Technical Report

Smart Sampling for Crop Yield Estimation in the Insurance Units of PMFBY : Technique Development and Implementation in Odisha State

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National Remote Sensing Centre, ISRO
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<tr><td>15.</td><td>Abstract (with Keywords)</td><td colspan="4">This report documents the development and implementation of smart sampling technique for improving the selection of paddy fields for Crop Cutting Experiments (CCEs) for yield estimation under PMFBY in Odisha state in kharif 2018-19. Paddy yield proxy was developed with multiple indices derived from satellite data and this proxy layer at 20m spatial resolution was used to select the locations for CCE through stratified random sampling approach. These locations were overlaid on cadastral database to facilitate easy identification of selected fields on the ground by the field functionaries. Besides ensuring improved distribution of CCE fields within the insurance units, this new approach minimises the subjectivity in the CCE mechanism. The Officials of the State Departments associated with CCE have been trained about this new methodology in advance. Odisha state becomes the first state for implementing this innovative technique as a part of technology interventions in PMFBY. The critical elements in the methodology are identified for further improvements

Keywords: Crop insurance, paddy crop mapping, paddy crop monitoring, Smart sampling, Crop Cutting Experiments</td></tr>
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Executive Summary

Crop yield measurement continues to be a critical element in the crop insurance mechanism, giving rise to disputes on yield-data quality in turn causing delays in claims settlement. Thus, crop yield estimation in the insurance units is still the biggest challenge in the country. Various limitations in the current system of crop yield estimation in the insurance units along with ways and means to improve the system by infusing satellite, mobile, GIS technologies and data analytics have been well documented (Technical Report of NRSC-RSAA-ASA-June 2018-TR-1154.1.0 and IRDAI Journal, April-June 2018)

NRSC (ISRO) and Department of Agriculture and Farmers Empowerment, Government of Odisha are working together from kharif 2017 to infuse technology based information products and services in to the crop insurance value chain. Bringing improvements in the crop yield estimation procedure is one of the tasks being addressed in this joint project.

Smart Sampling Techniques (SST) are being increasingly recommended under PMFBY to improve the Crop Cutting Experiments (CCEs) for crop yield estimation. There are two Levels/Approaches of smart sampling; (1) improve the distribution of CCE plots without altering the sample size, within each Insurance Unit and (2) reduce the sample size in CCE, in a given district/part of the district and derive the estimates for the constituting insurance units. A strong crop yield proxy is the requirement for these two Levels of SST. Successful testing of yield proxy through the first approach, leads to the second level of smart sampling which is the ultimate requirement of PMFBY.

The first level of smart sampling i.e., to rationalise the CCE fields selection in each insurance unit has been developed and implemented in Odisha in kharif 2018-19 and the present report deals with the details of the methodology and other aspects. Presently Crop Insurance (PMFBY) for paddy is being implemented in 6797 G.P.s & 114 ULBs (i.e. 6911 Insurance units) in the state.

An yield proxy for paddy crop was developed using satellite derived paddy crop layer, crop condition indices – NDVI, LSWI, RADAR back scatter and back scatter ratios. Crop risks such as flood and drought are also accounted in the methodology. Composite index of paddy yield was developed at 20m pixel resolution. The yield proxy is found to be sensitive to the yield variability. Each insurance unit is divided in to stratums using the yield proxy criteria – spatial variation and size of stratum. The number of stratums in different insurance units has ranged from 2-4. The four CCE fields fixed for each insurance unit were distributed among the stratums in proportion to the crop area and selected at random. Each CCE field is identified as 3*3 pixel window i.e., 60*60m with its central latitude and longitude. For each CCE field, two alternate/substitute fields were selected to overcome the unanticipated problems in the field such as (a) denial of farmer for doing CCE, (b) field not accessible, (c) crop already harvested and (d) in few cases, crop may not exist in such field. The field locations data are overlaid on cadastral map base and corresponding field survey numbers are identified. Locating the survey numbers of CCE plots was done through Bhu-Naksha or Google Earth and the guidelines for the same were provided to the field functionaries.

The total number of primary locations for winter paddy was 27524 with alternate locations of 53736 covering the entire state. Similarly for autumn paddy, 2987 primary locations and 5684 alternate locations were selected.

The Officials of the State Departments associated with CCE have been trained about this new methodology in August 2018.

The three major advantages of this new technique are (a) improved distribution of CCE fields in the insurance units on the basis of yield proxy enabling more representative yield estimates, (b) notification of CCE fields only a few days before harvest minimising moral hazard issues and (c) identification of CCE fields through digital map base minimising human bias/preferences in locating the fields.

Odisha state becomes the first state for implementing the technique towards strengthening crop insurance mechanism with technology interventions.

The critical elements in the methodology are identified for further improvements – (a) mapping autumn rice (upland rice) even with RADAR technology, (b) updated cadastral maps, (c) scope for improving the yield proxy.

There is scope for replicating the smart sampling technique implemented in Odisha for the entire country, for transplanted rice crop.

With the successful implementation of the improved CCE-fields selection based on yield proxy, technique development for reducing the CCE number needs to be investigated.

1. Introduction

Agriculture in India is exposed to multiple risks leading to frequent crop losses. As a result, crop insurance has become an indispensable risk management tool in agriculture sector. Increasing crop production risks in agriculture coupled with the alarmingly low growth and outreach of crop insurance signify the relevance of and huge potential for crop insurance in India. Strong system of insurance is a prerequisite to trigger innovations and enhance investments Agriculture. India has a long history in the design, development and implementation of various crop insurance schemes signifying improvements from time to time, to insulate the farming community against various cultivation risks (Mishra 1996, Singh 2013).

PMFBY being implemented from kharif 2016 is an area-yield insurance contract and has many positive features to compensate for multiple risks during the entire life cycle of crops.

The effectiveness and sustenance of area-yield insurance scheme largely dependent on the objective yield-loss assessment mechanism using reliable, current and historical crop yield data, which posed a serious challenge. In India, crop yield estimation in the insurance units is done by conducting Crop Cutting Experiments (CCE) in the field-plots selected through a sampling scheme. Subjectivity in the yield measurements has become a major concern and it is widely agreed that the quality of crop yield data needs to be improved drastically to enhance the strength of the crop insurance contracts for their sustenance. The biggest challenge in the crop insurance value chain is assessing crop yield in the insurance units for determining the indemnity payout. Technology interventions such as use of satellite data to improve crop yield estimation are largely recommended in PMFBY in kharif 2016.

National Remote Sensing Centre (ISRO) has taken several initiatives in recent years to demonstrate the technology capabilities to meet the information requirements of crop insurance. These initiatives include; (a) pilot studies in different districts, (b) development and implementation of Mobile technology for field data collection for improving crop yield estimation and crop loss assessment, (c) training to the field level personnel of State Departments on mobile based field data collection, (d) collaborative studies with Agricultural Insurance Company of India Limited (AICIL) to improve crop insurance with remote sensing and GIS technologies, (e) awareness-cum-training to the industry on technology utilisation, (f) development of a Decision Support System for crop insurance for Odisha state and (g) conducting special studies to support the States.

Various limitations in the current system of crop yield estimation in the insurance units along with ways and means to improve the system by infusing satellite, mobile, GIS technologies and data analytics has been well documented (Technical Report NRSC-RSAA-ASA-June 2018-TR-1154.1.0 and IRDAI Journal, April-June 2018)

NRSC and Department of Agriculture and Farmers Empowerment, Government of Odisha are working together since kharif 2017 to infuse technology based information products and services in to the crop insurance value chain.

Adoption of smart sampling techniques for improving crop yield estimation is one of the major initiatives of the Department of Agriculture and Farmers Empowerment, Government of Odisha for strengthening crop insurance with technologies. This report documents the details of technique development and implementation of smart sampling method in Odisha state in kharif 2018.

2. Smart sampling for crop yield estimation under PMFBY

It is widely recognised that crop yield measurement risk in the insurance units is increasing thereby reducing the efficiency of crop insurance mechanism. Disputes on the quality of yield data are ever increasing.

Three broad strategies suggested by various experts for improving the crop yield estimation in the insurance units include; (1) Improving the current CCE mechanism in terms of transparency and objectivity by way of improved distribution of CCE fields based on smart sampling, third-party supervision and recording yield data with mobile apps, (2) Smart sampling to reduce the number of CCE fields, and (3) Replace the CCE with alternate mechanism in the long run.

The first strategy refers to improve the distribution of CCE plots (currently 4 in number) in each insurance unit so as to generate the representative yield estimates. The second strategy tries to reduce the sample size i.e. number of CCE required, at aggregated scale i.e., limited number of CCE are conducted in a tehsil/district and these CCE data are used to generate estimates for different insurance units within the region. Both the strategies need a strong proxy for a given crop which is to be developed with multiple biophysical parameters. Reducing the CCE number is the ultimate requirement under PMFBY. The focus of this report is on first strategy above for immediate implementation. The second strategy is being addressed by many agencies and the workable solutions are yet to be evolved. The third strategy is the outlook for medium to long terms and is outside the scope of the study.

Human induced prejudices/choices and methodological limitations together impact the quality of yield data in the current system of CCE. Subjective factors related to manual process of CCE include timeliness in field selection, conducting CCE in the right field, objective recording of the data etc. Methodology related factors include distribution of CCE fields in the insurance units. Smart sampling methodology proposed in this project is intended to minimise these limitations.

Currently, four CCE plots in each insurance unit for a given crop and season are considered for yield measurement and average yield estimation. These four plots are identified in the randomly selected fields. The underlying assumption is that the insurance unit is homogeneous with respect to crop performance and hence the average yield of any four plots represents the insurance unit's average. The validity of this assumption is key to the success of this randomisation process. Unless and otherwise, it is established with real data, it remains as a theoretical assumption and may not match with ground situation. In an insurance unit, the crop area may be distributed under irrigated conditions, rainfed conditions, semi-dry conditions, fertile areas, less fertile areas etc. Further, in the event of risk occurrence, part of the insurance unit may only be affected. Thus, spatial variability of crop performance and spatial variability in the occurrence of different risks – floods, drought, pest, diseases etc, within the insurance unit would seriously distract the homogeneity assumption. Therefore, random selection of four CCE plots would tend to result in skewed representation of crop condition leading to biased estimate of the average yield.

