

Research Article

Sustainable Cereal Production in an Era of Climate Change in the Tribal Dominated Regions of Koraput District of Odisha Through Indigenous Sustainable Farming Practices

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Abstract

Agriculture and forestry are the life support system for tribal. Tribal men and women have been involved in agriculture since the inception of tribal civilization. Our study included 4 revenue blocks, namely Koraput, Jeypore, Kundra, and Boipariguda, of Koraput district of Odisha. We interviewed about 120 stakeholders from farming families using PRA tools and a pre-structured questionnaires. Rice, Finger millet, and Maize were the most commonly cultivated cereals, providing food, nutrition, and livelihood support. In this agricultural system, women farmers play a vital role in preparing organic formulations, as they are the main stakeholders in the entire agricultural operation. Basically, the traditional farming practices they followed meant low-level sustainable production for year-round consumption only. However, tribal farming communities aged 20-35 were found to adopt the introduction of high-yielding and resistant varieties, contributing to enhanced production and economic benefits. Production of local and resistant, high-yielding varieties was compared with the use of both traditional and modern sustainable practices. However, poor infrastructure, economic instability, and a lack of knowledge in commercial-scale cultivation often keep production gains below desired levels. Govt. and private sector participation can improve modern technical knowledge and combine traditional agricultural practices with improved agro-economic practices to enhance sustainable cereal production for livelihoods, socio-economic development, and self-sustainability of vulnerable, resource-poor tribal communities in an era of climate change and modern agricultural systems.

Keywords

Women Empowerment, Sustainable Cereal Production, Tribal Dominated, Stakeholders, Koraput District

1. Introduction

Koraput is one of the tribal dominated districts in Odisha, with 50.5 percent of the population tribal as per the 2011 census. The tribal community has its own lifestyle, and its livelihood depends on agriculture, followed by labor and petty business,

along with some forest collection-based livelihoods. Tribal communities have traditional wisdom and are intelligent enough to follow conventional agricultural practices to make

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them sustainable by balancing livelihood and environmental resources. They are optimistic about their future and therefore protect their agriculture in a sustainable manner, without becoming greedy or overexploiting natural resources. Tribal women are equally involved in agricultural activities at all stages, from plantation to harvesting, as well as post-harvest processing.

Agriculture is a stepping stone for survival but has a considerable impact on the environment. This is driven by a growing human population and demand for both the quality and quantity of food. Challenges related to deficiencies in the production, supply, and consumption of adequate food still persist, and livelihoods are affected more severely. Current estimates predict that, due to rising demand for food from a growing global population, agricultural production is expected to increase. Food becomes more affordable as household incomes rise. Changes in the production and prices of agricultural commodities will mostly affect vulnerable and low-income groups, most specifically women's communities [3]. The increased food production is leading to commercialization, and hence it has a greater impact on the environment. Changes in agricultural and land use patterns are leading to an increase in global emissions of greenhouse gases (GHGs) by nearly 23.1% [8]. In addition to this, there are much more pronounced catastrophic effects, including loss of biodiversity, water deficit, and soil degradation, affecting the environment and causing larger adverse impacts [4]. Faulty agricultural practices involving unsustainable use of natural resources and altered feeding habits create greater economic costs that may deepen the food crisis [11]. The Green Revolution-based agricultural trend, with rampant use of fertilizers and pesticides, produces excessive runoff that harms human health. Poor communities, involving mostly women, children, and the elderly, are mostly vulnerable to food-related poverty with intense food insecurity and malnutrition, which is further worsened by the climate crisis [8]. Three major challenges are putting immense pressure on human civilization: supporting provision for food and nutrition security, sustaining livelihoods, sustainable utilization of natural resources, and resilience against climate change. Implementing innovative agricultural technologies and sustainable production that reduces land use can mitigate these challenges and even help prevent global warming by reducing greenhouse gas emissions, which may reduce the climate crisis [10]. But, it is important to protect vulnerable groups [13]. Innovative technology in the farming practices is meant for sustainable production by reducing the impact of climate change [12].

