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HARNESSING ARTIFICIAL INTELLIGENCE FOR SUSTAINABLE AGRICULTURE IN CHHATTISGARH: OPPORTUNITIES AND CHALLENGES

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ABSTRACT

The integration of Artificial Intelligence (AI) into agriculture is reshaping farming practices by offering sustainable solutions tailored to regional needs. In Chhattisgarh, a state with a predominantly agrarian economy and a large population of small and marginal farmers, AI holds significant promise in addressing key challenges such as low productivity, climate vulnerability, and inefficient resource use. AI-enabled systems—including precision farming, automated irrigation, drone-based crop monitoring, and predictive analytics—can reduce dependency on manual labor, optimize input utilization, and increase crop yield with minimal environmental impact. By leveraging AI, farmers in Chhattisgarh can monitor soil health, detect pest infestations early, and access timely market insights, all of which contribute to more resilient and eco-friendly agricultural practices. Moreover, AI can aid government agencies in better policy implementation, subsidy targeting, and disaster response through real-time data analysis. However, barriers such as inadequate digital infrastructure, limited awareness among farmers, and high costs hinder widespread adoption. To achieve sustainable and inclusive agricultural growth, it is crucial to promote localized AI solutions, capacity building, and supportive policy frameworks. This paper explores the transformative potential of AI in promoting sustainable agriculture in Chhattisgarh, evaluates ongoing initiatives, and outlines strategic recommendations for scalable implementation.

Keywords: Artificial Intelligence, Sustainable Agriculture, Precision Farming, Chhattisgarh, Climate Resilience, Rural Development, Smart Farming, Agritech, Digital Inclusion, Policy Framework

1. INTRODUCTION

Agriculture in Chhattisgarh, often referred to as the “Rice Bowl of India,” plays a pivotal role in the socio-economic fabric of the state. With over 70% of the population dependent on agriculture for livelihood, ensuring the sector's sustainability is both a developmental and environmental imperative. However, Chhattisgarh’s agriculture is marred by challenges such as fragmented landholdings, unpredictable weather patterns, water scarcity, and limited access to modern farming technologies. These challenges are exacerbated in rural areas where small and marginal farmers constitute the majority.

Amidst these constraints, Artificial Intelligence (AI) emerges as a transformative force capable of reshaping the agricultural landscape. From enabling precision farming to real-time crop and soil monitoring, AI technologies offer scalable solutions to improve productivity, reduce environmental impact, and build climate resilience. With the potential to enhance decision-making, optimize input use, and bridge information gaps, AI can catalyze a shift toward sustainable agriculture.

This paper delves into the multifaceted role AI can play in advancing sustainable agriculture in Chhattisgarh. It examines the current state of AI adoption, identifies key barriers to implementation, and explores opportunities for integrating AI in a manner that aligns with local needs. By contextualizing technological possibilities within the socio-economic realities of the region, the study aims to propose actionable pathways for inclusive and sustainable agricultural development.

2. LITERATURE REVIEW

The application of Artificial Intelligence (AI) in agriculture has gained significant attention globally as a means to improve productivity, sustainability, and climate resilience. Countries like Israel, the Netherlands, and the United States have pioneered AI-driven innovations such as drone-based crop monitoring, AI-enabled irrigation, and predictive analytics, leading to substantial improvements in farm efficiency Mulla (2013), Wolfert et al. (2017). These global advancements have laid the groundwork for developing region-specific AI applications in countries like India.

At the national level, initiatives such as Digital India, PM-Kisan, and AI for Agriculture Innovation (AI4AI) by NITI Aayog have highlighted the potential of AI in enhancing food security and empowering rural economies. Studies by Kumar and Rajan (2021) and Singh et al. (2022) emphasize the role of AI in precision agriculture, particularly in improving input management, crop health monitoring, and yield forecasting. These studies indicate that when AI tools are adapted to local agro-climatic conditions and coupled with policy support, they can significantly boost smallholder farm incomes.

Despite this promise, research also points to key limitations in regional implementation. Sharma et al. (2020) noted that Eastern Indian states like Chhattisgarh face structural challenges such as fragmented landholdings, low digital literacy, and weak infrastructure that impede the deployment of advanced technologies. The digital divide remains a significant barrier, especially in tribal and remote areas, where internet access and smartphone usage are limited NITI Aayog. (2020).

Furthermore, several scholars have stressed the importance of contextualized AI solutions that reflect local languages, traditional farming practices, and socio-economic conditions Deshmukh and Patil (2021). Incorporating indigenous knowledge into AI systems not only enhances trust among rural users but also ensures relevance and inclusivity. The role of academic and public-private partnerships has also been recognized as critical in bridging the gap between research and field-level implementation Choudhury et al. (2023).

The existing literature also identifies the need for robust policy frameworks, data governance standards, and ethical guidelines to support AI adoption in agriculture. Without clear regulations and public trust, the scalability of AI applications remains limited Raman and Dubey (2022).

In sum, while global and national evidence affirms the transformative potential of AI in agriculture, region-specific studies and strategies are essential to address the unique barriers and opportunities present in Chhattisgarh. This research contributes to the literature by focusing specifically on AI integration within the state's socio-economic and agricultural context.

To explore existing research and real-world applications of AI in agriculture both globally and nationally, with emphasis on insights relevant to Chhattisgarh.

