Annual Progress Report

April 2019 – March 2020

Enhancing Agricultural Productivity and Rural Livelihoods through Scaling-up of Science-led Development in Odisha: Bhoochetana

Submitted to

Department of Agriculture & Farmer Empowerment

Government of Odisha

ICRISAT DEVELOPMENT CENTER

ICRISAT INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS

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1. Executive Summary

Under the Government of Odisha supported flagship initiative i.e. Odisha *Bhoochetana* project during 2019-20, the major milestones have been achieved in developing digital soil health maps and recommendation, and distribution of soil health cards to the farmers from where soil samples were collected, and implementation of demonstrations in pilot sites across 30 districts of the state. A detailed rainfall analysis is undertaken to understand the crop responses. The findings of soil health status, crop responses and the required scaling-up strategy are shared with department of Agriculture officials, while developing skills of farmers in the pilot sites.

ICRISAT has collected and analysed 40285 soil samples across various districts in the state. Soil samples were collected by using stratified random sampling method along with GPS coordinates. Analysis has been carried out by using the state-of-the-art infrastructure. Soil health cards were prepared in the local languge i.e Oria for the use by the farmers. The soil test cards were distributed on the occasion of World's Soil Health Day i.e. 5th December, 2019 and thereafter. So far 36908 cards were distributed and the rest of cards are under printing and would be provided to the farmers in due course very soon. Soil analysis data is interpolated to develop digital soil maps, along with recommendations and inputs required at block level (available online at: http://odmaps.s3.ap-south-1.amazonaws.com/map.html).

A total of 5001 demos covering an area of 2543 acres were conducted across 30 districts during 2019-20. During *kharif* 2019 demonstrations covering an area of 1003 acres and during *rabi* 3081 demos covering 1540 acres were organized. Cyclone FANI affected crop performance in Puri, Khurda, Kendrapara, Jagitsinghpur, Keonjohar and other districts. Majority of the demonstrations were laid out to showcase application of deficient micronutrient viz. zinc and boron, crop diversification options, improved cultivars, and humic acid. The crops chosen for demonstrations included paddy, finger millet, maize and groundnut during kharif, 2019 and chickpea, blackgram, greengram, groundnut and mustard during rabi, 2019-20. Average increase in crop yield with improved practices ranged between 26 to 51% and highest response was obtained in maize (51%) followed by groundnut (41%), finger millet (37) and paddy (26%) during kharif, 2019. Among technologies, improved cultivars, soil test based application of NPK along with boron and zinc showed higher yield response compared to the farmers practice.

Detailed rainfall analysis of Odisha was also undertaken based on district-wise monthly rainfall data for the period April 2019 to March 2020, collected from the Government of Odisha. It may be summarized that Odisha state experienced excess rainfall conditions in all three seasons viz., SW Monsoon 2019, Post-Monsoon 2019 and Rabi 2020, though Balangir, Bargarh, Boudh and Sonepur districts experienced deficit rainfall conditions in Post-Monsoon 2019. Due to heavy rainfall situation, inundation of crop fields was reported in some districts in the rainy season 2019. In general, the rainfall situation (both quantity and distribution) in Rabi 2020 season was favourable to crops.

As part of the project, two Master Trainer (MT) training programs were conducted during July, 2019 involving 60 district levels officials, two from each district. As part of its objectives, ICRISAT embarked upon mammoth task of conducting district level CB programs commencing

from September, 2019. In district level CB programs for Officers and VAW, capacities of 2576 officials were developed. In pilot sites, 625 training programs were conducted for the farmers during April-March 2019-20 across all the 30 districts covering 16115 farmers (11338 men and 4777 women). The trainings were imparted in in soil fertility assessment, fertilizer and micronutrient application, using of improved tolls and equipment, crop management and management of pests and diseases. Scientists provided handholding support to line department staff.

With regard to setting up of referral laboratories at Bhubaneswar and Sambalpur, the laboratory in Bhubaneswar and Sambalpur are ready for commissioning, however due nationwide lockdown on account of COVID-19 situation these facilities might start functioning once the normal situation is restored.

Detailed benchmarking of pilot sites is also undertaken to prepare for scaling-up through department of agriculture as the nodal agency, so as to precisely capture the impacts of scaling-up program later-on. Study highlighted that Operational holdings are highly skewed with more than 80 percent of those belonging to small and marginal categories and 20 percent belongs to medium and large categories. Odisha is primarily a food grain-growing state, and 88 percent of the area in kharif is occupied by food grain crops. Oilseeds and pulses are mainly grown in the rabi season. Paddy is a very prominent crop (85%) of this season and occupies 85 percent of total sown area. Vegetables are third most important crop during the kharif season occupying 2 percent of the cropped area. Cotton is the next to ragi occupying nearly 1 percent of the cropped area in kharif. The productivity levels of all major crops grown in the state below national statistics indicating the need for adopting best management practices as demonstrated in the pilots.

2. Objectives

The specific objectives of the project are;

- To upgrade two existing soil analytical laboratories in the state to serve as referral laboratories and run them efficiently with government support.
- Identify the best soil, crop, water and nutrient management options for sustainable intensification of major crops in different agro-ecoregions to increase productivity through demonstrations in pilot sites and scalingup in partnership with DoA and other partners through convergence.
- To assess the nutrient status of soils in the 30 districts of Odisha through stratified soil sampling.
- To build the capacity of DoA staff in undertaking soil analysis, handling data and that of other consortium partners including farmers for scalingup science-led holistic development strategy using ICT tools.
- To concurrently monitor, evaluate, assess and document the impacts of the scalingup approach in order to enable mid-course corrections.

3. Detailed Digital Soil Health Mapping and Recommendation

3.1. Delineation of nutrient deficiencies and development of digital maps and recommendations

The key input required to plan and implement balanced nutrient application strategy across the state is knowing the nutrient status in the soil. The results of soil analysis are either available to individual farmer in form of soil health card or tabulated summary at village / block / district level, which may limit the full utilization of such enormous data on soil nutrient across the country. In Bhoochetana project, soil nutrient maps were developed to facilitate policy maker and department officials to understand the spatial patterns on nutrient status in the state. These maps can be used to frame the policy on subsidy or resource mobilization to address the issue of large scale deficiencies of nutrients especially the micronutrients that are widely deficient across blocks and districts in the state.

3.2. Digital Soil Mapping

Digital Soil Mapping (DSM) or predictive soil mapping provides option to generate soil property surfaces at fine resolution with the uncertainty of prediction. Three steps procedure was adopted in preparation of digital soil maps that include 1) collection of legacy soil data or field and laboratory measurement of soil properties and development of the base maps from the available data including climatic information, land cover, terrain and geological variables; 2) estimation of soil properties by using quantitative relationship between point wise measured data and that of spatial maps that were prepared in the step one; 3) estimated soil properties were further used to derive more difficult-to-measure soil properties such as soil water storage, carbon density, and phosphorus fixation. Although the DSM products have some prediction uncertainties, but it provide the spatial information at much higher resolution and at lesser costs.

The methodology adopted in developing soil maps is given in Figure 1. The key variables used to develop the model for Odisha soils were soil type, agro ecological zones, elevation, precipitation, and temperature. The Digital Elevation Model (DEM) acquired from the Shuttle Radar Topographic Mission (SRTM) with spatial resolution of 90 m around the study area was downloaded for Odisha state and is being used in DSM product preparation. The global raster data of WorldClim Bioclimatic variables for WorldClim version 2 was used to extract the bioclimatic variables with respect to point wise data. These bio-climatic variables were average for years 1970-2000. The Random Forest Model was used to prepare maps using Bhoochetana data. While modelling, data partitioned into 75% points for calibration and 25% points for validation of the model. Calibrated models were used to prepare soil nutrient maps.

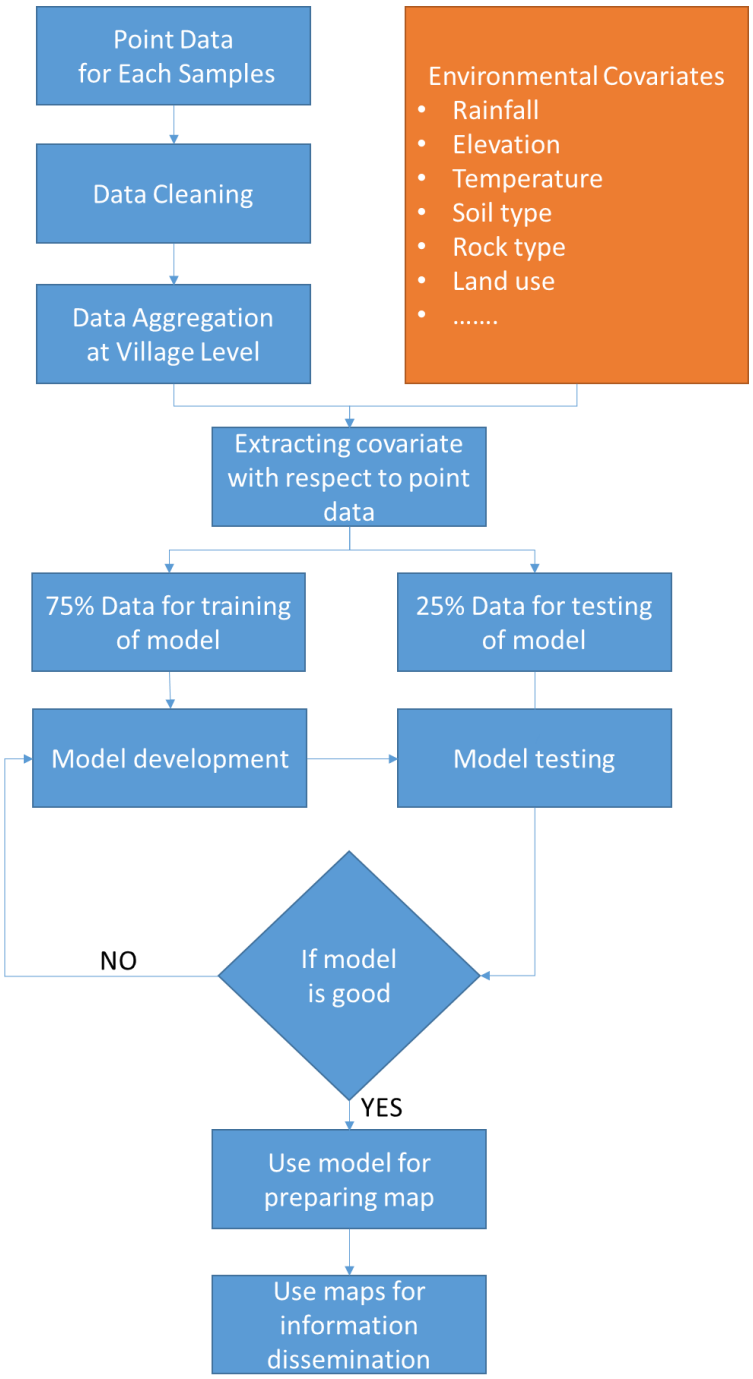

Figure 1: Methodology followed for developing the soil nutrient maps for Odisha state

3.3. Soil nutrient maps

Three types of maps were prepared for better interpretation of results. They are 1) map on soil parameter values at 118 x 118 m resolution (pixel level map), 2) map on soil parameter values classified as per fertility indices (classified map; Figure 2-9) and 3) map on classified soil parameters aggregated to block level. These three types of maps were prepared for pH, electrical conductivity (dS/m), organic carbon (%), exchangeable potassium (mg/kg) and for available nutrients viz. phosphorous (mg/kg), sulphur (mg/kg), boron (mg/kg) and zinc

(mg/kg). The pixel level and classified maps were also prepared for each district. The rules used for classification are presented in Table 1.

Table 1. Ranges of soil parameter values for classification in soil maps

Parameter	Value range	Class
pH	<4.4	Extreme to Ultra acidic
	4.5-5.5	Strong to very strong acidic
	5.6-6.5	Slight to moderately acidic
	6.6-7.3	Neutral
	7.4-8.4	Slight to moderate alkaline
	>8.4	Strong to very strong alkaline
Electrical conductivity (dS/m)	<0.8	Normal
	0.8-1.6	Critical to salt sensitive crops
	1.6-2.5	Critical to salt tolerant crops
	>2.5	Injurious to crop
Organic carbon (%)	<0.5	Low
	0.5-0.75	Medium
	>0.75	High
Available phosphorous (mg/kg)	<5	Low
	5-10	Medium
	>10	High
Exchangeable potassium (mg/kg)	<50	Low
	50-100	Medium
	>100	High
Available sulphur (mg/kg)	<10	Deficient
	>=10	Sufficient
Available boron (mg/kg)	<0.58	Deficient
	>=0.58	Sufficient
Available zinc (mg/kg)	<0.75	Deficient
	>=0.75	Sufficient