Agricultural enterprise can scale to amazing success only by introducing the gender equality in agriculture. This is because women farmers usually have less access to land, resources, information, and credit facilities [8]. Currently, women are gaining priority in the agriculture sector through training, involvement in innovative technology, and extension work to narrow the gap and move towards gender equality [9]. This will strategically enhance the opportunity for women in related activities

and can boost their performance and productivity too. [1] More women involvement can make intensification of agriculture with the use of more chemical fertilizers and pesticides and hence more productive gain target will work as stressors to break sustainable framework in agri-culture. It is very important to think about gender equality by providing opportunities to women stakeholders in a sustainable way through the introduction of innovative, sustainable modern technologies [14].

Tribal communities are generally familiar with conventional agriculture through their indigenous technical knowledge of existing crop varieties. These indigenous systems were not changed due to sustainable nature of their agriculture in traditional set up in tribal dominated regions of Koraput. The major crops cultivated include Paddy, ragi, and Maize. Tribal women were mostly engaged in family work along with the males. Due to population growth and increased demand for improved financial infrastructure, they are opting for the introduction of improved and resistant varieties and are involved in cultivation, harvesting, food preparation, and feeding, and are key players in the supply chain. Sustainable cereal cultivation contributes to employment generation and food, nutritional, and livelihood security not only for tribal women but also for their families and the area's vulnerable communities. This seems to be a bonus to the production due to Indigenous technical knowledge involving use of traditional practices such as use of organic manures, biopesticides, crop rotation as a method of traditional methods of sustainable production.

2. Materials and Methods

This study presented a literature review, followed by data collected from various stakeholders through a set of questionnaires and data compilation.

2.1. Research Sites

Our study included 16 tribal-dominated revenue villages in 8 GPs and 4 blocks, namely Koraput, Jeypore, Kundra, and Boipariguda, in Koraput district, Odisha. Two sampling sites (fields) of tribal villages were taken in each GP of the respective blocks. The study was conducted from June 2022 to May 2023. In total, eight sampling field areas were taken for the study of cultivation of three major cereals: Paddy (*Oryza sativa*), Maize (*Zea mays*), and Finger millet (*Eleusine coracana*). Four different blocks of Koraput district, namely Koraput, Jeypore, Kundra, and Baipariguda, were taken for the research study. Two GPs in each block and two villages in each GP were taken for field investigation with respect to different cereal crops. In total, eight GPs and sixteen villages were included for field research with respect to different cereal crops. Umari and Mastiput GPs of Koraput block, Dangorchucha and Patraput GPs of Jeypore block, Kundra and Lima GPs of Kundra block, and Badaput and Mahuli GPs of Boipariguda block were included. Crop field sites in sixteen blocks taken for the research study are Machhara, Khiloput,

Bagaraguda, Dongri Maliguda, Bisoiput, Bodapar, Kanjai, Maliguda, Chendia Jhilligam, Kaudiaguda, Kusumguda, Pradhaniguda, Kasiguda, Bhejaguda, Baliguda and Rauliguda.

2.2. Methods of Data Collection

Data were collected from 120 members of four blocks who are directly involved in cereal cultivation. They were interviewed using a pre-structured questionnaires with PRA tools. This was responsible for generating comprehensive data in the present study.

2.3. Interventions Studied in Cereal Cultivation

The tribal community adopts two types of interventions for cultivation of cereal crops across the Eastern Ghats high-mountain ecosystem. One is an old-age technology used to protect crops from various pests and insects. Another a bending technology based on the modern agriculture practice with indigenous flavor to used improved and resistant varieties with modern sustainable technologies (Table 1).

2.4. Statistical Analysis

The agricultural system was analyzed with reference to investment, production, gross value, and net profit for three different crops. Three major cereals, paddy, finger millet, and maize, were analyzed by two-way ANOVA using SPSS. The insect pests attack response for crop loss and the insect pests found in this region were also documented.

3. Results

Tribal communities almost fully depend on agriculture for their food and nutrition security, socio-economic stability, and livelihood. Three major cereals, paddy, finger millet, and maize, are cultivated in the tribal dominated regions of Koraput and constitute the major staples in the area. Tribal women are the major stakeholders within tribal communities. They contribute to child rearing, household work, as well as farming activities and are involved in all stages of agriculture (Figures 1, 2, 3 and 4). Due to the increase in the tribal population, demand for major staples, especially cereals, increased severalfold. In addition, irregular weather patterns and climate change sometimes reduce major cereal productivity in the area, intensifying the crisis. Tribal communities, since inception, have cultivated their locally available indigenous varieties of cereals by applying Indigenous Technical Knowledge (ITK). The system adopted in the traditional trend was found to be very sustainable but fails to meet the increased demand from a growing population.



