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CROP PRICE PREDICTION USING MACHINE LEARNING ALGORITHMS: A REVIEW

Tarang Garg, Tanya Saxena, Vimal Bajpai ABES Engineering College, Ghaziabad, Uttar Pradesh, India {anamika.goel,tarang.20b1531012,tanya.20b1531066,vimal.20b1531116}@abes.ac.in
Ms. Anamika Goel, Assistant Professor, Dept. Of CSE AIML, ABES Engineering College, Ghaziabad, Uttar Pradesh, India

Abstract
This extensive review systematically explores the methodologies, tools, and ethical considerations involved in developing a machine learning system dedicated to predicting crop prices. The primary focus is on augmenting farmers' decision-making capabilities in crop management. The review meticulously scrutinizes various machine learning algorithms, delves into diverse data collection techniques, and examines model development processes. With a paramount emphasis on the importance of data-driven insights, the primary objective is to equip farmers with advanced resources, empowering them to adeptly navigate the uncertainties inherent in crop pricing dynamics. By synthesizing information from various sources, including conferences and journals, the review critically evaluates existing models while also proposing innovative approaches to enhance the precision of crop price predictions. The overarching goal is to contribute significantly to the advancement of agricultural technology, providing valuable insights for researchers, policymakers, and practitioners actively engaged in the convergence of machine learning, agriculture, and sustainable resource management. This comprehensive overview strives to guide future research endeavors and technological developments, shaping a more informed and resilient future for the agricultural sector.
Keywords: Crop Price Prediction, Machine Learning, Agricultural Data, Regression, Decision Tree Algorithm, Ethical Considerations.

Introduction

The intricate relationship between agricultural sustainability and crop price volatility demands a detailed exploration, especially in leveraging machine learning for predictive analytics. This review aims to delve into multifaceted dynamics, elucidating complexities linked to developing a robust machine learning system for forecasting crop prices.

The global agricultural landscape is significantly influenced by market fluctuations, impacting farmers' livelihoods and global food security. Advanced tools are essential to empower farmers with timely, accurate information for effective market navigation. The examination thoroughly analyzes various machine learning algorithms, emphasizing their application in crop price prediction.

Data collection techniques, model development, and ethical considerations are scrutinized to understand challenges and opportunities in this domain. Synthesizing insights from diverse sources, including international conferences, journals, and technological advancements, the review aims to contribute to agricultural technology. It evaluates existing models and proposes innovative approaches to enhance precision and reliability in crop price predictions.

The overarching goal is to equip farmers with advanced resources for informed decision-making amid market uncertainties. As technology shapes the future of agriculture, this review serves as a resource for researchers, policymakers, and practitioners, offering insights into machine learning, agriculture, and sustainable resource management. It aims to guide future research and technological developments, contributing to the discourse on the sustainable future of agriculture.

In conclusion, this comprehensive review addresses the complexities associated with machine learning in the agricultural sector, emphasizing the need for advanced tools to empower farmers. By synthesizing insights from diverse sources, the review provides a holistic understanding of machine learning applications in crop price prediction. The proposed innovative approaches aim to enhance the precision of predictions, ultimately contributing to sustainable agriculture and food security.

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Literature Review

S.NO	Author & Year	Methodology	Key Findings	Relevance to Project
1	N. Heemageetha (2018)	Supervised machine learning algorithms	Predictive analytics for climate change planning in Southeast Asia. Data collection, training, testing, prediction, validation, and visualization were used.	Provides insights into the application of machine learning for climate-related predictions.
2	D. Jayanarayana Reddy	Comparison of learning machines for crop yield prediction	Utilized non-formal education system, online learning, and a flexible learning environment.	Offers a comparative analysis of different learning machines for predicting crop yield, providing a reference for model selection.
3	Dr. Y. Jeevan Nagandrakumar	Review of methods and parameters using machine learning for crop price prediction	Discusses the limitations of existing methods and experiments. Focuses on regression analysis.	Provides a critical review of existing methods, highlighting potential challenges in crop price prediction.
4	Mayank Chamapveri	Crop yield estimation using deep learning techniques	Explored web applications using deep learning techniques for crop yield estimation.	Offers insights into the application of deep learning techniques for agricultural applications.
5	Parul Agrawal	Estimation of setup and estimation cost using supervised machine learning algorithms	Explores the impact of machine learning on model solution quality.	Provides information on the potential impact of machine learning on traditional models.
6	Pranay Malik	Price prediction using Random Forest and Decision Tree Regression	Focuses on water resources and agriculture management. Uses Weather Forecast Model (WRF) for data reference.	|Relevant for understanding the application of machine learning in water resources and agriculture management.

