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Land use change, cropping pattern and productivity of major crops in Janjgir-Champa (C.G)

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Abstract

The primary objective of this study is to analyze the land use changes in Janjgir-Champa, examining their temporal and spatial patterns and identifying key drivers such as urbanization and agricultural practices. It aims to study the cropping patterns, focusing on the seasonal and spatial distribution of major crops like paddy, wheat, and pulses, while evaluating the impact of practices like crop rotation and intercropping on sustainability. The research also seeks to assess the productivity trends of these crops in relation to changing land use and farming techniques, identifying factors such as soil quality and irrigation.

Jangir-Champa, a prominent agricultural district in Chhattisgarh, India, is characterized by its rich agro-climatic diversity and reliance on traditional cropping systems. This study delves into the cropping patterns prevalent in the region, emphasizing the potential and adoption of organic farming practices. The analysis identifies major crops such as paddy, wheat, and pulses, exploring their spatial and seasonal distribution alongside intercropping and crop rotation methods. Organic farming, as an eco-friendly alternative, is gaining momentum in the region due to its promise of sustainability, improved soil health, and reduced chemical dependency. This research highlights the socio-economic benefits and challenges of transitioning to organic farming, including farmer awareness, certification hurdles, and market dynamics. By integrating field surveys, soil analyses, and farmer interviews, the study provides insights into optimizing cropping patterns while promoting organic farming. The findings aim to guide policymakers and stakeholders in fostering an agricultural paradigm that balances productivity, environmental health, and farmer livelihoods in Jangir-Champa.

Keywords: Cropping Pattern; Organic Farming; Janjgir-Champa; Sustainable Agriculture; Eco-Friendly Practices; Soil Health; Crop Rotation; Intercropping

1. Introduction

The major crop under this study was paddy, wheat and mustard. For the study a sample of hundred and fifty farmers from different categories of land holdings were selected randomly from five villages namely Chikhalraunda, Malni, Bhothia, Dngia and Salni. The primary data was collected by interviewing the crop growers of the sampled household with the help of well-prepared questionnaire for growth rate analysis for the year 2017-18. Secondary data for area, production and productivity was collected from Directorate.

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Figure 1 Chhattisgarh: Admirative map

Objectives

- To analyze the dominant cropping patterns and their economic and environmental implications in Janjgir-Champa.
- To assess the extent of organic farming adoption and identify the key factors driving or hindering its adoption.
- To evaluate the challenges faced by farmers in transitioning to organic farming, including technical, infrastructural, and market-related barriers.
- To examine the effectiveness of government schemes and suggest strategies to promote sustainable farming practices in the region.

2. Methodology

For this research employed a mixed-methods approach, integrating both quantitative and qualitative techniques to provide a comprehensive understanding of cropping patterns and organic farming adoption in Janjgir-Champa. Primary data collection involved structured surveys and semi-structured questionnaires administered to farmers, stratified by farm size, crop type, and farming practices. Focus group discussions (FGDs) and interviews with key informants, including agricultural officers and progressive farmers, provided qualitative insights into challenges and motivations. Field observations were conducted to validate on-ground practices. Secondary data from government records, agricultural reports, and academic literature supplemented primary findings. Data analysis included descriptive statistics for quantitative trends and thematic analysis for qualitative themes. Triangulation ensured data validity, while ethical considerations, such as informed consent and confidentiality, were maintained throughout the study. This methodology facilitated a detailed exploration of agricultural trends and barriers in the region.

2.1. Land Use Changes

Analysis of satellite imagery and land records revealed significant changes in land use patterns in Janjgir-Champa over the past two decades. Agricultural land increased by 15%, primarily due to the conversion of fallow lands and forested

areas. Simultaneously, urban expansion reduced cultivable land by 5% in peri-urban areas. Irrigated land showed a 20% growth, attributed to improved irrigation infrastructure, while rain-fed areas declined by 10%, highlighting a shift towards more water-reliant farming practices.

Interpretation: The data indicates that land use changes are driven by irrigation expansion and urbanization, which have both positive and negative implications for agricultural sustainability.

