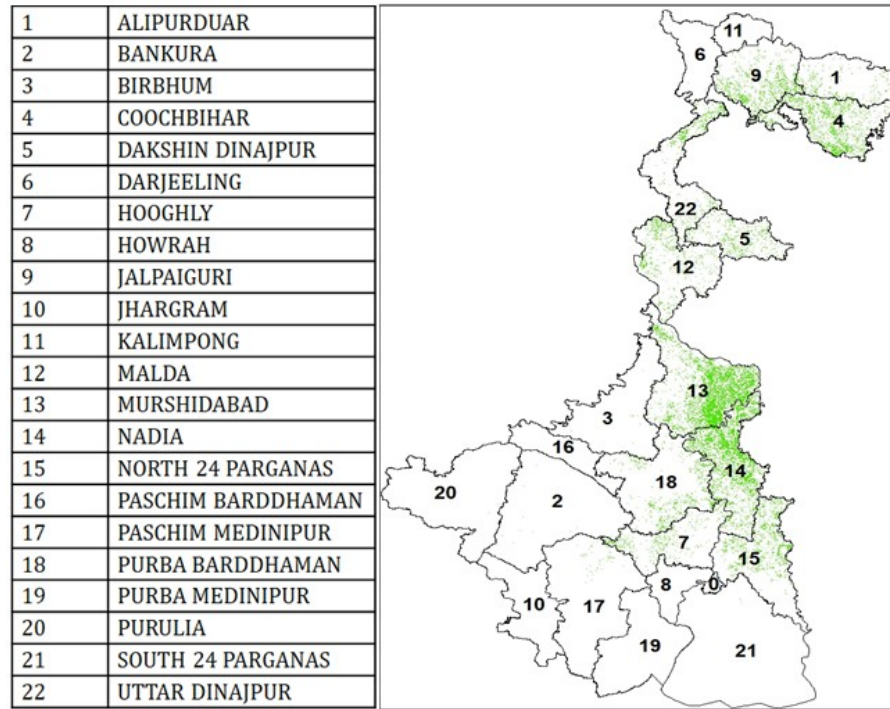
1	ALIPURDUAR
2	BANKURA
3	BIRBHUM
4	COOCHBIHAR
5	DAKSHIN DINAJPUR
6	DARJEELING
7	HOOGHLY
8	HOWRAH
9	JALPAIGURI
10	JHARGRAM
11	KALIMPONG
12	MALDA
13	MURSHIDABAD
14	NADIA
15	NORTH 24 PARGANAS
16	PASCHIM BARDDHAMAN
17	PASCHIM MEDINIPUR
18	PURBA BARDDHAMAN
19	PURBA MEDINIPUR
20	PURULIA
21	SOUTH 24 PARGANAS
22	UTTAR DINAJPUR

