E-ISSN: 2618-0618
P-ISSN: 2618-060X

NAAS Rating: 5.20
www.agronomyjournals.com
2025; 8(6): 485-490
Received: 01-04-2025
Accepted: 03-05-2025

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Adaptive crop planning for Cuttack: Leveraging soil and rainfall for drought mitigation

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DOI: https://www.doi.org/10.33545/2618060X.2025.v8.i6f.3064

Abstract
An observational study conducted in Cuttack district, Odisha, India, from 1988 to 2024, aimed to assess soil fertility, evaluate rainfall trends and drought patterns, and propose block-wise crop planning strategies to enhance drought resilience. Soil samples from 14 blocks were analyzed for texture (sandy clay loam to loamy sand, with sand: 56-83.3%, clay: 3.2-25.3%), pH (6.3-7.9), organic carbon (3.1-6.4 g kg^{-1}), and nutrients (nitrogen: 209-432 kg ha^{-1}, phosphorus: 4.2-147.5 kg ha^{-1}, potassium: 140.0-431.6 kg ha^{-1}) using standard methods. Rainfall data over the same period showed an increasing trend (e.g., 34.83 mm/year in Banki), with 76.1% of rainfall occurring during the monsoon and moderate droughts affecting 13% of years, particularly in Banki and Damapada. Using Markov chain and incomplete gamma distribution models, block-wise crop plans were developed, incorporating drought-resistant rice varieties (e.g., Pooja, Sarala), pulses, and intercropping systems to enhance agricultural resilience under variable rainfall and drought conditions.

Keywords: Rainfall variability, agricultural drought, meteorological drought, crop growing environment, crop planning

1. Introduction

Rainfall is a critical driver of agricultural productivity, particularly in rainfed regions like Odisha, where monsoonal variability impacts crop yields (Sahu and Mishra, 2005) [10]. Cuttack district, spanning 3933 km^2 in Odisha's east coast plain, experiences a tropical climate with 1601 mm annual rainfall, supporting crops like rice, pulses, and sugarcane. Erratic rainfall and droughts reduce productivity, necessitating tailored crop planning. This study analyzes soil properties and rainfall patterns (1988-2024) across Cuttack's 14 blocks to develop sustainable crop plans, integrating soil fertility and drought patterns to recommend adaptive strategies (Mandal *et al.*, 2015) [5].

2. Materials and Methods

2.1 Study Area

Cuttack district, Odisha, lies between 20°03′-20°40′ N and 84°58′-86°20′ E, at 36 m elevation. Bounded by the Mahanadi and Kathajodi rivers, it comprises 14 blocks across three subdivisions. The tropical climate features temperatures of 11-41 °C and southwest monsoon rainfall.

2.2 Soil Sampling and Analysis

2.2.1 Soil Sampling

Soil samples (0-30 cm depth) were collected from 14 blocks, with 3-5 samples per block, forming 42 composite samples. Samples were air-dried, sieved (2 mm), and analyzed. Core samplers assessed bulk density. Sampling coordinates are shown in Table 1.

Table 1: Geo-Coordinates of Sampling Sites Across Blocks

Sl.	District / Blocks	Latitude	Longitude
1	Cuttack Sadar	20°03' to 20°40' N	84°58' to 86°20' E
2	Baranga	19.083	84.575
3	Kantapada	20.347	86.419
4	Niali	20.130	86.073
5	Tangi-Choudwar	20.561	85.993
6	Salipur	20.484	86.120
7	Nischintakoili	20.479	86.185
8	Mahanga	20.560	86.193
9	Athagarh	19.604	84.814
10	Tigiria	20.280	84.340
11	Baramba	20.420	85.340
12	Narasinghpur	20.464	85.084
13	Banki	20.380	85.530
14	Damapada	20.453	85.102

2.2.2 Physical Properties
Soil texture was determined via the hydrometer method (Bouyoucos, 1927) [1]. Bulk density used the core method. Moisture retention at field capacity (0.033 MPa) and permanent wilting point (1.5 MPa) was measured with a pressure plate apparatus (Richards, 1949) [8]. Available moisture storage capacity (AMSC) was calculated (Peterson *et al*., 1971) [6].