Figure 1. Traditional system of finger millet cultivation.



Figure 2. Traditional farming of paddy transplanting.



Figure 3. Modern Technology for weeding.



Figure 4. Modern Technology for weeding

Three different crop varieties, rice, finger millet, and maize, showed different amounts of investment per acre of land, and it differs as investment cost includes Seed, planting material, labor charges, manure and fertilizers, irrigation, and miscellaneous expenses. These expenses differed. Investment for different crop variety and management were found to be different as it is varied between 8,500 per acre to 16,400 per acre. Production was also found to be different between different types of crops. Net profits also differed, with the lowest for Maize and the highest for finger millet (Table 1 Annexure-I). Investment parameters, average production, gross value, and profit are shown in Figures 5, 6, 7, and 8, respectively.

It is evident from the table that both crop production and management were statistically significant, and the corresponding 'F' values for crop and crop management were 130.862 and 191.478, with an interaction value between them of 11.394, which was statistically significant at $p < 0.05$ (Tables 2 and 3). The mean ANOVA values ranged from 10,000 to 15,323 (Table 4). CD values are also significant, with a mean of 1348.077 and SE(m) of 362.709. Similarly, ANOVA for Average production of the three crops shows an 'F' value of 185.866 for the interaction between crop and production, which is statistically significant at the level of $p < 0.01$ (Table 5). The mean of the interaction between the two showed that the crop varied between 15.633 and 26.867, and the mean of production between 15.750 and 27.750 (Table 6). C.D. and SE(m) are found to be 1.137 and 0.306, respectively (Table 7). Similarly, ANOVA for Gross value for three crops shows an F value of interaction between crop and gross value is 426.851 which is statistically significant at the level of $p < 0.01$ (Table 8). The mean interaction between the two factors showed that crop varied between 34,083.330 and 58,816.670, and gross value between 29,925.000 and 56,700.000 (Table 9). C.D. and SE(m) are found to be 1,616.254 and 434.864, respectively (Table 10). Similarly, ANOVA for profit across the three crops shows an 'F' value for the interaction between crop and profit of 643.494, which is statistically significant at the $p < 0.01$ level (Table 11). The mean of the interaction between the two showed that crop varied between 23,091.330 and 43,393.330, and profit between 15.750 and 27.750 (Table 12). C.D. and SE(m) are found to be 1,206.869 and 324.716, respectively (Table 13).

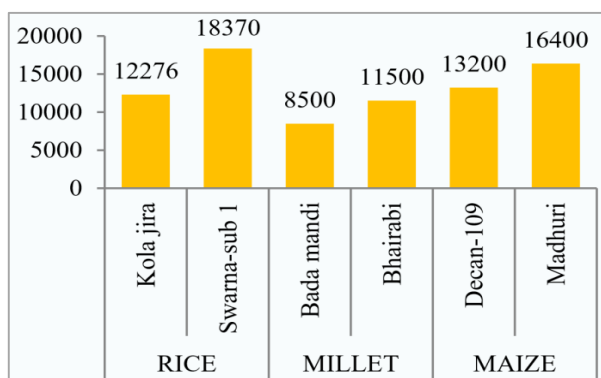


Figure 5. Investment for rice, millet and maize production

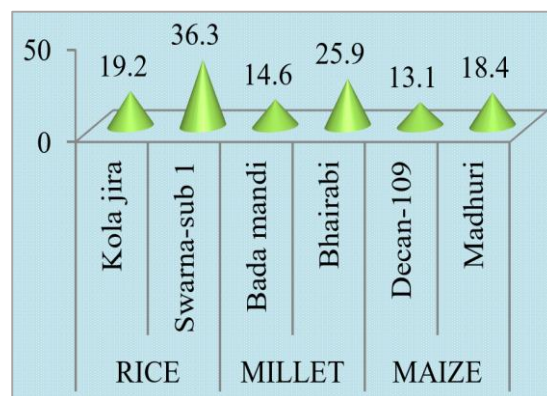


Figure 6. Modern Technology for weeding.