2.1 Need for this new technique

- Currently, four CCE plots are being selected in an insurance unit at random. It has been well recognised that randomised selection of CCE plots in an insurance unit, leads to their skewed distribution w.r.t crop condition causing bias in the yield estimation. Randomised selection works well if the crop performance in insurance is homogeneous/ uniform.

- Currently, the CCE fields are identified in the beginning of the crop season and hence the crop risks that occur during the season such as floods, droughts etc. are not taken in to account while selecting the CCE fields.

- As per the guidelines of PMFBY, states are advised to strengthen the yield estimation process either by improving CCE distribution or by reducing the number of CCE plots.

- Improving the CCE distribution using satellite based indices, for crop yield estimation was researched and reported way back in 1996. There is a need to popularise these techniques, taking the advantage of the wide range of satellite datasets currently available.

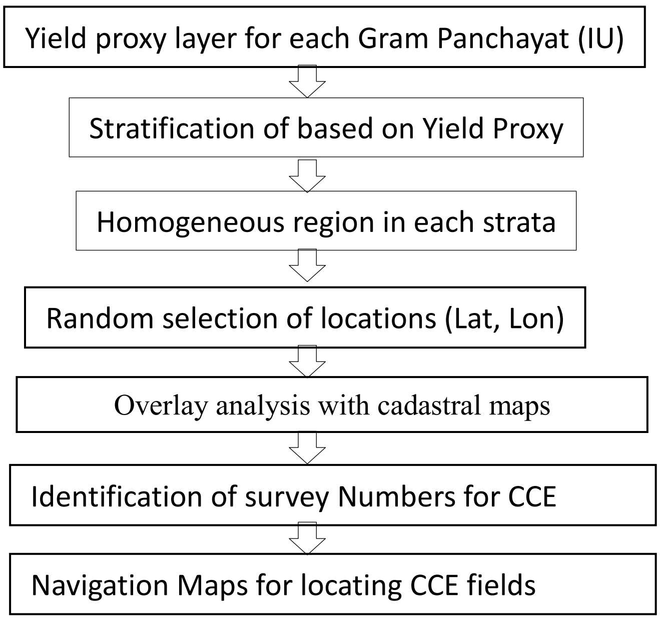
3. Institutions

Multiple institutions are associated with this exercise as given below
- NRSC
- Department of Agriculture and Farmers Empowerment
- ORSAC
- DES

4. Methodology

Crop yield proxy is the most crucial input in the methodology. The yield proxy is developed by taking in to account the crop's bio-physical parameters. Satellite derived crop condition indices are effectively exploited here. Broad details of methodology are shown in Fig followed by the details of each step. Yield proxy image of each insurance unit i.e., GP is stratified in to homogenous zones. Locations of CCE fields are selected from each zone at random. Field survey numbers corresponding to each location are identified using cadastral maps.

Fig. 1 Methodology framework



5 Paddy crop yield proxy

Fig. 2 Satellite derived winter paddy

The paddy crop yield proxy was developed with multiple parameters using composite indexing approach.

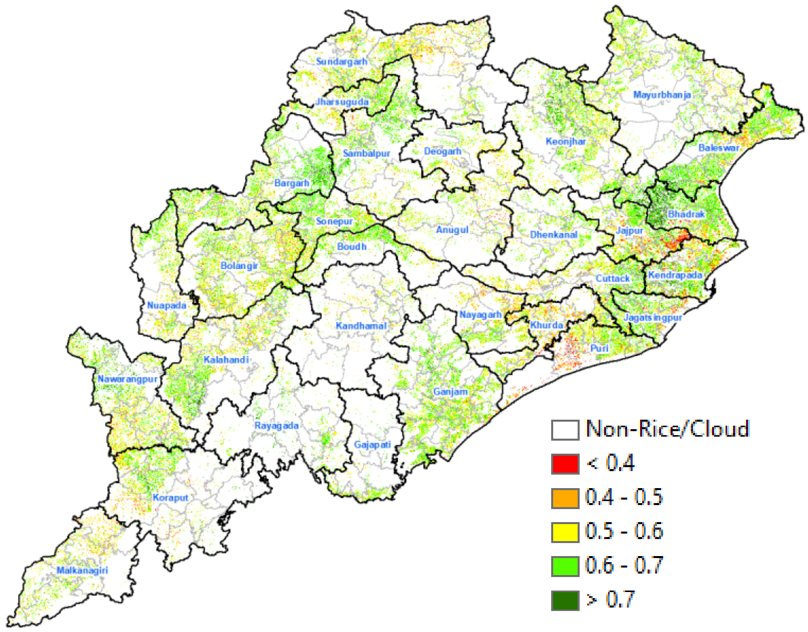
Rice crop area layer was provided by Department of Agriculture. This layer was generated by IRRI for the Department of Agriculture, using multi-temporal SAR backscatter images.

Rice crop condition during the season, was represented by three indicators derived from satellite data namely NDVI, LSWI, RADAR back scatter ratios.

5.1 Normalized Difference Vegetation Index (NDVI)

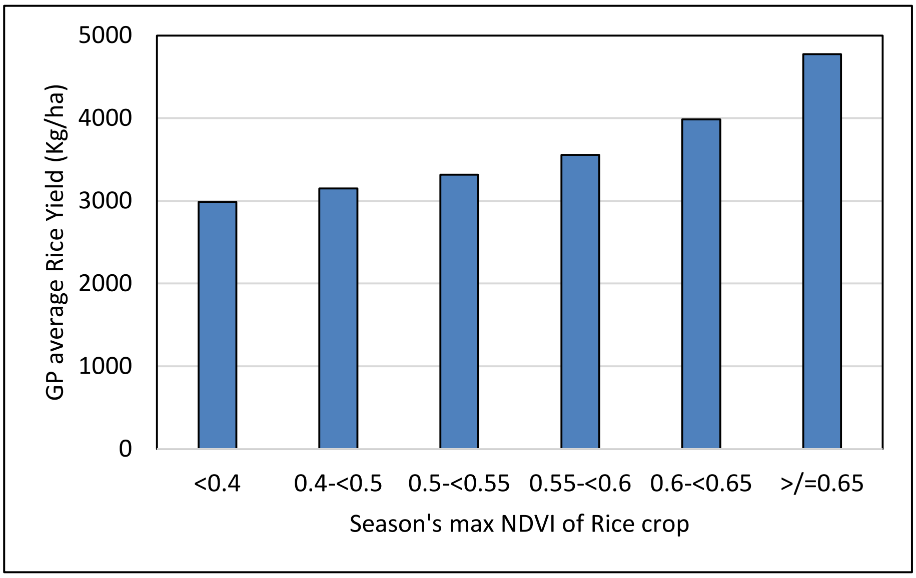
Remote sensing derived NDVI which represents crop vigour has been correlated with yield to investigate the possibility of developing crop yield index for crop insurance (Makaudze and Marinda, 2010; Turvey and McLaurin, 2012; Chintarat et al. 2013). Turvey (2012) reported that NDVI and yield relations are highly variable and hence NDVI may not improve the crop insurance product design. NDVI is adaptable for biomass assessment over pastures and range range lands, but its usefulness over crop lands is met with mixed results (Leblois and Quiron, 2012). The correlation between NDVI and crop growth is not significant in the study carried-out by Smith and Watts (2009). The results of the study carried-out by Makaudze and Miranda (2010), on the possibility of using NDVI for crop insurance for corn and cotton crops in Zimbabwe indicate the wide range of correlations between yield and NDVI starting from 0.4 to 0.7, thus limiting the use of NDVI, as a sole indicator in crop insurance.

Fig. 3 Time composite (20 Sep to 24 October 2018) Sentinel NDVI during the peak vegetative stage of paddy crop



The association between GP average NDVI and rice yield is analysed (Fig.). Season's max NDVI of Rice is associated with rice yield – positive correlation. This max. NDVI corresponds to heading/flowering phase of paddy crop. The average yield follows an increasing pattern with the NDVI value for all the 3 years. AWiFS NDVI with 60mt in spatial resolution is useful for GP level analysis. This association between NDVI and yield of paddy is useful to develop smart sampling method for selecting the CCE plots.

Figure 4 GP average rice yields and rice NDVI kharif 2017-18

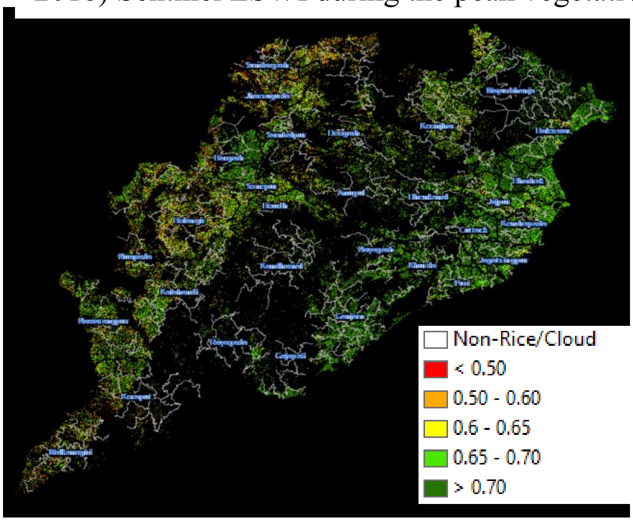


Considering the limitations of NDVI (Gao et al. 2013), some pilot studies have recommended the use of bio-physical variables derived from satellite data to develop index based crop insurance schemes. Roumigguie et al. (2015), developed Forage Production Index using fractional green vegetation cover integral from medium resolution data for index based insurance over grasslands.