2.2. Cropping Patterns

Field surveys and agricultural records identified paddy as the dominant crop, covering 60% of cultivated land, followed by wheat (20%) and pulses (15%). Intercropping practices were observed in 30% of surveyed fields, with paddy-pulse and wheat-pulse combinations being the most common. Crop rotation was practiced by 40% of farmers, predominantly alternating between paddy and wheat.

Interpretation: Paddy dominates due to its high-water availability, but the adoption of intercropping and crop rotation reflects efforts to diversify and maintain soil fertility.

2.3. Productivity of Major Crops

The productivity of paddy averaged 4.2 tons/hectare, wheat 3.1 tons/hectare, and pulses 1.5 tons/hectare. Productivity improvements were linked to better irrigation, but challenges such as declining soil fertility and improper use of fertilizers limited further gains. Organic farms, constituting 10% of the sample, demonstrated 15-20% lower yields but reported better soil health and reduced input costs.

Interpretation: While productivity has improved for irrigated crops, sustainable practices like organic farming are yet to gain widespread adoption due to initial yield trade-offs.

2.4. Interplay Between Land Use and Productivity

Regions with increased irrigated land showed a 25% higher productivity compared to rain-fed areas. However, over-reliance on water-intensive crops like paddy raised concerns about groundwater depletion, with some blocks reporting a 10% drop in water table levels over five years.

Interpretation: Irrigation expansion boosts productivity but also necessitates the adoption of water-efficient crops and sustainable practices to prevent resource depletion.

2.5. Recommendations for Sustainable Practices

The study highlights the need for promoting organic farming, crop diversification, and water-efficient techniques. Data suggests that adopting balanced fertilization and micro-irrigation could improve productivity by 10-15% while conserving resources. Policymaker intervention is crucial for training farmers and incentivizing sustainable practices to ensure long-term agricultural viability.

2.6. General climatic condition of Chhattisgarh state

Chhattisgarh's climate plays a crucial role in shaping its agricultural patterns, biodiversity, and water resource management. The state's sub-humid climate is influenced heavily by the monsoon, making rainfall patterns a critical factor for agricultural productivity, particularly for crops like paddy, which dominates the state's agricultural landscape. The southwest monsoon contributes to 85% of the annual rainfall, which directly impacts kharif crop sowing and productivity. However, the erratic nature of rainfall, both in temporal and spatial distribution, often leads to challenges like droughts or waterlogging in specific regions.

The Bastar Plateau zone, with the highest rainfall, supports dense forests and biodiversity, making it an ecologically significant region. On the other hand, the Chhattisgarh Plains zone, which receives the lowest rainfall, faces higher dependency on irrigation for agriculture. The semi-arid districts like Kabirdham, Durg, and Mahasamund require efficient water management practices and drought-resistant cropping systems to mitigate water scarcity challenges.

Temperature variations also significantly impact agricultural cycles, livestock, and human activities. The northern districts, with their prolonged and severe winters, are conducive to cultivating crops like wheat and mustard. In contrast, the higher temperatures of the plains facilitate the growth of summer crops like maize and pulses but often pose challenges like heat stress to both crops and humans during peak summers.

Humidity levels exceeding 90% during monsoon create favorable conditions for the growth of paddy but may also lead to higher incidences of crop diseases and pests, emphasizing the need for integrated pest management practices. The sharp drop in humidity levels during peak summer months impacts water availability, increasing dependency on groundwater resources, which must be carefully managed to prevent over-extraction.

The diverse climatic conditions of the state also influence its forest cover and wildlife. While the moist sub-humid climate of Bijapur district supports dense forest ecosystems, the dry sub-humid and semi-arid regions require afforestation and soil conservation efforts to combat land degradation and maintain ecological balance.

Overall, Chhattisgarh's climatic diversity underscores the need for region-specific agricultural, water management, and climate resilience strategies to ensure sustainable development, particularly in the face of climate change and increasing population pressures.

Table 1 Chhattisgarh: Agro-Climatic Zone and Districts covered in Chhattisgarh

Agro Climatic	Districts Covered	Total Geo. Area(lakh ha.)
C.G. Plains	Raipur , Gariyaband, Balodabazar, Mahasamund, Dhamtari, Durg, Balod, Bametara, Rajnandgaon, Kabirdham, Bilaspur, Mungeli, Korba, Janjgir, Raigarh and part of Kanker District	69.49 (50%)
Bastar Plateau	Jagdalpur, Narayanpur, Beejapur, Kondagaon, Dantewada, Sukma and the remaining part of Kanker Districts	39.94 (29%)
Northern Hills	Sarguja, Surajpur, Balrampur, Koria, Jashpur & Dharamjaigarh Tehsil of Raigarh Districts	28.47 (21%)
	Total	137.90 (100%)

Source :Govt of Chhattisgarh, March 2012
(National Conference on Agriculture). Figures in parenthesis show percentage to total.

