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AI & Emerging Technology in Coconut Cultivation in India

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ABSTRACT

This theoretical study explores the transformative role of AI and Emerging Technology in Coconut cultivation in India. In recent years population growth, rising labour and input prices, depletion of natural resources, shrinking land area, global climate change, rising temperatures, and a high prevalence of pests and illnesses, food security is the world's biggest concern. The Food and Agriculture Organization estimates that by 2050, there will be two billion more people on the planet, but only 4% more land will be farmed. As a result, smart farming becomes essential. It goes without saying that essential to upgrade traditional farming methods in an economical manner. By boosting agricultural productivity and giving them more control over prices, technologies like artificial intelligence (AI), cloud machine learning, satellite imagery, and advanced analytics can empower small-holder farmers and increase their income. AI is currently being quickly incorporated into agriculture through sensors, drones, and robotics. AI has gone from being a buzzword to a reality due to a confluence of algorithmic developments, data proliferation, and increases in processing power and storage. The most disruptive technology in agricultural services is expected to be cognitive computing in particular. For example, farmers were able to transition from conventional agricultural methods to precision farming with the

use of drones or unmanned aerial vehicles (UAVs). This theoretical study is to investigate the various functions of artificial intelligence (AI) and new technologies, with a focus on how they could improve rural livelihoods and encourage the inclusive, sustainable growth of the coconut sector.

INTRODUCTION

A prominent position in the Indian economy is held by the agriculture sector. The production, employment, and export growth rate contributions of agriculture and related sectors are continuously rising. Although Indians grow a variety of crops throughout the year, the cropping pattern has changed from traditional to commercial after independence. At the moment, India is the world's biggest producer of a variety of dry fruits, textiles based on agriculture, raw materials such as roots and tube crops, pulses, eggs, coconut, sugarcane, and a wide variety of vegetables. Another significant commercial crop in Indian agriculture is coconut.

The Coco's Nucifera is the botanical name for the coconut palm. It is known in Sanskrit as Kalpavriksha, or God's gift, Tree of Heaven. It is also referred to as the Tree of Life and Nature Supermarket since every component of the palm serves a purpose. In some communities, where it appears in their myths, songs, and oral traditions, it has cultural, social, and religious importance. Additionally, it had ceremonial value and gained religious significance in South Asian cultures, where it is utilized in Hindu rites from a person's birth to their death.

Global Scenario of Coconut

The International Coconut Community (ICC) 2024-25 study states that total production to rise from 3.50 million metric tons (MMT)in 2024 and 3.56 MMT in 2025. The Asia-Pacific region produces the most coconuts worldwide. Together, the top three coconut-growing nations Indonesia, the Philippines, and India—account for around three-fourths of the world's coconut production. The Philippines had the greatest area covered by coconut plantations, whereas India accounted for the highest portion of global coconut nut production and productivity.

India is one of the progressive countries which has export potential of horticultural crops. India is the second largest producer of horticultural crops in the world. Here is a need to study the growth of the

production and exports of fruits and vegetables, particularly most of the potential fruit like coconut. The total coconut production in India is 20,535.88 million nuts (2022-23).

Kerala, Karnataka, and Tamil Nadu, Andhra Pradesh, accounted for 90.04% of India's total production and 89.13% of its total land, were the main locations for coconut cultivation. When compared to unscientific methods, it has been shown that implementing scientific technologies in coconut cultivation can result in a four-fold increase in production. Therefore, there was the greatest potential to increase coconut yield by implementing scientific cultivation technology. Tamil Nadu and Andhra Pradesh had the highest productivity shares among the major coconut producers, whereas Kerala and Karnataka had the largest shares in terms of both production and area. Though Kerala has the largest share in area and production of coconut in the country, it has lower yield compared to all other major producers like Karnataka.

More than 12 million people in India depend on the coconut palm for their livelihood and food security. Additionally, it is a crop that produces fiber for around 15,000 coir-based enterprises, which employ close to 6 lakh people. At 9,871 nuts per hectare, the national coconut productivity for FY24 was among the greatest in the world. The nation's traditional coconut-based industries include the production of coir, the extraction of coconut oil, and the processing of copra. With 89.13% of the country's total area under cultivation and 90.77% of its total production in FY24, Kerala, Karnataka, Tami Nadu, and Andhra Pradesh account for the majority of India's coconut production. Other states in the nation that produce coconuts are Gujarat, Assam, Bihar, West Bengal, Orissa, and Maharashtra.