5.2 Land Surface Wetness Index (LSWI)

Despite its simplicity in computation and interpretation, NDVI as a sole parameter for crop assessment has certain inherent limitations. NDVI can be a more effective indicator of crop development/condition only after significant spectral emergence of crops. NDVI gets saturated with an increase in the Leaf Area Index and hence could not capture the variations when the crops are in maximum greenness stage (Gao *et al.* 2000).

Fig.5 Time composite (20 Sep to 24 October 2018) Sentinel LSWI during the peak vegetative



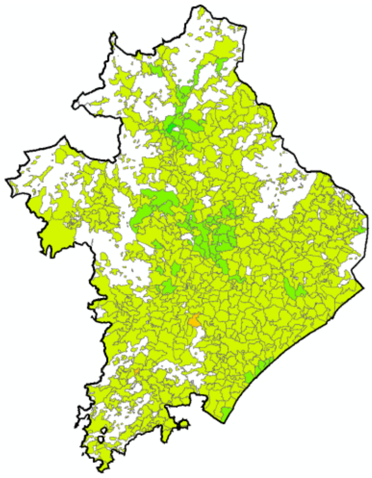
Indices based on the reflectance of Shortwave Infrared (SWIR) bands have been found to be sensitive to moisture available in the soil as well as in the crop canopy (Tucker and Choudhary 1987, Wang *et al.* 2008). Land Surface Wetness Index (LSWI) derived from two bands including a moisture sensitive SWIR band and insensitive NIR band (Gao1996). In the beginning of the cropping season, when soil background is dominant, SWIR is sensitive to surface wetness of top soil. As the crop progresses, SWIR becomes sensitive to leaf moisture content. When the crop is grown up, the response in SWIR band is mostly from canopy and not from the underlying soil. NDWI has been a popular index for crop stress detection and for monitoring moisture condition of crop/vegetation canopies over larger areas (Chen *et al.* 2005, Gu *et al.* 2007). The response of NDWI to moisture is instantaneous without any time lag. NDWI is more sensitive to both desiccation and wilting. NDVI is more sensitive to canopy chlorophyll changes and tend to saturate at high biomass levels. In view of the limitations associated with individual indicators either NDVI or LSWI, a combination of both the indicators may provide a robust approach for drought monitoring. Combination approach would amplify the anomalies and become more responsive to the ground agricultural situation. Gu *et al.* 2007 combined NDVI and LSWI to form the Normalized Difference Drought Index (NDDI) which was found to be more sensitive to drought conditions over grasslands. Combined use of NDVI and NDWI temporal anomalies has better delineated the rice transplanting areas in China (Xiao *et al.* 2002).

5.3 Cross polarisation ratio

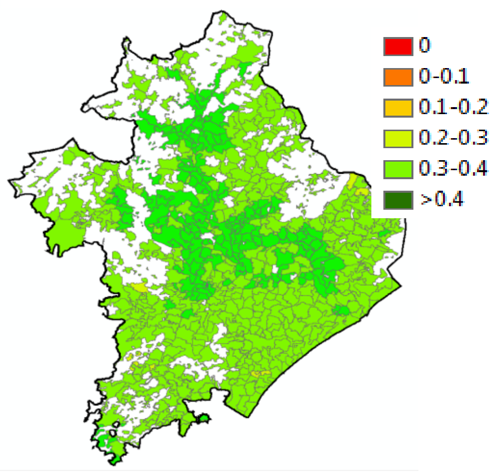
Many studies have found that the cross polarization ratio can be used as one of the crop growth indicators. Nuevo et.*al*. 2017, reported VH/VV ratio was the best for rice crop mapping as ratio was observed to be the lowest during agronomic flooding and maximum backscatter during maximum tillering period. They have also reported that VH backscatter was significantly correlated with the rice canopy height and hill diameter with acceptable coefficients of determination. Moran et.al, 2011 reported that the time series of σ^0 offers reliable information about the crop growth stage, such as jointing and heading in grain crops and leaf development and reproduction in corn and onion. Nelson et *al*., 2014 reported that the C-band HV polarization is strongly correlated with fAPAR and asserted that C-band σ^0 can provide information equivalent to the NDVI. Li et al., 2016 found that there exists a consistent relationship between the RADARSAT-2 σ^0 and rice biophysical parameters, especially in regard to σ^0_{VV} / σ^0_{VH} and rice LAI, FPAR, biomass and height. Setiyono et.al., 2017 used the SAR backscatter to infer the LAI values of rice crop and used as relative leaf growth rate parameters in ORYZA model. In a study by Zhaoqin Li & Xulin Guo, 2017, the largest R^2 values for NPV biomass estimation were achieved by the VH/VV ratio in semiarid mixed grassland. This study also indicated the potential of Radarsat-2 data for quantifying NPV biomass in the middle growing season when optical images, including Landsat 8 OLI and Sentinel-2A, have limited capability. The cross polarization ratio (VH/VV) was observed to increasing with the increasing crop growth.

Fig.6 Cross Polarization ratio of rice crop for Ganjam District-Kharif 2018

(a) 1st FN of October 2018 (Low ratio due to partial submergence)

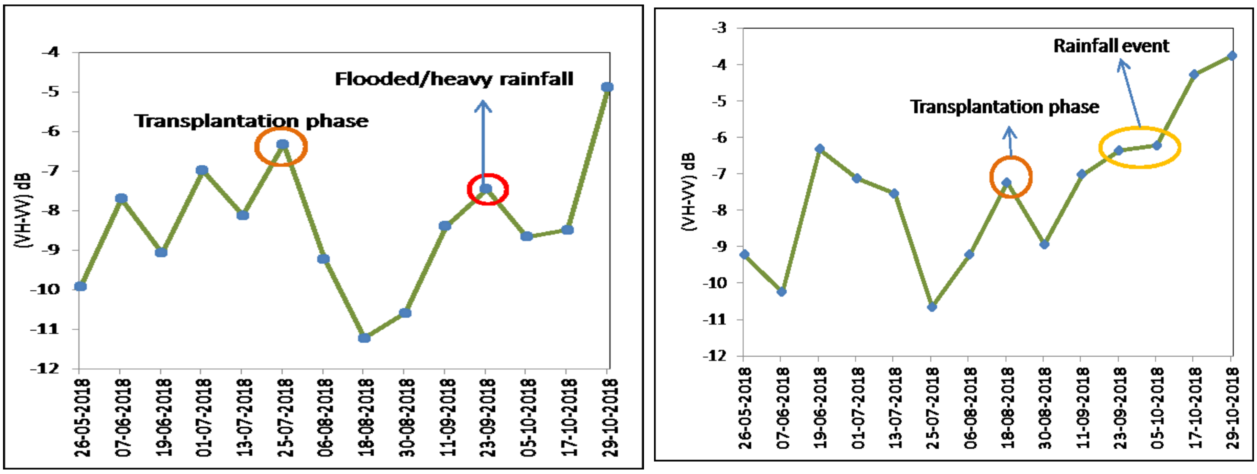


(b) Last week of October 2018 (Increase in Ratio value due to receded flood water)



VH attenuates more compared to VV during the initial crop growth stages and hence the VH/VV ratio would be low and further VH and VV continue to increase with the crop growth and hence the VH/VV also increases. The ratio will show consistent increase for normal crop till the maximum vegetative stage of the crop but there will be declination in the ratio whenever crop is under stress or subjected to flooding due to rainfall (Fig.). Due to the sensitivity of the cross polarization ratio to crop stress/ rain event, it can be used as one of the crop growth indicators of rice crop.

Figure 7 Crop polarisation ratio of paddy crop and its response to rainfall events



6. Composit indexing approach

Multiple indicators are used here to develop paddy yield proxy. Blending the multiple indicators leads to robust yield proxies. All these three input indicators are directly related to rice yield. In this study, the method given by Iyengar and Sudarshan (1982) and Murthy et al., (2015) to construct a statistically sound composite index from multivariate data was used.

It is assumed that there are N pixels, K indicators and x_{ij}, i=1, 2,…. M; j=*1, 2,* ---- -K are the normalized scores. The level or stage of development of i thzone, $\bar{y}_i$, is assumed to be a linear sum of x_{ij} as

$$\bar{y}_i = \sum_{j=1}^{K} w_j x_{ij} \text{ ----------------------------- (1)}$$

Where w's (0<w<1 and $\sum_{j=1}^{K} w_j = 1$) are the weights. In this method the weights are assumed to vary inversely as the variance over the pixels in an insurance unit in the respective indicators of vulnerability. That is, the weight w_j is determined by

$$w_j = \frac{c}{\sqrt{var(x_{ij})}} \text{ --------------------------------- (2)}$$

Where c is a normalizing constant such that

$$c=\left[\sum_{j=1}^{K} \frac{1}{\sqrt{var_i(x_{ij})}}\right]^{-1} \text{ -------------------- (3)}$$

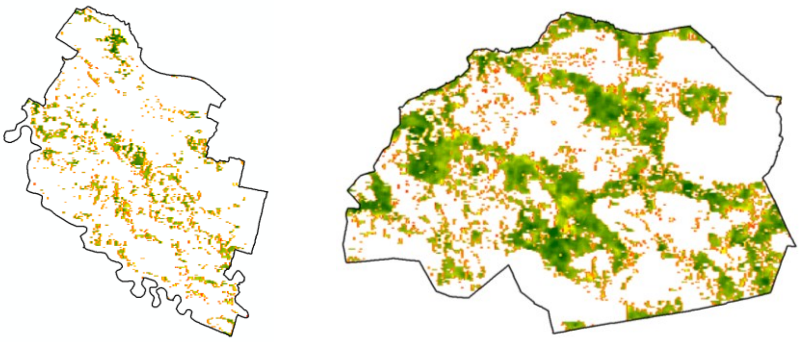
By assigning the weights in this manner, the large variation in any of the indicators will not unduly dominate the contribution of the rest of the indicators or distort inter-regional comparisons. The resulting index ranges between 0 and 1, with 1 indicating maximum and 0 indicating minimum intensity of respective index.