Table.1. Previous Price Prediction Model and their Accuracy

Author	Algorithm	Better Accuracy Model
Khodabakhshian Rasool et al. [3]	Linear Regression & Random Forest.	Random Forest
M. T. Shakoor et al. [5]	K-Nearest Neighbor [KNN], Decision Tree Learning [DTL], & ID3	DTL & ID3.
S. Pandit et al. [6]	Linear Regression, XG Boost, DTL, & Nearest Neighbor [NN].	XG Boost
Rakhra Manik et al. [7]	NN & DTL.	Both
Neeraj Soni et al. [8]	DTL & Random Forest.	DTL
Ranjani Dhanapal et al. [9]	DTL.	DTL.
Madhuri Shripathi Rao et al. [10]	DTL, KNN, & Random Forest.	DTL
Ishita Ghutake et al. [11]	Random Forest & DTL.	DTL
G. S. Kakaraparthi et al. [12]	DTL	DTL
R. Rohith et al. [13]	DTL, & Support Vector Regression	DTL
S. Vijayasree et al. [14]	KNN.	KNN

Proposed Methodology

Our project is a pioneering initiative aimed at effectively addressing the persistent challenge of predicting crop prices, a critical concern for impoverished farmers striving for reliable benefits. The approach we adopt is grounded in cutting-edge machine learning techniques, strategically harnessing diverse data sources to deliver solutions that transcend conventional methodologies. At the core of our methodology lies the application of Decision Tree regression methods, a robust algorithmic framework recognized for its efficacy in forecasting crop values.

The foundation of our system rests on the utilization of meticulously curated data from certified datasets, ensuring the model is trained with high-quality information. This training process is instrumental in enhancing the model's predictive capabilities, enabling it to discern intricate patterns and relationships within the data. By employing Decision Tree regression, our approach excels in forecasting crop values, offering a nuanced understanding of the dynamic agricultural landscape.

Our system goes beyond mere prediction; it comprehensively understands and anticipates crop values under varying environmental conditions. This adaptability is crucial for farmers who operate in diverse contexts and climates. The implementation of such a robust crop price forecasting system stands to revolutionize agricultural productivity, providing farmers with actionable insights that empower them to make informed decisions.

A distinctive aspect of our machine learning-based price prediction is its integration of both technical and fundamental analysis methods. Unlike traditional approaches, our system considers a multitude of price determinants, resulting in heightened accuracy. Furthermore, the system provides localized predictions at the granularity of individual farms or even smaller units, known as Mandy-level predictions. This localized precision enhances the usability of the predictions, particularly benefiting smallholder farmers.

Fundamental analysis, integrated into our approach, involves a deep understanding of external and internal factors influencing commodity prices. This holistic analysis, combined with the technical prowess of machine learning algorithms, creates a synergy that amplifies the accuracy and reliability of our predictions. The outcomes of our endeavor are conveniently presented through a user-friendly web application, ensuring easy accessibility for the target audience, particularly the farmers we aim to empower.

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3.1 Decision Tree Algorithm:

The Decision Tree algorithm, a crucial element in supervised learning, adeptly tackles both regression and classification challenges. Operating on the principle of learning decision rules from historical or training data, it constructs a model for predicting the class or value of the target variable. The Decision Tree's functionality involves traversing from the top to predict the class label of a given record. This process entails comparing the original attribute's value with the record's attribute value and subsequently making decisions based on these comparisons The tree-like structure of Decision Trees, where nodes represent decision points and branches indicate potential outcomes, provides a transparent and interpretable representation of the decision-making process. This transparency is particularly Advantageous in scenarios where understanding the logic behind predictions is crucial for decision-makers.

3.2 Criteria for property selection:

In the realm of Decision Tree algorithms, particularly when dealing with datasets possessing a considerable number of attributes (N), the selection of internal nodes at various levels of the tree becomes a crucial aspect. A random choice for the root node might lead to suboptimal results, necessitating a thoughtful approach for effective attribute selection.

