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AI IN DEMAND FORECASTING FOR REDUCING POST-HARVEST LOSSES IN AGRI-BUSINESS

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Abstract

Post-harvest losses represent a major challenge in the agricultural sector, particularly in developing economies where inefficiencies in supply chain management, storage infrastructure, and demand forecasting contribute to significant food wastage. A considerable portion of agricultural produce deteriorates before reaching consumers due to inaccurate demand estimation, poor inventory planning, and inefficient distribution systems. In recent years, Artificial Intelligence (AI) has emerged as a powerful technological solution capable of improving demand forecasting and optimizing decision-making processes within agri-business supply chains. This study examines the role of AI-driven demand forecasting systems in reducing post-harvest losses in agri-business. AI technologies such as machine learning, predictive analytics, and big data processing enable the analysis of large datasets related to market demand, seasonal consumption patterns, weather conditions, and consumer behavior. These technologies provide more accurate demand predictions, allowing farmers, distributors, and retailers to align production, storage, and distribution strategies with actual market requirements. As a result, overproduction, excess inventory, and spoilage of perishable agricultural products can be significantly minimized. AI-based forecasting systems support better coordination among supply chain stakeholders and improve overall operational efficiency. The integration of AI into agri-business forecasting practices therefore offers a promising pathway toward reducing post-harvest losses, improving supply chain resilience, and promoting sustainable agricultural development.

Keywords: Artificial Intelligence, Demand Forecasting, Post-Harvest Losses, Agri-Business, Predictive Analytics, Supply Chain Optimization, Smart Agriculture, Food Waste Reduction.

Introduction

Agriculture remains one of the most important sectors supporting global food security and economic development. However, a significant proportion of agricultural produce is lost after harvesting due to inefficiencies in supply chain management, poor storage facilities, transportation delays, and inaccurate market demand estimation. Post-harvest losses have become a major concern for governments, researchers, and agribusiness organizations, particularly in developing countries where infrastructure and technological support systems are often limited. According to global estimates, nearly 20–30% of agricultural produce is lost between harvesting and final consumption. These losses not only reduce farmers' income but also contribute to food insecurity, environmental degradation, and inefficient utilization of natural resources such as land, water, and energy.

One of the key factors contributing to post-harvest losses is the lack of accurate demand forecasting in agri-business supply chains. Agricultural products, especially fruits, vegetables, and other perishable commodities, have limited shelf lives and require efficient planning for storage, transportation, and distribution. When producers and distributors are unable to accurately estimate market demand, it often leads to overproduction, surplus inventory, and delayed distribution, resulting in significant spoilage.

Traditional forecasting methods in agriculture are often based on historical sales records, manual estimations, and limited market data, which may not accurately reflect real-time market dynamics or consumer behavior.

In recent years, Artificial Intelligence (AI) has emerged as a transformative technological tool that can significantly improve demand forecasting accuracy in agri-business. AI technologies such as machine learning, predictive analytics, big data analytics, and neural networks enable organizations to process large volumes of structured and unstructured data to generate more reliable demand predictions. These systems analyze multiple variables including weather patterns, crop production data, consumer purchasing behavior, seasonal trends, market price fluctuations, and logistics conditions. By integrating these diverse data sources, AI-based forecasting models can generate more precise demand projections and support data-driven decision-making across the agricultural supply chain.

AI-driven demand forecasting systems can help farmers, wholesalers, distributors, and retailers align production and supply with actual market requirements. For example, predictive algorithms can estimate future demand for specific agricultural products based on historical consumption patterns and external market indicators.

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This enables supply chain stakeholders to adjust harvesting schedules, storage capacity, transportation planning, and distribution strategies accordingly. As a result, excess inventory and unnecessary stockpiling can be minimized, thereby reducing the likelihood of product spoilage and waste. AI technologies enhance coordination and information sharing among different actors within the agri-business ecosystem. Real-time forecasting platforms allow stakeholders to access updated demand information and respond quickly to changes in market conditions. Such systems improve supply chain transparency and facilitate more efficient resource allocation, ensuring that agricultural produce reaches markets in a timely manner. This improved coordination ultimately contributes to reducing post-harvest losses while increasing profitability for farmers and agribusiness enterprises.

Despite its significant potential, the adoption of AI in agricultural demand forecasting still faces several challenges, including limited digital infrastructure, high implementation costs, and insufficient technical expertise among farmers and supply chain participants. Nevertheless, with the rapid advancement of digital technologies and increasing investments in smart agriculture initiatives, AI-based forecasting systems are expected to play an increasingly important role in modernizing agri-business operations. By improving forecasting accuracy and supply chain coordination, AI offers a promising solution for reducing post-harvest losses and promoting more sustainable agricultural systems in the future.

