Economic Performance of Coconut and Areca Nut Cultivation: A Comparative Field-level Study

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Abstract

This study evaluates and compares the economic performance of coconut and areca nut cultivation using farm-level survey data collected from 120 farmers. Descriptive statistics, cost return analysis, and benefit cost ratios were employed. Results show that areca nut cultivation generates significantly higher net returns despite higher production costs, while coconut cultivation offers more stable returns with lower investment requirements. The findings highlight the importance of considering both profitability and risk in plantation crop decision-making. Crop yield prediction plays a crucial role in agricultural planning, resource management, and economic stability, especially for plantation crops such as coconut (Cocos nucifera) and areca nut (Areca catechu). These crops are highly sensitive to climatic conditions, soil health, pest incidence, and farm management practices. In recent years, traditional statistical approaches have been increasingly complemented or replaced by machine learning (ML) and deep learning (DL) models to improve prediction accuracy. This survey reviews existing methodologies, datasets, influencing factors, and challenges in yield prediction specifically for coconut and areca nut crops, and identifies research gaps and future directions.

Keywords: Coconut, Areca nut, Cost of cultivation, Profitability, Plantation crops.

1. Introduction

Plantation crops play a crucial role in the agricultural economy of India by supporting livelihoods and generating employment. Coconut (Cocos nucifera L.) and areca nut (Areca catechu L.) are widely cultivated perennial crops, particularly in southern India. While coconut cultivation is known for its diversified uses and stable demand, areca nut cultivation is characterized by high commercial value and market-driven returns. Agriculture remains a backbone of the Indian economy, with plantation crops contributing significantly to rural livelihoods and export revenue. Coconut and areca nut are perennial crops predominantly grown in India, Sri Lanka, Indonesia, and Southeast Asia. Yield prediction for these crops is challenging due to their long gestation period, seasonal variability, and dependence on long-term climatic trends. Accurate yield prediction helps:

- Farmers plan irrigation and fertilization
- Governments estimate production and price stability
- Industries manage supply chains

With the availability of remote sensing data, IoT sensors, and historical climate records, data-driven prediction models have gained prominence.

Plantation crops such as coconut and areca nut occupy a unique position in tropical agriculture due to their perennial nature, long productive lifespan, and high economic value. Unlike seasonal crops, these crops require long-term planning and sustained management practices, making yield prediction a complex but essential task. Small variations in climatic conditions or soil health can lead to significant fluctuations in annual yield, directly affecting farmer income and market supply stability.

In recent decades, climate variability and climate change have introduced new uncertainties in agricultural productivity. Irregular monsoon patterns, rising temperatures, prolonged dry spells, and extreme weather events have increasingly impacted plantation crops. Coconut and areca nut, which are largely dependent on rainfall and soil moisture availability, are particularly vulnerable to these changes. As a result, traditional experience-based farming practices are no longer sufficient for reliable yield estimation.

Advancements in agricultural data collection technologies have opened new opportunities for accurate crop yield prediction. The availability of long-term historical climate datasets, soil health records, satellite imagery, and farm-level management data has enabled the application of data-driven approaches. Machine learning and deep learning models can effectively capture nonlinear relationships between multiple influencing factors and crop yield, offering improved predictive performance compared to conventional statistical techniques.

Furthermore, yield prediction for coconut and areca nut is critical not only at the farm level but also at the regional and national policy level. Accurate forecasts support government agencies in estimating production volumes, planning procurement and storage, managing price fluctuations, and ensuring food and industrial raw material security. For industries dependent on coconut-based products and areca nut trade, reliable yield estimates assist in supply chain planning and export management.

Problem Statement: Despite the growing interest in crop yield prediction, most existing research has focused on staple crops such as rice, wheat, and maize. Plantation crops, particularly areca nut, have received limited attention in the literature. The lack of standardized datasets, region-specific studies, and crop-focused prediction frameworks highlights the need for comprehensive surveys and targeted research in this domain. This survey aims to address this gap by systematically reviewing existing methodologies, identifying challenges, and outlining future research directions for yield prediction of coconut and areca nut crops.

2. Literature Survey

Yogita Masare[1] Maximize the Yielding Rate of Crops using Machine Learning Algorithm presents Agriculture is vital for India's economy, relying heavily on crop productivity. The selection of crops is crucial for effective farming planning. Machine learning techniques have been employed by researchers to predict crop yield rates, weather conditions, and soil and crop classifications. Upgrading agriculture with machine learning can enhance productivity and contribute positively to India's economy. This paper proposes a crop selection method aimed at addressing agricultural challenges, ultimately maximizing crop production yields and improving economic wealth.

E. Manjula [2], A Model for Prediction of Crop Yield presents Data mining is a developing field in agricultural crop yield analysis, addressing the critical issue of yield prediction for farmers. Traditionally, predictions relied on farmers' experience, but data mining techniques present a more robust solution. This research implements a system that uses association rule mining to predict crop yields based on historical data, specifically for the Tamil Nadu district in India. The study focuses on creating a predictive model and demonstrates through experiments that it can efficiently forecast crop yield production.