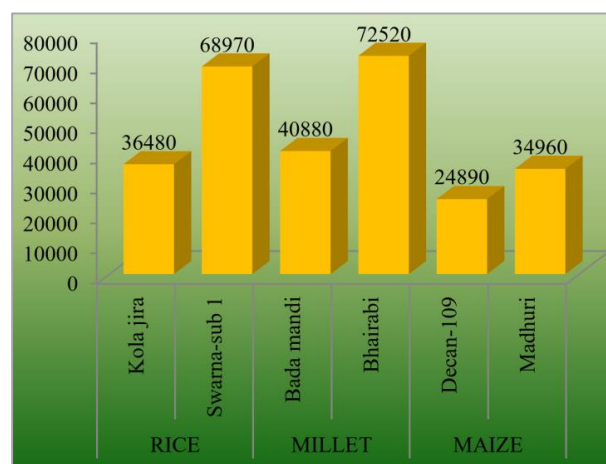


Figure 7. Gross value of rice, millet and maize

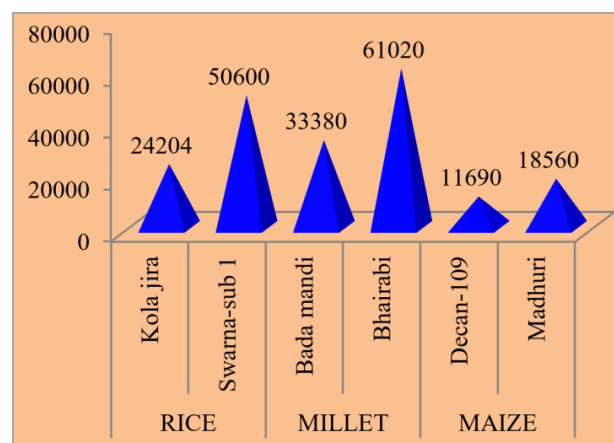


Figure 8. Profit under different cereal production.

5. Discussion

Three Although Kolajira varieties of rice, Bada mandia variety of finger millet and Deccan -109 variety of maize are found to be low input cultivations with investments of INR 12276, INR 8500 and INR 13200 per acre respectively and inputs are higher for some high yielding/resistant varieties like

Swarnim Sub –1 variety of rice, Bhairabi variety of finger millet and Madhuri variety of maize like INR 18370, INR 11500 and INR 16400 respectively but the profit is also higher in case of the improved varieties as compared to indigenous ones.

Profit ranges out of cereal cultivation involving indigenous technology, intervention varied between INR 11690(for Decan-109 variety of maize) to INR 24204(for Kolajara variety of rice) to maximum up to INR 33800(Badamandia variety of finger millet) but in the same areas introduction of improved variety lead to profit ranges between INR 18,560 to INR 61,020.

In Odisha, Swarna Sub-1 variety of rice show higher yield with 4.2% higher number of panicles per square meter as compared to earlier improved variety (Swarna variety) and 15.27% super grain yield too [15]. The production also offered greater profit to the tribal agropreneurs. As compared to traditional variety of Mandia, Bhairibi mandia shows excellent yield of 15.3 quintal per hectare [2]. Along with improved technologies farmers can use improved variety of maize such as Madhuri to enhance the production to about 83.3 q/ha [7].

There is a significant difference with respect to investment and profit observed as per the ANOVA result. It is evident from ANOVA for profit across the three crops shows an 'F' value for the interaction between crop and profit of 643.494, which is statistically significant at the $p < 0.01$ level. It indicates that the tribal farmer can optimize their production with reference to three studied crops with the introduction of improved and resistant variety of rice, finger millet and maize as well as improving the farm management condition with moderate use of fertilizers along with the use of indigenous technical knowledge involving the use of farm made composts as fertilizers and limited use of biopesticides.

6. Conclusions

Present study successfully demonstrated the higher-level crop production in tribal dominated areas of Koraput district with the introduction of improved/high yielding/resistant varieties of crops as compared to their traditional farming technologies with the use of traditional farming practices with the use of indigenous varieties of cereal crops which are used as the major staples in the area including varieties of rice, finger millet and the maize.