The data base consisting of three input indicators for all the rice pixels of 20m resolution is subjected to data normalisation, weights generation based on inverse variance approach to synthesize into yield proxy. Yield proxy is a relative index and it is generated for each GP separately.

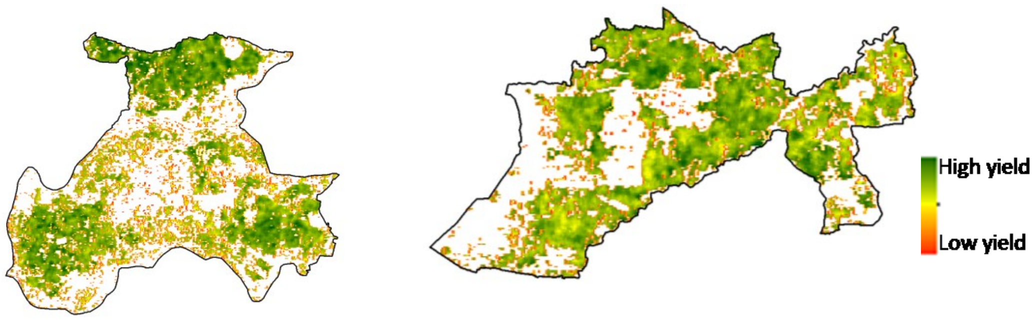
The paddy yield proxy layer for selected GPs is shown in Fig.

Figure 8 Winter paddy yield proxy for selected GPs

(a) Mangovindpur GP (Mayurbhanj dt) (b) Kachrapara GP, (Navarangpur dt)



(c) Kuchinda GP (Sambalpur dt) (d) Kurla GP (Nayagarh dt)



7. Sampling scheme for CCE fields selections

The sampling procedure suggested here is based on the research reported by Singh et al., 1992 and Murthy et al., 1996. Near real-time information on crop area and crop condition derived from satellite data which is directly related to the location and yield of crop respectively, can be successfully employed to improve the sampling design. The rice yield proxy which is a blended index representing the yield variability, is the driving index for selecting CCE fields.

7.1 Stratification of each Gram Panchayat based on yield proxy

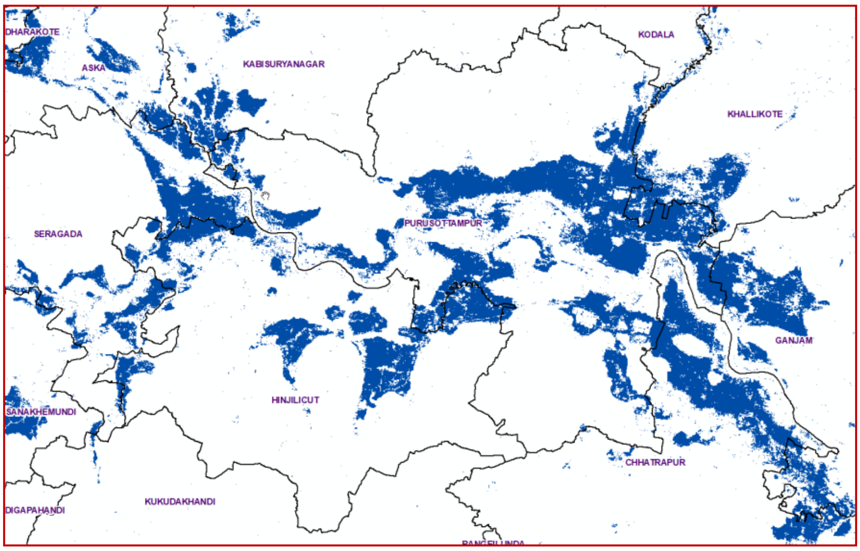
Based on yield proxy, each Gram Panchayat is stratified in to homogeneous stratums by adopting k means clustering. It is ensured that each stratum represents a minimum of 20% of population i.e., rice area. After implementing the clustering algorithm with the condition on cluster size, the number of clusters in different GPs has ranged from 1 to 4.

7.2 Selection of fields

The yield-proxy classes form the basis for selecting the CCE_fields. The flood affected rice crop area layer corresponding to mid-October 2018, was also included to ensure that this is factor is represented in the procedure. Sample size in each GP is four, as followed in PMFBY. These four field locations are selected in such a way that each stratum is represented in proportion to the area. Simple random selection is adopted within each stratum. Allocation of CCE for each stratum is done in proportion to the rice area.

In addition, proportion of flood affected rice area in each GP/IU is also considered to ensure its inclusion in the selected CCE fields. If the flood affected rice area is more than 10% of the respective stratum's rice area and if it is not represented in the random selection of fields, then the random selection process is repeated to ensure that the flood-affected rice area is represented by at least one field.

Figure 9 Flood affected rice area in Ganjam district, Odisha in October 2018



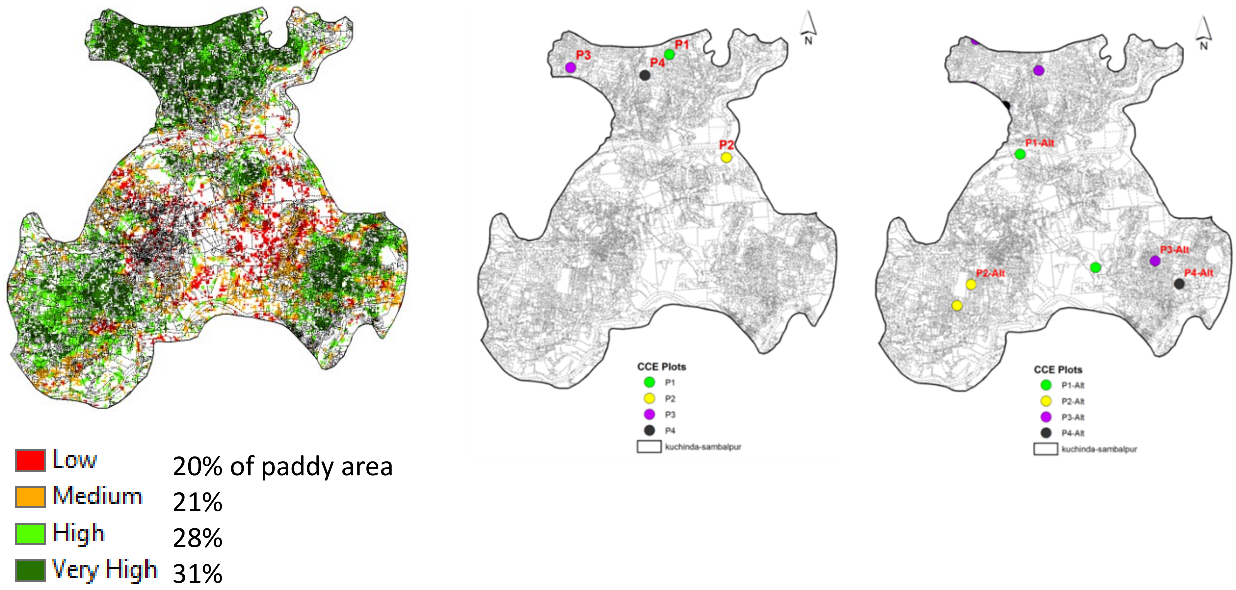
Latitude and longitude of each location represented in the form of 3*3 pixels area was identified. Four locations in each insurance unit, thus identified are designated as primary plots for conducting CCE. For each location i.e., primary field, two alternate fields are identified that corresponds to the same yield proxy class as that of primary field. The alternate fields are identified to overcome the unanticipated problems for conducting CCE at primary fields.

SST permits substitution of field survey number with alternate survey number representing similar crop condition, in case the originally identified survey number is not useful due to (a) denial of farmer for doing CCE, (b) not accessible and (c) crop already harvested. In a few cases, crop may not exist in such field. Such a substitution is acceptable in PMFBY. It will not contribute to sampling error. Therefore, in SST, substitute survey numbers are provided to ensure smooth implementation.

Figure 10 Smart sampling frame work for an insurance unit
Gram Panchayat: Kuchinda, Block: Kuchinda; District: Sambalpur

Stratums based on paddy yield proxy, kharif 2018-19

Selection of locations for CCE
(a) Primary (b) alternate



For each primary location two alternate/substitute locations representing similar crop condition are provided. In case, the primary location is not fit due to (a) denial of farmer for doing CCE, (b) not accessible, (c) crop already harvested and (d) in few cases, crop may not exist in such field, the corresponding alternate locations are useful.

Table 1 Details of CCE fields selected through Smart Sampling
(Gram Panchayat: Kuchinda, Block: Kuchinda; District: Sambalpur)

CCE fields	Survey number	Alternate fields (Survey numbers)
Location 1	2010	14 or 1961
Location 2	482	2094 or 1961
Location 3	201	291 or 1348
Location 4	1487	1368 or 593

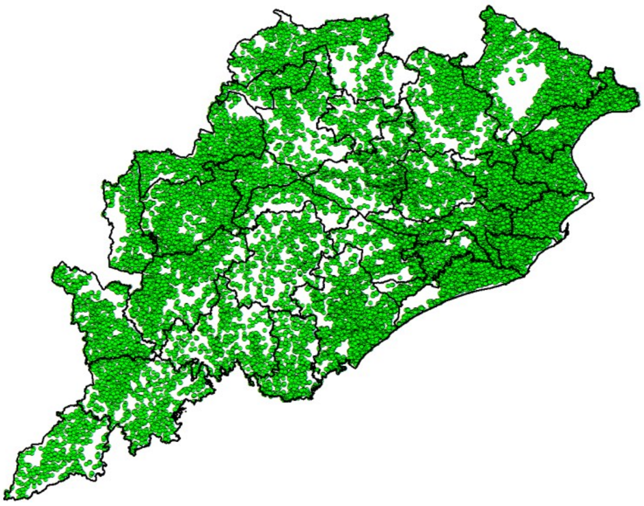
7.3 Overlay analysis for identifying CCE fields

The locations of primary and secondary fields, in the form of lat/long are overlaid on cadastral map base showing the field boundaries and survey numbers of corresponding fields are identified. These survey numbers are digitally identified on village maps and provided to the field functionaries. Further, Google navigation service is also used for fields identification. Cadastral level analysis was carried-out by Odisha Space Applications Centre (ORSAC).