2.2.3 Chemical Properties
Soil pH was measured (1:2.5 soil-to-water) using a digital pH meter (Jackson, 1973) [4]. Organic carbon was determined by wet digestion (Walkley and Black, 1934) [13]. Available nitrogen, phosphorus (P_2O_5), and potassium (K_2O) were measured using alkaline permanganate (Subbiah and Asija, 1956) [12], Bray-P1 extractant (Bray and Kurtz, 1945) [2], and flame photometry (Jackson, 1973) [4], respectively. Nutrient ranges are shown in Table 2.

Table 2: Nutrient Range Classification in Soil

Parameter	Low	Medium	High
Nitrogen (kg ha⁻¹)	<280	280-560	>560
Phosphorus (kg ha⁻¹)	<10	10-25	>25
Potassium (kg ha⁻¹)	<108	108-280	>280
Organic Carbon (g kg⁻¹)	<5.0	5.0-7.5	>7.5

2.3 Rainfall Analysis
2.3.1 Agricultural Drought
Agricultural drought was assessed per National Commission on Agriculture (1976) criteria: Kharif drought (four consecutive weeks with <50% normal rainfall, normal ≥5 mm/week); Rabi drought (six consecutive weeks with <50% normal rainfall).

2.3.2 Meteorological Drought
Meteorological drought was classified per IMD criteria: mild (<25% deficit), moderate (26-50% deficit), severe (>50% deficit).

2.3.3 Rainfall Probability Analysis
Markov chain analysis calculated initial and conditional probabilities of dry and wet weeks (Mandal *et al*., 2015) [5].

2.3.4 Assured Rainfall Estimation
Assured rainfall was estimated using the incomplete gamma distribution model (Mandal *et al*., 2015) [5].

3. Results and Discussion
3.1 Soil Texture, Moisture Retention, and Agricultural Suitability
Soils ranged from sandy clay loam to loamy sand (Table 3). Sand content was highest in Cuttack Sadar (83.3%) and lowest in Mahanga (56%); clay was highest in Damapada (25.3%). Bulk density ranged from 1.4 Mg m⁻³ (Banki, Damapada) to 1.8 Mg m⁻³ (Cuttack Sadar). Field capacity varied from 13.6% (Cuttack Sadar) to 25.2% (Damapada), with Mahanga having the highest available water (11.4%). Sandy soils suit pulses; clay-rich soils support rice (Sahu and Mishra, 2005) [10].

Table 3: Soil Texture, Moisture Retention, and Agricultural Suitability

Block	Soil Separates (%)			Texture	B.D Mgm⁻³	Soil Water retention (%)		
	Sand	Silt	Clay			F.C	P.W.P	Avl. water
Athagarh	70.5	17.3	12.2	SL	1.5	19.3	9.8	9.5
Banki	62.3	15.0	22.7	SCL	1.4	23.7	14.1	9.6
Damapada	57.3	17.4	25.3	SCL	1.4	25.2	15.1	10.1
Barang	69.5	20.7	9.8	SL	1.6	18.7	8.8	10.1
Badamba	60.7	16.7	22.6	SCL	1.4	23.9	14.1	9.8
Cuttack Sadar	83.3	13.5	3.2	LS	1.8	13.6	5.2	8.4
Kantapada	69.7	21.1	9.2	SL	1.6	18.5	8.5	10.0
Mahanga	56.0	27.8	16.2	SL	1.5	22.7	11.3	11.4
Niali	69.3	20.8	9.9	SL	1.6	18.8	8.8	10.0
Nischintakoili	57.7	19.1	23.2	SCL	1.4	24.5	14.3	10.2
Narasinghpur	69.7	19.2	11.1	SL	1.6	19.1	9.3	9.8
Salepur	68.6	20.1	11.3	SL	1.5	19.3	9.4	9.9
TangiChoudwar	65.3	18.2	16.5	SL	1.5	21.3	11.5	9.8
Tigiria	68.0	18.0	14.0	SL	1.5	20.2	10.5	9.7
Max	83.3	27.8	25.3		1.8	25.2	15.1	11.4
Min	56.0	13.5	3.2		1.4	13.6	5.2	8.4
Range	27.3	14.3	22.1		0.4	11.6	10.0	3.0
Mean	66.3	18.9	14.8		1.5	20.6	10.8	9.9
Median	68.3	18.6	13.1		1.5	19.7	10.1	9.9
Mode	72.3	18.1	9.7		1.5	17.9	8.9	9.9

3.2 Soil Fertility and Nutrient Status
Soil pH ranged from 6.3 to 7.9 (neutral in most blocks). Organic carbon was low to medium (3.1-6.4 g kg⁻¹). Nitrogen (209-432 kg ha⁻¹), phosphorus (4.2-147.5 kg ha⁻¹), and potassium (140.0-431.6 kg ha⁻¹) varied, indicating the need for targeted nutrient management (Table 4).