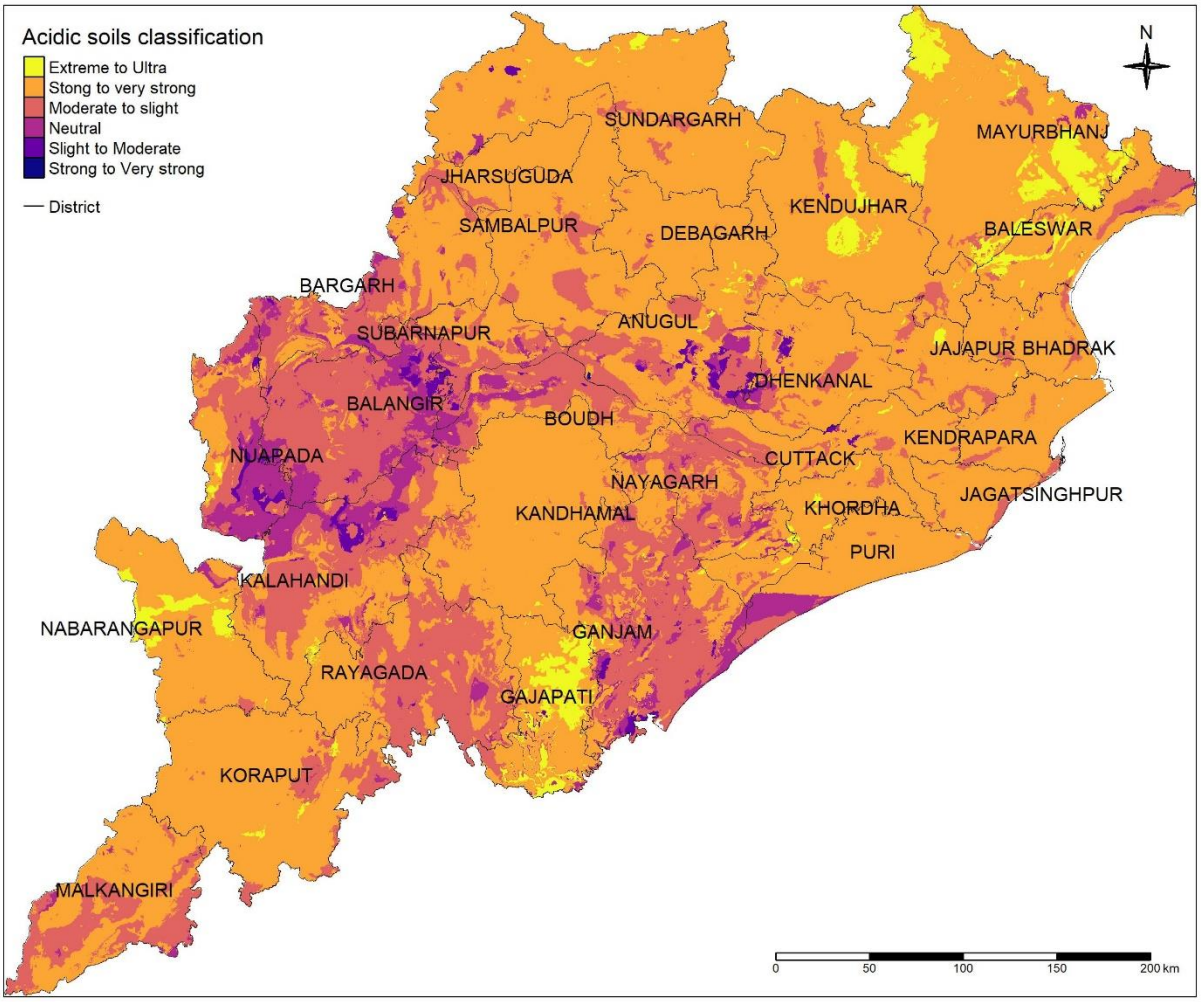

Figure 2: Acid soil classification based for soil pH

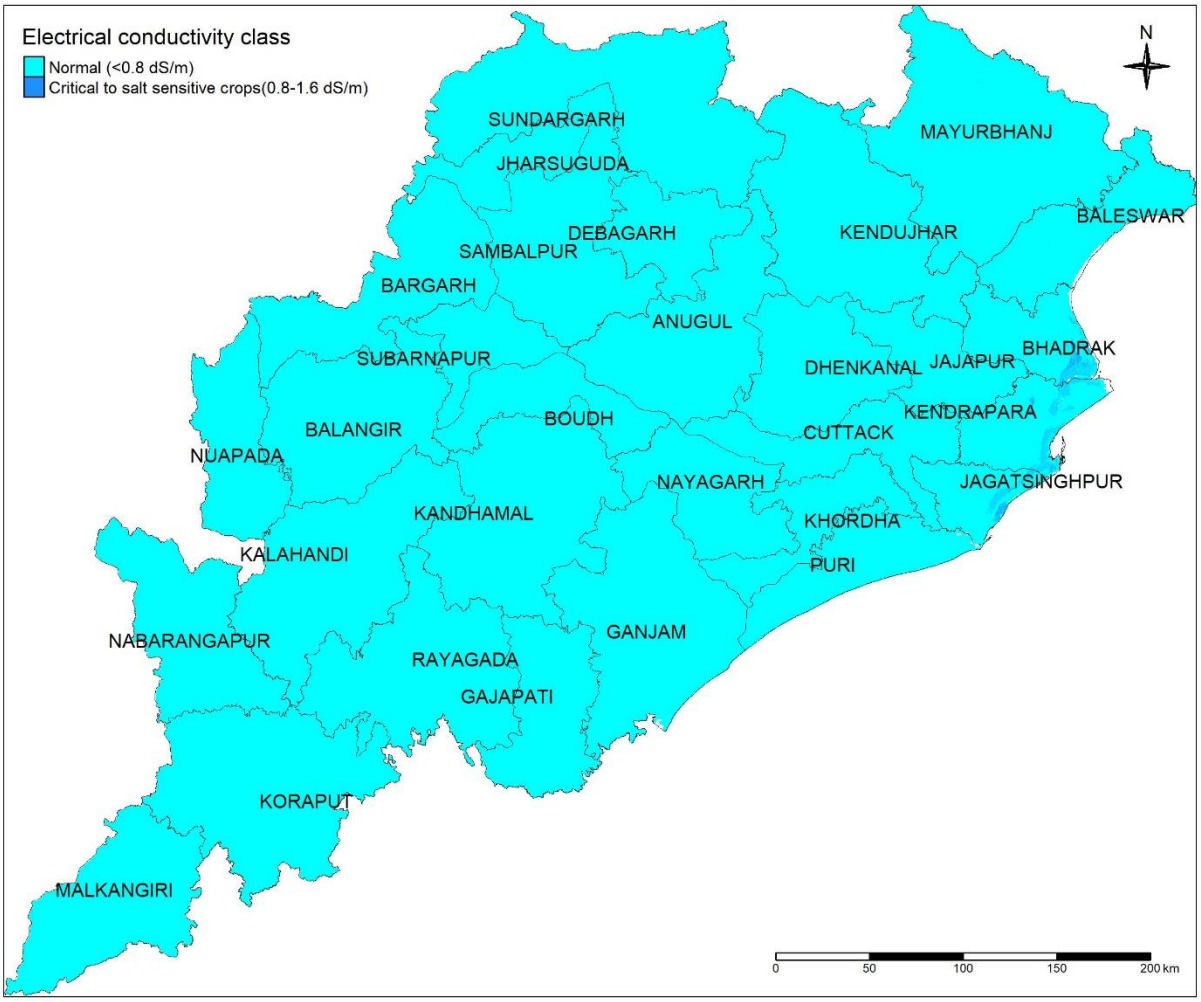

Figure 3: Map on classification of soils based on electrical conductivity

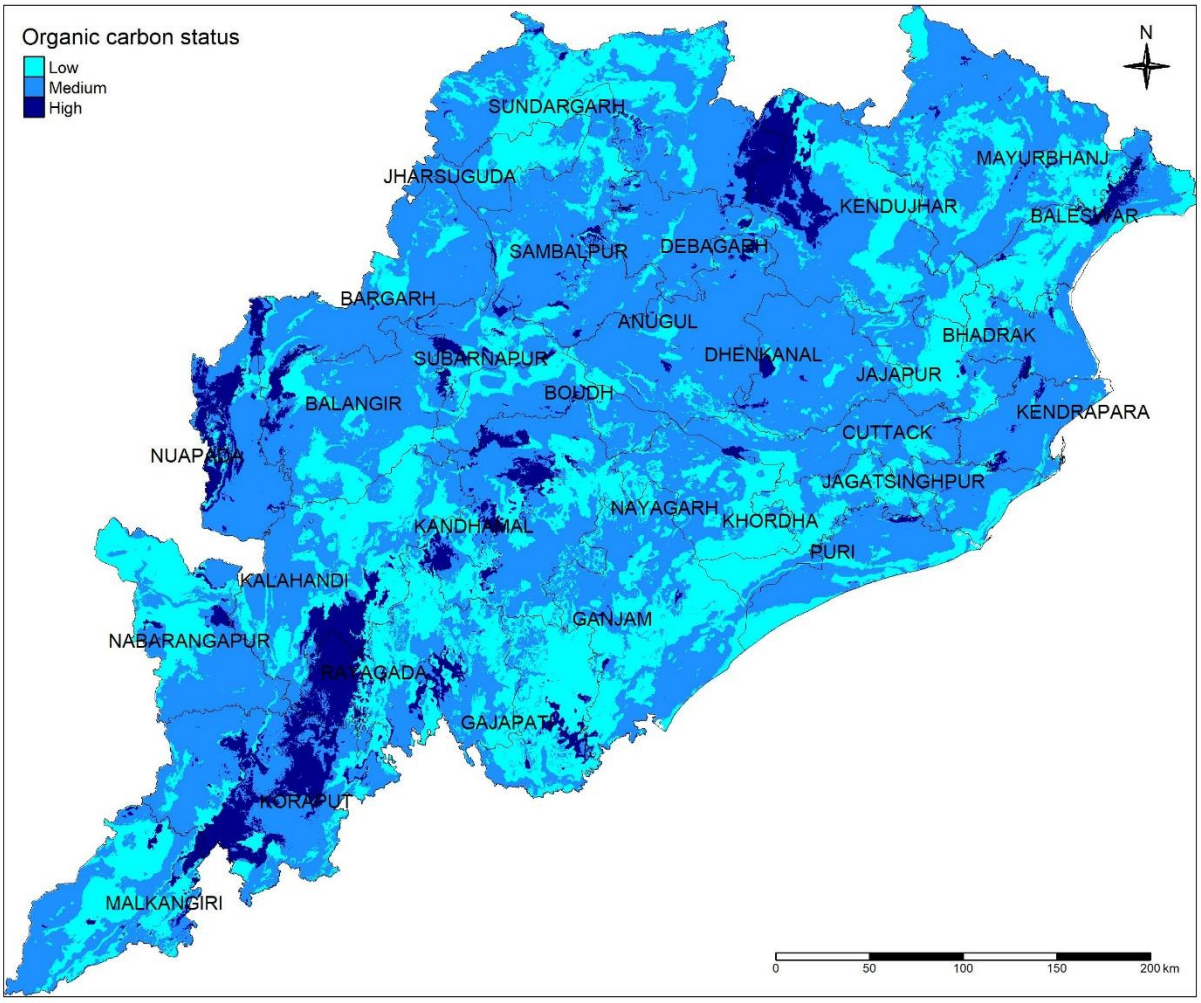

Figure 4: State level map for soil organic carbon

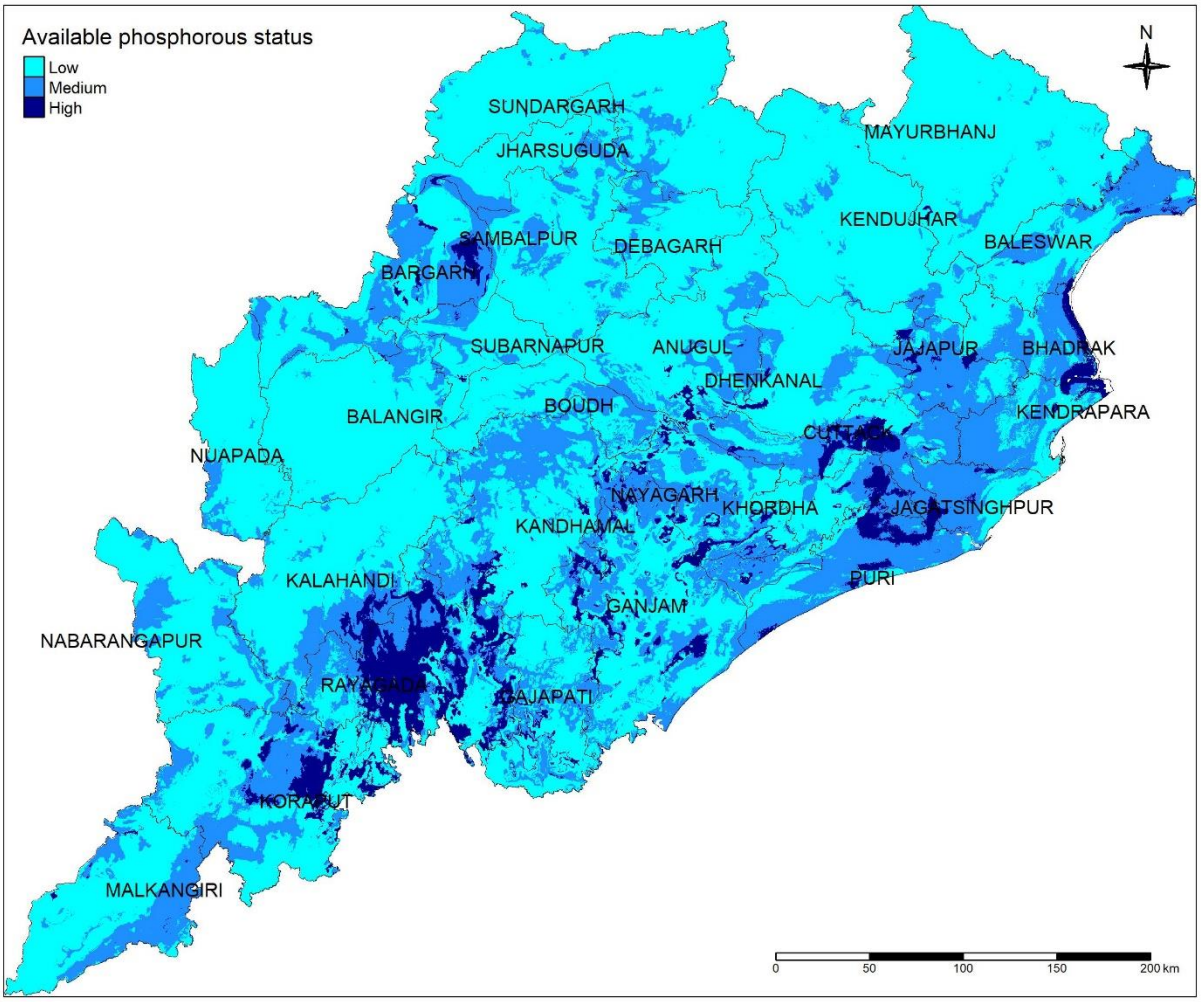

Figure 5: State level map on available phosphorous status

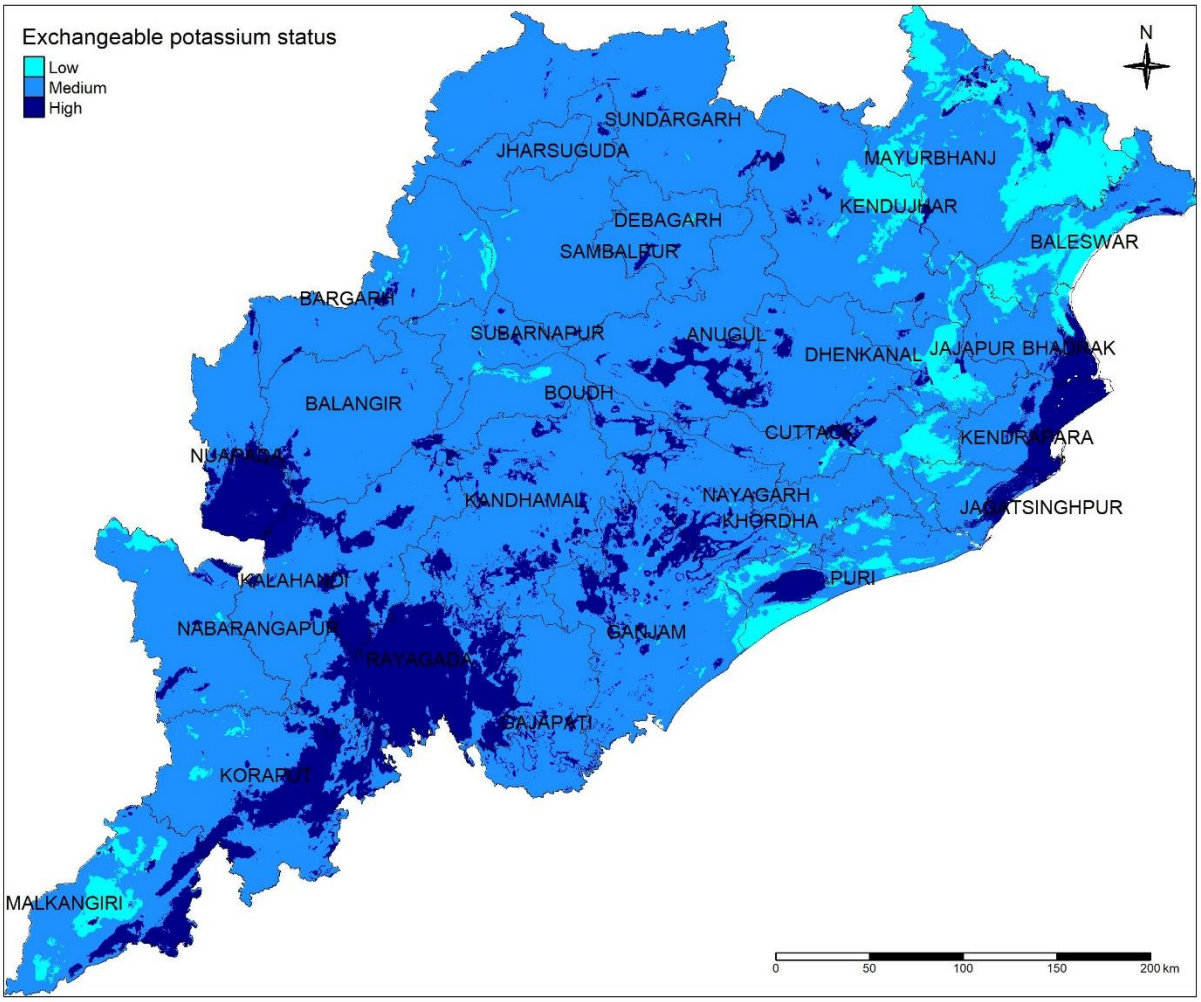

Figure 6: State level map of exchangeable potassium status in the soils

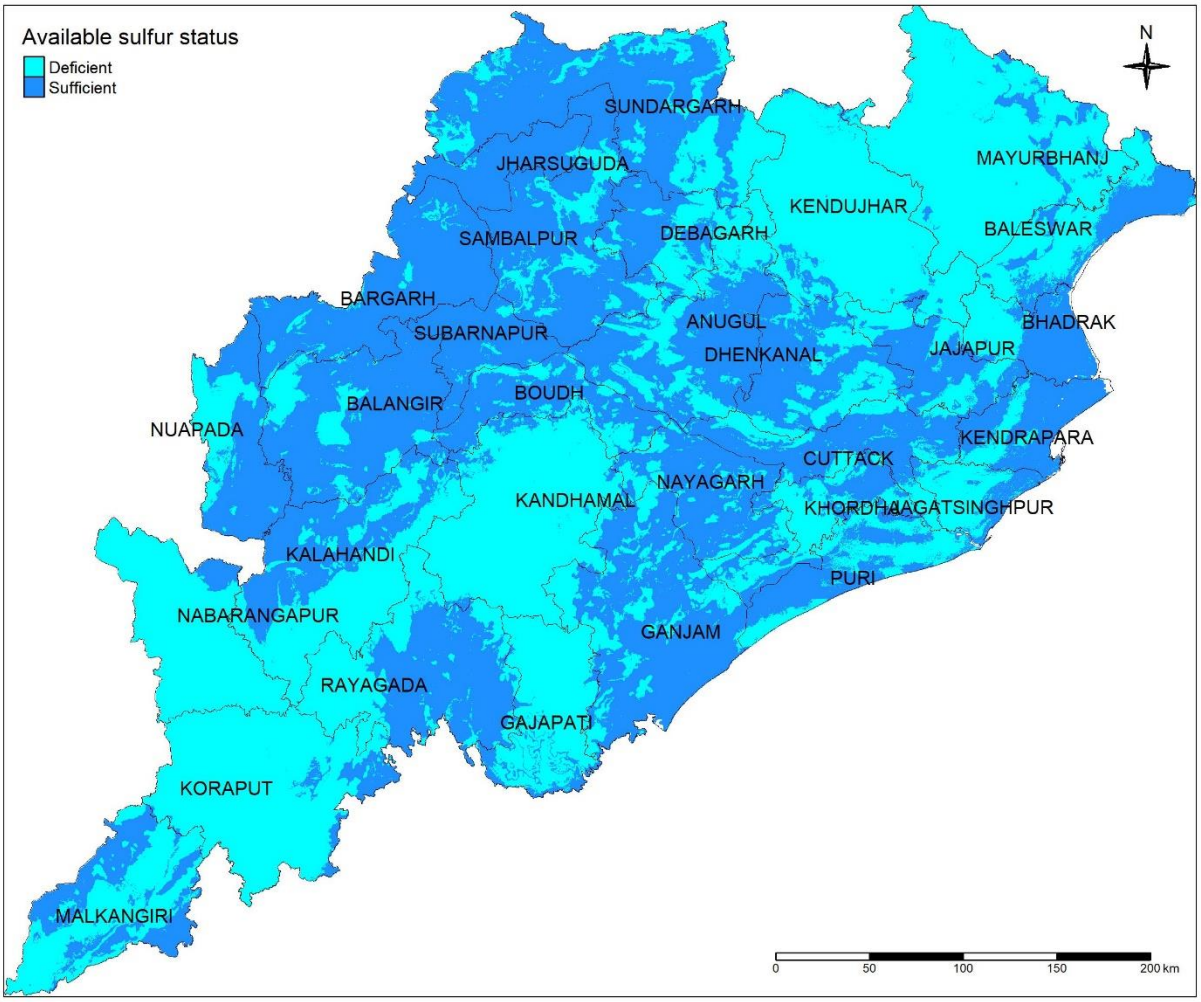

Figure 7: State level map of available sulfur status in soils

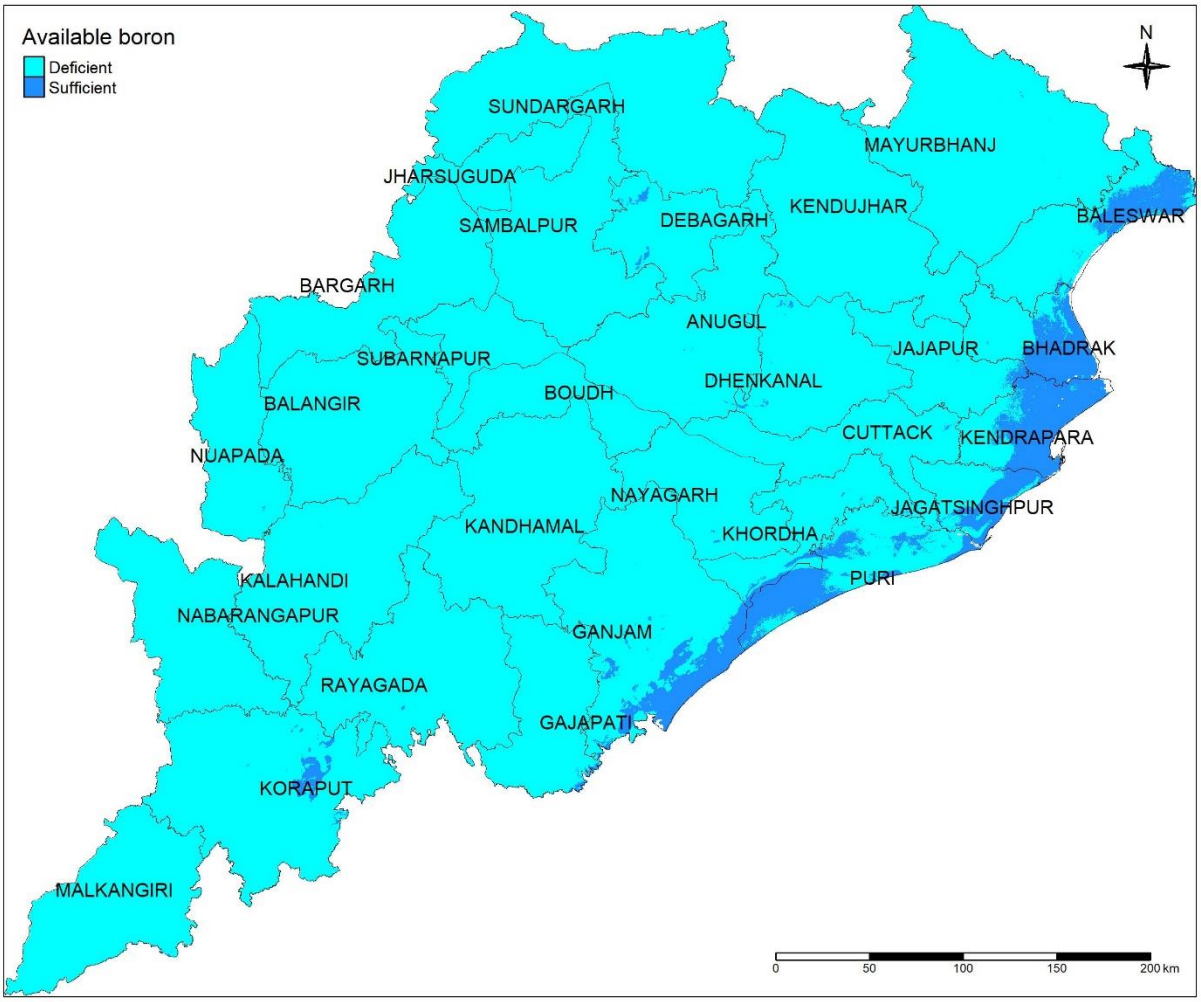

Figure 8: State level map on available boron status in soils

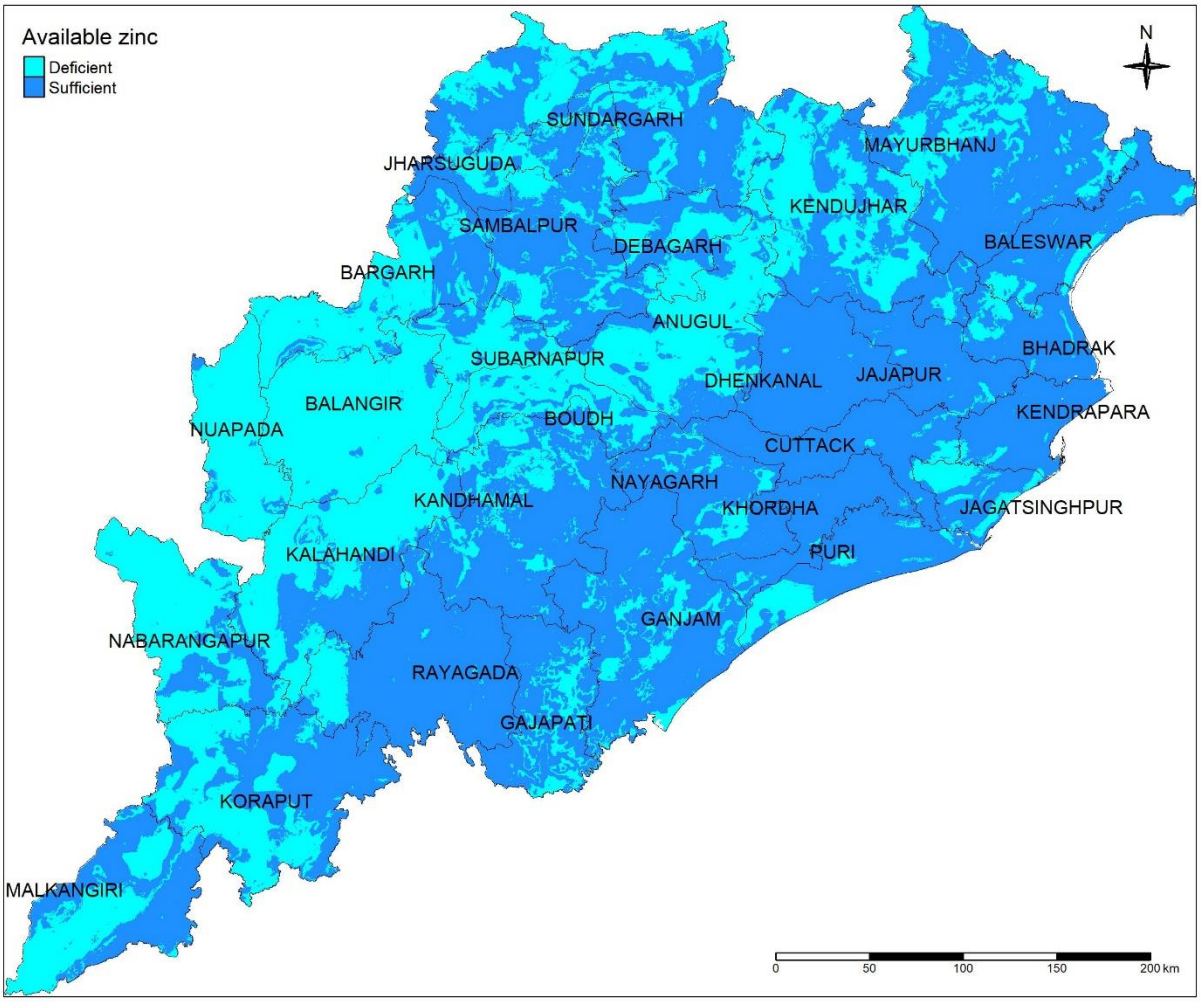

Figure 9: State level map on available zinc status in soils

3.4. ICT-enabled dissemination and scaling-up through tablets

One of the important outputs from Bhoochetana project is the soil nutrients maps for state of Odisha India. The data sets from the project is being used to develop the web app. The soil analysis data of 40000 soil samples collected across 30 districts in the state of Odisha was used as data base for developing the soil fertility indices. This database is used to develop the crop wise fertilizer recommendation up to village level and issuing of soil health cards to individual farmers with whom the soil samples were collected. The printed soil health cards not only have a limited reach but also involves huge cost and efforts for their printing and distribution. Thus, a web-based application is envisaged to be developed to provide soil health and fertility information at village, block, or district level in a seamless and cost effective manner (available online at: http://odmaps.s3.ap-south-1.amazonaws.com/map.html). Ninty tablets are also loaded with all analysis data, recommnedations and best practices to be handed over to the department of agriculture as per directions from the Director.

Application is developed using combination of PHP: Hypertext preprocessor and MYSQL environments. PHP is an open-source server-side scripting language, which can be embedded into an HTML document. MYSQL is an open-source data management system. During development stage, open-source software WAMP (version 2.2) was used as a testing

environment on a local computer. WAMP is a bundle of different softwares including apache web server (version 2.2.21), PHP processor (version 5.3.8), and MYSQL server (version 5.5.16). The existing web application is being hosted on ICRISAT server.

4. Demonstration of Improved Practices

As part of the Bhoochetana project, ICRISAT has committed to carry out 1600 crop trials per year covering all 30 districts of the state. Based on results of soil samples analyzed, trials were laid out in farmer-participatory mode during *kharif*, 2019 (Table 2). A total of 5001 demos covering an area of 2543 acres were conducted across 30 districts during 2009-20. In *kharif* 1920 demonstrations covering an area of 1003 acress and in *rabi* 3081 demos covering 1540 acres were organized. Untimely cyclone FANI afftected the crop performance in Puri, Khurda, Kendrapara, Jagitsinghpur, Keonjohar and other districts. Majority of the demos were laid out for evaluation of crop diversification options, improved cultivars and nutrient application based on Soil Test Based Recommendation of including micronutrients (Zn and B). In view of wide spread deficiency of organic carbon and low productivity, demonstration were also organized on application of humic acid wherever feasible. Majority of the soils being acidic in nature and higher prevalence of micro-nutrient deficiencies like zinc and boron, demonstrations were organized with a combination of micronutrients and soil test based nutrient management practices. Wherever farmers have the practice using non-descript local varieties, demonstrations on improved cultivars that are responsive to nutrients and showing tolerance to abiotic stress like submergence, moisture and nutrient stress and pest and disease infestation were organized according to location specific situation. Demos were conducted in area of 0.5 - 1.0 acre in the farmers fields depending on the availability of land in contiguity for accommodation of improved and farmers practices with the same farmers.

Table 2. District-wise demonstration conducted during 2019-20

District	Kharif		Rabi		Total	
	Area (acre)	No. of Demos.	Area (acre)	No. of Demos.	Area (acre)	No. of Demos.
Angul	11	29	24	47	35	76
Balangir	0	60	38	76	38	136
Balasore	30	60	77	153	107	213
Bargarh	30	59	84	169	114	228
Bhadrak	33	68	30	59	63	127
Boudh	24	50	46	92	70	142
Cuttack	23	45	20	40	43	85
Deogarh	49	104	72	145	121	249
Dhenkanal	23	45	19	38	42	83
Gajapathi	67	142	67	133	134	275
Ganjam	43	60	43	85	86	145
Jagatsinghpur	38	75	83	166	121	241
Jajpur	40	80	31	62	71	142
Jharsuguda	57	70	51	103	107	173
Kalahandi	30	60	49	98	79	158
Kandhamal	15	30	10	20	25	50

Table 2. District-wise demonstration conducted during 2019-20						
District	Kharif		Rabi		Total	
	Area (acre)	No. of Demos.	Area (acre)	No. of Demos.	Area (acre)	No. of Demos.
Kendrapara	43	85	83	166	126	251
Keonjhar	64	128	62	124	126	252
Khorda	25	50	80	160	105	210
Koraput	24	48	50	100	74	148
Malkangiri	39	60	75	150	114	210
Mayurbhanj	35	70	96	192	131	262
Nabarangapur	14	28	60	120	74	148
Nayagarh	47	70	20	40	67	110
Nuapada	0	60	38	76	38	136
Puri	15	30	49	98	64	128
Rayagada	15	30	30	60	45	90
Sambalpur	66	66	48	95	114	161
Sonepur	30	60	45	90	75	150
Sundargarh	76	98	62	124	138	222
Grand Total	1003	1920	1540	3081	2543	5001

4.1 Response of crops to various technologies

There is a varied response of crops to improved technologies viz. improved cultivar, soil test based nutrient management, application of mircro-nutirients (boron and zinc) across various districts in Odisha. Highest yield response was obtained in maize (51%) followed by groundnut, fingermillet and paddy (Figure 10).

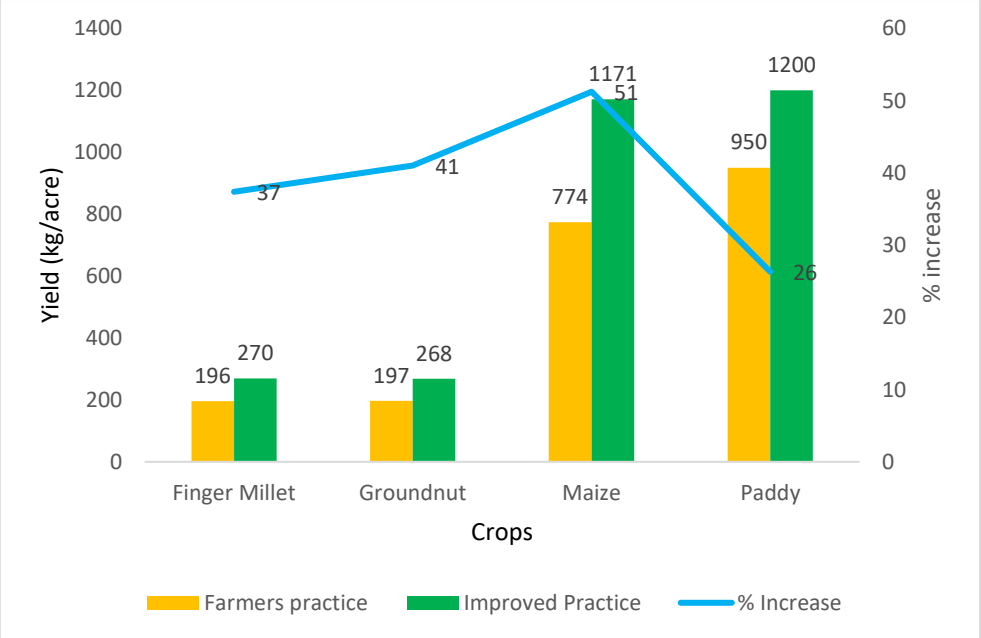

Figure 10. Response of crops to improved technologies during kharif, 2019 in Odisha

4.2 Responses to improved crop cultivars

4.2.1. Fingermillet

Demonstrations on fingermillet were conduted in Angul, Malkangiri and Koraput. Among four varieties tested, the yield respose w.r.t. GPU-28 and GPU48 was good (39%) as compred to MR-1 (Figure 11). The district wise yield response of GPU-48 was 52% in Angul and 40% in Malkangiri and 30% in Koraput (Figure 12). The performace of GPU-28 was almost similar in Koraput (39%) and Malkangiri (38%) and with regard to MR-1 variety, it performaced well in Malkangiri (41%) compared to Koraput (26%).

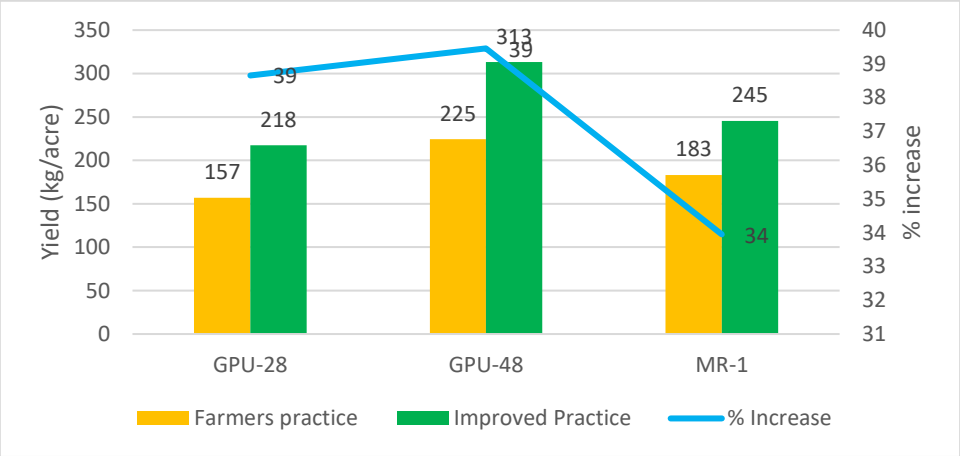

Figure 11: Performance of fingermillet cultivars in kharif, 2019

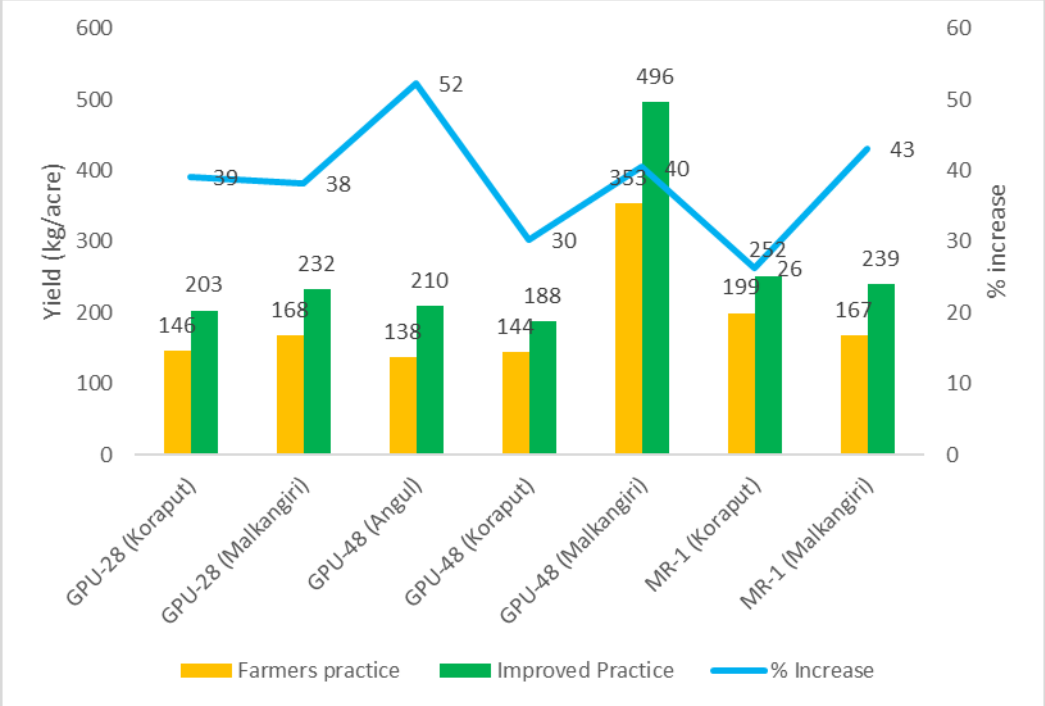

Figure 12: District wises performance of fingermillet varieties in kharif, 2019

4.2.2. Groundnut

Groundnut demonstrations were conducted in four districts viz. Angul, Balangir, Deogarh and Nuapada. Devi variety was tested against non-descript variety viz. Teenbeej (Figure 13). The performace of Devi varieity varied among districts with highest response of 64% in Deogarh followed by18% in Nuapada and 10% in Balangir and 5% in Angul.

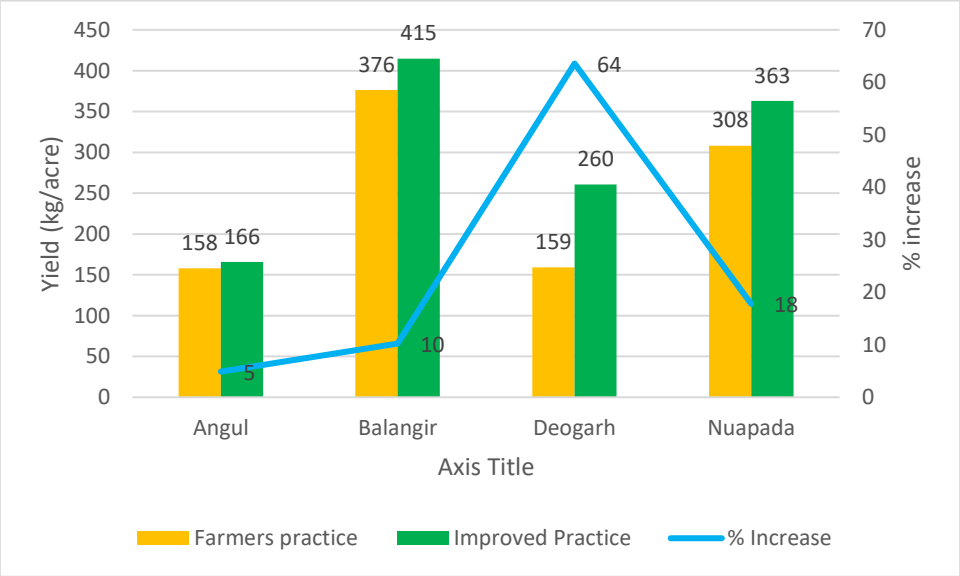

Figure 13: Performance of Devi variety in kharif, 2019

4.2.3. Maize

Demonstations in maize were conducted in Boudh and Mayurbhanj with three cultivar viz. HT-5402, Adventapac-751 Elite and VNR-4343 (Figure 14). Improved cultivar HT-5402 performerd well with a yield response of 48% followed by VNR-4343 and Adventapac-751 Elite.

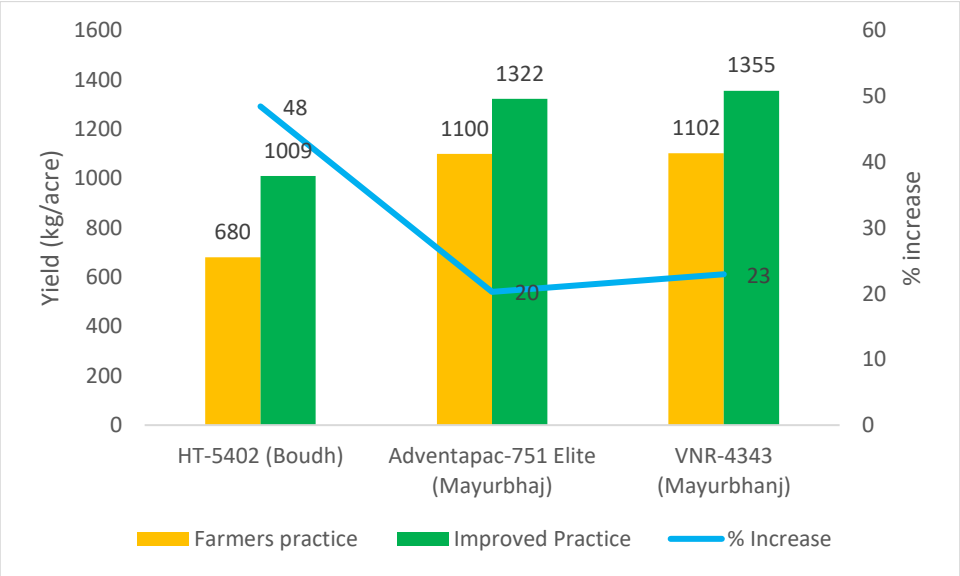

Figure 14: Performance of maize cultivars in kharif, 2019

4.2.4. Paddy

Paddy demonstrations were conducted during kharif, 2019 in Odisha and there is varied performace among the distriscts (Figure 15). Highest yield response was obtained in Kandhamal (41%) followed by Malkangiri (39%), Rayagada (39%), Balasore (34%), Dhenkanal (27%), Sonepur (27%), Bargarh (24%), Boudh (23%), Cuttack (22%) and Nuapada (20%), while lowest response of 6% was recorded in Puri.

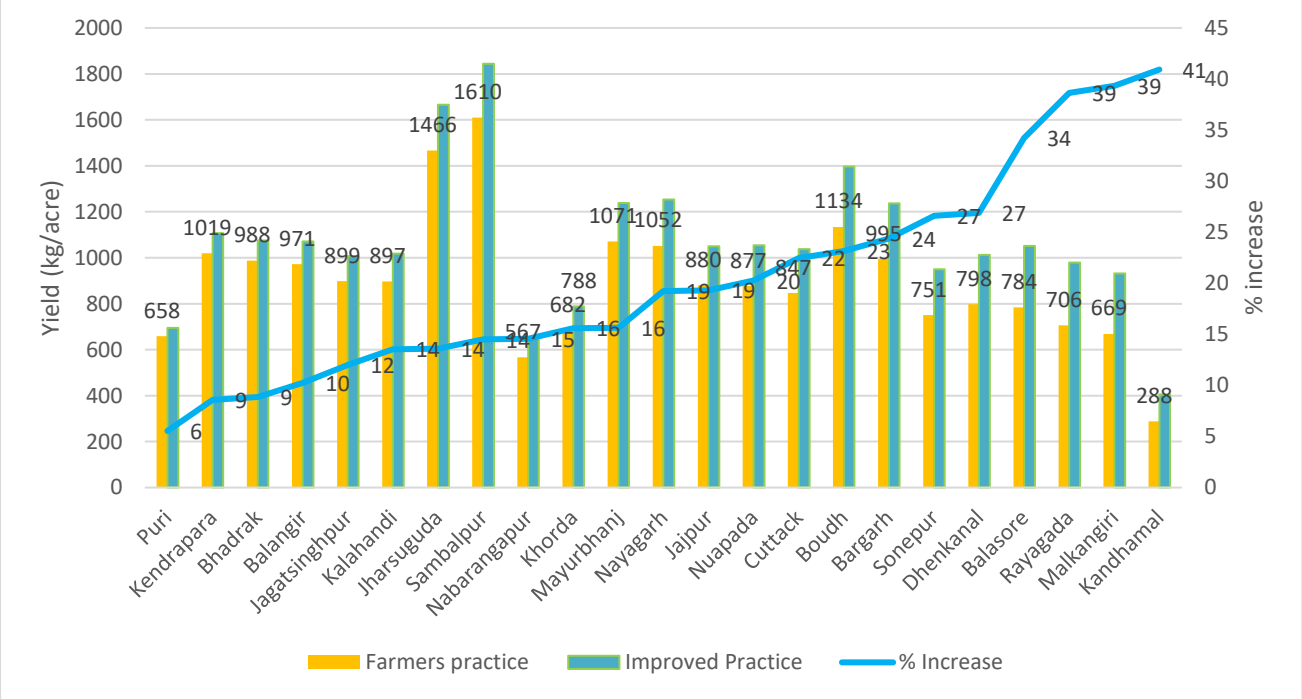

Figure 15: Performance of paddy in kharif, 2019

Among various improved cultivars that tested (Figure 16), the yield response of Ranidhan (32%) was good followed by Sahabhagi Dhan (25%), MTU-1001 (21), Pratikshya (17%), Pooja (17%), Mandakini (16%), Swarna Sub-1 (15%), CR-1009 (15%) and MTU-1010 (14%). Improved cultivar MTU-1001 was demonstrated in eight districts and highest yield response was noticed in Malkangiri (39%) followed by Balasore, Bargarh, Boudh and Nayagarh (Figure 17). With regard to Pooja variety, highest yield resonse was obtained in Dhenkanal (25%) followed by Cuttack, Sonepur, Boudh, Nayagarh and Khorda (Figure 18). Highest yield response of 32% was recorded with regard to Pratikshya variety in Dhenkanal followed by Mayrubhanj and Jharsuguda (Figure 19). Results showed that improved cultivar Ranidhan gave best performace in Rayagada (38%) followed by Sonepur and Kendrapara (Figure 20). Similarly, improved cultivar viz. Sahabhagi Dhan gave good performace in Rayagada (40%) followed by Sonepur and Nuapada (Figure 21). With regard to Swarna Sub-1 i.e. a submergence resistant variety, highest yield response was noticed in Balasore (33%) followed by Dhenkanal, Bargarh, Cuttack, Boudh and Khorda, Mayurbhanj and Jharsuguda (Figure 22).