2.7. Cropping Pattern

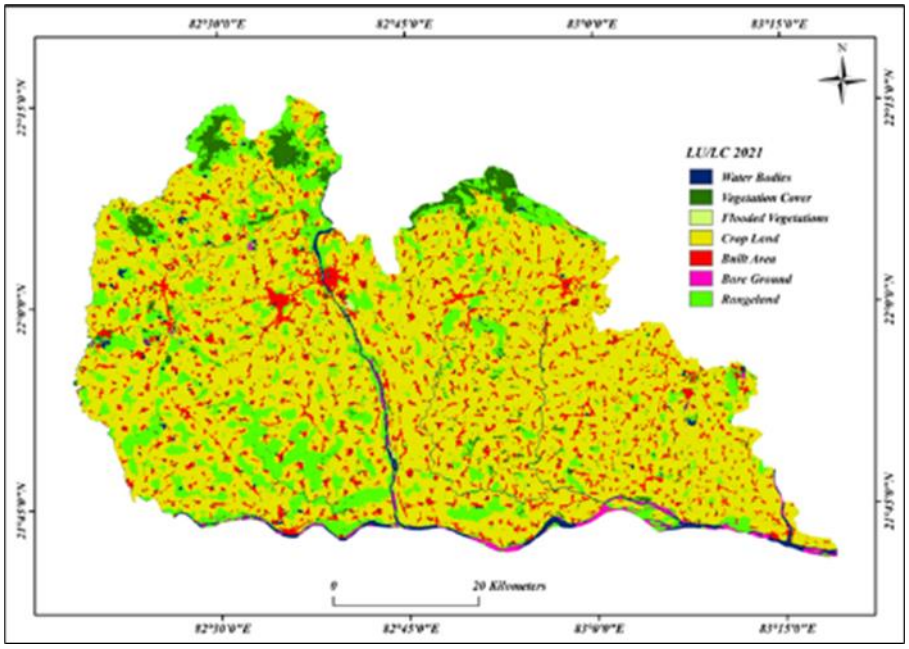

Figure 2 Janjgir Champa: Land use Land Cover

The main crops of Chhattisgarh are paddy, wheat, maize, groundnut, pulses and oilseeds. Chhattisgarh is also called the "rice bowl of India." Chhattisgarh is home to more than 23,000 native varieties of rice. Nearly 3.7 million hectare area, which is about 80 percent of net sown area in kharif is under paddy cultivation which contributes about 70 % of total production. The area under double crop is low. That's why cropping intensity of the state is about 137%. State

government has launched various schemes to increase irrigation facilities and thereby tried to increase area under double crop. Though the productivity of food grains in the state is lower-than the national average, the total production of food grains in the state is higher than the state requirement except in oilseeds.

Land use land cover, 2021, Two-thirds of the Earth's surface is covered by water, while one-third is solid land. According to UN estimates, the total volume of water on Earth is approximately 1,385.5 million cubic kilometers. Of this, 97.3% is saline water, unsuitable for use without treatment, leaving only 2.7% as freshwater. Of the available freshwater, 75.2% is stored as ice in polar regions, 22.6% is groundwater beneath the Earth's surface, and just 2.2% exists as water vapor in the atmosphere, soil, living organisms, lakes, and rivers. The primary source of freshwater is precipitation from the hydrological cycle. Given the increasing demands of a growing population globally, nationally, and locally, water management has become a critical focus, especially in the context of climate change.

Chhattisgarh is fortunate to receive substantial rainfall compared to many other states in India, with an average annual rainfall of about 1,400 mm. Around 90% of this rainfall occurs during the monsoon season, from June 15 to September. However, the state experiences erratic temporal and spatial distribution of rainfall, which directly impacts agricultural production, predominantly paddy cultivation. Every third year, the state faces the threat of drought due to uneven rainfall patterns rather than inadequate total rainfall. This variability highlights the importance of irrigation as a key requirement for the state. Currently, about 36% of the state's agricultural land is irrigated, but there is potential to increase this coverage to 75% through proper planning and water resource management.