Table 4: Soil Fertility Dynamics and Nutrient Status

Block	pH	Org. carbon (g kg^{-1})	Avail. N (kg ha^{-1})	Avail. P (kg ha^{-1})	Avail. K (kg ha^{-1})
Athagarh	7.3	4.4	297	51.9	312.8
Banki	6.9	6.1	411	9.8	431.6
Damapada	6.8	6.4	432	4.2	216.1
Barang	7.1	3.7	249	92.4	149.3
Badamba	6.8	6.0	405	9.9	177.7
Cuttack Sadar	7.2	3.1	209	147.5	197.5
Kantapada	7.9	3.4	229	106.5	332.2
Mahanga	6.5	5.2	351	23.7	215.8
Niali	7.0	3.8	256	86.7	259.5
Nischintakoili	6.3	6.3	425	9.6	140.0
Narasinghpur	7.4	4.2	283	67.3	384.5
Salepur	7.0	4.3	290	64.2	151.6
TangiChoudwar	6.9	5.4	364	23.2	169.5
Tigiria	7.9	4.5	303	44.7	349.8
MAX	7.9	6.4	432	147.5	431.6
MIN	6.3	3.1	209	4.2	140.0
Range	1.6	3.3	223	143.3	291.6
Mean	7.1	4.8	322	53.0	249.1
Median	7.0	4.5	300	48.3	216.0
Mode	6.91	3.81	257	38.96	149.57

3.3 Rainfall Trends

Annual rainfall increased, notably in Banki and Damapada (34.83 mm/year) (Table 5, Figure 1). Monsoonal rainfall declined in Barang and Tigiria but increased in Banki (27.23 mm/season).

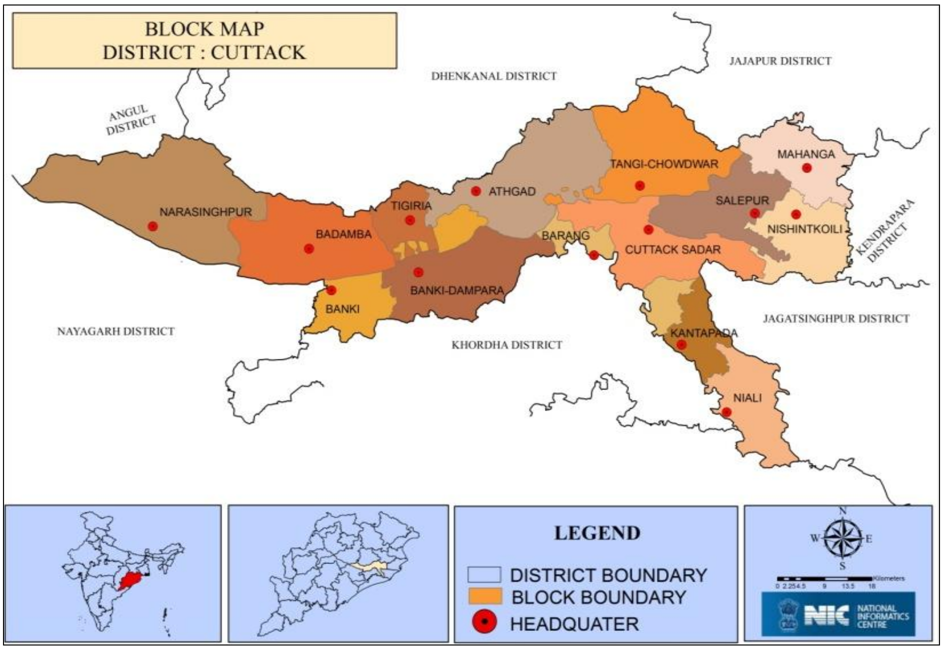

Fig 1: Spatial distribution of the 14 blocks in Cuttack district, Odisha, showing their geographical locations as referenced in the study