1) Global trends in AI-based agriculture (e.g., in Israel, the Netherlands, USA).
2) National initiatives (like Digital India, PM-Kisan, AI4AI by NITI Aayog).
3) Previous studies on AI in Indian agriculture.
4) Gaps in research specific to regional implementation (Eastern India, tribal areas, Chhattisgarh).

3. RESEARCH METHODOLOGY

Currents research study is based on descriptive research analysis based on secondary sources i.e. Government reports, agri-tech platforms, academic journals, and Interviews with farmers'. For finding results analysis based on SWOT analysis or PESTEL analysis (Political, Economic, Social, Technological, Environmental, Legal) to assess AI adoption in the state. For this research study we have selected Chhattisgarh State for data collection. We have also taken information from Government schemes and support mechanisms (e.g., Rajiv Gandhi Kisan Nyay Yojana).

3.1. APPLICATIONS OF AI IN SUSTAINABLE AGRICULTURE

Below are the major areas taken as research variables to understand role of AI in sustainable Agriculture in the state.

1) **Precision farming:** Soil health analysis, input optimization.
2) **Irrigation management:** AI-enabled drip irrigation.
3) **Crop health monitoring:** Drones, remote sensing, pest/disease detection.
4) **Yield prediction & market intelligence.**
5) **Supply chain optimization:** Post-harvest management and logistics.
6) **AI in policy planning:** Resource allocation, weather forecasting, subsidy targeting.

3.2. OPPORTUNITIES FOR GROWTH IN THE CHHATTISGARH

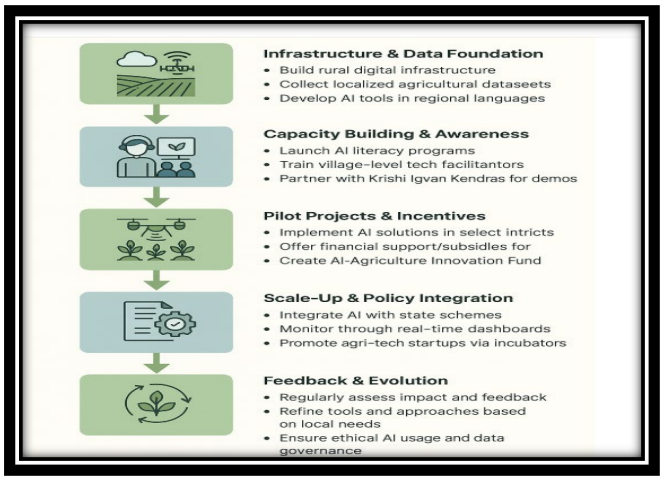
Chhattisgarh presents substantial opportunities for growth through the integration of AI in agriculture, particularly by empowering tribal and rural communities with digital tools that can improve decision-making and productivity. The region holds promise for fostering a vibrant ecosystem of agri-tech startups, generating new employment opportunities in AI-driven services such as precision farming, data analysis, and smart supply chain management. Moreover, AI technologies can significantly enhance agricultural resilience by enabling early warnings and adaptive strategies against droughts, pest outbreaks, and other climate-related risks. Strategic partnerships with academic institutions and agri-tech firms can further accelerate innovation, ensure contextual relevance of solutions, and support capacity-building efforts across the state.

3.3. CHALLENGES AND BARRIERS

The implementation of AI in agriculture in Chhattisgarh faces several significant challenges and barriers that must be addressed for effective adoption. One of the foremost issues is the digital divide, characterized by low internet penetration and limited access to technology in rural and tribal regions, which restricts farmers' ability to engage with AI tools. High initial costs of AI solutions, coupled with the lack of affordable financing options, further discourage adoption, especially among small and marginal farmers. Additionally, concerns around data privacy and the absence of standardized data protocols pose risks and reduce trust in AI systems. Farmer skepticism, driven by low digital literacy and unfamiliarity with emerging technologies, hampers user acceptance and engagement. Finally, policy and regulatory gaps, including the lack of a clear framework for AI deployment in agriculture, create uncertainty and inhibit both public and private sector initiatives from scaling effectively.

3.4. RECOMMENDATIONS

Suggested policy roadmap for AI in sustainable agriculture in Chhattisgarh



To harness the transformative potential of Artificial Intelligence (AI) in Chhattisgarh's agriculture sector, a comprehensive and inclusive strategic approach is imperative. First, robust policy support through a State-level AI-Agriculture Mission, integration with existing schemes like PM-Kisan and RKVY, and financial incentives for AI adoption can provide a clear framework and motivation for stakeholders. Second, capacity building is critical—farmer training programs, AI literacy centers at Krishi Vigyan Kendras (KVKs), and the development of "AI Champions" at the village level will ensure grassroots engagement. Third, public-private partnerships should be fostered by encouraging collaborations with agri-tech startups, academic institutions such as IIIT Naya Raipur, and agri-universities to pilot innovations. Fourth, significant investment in infrastructure—including rural internet connectivity, mobile platforms, and localized data centers—is necessary to bridge the digital divide. Fifth, the creation of localized AI models tailored to Chhattisgarh's soil, weather, and crop conditions, developed in regional languages, will enhance relevance and adoption. Additionally, ensuring inclusivity by making AI tools accessible to women and marginalized communities, and embedding traditional knowledge into AI systems, will promote equity. Finally, a

strong monitoring and evaluation mechanism with real-time dashboards and outcome-based metrics should be implemented to continuously assess AI effectiveness in improving yields, reducing input costs, and increasing adoption rates.

CONFLICT OF INTERESTS

None.

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