Although traditional farming practices involve low input and ecofriendly system but with rise of tribal populace in the era of development this is not sustainable for emerging economy and not suitable to safeguard the livelihood of tribal populace. Although investment amount per acre varied for three major indigenous crops of maize, rice and finger millet varied between INR 8500 to INR 13200 and for improved varieties between INR 11500 to INR 18370 per acre but the profit ranges of indigenous crops lies between INR 11690 to INR 33800 but for that of improved cultivation varied between INR 18560 to INR 61020. The study also emphasized the significance of the traditional farming practices with infusion of modern practices.

Future research should direct and focus towards trial of more improved varieties of staple cereal crops along with other food crops in the area with the use of sustainable technologies involving fusion of traditional as well as modern technologies in the local farm environment. This can not only enhance the financial infrastructure of tribal populace but also build their sustainable livelihood as well as for bright future by conservation of indigenous technical knowledge as well as modern technologies.

Table 1. Crop varieties with investments, production, and Gross revenue and profit in cereal cultivation.

Sl.No	CROP	CROP VARIETY	Crop management	Investment(INR/acre)	Average Production (quintals /acre)	Gross value(INR/acre)	Profit (INR/acre)
1	Rice	Kalajera (Local)	ITK+Low fertilizer use +No chemical pesticide	12,276	19.2	36,480	24,204
		Swarna-sub 1 (HighYielding)	ITK + moderate fertilizer use + moderate pesticide use in emergency	18,370	36.3	68,970	50,600
2	Millet	Bada mandi(Local)	ITK+Low fertilizer use +No chemical pesticide	8,500	14.6	40,880	32,380
		Bhairabi(High yielding)	ITK+ moderate fertilizer use + moderate pesticide use in emergency	11,500	25.9	72,520	61,020
3	Maize	Decan-109	ITK+Low fertilizer use +No chemical pesticide	13,200	13.1	24,890	11,690

SL.No	CROP	CROP VARIETY	Crop management	Investment(INR/acre)	Average Production (quintals /acre)	Gross value(INR/acre)	Profit (INR/acre)
		Madhuri	ITK+ moderate fertilizer use + moderate pesticide use in emergency	16,400	18.4	34,960	18,560

Table 2. Analysis of Variance of crop and crop management and investment.

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	1	142,572.000			
Factor A-crop	2	68,863,810.667	34,431,905.333	130.862	0.00005
Factor B-crop management	1	50,380,812.000	50,380,812.000	191.478	0.00004
Interaction A X B	2	5,996,024.000	2,998,012.000	11.394	0.01373
Error	5	1,315,580.000	263,116.000		

Table 3. Two-Way Mean Table.

	B1	B2	Mean A
A1	12,276.000	18,370.000	15,323.000
A2	8,500.000	11,500.000	10,000.000
A3	13,200.000	16,400.000	14,800.000
Mean B	11,325.330	15,423.330	

Table 4. Table of SEm, SEd and C.D.

Factors	C.D.	SE(d)	SE(m)
Factor(A)	953.235	362.709	256.474
Factor(B)	778.313	296.151	209.410
Factor(A X B)	1,348.077	512.948	362.709

Table 5. Analysis of Variance of Average Production.

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	1	4.563			
Factor A	2	294.000	147.000	784.824	0.00000
Factor B	1	378.563	378.563	2,021.125	0.00000
Interaction A X B	2	69.627	34.813	185.866	0.00002
Error	5	0.937	0.187		

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
Total	11	747.690			

Table 6. Two-way mean table.

	B1	B2	Mean A
A1	19.200	36.300	27.750
A2	14.600	25.900	20.250
A3	13.100	18.400	15.750
Mean B	15.633	26.867	

Table 7. Table of sem, sed and c.d.

Factors	C.D.	SE(d)	SE(m)
Factor(A)	0.804	0.306	0.216
Factor(B)	0.657	0.250	0.177
Factor(A X B)	1.137	0.433	0.306
Factors	C.D.	SE(d)	SE(m)

Table 8. Analysis of Variance of Gross Value.

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	1	3,328,533.333			
Factor A	2	1,670,055,000.000	835,027,500.000	2,207.821	0.00000
Factor B	1	1,835,213,333.333	1,835,213,333.333	4,852.323	0.00000
Interaction A X B	2	322,881,266.667	161,440,633.333	426.851	0.00000
Error	5	1,891,066.667	378,213.333		
Total	11	3,833,369,200.000			Total

Table 9. Two-Way Mean.