Table 5: Long-term Rainfall Trends Across Blocks

Block	Annual Rain (mm)	Annual Rain Equation	Monsoonal Rain Equation
Athagarh	1871	$y = 8.67x + 1719$ (1)	$y = 6.39x + 1295$ (2)
Banki	1809	$y = 34.83x + 1198$ (3)	$y = 27.23x + 915.2$ (4)
Damapada	1809	$y = 34.83x + 1198$ (5)	$y = 27.23x + 915.2$ (6)
Barang	1576	$y = -3.94x + 1640$ (7)	$y = -5.30x + 1288$ (8)
Badamba	1379	$y = 7.30x + 1248$ (9)	$y = 2.79x + 1003$ (10)
Cuttack-Sadar	1555	$y = 3.33x + 1490$ (11)	$y = -1.90x + 1245$ (12)
Kantapada	1791	$y = 26.25x + 1335$ (13)	$y = 19.03x + 1028$ (14)
Mahanga	1708	$y = 9.15x + 1546$ (15)	$y = 6.46x + 1215$ (16)
Niali	1663	$y = -7.15x + 1780$ (17)	$y = -5.78x + 1329$ (18)
Nischintakoili	1488	$y = -4.15x + 1410$ (19)	$y = -1.18x + 1036$ (20)
Narasinghpur	1412	$y = -0.41x + 1420$ (21)	$y = -0.45x + 1075$ (22)
Salepur	1434	$y = 5.51x + 1339$ (23)	$y = 4.85x + 990.6$ (24)
Tangi-Choudwar	1438	$y = 8.19x + 1285$ (25)	$y = 5.67x + 980.2$ (26)
Tigiria	1664	$y = -10.36x + 1838$ (27)	$y = -8.94x + 1431$ (28)

3.4 Seasonal Rainfall Shifts

Kharif rainfall had a coefficient of variation (CV) of 44.8-59.8%; Rabi CV was 125.5-174.1% (Table 6). High Rabi variability necessitates irrigation support.

Table 6: Seasonal Rainfall Shifts and Agricultural Impacts

Blocks	Season	Av. Rain (mm)	% of Total Rain	SD	CV%
Athagarh	Kharif	1425.2	74.8	172.1	48.9
	Rabi	215.4	15.2	126.7	138.5
Banki	Kharif	1401.8	76.5	196.4	55.8
	Rabi	218.9	12.3	139.2	174.1
Damapada	Kharif	1384.6	76.8	202.3	58
	Rabi	208.5	12.1	137.6	173.2
Barang	Kharif	1212.5	75.7	133.8	46.8
	Rabi	177.4	11.3	90.1	139.8
Badamba	Kharif	1065.9	75.9	120.3	44.8
	Rabi	158.2	11.4	85.6	152.3
Cuttack-Sadar	Kharif	1208.3	77.6	147.9	47.6
	Rabi	170.5	10.9	95.3	145.2
Kantapada	Kharif	1352.7	75.8	198.7	57.6
	Rabi	230.9	12.9	112.3	125.5
Mahanga	Kharif	1321.4	77.5	178.2	52.8
	Rabi	190.1	11.5	107.2	149.3
Niali	Kharif	1220.5	73.6	181.1	59.8
	Rabi	232.5	14	118.4	133.7
Nischintakoili	Kharif	1089.8	73.5	129.5	47.9
	Rabi	207.2	14.1	132.8	160.4
Narasinghpur	Kharif	1078.3	75.5	124.6	46.7
	Rabi	149.2	10.4	86.3	137.1
Salepur	Kharif	1095.7	75.1	130.2	49.9
	Rabi	187.9	12.5	109.6	153.2
Tangi-Choudwar	Kharif	1092.4	75.8	128.7	48.3
	Rabi	178.5	12.4	101.2	145.9
Tigiria	Kharif	1268.2	76.6	148.9	45.7
	Rabi	181.3	11.3	98.4	152.8

3.5 Meteorological and Agricultural Drought

Meteorological droughts (IMD criteria) showed 84.5% drought-free years, 13% moderate, and 2.5% severe (Table 7). Agricultural droughts were more frequent, with Narasinghpur (18 years) and Salepur (17 years) most affected, particularly in late season (Sachan and Chandola, 2018) [9].