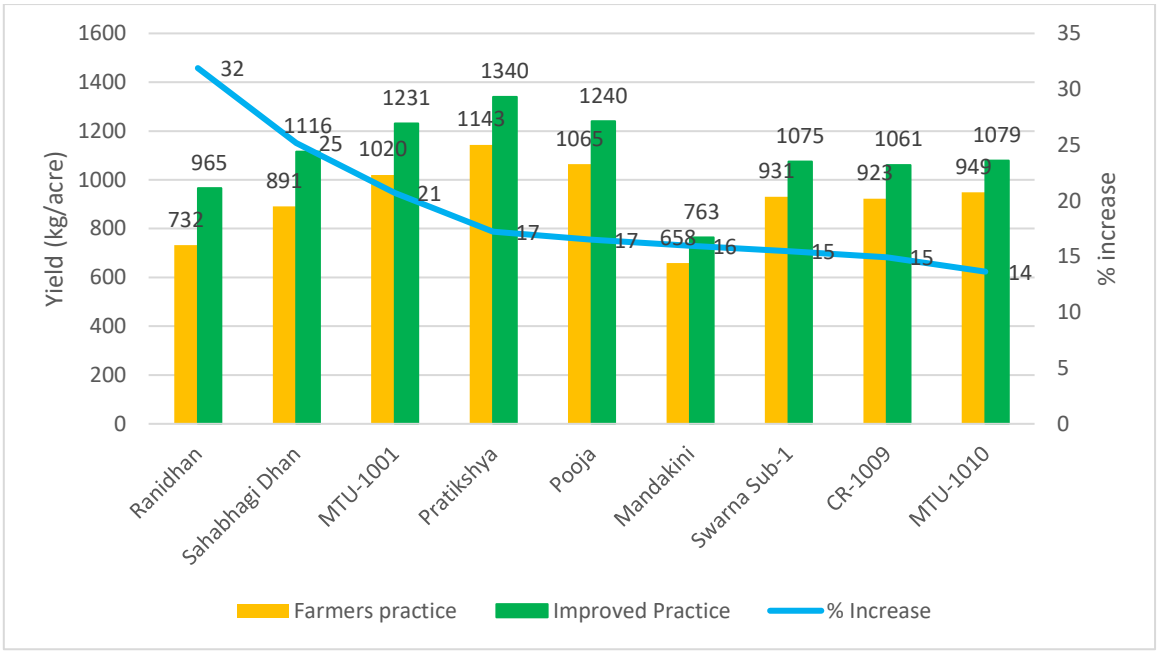

Figure 16: Performance of improved cultivars of paddy in kharif, 2019

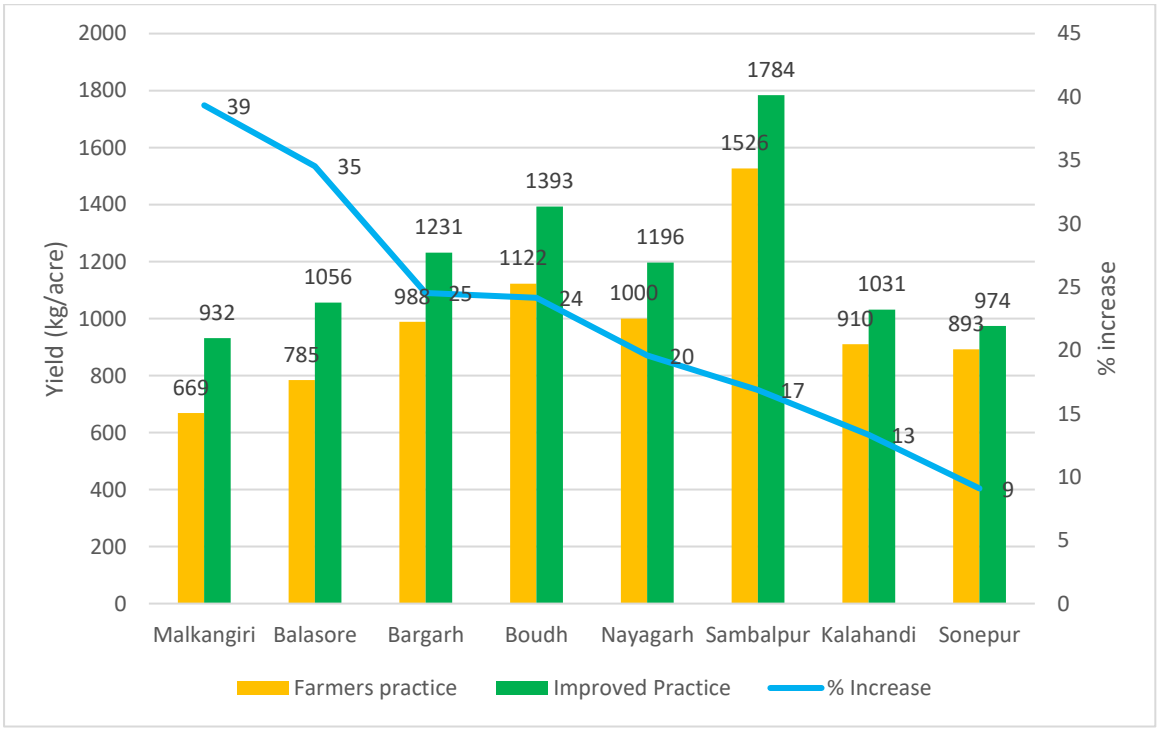

Figure 17: Performance of paddy varity MTU-1001 in kharif, 2019

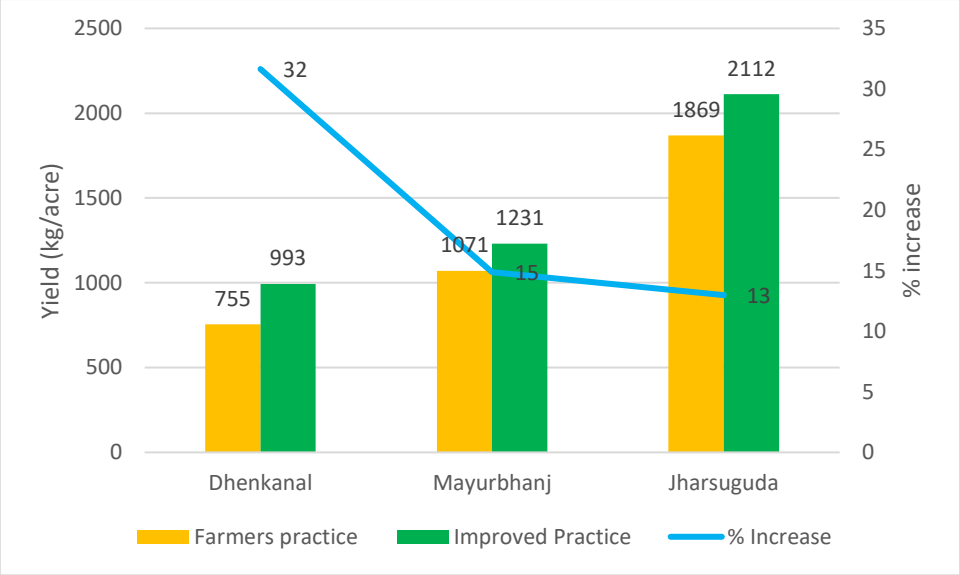

Figure 18: Performance of paddy variety Pratikshya in kharif, 2019

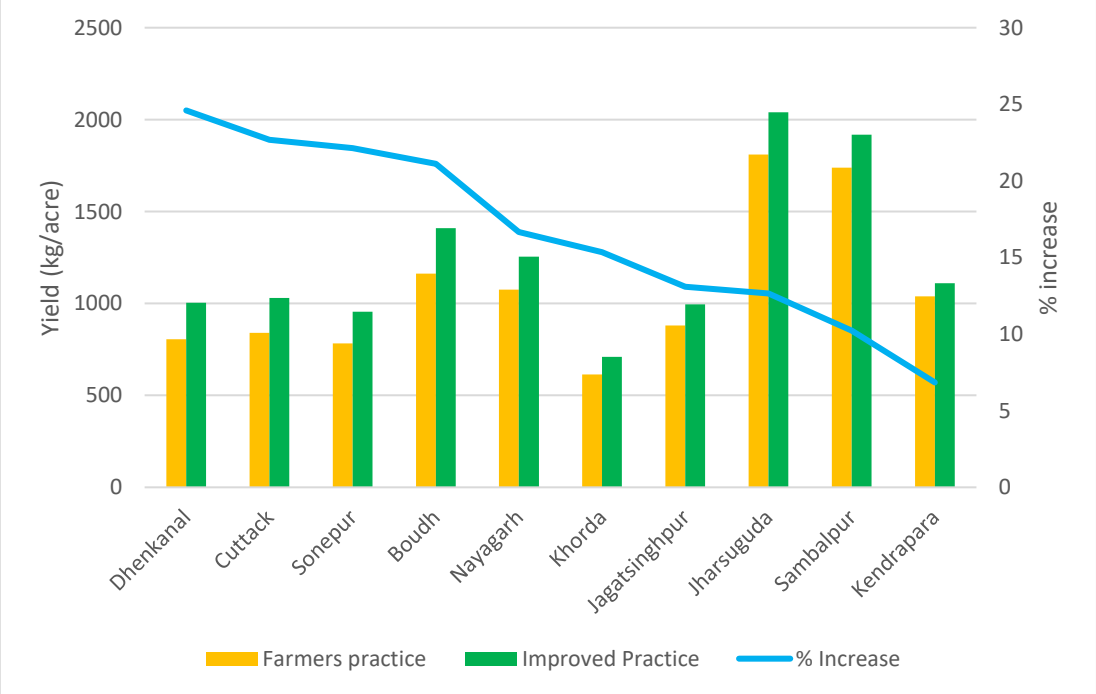

Figure 19: Performance of paddy variety Pooja in kharif, 2019 demonstrations

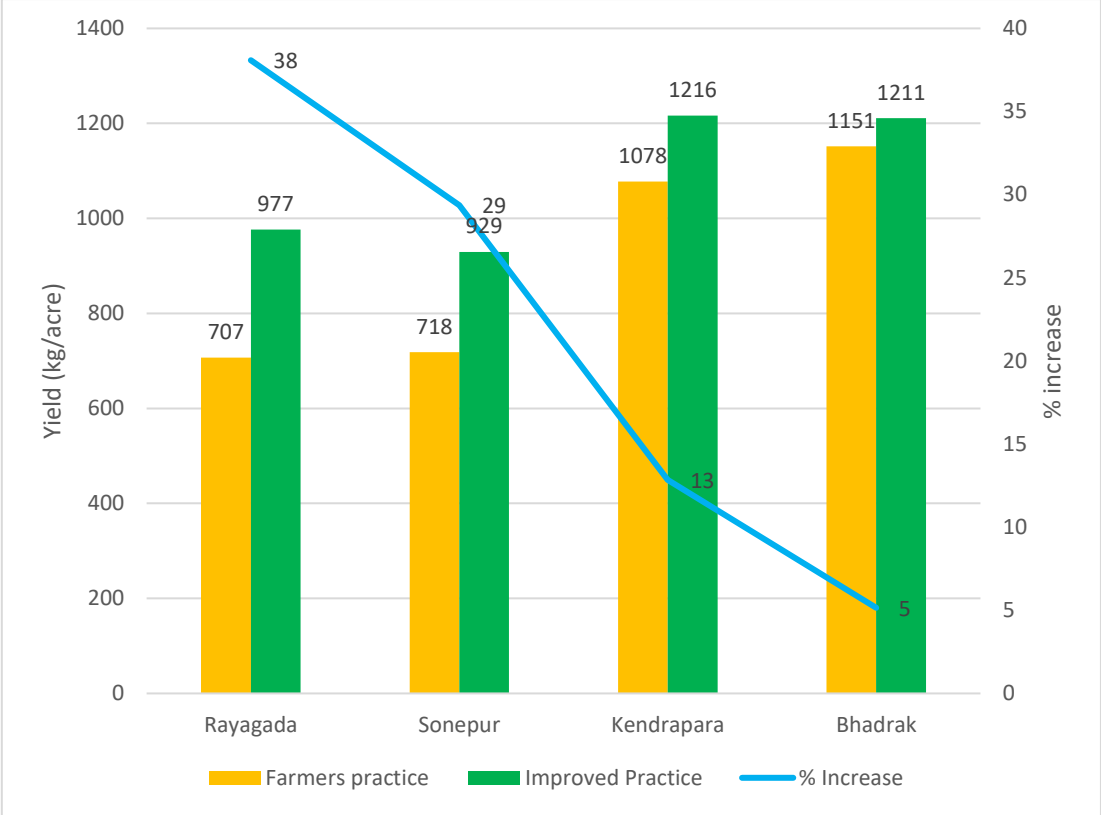

Figure 20: Productivity Ranidhan variety of paddy in kharif, 2019

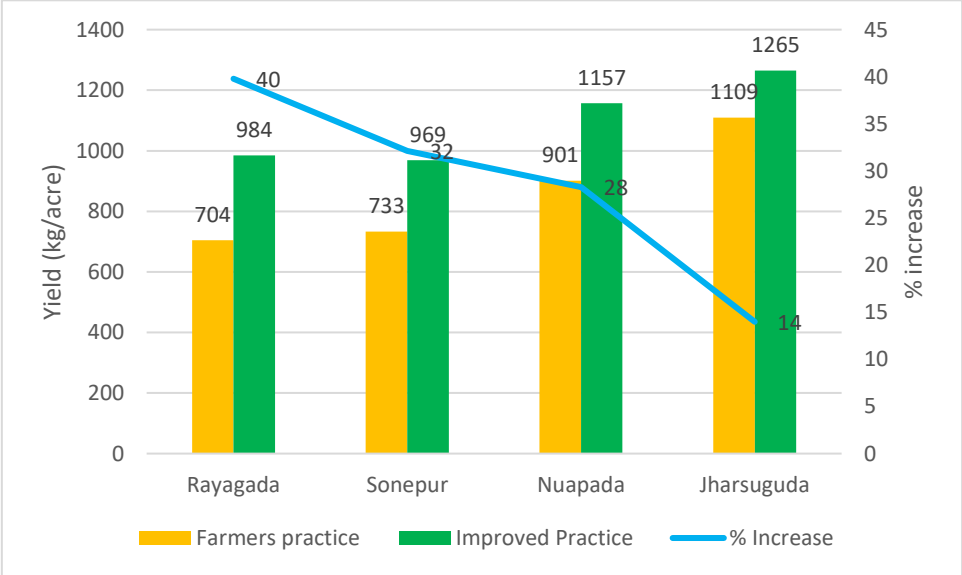

Figure 21: Performance of paddy variety Sahabhagi Dhan in kharif, 2019

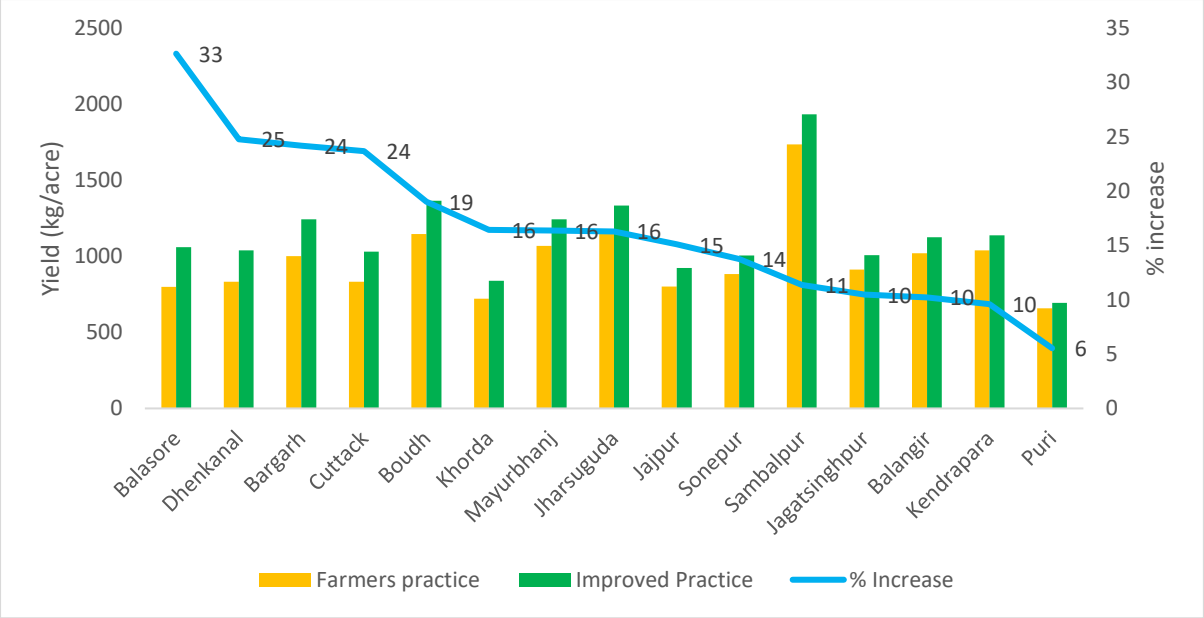

Figure 22: Performance of paddy variety Swarna Sub-1 in kharif, 2019 demonstrations

4.3 Responses of crops to soil test based nutrient mangement

Plant nutrients play a crucial in growth and yield of crops. When these nutrients are applied in appropriate quantities, the same are being absorbed by the crops from soil and resulting in higher yields. Indiscreminate use of fertilizers nutrients in the recent past lead to building of toxic levels on one hand and deficiencies of certain nutrients elements on the other side. ICRISAT colleceted and analyzed about 40000 soil samples across various districts and noticed there there is wide spread occurance of soil acidity and deficiencies of Zn and B in many districts in the state of Odisha. Hence, Soil Test Based Recommendation (STBR) strategy is being developed as a strategy to overcome the nutrient deficiencies and also to curtail excess usasge and reduce the cost of cultivation. Efforts were made to demonstrate the efficacy of STBR by conducting several crop based demonstrations across various districts during *kharif*, 2019.

There was a varied respose of fingermillet to nutrient management practices during *kharif*, 2019. Application of boron along with NPK at recommened doses gave higher yield response (52%) compared to application of NPK alone without boron and or application NPK with zinc + boron (Figure 23). In case of groundnut, soil test based application of nutrient application i.e. NPK along with zinc and boron and improved cultivar gave higher yields compared to application of NPK with zinc and boron or application of NPK with boron alone (Figure 24). Application of soil test based NPK along with zinc and boron in maize gave higher yield reponses i.e. 68% compared to improved cultivar along with NPK and boron (Figure 25). There is a varied responses of paddy to nutrient management practices. Higher yield response was observed by application of soil test based application of NPK along with boron with or without improved cultivar (20% and 19%) compared to application of NPK along with zinc + boron with or without improved cultivar (Figure 26). Similarly paddy also responded well to application of humic acid. Application of soil test based NPK along with zinc and boron with improved cultivar gave higher yield by 23% compared to application of NPK with zinc or boron and improved variety with humic acid (Figure 27).

Figure 23: Performance of fingermillet to nutrient management practices in kharif, 2019

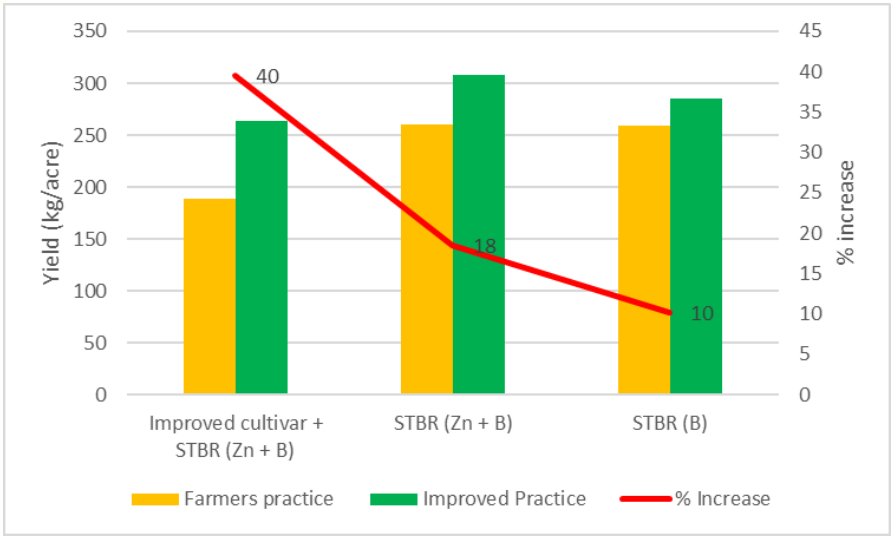

Figure 24: Performance of groundnut under various nutrient management practices in kharif, 2019

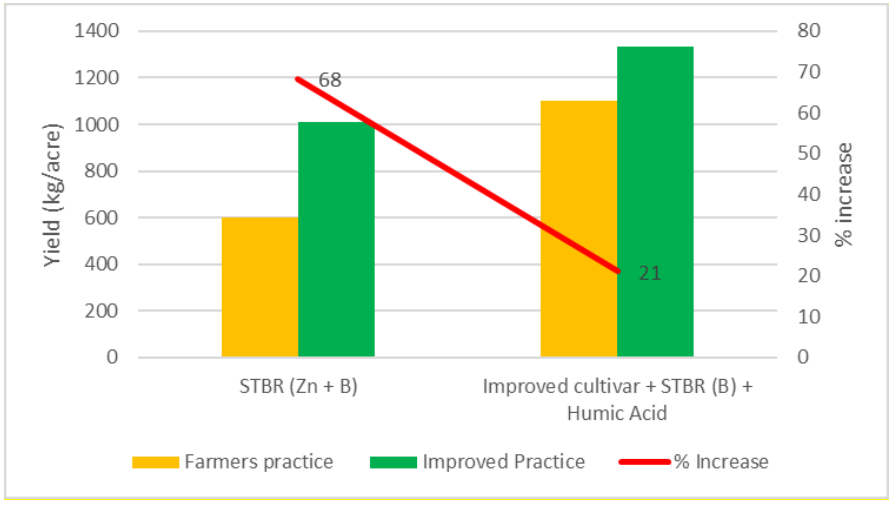

Figure 25: Repsonse of maize to nutrient management in kharif, 2019

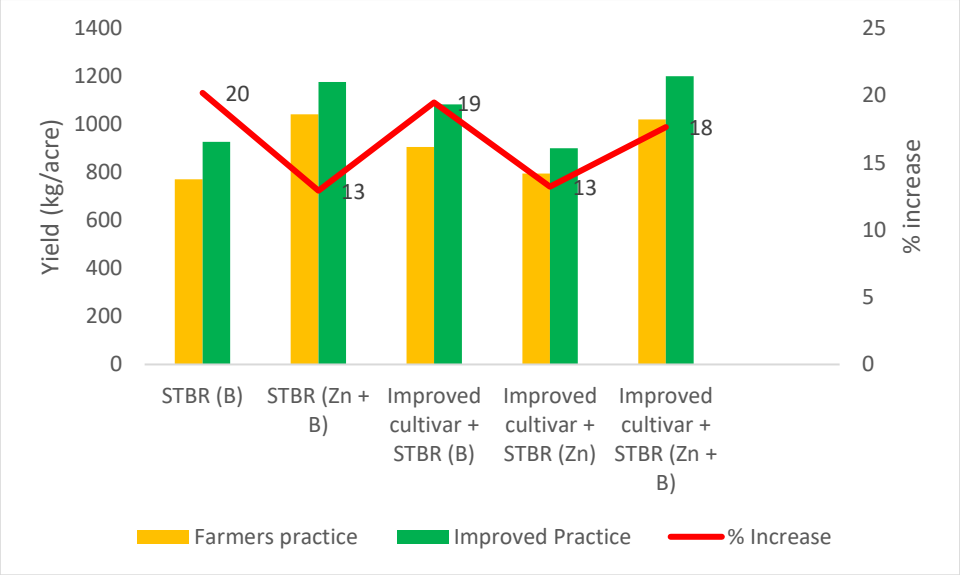

Figure 26: Response of paddy improved nutrient management practices in kharif, 2019

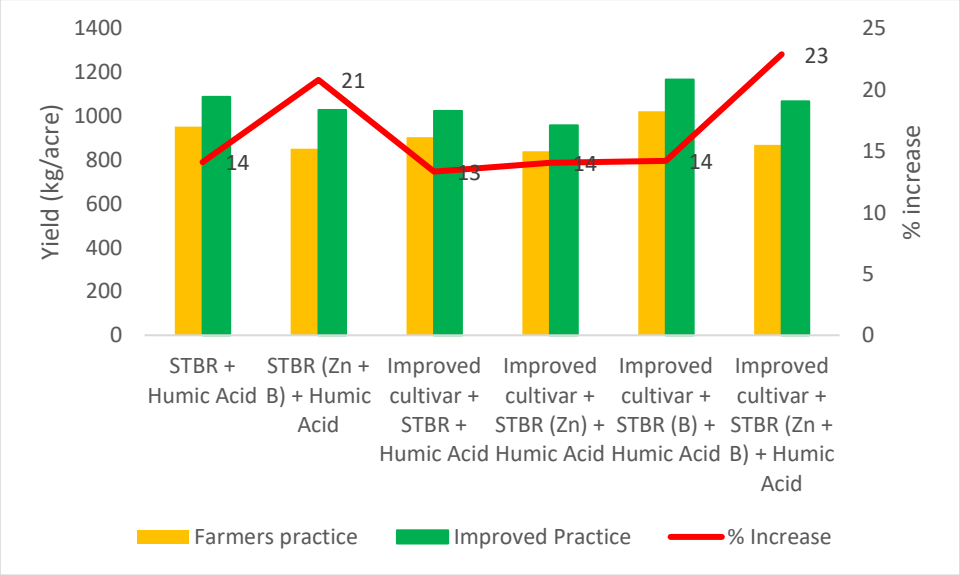

Figure 27: Response of paddy to humic acid application in kharif, 2019

5. Odisha – Rainfall report for the year 2019-20

Odisha State has two broad regions; the plateau region and the coastal region. There are thirty districts and 314 blocks in Odisha. Based on rainfall, soil and crops, there are ten agroclimatic zones in Odisha. The zones are 1) North Western Plateau, 2) North Central Plateau, 3) North Eastern Coastal Plain, 4) East & South Eastern Coastal Plain, 5) North Eastern Ghat, 6) Eastern Ghat High Land, 7) South Eastern Ghat, 8) Western Undulating Zone, 9) Western Central Table Land and 10) Mid Central Table Land.

As per the classification of Agro-Ecological Sub Regions by the ICAR, Odisha has three major Ecological Sub-Regions. The coastal region is under hot dry sub humid Ecological Sub-Region

(ESR) with deep, loamy to clayey coastal and deltaic alluvium derived soils, medium Available Water Capacity (AWC) of about 100-150 mm and with a LGP of 180-210 days. Large parts of midlands are under hot moist sub humid ESR with deep loamy Red and Lateritic soils, low to medium AWC of about 50 to 150 mm and with a LGP of 180-210 days. Very little area bordering Madhya Pradesh is under hot moist / dry subhumid transitional ESR with deep loamy to clayey Red and Yellow soils, medium AWC of about 100-150 mm and with a LGP of 150-180 days.

In this report, district-wise monthly rainfall for the period April 2019 to March 2020 was collected from the Government of Odisha and seasonal totals were computed for analysis. Seasons were classified as Apr-May considered as pre-monsoon, Jun-Sep as Southwest Monsoon (SWM), Oct-Dec as Post-Monsoon (POM) and Jan-Mar as Rabi 2020.

5.1 Rainfall situation during April-May 2019

April to May is pre-monsoon season and is very hot; in general maximum temperatures vary from 38 to 40 °C and in certain areas and days, the maximum temperature could be as high as 45 °C. Rains are mostly thunderstorm based and accompanied by strong winds, lightening and thunderbolts. In Odisha, lightening is also common throughout SWM and POM season. In Apr-May 2019, Odisha received a total rainfall of about 123 mm compared to the normal of about 102 mm. Mayurbhanj district received high rainfall of about 98 mm in April and Khordha district received high rainfall of about 186 mm in May 2019. Nuapada district received only 30 mm while Mayurbhanj received about 274 mm during Apr-May 2019.

5.2 Southwest Monsoon 2019

Southwest Monsoon has set in over Kerala on 08 June, 2019 against the normal date of 01 June. It further advanced into parts of Odisha by 20 June and covered the whole of Odisha state by 22 June. During the period from 01 June to 30 September 2019, Odisha State as a whole received about 1257 mm of rainfall as against the normal rainfall of 1150 mm; the percentage departure from normal was +9 per cent and was classified under normal category. Monthly district-wise rainfall received during the SW Monsoon season in 2019 is shown in Table 3. Spatial distribution of SW Monsoon rainfall received over Odisha in 2019 and its departure from long-period normal is presented in Figure 28a,b.

Table 3. Southwest monsoon rainfall in 2019

Sl. No.	District	Rainfall in mm				
		Jun	Jul	Aug	Sep	SW Monsoon
1	Gajapati	60	234	323	329	946
2	Angul	151	227	309	271	958
3	Bhadrak	151	179	374	319	1023
4	Rayagada	73	305	427	237	1042
5	Baleswar	143	224	332	347	1046
6	Nuapada	124	291	356	278	1049
7	Kendujhar	143	232	327	354	1056
8	Ganjam	112	225	302	427	1066
9	Dhenkanal	199	214	345	315	1073
10	Mayurbhanj	176	217	407	274	1074
11	Deogarh	177	246	347	307	1077
12	Kendrapara	128	237	388	344	1097

Table 3. Southwest monsoon rainfall in 2019						
Sl. No.	District	Rainfall in mm				
		Jun	Jul	Aug	Sep	SW Monsoon
13	Sundargarh	120	222	448	313	1103
14	Jajpur	254	184	447	307	1192
15	Nayagarh	108	273	368	446	1195
16	Jagatsinghpur	141	297	305	458	1201
17	Khordha	140	370	317	427	1254
18	Cuttack	165	353	389	399	1306
19	Boudh	165	294	520	338	1317
20	Sambalpur	140	312	493	377	1322
21	Puri	151	375	288	533	1347
22	Kandhamal	106	285	614	361	1366
23	Bargarh	136	413	449	429	1427
24	Balangir	123	287	693	343	1446
25	Nabarangpur	217	495	443	310	1465
26	Subarnapur	168	345	553	475	1541
27	Kalahandi	157	454	657	279	1547
28	Jharsuguda	172	316	723	372	1583
29	Koraput	198	544	591	381	1714
30	Malkangiri	151	634	763	340	1888

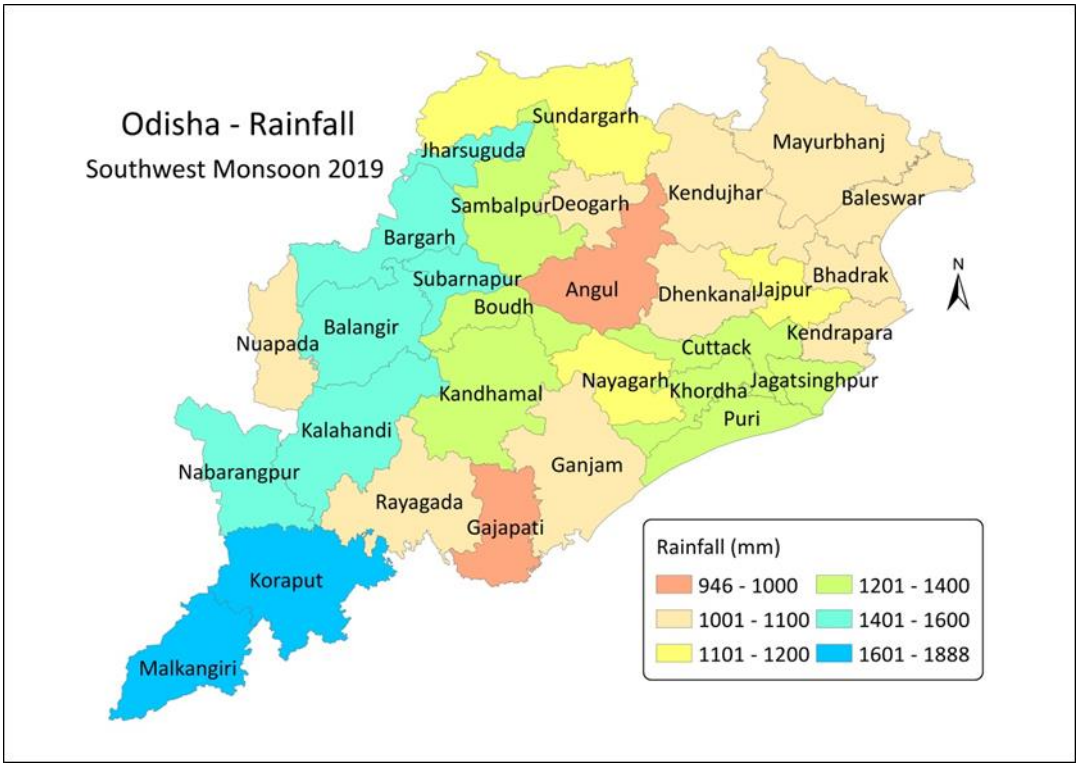

Figure 28a: Southwest Monsoon Rainfall in Odisha in the year 2019

In the SW Monsoon season 2019, Gajapati and Angul districts received lowest rainfall of about 946 and 958 mm with a departure from normal of about -5 and -15 per cent. In fact, Gajapati district received just 60 mm which was lowest among all the thirty districts and four months in the SW Monsoon season. This lower rainfall in the beginning of the season impacts the timely sowing of rainfed crops. Seasonal rainfall distribution map shows that Angul and Gajapati districts received low rainfall while, Koraput and Malkangiri received a rainfall of

more than 1600 mm in the SW Monsoon 2019. Koraput received 1715 mm and Malkangiri received 1888 mm. Except for Nuapada and Sundargarh districts, all western districts bordering Madhya Pradesh received a rainfall between 1400 and 1600 mm. In general, northern districts like Mayurbhanj, Kendujhar and Baleswar received relatively low rainfall of 1000-1100 mm in the SW Monsoon season.