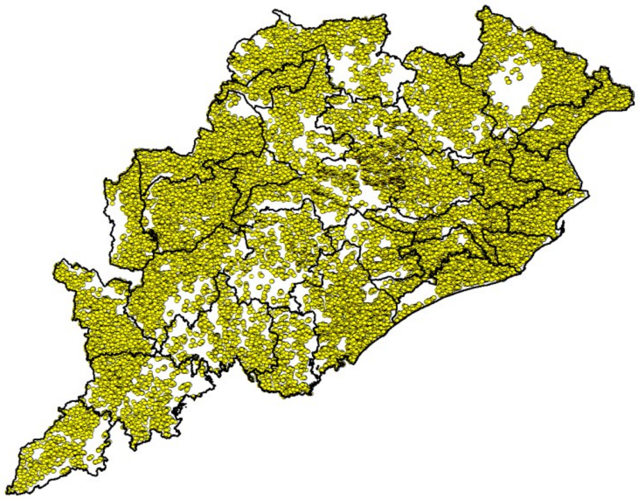
List of CCE locations for one district i.e., Sambalpur is provided in Annexure. List of such locations for all the districts are provided through a separate report

Figure 11 Locations of CCE Fields for winter paddy, Odisha (harvesting in Nov/Dec 2018)

A. Primary locations (27524 points)

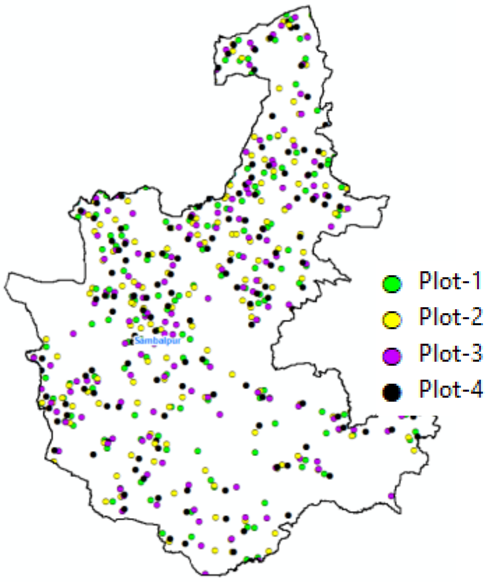


B. Alternate locations (53736 points)

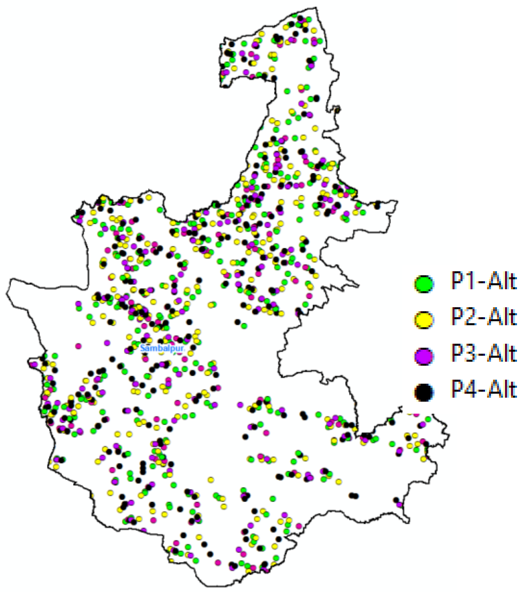


Sambalpur district

A. Primary locations (564 points)

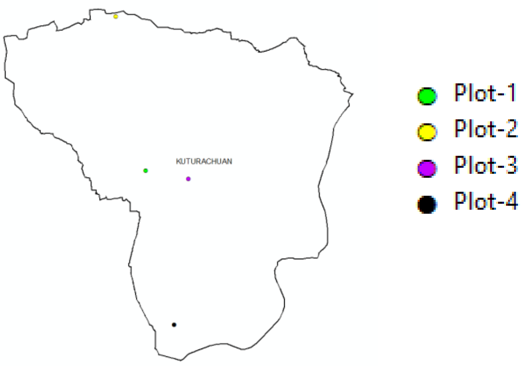


B. Alternate locations (1120 points)



Insurance Unit: Kuturachuan, Sambalpur dist.

Primary locations



B. Alternate locations (substitutes)

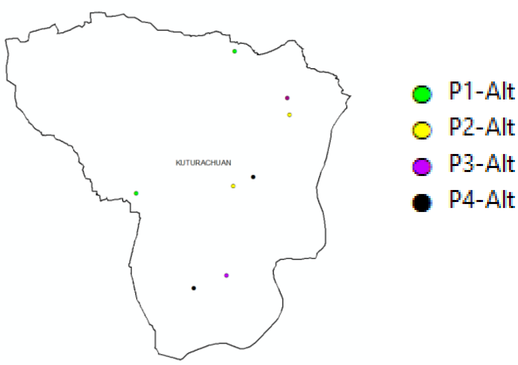
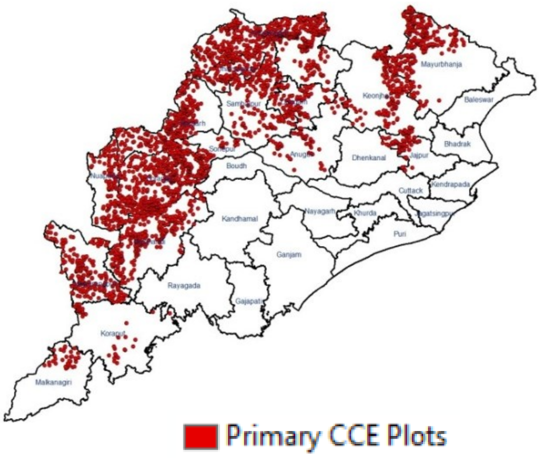


Figure 12 Locations of CCE Fields for autumn paddy, Odisha (harvesting in Sep/Oct 2018)



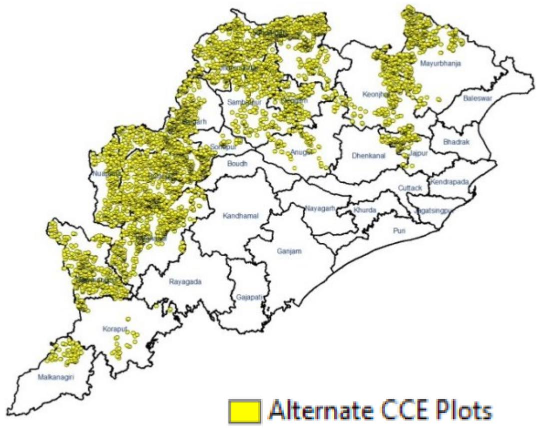


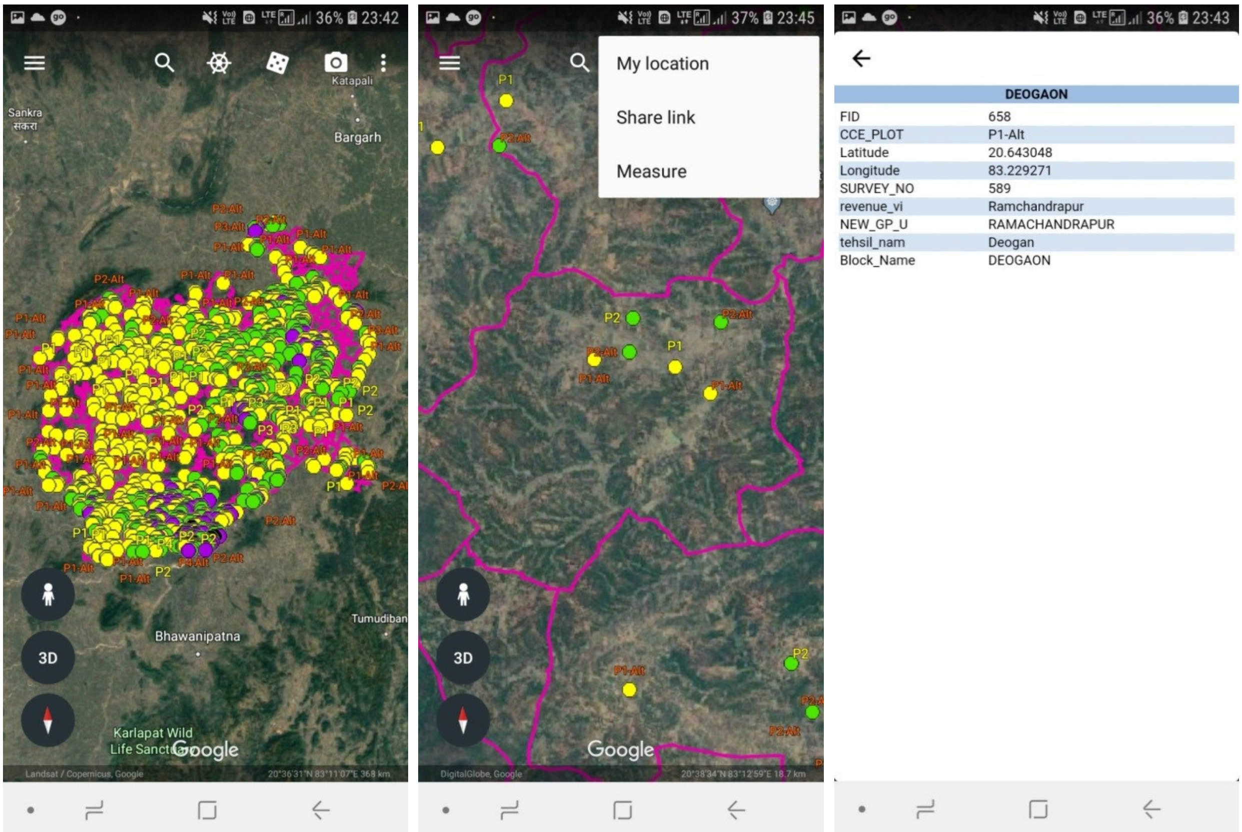
Table 2 District wise total number of CCE Locations (Winter paddy)