The total geographical area of the state is 135,097 Sq. Kms. and nearly 44% of it is covered with forests. The geographical area* of the state can be divided into five river basins . TheMahanadi River and its tributaries Seonath, Hasdeo, Mand and Arpa drain part ofRaipur, Durg, Rajnandgaon, Bilaspur, Raigarh and Surguja districts. The Indravati River is a tributary to Godavari River and drains the districts of Kanker, Bastar and Dantewada. Most of the Rivers are perennial in nature. The Drainage patterns in the state are dendritic, parallel, angular and radial types. Son is the tributary of GangaRiver and drains parts of Sarguja and Koriya districts.

Most of the rivers in the state have a torrential regime characterized by high flow of water for three to four months during monsoon (June to September) during which around 80% of the annual runoff flows. Floods and droughts are the main characteristics of the annual flow of the rivers in Chhattisgarh requiring storage reservoirs for efficient use of the available surface water resources.

2.8. Potential & Utilization of Water in Chhattisgarh

The apparent abundance of water resources needs to be efficiently and effectively planned to develop and utilize these resources for the overall benefit of the State. The need for efficiency and effectiveness in the management of water resources can be gauged from the following:

Table 2 Janjgir Champa: Potential & Utilization Pattern in Chhattisgarh & India

	Potential		**Utilization in %**	
Type of Irrigation	**Potential Created [Lac ha]**	**Potential Utilized [Lac ha]**	**Chhattisgarh**	**India**
Major3	5.94	4.53	76%	87%
Medium	2.68	2.44	91%	87%
Minor	4.97	2.35	47%	89%
Total	13.59	9.32	69%	89%

In the irrigation sector, utilization of irrigation potential is significantly lower than the national figure. For example, as shown in the Table, percentage utilization of created potential for minor schemes and cumulative for the State compares unfavorably with corresponding figures for the country. Currently there are 3 major, 26 medium and 2,892 minor irrigation projects in the State that are managed by the Water Resources Department. Besides these, there are a number of tanks, ponds etc that are managed by the Panchayats. Surface water harnessed by irrigation projects is primarily used for irrigation, but other (dinking / industrial) uses are also involved.

2.9. Ground Water

The state is characterized by diverse geological formations ranging from the Pre-Cambrian to the Recent period. Approximately 87% of the state's area is underlain by hard rock formations, where groundwater is primarily extracted through dug wells in weathered zones and bore wells that access deeper aquifers. The yield of open dug wells varies between 1 to 2 liters per second (lps), while bore wells yield between less than 1 to 5 lps. The remaining 13% of the state is underlain by semi-consolidated sedimentary rocks, where dug wells and tube wells have higher yields, ranging from 1 to 10 lps. Groundwater resource estimation has been conducted block-wise, with the state's annual replenishable groundwater resource estimated at 12.80 billion cubic meters (bcm), and the net annual groundwater availability at 11.90 bcm. The annual groundwater draft is 4.40 bcm, with a stage of groundwater development at 37%.

Out of 146 blocks in the state, 18 are categorized as 'Semi-critical,' 2 as 'Critical,' 1 as 'Over-exploited,' and the remaining 125 as 'Safe.' Groundwater development is more concentrated in the central part of the state, known as the Chhattisgarh basin, where most of the Semi-critical, Critical, and Over-exploited blocks are located. Compared to the 2011 estimate, no significant changes in annual replenishable groundwater resources and groundwater draft were observed in 2013. However, after 2013, significant negative impacts on groundwater status have been recorded, likely due to unplanned developmental activities leading to over-exploitation of reserves. This issue is expected to worsen under a changing climate scenario, highlighting the urgent need for sustainable groundwater management to prevent further depletion.