Coconut farming is more than just an agricultural practice—it’s a critical industry that supports millions of livelihoods globally. With over 60 million metric tons of coconuts produced annually this industry is a powerhouse in tropical economies. However, as we look to the future, the industry must adapt to new challenges through innovation and sustainability.

In view of this, the study makes a modest attempt at understanding role of AI & Emerging technologies in coconut cultivation, that contribute on economic growth and sustainability factors that helps to enhance the livelihood of coconut growers and also improve coconut productivity to overcome the problems faced by the coconut growers.

Utilization pattern of Coconut

According to Coconut Development Board, the utilization pattern of coconut has changed significantly in last few years. Mature coconuts, of which 30 percent were used domestically and 69 percent for

industrial purposes, accounted for about 91 percent of production. Approximately 80% of the industrial use was transformed into copra, of which 31% was ball copra and 69% was milled to make coconut oil for use in cosmetics, toiletries, and other items. Other industrial uses, such as the creation of value-added products such desiccated coconut, virgin coconut oil, coconut milk or cream, slice, grated, or dried coconut, accounted for the remaining 20%.

Technological Innovation

Revolutionizing Transparency and production modernizing coconut farming is mostly dependent on technology. Drones and satellite imagery are being used in precision agriculture to assist farmers monitor crop health and manage irrigation. It has been demonstrated in this method can reduce water use by 30% while increasing yields by up 20%. Another revolutionary development is blockchain technology. By improving supply chain transparency, it guarantees that customers can track the provenance of the coconut goods they purchase. Such openness is essential for preserving consumer confidence and promoting ethical sourcing methods, as the worldwide coconut water market is expected to reach a valuation of $4.97 billion in 2030.

Innovation and sustainability must be embraced if coconut farming is to survive. By 2025, the demand for coconut goods is predicted to reach $15 billion worldwide, therefore the sector needs to embrace sustainable practices, adjust to environmental difficulties, and use technology to its advantage. We can guarantee that coconut farming remains an essential and sustainable component of the global economy for many generations to come by helping the farmers at the core of this sector.

REVIEW OF LITERATURE

The integration of AI and Emerging technologies into agriculture has generated a robust body of academic literature that explores its multifaced impact on coconut cultivation, productivity and livelihood outcomes.

A number of farming methods have changed as a result of the integration of Internet of Things (IoT) technology, which offers previously unheard-of simplicity and efficiency. IoT can potentially revolutionize agricultural practices drastically, and also (Chacko, N. M., et.al 2023) emphasizing the significance of interdisciplinary collaboration and the consequences of BIoT deployment in agriculture.

The study indicated that the farmers' decision to adopt bioagents was largely influenced by their level of education, farming experience, agricultural returns, and the availability of technical support. (Devi, P.

Indira, et.al 2015) Subsidies make technology more affordable, but they do not guarantee long-term uptake or appropriate scientific application.

Green technology is applied with the understanding of preserving the environment and natural resources while lowering human participation. Green technology helps the agriculture sector in a nation like India flourish sustainably. The research made an effort to explain green technology and associated jargon, as well as how it contributes to sustainable development. (T. R. Ghadiyali, M. M. Kayasth 2013) the research addresses a number of scientific and practical aspects of green technologies, including wind energy, biomass, biogas, biofuel, organic farming, integrated pest management, and the use of ICT to support green technology.

ML model is derived that helps in predicting fertilization requirements based on soil parameters. A model called Linear Regression is built to predict the amount of fertilizer needed using the values of soil parameters such as soil pH, potassium, nitrogen, phosphorus, boron, zinc, soil carbon, manganese, and so on as input features. (Lekshmi, Gs, and P. Rekha, 2022). With a 93.5% prediction accuracy for fertilizer, the model shows promise and can be utilized by farmers as a scientific agricultural tool to increase crop yields.

Meaning of Artificial Intelligence:

The ability of a machine to carry out cognitive processes like perception, reasoning, learning, and problem solving that we identify with human minds can be referred to as artificial intelligence (AI). Through the use of computational models, it is the study of mental abilities and enhances the functionality and capacity of computers. Applying machine learning to extremely big data sets has led to the majority of recent advancements in AI.

The revolutionary technology known as artificial intelligence (AI) makes it possible for robots to solve problems in a manner similar to that of humans. AI enables companies to make more informed decisions at scale by doing everything from image recognition and creative content creation to data-driven prediction. Organizations create enormous volumes of data via sensors, user interactions, and system logs in today's digital environment. AI uses this data to improve marketing campaigns, automate customer service, and provide actionable insights through advanced analytics.