District	Total Primary CCE locations	Total Alternate CCE locations
Angul	908	1584
Baleswar	1452	2768
Bargarh	1028	2040
Bhadrak	876	1744
Bolangir	1280	2500
Boudh	280	552
Cuttack	1508	2940
Deogarh	280	552
Dhenkanal	864	1692
Gajapati	604	964
Ganjam	2076	4068
Jagatsingpur	800	1588
Jajpur	1248	2456
Jharsuguda	324	648
Kalahandi	1256	2320
Kandhamal	688	1124
Kendrapada	1004	1960
Keonjhar	1200	2376
Khurda	780	1560
Malkanagiri	448	848
Mayurbhanja	1632	3100
Nawarangpur	764	1516
Nayagarh	792	1532
Nuapada	528	1032
Puri	1080	2036
Rayagada	736	1296
Sambalpur	564	1120
Sonepur	448	896
Sundargarh	1064	2032
Koraput	972	1656

Table 3: District wise total number of CCE Locations (Autumn paddy)

District	Total Primary CCE	Total Alternate CCE
Angul	55	109
Balangir	482	917
Bargarh	277	536
Deogarh	104	196
Jajpur	86	169
Jharsuguda	119	214
Kalahandi	262	488
Keonjhar	143	277
Koraput	36	62
Malkangir	32	63
Mayurbhanj	276	506
Nabarangpur	201	385
Nuapada	149	278
Sonepur	80	156
Sundargarh	504	974
Sambalpur	175	337

Figure 13 Navigation services for locating the fields for conducting CCE



8. Training

- Training was imparted to District level officials on Smart Sampling Methodology and navigation strategy to reach CCE plots between 10th and 12th August 2018 in Bhubaneswar.

- New methodology has been explained to all the participants covering all the districts.

- Time lines for identification of CCE locations and advise to districts have been communicated.

- Issues such as no crop or inaccessibility of Primary plots and relying on alternate plots in such events are explained.

- Presentation on locating the survey numbers of CCE plots through Bhu-Naksha or Google Earth were made and Guidelines documents were provided.

- Cadastral map with updated field boundaries is the most essential requirement and the officials have been sensitized on this aspect. The field survey numbers in cadastral map and the survey numbers mentioned in the Form-1 of field register should match with each other.

- Mobile apps utilization during the harvesting time has been emphasized for recording the data.

- Sensitized the Officials on the GPS accuracy levels and advised to achieve less than 10m accuracy.

- Since this is for the first time the new methodology is being implemented, all the field Officials were asked to contact NRSC/ORSAC for any support while identifying the fields.

Figure 14 Cadastral map of Kelandapali village,

Table 4 Activity schedule of Smart Sampling exercise completed in kharif 2018

S.no	Activity	Institutions	Time line
1	Initiation and discussions	NRSC, Dept. of Agriculture, ORSAC	June and July
2	Preparatory activities	NRSC and Dept. of Agriculture	July and August
3	Training to the District Officials	NRSC	12-14 August
4	Receiving the Autumn season's rice layer	IRRI/Dept. of Agriculture	1st Week Sep
5	Generation of yield proxy for Autumn rice	NRSC	1st Week Sep
7	Field visits	NRSC	2nd Week Sep
8	CCE plot selection through smart sampling (Autumn rice)	NRSC	2nd Week Sep
9	Identification of Village and Survey number for CCE plots	ORSAC	2nd Week Sep
10	Delivery of district-wise CCE location details	ORSAC/NRSC	2nd Week Sep
11	Implementation of smart sampling for Autumn Rice (16 districts)	Dept of Agril, Govt of Odisha	3rd Week Sep to 2nd week Oct
12	Receiving the winter Rice Map	IRRI/Dept. of Agriculture	3rd Week Oct
13	Generation of Yield Proxy for winter rice	NRSC	3rd Week Oct
14	CCE plot selection through smart sampling (winter rice)	NRSC	4th Week Oct 2018
15	Identification of Village and Survey number for CCE plots	ORSAC	1st week Nov 2018
16	Delivery of district-wise CCE location details	ORSAC/NRSC	1st week Nov
17	Implementation of smart sampling for winter Rice (all districts)	Dept of Agril, Govt of Odisha	2nd week Nov to till date
18	CCE query clarification and suggesting alternate plots (case-wise)	NRSC/ORSAC	2nd week Nov to end of Dec

9. Specific advantages of this new technique

The three major advantages of this new technique are

(a) Improved distribution of CCE fields in the insurance units on the basis of yield proxy enabling more representative yield estimates
(b) Crop condition during the most part of the season is taken in to account while selecting the fields
(c) Notification of CCE fields only a few days before harvest minimising the moral hazard issues

(d) Identification of CCE fields through digital map base minimising the human bias/preferences in locating the fields.

10. Conclusion

Smart sampling Technique (SST) implemented in Odisha is aimed improved the distribution of CCE plots in an Insurance Unit (IU) by taking in to account the variability in crop condition. As per the guidelines of PMFBY, states are advised to strengthen the yield estimation process either by improving CCE distribution or by reducing the number of CCE plots.

Improving the CCE distribution using satellite based indices, for crop yield estimation was researched and reported since 1996 and is now becoming popular for operational implementation.

The paddy yield proxy is the most critical input in the smart sampling process. In this project, the yield proxy layer was developed at 20m resolution by including multiple indices that are directly related to the crop yield. The, the yield proxy has captured the variability of crop within the insurance unit.

There are minor implementation hurdles in locating the fields, which were addressed by NRSC, Department of Agriculture and ORSAC.

As a way forward, perfection of rice layer generation is essentially required as it forms the basis of plot selection. Autumn rice crop grown under direct seeding/upland conditions is difficult to be spectrally differentiated even with SAR data.   To overcome the problem of possible inaccuracy in rice layer, two alternate fields for every primary field were selected. Simultaneously, efforts are initiated to improve the accuracy of rice map, through synergistic use of SAR and optical data.

Cadastral map updated with latest information on field survey numbers is the most essential requirement.

Yield proxy is the most crucial input in this technique. Better the yield proxy better is the sampling scheme. Yield proxy adopted in this methodology is derived from multiple indices. Scope for improving the yield proxy further with more parameters is being explored.

11. Acknowledgements

We are grateful to the Department of Agriculture and Farmers Empowerment, Government of Odisha, for the collaborative project with NRSC to develop technology based solutions for crop insurance. We express our sincere gratitude to Sri Santanu Chowdhury, Director, National Remote Sensing Centre for his constant encouragement and guidance.

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Annexure 1

List of CCE_field locations identified through Smart Sampling for Sambalpur district – Autumn Paddy 2018-19

(P1: Field 1, P2: Field 2, P3: Field 3, P4: Field 4, Alt: Alternate Field, S.No: Field Survey Number)

GRAM PANCHAYAT	TEHSIL	P1 S.No	P2 S.No	P3 S.No	P4 S.No	P1 Alt S.No	P1 Alt S.No	P2 Alt S.No	P2 Alt S.No	P3 Alt S.No	P3 Alt S.No	P4 Alt S.No	P4 Alt S.No
BABUNAKTIMAL	Bamara	319	331			439	99	318	292				
BAUNSALAGA	Bamara	2166	599			563	666	969	1411				
GADAPOSH	Bamara	1316	1378			283	1566	221	329				
GOVINDAPUR	Bamara	401	174			684	405	550	2337				
JARABAGA	Bamara	1096	366			1095	411	1044	107				
KABARIBAHAL	Bamara	1211	1313			3951	24	444	1054				
KESEIBAHAL	Bamara	1002	1501			1174	320	303	1494				
KINABAGA	Bamara	684				152	580						
KUTARIMAL	Bamara	2023	120			167	201	1238	114				
LARIAPALI	Bamara	1081	605			934	858	1421	1384				
MAHULPALI	Bamara	668	400			245	643	65	499				
PINDAPATHAR	Bamara	308				1762	1759						
RABAGA	Bamara	1461				589							
RANGIATIKRA	Bamara	675				1111	102						
SAGARA	Bamara	28	429			826	13	1197	145				
TUREI	Bamara	906				840	95						
UCHAKAPAT	Bamara	2355	1888			197	1339	442	50				
BADAMAL	Jamankira	1941				1939	71						
BADARAMA	Jamankira	599				376	541						
BHOJPUR	Jamankira	2033	596			598	2166	146	731				
CHAKULIABAHAL	Jamankira	360				356	531						
DHUDIPALI	Jamankira	631				1311	2648						
DIMIRIMUNDA	Jamankira	561	24			2	461	43	39				
GUNDURUCHUAN	Jamankira	279				802	462						
JAMANKIRA	Jamankira	127				1368	298						
KASADA	Jamankira	1118				1299							
KATANGAPANI	Jamankira	751	214			1412	356	311	66				
KENADHIPA	Jamankira	162				183	188						
KHARSALAMAL	Jamankira	260				293	261						
KULUNDI	Jamankira	97				355	147						
MAHADA	Jamankira	225				399	162						
MUNDENPALI	Jamankira	891				770	141						
PHASHIMAL	Jamankira	446				38	124						
SIRIDI	Jamankira	1358	1293			136	351	1278	1622				
SUBERNAPALI	Jamankira	3018	1068			2072	2362	591	2838				