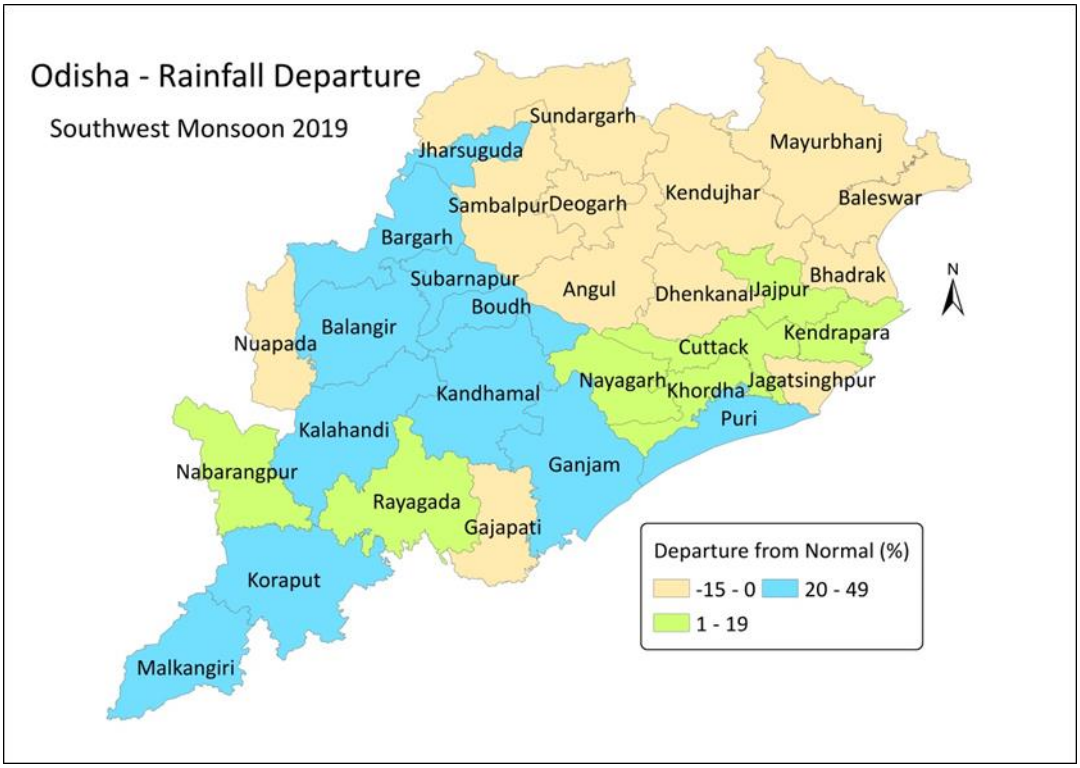

Figure 28b: Southwest Monsoon Rainfall in Odisha in the year 2019

In July 2019, Bhadrak received a rainfall of about 179 mm, which was the lowest among the districts. Puri district received 288 mm in July and Rayagada received 237 mm in August; both were the lowest values among the districts. When high rainfall situation is considered, Jajpur district received about 254 mm in June; which is more than three times the rainfall (60 mm) of Gajapati in the same month. Similarly, Malkangiri received very high rainfall of 634 mm and 768 mm in July and August months, compared to the 288 mm (Puri) and 237 mm (Rayagada) in respective months. Puri district received high rainfall of 533 mm in September 2019. Difference between minimum and maximum rainfall was sometimes two to three times across districts and months. This shows that monthly rainfall over Odisha in the SW Monsoon season 2019 varied greatly across districts.

Spatial distribution of rainfall departures shows that all the northern districts and Nuapada, Gajapati and Jagatsinghpur, show negative values. Remaining 18 districts have normal to excess rainfall conditions during SW Monsoon. In general, rainfall departures appear to change from negative to positive as one move from north to south in Odisha during SW Monsoon 2019. Angul has the lowest negative departure of -15 per cent and by coincidence; its neighbouring district Boudh has highest positive departure of +49 per cent.

5.3 Post-Monsoon 2019

Southwest monsoon withdrawal commenced from west Rajasthan on 09 October and withdrew from Odisha by 15 October and from the entire country by 16 October 2019. During the post-monsoon period, Odisha state as a whole recorded 202 mm of rainfall against the normal rainfall of 149 mm with percentage departure from normal being +36% and classified under excess category. Monthly district-wise rainfall received during the Post-Monsoon season 2019 is shown in Table 4 and district-wise spatial distribution of Post-Monsoon rainfall and its departure from long-period normal is presented in Figure 29a,b.

Table 4. Post-Monsoon rainfall in 2019

Sl. No.	District	Rainfall in mm			
		Oct	Nov	Dec	Post-Monsoon
1	Balangir	44	1	1	46
2	Subarnapur	53	0	4	57
3	Bargarh	64	0	2	66
4	Nuapada	62	7	0	69
5	Boudh	94	0	0	94
6	Nabarangpur	83	12	0	95
7	Kalahandi	92	5	0	97
8	Sambalpur	117	0	2	119
9	Jharsuguda	123	0	0	123
10	Deogarh	139	0	3	142
11	Angul	139	0	4	143
12	Kandhamal	144	9	2	155
13	Sundargarh	157	0	5	162
14	Dhenkanal	160	0	3	163
15	Kendujhar	162	1	4	167
16	Malkangiri	171	3	0	174
17	Mayurbhanj	181	17	8	206
18	Rayagada	221	3	0	224
19	Nayagarh	255	0	0	255
20	Jajpur	237	31	2	270
21	Koraput	248	25	1	274
22	Baleswar	224	73	2	299
23	Ganjam	300	8	0	308
24	Cuttack	302	10	0	312
25	Bhadrak	237	78	1	316
26	Jagatsinghpur	260	60	0	320
27	Khordha	328	2	0	330
28	Gajapati	326	12	8	346
29	Kendrapara	250	101	0	351
30	Puri	350	12	1	363

In the Post-Monsoon season 2019, Balangir district received lowest rainfall of about 46 mm with a departure from normal of about -44 per cent and is classified as under deficit category. Much of the Post-Monsoon rainfall was received in October only; only Kendrapara received 101 mm in November. Subarnapur, Nuapada, Bargarh, Nabarangapur, Kalahandi and Boudh districts received less than 100 mm in November 2019. Ganjam, Cuttack, Gajapati, Khordha and Puri districts received rainfall between 300 and 350 mm.

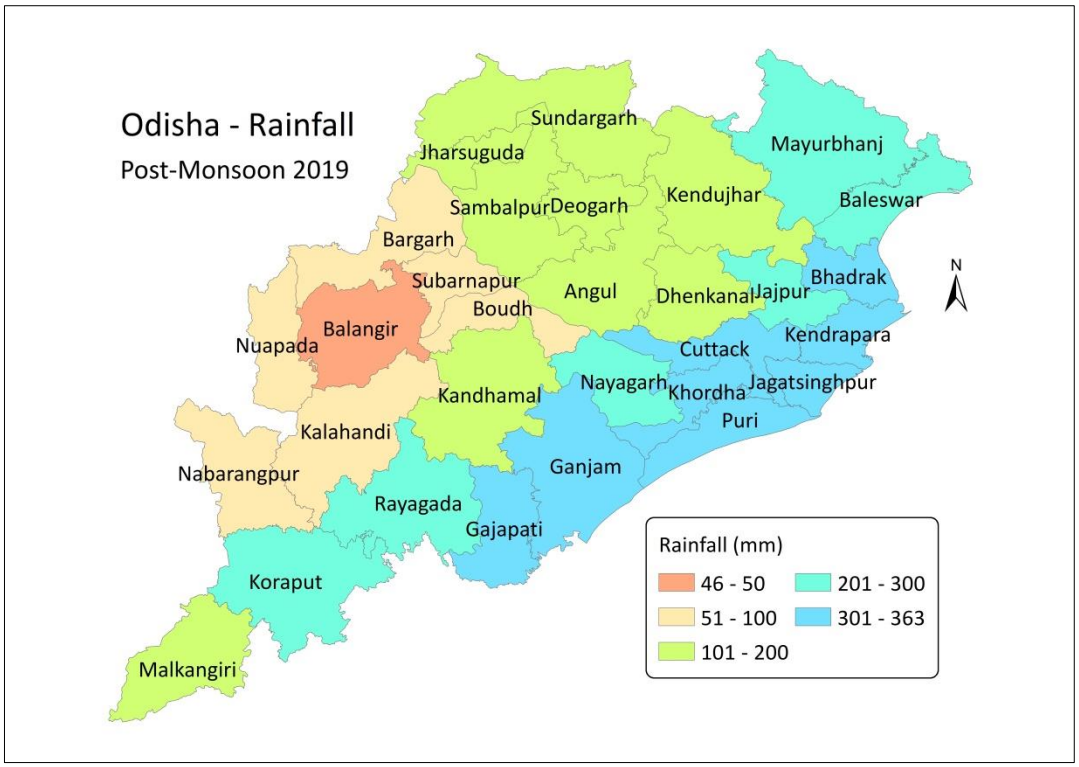

Figure 29a: Post-Monsoon Rainfall in Odisha in the year 2019

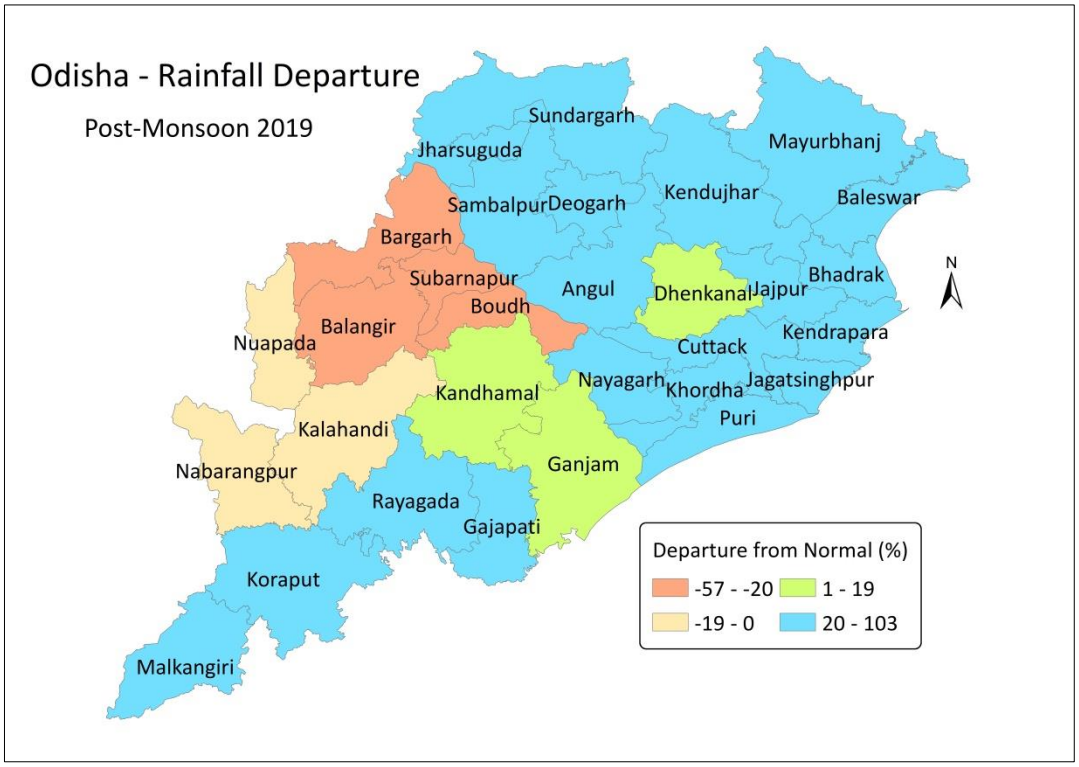

Figure 29b: Post-Monsoon Rainfall in Odisha in the year 2019

Boudh, Jharsuguda and Nayagarh districts received zero rainfall in November and December 2019. In December, thirteen districts received no rainfall at all and the other seventeen received a meagre rainfall between 1 to 8 mm. When total Post-Monsoon season is

considered, Balangir received 46 mm and Puri district received 363 mm. Thus the difference between minimum and maximum Post-Monsoon rainfall was almost eight times across these two districts. This shows large spatial rainfall variability in Post-Monsoon season compared to SW Monsoon season in the year 2019. Post-Monsoon rainfall appears to decrease from coastal region towards interior Odisha i.e., from southeast to northwest.

If the departure of actual rainfall from normal is more than or equal to 20%, then rainfall is classified as “Excess”; if it is between –19% and +19% it is classified as “Normal”; if it is between –20% and –59% it is classified as “Deficit”; and if it is between –60% and –99% then it is classified as “Scanty”.

Spatial distribution of rainfall departures (Figure 2) shows that in the Post-Monsoon season, twenty districts have received excess rainfall and six districts received normal rainfall. Dhenkanal, Ganjam and Kandhamal districts recorded slightly higher rainfall compared to Kalahandi, Nabarangpur and Nuapada district, though all the six districts are in normal rainfall category. Balangir, Bargarh, Boudh and Subarnapur districts received rainfall in the deficit category. In general, rainfall departures appear to change from positive to negative as one move from east to west except in the northern Odisha during Post-Monsoon 2019. Boudh has the lowest negative departure of -57 per cent and Sundargarh has highest positive departure of +103 per cent.

5.4 Week-wise rainfall variation

Though rainfall appears to be normal when the total season is considered, however when weekly rainfall distribution is observed, there will be periods with excess and deficit rainfall conditions. High rainfall received in a week is likely to support water requirements of crops in the next one or two weeks. Weekly cumulative actual and normal rainfall distribution and weekly rainfall departures from normal for the entire rainy season 2019 were analysed for three situations i.e., Excess, Normal and Deficit. Results for three representative districts viz., Koraput, Kalahandi and Kendujhar are shown in Figures 30a,b; 31a,b and 32a,b.

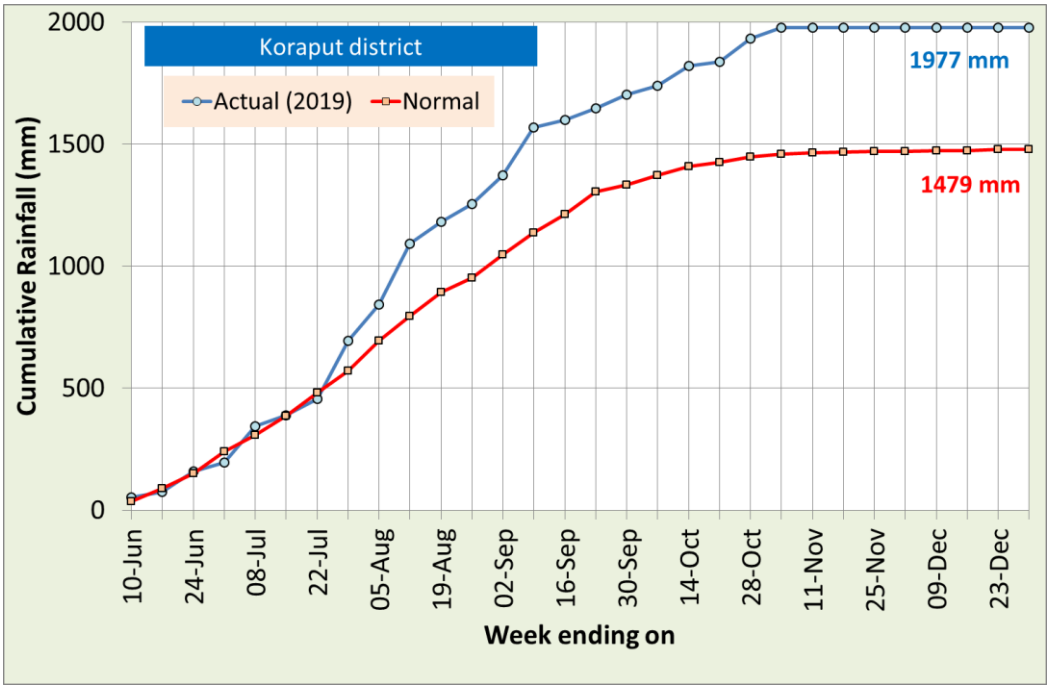

Figure 30a: Cumultive rainfall and rainfall departures in Koraput in rainy season 2019

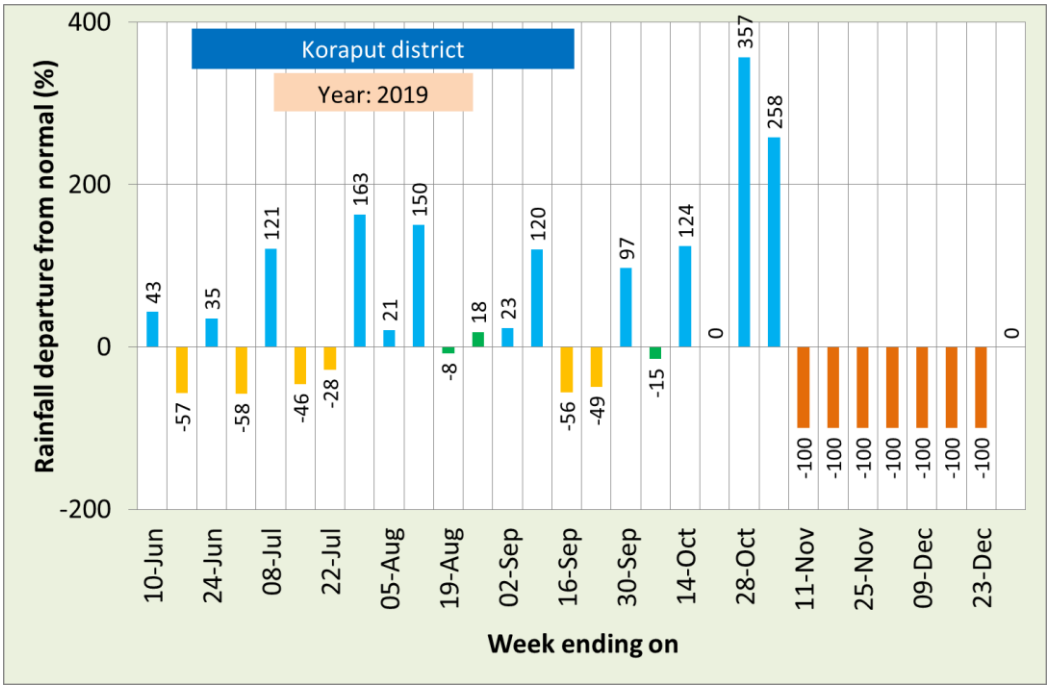

Figure 30b: Cumultive rainfall and rainfall departures in Koraput in rainy season 2019

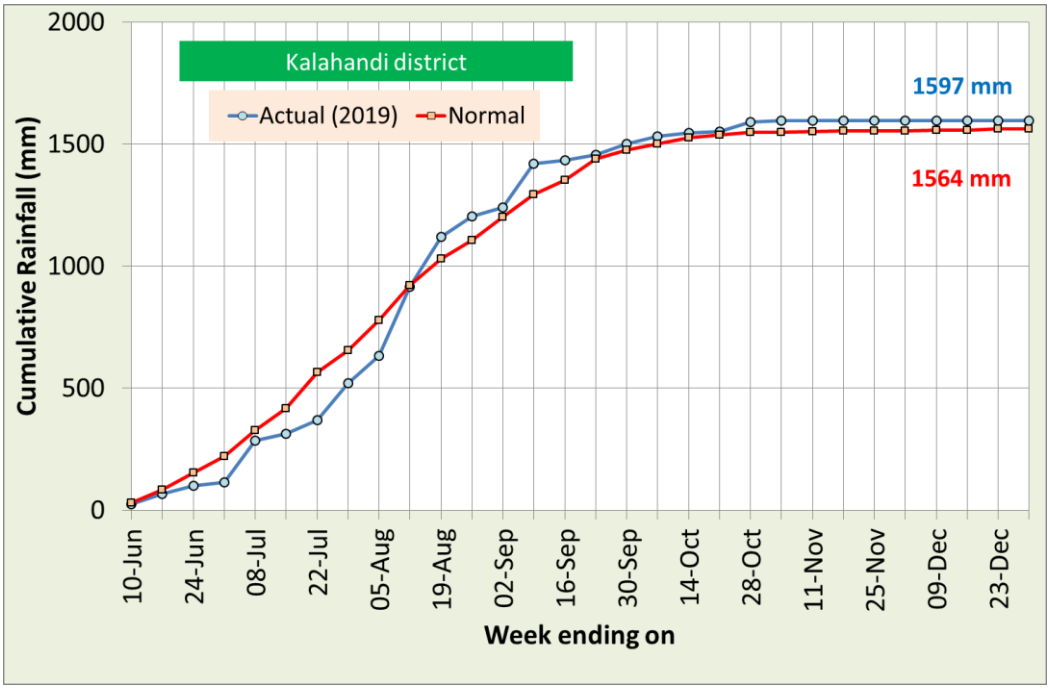

Figure 31a: Cumultive rainfall and rainfall departures in Kalahandi in rainy season 2019

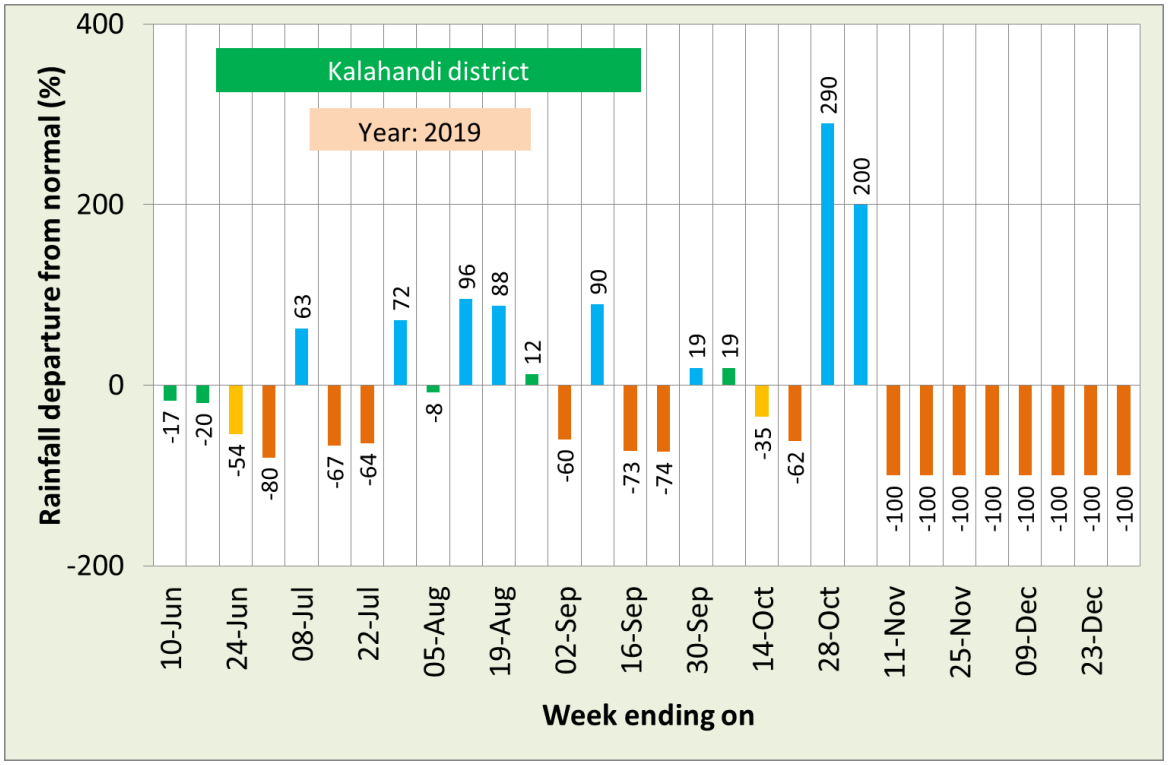

Figure 31b: Cumultive rainfall and rainfall departures in Kalahandi in rainy season 2019

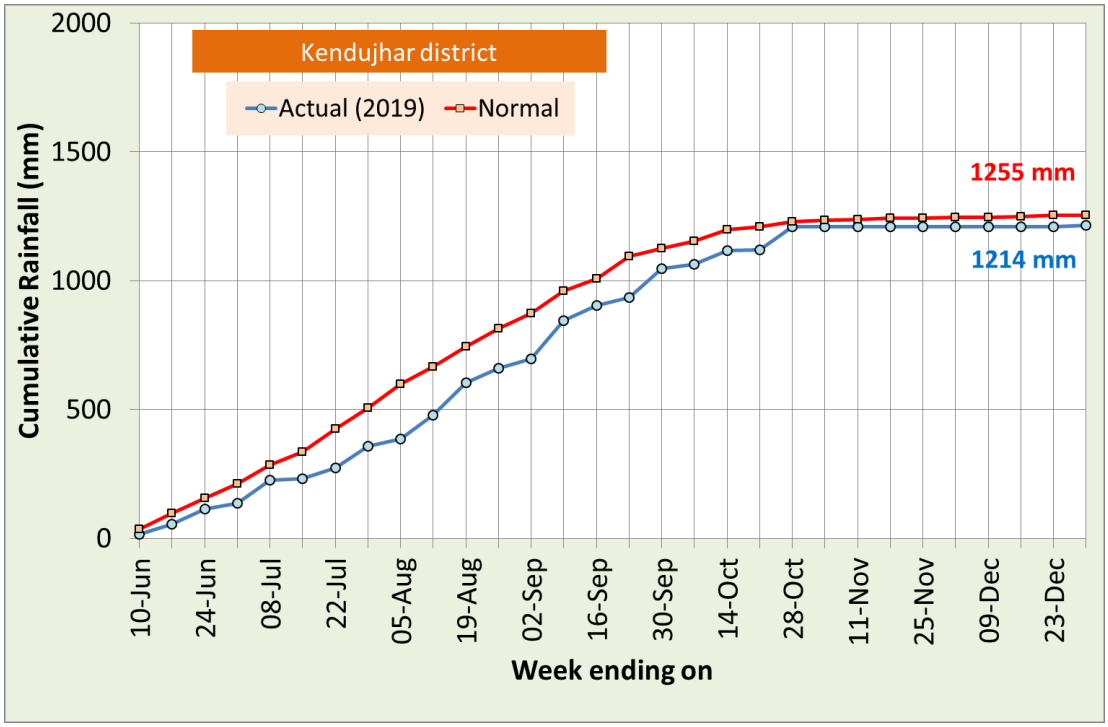

Figure 32a: Cumultive rainfall and rainfall departures in Kendujhar in rainy season 2019

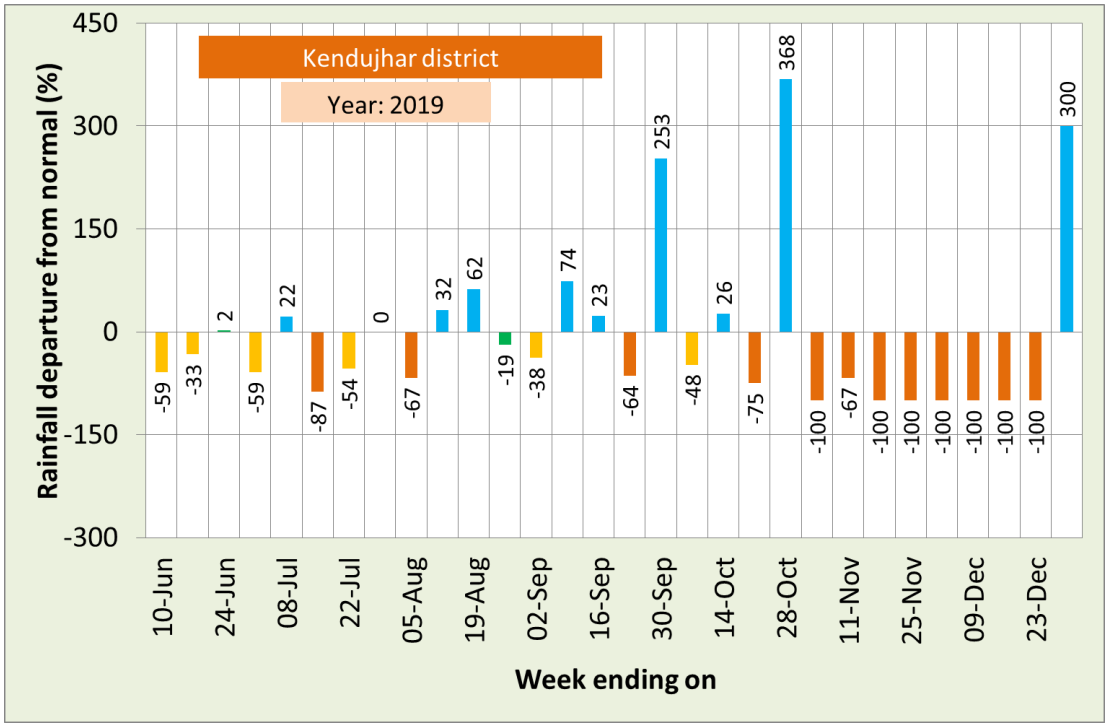

Figure 32b: Cumultive rainfall and rainfall departures in Kendujhar in rainy season 2019

5.4.1. Koraput district

During the total rainy season from June to December, Koraput district received a total rainfall of about 1977 mm of rainfall against a normal of 1479 mm (Figure 3); total rainfall departure being +34% and is classified as excess. Up to 22 July, actual rainfall followed the normal in

general, but afterwards actual cumulative rainfall was always higher than normal till the end of December 2019. Difference between cumulative actual rainfall and cumulative normal rainfall has increased continuously up to 517 mm recorded on 04 November 2019.

Though the rainfall appears to be excess when the total season is considered, however when weekly rainfall distribution was observed, there were two fortnights experienced deficit rainfall conditions. The first fortnight was from 09 to 22 July and the second deficit rainfall fortnight was during 10 to 23 September 2019. There were also two dry weeks in the SW Monsoon season, with week ending on 17 June and 01 July 2019. Normal to excess rainfall conditions were present continuously for 49 days during 23 July to 09 September and from 24 September to 04 November (42 days). There were also seven weeks distributed randomly in the season with normal to excess rainfall conditions. Thus, a total of 119 days with normal or excess rainfall conditions were observed in the year 2019 in Koraput. Rainfall was very high continuously for three weeks starting from 23 July to 12 August with a total rainfall of about 637 mm; rainfall for individual week was 237 mm, 150 mm and 250 mm.

No rainfall was received from 05 November onwards till the end of December 2019, leading to scanty rainfall conditions. Considerably long periods of excess rainfall separated by a few dry spells during June to first week of November are characteristics of rainfall in Koraput in the year 2019.

5.4.2. Kalahandi district

Kalahandi district received a total rainfall of about 1597 mm of rainfall against a normal of 1564 mm in the rainy season 2019; total rainfall departure being +2% and is classified as normal. As shown in the Figure 4, up to 12 August, actual rainfall was slightly lower than the normal, later actual cumulative rainfall was always higher than normal till the end of December 2019. Difference between cumulative actual rainfall and cumulative normal rainfall was lowest at -198 mm at the week ending on 22 July and it was highest at +126 mm at the week ending 09 September 2019. Due to good rainfall received in October, the difference continued to be positive till the end of December 2019 and stood at +33 mm.

Though the rainfall in Kalahandi was normal when the total season is considered, however when weekly rainfall distribution was observed, four fortnights experienced rainfall ranging from deficit to scanty conditions. The first fortnight with both deficit and scanty rainfall conditions was from 18 June to 01 July 2019 and the second fortnight with scanty rainfall conditions was from 09 to 22 July. The third fortnight with scanty rainfall conditions was from 10 to 23 September; and the fourth fortnight having both deficit and scanty rainfall conditions was during 08-21 October 2019. There was also one week with scanty rainfall in Kalahandi in the SW Monsoon season, with week ending on 02 September.

Normal to excess rainfall conditions were present continuously for 35 days during 23 July to 26 August; normal rainfall conditions for 14 days during 24 September to 07 October. Due to high rainfall, excess category of rainfall was observed for 14 days from 22 October to 04 November 2019. There were also four weeks distributed randomly in the season with normal to excess rainfall conditions. Thus, there were 91 days having normal or excess rainfall conditions in Kalahandi in 2019. Rainfall was very high continuously for two weeks starting

from 06-19 August with a total rainfall of about 487 mm; rainfall for individual week was 282 mm and 205 mm. During 22-28 October, Kalahandi district received a total rainfall of 39 mm while the normal was only 10 mm which resulted in highest departure of 290 per cent. Similarly the next week from 29 October to 04 November received just 6 mm and the normal was only 2 mm which resulted in a high departure of 200 per cent. Hence, rainfall departures have to be interpreted with reference to the normal rainfall for arriving at correct interpretation of results. No rainfall was received from 05 November onwards till the end of December 2019, thus leading to scanty rainfall conditions. Periods of normal to excess rainfall separated by dry spells with deficit and scanty rainfall conditions during June to first week of November are characteristics of rainfall in Kalahandi in the year 2019.

5.4.3. Kendujhar district

Kendujhar district received a total rainfall of about 1214 mm of rainfall against a normal of 1255 mm in the rainy season 2019 (Figure 5); total rainfall departure being -3% and is classified as normal. Actual cumulative rainfall was always lower than normal till the end of December 2019. Difference between cumulative actual and cumulative normal rainfall was lowest at -211 mm at the week ending on 05 August and -20 mm at the week ending 28 October. Due to good rainfall received in the last week of October, difference became smaller and continued till the end of December 2019 and stood at -3 mm. Large difference between actual and normal cumulative rainfall was observed between third week of July to first week of September, which coincides with vegetative growth phase for major crops.