Table 7: Meteorological and Agricultural Drought in the Cuttack District

	Meteorological Drought						Agricultural Drought			
Blocks	No Drought (Years)	% of Total Years	Moderate Drought (Years)	% of Total Years	Severe Drought (Years)	% of Total Years	Total Drought Years	Early Drought (22-28 SMW)	Mid Drought (29-35 SMW)	Late Drought (36-42 SMW)
Athagarh	30	81	6	16	1	3	7	2	2	3
Banki	29	78	8	22	0	0	15	5	4	6
Damapada	29	78	8	22	0	0	15	5	4	6
Barang	33	89	4	11	0	0	8	6	1	1
Badamba	32	86	4	11	1	3	13	6	3	4
Cuttack-Sadar	30	81	6	16	1	3	12	5	3	4
Kantapada	28	76	7	19	2	5	15	8	3	4
Mahanga	31	84	5	14	1	3	12	5	3	4
Niali	31	84	4	11	2	5	11	5	2	4
Nischintakoili	33	89	2	5	2	5	12	3	4	5
Narasinghpur	34	92	3	8	0	0	18	6	4	8
Salepur	33	89	4	11	0	0	17	6	6	5
Tangi-Choudwar	31	84	5	14	1	3	14	4	5	5
Tigiria	34	92	3	8	0	0	11	4	3	4
District Avg.	31.9	84.5	4.9	13	0.9	2.5	12.9	5.0	3.4	4.5

SMW - Standard Meteorological Week

3.6 Assured Rainfall Estimation

Assured rainfall decreased with higher probability levels (Table 8). At 50% probability, rainfall matched normal values, supporting rainfed farming in Athagarh and Banki.

Table 8: Gamma-Distributed Estimation of Annual Rainfall at Various Probability Levels

Block	Annual Rain (mm)	Probability level (%)				
		90	75	50	25	10
Athagarh	1865	1260	1510	1820	2190	2535
Banki	1812	1100	1380	1750	2170	2598
Damapada	1810	1102	1381	1742	2166	2600
Barang	1580	1172	1345	1555	1788	2015
Badamba	1380	1000	1160	1352	1575	1788
Cuttack-Sadar	1550	1005	1225	1508	1830	2155
Kantapada	1792	1085	1366	1728	2140	2580
Mahanga	1708	1180	1399	1672	1976	2288
Niali	1682	1105	1340	1645	1980	2320
Nischintakoili	1485	1025	1215	1450	1722	1988
Narasinghpur	1412	1095	1230	1392	1575	1750
Salepur	1440	1000	1185	1405	1662	1915
Tangi-Choudwar	1430	988	1173	1403	1662	1915
Tigiria	1660	1186	1382	1630	1905	2180

3.7 Crop Growing Environment
Sandy loam soils dominate, with low water retention in Cuttack Sadar and higher retention in Banki (Table 9). Neutral pH and low organic carbon suggest organic amendments.

Table 9: Crop Growing Environment Across Blocks

Block	Soil Texture	Available Water (%)	Soil Reaction (pH)	Organic Carbon	Available N	Available P	Available K	Assured Rainfall (SMW)
Athagarh	Medium to coarse	Oct-25	Neutral	Low	Medium	High	High	≥20 mm (20-41)
Tigiria	Sandy loam	9.7	Slightly alkaline (7.9)	Low	Medium	High	High	>20 mm (23-41)
Banki & Damapada	Medium to heavy	10	Neutral	Medium	Medium	Low	Medium	>30 mm (25-38)
Nischintakoili	Sandy loam	10.2	Slightly acidic (6.0-6.3)	Medium	Medium	Low	Medium	≥25 mm (24-40)
Barang	Sandy loam	10.1	Neutral (7.1)	Low	Low	Medium	High	≥10 mm (20-41)
Cuttack Sadar	Loamy sand	8.4	Neutral	Low	Low	High	Medium	>25 mm (24-39), >10 mm (23-41)
Kantapada	Sandy loam	10	Slightly alkaline (7.4-7.9)	Low	Low	High	High	>25 mm (24-40)
Niali	Sandy loam	10	Neutral (7.0)	Low	Low	High	Medium	>25 mm (24-41)
Mahanga	Sandy loam to loam	11.4	Slightly acidic (6.5)	Medium	Medium	Medium	Medium	>25 mm (24-40)
Tangi Choudwar	Sandy loam	9.8	Neutral (6.9)	Medium	Medium	Medium	Medium	>10 mm (21-41), >20 mm (23-39)
Badamba	Coarse	9.8	Neutral (6.8)	Medium	Medium	Low	Medium	>30 mm (25-38)
Salepur	Sandy loam	9.9	Neutral (7.0)	Low	Medium	High	Medium	>20 mm (24-40)
Narsinghpur	Sandy loam	9.8	Slightly alkaline (7.4)	Low	Medium	High	High	>25 mm (24-38), >10 mm (20-41)