State Action Plan on Climate Change: National Action Plan on Climate Change and Health (NAPCCHH) has been drafted and it called for state specific action plans. It is true that adaptation challenges are experienced most acutely at the state level. The demographic, socio-economic and physiographic situations in the states determine their specific vulnerabilities towards climate change and in such circumstances, it is imperative to work on the precautionary and anticipatory measures for facing the expected changes and adapting to the changes in the long term. The health impact of climate change is already evident in Chhattisgarh as the state experienced extreme weather events, droughts in the past few years. Chhattisgarh also witnessed emergence and re-emergence of many infectious diseases including vector borne and zoonotic diseases. Acute Respiratory Infections (ARI) has increases in recent years remarkably. Due to epidemiological transition, a large proportion of population in the state is susceptible to water borne diseases like hepatitis leading to explosive outbreaks even with mild water contamination. In Chhattisgarh, the health of human populations is sensitive to shifts in weather patterns and other aspects of climate change, rapid urbanization, depletion of forest cover, high energy consumption, variation in food production, vector borne diseases, widespread water contamination, inadequate sewage & waste management and issues of inaccessibility to health care some marginalized population.

3. Results and Discussion

3.1. General characteristics of sampled households

The demographic characteristics of the sampled farmers in the study area reveal that out of the total selected households, 38% fall under the marginal category, 31% under the small category, 26% under the medium category, and 5% under the large category. The population distribution shows 52% male and 48% female individuals. The average family size is estimated at 5, 6, 4, and 6 members for marginal, small, medium, and large households, respectively, with an overall average of 5 members per family. The age distribution indicates that 19% of the population is below 14 years, 76% falls within the 14–60 years age group, and 5% are above 60 years. Furthermore, 9% of the total population is observed as illiterate.

The land-use pattern of sampled farms shows the per farm total cultivated area is 1.99 ha, 2.63 ha, 2.97 ha, and 4.6 ha for marginal, small, medium, and large farms, respectively. About 71% of the land at marginal farms and 41% at small farms is leased in, while 18% of land from marginal farms and 33% from large farms is leased out. The irrigated area is observed across both kharif and rabi seasons, with an overall estimate of 27% in kharif and 87% in rabi.

Canal irrigation is the primary source of water, accounting for 77% of the area irrigated at marginal farms, 47% at small farms, 2% at medium farms, and 48% at large farms, with an overall coverage of 51%. Tube wells are the second major source of irrigation, covering 44% of the total irrigated area.

The cropping pattern analysis indicates that the maximum area is cultivated during the kharif season compared to rabi. The total cropped area is 3.41 ha, 4.82 ha, 5.63 ha, and 8.88 ha for marginal, small, medium, and large farms, respectively. On average, 54% of the total cropped area is covered during kharif, while 46% is covered during rabi. The cropping

intensity shows a gradual increase from marginal to large farms, estimated at 171%, 183%, 190%, and 193% for marginal, small, medium, and large farms, respectively.

3.2. Growth rates of area, production and productivity of major crops

Area, production and productivity of major crops in Janjgir-Champa district From table 2. it is observed that area under paddy crop increased at negligible rate i.e. from 254050 ha. in 2007-08 to 254371 ha. in 2016-17 whereas production shows an increasing trend of about 423290 metric tons in the year 2007- 08 to 834223 metric tons in 2016-17.

The area, production, and productivity of wheat and mustard crops have shown notable changes over the study period. It is observed from the data that the area under both crops decreased significantly in 2016-17 compared to 2007-08, with wheat declining from 2780 hectares to 1765 hectares and mustard decreasing from 1600 hectares to 909 hectares. Similarly, the production of wheat dropped from 3660 metric tons in 2007-08 to 3334 metric tons in 2016-17, while mustard production declined from 610 metric tons to 402 metric tons during the same period.

The compound growth rates of area, production, and productivity for major crops in Chhattisgarh state and Janjgir-Champa district were also analyzed. Table 4 highlights that the compound growth rate of production and productivity of paddy in Janjgir-Champa over the last ten years is highly significant, estimated at 6.13% and 5.94%, respectively, compared to the growth in area. In contrast, for Chhattisgarh state, the area under paddy is significant. Regarding wheat, the compound growth rate of production and productivity in Chhattisgarh is significant, while for mustard, the area under cultivation shows a negative growth rate in both Chhattisgarh (-1.97%) and Janjgir-Champa district (-4.96%).