TIKIBA	Jamankira	252				247	245						
TIKILIPADA	Jamankira	2062	896			3123	1660	218	1145				
BIRASINGADA	Jujomura	566				503	1009						
CHHAMUNDA	Jujomura	1333				1320	1323						
DANGARPADA	Jujomura	1726				1166	321						
GADALOISINGH	Jujomura	768				92	770						
GHENUPALI	Jujomura	1919				1541	1915						
JUJUMURA	Jujomura	1527				2896	1525						
KANSAR	Jujomura	148				176	175						
KAYAKUDA	Jujomura	192	138			164	174	143	144				
KESHAPALI	Jujomura	120				86	476						
LIPINDA	Jujomura	1132				687	712						
MEGHAPAL	Jujomura	1212	2042			1214	952	1887	1266				
NUABARANGAMAL	Jujomura	1296				1385	1355						
TAMPHARGADA	Jujomura	1577				1893	1576						
ARDABAHAL	Kochinda	138	66			2243	1828	9	90				
BANKE	Kochinda	790	3842			2401	587	281	112				
BAURIGUDA	Kochinda	1776	805			1849	829	1503	2830				
BAXMA	Kochinda	1355	1538			91	161	410	116				
CHANDINIMAL	Kochinda	50	1634			715	1645						
GOCHHARA	Kochinda	1466	2266			545	1412	2335	1138				
HADIPALI	Kochinda	157	1816			2738	142	1784	1804				
JAMANKIRA	Kochinda	204	588			662	540	670	97				
KHANDAKOTA	Kochinda	3687	147			1030	2237	2200	591				
KUDAPARA	Kochinda	3662	177			3666	1135	176	414				
KUNTARA	Kochinda	549	191			546	415	188	1				
KUSUMI	Kochinda	1418	20			346	415	478	748				
KUTURACHUAN	Kochinda	2673	1231			116	96	727	1172				
PARUABHADI	Kochinda	1360	1896			1246	889	1897	426				
SALHEBHADI	Kochinda	460	365			459	448	181	77				
TAINSHARA	Kochinda	510	153			78	601	1553	1842				
TELITILEIMAL	Kochinda	412	1018			547	324	262	291				
BADUAPALI	Menswar	1015				1094							
NUATIHURA	Menswar	383				382							
BALAM	Naktideula	1509	51			1549	679	2531	1655				
BATAGAON	Naktideula	1659	2917			3593	1002	1640	923				
DAINCHA	Naktideula	121	582	1104		485	556	354	884	3265	1010		
GHOSHARAMAL	Naktideula	958	86			1394	1014	1083	129				
GIRISCHANDRAPUR	Naktideula	609				24	653						
GOGUA	Naktideula	573	55	341		451	309	1158	383	2765	38		
JAMJORI	Naktideula	1412	86			347	497	247	1154				
KISINDA	Naktideula	177	1063			1487	1062						
NAKTIDEUL	Naktideula	1459	510			1399	1462	508	1412				
PANIMURA	Naktideula	396	357			411	77	393	306				

SAHEBI	Naktideula	979	79			911	25	393	388				
SAHLEBHATA	Naktideula	620	366			828	631	238	1048				
SARAPALI	Naktideula	1576				57	815	198	200				
SHIMULIPAL	Naktideula	2150	1382	1153		3378	2020	711	780	1154	310		
BADAMAL	Redhakhol	1159				336							
BANSAJAL	Redhakhol	1209				1903	78						
BHALIAKATA	Redhakhol	480				475	86						
BURUDA	Redhakhol	724	193			499	197						
CHARMAL	Redhakhol	323	35			1063	114	53	781				
GADGADBAHAL	Redhakhol	431	513			353	355	860	38				
LUHAPANKA	Redhakhol	176				732	169						
MOCHIBAHAL	Redhakhol	398				40	539						
BAMALOE	Rengali	1015	1256			1386	651	1480	700				
GHICHAMURA	Rengali	173				521	455						
JANGALA	Rengali	653	3929			4594	613	1928	3933				
JHANKERPALI	Rengali	93				395	232						
KATARBAGA	Rengali	2794	376			4177	3126	554	555				
KHINDA	Rengali	1939	1730	152		2132	1584	1501	2302	325	148		
KINALOE	Rengali	1277	1981			1394	1275	1999	907				
LAIDA	Rengali	2515	2592			2523	103	80	250				
LAPANGA	Rengali	1002	583	350		642	596	841	845	619	358		
NISHANBHANGA	Rengali	1224				1838	819						
RENGALI	Rengali	3951	3963			4922	3917						
RENGALOI	Rengali	2177	206			2923	1209						
SALAT	Rengali	1868				1882	1867						
TAMPHARKELA	Rengali	1479				185	746						
THELKOLOI	Rengali	990	1949	476		993	1074	3458	3456	662	466		
KILASAMA	Sambalpur	1161				3307	3274						

Annexure 2

List of CCE_field locations identified through Smart Sampling for Sambalpur district – Winter Paddy 2018-19

(P1: Field 1, P2: Field 2, P3: Field 3, P4: Field 4, Alt: Alternate field, S.No: Field Survey Number)

GRAM PANCHAYAT	TEHSIL	P1 S.No	P2 S.No	P3 S.No	P4 S.No	P1 Alt S.No	P1 Alt S.No	P2 Alt S.No	P2 Alt S.No	P3 Alt S.No	P3 Alt S.No	P4 Alt S.No	P4 Alt S.No
BABUNAKTIMAL	Bamara	185	216	576	160	301	544	691	161	156	584	1064	728
BAUNSALAGA	Bamara	145	197	2477	1806	1490	1709	1611	291	2190	95	1982	2206
GADAPOSH	Bamara	1261	286	2367	1155	350	1557	1107	1846	326	736	775	360
GOVINDAPUR	Bamara	333	507	831	3200	2340	1482	2241	238	2144	2016	166	730
JARABAGA	Bamara	379	492	569	160	1438	512	399	178	265	221	554	742
KABARIBAHAL	Bamara	3511	42	296	2441	3372	1384	969	852	1209	466	4443	308
KESEIBAHAL	Bamara	1501	203	9	1001	748	1424	1039	745	278	41	133	833
KINABAGA	Bamara	200	663	2030	43	1081	3203	2373	1731	2068	1828	1698	532
KUTARIMAL	Bamara	1988	1547	719	1504	94	65	18	237	351	338	444	205
LARIAPALI	Bamara	17	549	881	1516	970	202	1381	788	1003	563	906	1470
MAHULPALI	Bamara	482	1209	827	513	129	316	38	1717	335	119	327	1134
PINDAPATHAR	Bamara	1477	476	3524	248	517	51	1339	1249	860	310	4043	166
RABAGA	Bamara	1468	428	643	567	419	587	227	222	588	240	423	360
RANGIATIKRA	Bamara	467	493	207	210	946	355	117	362	854	109	218	423
SAGARA	Bamara	1613	184	2215	999	308	255	1650	2282	1760	1747	451	847
TUREI	Bamara	416	1650	1643	762	844	768	3067	138	3118	123	1488	2314
UCHAKAPAT	Bamara	1327	885	1050	1734	606	1001	76	154	215	1020	1588	204
BADAMAL	Jamankira	658	673	411	1828	666	767	507	301	759	359	226	108
BADARAMA	Jamankira	2015	657	463	880	85	464	2016	631	684	954	522	605
BHOJPUR	Jamankira	657	455	42	627	944	1202	244	197	548	1239	521	166
CHAKULIABAHAL	Jamankira	496	182	85	942	529	1102	328	149	1400	1710	363	658
DHUDIPALI	Jamankira	2136	580	2049	1135	246	1659	371	855	1583	135	486	523
DIMIRIMUNDA	Jamankira	399	1557	324	1069	821	684	36	37	40	4	520	643
GUNDURUCHUAN	Jamankira	1692	164	621	477	1077	751	650	1824	825	455	1731	68
JAMANKIRA	Jamankira	1274	74	602	435	2124	3446	144	325	1031	322	744	3645
KASADA	Jamankira	1117	127	284	1051	1118	121	128	417	377	138	578	453
KATANGAPANI	Jamankira	303	25	625	270	2561	1979	418	2165	77	900	37	200
KENADHIPA	Jamankira	1269	442	791	140	49	729	928	935	784	1050	1163	1128
KHARSALAMAL	Jamankira	1216	385	259	193	1298	957	388	196	247	927	1092	861
KULUNDI	Jamankira	363	97	585	522	19	75	1826	74	1576	404	83	297
MAHADA	Jamankira	702	269	268	543	1114	646	431	52	291	90	73	350
MUNDENPALI	Jamankira	782	343	1524	61	94	450	327	891	144	118	693	672
PHASHIMAL	Jamankira	64	359	1510	892	1075	667	787	448	943	968	2481	334
SARADA	Jamankira	138	39	117	572								
SIRIDI	Jamankira	1898	1	1260	1152	840	1589	160	118	738	623	1317	91
SUBERNAPALI	Jamankira	915	650	2889	3629	311	592	2503	452	359	61	1234	222
TIKIBA	Jamankira	92	134	247	80	172	173	23	145	455	266	349	239