Though normal rainfall was received in Kendujhar when the total season from June to December is considered, however when weekly rainfall distribution was observed, the rainfall situation was not very good till first week of August 2019. Starting from June to 05 August, rainfall departures were in deficit or scanty categories except for two weeks with normal rainfall and one week with slightly excess rainfall. Period from middle of August to middle of September was slightly better with rainfall varying from normal to excess categories. There were three high rainfall weeks in the season; the first was about 126 mm during 13-19 August, the second was about 148 mm during 03-09 September and the third was about 113 mm from 24-30 September 2019. During 22-28 October, Kendujhar district received a total rainfall of 89 mm while the normal was only 19 mm which resulted in highest departure of 368 per cent. Similar is the case of last week of December 2019 when the actual rainfall was only four mm and the normal was one mm, thus the departure was 300 per cent. Kendujhar district has 63 days under excess rainfall conditions, 21 days under normal, 42 days under deficit and 84 days under scanty rainfall conditions.

Table 5. Days with various rainfall categories across selected districts in 2019

District	Rainfall category			
	Excess	Normal	Deficit	Scanty
Koraput	84	35	42	49
Kalahandi	49	42	14	105
Kendujhar	63	21	42	84

It is seen from the Table 5 that days under normal category have decreased in Kendujhar compared Koraput, while in Kalahandi they have increased. Days under deficit category also are very low for Kalahandi compared to Koraput and Kendujhar indicating that Kalahandi enjoyed mostly normal rainfall conditions during June to December 2019. Koraput had total excess rainfall of 498 mm, Kalahandi had just 34 mm and Kendujhar had -41 mm. As mentioned earlier, rainfall departures need to be interpreted with reference to normals.

5.5 Rabi 2020

Rabi season crop plantings in Odisha generally start by middle of December and continue till January. Thus, January to March / April is considered as Rabi in Odisha. During the period from 01 January to 31 March 2020, Odisha State as a whole received about 121 mm of rainfall as against the normal rainfall of 57 mm; the percentage departure from normal was +112 per cent and was classified under excess category. Monthly district-wise rainfall received during the Rabi 2020 is shown in Table 6. Spatial distribution of Rabi rainfall received over Odisha in 2020 and its departure from long-period normal is presented in Figure 33a,b.

Table 6. Rainfall during Rabi 2020

Sl. No.	District	Rainfall in mm			
		Jan	Feb	Mar	Rabi
1	Malkangiri	2	0	11	13
2	Puri	8	22	26	56
3	Nabarangpur	8	9	41	58
4	Jagatsinghpur	7	28	35	70
5	Koraput	9	18	47	74
6	Khordha	12	50	28	90
7	Rayagada	10	23	58	91
8	Kalahandi	9	22	61	92
9	Balangir	11	51	40	102
10	Jajpur	17	36	52	105
11	Baleswar	42	16	52	110
12	Ganjam	4	47	60	111
13	Kendrapara	11	16	85	112
14	Bhadrak	38	23	55	116
15	Mayurbhanj	40	19	59	118
16	Nayagarh	16	55	47	118
17	Gajapati	6	49	70	125
18	Dhenkanal	18	50	63	131
19	Nuapada	11	40	84	135
20	Cuttack	8	55	73	136
21	Kendujhar	40	55	49	144
22	Sundargarh	20	35	97	152
23	Boudh	18	84	57	159
24	Jharsuguda	16	41	104	161
25	Sambalpur	16	83	65	164
26	Bargarh	9	101	57	167
27	Kandhamal	8	61	98	167
28	Angul	25	76	74	175
29	Deogarh	33	94	48	175
30	Subarnapur	24	126	44	194

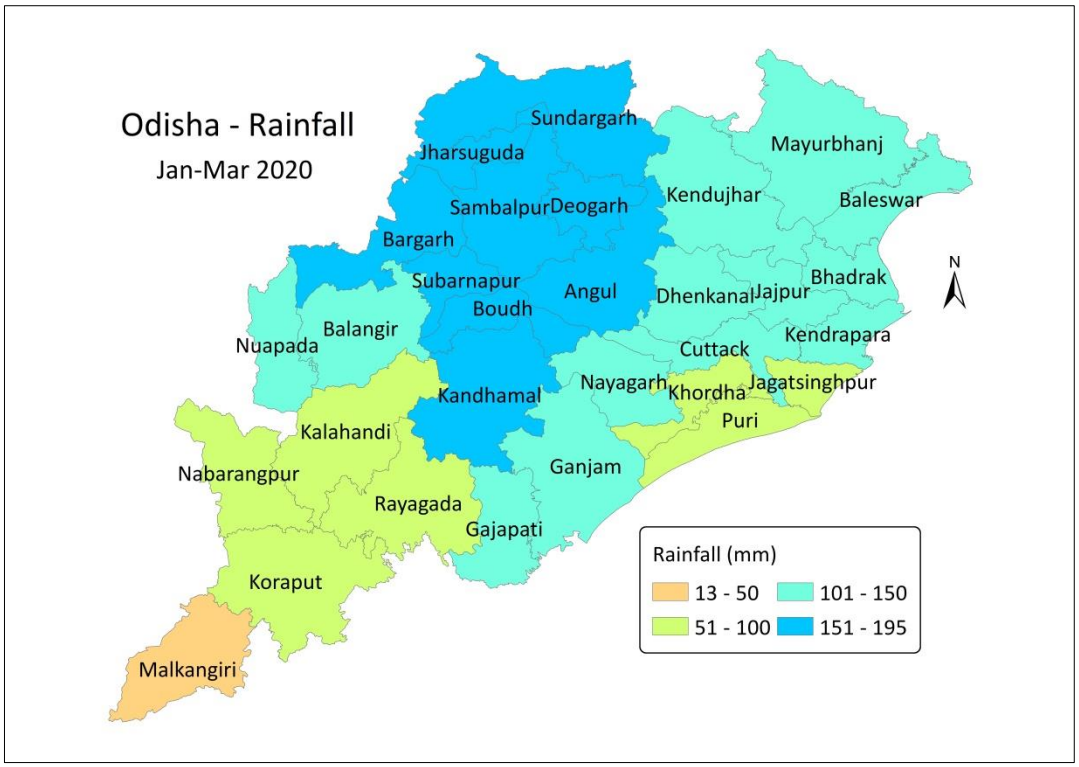

Figure 33a: Rabi Rainfall in Odisha in the year 2020

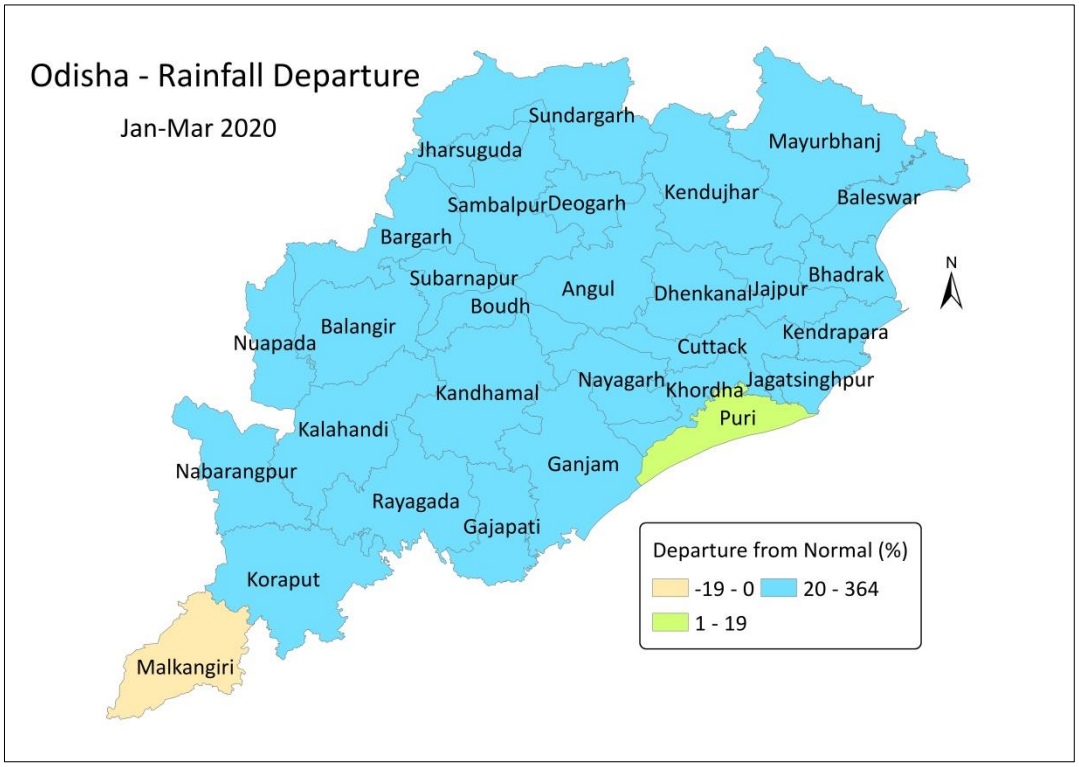

Figure 33b: Rabi Rainfall in Odisha in the year 2020

In the Rabi 2020, Malkangiri district received lowest rainfall of 13 mm as against the normal rainfall of 16 mm; the percentage departure from normal was -16 per cent and was classified

under normal category. Puri district received rainfall of 56 mm as against the normal rainfall of 49 mm; the percentage departure from normal was +15 per cent and was classified under normal category. Subarnapur district received highest rainfall of 194 mm as against the normal rainfall of 42 mm; the percentage departure from normal was +362 per cent and was classified under excess category.

As the Rabi season progressed, Odisha rainfall has shown a continuous increase from 17 mm in January, 46 mm in February and 58 mm in March 2020. Baleswar district received high rainfall of 42 mm in January, Subarnapur received 126 mm in February and highest rainfall of 104 mm was received by Jharsuguda in Rabi 2020. Malkangiri is the only district that received zero rainfall in February in Rabi 2020. It may be noted that Malkangiri received highest SW Monsoon 2019 rainfall of about 1888 mm, received about 174 mm against a normal 138 mm in Post-Monsoon and received lowest Rabi 2020 rainfall of about 13 mm.

Seasonal rainfall distribution map shows that rainfall increased from south to north in the Rabi 2020. Malkangiri, Koraput, Nabarangpur, Kalahandi, Rayagada, Puri, Khordha and Jagatsinghpur districts received rainfall between 13 and 92 mm. Sundargarh, Boudh, Jharsuguda, Sambalpur, Kandhamal, Bargarh, Angul, Deogarh and Subarnapur districts received rainfall ranging from 152 to 195 mm. Remaining thirteen districts a rainfall between 102 and 144 mm.

Spatial variability of Rabi 2020 rainfall across districts in Odisha is much lower compared to the variability in SW Monsoon 2019 and Post-Monsoon 2019. Spatial distribution of rainfall departures shows that except Malkangiri and Puri districts, all districts show excess rainfall conditions. Nuapada, Bargarh and Subarnapur districts have very high rainfall departure values of 219, 223 and 364 per cent.

5.6 Summary

Rainfall analysis of Odisha was attempted based on district-wise monthly rainfall data for the period April 2019 to March 2020, collected from the Government of Odisha. In the pre-monsoon season (Apr-May 2019), Odisha received a total rainfall of about 123 mm compared to the normal of about 102 mm. Nuapada district received only 30 mm while Mayurbhanj received about 274 mm during Apr-May 2019.

Southwest Monsoon advanced into parts of Odisha by 20 June and covered the whole of Odisha state by 22 June. During the period from 01 June to 30 September 2019, Odisha State as a whole received about 1257 mm of rainfall as against the normal rainfall of 1150 mm; the percentage departure from normal was +9 per cent and was classified under normal category. Gajapati and Angul districts received lowest rainfall of about 946 and 958 mm with a departure from normal of about -5 and -15 per cent while, Koraput received 1715 mm and Malkangiri received 1888 mm. Difference between minimum and maximum rainfall was sometimes two to three times across districts and months, which shows that monthly rainfall over Odisha in the SW Monsoon season 2019 varied greatly across districts. In general, rainfall departures appear to change from negative to positive as one move from north to south in Odisha during SW Monsoon 2019. Angul has the lowest negative departure of -15 per cent

and by coincidence; its neighbouring district Boudh has highest positive departure of +49 per cent.

In the post-monsoon period, Odisha state as a whole recorded 202 mm of rainfall against the normal rainfall of 149 mm with percentage departure from normal being +36% and classified under excess category. Much of the Post-Monsoon rainfall was received in October only; only Kendrapara received 101 mm in November. When total Post-Monsoon season is considered, Balangir received 46 mm and Puri district received 363 mm. Thus the difference between minimum and maximum Post-Monsoon rainfall was almost eight times across these two districts. This shows large spatial rainfall variability in Post-Monsoon season compared to SW Monsoon season 2019. Post-Monsoon rainfall appears to decrease from coastal region towards interior Odisha i.e., from southeast to northwest. Thus, rainfall departures appear to change from positive to negative as one move from east to west except in the northern Odisha. Boudh has the lowest negative departure of -57 per cent and Sundargarh has highest positive departure of +103 per cent in the Post-Monsoon 2019.

In addition to seasonal analysis, weekly cumulative actual and normal rainfall distribution and weekly rainfall departures from normal for the entire rainy season 2019 were analysed for three situations i.e., Excess (Koraput district), Normal (Kalahandi) and Deficit (Kendujhar). Weekly rainfall analysis indicated occurrence of wet and dry spells in the rainy season at all the three selected districts.

Koraput district received a total rainfall of about 1977 mm of rainfall against a normal of 1479 mm during Jun-Dec 2019; total rainfall departure being +34% and is classified as excess. A total of 119 days with normal or excess rainfall conditions were observed in the year 2019 in Koraput. No rainfall was received from 05 November onwards till the end of December 2019, leading to scanty rainfall conditions. Considerably long periods of excess rainfall separated by a few dry spells during June to first week of November are characteristics of rainfall in Koraput in the year 2019.

Kalahandi district received a total rainfall of about 1597 mm of rainfall against a normal of 1564 mm in the rainy season 2019; total rainfall departure being +2% and is classified as normal. When weekly rainfall distribution was considered, four fortnights experienced rainfall ranging from deficit to scanty conditions. In Kalahandi district, a total of 91 days with normal or excess rainfall conditions were observed in the year 2019. No rainfall was received from 05 November onwards till the end of December 2019, thus leading to scanty rainfall conditions. Periods of normal to excess rainfall separated by dry spells with deficit and scanty rainfall conditions during June to first week of November are characteristics of rainfall in Kalahandi in the year 2019.

Kendujhar district received a total rainfall of about 1214 mm of rainfall against a normal of 1255 mm in the rainy season 2019 total rainfall departure being -3% and is classified as normal as per classification. However, considering the more number of dry spells and actual cumulative rainfall being lower than the cumulative normal throughout the period Jun-Dec 2019, Kendujhar was considered to represent deficit rainfall conditions. Large difference between actual cumulative and normal cumulative rainfall was observed between third week

of July to first week of September 2019, which coincides with vegetative growth phase for major crops. Period from middle of August to middle of September was slightly better with rainfall varying from normal to excess categories. There were three separate high rainfall weeks in the season with a total rainfall of 387 mm. Kendujhar district has 84 days under excess and normal rainfall conditions, 126 days under deficit and scanty rainfall conditions. In the year 2019, Kendujhar district is characterized by fewer periods of normal to excess rainfall events and relatively more number of dry spells with deficit and scanty rainfall conditions. During Rabi (Jan-Mar 2020), Odisha State as a whole received about 121 mm of rainfall as against the normal rainfall of 57 mm; the percentage departure from normal was +112 per cent and was classified under excess category.

In the Rabi 2020, Malkangiri district received lowest rainfall of 13 mm and Subarnapur district received highest rainfall of 194 mm. As the Rabi season progressed, Odisha average rainfall has shown a continuous increase from 17 mm in January, 46 mm in February and 58 mm in March 2020. Malkangiri received highest SW Monsoon 2019 rainfall of about 1888 mm, received about 174 mm in Post-Monsoon and received lowest Rabi 2020 rainfall of about 13 mm. Rainfall increased from south to north in the Rabi 2020. Except Malkangiri and Puri districts, all districts show excess rainfall conditions. Spatial variability of Rabi 2020 rainfall across districts in Odisha is much lower compared to the variability in SW Monsoon 2019 and Post-Monsoon 2019.

It may be summarized that Odisha state experienced excess rainfall conditions in all three seasons viz., SW Monsoon 2019, Post-Monsoon 2019 and Rabi 2020, though Balangir, Bargarh, Boudh and Subarnapur districts experienced deficit rainfall conditions in Post-Monsoon 2019. Due to heavy rainfall situation, inundation of crop fields was reported in some districts in the rainy season 2019. In general, the rainfall situation (both quantity and distribution) in Rabi 2020 season was favourable to crops. Better water and nutrient management approach is the key and Integrated Watershed Management plays a major role in sustaining crop productivity under excess and deficit rainfall conditions in Odisha.

6. Soil health card distribution

As a part of the project, ICRISAT was committed to analyse about 40000 soil samples across various districts. Accordingly soil samples were collected by using stratefied random sampling method and GPS coordinates were also captured at the time of soil sample collection. Analysis has been carriedout in the CRL laboratory, ICRISAT by using state-of-the-art infrastructure. Soil health have been prepared in the local languge i.e Oria for the use by the farmers. The soil test cards were distributed on the occasion of World's Soil Health Day i.e. 5th December, 2019. On the occasion the CADO's of the respective districts facilitated distribution of soil health by involving various dignitaries viz. Hon'ble Ministers, people's representative's viz. Members of Parliament/Members of Legeslative Assembly etc. The district wise distribution of soil health cards is presented in Table 7. So far 36908 cards were distributed and the rest of cards i.e. 2927 (under printing) would be provided to the farmers in the due course of time.

Table 7. District-wise distribution of soil health cards in Odisha		
S. No.	District	Number of SHC
1	Angul	1020
2	Balangir	1779
3	Balasore	1550
4	Bargarh	1530
5	Bhadrak	870
6	Boudh	370
7	Cuttack	1770
8	Deogarh	390
9	Dhenkanal	1000
10	Gajapathi	538
11	Ganjam	2799
13	Jagatsingpur	1040
12	Jajpur	1160
14	Jharsuguda	430
15	Kalahandi	1120
16	Kandamal	1467
17	Kendrapara	1150
18	Keonjhar	1540
19	Khurda	1280
20	Koraput	1269
21	Malkangiri	509
22	Mayurbhanj	3047
23	Nabarangapur	1213
24	Nayagarh	1040
25	Nuapada	627
26	Puri	1420
27	Rayagada	1010
28	Sambalpur	1090
29	Sonepur	780
30	Sundargarh	2100
	Total	36908

7. Capacity Building of Farmers in Pilot Sites

There is no better way to integrate capacity building with agricultural development other than equipping farmers with the skills to adopt best agricultural practices. As part of the Bhoochetana project, 615 capacity building courses were conducted during April-March 2019-20 in all the 30 districts (Table 8) covering 16115 farmers (11338 men and 4777 women). The courses varied from training in soil fertility assessment, fertilizer and micronutrient application, using of improved tolls and equipment, crop management and management of pests and diseases. Scientists provided handholding support to line department staff.

Table 8. Details of capacity building programmes organized for farmers				
District	No. of programmes	Participants		
		Male	Female	Total
Angul	10	191	37	228
Balangir	10	77	238	315
Balasore	21	485	116	601
Bargarh	28	444	59	503
Bhadrak	43	748	164	912
Boudh	24	512	110	622
Cuttack	31	397	57	454
Deogarh	20	488	322	810
Dhenkanal	26	648	0	648
Gajapathi	11	258	78	336
Ganjam	35	433	360	793
Jagatsinghpur	34	550	25	575
Jajpur	30	620	40	660
Jharsuguda	21	645	360	1005
Kalahandi	22	374	75	449
Kandhamal	10	233	265	498
Kendrapara	21	556		556
Keonjhar	4	85	32	117
Khordha	12	248	104	352
Koraput	22	150	42	192
Malkangiri	14	261	23	284
Mayurbhanj	24	438	216	654
Nabarangpur	23	96	689	785
Nayagarh	17	206	16	222
Nuapada	20	120	368	488
Puri	6	85		85
Rayagada	12	173	190	363
Sambalpur	30	790	273	1063
Sonepur	16	669	347	1016
Sundargarh	18	358	171	529
Total	615	11338	4777	16115

8. Capacity Building of DoA Officials

8.1 Capacity building of Master Trainers

The Capacity Building (CB) program is an integral component of the Odisha B.C project. Collaborative organizations such as DoA, State Agricultural Universities (SAUs), Krishi Vigyan Kendras (KVK), Civil Society organizations will be the other stakeholders in the area of capacity

building. IDC of ICRISAT proposed to the DoA, Government of Odisha (GoO) that at least two officials from each district may be trained as Master Trainers (MT) for scaling up the Capacity Building program as envisaged in the Project Document to the level Assistant Agricultural Officer Officers (AAOs) and Village Level Workers (VLW) in each district in a time bound manner. Accordingly DoA was requested to nominate officials for this Master Trainer program. IDC appreciates the prompt action by DoA, Government of Odisha (GoO) and the first batch comprising of soil science officials participated from 8-10 July at ICRISAT center. The 2nd batch of officials from Odisha participated in the program from 15-17 July, 2019. The following were the objectives of the programme:

- Train officials from the districts of Odisha as MTs in science led scaling up of the Odisha Bhoochetna project and make them aware in the major themes of the project
- Empower the MTs in the principles and methods of training
- Practice designing and delivery of training programs

Figure 34: Pictures of Doa officials trainings at ICRISAT

8.1.1. The program

Since the 1st batch participants were all the officials from soil testing laboratories, the curriculum focused on soil health management and plant nutrient management. The program for the 2nd batch covered the areas of cropping systems management, integrated pest and disease management apart from the main area of soil health and nutrient management. The size, age and gender distribution of the participants is appended as **Annexure 2**.

Apart from training attending the sessions in the conference hall, the participants were taken around the ICRISAT fields where they visited various facilities and units viz. the Heritage Watersheds, Aerobic Composting area, techniques of transplanting pigeon pea and waste water utilization and demonstration unit. The session plan for the 2nd batch is appended.
The program started with an overview of the Bhoochetna Project by Dr. Girish Chander, State Coordinator from IDC. The program was designed to focus on Odisha Bhoochetna rather than general production initiatives as the main component and create an awareness among the participants of the project objectives which should facilitate the scaling up the project which is a challenge to all stakeholders.

The Training Pedagogy session had group exercises where participants were asked to design the program in detail for taking this program to the district level. The groups did a very good job and the inputs given were very helpful when the participants sat down and designed the actual program for rolling out the CB programmes at district level.

Delegates of the 1st batch comprising the Soil Chemists also deliberated on the proforma to capture the status report of soil testing laboratories in the districts, which all agreed to submit soon. This information will facilitate in identifying the critical constraints in each and every laboratory, and take appropriate decisions at policy-makers level for infrastructure development and operation for precise analysis of large number of samples in the state.

8.1.2. Documentation

A manual was developed in a modular form so that any tailor-made program can be organized depending on the need of stakeholders. The contents have been developed by ICRISAT scientists who has also developed tools for presentations for a program. It has a section on “Adult Learning Principles” (Andragogy) for equipping trainers for an appropriate training methodology - often ignored or little understood. Following are the major themes of the program:

- Climate and weather, climate change impacts, adaptation and mitigation strategies
- Soil fertility and soil health, Integrated nutrient management
- Fertilizer calculation, fertilizer application, fertigation
- Cropping system diversification
- Crop care, gap filling, weed management
- Integrated pest and disease management (IPDM), pest surveillance, concept of ETL
- Field practical on Soil, sampling, farm machinery, RWH structures, dual purpose rain gauge, calibration of sprayers
- Methodologies of training, participatory training, developing training tools, protocols for conducting and designing training programs- group exercise, case studies, Andragogy

A hard copy of the manual was given to all participants. All the presentations were also given to participants in digital format loaded in a pen drive.

8.1.3. Performance evaluation

As a standard practice of any customized training program, it is an important exercise to evaluate the extent of knowledge the participants may had before the program and the knowledge gained after the course. This was done through a pre and post course evaluation. Unfortunately, due to late arrival of several participants, the session plan had to change and the pre-course evaluation for the first batch could not be held. The salient findings are:

- Average percentage marks of the first batch was 61%
- Range varied from 45 % to 85 %
- 2nd batch showed an average of 59% at the pre-training evaluation and showed 69% at the post- training evaluation a gain of ten percentile
- Highest gain was recorded from 64 % to 94 %
- Group range – 47 % to 94 %
- Maximum gain showed from 36 % to 72 %

8.1.4. Way forward

This program is the precursor of the larger program which will cover all the 30 districts of Odisha and we believe it will cover about 3000 staff including VLWs. This will be the scaling up exercise as far as CB program is concerned in the project objectives. It is planned to have a workshop in the second half of August where the design and delivery mechanisms will be decided. The training team at each district will comprise of two participants who came to ICRISAT in July and the Scientific Officers (SO) of the district and/or the personnel from the NGO partner. The District Coordinator of each district will be the part of the team for handholding the exercise. This will be a big challenge for all the concerned to effectively conduct the programs for a long lasting impact in the area of capacity building as well as productivity enhancement initiative.

8.2 District-level capacity building of DoA officials

Consequent upon organizing Master Traininer's Training programmes during July, 2019 and as envisaged in the project document, IDC, ICRISAT has takenup the mamooth task of conducting capacity building to DoA staff including VLW's at district level beginning from the 2nd week of September, 2019 onwards to create large scale awareness on science led scaling up of the Odisha Bhoochetna project among the officials across the districts. Based on the feedback received during MT training programme, the training manual was simplified and the powerpoint presentations were revised in order to make the sessions more interesting and interactive in nature. The concerned District Coordinators laised with the the Deputy Director of Agriculture and MT of the respective districts with regard to planning, ensuring the attendance of the officials and logistics. Separate sessions were organized for officers and VAW on different dates and whereever there is meagre strength of the officials in the districts, the sessions were combined. A total of 2576 officials have been trained across 30 districts during September-December, 2019. The district wise participation of officials and the dates of the CB programmes is given in Table 9.

Figure 35: Pictures of DoA officials trainings at district level in Odisha

Table 9. Details of capacity building programmes organized for DoA officers		
District	Dates	Number of officers
Angul	25-26. Sept. 2019	75
Balasore	24-25 Sept. 2019	90
Bargarh	30-31 Oct. 2019	63
Bhadrak	12 Sept. 2019	80
Bholangir	12-13 Sept. 2019	79
Boudh	18 Sept. 2019	66
Cuttack	24-25 Sept. 2019	97
Deogarh	13th Sept 2019	45
Dhenkanal	18-19 Sept. 2019	93
Gajapati	17-18 Sept. 2019	38
Ganjam	15-16 Nov. 2019	98
Jagatsinghpur	26-27 Sept. 2019	91
Jajpur	13 Sept. 2019	78
Jharsuguda	14 Nov. 2019	54
Kalahandi	20-21 Sept. 2019	63
Kandhamal	5-6 Nov. 2019	83
Kendrapara	24-25 Sept. 2019	87
Kendujhar	18-19 Nov. 2019	98
Khorda	23-24 Oct. 2019	100
Koraput	13 Nov. 2019	95
Malkanagiri	30 Oct. 2019	77
Mayurbhanj	26-27 Sept. 2019	101
Nabarangpur	23-24 and 25 Sept. 2019	94
Nayagarh	7-8 Nov. 2019	63
Nuapada	16-17 Sept. 2019	80
Puri	11-13 Sept. 2019	95
Rayagada	17-18 Sept. 2019	79
Sambalpur	27-28 Oct. 2019	80
Sonepur	12-13 Sept. 2019	105
Sundargarh	20 Oct. 2019	229
	Total	2576

9. Upgradation of Referral Laboratories

In commensurate with the project document IDC, ICRISAT has committed establishement of two referral laboratories at Bhuhaneswar and Sambalpur with the state-of-the-art facilities. In this regard, the renovation of buildings, furniture, airconditioning of the lab, electric fitting, water and drainage pipelines works have been completed. The imported equipment has been transported to the respective places and installation of the equipment is under progress and the labs would start functioning soon. Both these laboratories i.e. one at each at Bhubaneswar and Sambalpur, are ready for commissioning, however due nationwide lockdown on account of COVID-19 situation these facilities might start functioning once the lockdown is lifted.

Figure 36: Visit of IOCRISAT to referral site laboratories for upgradation works

10. Detailed Benchmarking of Project Sites

A benchmark socioeconomic survey was carried out in the cluster of villages under the project "Enhancing Agricultural Productivity and Rural Livelihoods through Scaling-up of Science-led Development in Odisha: Bhoochetana." The survey was conducted in all the 30 districts of Odisha in selected blocks and villages within. The survey was conducted using a structured questionnaire developed by ICRISAT. The questionnaire has seven modules, and it covered household-level information on demographic details, literacy, household resource base, cropping pattern, utilization, and consumption of staples. The data collected pertains to the crop year 2017-18, i.e., the year before the start of the collaboration with ICRISAT.

The framework for the identification of blocks and villages for conducting a baseline survey is followed from the soil sample collection strategy adopted by the ICRISAT for assessing the nutrient status. The different strata identified for the soil sampling are; Topo-Sequence, Soil Types, Cropping Pattern, and Farmer Type. Table 10 gives the sampling framework for the baseline survey.

The state of Odisha is having 51349 villages spread across 314 blocks and 30 districts. All the 314 blocks from the state are selected for the study and the number of sampled villages selected for the soil sampling (4082) forms the base for the selection of villages for the household survey. All the soil sampled villages from each block were listed and first, and 10 percent of the villages were randomly selected. From each selected village 10 farmers were

selected for whom the soil samples were collected from their fields. The sample for the survey constitutes 30 districts, 314 blocks, 397 villages, and 3970 households.

Table 10. Sample design details

S.No	District	Blocks	No of Villages	Number of Villages Selected for soil sampling	Number of Villages selected for Primary Survey	Number of HH selected for Primary Survey
1	Cuttack	14	1950	182	18	180
2	Dhenkanal	8	1215	104	10	100
3	Khurda	10	1551	130	13	130
4	Puri	11	1715	143	14	140
5	Bhadrak	7	1311	91	9	90
6	Jajpur	10	1778	130	13	130
7	Balasore	12	2952	156	15	150
8	Mayurbhanj	26	3950	338	33	330
9	Jagatsingpur	8	1288	104	10	100
10	Kendrapara	9	1540	117	11	110
11	Bargarh	12	1207	156	15	150
12	Jharsuguda	5	348	65	6	60
13	Sambalpur	9	1322	117	11	110
14	Sonepur	6	959	78	7	70
15	Koraput	14	2028	182	18	180
16	Malkangiri	7	1045	91	9	90
17	Kalahandi	13	2236	169	16	160
18	Nawarangpur	10	901	130	13	130
19	Rayagada	11	2667	143	14	140
20	Angul	8	1910	104	10	100
21	Deogarh	3	875	39	4	40
22	Boudh	3	1186	39	4	40
23	Nayagarh	8	1695	104	10	100
24	Kandhamal	12	2546	156	15	150
25	Keonjhar	13	2122	169	16	160
26	Sundargarh	17	1764	221	22	220
27	Gajapati	7	1619	91	9	90
28	Ganjam	22	3212	286	28	280
29	Nawapara	5	663	65	6	60
30	Balangir	14	1794	182	18	180
Total	30	314	51349	4082	397	3970

10.1 Methods

All the resulted are tabulated and presented in either in absolute numbers or in percentages. The methods for developing the indicators were obtained from Rana and Rana (2011)[1]

10.1.1. Multiple Cropping Index or Multiple Cropping Intensity (MCI)

It was proposed by Dalrymple (1971). It is the ratio of the total area cropped in a year to the land area available for cultivation and expressed in percentage (sum of area planted to different crops and harvested in a single year divided by total cultivated area times 100).

$$MCI = \frac{\sum_{i=1}^{n} a_i}{A} * 100$$

Where, n is total number of crops, a_i is area occupied by ith crop and A is total land area available for cultivation.

It is similar to cropping intensity.

$$MCI = \frac{a_1 + a_2 + \cdots + a_n}{A} * 100$$

Where $a_1 + a_2 + \ldots + a_n$ is the gross cropped area and A the net cultivated area.

10.1.2. Control Charts

The control chart is a graph used to study how a process changes over time. Data are plotted in time order or by process/units. A control chart always has a central line for the average, an upper line for the upper control limit, and a lower line for the lower control limit. These lines are determined from historical data. The Top Advantages of Statistical Process Control: helps reduce the margin of error. Because control charts reveal what's going on in a process in real-time, they allow the researcher to detect and correct issues before they cause deeper problems in processes and products

The average in a control chart can be a system generated or can be inputed by a researcher by obtained best management practices. The study considers state and national averages reference points for intra and inter comparison between state and national statistics.