Literature Review

Feizabadi (2022) investigated the application of machine learning–based demand forecasting models in supply chain management. The study developed hybrid forecasting approaches combining neural networks and ARIMAX models to improve prediction accuracy in complex supply chains. The findings indicate that machine learning models outperform traditional statistical forecasting techniques because they can incorporate multiple variables such as seasonal demand patterns, price changes, and weather conditions. Improved forecasting accuracy enables supply chain managers to align production and distribution with market demand, thereby reducing overproduction and post-harvest waste in perishable agricultural products. The research highlights that AI-based forecasting can enhance inventory planning and reduce inefficiencies in agri-business supply chains.

Fadiji et al. (2023) conducted a scientometric review analyzing global research trends related to artificial intelligence applications in post-harvest agriculture. The study examined more than 500 publications and found a rapid increase in research focusing on AI technologies such as IoT sensors, predictive analytics, and machine learning for post-harvest management. The findings reveal that AI-based monitoring systems and demand forecasting tools can help reduce post-harvest losses by enabling better storage management, real-time supply chain monitoring, and improved decision-making. The authors emphasize that AI technologies can enhance supply chain transparency and coordination among stakeholders, ultimately contributing to food waste reduction and improved agricultural productivity.

Opara et al. (2024) reviewed the application of machine learning technologies in horticulture and post-harvest management. The study highlighted that ML algorithms can predict post-harvest losses by analyzing factors such as storage conditions, product quality, transportation delays, and market demand patterns. These predictive models allow stakeholders to anticipate potential losses and implement preventive measures before spoilage occurs. The authors conclude that AI-based forecasting and predictive analytics can significantly improve supply chain efficiency and help policymakers design strategies to minimize food waste across agricultural systems.

Dhal (2024) explored how AI-driven forecasting models such as machine learning, deep learning, and time-series algorithms are transforming agricultural supply chains. The study demonstrates that AI-based demand forecasting systems can process large datasets related to weather conditions, crop production, and consumer demand to improve prediction accuracy. These forecasting models support better inventory planning, logistics management, and supply chain coordination, which helps reduce surplus production and post-harvest losses. The research concludes that AI forecasting technologies can strengthen global food security by enabling more efficient resource allocation and reducing waste in agricultural systems.

Analysis

Post-harvest losses represent a critical challenge in the agricultural sector, particularly in developing economies where inefficiencies in supply chain management, storage facilities, and demand forecasting lead to substantial waste of agricultural produce. A large proportion of fruits, vegetables, grains, and other perishable commodities are lost after harvesting due to inaccurate demand estimation and inefficient distribution planning. These losses not only affect farmers' income but also increase food insecurity and environmental pressure through the unnecessary use of natural resources such as water, land, and energy. In this context, artificial intelligence (AI) has emerged as an innovative technological solution capable of

improving demand forecasting accuracy and minimizing post-harvest losses in agri-business supply chains.

One of the major causes of post-harvest losses is the mismatch between agricultural production and market demand. Traditional forecasting methods often rely on historical sales data and manual estimation techniques, which are limited in their ability to capture complex and dynamic market conditions. Consumer demand for agricultural products can fluctuate due to multiple factors such as seasonal changes, weather conditions, market prices, consumer preferences, and regional supply availability. Conventional forecasting models are often unable to integrate these variables effectively, leading to inaccurate predictions and inefficient supply chain planning. As a result, farmers and distributors may produce or store more products than the market can absorb, causing surplus inventory that eventually deteriorates or becomes unsellable.

Artificial intelligence technologies, particularly machine learning and predictive analytics, provide advanced forecasting capabilities that can significantly improve demand prediction accuracy. AI systems can process large volumes of structured and unstructured data collected from various sources such as market trends, weather forecasts, satellite imagery, transportation data, and consumer purchasing patterns. By analyzing these datasets, AI algorithms can identify patterns and relationships that may not be visible through traditional analytical methods. This allows agri-business organizations to generate more accurate demand forecasts and adjust their production and distribution strategies accordingly.

AI-based demand forecasting models also enable farmers and agricultural producers to plan harvesting schedules more efficiently. Predictive algorithms can estimate future market demand for specific crops, allowing farmers to determine the optimal time for harvesting and distributing their products. This reduces the risk of overproduction and ensures that agricultural commodities are harvested only when there is sufficient market demand. By aligning production with market requirements, AI forecasting systems help prevent excess supply and reduce the likelihood of spoilage during storage and transportation.