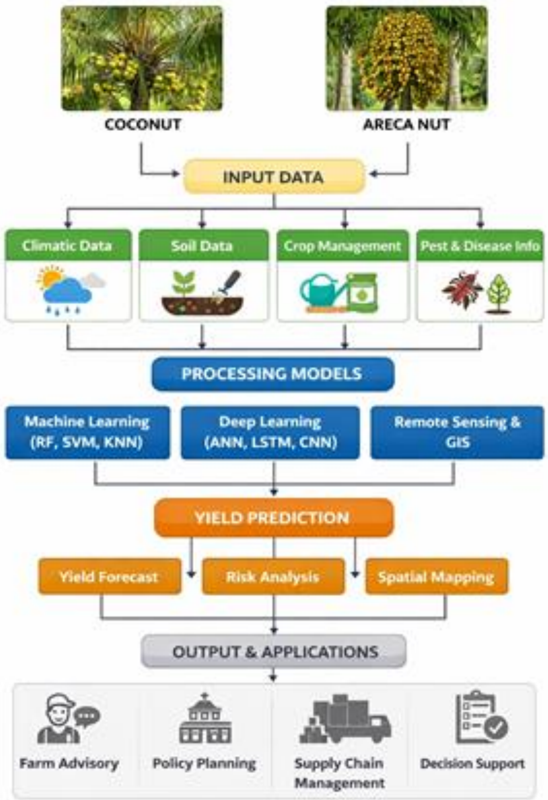
P. Sathiyapriya1[3] et .al, Machine learning in crop yield prediction based on RNN algorithm presents with global warming and increasing of extreme climate evens, climate change may impose positive or negative effects on crop growth and yield. The traditional crop productivity simulations based on crop models are normally site-specific. The simulation accuracy can be improved by using the detailed field management information, such as temperature, climate, soil, location and water PH value.

Gomathy G [4] et al, Site-Specific Crop Management presents Machine learning (ML) is an emerging technology in which both researchers and academic communities have been able to obtain a distinct range of numerous applications such as image recognition, healthcare, fraud detection and so on. In addition to this, ML algorithms have been identified for prediction, classification, and other purposes. On the contrary, agriculture plays an important role in a country's economy. Further the crop yield is mainly affected by diverse factors like types of soil, temperature, moisture, and rainfall. Moreover, the crops are not evenly distributed in an agricultural field restricting the possibility of complete utilization of the field. In today’s world even technologies like the Internet of Things, Artificial Intelligence and ML plays a significant role to overcome the issues in agricultural factors. Thereby ML is reliable and suitable and well developed, which are not utilized properly by farmers. The proposed research work is to predict the crop yield of a given area and map the yield distribution using ML algorithm through Random Forest (RF) mechanism. RF algorithm is one among the popular supervised learning algorithms used for classification and regression purposes. Hence crop yield prediction is carried out by analyzing data of various factors affecting agriculture like temperature, soil type, moisture etc. Subsequently the main motivation of this research is to build an interactive user-friendly interface for the farmers which provides the yield map distinguishing the yield rate in a given field along with suggestions for the better utilization of the low yielding areas.

Andrés Vega et al,[5] Protocol for automating error removal from yield maps presents Yield mapping is one of the most widely used precision farming technologies. However, the value of the maps can be compromised by the presence of systematic and random errors in raw within field data. In this paper, an automated method to clean yield maps is proposed so as to ensure the quality of further data processing and management decisions. First, data were screened by filtering null and edge yield values as well global outliers. Second, spatial outliers or local defective observations were deleted. The local Moran's index of spatial autocorrelation and Moran's plot were used as tool to identify the spatial outliers. The protocol to filter out global and local outliers was evaluated on 595 real yield datasets from different grain crops. Significant improvements in the distribution and spatial structure of yield datasets was found. Approximately 30% of the dataset size was removed from each monitor dataset, with one third of the removal occurring during filtering of spa- tial outliers. The automation of null, edge yield values and the removal of global outliers improved yield distributions, whereas the cleaning of local outliers impacted the yield spa- tial structure for all yield maps and crops. The algorithm proposed to clean yield maps is easy to apply for preprocessing the growing number of available yield maps.

3. Methodology

The block diagram shown in Fig. 1 illustrates the overall framework for crop yield prediction of coconut and areca nut using data-driven approaches.



The architecture integrates multi-source agricultural data with machine learning, deep learning, and remote sensing techniques to generate accurate yield forecasts and decision-support outputs. The system begins with the selection of plantation crops, namely coconut and areca nut, which are highly sensitive to climatic and environmental variations. Yield prediction for these crops requires long-term monitoring of multiple influencing parameters.