10.2 Results and Discussion

10.1.2. Land use pattern

The study of land use is important not only in agriculturally dominated, overpopulated developing regions because of its relationship with different human phenomena. It's important also increased during the population pressure and decreasing man and land ratio, increasing demand for food and raw materials they need for optimum utilization of land in an integrated manner has assumed greater relevance.

Some land is for a specific use depending mostly on the physical characteristics of the land to its suitability for a particular use is related. Five major categories of land use are noted in the season and crop report for Odisha state which are

1. Area under forest
2. Land not available for cultivation including
    i) Barren and uncultivated land

[1] Rana S S and M C Rana. 2011. Cropping System. Department of Agronomy, College of Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, 80 pages.

ii) Land put to non-agricultural uses

3. Other pastures and grazing land including
    i) Cultivable waste land
    ii) Permanent pasture and grazing land
    iii) Land under miscellaneous tree crops and groves.
4. Fallow lands including
    i) Current fallow
    ii) Other fallow
5. Cropped area including
    i) Net sown area (NSA)
    ii) Area sown more than once
    iii) Gross cropped area (GCA)

The general land use pattern of Odisha state is discussed here and statistics for the years 2016 to 2017 have been abstracted from the Statistical Abstracts prepared by the Directorate of Economics and Statistics. The total geographical area of the state is 155.71 lakh ha and reporting area under total LUS in the year 2016-17 was 115.35 lakh hectares. According to the statistics the land under agricultural use is nearly 36%, forest area by 16.45%, the area under non-agricultural use by 12.18%, current fallows by 9.41% and remaining area by others classes (Figure 37)

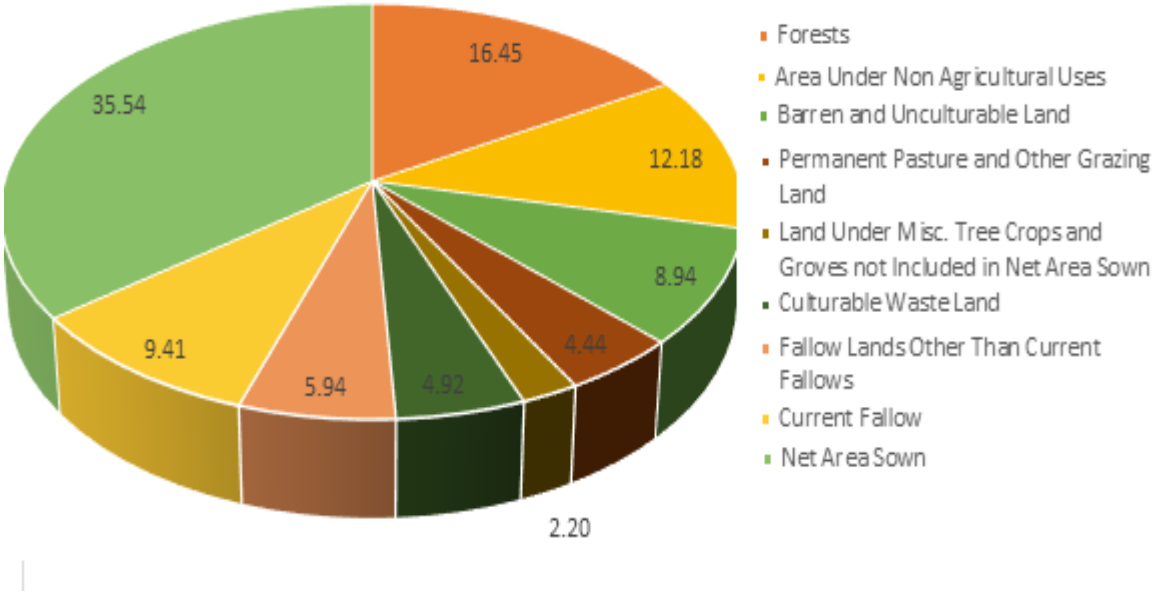

Figure 37: Land-use utilization pattern of Odisha – 2016-17

The comparative analysis of land utilization patterns among districts is presented in Figure 38. The values (percentages) represents a share in the districts' geographical area (Annexure 1). The distributional pattern of forest shows that the area under forest is lowest in Bhadrak (0.42% of district geographical area) and highest in Deogarh (40.88%). The 36% of the districts (Bhadrak, Jagatsinghapur, Baleshwar, Balangir, Puri, Kendrapara, Bargarh, Cuttack, Sonepur, Ganjam, Jajpur) have forest area less than 10% and 33% of districts have forest area up to 20% of their geographical area and remaining districts above 20% of their geographical area.

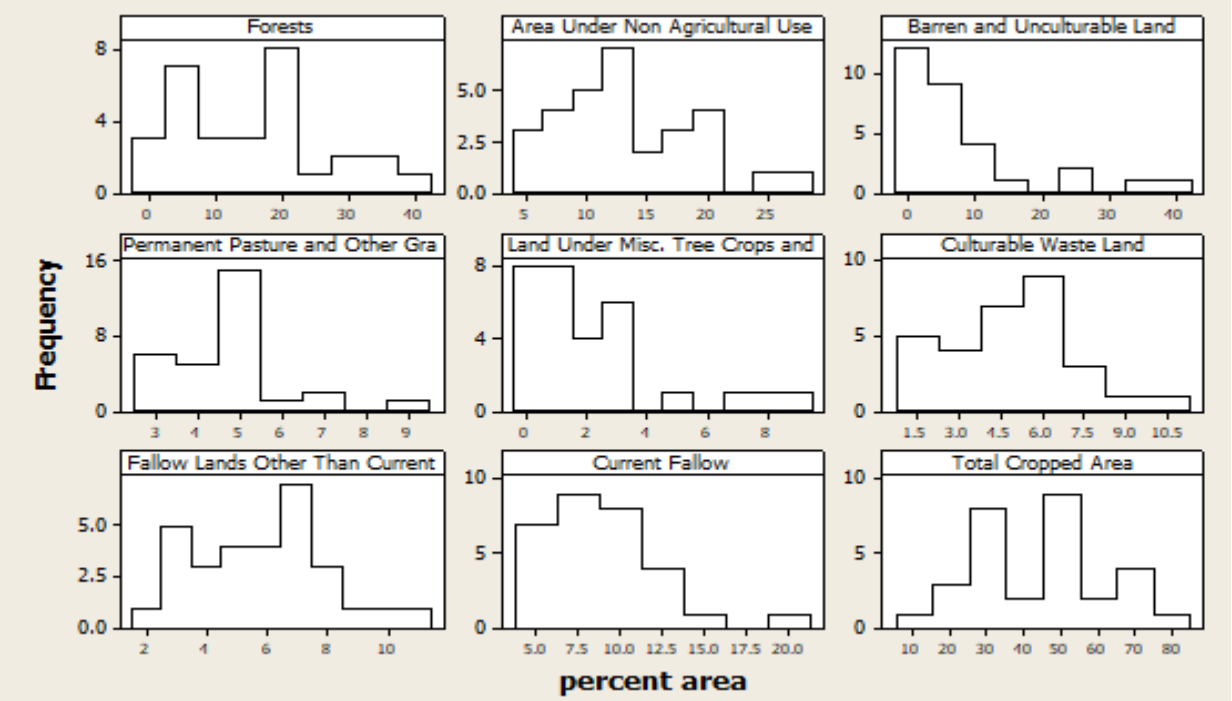

Figure 38: Distribution of land-use utilization pattern by districts of Odisha

The current fallows in the state are nearly 10% and thirty percent of the districts (Ganjam, Kalahandi, Jharsuguda, Puri, Kendujhar, Nuapada, Anugul, Dhenkanal, Balangir) have current fallows more than 10% of their respective geographical area. Farmers leave land fallow because of several other reasons including lack of resources, poor irrigation facilities, extreme weather conditions, and soil erosion. The culturable wasteland is highest in Dhenkanal (11.1%) and remaining districts have culturalble wasteland less than 10% and the permanent pasture and other grazing land is highest in Boudh (9.4%). The total cropped area is highest in Sonepur district (80%) and 63% of the districts in the state have a total cropped area less than 50%.

10.1.3. Profile of Households

10.1.3.1. Age of the Respondent

As far as the demographic profile is concerned, the majority of funded farms are located in the younger and mature phases of the life cycle (Figure 39). The respondent's age ranges between 20 and 80 are over-represented in this survey sample, and the average age of the respondents is around 46 years. The inter-quartile range of data-set shows that the age of the respondents is between 39 and 54 years indicating that 50% of farmers (respondents) of Odisha are middle-aged.

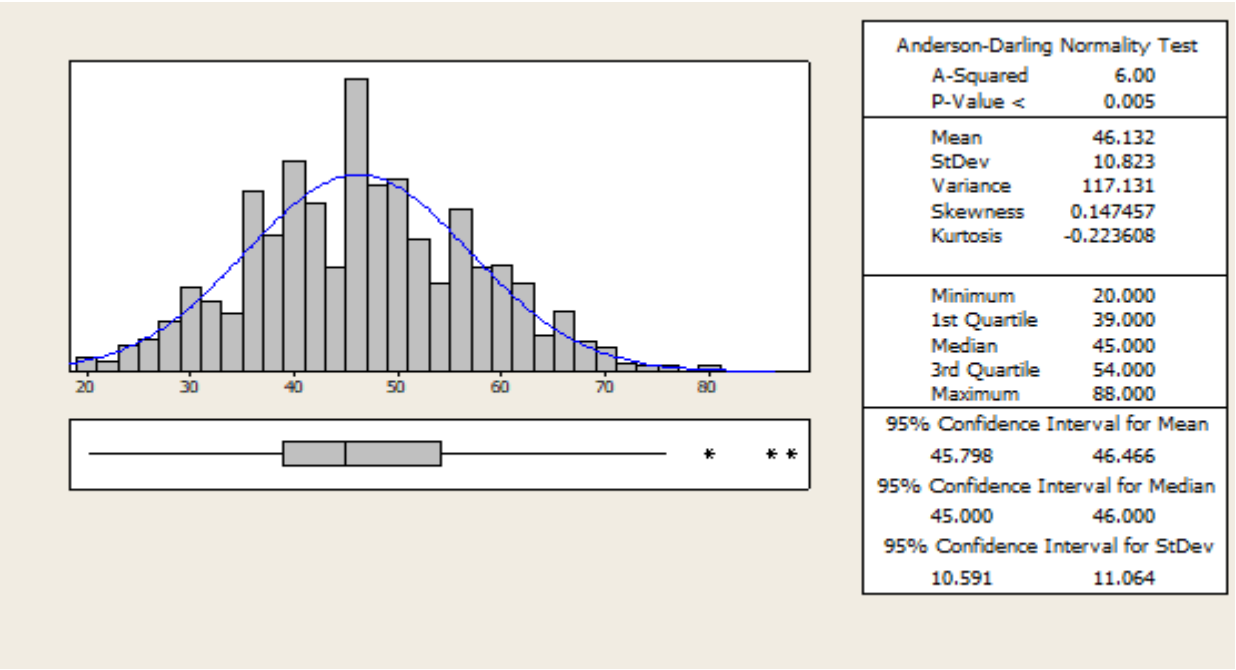

Figure 39: Distribution of respondent's age

The average age of the respondents by districts is presented in Figure 40, and it shows that the age of the respondents ranges between 40-50 years across the districts.

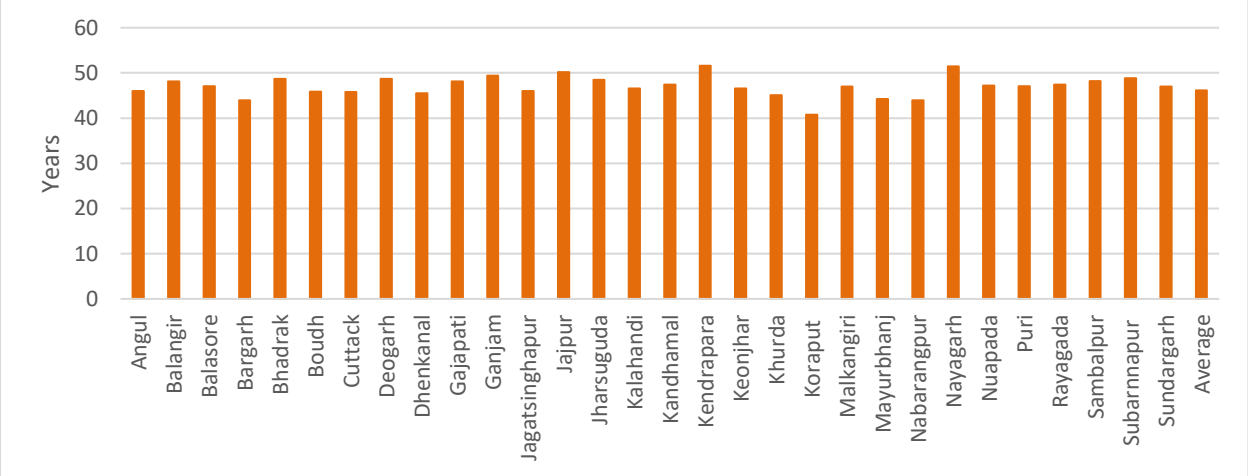

Figure 40: Age distribution of respondents by district

10.1.3.2. Education

The data reveals that 7.4 percent of respondents in the study are illiterates (Figure 41) and 37.3 percent of respondents (Annexure 2) are literates who have a formal education (lower education). 9.4 percent of respondents were completed their upper primary, 35.5% High primary and remaining 10.4 percent have completed their education levels more than 10^{th}.

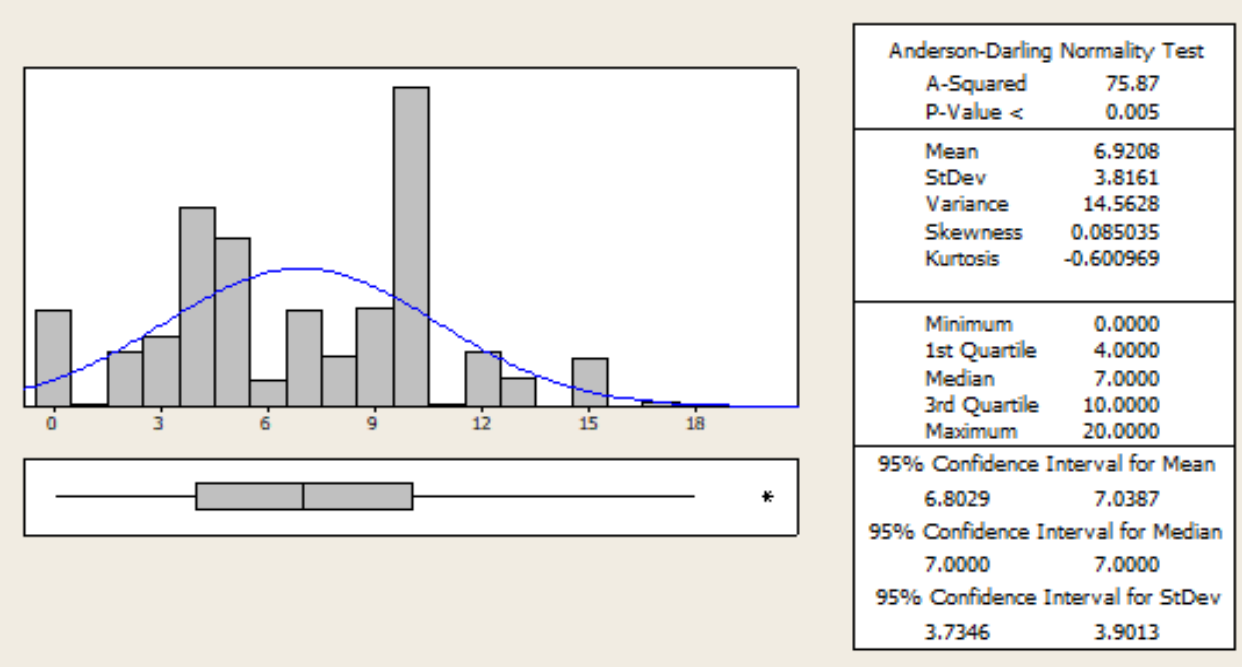

Figure 41: Distribution of respondents' education

Average levels of education by district were shown in Figure 42 and average levels of education of respondents in the districts range from 5-10 years. The 43% of the districts (Cuttack, Mayurbhanj, Jharsuguda, Deogarh, Nayagarh, Sambalpur, Khurda, Bargarh, Balasore, Jajpur, Dhenkanal, Kendrapara and Bhadrak) have farmers with high primary completed. The education pattern by district shows that the respondent farmers are fairly educated but there is way ahead in this digital era and government initiatives are need of the hour to improve the education levels among the farming community.

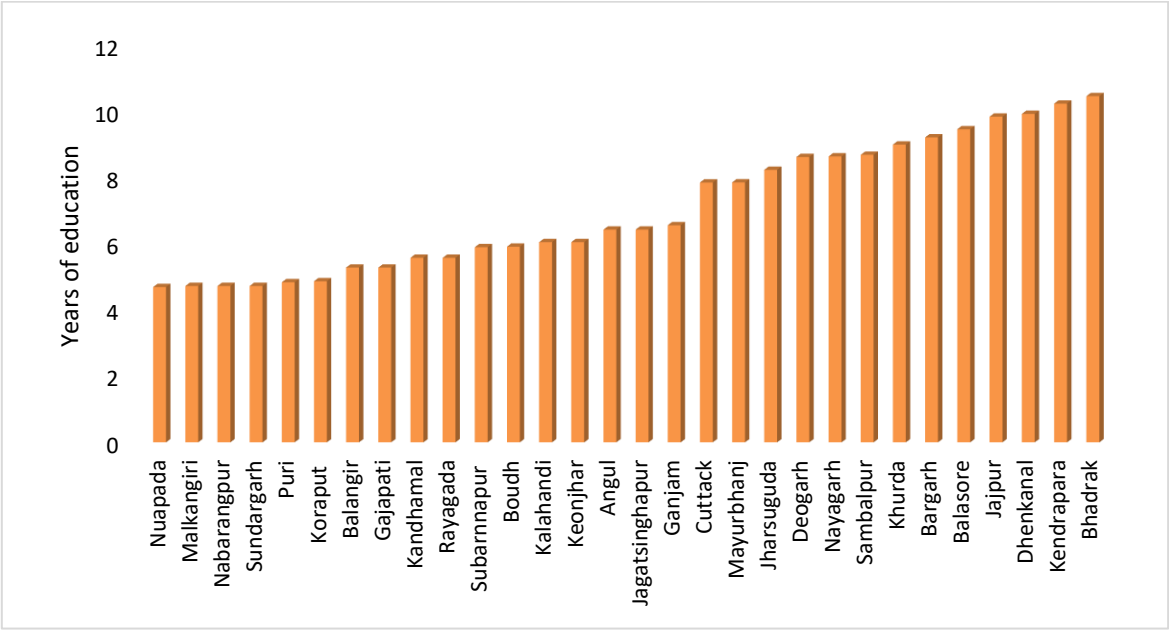

Figure 42: Average years of education of the respondents-by district

10.1.3.3. Family Composition

The household, defined as a group of persons who make common provision of food, shelter and other essentials for living, is a fundamental socioeconomic unit in human societies. Households are the centers of demographic, social and economic processes. Understanding the patterns of household size and composition can thus inform efforts towards the achievement for sustainable development. The study analyses the composition of the family and the composite distribution is presented in Figure 43. The total number of families is differentiated into 40 percent male, 38 percent female, and children 22 percent. The adult male to female ratio is almost 1:1 and the children's ratio is 1:1.25 per household indication that one or two children lived in the family. The presence of children in the household has major implications for a household's priorities, particularly with respect to the demand for food, allocation of resources, education and health care.

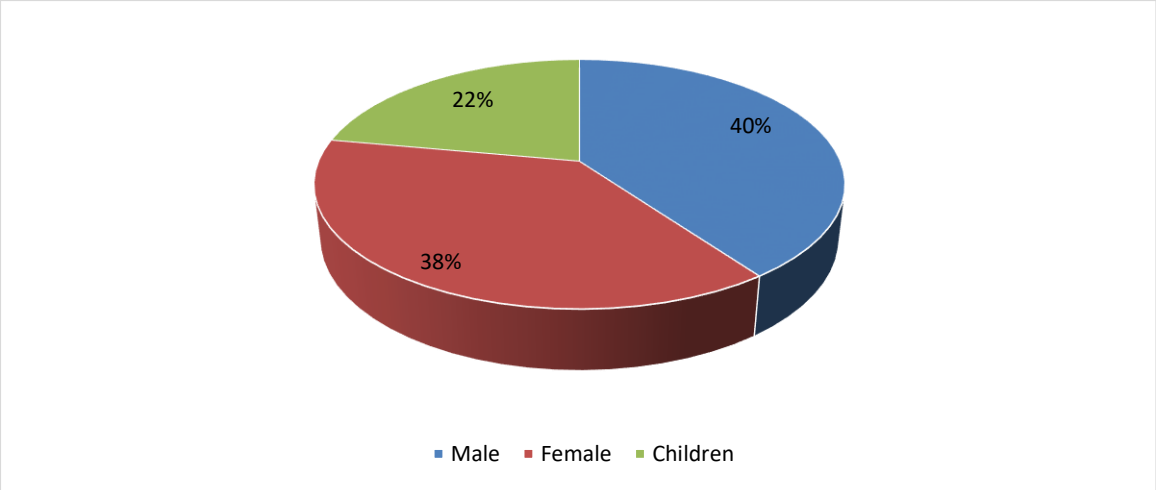

Figure 43: Family composition-state

The family composition by the district is presented in Figure 44. In districts like Cuttack and Koraput a substantial majority of households (40%) have children of less than 15 years of age. By contrast, in Jajpur and Nabrangapur have less number of children per household.

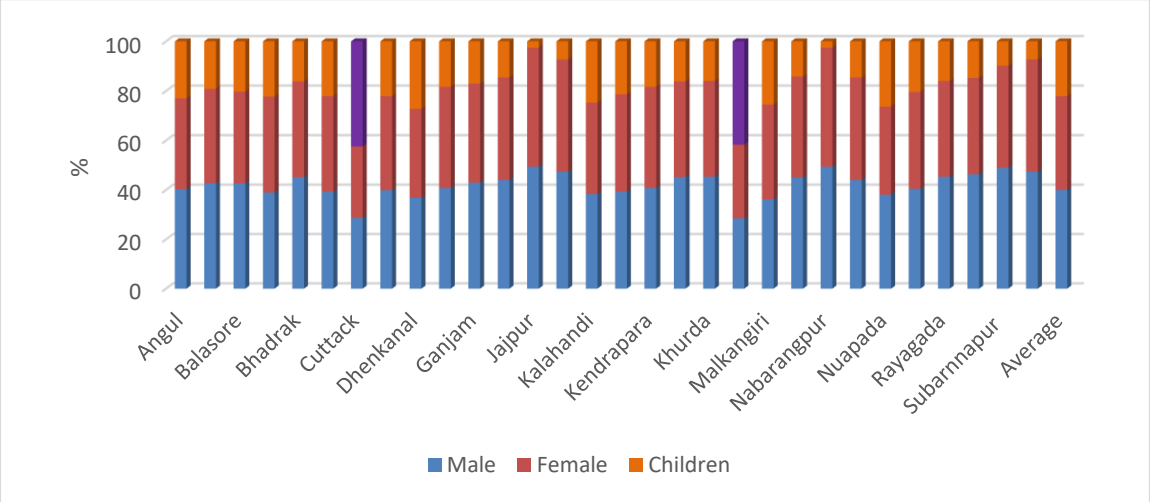

Figure 44: Family composition by district

10.1.3.4. Household workforce- Worker Population Ratio (WPR)

Rural households understood as a household that combines family, farm, and commercial activity, and on-family farms labor division has generally been based on complementarity between persons of different gender and generations, resulting in specific male and female spheres and tasks. As per the Government of Odisha's Economic Survey 2017-18, 48.8% of workers (aged 15 and above as per Usual Principal and Subsidiary Status (UPSS) are engaged in agriculture and allied activities. This sector is a major source of employment, especially in rural areas; 56% of the total rural workers are employed in the agriculture sector. The results of the primary survey on worker population ratio are presented in Figure 45, and it displays the proportion of labour force in the total population obtained from the sample survey. The Worker Population Ratio (WPR) signifies the proportion of workers/ employed persons in the total population for a specific age group. It was estimated at 50 percent for Odisha, which means 50 percent of persons aged 15 years and above were employed in the State (Figure 28) and 60 percent of the workforce was constituted by the male population.

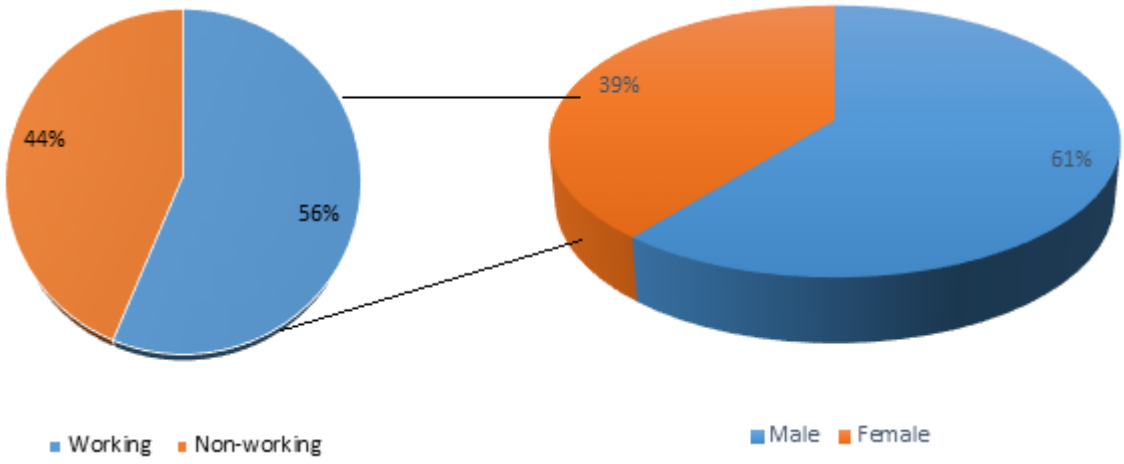

Figure 45: Workforce by gender

There can be great diversity in the family workforce and uniform categorization will not yield a unique definition of family farming. Nevertheless, a concept of family farming exists and its important role in rural development and in the agricultural sector has been and continues to be recognized across all regions in the country. In the next part, a gender-wise split of workforce across the districts was presented (Figure 46). The district Puri has shown highest number of male workforce and no gender disparity is observed in Jharsiguda.

Figure 46: District wise workforce by gender

10.1.3.5. Occupational pattern

According to Fuller (1991), "full-time farming is the aberration and in modern farming history multiple jobs holding among farm households are the norm". In the agrarian context, the days' time is mainly divided between a combination of agricultural activity (farm and off-farm) with other forms of gainful employment. The primary occupation of the majority of respondents is agriculture and in 63 percent of districts (Figure 47) the respondents reported that their secondary occupation is farm-labor. Only Kendrapada has shown a significant pluri-activity and to some extent the Naupada.Pluri-activity entails allocation of an individual's time in multiple activities; here activities with economic benefits are preferred so as to maximize the returns.

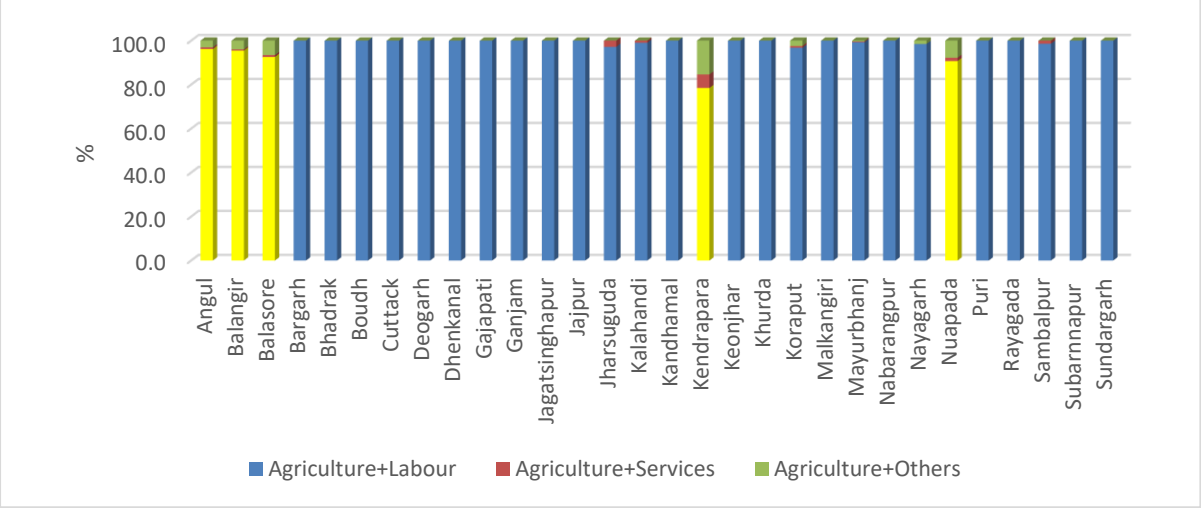

Figure 47: Occupational pattern of respondents-by distric

10.1.4. Agriculture

Agriculture is the mainstay of Odisha's economy providing employment and sustenance directly or indirectly to more than 50 percent of the state's total workforce. According to Odisha's Economic Survey Report 2017-18, the state has a cultivated area of 61.80 lakh

hectares, and agriculture accounted for 60 percent of Agricultural GVA in 2017-18 and 2018-19. Rice is the lead crop in the state, with almost half the share of gross cropped area. Pulses are the second-largest crop group in the State. Mango, banana, and guava are the major fruit crops grown in the state; among vegetables, brinjal is the leading crop with a gross cropped area of 117'000 ha. Yield in rice has been low (1.74 qt/ha) in Odisha compared to national average (2.78 qt/ha) due to high dependence on rainwater for irrigation. As the objective of the project is the assessment of nutritional status of the soils in the state and improve the productivity of major crops, the study is confined to these parameters, and the baseline results are presented in below sub-chapters.

10.1.4.1. Land Ownership

The pattern of operational holdings is highly skewed with more than 80 percent of those belonging to small and marginal categories and 20 percent belongs to medium and large categories (Figure 48).

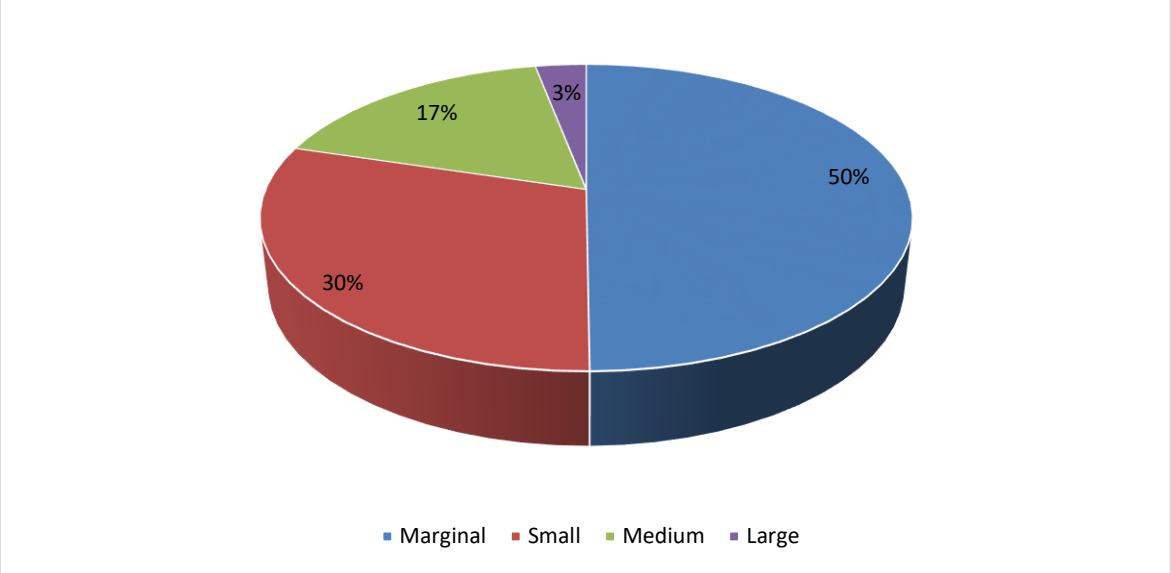

Figure 48: Farmers' classification by type

District wise distributional pattern of farmers by size of holding is presented in Figure 49. The figure shows that the distribution pattern of farmers types is more or less same across the districts except in Rayagada (93%) and Malkangiri (91%) districts where the percentage of marginal farmers is more than 90 percent. However, the share of marginal farmers is lowest in Sambalpur (9%) and Gajapati (12%). The highest number of large farmers are observed in Bargarh (27%) and medium farmers are in Sambalpur (46%).