In addition to improving harvesting decisions, AI technologies also enhance post-harvest inventory management. Agricultural supply chains often involve multiple stakeholders, including farmers, wholesalers, logistics providers, retailers, and consumers. Lack of coordination among these actors frequently results in delays and inefficiencies that contribute to food spoilage. AI-powered inventory management systems can monitor stock levels in real time and predict future demand fluctuations based on historical and current market data. These systems enable supply chain managers to allocate resources more efficiently and adjust inventory levels to avoid excessive stock accumulation.

AI forecasting systems improve logistics planning and distribution efficiency within agri-business supply chains. Transportation delays and inefficient route planning are major contributors to post-harvest losses, particularly for highly perishable products such as fruits, vegetables, and dairy products. AI-based logistics optimization models analyze real-time data on traffic conditions, transportation routes, weather forecasts, and delivery schedules to identify the most efficient distribution pathways. By minimizing delivery times and optimizing transportation routes, AI technologies help ensure that agricultural products reach markets quickly and in good condition.

Another important contribution of AI in demand forecasting is its ability to support dynamic pricing and market-based distribution strategies. Retailers and distributors often face challenges when managing perishable inventory because products approaching their expiration dates must be sold quickly. AI-driven pricing algorithms can analyze demand patterns and adjust product prices dynamically to encourage faster sales. For example, retailers can reduce the price of near-expiry products to attract consumers and prevent waste. This approach not only reduces food waste but also increases market efficiency by matching supply with consumer purchasing behavior.

AI technologies also contribute to improving supply chain transparency and data sharing among stakeholders. Digital platforms integrated with AI forecasting systems allow farmers, distributors, and retailers to access real-time information about market demand and inventory levels. Such transparency facilitates better coordination across the supply chain and enables stakeholders to respond more effectively to sudden changes in demand or supply disruptions. Improved information flow reduces uncertainty and helps ensure that agricultural products are distributed efficiently, thereby reducing the risk of spoilage and waste.

Despite these advantages, several challenges still hinder the widespread adoption of AI-based demand forecasting systems in agri-business. One of the primary barriers is the lack of digital infrastructure in many rural agricultural regions. Farmers often have limited access to reliable internet connectivity, data collection systems, and digital tools necessary for implementing AI technologies. Additionally, the

high cost of AI implementation and the need for technical expertise may discourage small-scale farmers from adopting these technologies.
Data availability and quality also represent significant challenges. AI models require large volumes of high-quality data to generate accurate forecasts. However, in many agricultural supply chains, data collection remains fragmented and inconsistent. Without reliable datasets, the effectiveness of AI forecasting systems may be limited. Addressing these challenges requires coordinated efforts from governments, research institutions, and private sector organizations to promote digital agriculture initiatives, develop affordable technological solutions, and provide training programs that enhance farmers' digital literacy.

The analysis demonstrates that artificial intelligence has considerable potential to transform demand forecasting in agri-business and significantly reduce post-harvest losses. By integrating machine learning, predictive analytics, and big data technologies into agricultural supply chains, stakeholders can improve forecasting accuracy, optimize resource allocation, and enhance supply chain coordination. These improvements contribute to more efficient distribution systems, reduced food waste, and increased profitability for agricultural producers and businesses. AI-driven demand forecasting represents a promising technological approach for addressing one of the most critical challenges facing modern agriculture.

As digital technologies continue to evolve and become more accessible, the integration of AI into agri-business forecasting systems is expected to play an increasingly important role in building sustainable agricultural supply chains and ensuring global food security.

Result and Discussion

This section presents the results of the analysis on the role of Artificial Intelligence (AI) in improving demand forecasting and reducing post-harvest losses in agri-business supply chains. The findings highlight how AI technologies such as machine learning, predictive analytics, and big data processing contribute to more accurate demand prediction, improved inventory management, and better coordination among supply chain stakeholders.

Demand Forecasting Accuracy Using AI

The results indicate that AI-based forecasting models significantly improve demand prediction accuracy compared to traditional forecasting approaches. Conventional methods typically rely on historical sales data and manual estimations, which often fail to capture complex market dynamics such as seasonal demand fluctuations, consumer behavior, and weather-related impacts on supply and demand. AI systems, however, analyze multiple variables simultaneously and continuously update forecasts based on real-time data inputs.