Table 10: Block-wise Crop Planning Recommendations

Block	Normal (Up to 2nd Fortnight of June)	Early Drought (28 May-8 July)	Medium Drought (23 July-30 Sep)	Late Drought (17 Sep-21 Oct)
Athagarh, Tigiria	Sole: Rice (Pooja, Sarala), Jute (Naveen), Groundnut (Tarini) Intercrop: Rice + Groundnut (1:2)	Sole: Rice (Lalat, Naveen), Groundnut (Devi), Maize (HQPM-5), Moong (Dhauli), Toria (Parvati) Intercrop: Rice + Groundnut (1:2)	Sole: Rice (Jogesh), Blackgram (PU-30), Greengram (PDM-54), Jute (Navin) Intercrop: Rice + Blackgram	Sole: Rice (MTU-1010), Groundnut (Devi), Horsegram (Urmi), Sesamum (Uma), Brinjal (Utkal Tarini) Intercrop: Rice + Groundnut (1:2)
Banki, Damapada, Nischintakoili	Sole: Rice (CR-1018), Blackgram (PU-30), Brinjal (Utkal Tarini) Intercrop: None	Sole: Rice (Pratikhya), Blackgram (PU-30), Groundnut (Devi), Sunflower (KBSH-1) Intercrop: Rice + Blackgram	Sole: Rice (Tulasi), Blackgram (PU-30), Greengram (Sujata) Intercrop: Rice + Blackgram	Sole: Rice (Tulasi), Blackgram (T-9), Horsegram (Urmi), Brinjal (Utkal Tarini) Intercrop: Rice + Blackgram
Barang, Cuttack Sadar, Kantapada, Niali	Sole: Rice (CR-1018), Blackgram (PU-30), Jute (Naveen) Intercrop: None	Sole: Rice (Jaladidhan), Blackgram (PU-30), Groundnut (Devi), Sunflower (KBSH-1) Intercrop: Rice + Blackgram	Sole: Rice (Jogesh), Blackgram (PU-30), Greengram (PDM-54), Jute (Navin) Intercrop: Rice + Blackgram	Sole: Rice (Indravati), Blackgram (PU-30), Mustard (Parvati), Brinjal (Utkal Dipti) Intercrop: Rice + Blackgram
Mahanga, Tangi-Choudwar	Sole: Rice (Pooja), Maize (Kiran), Blackgram (Sarala), Cowpea (Utkala Manika) Intercrop: None	Sole: Rice (Hira), Maize (Kiran), Sesamum (Uma), Cowpea (Utkala Manika) Intercrop: Arhar + Cowpea (2:2)	Sole: Maize (Kiran), Groundnut (Devi), Sesamum (Uma), Cowpea (Utkala Manika) Intercrop: Arhar + Cowpea (2:2)	Sole: Rice (Indravati), Maize (Vivek-21), Sesamum (Uma), Mustard (Parvati) Intercrop: Arhar + Horsegram (2:3)
Badamba, Salepur, Narasinghpur	Sole: Rice (CR-1018), Maize (HQPM-5), Groundnut (Devi), Brinjal (Utkal Tarini) Intercrop: None	Sole: Rice (Jaladidhan), Maize (Kiran), Groundnut (Devi), Blackgram (PU-30) Intercrop: Rice + Blackgram	Sole: Maize (Kiran), Groundnut (Devi), Sesamum (Uma), Cowpea (Utkala Manika) Intercrop: Arhar + Cowpea (2:2)	Sole: Rice (Tulasi), Maize (Vivek-21), Sesamum (Uma), Mustard (Parvati) Intercrop: Arhar + Horsegram (2:3)

4. Conclusion
Block-specific crop planning, integrating soil and rainfall data, recommends drought-resistant rice (e.g., Pooja, Sarala), pulses, intercropping, and fodder crops (e.g., cowpea, mesta) to enhance resilience in Cuttack's variable climate (Table 10).