TIKILIPADA	Jamankira	149	187	1103	688	65	964	90	269	968	1783	1387	2000
BAHAM	Jujomura	1390	1902	313	976	370	26	2027	369	201	2099	133	1088
BIRASINGADA	Jujomura	1048	123	1488	1031	781	1231	670	1051	45	1655	1500	1981
CHHAMUNDA	Jujomura	590	121	1375	10	794	2266	1296	1201	142	1320	1465	1361
DANGARPADA	Jujomura	230	2614	441	652	1210	750	3156	635	1628	621	896	3482
GADALOISINGH	Jujomura	573	285	83	641	219	547	321	146	131	57	485	25
GHENUPALI	Jujomura	1457	35	1347	28	657	577	665	1350	1206	1182	76	636
JAYANTAPUR	Jujomura	831	1510	674	1726	2103	745	1005	1147	732	183	99	548
JHANKERPALI	Jujomura	13	1312	1574	388	723	522	1	303	260	1427	177	600
JUJUMURA	Jujomura	1942	379	814	1541	2154	1361	2122	500	2850	427	2672	2232
KABARAPALI	Jujomura	1105	824	894	86	209	146	302	16	761	879	640	46
KANSAR	Jujomura	1505	1417	486	652	1522	19	122	1991	129	1259	69	35
KAYAKUDA	Jujomura	790	90	66	124	583	138	606	143	438	180	122	253
KESHAPALI	Jujomura	274	15	205	447	388	130	4	464	189	56	542	26
KUKUDAPALI	Jujomura	34	1166	47	28	591	1366	1381	1209	525	8	1303	197
LIPINDA	Jujomura	253	118	280	426	192	649	225	37	1179	563	23	422
MEGHAPAL	Jujomura	619	163	971	1333	97	1047	876	720	469	945	128	519
NUABARANGAMAL	Jujomura	3108	3352	3290	1395	3313	1079	1288	763	2291	4234	517	174
TAMPHARGADA	Jujomura	2395	5	165	787	554	796	273	77	128	612	338	160
ARDABAHAL	Kochinda	1649	155	366	1602	1500	1550	15	244	301	1389	1240	408
BANKE	Kochinda	102	109	1554	1656	797	335	2472	329	1099	666	1560	910
BAURIGUDA	Kochinda	1570	369	378	885	1838	2210	1103	2138	3188	3271	3262	3176
BAXMA	Kochinda	296	22	1248	1008	225	216	298	599	1149	2520	855	1666
CHANDINIMAL	Kochinda	1718	1426	412	1601	533	538	702	1216	79	230	668	1043
GOCHHARA	Kochinda	1	1406	1848	251	2640	34	1086	18	1620	789	222	2790
HADIPALI	Kochinda	2616	20	2980	1869	2599	761	756	208	207	2325	1899	2644
JAMANKIRA	Kochinda	216	951	1679	865	117	423	981	52	1883	1964	287	1696
KHANDAKOTA	Kochinda	4	507	2380	1388	422	604	2225	203	2018	963	585	658
KUCHINDA_NAC	Kochinda	2010	482	201	1487	14	1742	2094	1961	291	1348	1368	593
KUDAPARA	Kochinda	385	1960	1590	56	55	302	167	241	2161	276	1238	1645
KUNTARA	Kochinda	3012	423	95	1318	87	64	515	2429	625	136	325	2621
KUSUMI	Kochinda	536	479	558	252	544	374	927	991	1000	930	59	349
KUTURACHUAN	Kochinda	870	419	62	3766	965	2134	3128	607	3194	2475	1252	3401
PARUABHADI	Kochinda	2492	2960	1886	1151	1595	225	2350	782	2780	642	2571	2866
SALHEBHADI	Kochinda	565	300	369	281	702	123	73	235	288	464	695	182
TAINSHARA	Kochinda	18	1246	1065	670	1657	486	692	79	1424	909	1312	572
TELITILEIMAL	Kochinda	26	35	505	387	5	1163	1104	655	337	238	380	326
BADUAPALI	Menswar	753	523	59	1096	584	1581	589	516	573	221	502	113
BARAGAON	Menswar	590	290	393	609	153	219	587	63	596	456	605	160
BATEMURA	Menswar	1120	1017	506	63	287	248	234	248	433	144	130	378
BHIKAMPUR	Menswar	1297	1628	1355	1049	577	2246	1617	228	1119	375	5	556
DAKARA	Menswar	157	146	969	677	174	1005	807	800	510	474	392	800
DEOGAON	Menswar	2400	1376	2473	2400	2746	2225	67	647	2397	2828	2722	2471
DHAMA	Menswar	129	574	160	69	432	757	200	1234	17	1217	78	150

HUMA(BHAIRAPALI)	Menswar	285	267	150	210	79	612	197	191	325	103	113	450
NUATIHURA	Menswar	1998	1782	3117	1491	2243	2115	1897	1797	947	387	1398	949
PARAMANAPUR	Menswar	502	687	1760	36	525	600	1974	501	2226	2235	487	946
SAHASAPUR	Menswar	750	208	648	1326	1732	1775	1450	466	1119	751	196	175
TABALA	Menswar	831	2753	1546	840	2062	2351	1521	775	650	937	435	1134
BALAM	Naktideula	160	111	480	275	2927	2432	1493	1921	533	1400	152	1263
BATAGAON	Naktideula	635	263	1683	900	720	693	166	1059	277	960	3574	76
DAINCHA	Naktideula	745	712	805	2388	555	697	2250	2825	443	576	2549	1658
GHOSHARAMAL	Naktideula	6	641	1051	262	619	256	472	615	992	1251	206	597
GIRISCHANDRAPUR	Naktideula	657	669	672	273	440	9	163	144	542	952	405	215
GOGUA	Naktideula	846	458	242	433	504	327	927	566	241	258	165	618
JAMJORI	Naktideula	1221	268	738	3013	277	396	232	276	1086	502	2292	1013
KISINDA	Naktideula	1213	590	1402	3452	1012	1305	175	360	1907	522	3314	419
NAKTIDEUL	Naktideula	628	2564	2210	1781	598	2940	650	646	3216	1263	1848	439
PANIMURA	Naktideula	132	598	86	243	101	261	109	72	181	177	38	347
SAHEBI	Naktideula	17	22	185	1057	1055	18	637	2336	72	522	35	1234
SAHLEBHATA	Naktideula	1432	46	999	273	279	41	140	1541	311	1363	622	485
SARAPALI	Naktideula	962	1715	1564	18	345	1186	1480	142	1106	169	638	183
SHIMULIPAL	Naktideula	1645	731	3184	71	325	312	388	1814	3094	2766	414	3442
BADABAHAL	Redhakhol	536	1444	1329	68	1123	498	42	391	463	283	1366	254
BADAMAL	Redhakhol	101	1198	1301	1399	99	207	657	235	468	2159	496	733
BANSAJAL	Redhakhol	209	1201	1954	323	115	2114	1035	788	318	2052	384	267
BHALIAKATA	Redhakhol	446	51	416	619	200	250	48	385	200	99	656	174
BHARATPUR	Redhakhol	152	555	399	107	740	437	763	423	176	440	667	243
BURUDA	Redhakhol	591	608	60	218	362	502	497	441	445	142	638	1066
CHARMAL	Redhakhol	236	84	7	977	549	46	366	82	1281	679	35	198
GADGADBAHAL	Redhakhol	703	547	148	559	393	350	260	724	272	348	405	241
KADALIGARH	Redhakhol	369	1431	584	736	1521	509	370	675	163	74	327	604
KUKUDABAHALI	Redhakhol	492	715	722	892	444	192	17	2139	1639	176	1841	1098
LUHAPANKA	Redhakhol	297	1018	643	38	336	329	390	130	656	190	654	781
MOCHIBAHAL	Redhakhol	41	541	785	578	70	121	339	371	583	688	28	613
RAIRAKHOL_NAC	Redhakhol	323	522	511	1090	79	3558	3497	3152	161	587	152	244
RENGALI	Redhakhol	508	666	781	661	774	107	246	97	663	418	886	22
TRIBENIPUR	Redhakhol	353	328	2061	189	832	1316	225	136	200	153	415	582
BAMALOE	Rengali	3107	761	993	2877	3210	3215	2760	354	1319	662	1061	680
GHICHAMURA	Rengali	2620	1504	427	179	2941	727	2396	888	765	665	495	429
JANGALA	Rengali	4700	3865	1259	999	519	4521	1058	205	652	2263	3582	4319
JHANKERPALI	Rengali	2589	1116	1854	3735	1061	1433	693	213	679	1096	2335	3315
KATARBAGA	Rengali	4961	4534	2936	4105	2388	2359	2642	2827	3099	1306	1896	3378
KHINDA	Rengali	2453	2120	1393	1983	1946	2482	2439	893	1737	325	2725	2620
KINALOE	Rengali	86	3337	95	1823	96	654	60	1915	74	236	1301	1118
LAIDA	Rengali	249	28	1038	1752	2243	1827	1171	404	471	1828	929	164
LAPANGA	Rengali	1137	2768	1384	187	404	2762	338	295	848	2777	2686	551
NISHANBHANGA	Rengali	2236	387	87	1233	79	376	394	668	1446	614	1059	1234

RENGALI	Rengali	425	1902	1836	1294	200	5253	4190	4046	4112	3507	4684	1400
RENGALOI	Rengali	236	1948	2173	739	97	121	1941	1011	2588	1817	171	1675
SALAT	Rengali	425	1973	1943	1341	1964	3014	1430	1972	2395	1858	2202	1746
TABADABAHAL	Rengali	3522	278	433	1408	251	95	536	280	200	935	896	450
TAMPHARKELA	Rengali	1358	274	4524	785	2343	172	131	2273	801	756	674	5141
THELKOLOI	Rengali	2940	786	1918	1152	3046	219	1545	222	1906	392	1074	1934
BASANTAPUR	Sambalpur	2	385	372	284	6	344	6	8	67	10	102	593
BISHALKHINDA	Sambalpur	2420	952	2781	2772	1020	798	1021	447	760	737	940	646
GUNDERPUR	Sambalpur	126	265	276	300	351	397	671	946	332	153	169	412
KALAMATI	Sambalpur	4771	2662	1699	5147	35	4971	4058	5322	1089	999	4036	3602
KANAKHINDA	Sambalpur	222	1404	1356	278	249	1381	1539	378	66	54	1263	1223
KARADOLA	Sambalpur	1554	1539	1248	484	1000	1547	988	445	1495	425	830	1298
KILASAMA	Sambalpur	443	1555	534	2010	499	4005	264	2154	2201	208	741	618
SAMBALPUR_M	Sambalpur	2927	1400	173	891	535	152	412	2164	279	101	360	23
SHASAN	Sambalpur	140	1459	1127	73	440	455	6	1206	991	1659	338	385
TALABA	Sambalpur	686	1526	589	2151	1126	90	2825	1162	798	431	824	1125