The input layer consists of heterogeneous data collected from various sources. Climatic data include rainfall, temperature, humidity, and sunshine hours, which significantly influence flowering, nut development, and yield formation. Soil-related parameters such as soil moisture, pH, nutrient content (NPK), and organic carbon are used to assess soil fertility and water availability. Crop management data include information on irrigation practices, fertilizer application, plant age, and spacing, while pest and disease data represent biotic stress factors affecting crop productivity. The collected input data are processed using advanced computational models. Machine learning techniques such as Random Forest, Support Vector Machine, and K-Nearest Neighbors are employed to capture nonlinear relationships between input variables and crop yield. Deep learning models, including Artificial Neural Networks, Long Short-Term

Memory networks, and Convolutional Neural Networks, are utilized to model complex temporal and spatial patterns, particularly for long-term yield prediction. In addition, remote sensing and Geographic Information System (GIS) techniques are integrated to extract vegetation indices and enable spatial analysis at regional scales. Based on the processed information, the system generates yield prediction outputs in terms of expected production levels, risk analysis under varying climatic and pest conditions, and spatial yield mapping. These outputs provide actionable insights for multiple stakeholders.

The final application layer supports farm-level advisory services, policy and production planning, supply chain management, and decision support systems. The proposed architecture demonstrates an integrated and scalable approach for accurate yield prediction of plantation crops, contributing to sustainable agricultural management and informed decision-making.

A. Factors Affecting Coconut and Areca Nut Yield

1) Climatic Factors

- Rainfall distribution
- Temperature (maximum & minimum)
- Relative humidity
- Sunshine hours
- Extreme events (drought, cyclones)

2) Soil Factors

- Soil moisture
- pH level
- Nitrogen, Phosphorus, Potassium (NPK)
- Organic carbon content

3) Crop Management Factors

- Fertilizer application
- Irrigation frequency
- Plant age
- Spacing and intercropping practices

4) Biotic Stress

- Pest attacks (mite, rhinoceros beetle, root grub)
- Diseases (bud rot, stem bleeding, fruit rot)

B. Machine Learning-Based Approaches

1) Supervised Learning Techniques

Machine learning models have shown improved performance over traditional methods.

Model	**Application**
Decision Tree	Yield classification
Random Forest	Feature importance & yield prediction
Support Vector Machine (SVM)	Small dataset prediction
K-Nearest Neighbors (KNN)	Pattern-based estimation

Example:

Random Forest models have been used to predict coconut yield using rainfall, temperature, and fertilizer input with higher accuracy than regression models.

2) Deep Learning Techniques

Deep learning is increasingly used where large datasets are available.

- Artificial Neural Networks (ANN)
- Long Short-Term Memory (LSTM) for time-series climate data
- Convolutional Neural Networks (CNN) with satellite imagery

Advantages:

- Handles non-linearity
- Learns temporal patterns
- Suitable for long-term yield trends

C. Yield Prediction Studies on Coconut and Areca Nut

1) Coconut

- Studies in Kerala and Karnataka use ANN and Random Forest
- Yield correlated with monsoon rainfall and minimum temperature
- Remote sensing used for crown density estimation

2) Areca Nut

- Fewer studies compared to coconut
- Models use rainfall, humidity, and soil moisture
- ML models outperform linear regression

4. Results

Comparison of Prediction Techniques

Technique	Accuracy	Data Requirement	Complexity
Regression	Low	Small	Low
Random Forest	High	Medium	Medium
ANN	High	Large	High
LSTM	Very High	Time-series	Very High

Table 1: Socio-economic characteristics of sample farmers

Parameter	Coconut	Areca nut
Average age (years)	48.2	45.6
Education (years)	9.1	10.3
Landholding (ha)	1.85	1.42
Farming experience (years)	22.4	19.6

Table 2: Cost of cultivation (₹/ha/year)

Cost component	Coconut	Areca nut
Labour	48,500	56,200
Fertilizers & manure	18,400	24,600
Irrigation	12,300	15,800
Plant protection	6,700	9,400
Miscellaneous	4,100	5,600
Total cost	90,000	1,11,600

Table 3: Yield and profitability of coconut and areca nut cultivation

Indicator	Coconut	Areca nut
Average yield	10,200 nuts	2,150 kg
Gross returns (₹/ha)	1,22,400	6,02,000
Net returns (₹/ha)	32,400	4,90,400
Benefit–cost ratio	1.36	5.40

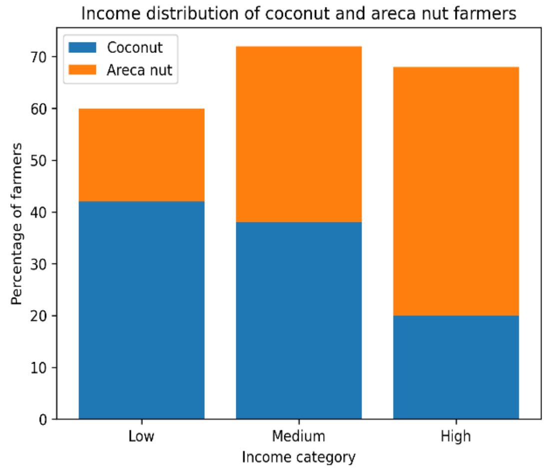


Figure 2. Income distribution of coconut and areca nut farmers

5. Conclusion

Crop yield prediction for coconut and areca nut has evolved from traditional statistical models to advanced machine learning and deep learning approaches. While coconut has received moderate research attention, areca nut remains underexplored. Future systems must focus on accuracy, scalability, and farmer usability to support sustainable agriculture.

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