Acknowledgements
This research received no specific funding.

Competing Interests
Authors have declared that no competing interests exist.

Authors' contributions
Satya Pragyan Kar: Conceptualization, Methodology, Data Collection, Data Curation, Formal Analysis, Visualization, Writing - Original Draft.

Juhi Rani: Investigation, Validation, Writing - Review & Editing.

Nisha Rani Chiranjivi: Software, Statistical Analysis, Data Interpretation, Writing - Review & Editing.

Swadhin Kumar Swain: Resources, Supervision, Writing - Review & Editing, Project Administration.

Bhawna Bhagat: Literature Review, Field Support, Data Entry, Writing - Review & Editing.
All authors read and approved the final manuscript.

Consent
Not applicable.

Ethical approval
Not applicable.

Data availability
The data supporting this study are confidential and not publicly available due to institutional and proprietary restrictions.

5. References
1. Bouyoucos GJ. The hydrometer as new method for mechanical analysis of soils. Soil Sci. 1927;23(5):343-53. https://doi.org/10.1097/00010694-192705000-00003
2. Bray RH, Kurtz LJ. Determination of total, organic and available forms of phosphorus in soils. Soil Sci. 1945;59(1):39-45. https://doi.org/10.1097/00010694-194501000-00006
3. Haldar AK, Srivastava R, Thampi CJ, Sarkar D, Singh DS, Sehgal J, *et al*. Soils of Bihar for optimizing land use. NBSS Publ. 1996;50b:70.
4. Jackson ML. Soil Chemical Analysis. New Delhi: Prentice Hall of India Pvt. Ltd.; 1973.
5. Mandal KG, Padhi J, Kumar A, Ghosh S, Panda DK, Mohanty RK, *et al*. Analyses of rainfall using probability distribution and Markov chain models for crop planning in Daspalla region in Odisha, India. Theor Appl Climatol. 2015;121(3-4):517-28. https://doi.org/10.1007/s00704-014-1229-3
6. Peterson GW, Cunningham RL, Matelski RP. Laboratory measurement of available soil water. Soil Sci Am Proc. 1971;35(6):852. https://doi.org/10.2136/sssaj1971.03615995003500060011x
7. Pradhan A, Chandrakar T, Nag SK, Dixit A, Mukherjee SC. Crop planning based on rainfall variability for Bastar region of Chhattisgarh, India. J Agrometeorol. 2020;22(4):509-17. https://journal.agrimetassociation.org.in/index.php/jam/article/view/92
8. Richards LA. Pressure membrane apparatus construction and use. Agro Eng. 1949;28(10):451-4.
9. Sachan S, Chandola VK. Optimal crop planning under climate change effect using CROPWAT model in canal command area. J Soil Water Conserv. 2018;17(3):267-74. https://doi.org/10.5958/2455-7145.2018.00037.7
10. Sahu GC, Mishra A. Soil of Orissa and its management. Orissa Rev. 2005;16(2):56-60.
11. Sharma P, Praveen B, Talukdar S, Mahato S, Mondal J, Islam ARM, *et al*. Analyzing trend and forecasting of rainfall changes in India using non-parametrical and machine learning approaches. Sci Rep. 2020;10(1):1-21. https://doi.org/10.1038/s41598-020-67228-7
12. Subbiah BV, Asija GL. A rapid procedure for the determination of available nitrogen in soil. Curr Sci. 1956;25(8):259-60. https://www.currentscience.ac.in/Volumes/25/08/0259
13. Walkley A, Black IA. An examination of the Degtjareff method for determination soil organic matter and a proposed modification of chromic acid titration method. Soil Sci. 1934;37(1):29-38. https://doi.org/10.1097/00010694-193401000-00003