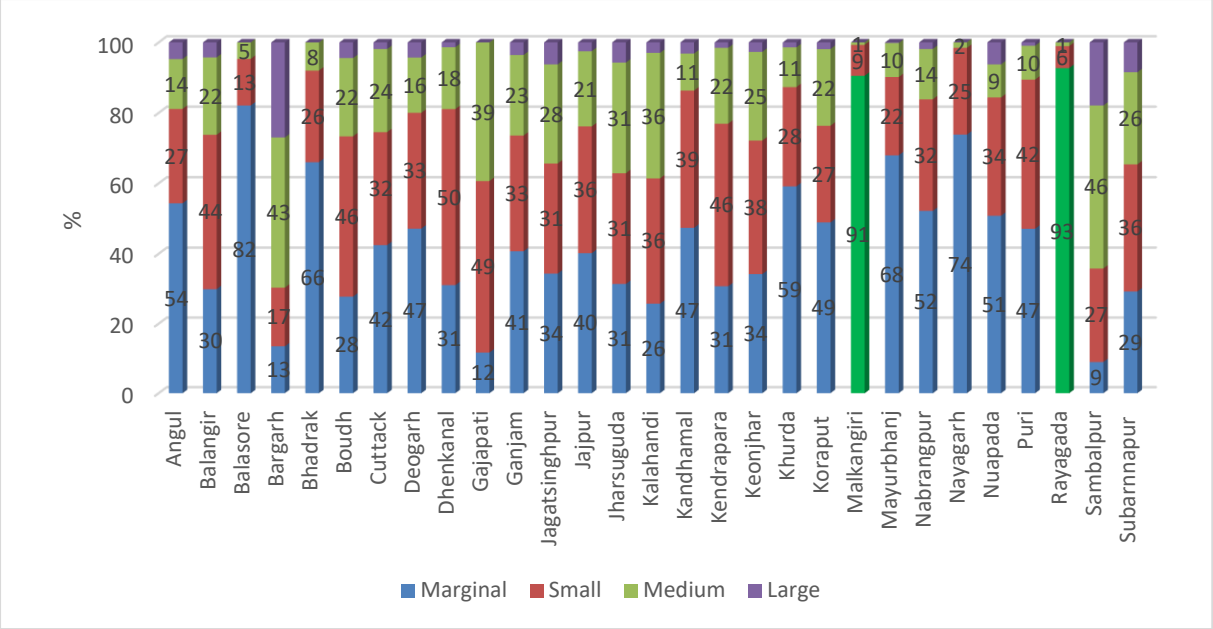

Figure 49: Farmers' classification across the districts by type

10.1.4.2. Cropping pattern

Cropping pattern indicates the proportion of area under various crops at a point of time whereas the crop combination indicates to grow different types of crops under the same agriculture field. Cropping pattern and combination are also part of the behavioral approach in geography because it reflects the performance of the farmer for various crops sown in an agricultural field. The share of area under two prominent seasons of Odisha is presented in Figure 50, and it indicates that kharif (rainy season) is the major season for the farmers in the state where it occupies 97% of the total cropped area of a farmer in year. The area under the rabi season is nearly 22% indicating the dependency of farming on rains and other climatic factors.

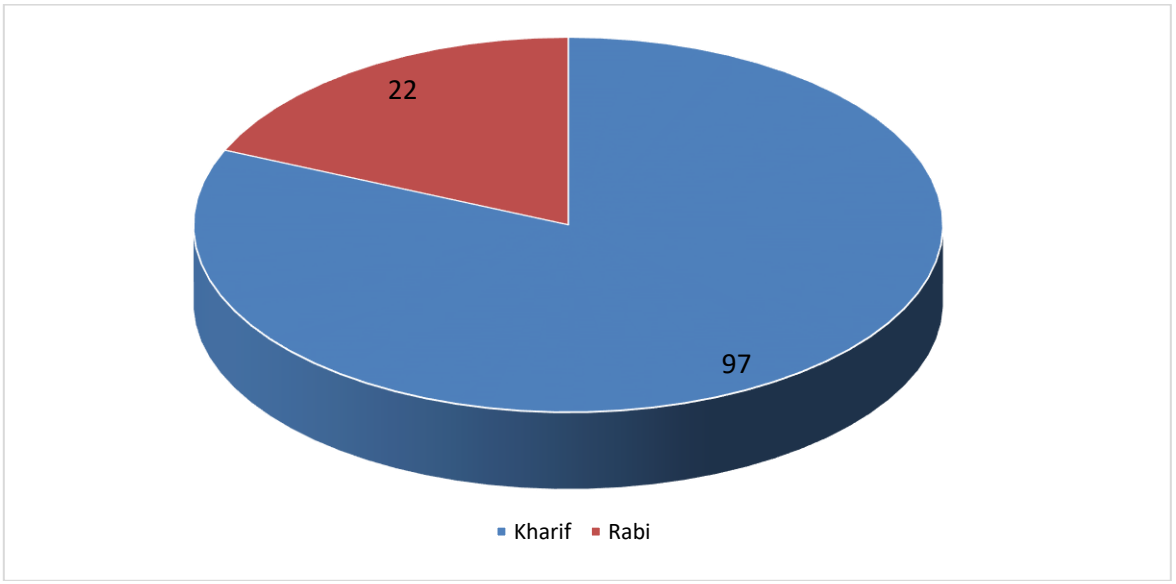

Figure 50: Season wise share of cropped area

District wise share of the cropped area by season is presented in Figure 51 and it is evident that the share of kharif area to total available crop area of a farmer is 100 percent, which means all the cultivable land of a farmer is brought into cultivation during the study year except in the Malkangiri district. This can be probably due to a lack of rainfall during the season in the district. However, the pattern reverses in rabi season where the Malkangiri has shown show highest area (96%). The cropped area in rabi season is nearly 20% in majority of districts indicating the need a policy on kharif fallows.

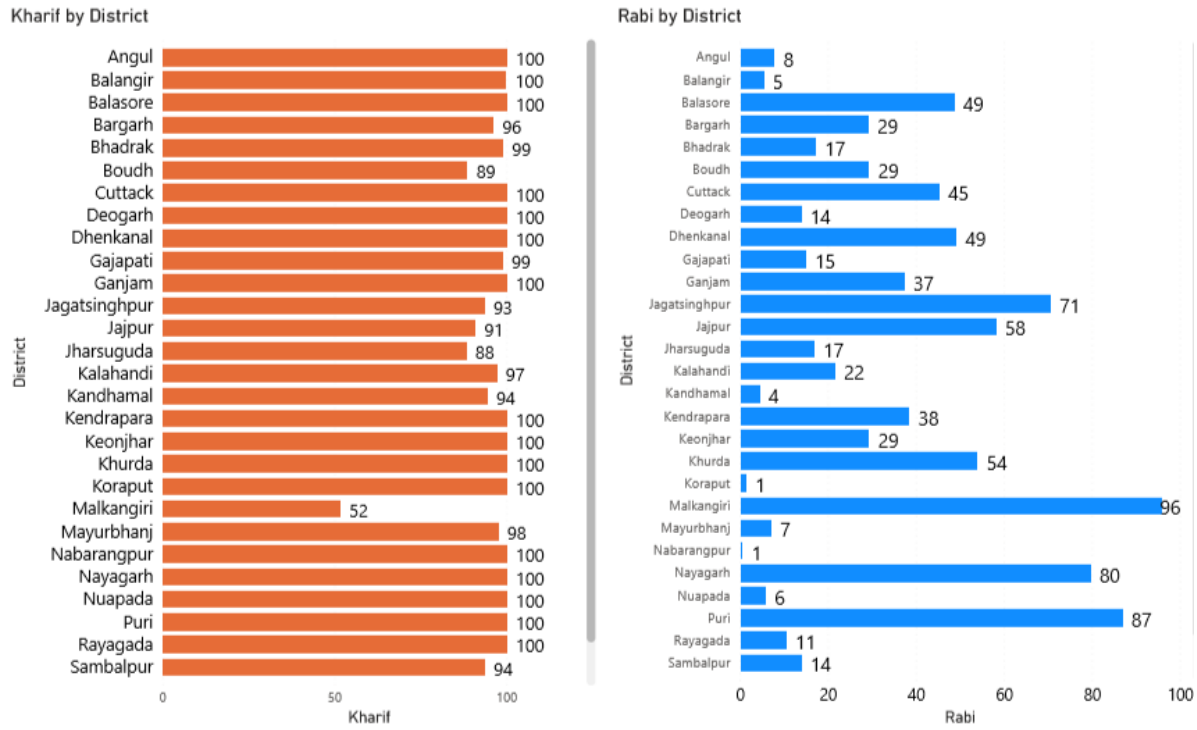

Figure 51: District and season wise share of cropped area

10.1.4.3. Crops by season

Odisha is primarily a food grain-growing state, and 88 percent of the area in kharif is occupied by food grain crops (Figure 52). Oilseeds and pulses are mainly grown in the rabi season (Figure 53). *Kharif* is a very important cropping season during June to October. It occupies more than rabi cropped area. Paddy is a very prominent crop (85%) of this season and occupies 85 percent of total sown area. Vegetables are third most important crop during the *kharif* season occupying 2 percent of the cropped area. Cotton is the next to ragi occupying nearly 1 percent of the cropped area in *kharif*

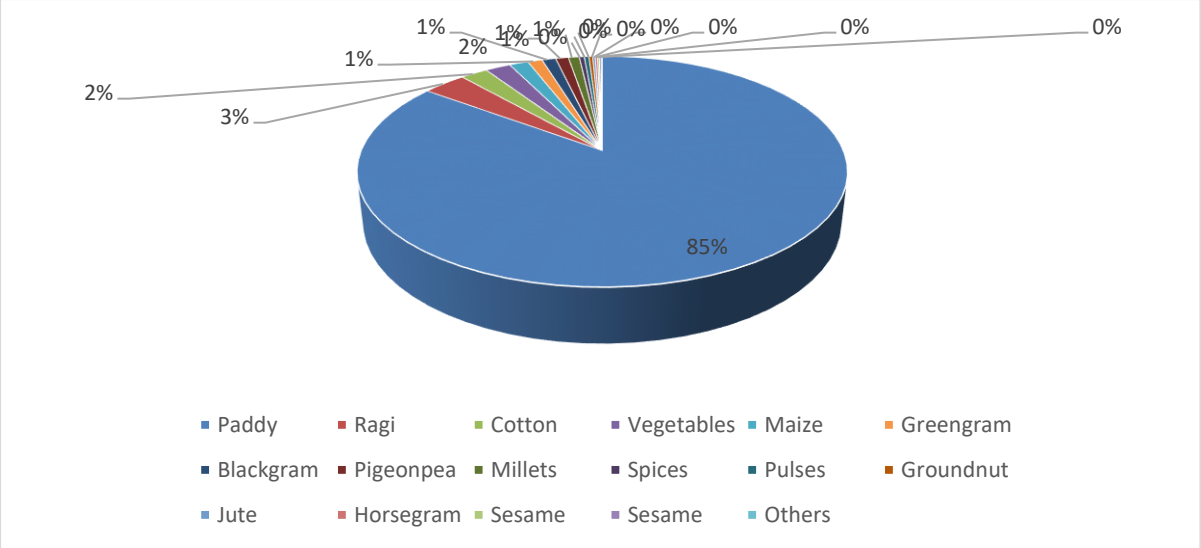

Figure 52. Kharif season crops

The Rabi crops are cultivated with the advent of the winter season, generally from the end of October to beginning of November. The main Rabi crops are paddy, greengram, blackgram, chickpea, and commercial crops like groundnut also grown this season.

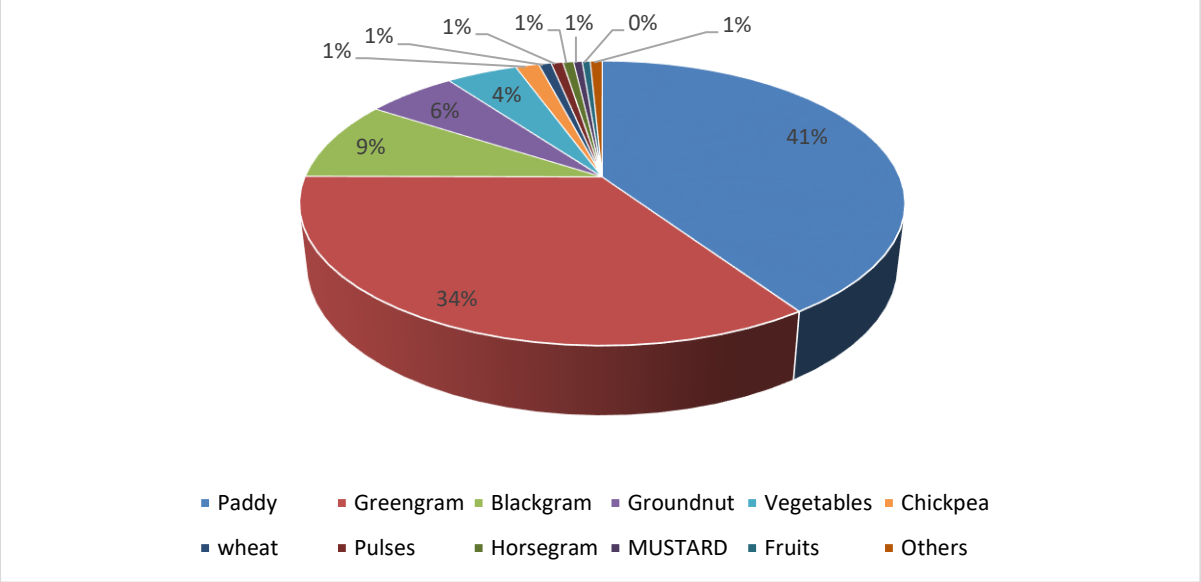

Figure 53: Rabi season crops

10.1.4.4. Cropping Intensity

There are only two ways to satisfy the increasing food and other demands of the country's rising population—either expanding the net area under cultivation or intensifying cropping over the existing area. Thus, higher cropping intensity means that a higher proportion of the net sown area is being cropped more than once during one agricultural year. This also implies higher productivity per unit of arable land during one agricultural year.

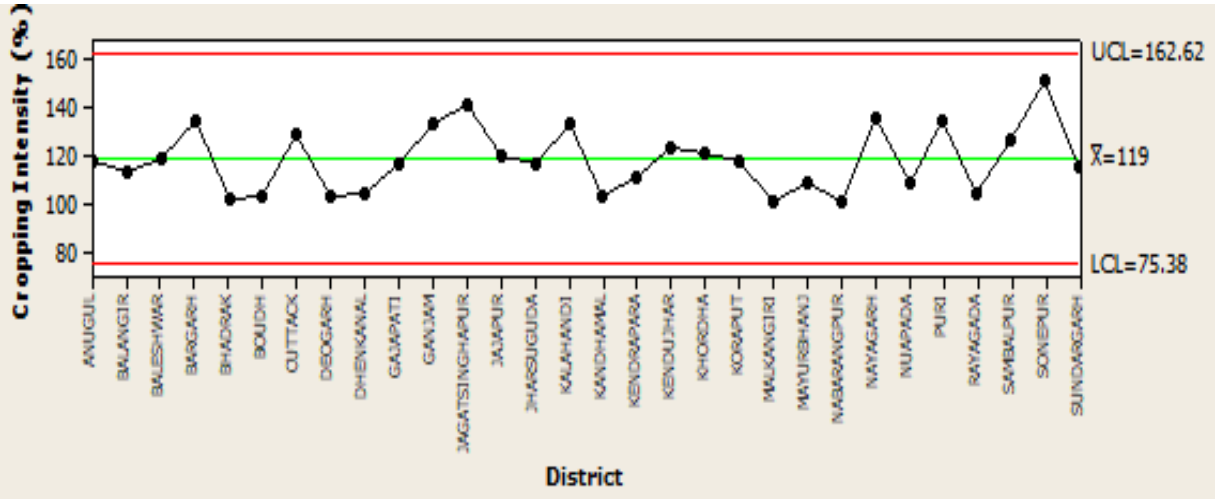

Figure 54: Cropping intensity by district (values in %)

Figure 54 shows that the average cropping intensity of state (sample respondents) is 119 percent, and around seven districts have a cropping intensity of around 100 percent indication the dependency of farmers on rainfall and scope for bringing more land under cultivation either in kharif season or rabi.

10.1.4.5. Productivity

Crop productivity is the quantitative measure of crop yield in a given measured area of field. The use of new crop varieties and the efficient application of agrochemicals immensely contributed to increased plant productivity. Following sub-sections provides an insight into the productivity of major crops grown in the state

10.1.4.5.1. Paddy

The Figure 55 provides a comparative analysis of district wise productivity of paddy with state and nations average. A comparision with nation's productivity shows that, except two districts (Cuttack and Angul), 93 percent of the districts fall below the nation's average. This indicates the need and scope for improvement. The list districts as per the serial number is provided in Annexure 3.

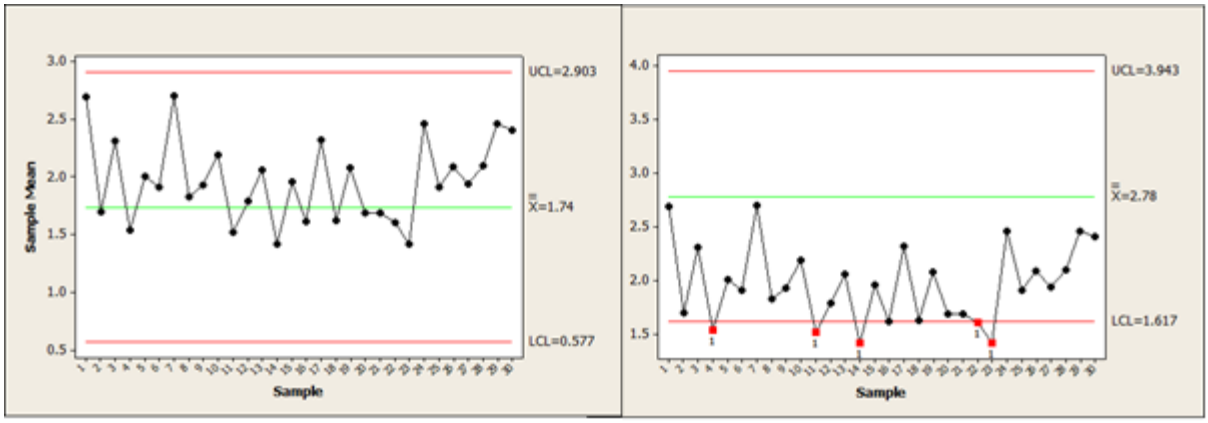

Figure 55: Average productivity of paddy by district (tonnes/ha)

10.1.4.5.2. Maize

The sample survey shows that maize is predominantly grown in 17 districts in the state (Annexure 4). The average productivity of maize at state and national levels is 2.51 and 2.56 tonnes/ha. However, Figure 56 shows that except two districts (Jharsuguda and Nabarangapur) average productivity of remaining districts is lower than the state and nation's estimates.

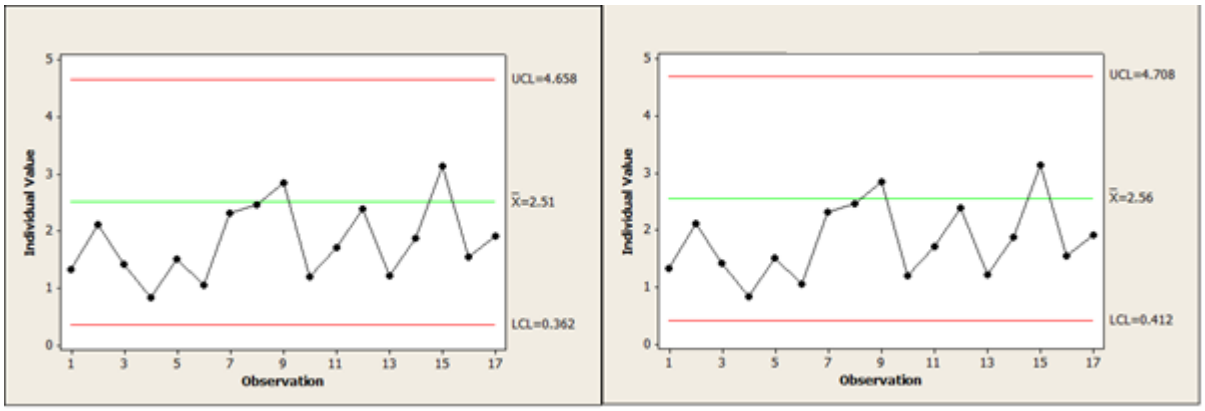

Figure 56: Average productivity of maize by district (tonnes/ha)

10.1.4.5.3. Finger Millet

The sample survey shows that maize is predominantly grown in 5 districts in the state (Koraput, Rayagada, Malkangiri, Kalahandi, and Gajapati). The average productivity of maize at state and national levels is 0.77 and 1.7 tonnes/ha. However, Figure 57 shows that except in two districts (Gajapati and Koraput) average productivity of remaining districts is lower than the state and nation's estimates. List of districts is provided in Annexure 5.

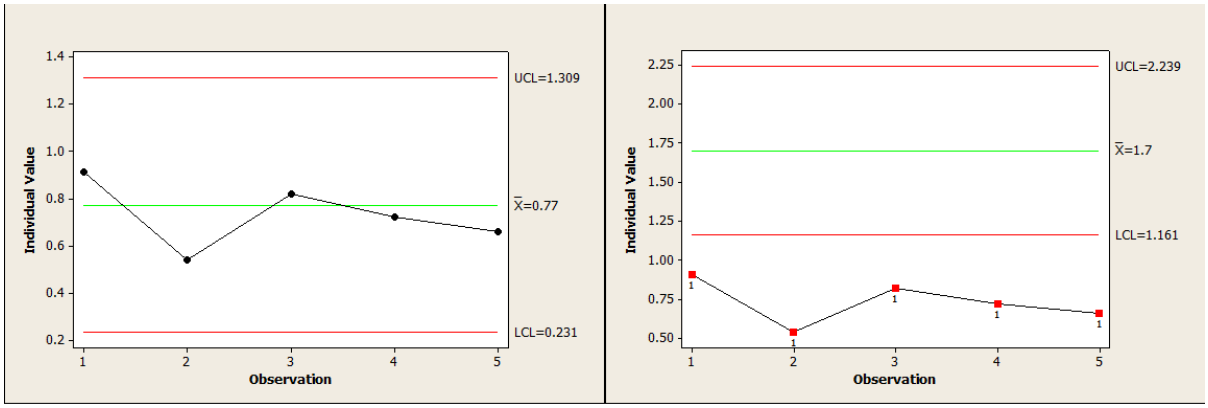

Figure 57: Average productivity of ragi by district (tonnes/ha)

10.1.4.5.4. Greengram

Greengram is the second most important crop next to paddy is grown across all the districts in the state. The average productivity of maize at the state and national level is 0.39 and 0.46 tonnes/ha. However, the Figure 58 shows that except in 7 districts (Annexure 6) average

productivity of remaining districts is higher than the state average. A comparison with nation's estimates shows that only 33% of the districts are above the nation's average.

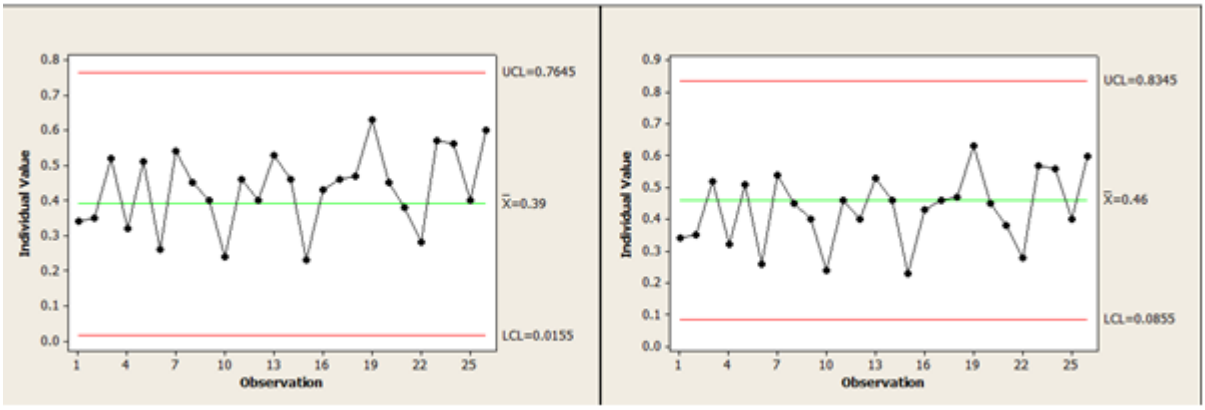

Figure 58: Average productivity of greengram by district (tonnes/ha)

10.1.4.5.5. Blackgram

Greengram is an important pulse crop next to greengram and grown across all the districts in the state. The average productivity of maize at state and national level is 0.37and 0.57 tonnes/ha. However, the Figure 59 shows that except in 12 districts (Annexure 7) average productivity of remaining districts is higher than the state average. A comparison with nation's estimates shows that except (Jharsiguda and Sambalpur) the productivity below the nation's average.

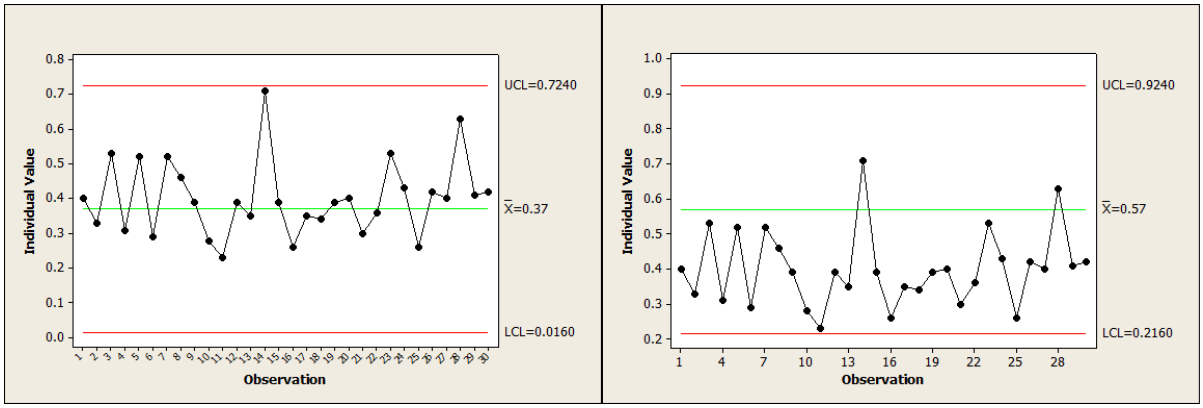

Figure 59: Average productivity of blackgram by district (tonnes/ha)

10.1.4.5.6. Horsegram

Horsegram is majorly grown in Sundargarh and have its presence 7 districst of the state (Annexure 8). The average productivity of maize at state and national level is 0.41and 0.48 tonnes/ha. The Figure 60 shows that except 2 districts (Kalhandi and Balangir) the productivity levels are on par with state average. The average productivity of Nabarangpur district is higher than the nations average.

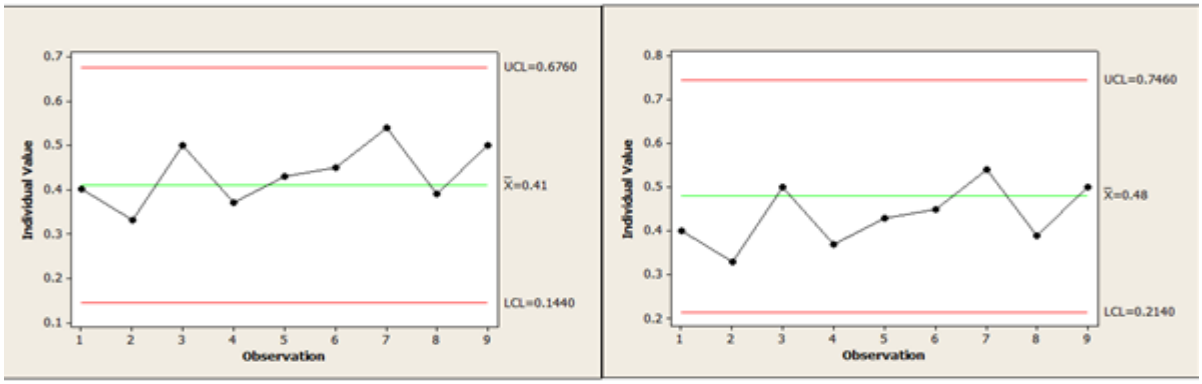

Figure 60: Average productivity of blackgram by district (tonnes/ha)

10.1.4.5.7. Groundnut

Groundnut is the major oilseed crop grown in 11 out 30 districts in the state (Annexure 9). The average productivity of the crop at state and national level is and 1.13 and 1.71 tonnes/ha. The Figure 61 shows that the farmers of Malkangiri has reaped highest productivity per hectare (3.04 tonnes/ha) during the study period reason for 3 standasrd deviation from the mean. However, excluding the Malkangiri, the productivity levels of remaining districts lesser than the nation's average.

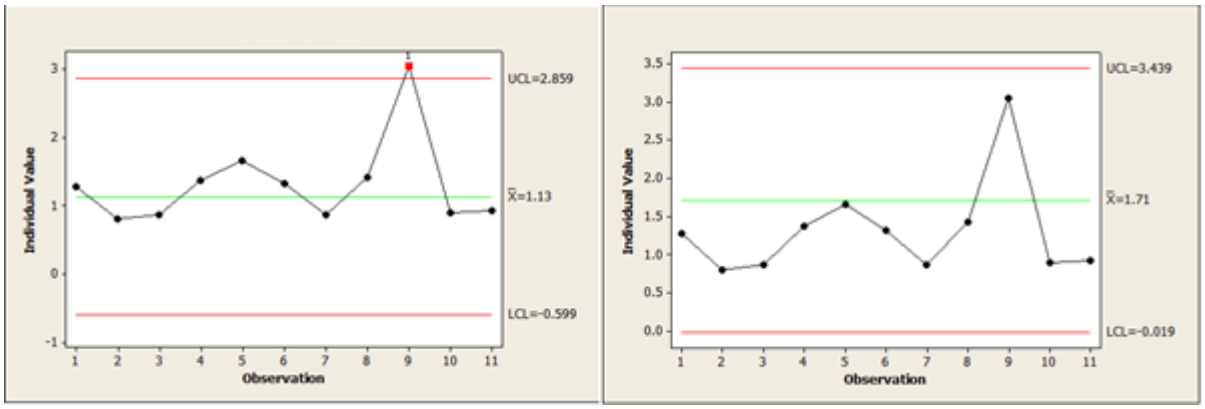

Figure 61: Average productivity of groundnut by district (tonnes/ha)

10.1.4.5.8. Sesame

Sesame is the majorly grown in three districts (Angul, Malkangiri and Rayagada) and the average of sample survey is much lesser than state and national estimates (Figure 62)

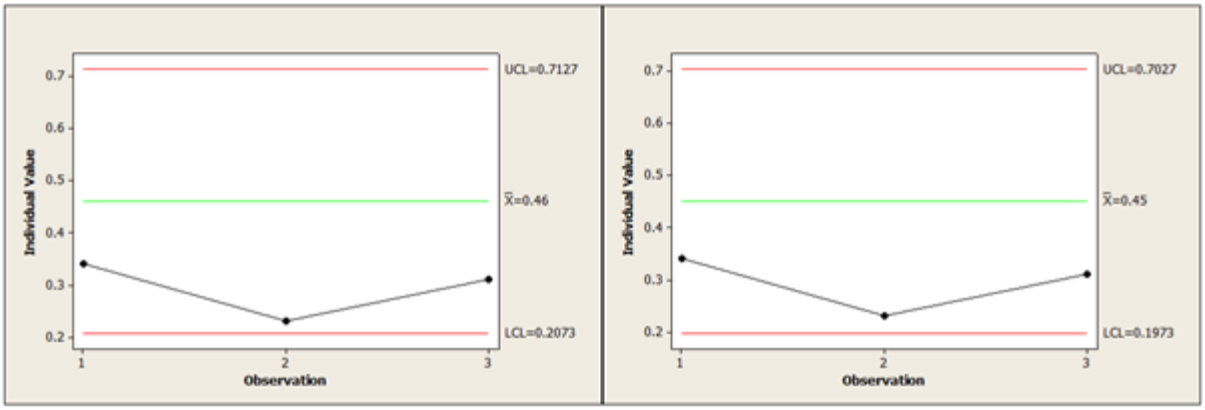

Figure 62: Average productivity of sesame by district (tonnes/ha)

10.1.4.6. Seed Replacement Rate

Seed systems are the vehicle through which farmers get a high-quality seed of the new crop varieties they want and need. Effective seed systems have the potential to increase production quickly and economically. They give farmers access to good-quality seed and knowledge of improved practices, and their harvests can rise dramatically.