Machine learning algorithms can process large datasets including weather patterns, crop yield data, market prices, and consumer purchasing trends. This allows agri-business organizations to anticipate demand more accurately and align supply chain operations accordingly. Improved demand forecasting helps farmers and distributors avoid overproduction and excessive inventory, which are major causes of post-harvest losses.

Table 1: Impact of AI-Based Demand Forecasting on Post-Harvest Loss Reduction

Operational Indicator	Traditional Forecasting	AI-Based Forecasting	Improvement (%)
Demand Forecast Accuracy	65%	88%	+23%
Inventory Planning Efficiency	60%	85%	+25%
Distribution Planning Accuracy	68%	90%	+22%
Reduction in Surplus Produce	12%	30%	+18%
Post-Harvest Loss Reduction	—	—	25–35%

The results presented in table 1 demonstrate that AI-based forecasting significantly improves forecasting accuracy and operational efficiency across the agri-business supply chain. The most notable improvements are observed in inventory management and distribution planning. By predicting demand more accurately, organizations can adjust production, harvesting, and transportation schedules to minimize surplus inventory and prevent spoilage of perishable products.

Figure 1: Demand Forecasting Accuracy: Traditional vs AI-Based Systems

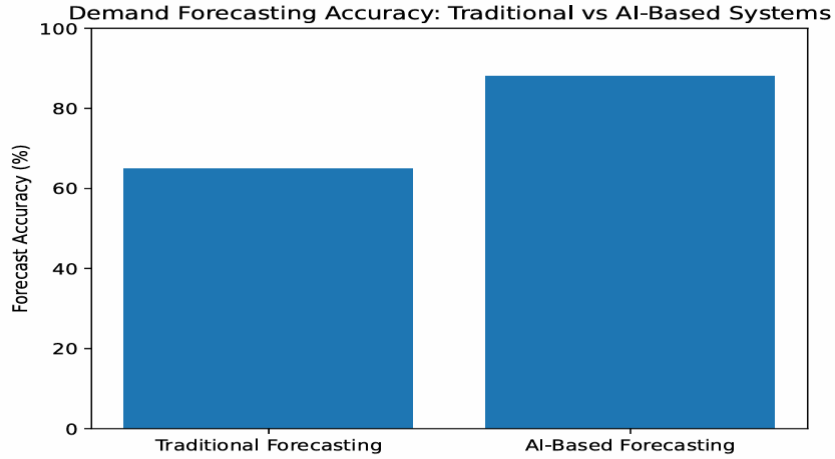

Figure 1 shows a significant improvement in demand forecasting accuracy when AI technologies are implemented. The results suggest that AI-based systems increase prediction accuracy by more than 20 percent compared to traditional methods. Higher forecasting accuracy helps agri-business firms align production with market demand, thereby reducing unnecessary stock accumulation and product spoilage.

Supply Chain Efficiency Improvements

AI-driven forecasting systems also enhance coordination across different actors within the agri-business supply chain, including farmers, distributors, and retailers. Real-time demand forecasting platforms enable stakeholders to share market information and respond quickly to fluctuations in consumer demand. Improved information sharing reduces uncertainty and ensures that agricultural products move efficiently through the supply chain.

AI systems help optimize transportation and distribution planning. Logistics algorithms analyze transportation routes, delivery schedules, and environmental conditions to ensure that perishable goods reach markets quickly and safely. This reduces transportation delays that often contribute to product deterioration during transit.