Researchers have proposed several methodologies for attribute selection, each with its distinct advantages and considerations. Some of the widely acknowledged criteria include:

1. **Uncertainty**: This criterion measures the degree of impurity or uncertainty in a dataset. Aiming to minimize uncertainty guides the algorithm in making decisions that lead to more accurate predictions.
2. **Data Gain**: Data Gain assesses the improvement in predictive accuracy achieved by considering a particular attribute for node splitting. Higher gain values indicate attributes that contribute significantly to better predictions.
3. **Gini Index**: The Gini Index evaluates the impurity of a dataset, with lower values indicating a purer dataset. Decision Trees seek to minimize the Gini Index at each node, leading to well-defined and distinct decision boundaries.
4. **Gain Ratio**: Similar to Data Gain, the Gain Ratio considers the improvement in predictive accuracy but adjusts it based on the intrinsic information content of the attribute. This adjustment helps prevent bias towards attributes with more categories.
5. **Variance Reduction**: Primarily used in regression tasks, Variance Reduction aims to minimize the variance of predicted values at each node. This is crucial for continuous target variables.
6. **Chi-Square**: Commonly employed in classification tasks, the Chi-Square criterion assesses the independence between attributes and the target variable. It helps identify attributes that significantly contribute to the classification process.

The choice of attribute selection criteria depends on the nature of the dataset and the specific goals of the analysis. Researchers and practitioners need to consider these parameters carefully to tailor Decision Tree models to their particular use cases effectively.

3.3 Regression in Decision Tree algorithm:

The utilization of Decision Tree Regression is integral to our system, given the continuous nature of dataset information and the inherent seasonality of crop prices. This method effectively addresses variations observed in crop prices over time. By incorporating essential parameters like rainfall and the Wholesale Price Index (WPI), our system ensures accurate and reliable predictions. At the core of our architecture is the Decision Tree Regressor, a robust algorithm playing a pivotal role in providing precise forecasts for various agricultural commodities. Beyond predicting crop prices, the Decision Tree Regressor contributes to agricultural decision-making by aiding in identifying optimal cultivation locations and determining the most favorable seasons for crop growth. This holistic approach enhances overall agricultural management efficiency, empowering stakeholders with valuable insights for informed decision-making and strategic planning

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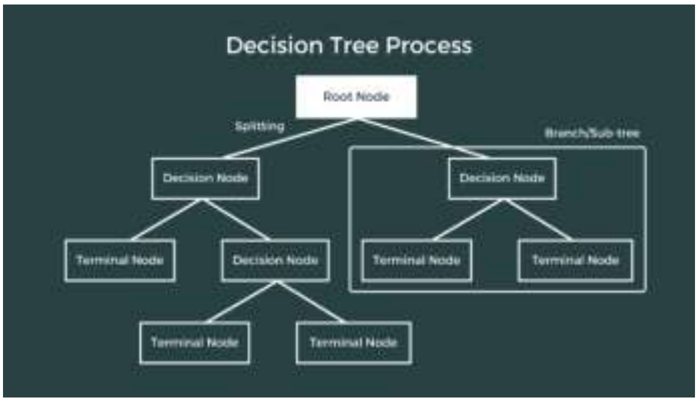

Fig. 1. Decision Tree Regression

3.4 Architecture:

In our architecture, we've implemented the Decision Tree Regressor for predicting crop prices. This system provides the price of each agricultural commodity, the optimal location for cultivation, and the most favorable season for growing each crop.

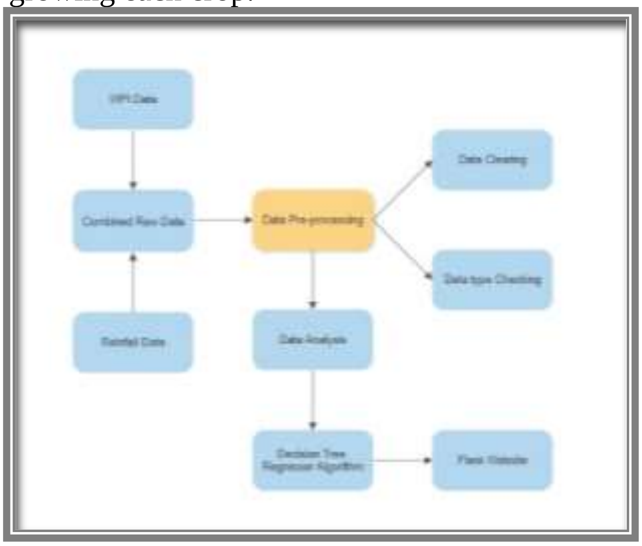

Fig. 2. Process Flow Diagram

3.5 List of Commodities in the system:

1. Rice
2. Wheat
3. Pearl Millet
4. Niger Seeds
5. Mung Beans
6. Coconut
7. Corn
8. Cotton
9. Soybean
10. Barley
11. Sesame Seeds
12. Pigeon Peas
13. Lentils
14. Cotton
15. Groundnut
16. Mustard Seeds