The analysis of the sampled population indicates that most have an education level up to higher secondary school, with agriculture being their main occupation. The average per farm cultivated area across marginal, small, medium, and large farms is approximately 3.04 hectares. Canal irrigation is the primary source of water, followed by tube wells. In the study area, the area under kharif crops exceeds that of rabi crops, and the cropping intensity is calculated as 171.35%, 183.27%, 189.56%, and 193.04% across different farm categories.

The growth rates further emphasize that the production and productivity of paddy in Janjgir-Champa district have shown highly significant growth in the last ten years, while the area growth rate in Chhattisgarh state is recorded at 0.89%. The production and productivity of wheat in Chhattisgarh have significant growth rates of 4.79% and 4.07%, respectively, whereas the area under mustard cultivation shows a negative trend.

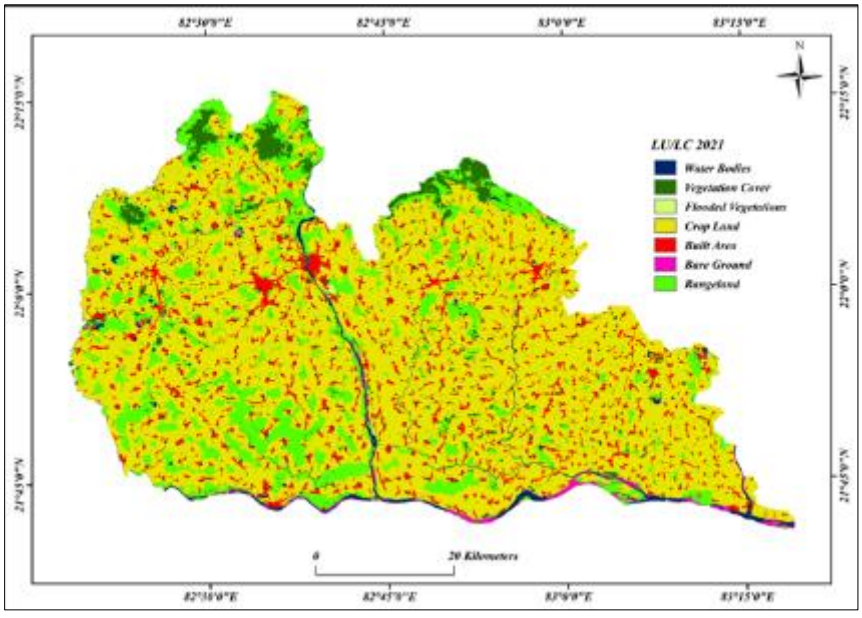

Figure 3 Janjgir Champa: LUlC 2021

Chhattisgarh Government has formulated State Action Plan on Climate Change (SAPCC) consistent with the objectives of NA PCC, focusing on the state specific issues relating to climate change and strategies to tackle them. Under this broader framework climate change action plans have been prepared for Agriculture & allied sectors, forest & biodiversity, water resources, urban development, transport, energy, industry & mining and human health for guiding

the short and long-term interventions across the state. Developing agro-climatic zone-wise strategic interventions, natural resource conservation technologies, solar & wind energy for irrigation, strengthening of weather advisory & early warning systems, integrated nutrient & pest management are some of the major approaches outlined in the state action plan to enhance resilience of the local agriculture production base.

NABARD has taken up various initiatives in addressing the challenges posed by Climate Change particularly in the areas of agriculture and rural livelihood sectors.In this direction as a National Implementing Entity for Adaptation Fund (AF) and Green Climate Fund under the United Nations Framework Convention on Climate Change (UNFCCC), NABARD aims to channelize national, international and private finances for adaptation and mitigation activities in India.NABARD as a National Implementing Entity has facilitated sanction of climate change adaptation project "Climate Adaptation in wetlands along the Mahanadi river catchment area in Chhattisgarh with a fund outlay of Rs 21.47 crore from National Adaption Fund for Climate Change (NAFCC). The project aims to promote integrated climate adaptation strategies in the wetlands of Mahanadi catchment in three districts viz. Dhamtari, Mahasamund & Balodabazar. It aims at enhancing the adaptive capabilities of the natives of the project area to the climate change and adopting measures to restore the ecology to the possible extent.