APPLICATIONS OF AI IN COCONUT SECTOR

Through better disease and nutrient deficiency diagnosis, precision irrigation and fertilization, resource allocation optimization, harvesting process automation, and data-driven insights via crop mapping and monitoring systems, artificial intelligence (AI) has the potential to completely transform coconut production in India. Applications that result in higher yields, lower costs, and more sustainable practices include automated DE husking machines, AI-powered platforms for health prediction and nutrient management, drone-based pest and disease monitoring, and AI bots for interactive farmer support.

All of the AI applications in agriculture apply to the cultivation of coconuts in India. In addition, there is a great deal of promise for the use of AI in quality control and the coconut processing sector. A few of the several studies that have been conducted on the application of AI in coconut sector are listed below.

Coconut fertilizer application: The crop's productivity and profitability are largely dependent on the timely and sufficient application of fertilizers. To forecast the amount of fertilizer needed, many statistical and computational methods can be applied. Impressive methods for forecasting fertilizer application rates are provided by Artificial Neural Network and Deep Neural Network models. A study on the Impact of Deep Neural Network on predicting application rate of fertilizers with focus on coconut trees of Kerala Northern Coastal Plain Agro ecological unit by Suchithra and Maya (2018) has revealed that the predicted accuracy rate for fertilisers - Urea, Muriate of Potash and lime using Deep Neural network was more than 95% accurate in the coconut sector.

Automated harvesting of coconut through robots: According to research on color and contour-based recognition of coconut bunch stems, Rajesh et al. (2017) shown that fully automated robots might be used to identify coconuts for harvest and bunch cutting. Robots that can be controlled remotely have been created to climb palm trees and gather coconuts.

Modelling of an industrial drying process through artificial neural networks: According to Assidji et al. (2008), a neural network architecture could be used to address the quality problems in grated coconut caused by inadequate product humidity regulation. In the initial drying cycle, the percentage of rejected products might be lowered to 3%. These applications could be used in the processing of coconuts to create a variety of goods with additional value, such as desiccated coconut and coconut milk powder.

Detecting adulteration in coconut oil: The marketing of coconut oil faces a significant problem due to the high rate of adulteration with less expensive oils and even additional chemicals. According to a study on olive oil conducted by Ordukaya and Karlik (2017), ML and an electronic nose could be used to successfully complete an adulteration test for quality control in olive oil. For identifying and classifying

quality control in various olive oil kinds, both approaches were shown to be quicker and significantly less expensive than traditional chemical analysis techniques. It would be possible to use comparable methods to coconut oil.

Production forecasting and Modelling: More accurate marketing choices would come from production forecasting. The production of coconuts could be modelled and predicted. Rathod et al. (2018) used non-linear support vector regression and time delay neural networks to model and forecast oilseed production using artificial intelligence.

AI-Powered Coconut DE husker: An inventive way to improve and expedite the coconut DE husking process is the AI-powered coconut DE husker machine. This device analyses each coconut's characteristics, including size, shape, and husk thickness, using sophisticated artificial intelligence. In light of this study, the machine cleverly modifies its torque and speed to guarantee reliable and effective husk removal without causing any harm to the coconut.

AI integration enhances performance and dependability by enabling the machine to adjust to changing coconut conditions. The machine's automated operation, easy-to-use controls, and safety features increase efficiency and decrease human labor, making it perfect for processing coconuts on a small or large scale. This AI-powered solution guarantees accuracy, saves time, and boosts output by fusing contemporary technology with conventional DE husking requirements. It provides a clever and sustainable way to satisfy the expectations of the coconut business.

AI-powered chatbots: It is also known as virtual assistants, are being employed in the media, insurance, retail, and travel industries. By offering farmers advice and solutions for certain issues, agriculture might potentially benefit from this technology. The artificial Intelligence chatbot for Assisting Farmers in Detecting Coconut Tree Diseases initiative seeks to empower coconut farmers by offering an innovative solution for disease detection and control. This AI-powered chatbot will act as a virtual adviser, providing agricultural information and professional advice suited to farmers' individual requirements. The bot's capacity to examine uploaded photographs of coconut trees, using powerful image recognition algorithms to identify different crop illnesses, is crucial to its operation. Following diagnosis, the chatbot will provide full information about the diagnosed illnesses, including causes and suggested preventative actions.