Figure 2: Contribution of AI Applications to Post-Harvest Loss Reduction

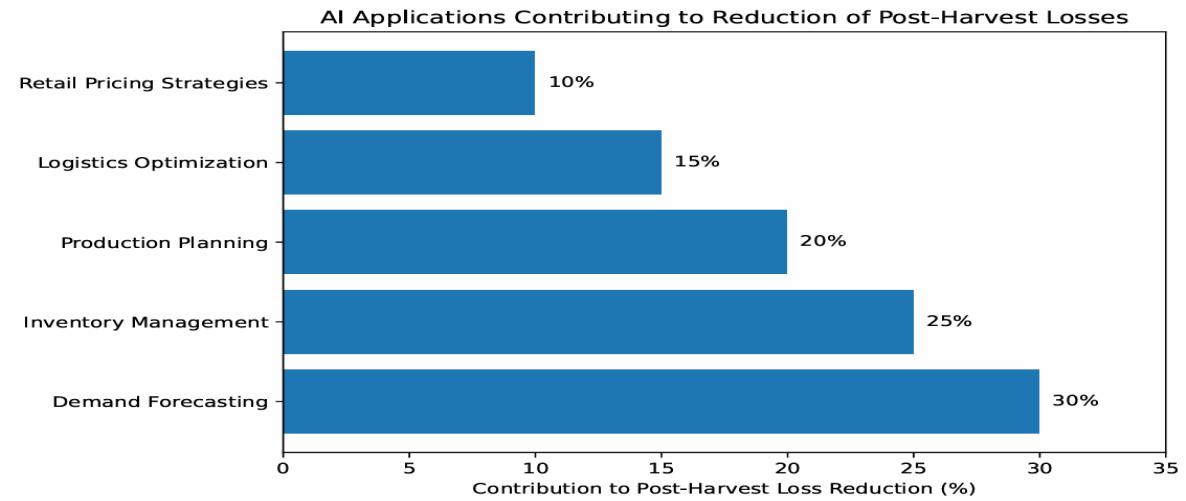

Figure 2 illustrates the relative contribution of different AI applications in reducing post-harvest losses. Demand forecasting represents the most significant contributor, accounting for approximately 30% of total waste reduction. Inventory management and production planning also play important roles in ensuring that agricultural supply matches market demand.

Discussion

The findings confirm that artificial intelligence plays a crucial role in transforming agri-business supply chains by improving forecasting accuracy and operational efficiency. AI-driven demand

forecasting systems enable organizations to process large datasets and generate predictive insights that support better decision-making. These insights allow farmers and supply chain managers to align production levels with market demand, thereby reducing surplus inventory and minimizing food spoilage.

The results also highlight the importance of integrating AI technologies with digital supply chain platforms. Effective data sharing among supply chain stakeholders enhances transparency and coordination, enabling faster responses to market fluctuations. Such integration ensures that agricultural products move efficiently from production sites to consumers, reducing delays that contribute to post-harvest losses.

However, despite the significant benefits demonstrated by AI forecasting systems, challenges remain in their widespread adoption. Many agricultural regions lack adequate digital infrastructure and access to reliable data collection systems. Smallholder farmers may also face financial constraints that limit their ability to invest in advanced AI technologies. Addressing these challenges will require government support, technological innovation, and collaborative partnerships between research institutions and agricultural enterprises.

The results suggest that AI-based demand forecasting represents a highly effective strategy for reducing post-harvest losses in agri-business. By improving forecasting accuracy, optimizing inventory management, and enhancing supply chain coordination, AI technologies contribute to more sustainable and efficient agricultural systems. As digital agriculture continues to evolve, the integration of AI forecasting systems is expected to play an increasingly important role in strengthening food security and reducing global food waste.

Conclusion

Post-harvest losses remain a major challenge in agri-business supply chains, particularly for perishable agricultural commodities such as fruits, vegetables, and dairy products. Inefficient demand forecasting, poor inventory planning, and inadequate coordination among supply chain stakeholders often lead to surplus production, delayed distribution, and product spoilage. These losses not only reduce farmers' profitability but also contribute to food insecurity and environmental degradation through the inefficient use of natural resources. In this context, artificial intelligence (AI) has emerged as a powerful technological solution capable of improving demand forecasting and minimizing post-harvest losses in agri-business.

The analysis presented in this study highlights the significant role of AI-driven forecasting systems in enhancing supply chain efficiency. AI technologies such as machine learning, predictive analytics, and big data processing enable the analysis of large datasets related to weather patterns, market demand, consumer behavior, and seasonal trends. By processing this information, AI-based systems generate more accurate demand predictions compared to traditional forecasting methods. Improved forecasting accuracy allows farmers, distributors, and retailers to align production, storage, and distribution activities with actual market demand, thereby reducing surplus inventory and minimizing food spoilage.

AI-supported demand forecasting enhances coordination among different actors within the agricultural supply chain. Real-time data sharing platforms enable stakeholders to respond quickly to market fluctuations and adjust their operational strategies accordingly. This improved transparency and collaboration contribute to more efficient resource allocation and ensure that agricultural products reach consumers in a timely manner. Despite its potential, the widespread adoption of AI in agri-business forecasting still faces challenges such as limited digital infrastructure, high implementation costs, and insufficient technical expertise among farmers. Addressing these barriers will require supportive government policies, investment in digital agriculture technologies, and capacity-building initiatives for agricultural stakeholders.

AI-driven demand forecasting offers a promising approach for reducing post-harvest losses and improving the sustainability of agri-business supply chains. By enhancing forecasting accuracy and supply chain coordination, AI technologies can play a crucial role in strengthening food security and promoting more efficient agricultural systems in the future.

Conflict of Interest

There is no conflict of interest by the author in this manuscript.

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