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17. Chickpeas
18. Sugar Cane
19. Finger Millet
20. Black Gram
21. Sunflower
22. Safflower Seeds
23. Jute
24. Sorghum


Fig. 3. Commodities in the system

Applications

Absolutely! A crop price prediction project leveraging machine learning through a website has numerous practical applications across diverse sectors, fundamentally transforming the agricultural sector.

1. **Empowering Farmers' Decision-Making**: These predictions are invaluable for farmers, offering critical insights into optimal times to sell their produce. Armed with this foresight, farmers can strategize better, maximizing profits by selling at opportune moments while avoiding potential losses during market downturns.
2. **Market Intelligence for Traders and Analysts**: The predictions provide a strategic advantage for traders and market analysts, enabling them to anticipate and plan for price trends. This informed approach aids in making smarter trading decisions and managing risks effectively in the volatile agricultural market.
3. **Government Policy Formulation**: Predictive data guides policymakers in formulating agricultural policies. It assists governments in designing interventions and support systems to ensure stability and sustainability within the agricultural sector.
4. **Informed Consumer Decisions**: Access to anticipated price fluctuations empowers consumers to plan their purchases more effectively. This foresight allows them to manage their budgets efficiently and make informed choices based on expected price trends.
5. **Streamlining Agricultural Supply Chains**: Businesses involved in the agricultural supply chain benefit from predictive data. It enables them to optimize their logistical operations, storage facilities, and distribution networks based on projected price trends, leading to reduced waste and enhanced operational efficiency.
6. **Tailored Financial Products**: Financial institutions can leverage this information to design specialized financial products and services for farmers. This assists in enhancing financial inclusion and providing tailored support to the agricultural community.
7. **Advancements in Research and Development**: The project contributes significantly to agricultural research. It aids researchers in analyzing historical price data, identifying trends, and

understanding the factors influencing crop prices. This information fuels the development of more accurate prediction models and enhances comprehension of market dynamics.

By consolidating these applications within an accessible website interface, valuable insights are disseminated to a broader audience. This transparency and accessibility foster collaboration and efficiency within the agricultural market, benefitting stakeholders across various sectors. The interconnectedness facilitated by this platform bolsters individual decision-making while bolstering the overall sustainability and resilience of the agricultural sector

Conclusion

The landscape of time-series analysis in crop price forecasting has witnessed considerable growth, particularly addressing challenges prevalent in emerging economies like India. In our investigation, we leveraged a machine learning algorithm to predict crop prices over the next twelve months. By incorporating annual rainfall and the Wholesale Price Index (WPI) as predictive parameters, our approach yielded accurate and reliable results. The significance of this initiative lies in its role as a practical and valuable tool for farmers. Through access to informed predictions, farmers can strategically navigate market dynamics, optimize crop management practices, and ultimately enhance their profits. The success of this study underscores the potential of machine learning in mitigating uncertainties associated with crop prices, contributing to the sustainable development of the agricultural sector. As technological advancements continue, further refinement of predictive models and the integration of additional variables hold promise for even more precise and insightful crop price forecasts, ensuring a positive impact on farmers' livelihoods and the overall agricultural landscape.

Future Scope

Future advancements for this endeavor involve extending the application to governmental organizations (NGOs) and governmental bodies are pivotal for expanding the tool's outreach to village panchayats, ensuring accessibility to a broader audience. To make this technology inclusive, the incorporation of a dedicated technical support team is essential, catering to the needs of even those farmers who may have limited literacy, thus maximizing the impact of this predictive tool in the agricultural sector.encompass crop prediction based on the acquired price data, providing farmers with comprehensive insights into market trends. Further enhancements can be achieved by integrating additional variables such as insurance and logistics prices, contributing to more refined and accurate predictions.

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