By using this technology, farmers will have access to timely information to treat tree health concerns, thereby increasing agricultural productivity and sustainability. The chatbot will also have an

interactive interface, enabling farmers to ask questions and get individualized advice tailored to their specific agricultural situations. Through this initiative, we want to bridge the gap between technology and traditional farming techniques, promoting a more informed and proactive approach to agricultural disease control in the coconut sector.

Automated Tapping: According to Charles Vijay Varghese, founder of Nava Innovation, new technologies can identify the best moment to tap a tree and monitor its health. A game-changing technology is poised to transform toddy and neera tapping from coconut trees and address the shortage of qualified tappers. By using AI robots and the Internet of Things, the automatic sap tapping system created by Kochi-based agri-start-up Nava Innovation will gather fresh or toddy sap from a container at the base of the coconut tree, doing away with the need for the tapper to climb the tree every day.

AI START UPS CASE STUDIES IN AGRICULTURE

Prospera, an Israeli company formed in 2014, uses a cloud-based solution that combines in-field devices with all available data, including aerial photos, soil/water sensors, and more, to create forecast. Founded in 2011,

- **Blue River Technology** is a California-based company that integrates robotics, computer vision, and artificial intelligence. Robotics allows the intelligent devices to operate, machine learning determines how to handle each unique plant, and computer vision recognizes Each in individual plant.
- **Farm Bot** was established in 2011 and uses an open-source software system to assist farmers in doing all aspects of farming on their own, from planting seeds to detecting weeds, testing soil, and watering plants.
- **AI Seeding App** Microsoft and ICRISAT worked together to create an AI seeding app that uses the Microsoft Cortana Intelligence Suite, which includes Power BI and machine learning. The best thing is that farmers don't have to spend any money or install any sensors in their fields. They only require a feature phone that can send and receive text messages.
- **Crop In** Utilizing AI to Increase Per-Acre Value In essence, CropIn helps businesses analyze and interpret data to obtain actionable insights on standing crops and projects across regions in real time by utilizing technologies like artificial intelligence. Utilizing agri-alternate data, its agri-business intelligence solution, Smart Risk, "offers risk mitigation and forecasting for efficient credit risk assessment and loan recovery assistance."

- **Ag Voice** For professionals working in food and agriculture, this system offers a voice-to-data and work flow management solution. They may be in-depth specialists, such as plant breeders in a research and development setting or qualified agronomists or pest management consultants assisting producers. However, Ag Voice allows users to accomplish verifiable fast inspections, reporting, and work flow management for the agri-food supply chain more accurately than current conventional processes by fusing a proprietary analytics platform with a specially designed industrial grade voice enabled user experience.
- **Intello Labs** Using deep learning for image analysis, Intello Labs, based in Bengaluru, offers cutting-edge image identification technology that can identify faces, objects, plants, and animals and tag them in any picture. According to the business, a new generation of intelligent apps for industries including manufacturing, curation, advertising, eCommerce, and agriculture are being developed using deep learning algorithms.
- **Gobasco** The Intelligent Agri-Supply Chain by Gobasco, a company based in Uttar Pradesh, uses AI-optimized automated pipelines in conjunction with real-time data analytics on data streams originating from various sources around the nation to significantly boost the efficiency of the current Agri-supply chain.

OTHER TECHNOLOGIES USED IN AGRICULTURE

Agriculture is being revolutionized by technology in ways other than artificial intelligence. Numerous other technologies also exist. For example.

- Hydroponics uses mineral fertilizer solutions in a water solvent to grow plants without soil. Using this technique, Sundrop, an Australian business, has installed a seawater greenhouse to grow veggies anywhere in the world.
- The production of food is now utilizing 3D printing, sometimes referred to as associated manufacturing. Food fraud can be prevented with the usage of block chain, the distributed ledger technology that powers Bitcoin.
- Precision agriculture is undergoing a new revolution thanks to nanotechnology. Today's fertilizers with nano capsules deliver nutrients to plants precisely by releasing them gradually over time.
- Vertical farming, which involves cultivating food in layers that are stacked vertically, is also catching momentum in areas where there is a lack of suitable land. For example, the US-based company Aero Farms is a leader in high-tech, data-driven vertical farming and has demonstrated

that productivity may reach previously unattainable levels. The Netherlands, which produces 35% of its veggies in greenhouses that take up less than 1% of its farmland, has also seen a growth in indoor horticulture thanks to technology.