Informal seed systems models are not delivering with the efficiency and effectiveness needed. For example, farmers often rely on seed distribution from their fellow farmers, which is just too slow for new varieties to have a major impact. In parallel, formal seed systems tend to focus on a few profitable seed crops such as maize and vegetable seed, leaving less profitable crops by the wayside.

From Figure 63 it was evident that the Seed Replacement Rate (SRR) of paddy in case of Odisha is very low (18%), and farmers are using old seed year by year. The majority (74%) of farmers have replaced their seed within three years and 18 percent of farmers reported that they never replaced their seed. This may result in gradual decrease in yield and eventually income per unit of land.

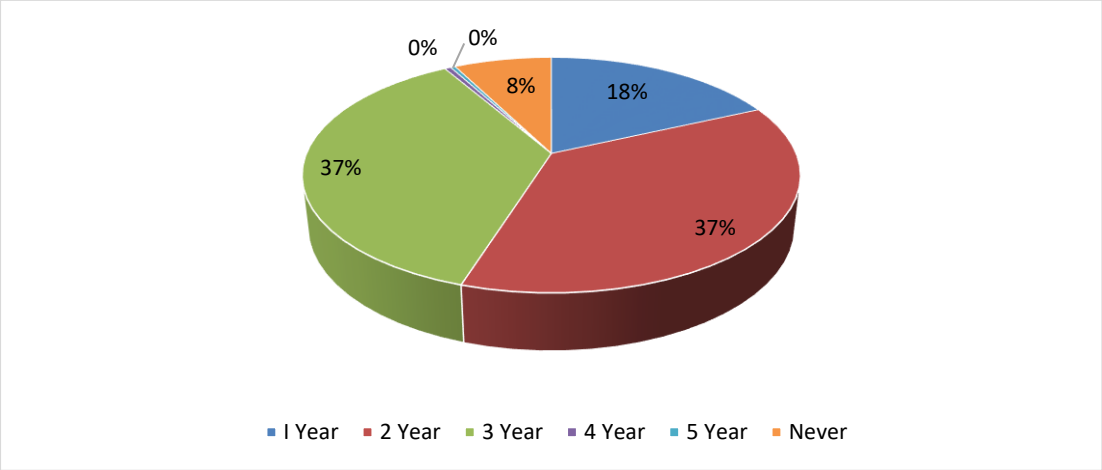

Figure 63: Seed replacement rate of paddy

The SRR for other crops like ragi and pulses (Greengram, Blackgram) is very minimal but hybrids like cotton and maize have 100 percent SRR.

10.1.4.7. Soil Nutrient Status

Odisha Bhoochetana project aims at improving and sustaining crop productivity and rural livelihoods through science-based natural resource management (soil management in particular) in the state of Odisha. This will provide a sound base for precise fertilizer management not only for NPK but also deficient secondary and micro-nutrients. Declining soil health is often cited as one of the reasons for stagnating or declining yields. The limiting nutrients do not allow the full expression of other nutrients, lower the fertilizer response and crop productivity. The constraints of emerging S, Zn, Mn and B deficiencies in specific cropping systems/ regions also need to be alleviated to enhance soil-crop productivity.

Preliminary soil analysis results for pilot sites have shown multi-nutrient deficiencies of secondary and micro-nutrients like sulphur (S), boron (B) and zinc (Zn) along with nitrogen (N), phosphorus (P) and potassium (K). The imbalanced and sole use of high analysis NPK fertilizers coupled with declining use of organic manures in the past decades has resulted in soil fertility degradation through developing negative balances of secondary and micronutrients and low carbon (C) levels. The deficiencies will further aggravate when we attempt increasing crop productivity without resorting to proper soil fertility management practices.

To understand the soil nutrient status of Odisha State, 40000 soil samples were collected from all the 30 districts and results are presented in (Annexure 10)

10.1.4.7.1. Outcomes of Odisha Bhoochetana soil analysis

- More than 82 percent of analyzed soils are acidic in nature with low soluble salts
- Organic carbon is deficient (41%) in most of the analyzed soil samples
- Exchangeable bases followed the deficiency order: Ca > K > Mg
- Sulphur deficiency (48%) was also prominent in analyzed soils
- Boron (80%) was the most limiting amongst all micro-nutrient followed by zinc (43%)
- Micronutrient deficiency followed the order: Zn > Fe >Mn> Cu

10.1.4.7.2. Fertilizer Consumption pattern – Paddy

Chemical fertilizers enable farmers to increase farm production and get higher returns to their expenditure on various agricultural activities. The use of chemical fertilizers has been one of the significant factors in bringing about great improvements in the productivity of agriculture. The study pointed out that the 41 percent of soils of Odisha are deficient in OC which means existence of N deficiency. To overcome this use of chemical fertilizers nitrogen, phosphorus and potassium (N+P+K) is one of the vital inputs in increasing the farm production. The Figure 64 shows that nitrogen (N) application in paddy fields is lesser than the recommended dosage. However the dosage of other major nutrients as per the recommendation.

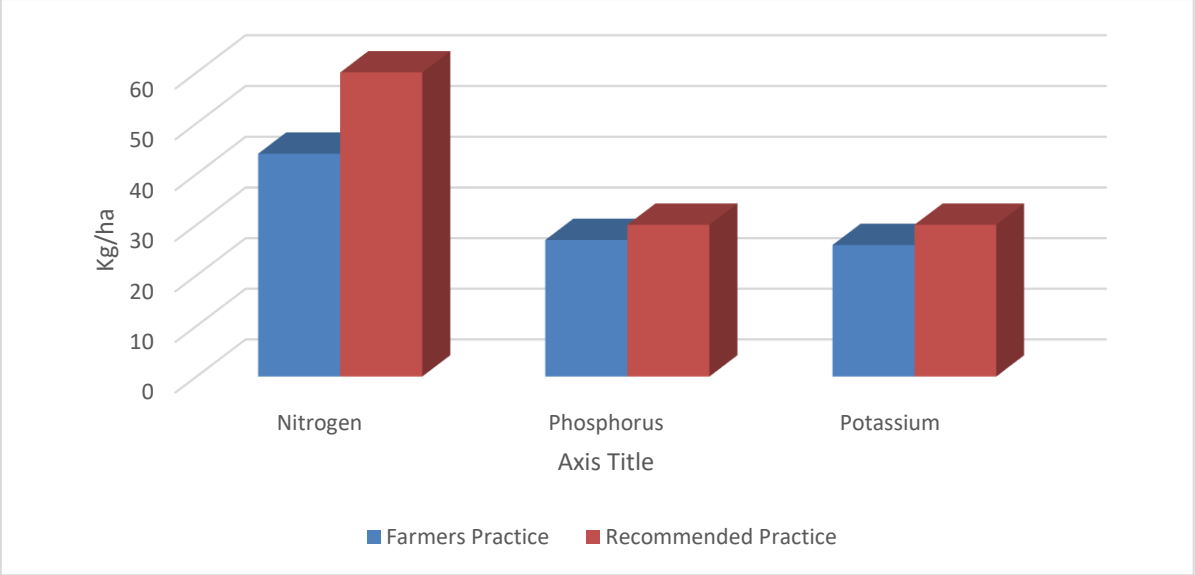

Figure 64: Farmer and Recommended practices of nutrient management

10.1.4.8. Economics of Production-Paddy

Figure 41 discusses about cost benefit analysis of per hectare of rice production at different districts of Odisha. The average gross returns per hectare rice production is Rs 26500 and highest returns was observed in Angul and lowest in Khandamal (Figure 65). The average cost of cultivation amounted to Rs. 13647 per hectare and price per quintal is Rs 1347/quintal. However, the highest Benefit Cost Ratio (BCR) was observed in Boudh compared to other districts due to low cost of cultivation. To improve the BCR across the districts, awareness about the best management practices in paddy should be given to farmers.

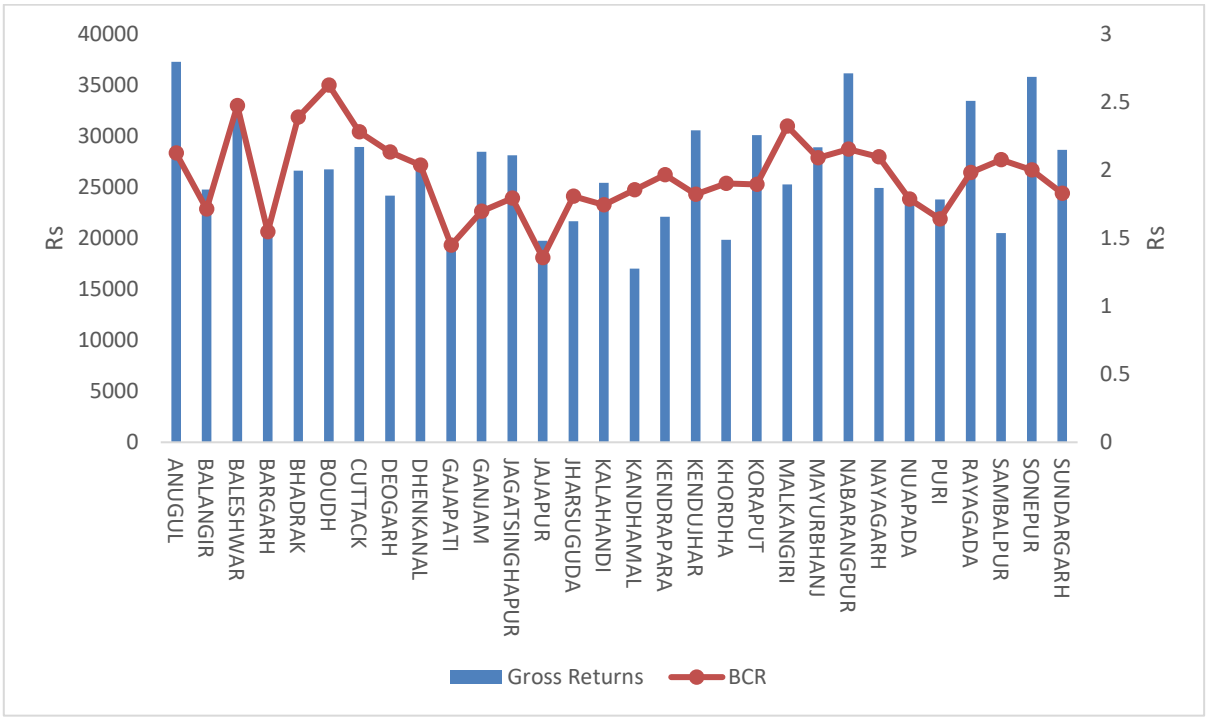

Figure 65: Benefit-Cost ratio of paddy cultivation across the districts

10.1.5. Consumption pattern

The food consumption is also a marker of social status and indicates the presence of social diversity and inequality. Food often becomes an important aspect of the boundaries between groups and shows significant variations across geographies. As the economic activity levels increases the consumption pattern changes. The study also presents the consumption pattern of major food items like cereals pulses, oils and milk (Figure 66). The per capita consumption of cereals per months is around 8 kg/month, pulses 1.31 kg/month, meat/fish 0.64 kg/month, eggs nearly 3/month, oils 0.4 litres and vegatables 3 kg/month. Among the districts, highest cereal consumption was observed in Jagatsighpur and Balasore; pulses consumption in Dhenkanal (Figure 67).

Consumption of different food items varies among socio-economic groups and regions. Persons with better incomes, belonging to 'higher' social class, having small families and working as self employed show higher intake of almost all food items and also exhibit diet diversity which make them nutritionally more secure and healthy. These variations caused by different factors may lead to inequality in nutrition and resultant health behaviour across different groups. Hence government should take necessary steps minimize inequalities across the groups

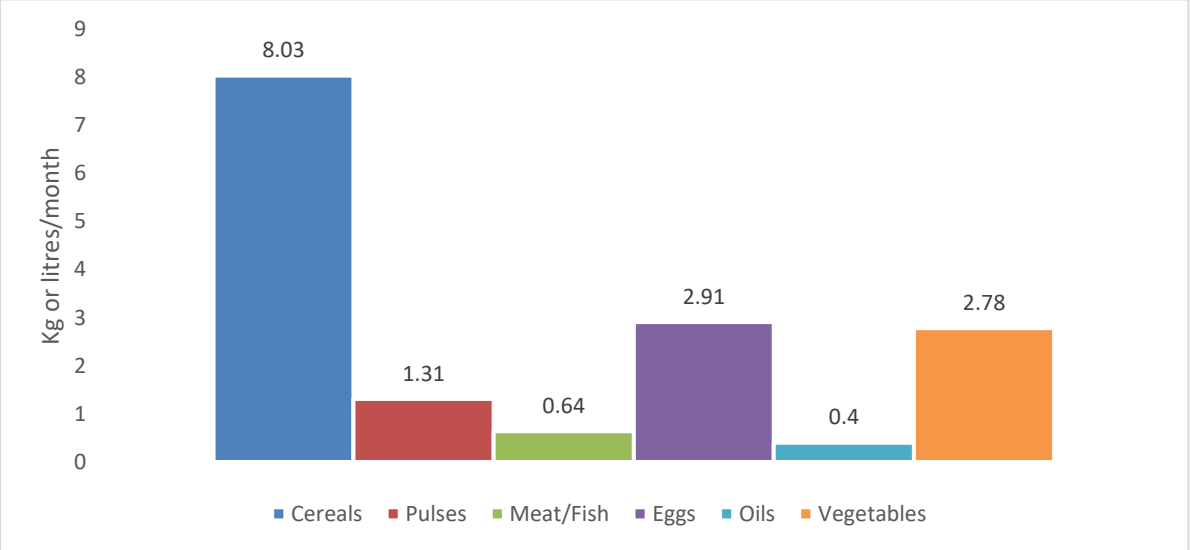

Figure 66: Per capita consumption of food

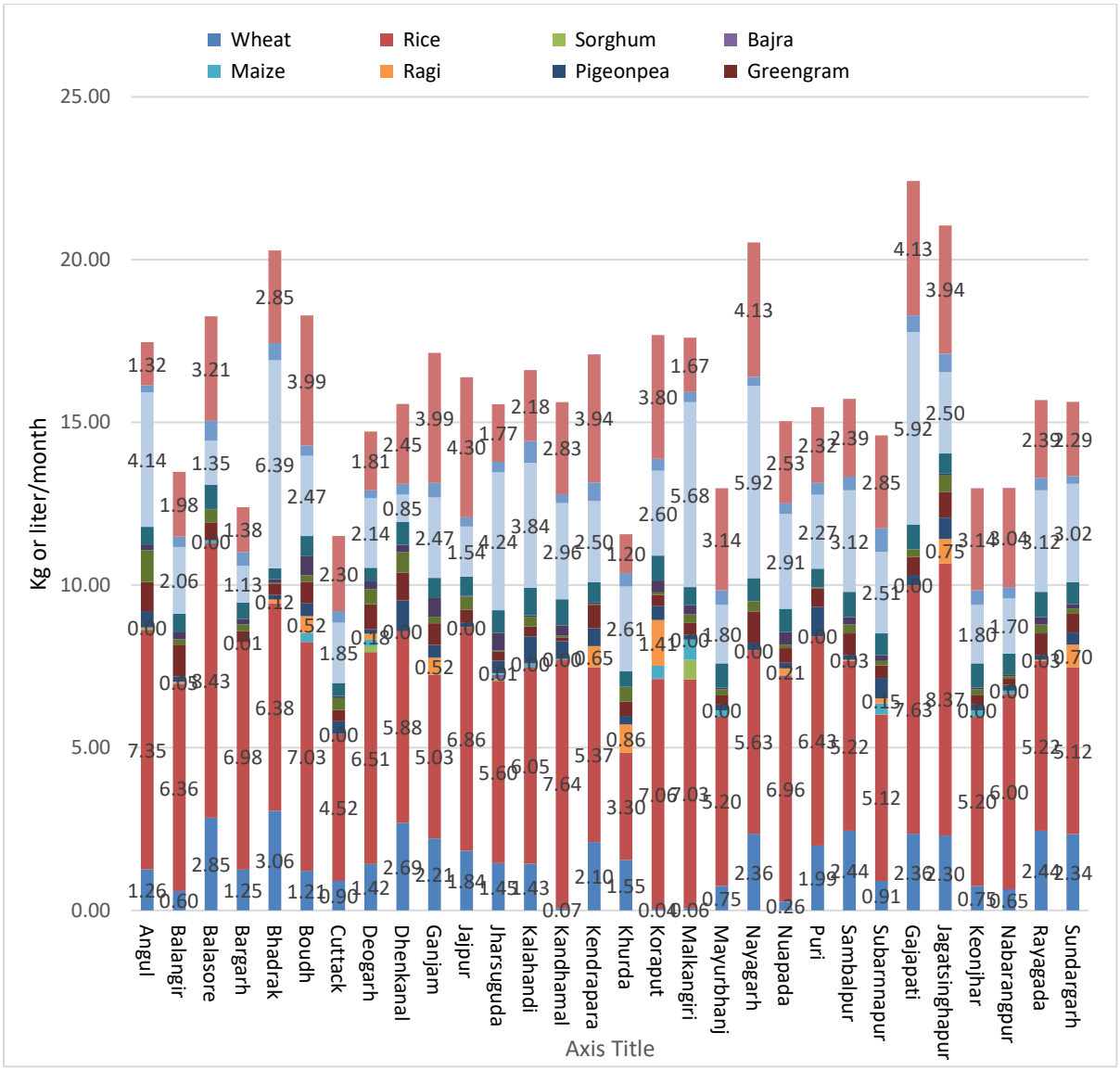

Figure 67: Per capita consumption of food by district

10.1.6. Summary and Conclusions

Agriculture is the mainstay of Odisha is the key to the overall development of the state. It has a total cultivable land area of 6.18 million ha (65% rainfed and 35% irrigated supporting a population of 50 million) out of which 2.91 million ha (47%) is highland, 1.75 million ha (28%) midland and 1.51 million ha (25%) is lowland. According to the statistics the land under agricultural use is nearly 36%, forest area by 16.45%, the area under non-agricultural use by 12.18%, current fallows by 9.41% and remaining area by others classes.

Demographic profile of the respondents shows that the majority of funded farms are located in the younger and mature phases of the life cycle. Nearly 8 percent of respondents are illiterates and 37.3 percent of respondents are literates who have a formal education (lower education) 10.4 percent have completed their education levels more than 10th. The total number of families is differentiated into 40 percent male, 38 percent female, and children 22

percent. The adult male to female ratio is almost 1:1 and the children's ratio is 1:1.25 per household indication that one or two children lived in the family. The Worker Population Ratio (WPR) signifies that 50 percent of persons aged 15 years and above were employed in the State and 60 percent of the workforce was constituted by the male population. The primary occupation of the majority of respondents is agriculture and in 63 percent of districts the respondents reported that their secondary occupation is farm-labor.

Operational holdings is highly skewed with more than 80 percent of those belonging to small and marginal categories and 20 percent belongs to medium and large categories. The share of area under two prominent seasons of Odisha indicates that kharif (rainy season) is the major season for the farmers in the state where it occupies 97% of the total cropped area of a farmer in year. The area under the rabi season is nearly 22% indicating the dependency of farming on rains and other climatic factors. Odisha is primarily a food grain-growing state, and 88 percent of the area in kharif is occupied by food grain crops. Oilseeds and pulses are mainly grown in the rabi season. Paddy is a very prominent crop (85%) of this season and occupies 85 percent of total sown area. Vegetables are third most important crop during the kharif season occupying 2 percent of the cropped area. Cotton is the next to ragi occupying nearly 1 percent of the cropped area in kharif.

The productivity levels of all major crops grown in the state below national statistics indication the need for adopting best management practices. One of the main reason for low productivity can be attributed to low SRR and climatic vagaries. Other reason could be low nitrogen application than the recommended dosage.

The average gross returns per hectare rice production is Rs 26500 per hectare with cost of cultivation amounted to Rs. 13647 and price per quintal is Rs 1347/quintal. The average benefit-to-cost ratio is around 1:2, which means farmer are getting 2 rupees for every one rupee investment. As the cropping intensity is only 119% virtually minimal rabi area, government to focus on rice-fallows. This not improves the economic sustainability of farmer but also adds to gross income to government.

11. Technical backstopping and Team-strengthening

a. Visits by scientists and scientific officers
   In order to monitor the field activities and guide the farmers, regular vistis by the concerned scientists and scientific officers is being done as a regular practice. The District Coordinator's of concerned districts conducted field visits on once in a month basis and the Scientific Officer in-charge of the district on a weekly basis. The RT's in the concerned block and partnering NGOs on daily basis monitor the filed activities and build the capacity of farmers on various aspects of crop practices.
b. Strengthening of ground team
   It is being endeavoured to place atleat one Scientific Officer per district basis and where ever there is a shortfall due to attrition, recruitment is being undertaken on a regular basis to strengthen the filed activity and giving regular advices to the farmers in the project area.
c. Collaboration with OUAT
   To improve the technical competency of the field staff and farmers, efforts are being made to collaborate with Scientists of OUAT by associating them in the capacity building programmes and identification of best bet improved practices across the districts. In this regard one day capacity building programme for RTs and SOs on Kharif, 2019 interventions was organized on 24th June, 2019 under the aegis of the OUAT and ICRISAT scientists. Similarly, the sourcing of seed for the kharif, 2019 and Rabi, 209-20 demonstrations has been done with the activie association of various seed farms under the abled guidance of Dr. T. K. Mishra, ADR (Seeds), OUAT, Bhubaneswar.

Annexures

Annexure 1. Land utilization patterns in different districts of Odisha

District	Geographical Area (Hectare)	Forests (%)	Area Under Non-Agricultural Uses (%)	Barren and Uncultivable Land (%)	Permanent Pasture and Other Grazing Land (%)	Land Under Misc. Tree Crops and Groves not Included in Net Area Sown (%)	Cultivable Waste Land	Fallow Lands Other Than Current Fallows	Current Fallow	Net Area Sown	Total Cropped Area
Anugul	423154	31.43	11.58	2.36	4.49	1.42	6.62	9.93	13.23	18.94	22.33
Balangir	542234	3.69	13.28	2.58	7.01	0.18	4.06	5.72	20.66	42.83	48.52
Baleshwar	350244	1.14	19.70	0.86	4.57	3.14	6.00	2.86	5.14	56.60	67.43
Bargarh	467917	5.34	14.53	2.14	5.13	0.21	4.49	5.34	9.62	53.20	71.68
Bhadrak	237915	0.42	16.39	0.00	5.04	0.84	3.78	2.10	4.62	66.79	68.49
Boudh	202962	16.26	12.81	6.90	9.36	0.00	8.87	6.90	7.39	31.51	32.61
Cuttack	333921	5.69	28.45	1.80	3.59	2.70	4.19	5.99	9.28	38.31	49.31
Deogarh	171237	40.88	8.18	2.92	2.92	0.58	7.01	4.67	5.84	27.00	27.86
Dhenkanal	332410	18.05	12.63	2.71	3.91	2.11	11.13	11.13	14.14	24.19	25.42
Gajapati	308883	20.72	5.18	41.12	4.21	2.27	1.62	2.59	3.88	18.42	21.47
Ganjam	608080	6.91	12.50	8.55	2.63	2.63	6.58	8.06	10.36	41.78	55.94
Jagatsinghapur	172363	0.58	25.53	0.00	4.64	1.74	7.54	2.90	4.64	52.43	74.17
Jajapur	266204	8.26	19.91	7.51	4.13	2.25	3.76	4.88	6.39	42.90	51.70
Jharsuguda	169934	20.01	18.24	2.35	6.47	0.59	6.47	9.42	11.18	25.27	29.45
Kalahandi	579775	20.87	10.18	3.28	5.17	1.21	5.17	6.55	11.04	36.53	48.66
Kandhamal	437605	36.56	3.88	26.05	3.20	0.23	4.57	6.17	8.46	10.88	11.21
Kendrapara	228920	4.81	19.66	0.00	4.81	0.87	1.75	3.49	7.86	56.75	62.89
Kendujhar	648447	22.21	9.41	12.65	3.55	1.08	5.86	7.40	12.03	25.82	31.78
Khordha	272619	10.64	17.61	6.60	5.14	6.97	7.34	5.87	4.03	35.81	43.21
Koraput	608171	14.31	7.40	22.86	3.12	8.55	2.96	4.28	8.55	27.98	33.08
Malkangiri	424270	37.24	6.36	12.02	5.19	0.24	0.94	3.06	8.25	26.70	26.92
Mayurbhanj	699131	11.59	12.59	2.15	4.58	4.58	6.44	7.01	8.87	42.21	45.84
Nabarangpur	401703	18.42	9.96	2.24	3.24	2.99	2.24	2.49	5.23	53.20	54.00
Nayagarh	246117	19.10	13.00	4.88	5.28	2.84	3.66	6.91	6.91	37.43	50.79
Nuapada	244320	14.73	9.41	2.87	5.73	0.41	2.46	5.32	13.10	45.97	49.96
Puri	278053	3.96	20.14	3.24	4.68	7.91	3.60	6.47	11.87	38.14	51.15
Rayagada	572211	19.05	5.59	34.78	2.62	2.62	1.22	3.84	8.39	21.88	22.98
Sambalpur	406530	29.03	8.36	1.48	5.17	0.98	6.40	7.13	9.59	31.86	40.31
Sonepur	185850	6.46	14.53	1.61	4.84	0.00	6.46	7.53	9.15	49.42	74.96
Sundargarh	713881	23.95	10.79	10.37	4.48	0.14	6.72	7.56	7.98	28.00	32.42
State	11535061	16.45	12.18	8.94	4.44	2.20	4.92	5.94	9.41	35.54	42.34

Annexure 2. Education details of respondents

Education	Years of Education	Number	Percentage
Illiterate	Illiterate	296	7.4
Lower Primary	1	6	0.1
	2	169	4.2
	3	213	5.3
	4	605	15.0
	5	511	12.7
Upper Primary	6	81	2.0
	7	296	7.4
High Primary	8	152	3.8
	9	301	7.5
	10	974	24.2
High Secondary	11	5	0.1
	12	166	4.1
Higher Secondary	13	88	2.2
	14	0	0.0
	15	148	3.7
Post Graduation	16	1	0.0
	17	12	0.3
	18	1	0.0
	19	0	0.0
	20	2	0.0

Annexure 3. List of districts as per the serial number in Figure 55 for average productivity of paddy.

S.no	District
1	Anugul
2	Balangir
3	Baleshwar
4	Bargarh
5	Bhadrak
6	Boudh
7	Cuttack
8	Deogarh
9	Dhenkanal
10	Ganjam
11	Jajapur
12	Jharsuguda
13	Kalahandi
14	Kandhamal
15	Kendrapara
16	Khordha
17	Koraput

S.no	District
18	Malkangiri
19	Mayurbhanj
20	Nayagarh
21	Nuapada
22	Puri
23	Sambalpur
24	Sonepur
25	Sundargarh
26	Gajapati
27	Jagatsinghapur
28	Kendujhar
29	Nabarangpur
30	Rayagada

Annexure 4. List of maize growing districts (reference Figure 56).

1	Anugul
2	Balangir
3	Bargarh
4	Boudh
5	Deogarh
6	Dhenkanal
7	Gajapati
8	Ganjam
9	Jharsuguda
10	Kandhamal
11	Kendujhar
12	Koraput
13	Malkangiri
14	Mayurbhanj
15	Nabarangpur
16	Rayagada

Annexure 5. List of finger millet growing districts (reference Figure 57).

1	Gajapati
2	Kalahandi
3	Koraput
4	Malkangiri
5	Rayagada

Annexure 6. List of green gram growing districts (reference Figure 58).

1	Angul
2	Balangir
3	Baleshwar
4	Bargarh
5	Bhadrak
6	Boudh
7	Cuttack
8	Deogarh
9	Dhenkanal
10	Ganjam
11	Jagatsinghapur
12	Jajapur
13	Jharsuguda
14	Kalahandi
15	Kandhamal
16	Kendrapara
17	Kendujhar
18	Koraput
19	Mayurbhanj
20	Nabarangpur
21	Nayagarh
22	Nuapada
23	Rayagada
24	Sambalpur
25	Sonepur
26	Sundargarh

Annexure 7. List of black gram growing districts (reference Figure 59).

1	Anugul
2	Balangir
3	Baleshwar
4	Bargarh
5	Bhadrak
6	Boudh
7	Cuttack
8	Deogarh
9	Dhenkanal
10	Gajapati
11	Ganjam
12	Jagatsinghapur
13	Jajapur
14	Jharsuguda
15	Kalahandi

16	Kandhamal
17	Kendrapara
18	Kendujhar
19	Khordha
20	Koraput
21	Malkangiri
22	Mayurbhanj
23	Nabarangpur
24	Nayagarh
25	Nuapada
26	Puri
27	Rayagada
28	Sambalpur
29	Sonepur
30	Sundargarh

Annexure 8. List of horse gram growing districts (reference Figure 60).

1	Anugul
2	Balangir
3	Cuttack
4	Kalahandi
5	Kendujhar
6	Koraput
7	Nabarangpur
8	Rayagada
9	Sundargarh

Annexure 9. List of groundnut growing districts (reference Figure 61).

1	Anugul
2	Baleshwar
3	Bargarh
4	Cuttack
5	Dhenkanal
6	Ganjam
7	Jajapur
8	Koraput
9	Malkangiri
10	Nayagarh
11	Nuapada

Annexure 10. Soil nutrient status of Odisha State

District	% fields with low C levels	% deficient fields in available nutrients									
		P	K	Ca	Mg	S	Zn	B	Fe	Cu	Mn
Koraput	25	42	15	15	46	87	49	83	0	1	0
Malkangiri	42	67	36	10	40	59	52	92	1	3	2
Angul	34	49	11	6	24	36	61	80	3	3	8
Deogarh	28	64	18	5	21	42	55	76	2	1	1
Jagatsinghpur	44	32	27	2	3	58	55	63	0	0	2
Kendrapara	27	42	17	1	1	36	19	36	0	0	0
Khorda	62	50	38	13	27	65	25	83	0	0	2
Kandhamal	42	50	11	8	54	71	41	87	2	6	0
Nayagarh	54	42	25	4	13	48	42	81	1	0	1
Kalahandi	51	67	11	3	18	54	63	87	3	1	5
Nabrangpur	38	61	21	12	37	70	59	95	0	1	5
Rayagada	53	24	5	7	34	44	28	80	4	3	1
Cuttack	37	34	33	2	8	41	18	83	1	0	1
Dhenkanal	32	56	19	4	17	42	19	74	1	0	2
Puri	44	29	35	10	14	50	30	63	0	4	7
Bhadrak	40	41	25	2	4	49	38	57	1	0	1
Jajpur	49	37	38	6	18	47	25	77	2	1	3
Jharsuguda	39	53	19	18	38	37	21	98	0	0	1
Jharsuguda	39	53	19	18	38	37	21	98	0	0	1
Sambalpur	39	54	18	13	35	44	41	92	2	1	3
Boudh	51	51	29	5	21	52	66	94	8	2	6
Sonepur	36	56	23	6	25	25	64	90	2	2	4
Bargarh	36	37	26	7	38	29	53	90	1	3	3
Balangir	46	68	16	4	21	44	76	92	6	5	7
Nuapada	22	64	1	1	4	27	72	80	2	1	8
Balasore	52	49	47	11	31	37	41	68	5	3	6
Mayurbhanj	45	74	47	26	50	66	39	92	1	1	2
Gajapti	63	49	7	40	76	82	42	93	4	1	2
Ganjam	45	56	15	5	21	40	32	64	1	0	3
Keonjhar	47	69	35	18	42	71	55	90	1	3	2
Sundergargh	47	73	19	15	37	45	39	95	1	5	1
Odisha total	**43**	**53**	**25**	**10**	**28**	**51**	**43**	**81**	**2**	**2**	**3**

About ICRISAT

International Crops Research Institute for the Semi-Arid Tropics

ICRISAT is a member of the CGIAR Consortium

The **International Crops Research Institute for the Semi-Arid Tropics** (ICRISAT) is a non-profit, non-political organization that conducts agricultural research for development in Asia and sub-Saharan Africa with a wide array of partners throughout the world. Covering 6.5 million square kilometers of land in 55 countries, the semi-arid tropics have over 2 billion people, of whom 644 million are the poorest of the poor. ICRISAT innovations help the dryland poor move from poverty to prosperity by harnessing markets while managing risks – a strategy called Inclusive Market-Oriented Development (IMOD).

ICRISAT is headquartered in Patancheru near Hyderabad, Andhra Pradesh, India, with two regional hubs and five country offices in sub-Saharan Africa. It is a member of the CGIAR Consortium. CGIAR is a global research partnership for a food secure future.

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