Fig. 12 Satellite-based jute crop map of West Bengal of 2022

A special initiative has also been taken to conduct Crop Cutting Experiments (CCE) for jute crop for objective assess the jute yield in terms of biomass and fibre. These data will be the base for further modeling and up-scaling, using satellite and weather based information. The first step of CCE is to identify its locations which is randomized and can accommodate all the variability of the jute yield. Hence, jute yield proxy was generated using satellite derived NDVI, LSWI, integrated cross-polarized backscatter to represent the jute crop vigour and health. Stratification of jute crop area was done based on the yield proxy. Maximum four strata were made as "Very high", "High", "Moderate", and "low" yield zone. A smart sampling module was generated based on python code to distribute the CCE locations based on the yield strata, area under the crop in each strata and mutual distance between the location and ease of reaching to the locations. Primary locations of the CCEs were distributed over five selected district i.e. Murshidabad, Nadia, Koochbihar, Araria, Noagaon as presented in the Fig. 13. Each primary location is provided with two alternative locations in case first one is not achieved due to logistics or any other issues. All the CCE locations were then converted in KML file and linked to google map with navigational support. The field officials can click a particular location and get the navigational support (road direction) from google map so that the location could be reached at ease (Fig. 14). Proper training and support has also been provided to use the service and conduct the CCE. The JCIL successfully conducted the CCE over the five selected districts and the data points were quality checked, geo-tagged and analyzed. These CCE data points are further being used for modeling the jute crop yield using LUE or AI/ML based approaches.
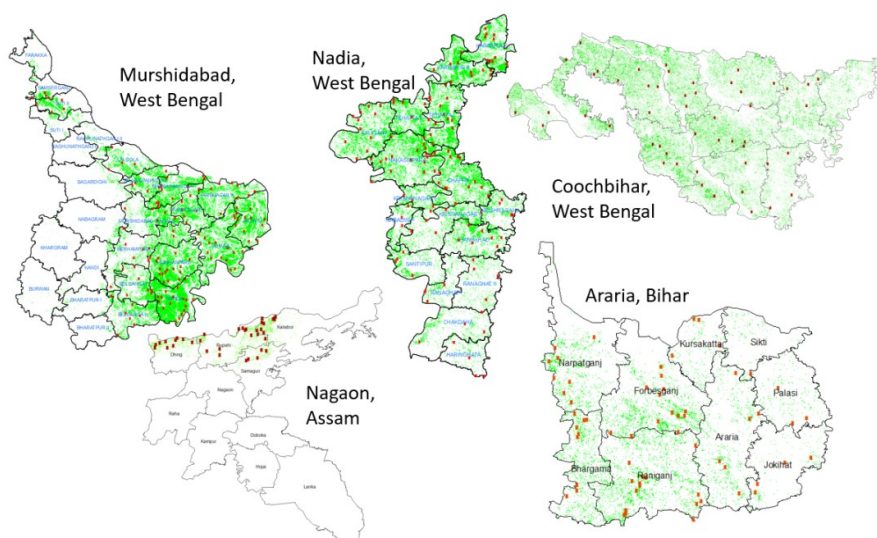
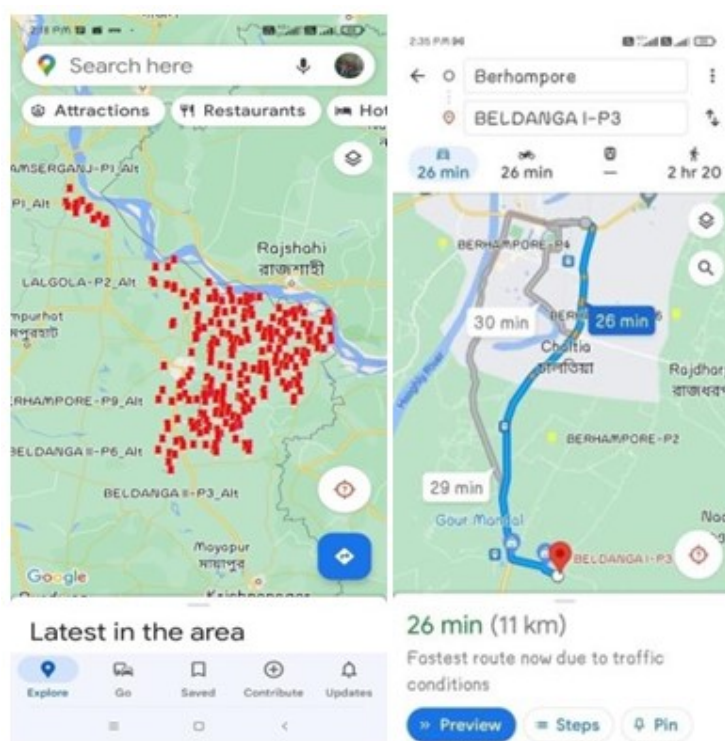Fig 13. CCE locations of jute crop based on smart sampling method over the selected districts

Fig 14. Navigational support to reach the CCE locations

Conclusion

The article is a brief compilation of the capabilities of geospatial technologies to cater / support to the jute sector in terms of monitoring in-season jute crop condition, pre-harvest estimation of the area under jute crop, mid-season adversities and assessment of the jute

yield etc. All possible advanced geospatial technologies have been utilized such as mobile technology for objective field data collection over the jute growing areas, assessment of in-season jute prospect based on mobile data collected involving web analytics, satellite based jute crop mapping, conducting crop cutting experiments of jute using smart sampling techniques, and assessing jute yield by modeling approach. It is planned to host all these databases in a centralized dedicated portal as "Jute Crop Information System" for operational use. Such intervention can be considered as a digital agriculture initiatives for fibre crop like jute under Ministry of Textiles.

Acknowledgements

Abbreviation:

NRSC : National Remote Sensing Centre

ISRO: Indian Space Research Organization

JCIL: The Jute Corporation of India Ltd

NJB: National Jute Board

SOP: Standard Operating Procedure

CCE: Crop Cutting Experiment

SAR: Synthetic Aperture RADAR

LUE: Light Use Efficiency

AI/ML: Artificial Intelligence/ Machine Learning

NDVI: Normalize Difference Vegetation Index

LSWI: Land Surface Water Index

KML: Keyhole Markup Language

IMD: India Meteorological Department

SMAP: Soil Moisture Active Passive

Jute ICARE: Jute Improved Cultivation and Advanced Retting Exercise

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