The coconut industry might not be able to use this technology. However, technologies cannot be viewed in a vacuum. Furthermore, from a holistic standpoint, the coconut industry cannot be separated from the agriculture industry.

For instance, a prototype for tracking and recording the supply chain in a block chain and verifying its validity via a mobile application may be created in order to detect adulterated coconut oil. Right Place, Right Time, and Right Product must define the path ahead. It is evident what the agricultural sector, its diverse stakeholders, and its multilevel players must decide.

DIFFICULTIES IN APPLYING AI IN AGRICULTURE:

The absence of high-quality data infrastructure is the main obstacle to the application of AI in agriculture. To train the many models in applications like deep learning, a large amount of high-quality data must be analysed. To acquire accurate results, you need reliable data. Obtaining temporal data is challenging. The data infrastructure takes years to develop, and the majority of crop-specific data is only available once a year.

To create a strong machine learning model, a considerable amount of time is needed. Another limitation is a lack of knowledge about advanced machine learning technologies in farms. In addition, farming is exposed to a variety of outside variables, such as the weather, the soil, and the existence of pests. Therefore, due to changes in external circumstances, what may have seemed like a good answer while planning at the beginning of harvesting may not be the best option.

AI is also prohibitive due of the high cost of various cognitive farming technologies. Concerns about privacy, operational safety, and insurance coverage are crucial when it comes to drones. Furthermore, there hasn't been much of a push for more advanced sensors and cameras or research into creating highly automatic drones that need less training.

Government and institutional support

- The Coconut Development Board (CDB): The CDB, a statutory body under the Ministry of Agriculture, promotes the adoption of modern technologies and provides financial assistance for processing and research.

- Skill development: The CDB's "Coco mitra" scheme trains unemployed youth in using mechanical climbing devices and other modern techniques for coconut management, transforming climbing into a safer, more sustainable profession.
- Research collaboration: The CDB partners with research institutes like the CPCRI and technology firms to develop and demonstrate new solutions, such as drone-based pest surveillance.

RESEARCH METHODOLOGY

Nature of the Study

This research is conceptual and theoretical in nature. Rather that employing empirical methods such as field surveys or experimental designs, the study synthesizes existing theoretical framework and literature to critically explore the transformative potential of Artificial information and emerging technologies in coconut cultivation particularly in the context of enhancing rural livelihoods. The focus is on interpreting patterns, principles, and relationships that emerge from existing academic discourse and policy debates.

Research Design

The character of this study is both conceptual and descriptive. The research for the article was done using secondary data. The purpose of the paper is to search the literature on artificial intelligence (AI) and emerging technologies in agricultural practices related to the production and processing of coconuts. Journals, books, newspapers, articles, and online sources are some of the places where secondary data has been gathered. The gathered data is expanded upon and applied in the current study.

Data Source

Since the study is non empirical, it relies on secondary data drawn from:

- Academic journals indexed in Scopus, Web of Science, JSTOR and Google Scholar.
- Reports and white papers from international organizations such as FAO, World Bank, CDB.ICAR.
- Case studies from government and non-governmental initiatives like Kisan, IFFCO Kisan and various agri-tech startups in South Asia.

Delimitations of the Study

- The study is limited to theoretical perspectives and does not include primary data collection or empirical validation

- Focus is primarily on developing economies particularly regions with high agricultural dependency and digital intervention initiatives.
- While case references are included, they serve illustrative not evaluative purpose.

Ethical considerations

As the study is based solely on publicly available secondary data and theoretical frameworks, no ethical clearance is required. However, due academic integrity is maintained by ensuring proper citations and referencing of sources.

CONCLUSION:

The journey toward integrating AI into India's coconut cultivation is an intersection of traditional farming and technological innovation. While AI-powered tools offer transformative solutions for early disease detection, enhanced productivity, and optimized resource management, their ultimate success depends on addressing fundamental issues of cost, data availability, and digital literacy. By designing accessible, affordable, and sustainable AI technologies, and ensuring equitable access to training and infrastructure, India can empower its coconut farmers. This approach will not only secure a more resilient and profitable future for the coconut industry but also set a precedent for a more sustainable and technologically advanced agricultural sector globally.

The future of AI in Indian coconut cultivation is a balancing act between innovation and equity. For AI to realise its full potential, it must be developed as an accessible and sustainable tool not just a high-tech solution for a few. Ultimately the success of AI in coconut farming will depend on Government support, localised solutions, and inclusive implementation by taking these steps AI can become a powerful force for a more productive sustainable and prosperous future for India’s coconut farmers.

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