	B1	B2	Mean A
A1	36,480.000	68,970.000	52,725.000
A2	40,880.000	72,520.000	56,700.000
A3	24,890.000	34,960.000	29,925.000
Mean B	34,083.330	58,816.670	

Table 10. *SEm, SEd and C.D.*

Factors	C.D.	SE(d)	SE(m)
Factor(A)	1,142.864	434.864	307.495
Factor(B)	933.145	355.065	251.069
Factor(A X B)	1,616.254	614.991	434.864

Table 11. *Analysis of Variance of Profit.*

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Source of Variation
Replication	1	1,575,425.333			Replication
Factor A	2	2,161,428,210.667	1,080,714,105.333	5,124.750	Factor A
Factor B	1	1,236,513,612.000	1,236,513,612.000	5,863.552	Factor B
Interaction A X B	2	271,401,704.000	135,700,852.000	643.494	Interaction A X B
Error	5	1,054,406.667	210,881.333		Error
Total	11	3,671,973,358.667			Total

Table 12. *Two-Way Mean Table.*

Factors	C.D.	SE(d)	SE(m)
Factor(A)	1,142.864	434.864	307.495
Factor(B)	933.145	355.065	251.069
Factor(A X B)	1,616.254	614.991	434.864

Table 13. *Analysis of Variance of profit.*

Factors	C.D.	SE(d)	SE(m)
Factor(A)	853.386	324.716	229.609
Factor(B)	696.786	265.130	187.475
Factor(A X B)	1,206.869	459.218	324.716

Abbreviations

HH	House Hold
GHG	Greenhouse Gases
GP	Gram Panchayat
SHG	Self-Help Group
FPO	Farmer Producer Group
ITK	Indigenous Technical Knowledge.
PRA	Participatory Rural Appraisal

ANOVA	Analysis of Variance
SPSS	Statistical Package for the Social Sciences
CD	Critical Difference
WFC	Women Farming Communities

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hoods related to cereal cultivation. We also thanks all respondents from the tribal farming community who participated in the interview during data collection.

Author Contributions

Samir Mohanty: Investigation, Methodology, Writing-original draft.

Nirmal Chandra Biswal: Formal analysis

Kartik Charan Lenka: Conceptualization, Data curation

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Conflicts of Interest

The authors declare no conflicts of interest.

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Biography



Samir Mohanty working as Lecturer in Zoology in Pendrani Mahavidyalaya, Umerkote, Dist. Nabarangpur, Odisha since from the year 2005. He has completed his Master degree in Zoology from the Berhampur University in the year 2004. He is a research scholar in the field Entomology in Zoology department of GIET University, Gunpur since from 2019. He is particularly expertise in the field of Zoology.



Nirmal Chandra Biswal currently working as Associate Professor in GIET UNIVERSITY, Gunupur in Department of Life sciences and Biotechnology. He has Completed Masters in Zoology from Berhampur University, Bhanja Vihar and completed Ph.D. in zoology from Utkal University, Vani Vihar, Bhubaneswar and qualified TOEFL and GRE conducted by ETS, USA and was selected to pursue doctoral research in University of Nebraska, Lincoln, USA. His current area of research is Fishery sciences, Environ-mental Biology, Toxicology, Conservation Biology and Bio-technology. He is a member and active participant in UN's ONE PLANET NETWORK towards sustainable development.



Kartik Charan Lenka Ph.D in Botany, currently working as a scientist at M S Swaminathan Research Foundation Jeypore, Odisha. Dr Lenka is having expertise on plant taxonomy, development of genetic garden, documenting ethno-medicinal plants, preparation of Peoples' Biodiversity Register, Bio-input production etc. last 20 years. Participated 90 national and international conferred Nuffic fellowship and 21 days study on Biodiversity in Nepal. He has around 35 national and international research articles to his credit. one national fellowship from Department of Science and Technology, Govt. of India (DST) fellowship. He won 5 national and international award in the field of biodiversity conservation.

Research Field

Samir Mohanty: Entomology, Zoology

Nirmal Chandra Biswal: Environ-mental Biology, Toxicology, Conservation Biology

Kartik Charan Lenka: Biodiversity