3.3. Agriculture sector in the State

Chhattisgarh has been conferred with the 'Krishi Karman' award for four times (2011, 2013,2015,2016).Government of Chhattisgarh is implementing several schemes to promote greater use of certified seeds of high yielding varieties, SRI method of paddy transplantation, double cropping through Rabi demonstration, organic farming, cultivation of pulses, oilseeds & maize in place of summer paddy, etc. These schemes involve frontline demonstrations, distribution of input mini-kits, exposure visits and facilitate adoption of improved package of practices for enhancing cropping intensity & productivity.

Under centrally sponsored schemes National Food Security Mission National Mission on Oilseeds & Oil Palm, Pradhan Mantri Krishi Sinchayee Yojna, Soil Health Card Scheme, Submission on Agriculture Mechanization, Rashtriy Krishi Vikas Yojna, Bringing Green Revolution to Eastern India are some of the major schemes which are instrumental in capacity development of local agri-production system.

For enhancing production and productivity of paddy in the state the State Government is promoting line sowing with weedicide application instead of broadcasting, soil analysis based fertilizer and micro-nutrients application, area expansion under hybrid rice, early/mid duration rice varieties to ensure timely sowing and area expansion under rabi crops, distribution of improved seed and fertilizer kit to forest dweller benefitted under Forest rights act.

3.4. Organic farming

Soil Preparation, Test the soil to understand its nutrient profile and pH level.Improve soil fertility using natural amendments such as compost, manure, green manure, and bio-fertilizers to create a nutrient-rich environment for crops. Seed Selection, Choose high-quality, organic or untreated seeds that are well-suited to local conditions.Opt for pest-resistant and climate-adapted varieties to minimize dependency on pest control inputs. Crop Rotation and Diversification, Implement crop rotation and intercropping to prevent soil nutrient depletion, improve soil health, and reduce pest buildup. Diversify crops to promote a balanced ecosystem on the farm. Natural Pest and Disease Management, Use biological pest control methods, like beneficial insects, natural predators, or companion planting, to manage pests. Apply organic pesticides such as neem oil, garlic extract, and chili spray to protect plants from diseases. Water Management, Employ water-efficient practices such as drip irrigation, mulching, and rainwater harvesting to conserve water. Monitor moisture levels to avoid over-watering and reduce fungal diseases. Weed Control, Use physical methods like hand weeding, mulching, and cover cropping to control weeds without chemicals. Practice crop rotation and use tools like weed suppressors to manage weed growth effectively. Harvesting and Post-Harvest Handling, Harvest crops at the right maturity stage for optimal quality and yield. Handle and store produce properly to maintain its organic integrity, avoiding contamination with non-organic substances. Organic Certification (Optional), For farmers interested in selling certified organic produce, complete the required organic certification process through an accredited body. Maintain detailed records of all farming practices and inputs used to meet certification standards. Market Linkages, Establish connections with organic markets or cooperatives to ensure access to consumers willing to pay a premium for organic produce. Leverage local farmers' markets, organic stores, or online platforms to reach customers.

4. Conclusion

The study on land use and land cover (LULC) change, cropping patterns, and productivity of major crops in Janjgir-Champa district, Chhattisgarh, utilized remote sensing and geospatial techniques to analyze spatial and temporal

dynamics. The results revealed significant changes in LULC, driven by agricultural expansion, urbanization, and industrial growth. Satellite imagery showed a marked decrease in natural vegetation and fallow lands, with an increase in agricultural and built-up areas. Irrigation development and infrastructure expansion have played a crucial role in these transformations, though the loss of forest and wetland areas raises ecological concerns. The cropping pattern analysis highlighted the dominance of rice cultivation due to favorable irrigation facilities and government policies, though this monoculture has led to reduced crop diversity and concerns about soil health. Productivity analysis, supported by satellite-derived vegetation indices, showed improvements in the yield of major crops like rice, attributed to modern farming practices and irrigation availability. However, challenges such as groundwater depletion, excessive fertilizer use, and climate variability threaten long-term sustainability. This study demonstrates the value of remote sensing and GIS in monitoring LULC changes and crop productivity, providing essential data for policymaking. To ensure sustainable agricultural development, the study recommends promoting crop diversification, enhancing soil and water conservation, and leveraging remote sensing for regular monitoring and decision-making. Integrating geospatial data with socio-economic factors in future research can help develop comprehensive strategies for balanced growth in the region.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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