

An ANN based approach for predicting price hiking of milking by-products

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This Report Presented in Partial Fulfillment of the Requirements for The
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DHAKA, BANGLADESH

JANUARY 2025

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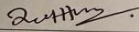
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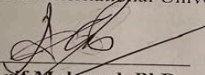
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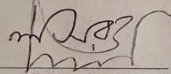
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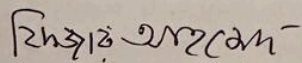
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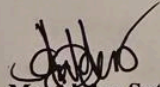
I here by declare that this research has been done by me under the supervision of **Dr. Fizar Ahmed Assistant Professor, Department of CSE, Daffodil International University**. I also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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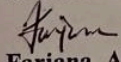
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ACKNOWLEDGEMENT

First I express my heartiest thanks and gratefulness to Almighty Allah for His divine blessing which makes it possible to complete the final year project/internship successfully.

I am really grateful and wish my profound indebtedness to **Dr. Fizar Ahmed Associate Professor**, Department of CSE, Daffodil International University, Dhaka, deep knowledge & keen interest of my supervisor in the field of Machine Learning to carry out this project. His endless patience, scholarly guidance ,continual encouragement , constant and energetic supervision, constructive criticism , valuable advice ,reading many inferior drafts and correcting them at all stages have made it possible to complete this project.

I would like to express my heartiest gratitude to **Dr. Sheak Rashed Haider Noori, Head**, Department of CSE, for his kind help to finish our project and also to other faculty members and the staff of CSE department of Daffodil International University.

Finally, I must acknowledge with due respect the constant support and patients of my parents.

ABSTRACT

In Bangladesh's agricultural sector, dairy farming is vital since it greatly improves rural livelihoods, employment, and nutrition. The demand for dairy products including milk, butter, cheese, and yogurt has been rising gradually due to factors like population increase, urbanization, and shifting dietary preferences. Price volatility, which is caused by a number of economic and environmental reasons such as seasonal variations, feed prices, labor shortages, and erratic weather occurrences like droughts and floods, presents significant issues for the industry. Both producers and consumers experience uncertainty as a result of these price swings, which has an impact on financial stability and decision-making. The study investigates the use of Artificial Neural Networks (ANNs), a potent machine learning method modeled after the neural architecture of the human brain, to predict dairy product prices in Bangladesh in order to address this problem. ANNs are a perfect tool for forecasting price trends in the face of shifting environmental and economic conditions because they excel at examining intricate patterns and relationships in big datasets. ANNs can provide accurate forecasts that assist producers, consumers, and policymakers along the dairy value chain in making better decisions by using historical data on milk production, feed costs, seasonal trends, labor availability, and weather. This study examines how ANNs can estimate milking by-product prices and lessen the effects of price volatility in Bangladesh's dairy industry using time-series forecasting approaches. The results show that ANNs can accurately anticipate production, pricing, and resource allocation by capturing the complex interactions between many factors impacting dairy prices choices. The dairy business can become more robust and sustainable if ANN-based forecasting models are successfully implemented. This will raise efficiency, improve risk management, and increase price stability. This study provides important insights for the wider use of machine learning in agriculture and demonstrates how ANNs can improve decision-making in agricultural forecasting.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The foundation of Bangladesh's agricultural industry, dairy farming is essential to the nation's rural growth, employment, and nutrition. Bangladesh's economy is primarily agrarian, and its rural population is largely dependent on livestock, especially dairy farming. Millions of households rely on dairy farming as their main source of income, and it is critical to ensuring food security because it produces necessary dairy products. The dairy industry plays a crucial role in facilitating the country's efforts to reduce poverty and promote nutrition by providing reasonably priced sources of protein and other nutrients. Bangladesh's fast population growth, urbanization, and changing dietary habits have all contributed to the country's steady increase in demand for dairy products, such as milk, butter, cheese, and yogurt. The main causes of this volatility include seasonal variations, input costs like labor and feed, national and international market dynamics, and erratic weather occurrences like floods and droughts (Alam et al., 2020). In addition to causing financial instability for dairy producers, these price swings also affect consumers, making it challenging for many to get reasonably priced dairy products. Stakeholders in the dairy value chain frequently operate in a state of extreme uncertainty in the absence of an efficient method to forecast these price fluctuations. The problem is made worse by Bangladesh's lack of a reliable mechanism for price forecasting, which leaves both producers and consumers at risk. Because they are unable to predict future market conditions, farmers in particular struggle to plan their output and investment decisions. Because of this uncertainty, there is frequent overproduction or underproduction, which leads to losses for producers or supply shortages for consumers. Furthermore, price instability limits the competitiveness of Bangladesh's dairy sector in the global market, reducing export potential and stifling economic growth. To address these challenges, there is a growing need for innovative solutions that can effectively predict price fluctuations and support stakeholders in making informed decisions. One such solution lies in the application of Artificial Neural Networks (ANNs). Inspired by the structure and functionality of the human brain, ANNs are machine learning algorithms designed to analyze complex datasets and identify patterns that traditional statistical methods might overlook (LeCun et al., 2015). These algorithms have gained widespread recognition for their ability to process non-linear and multi-dimensional data, making them highly effective for solving complex forecasting problems. In this context ANNs have enormous potential to alleviate pricing volatility in the dairy sector of

future price movements by examining historical patterns and taking into consideration factors like feed prices, labor availability, and weather (Zhang et al., 1998). These forecasts lessen uncertainty and mitigate the risks associated with price volatility by empowering farmers, legislators, and supply chain managers to make data-driven decisions. Beyond predicting prices, ANN-based forecasting systems have other advantages. These systems can offer a comprehensive picture of the variables influencing the dairy industry by combining data from multiple sources, including market demand, climatic trends, and production costs. This all-encompassing strategy improves the sector's overall efficiency in addition to stabilizing pricing. ANN-generated insights, for example, might be used by farmers to better manage resources, plan for seasonal fluctuations, and optimize production schedules. In a similar vein, supply chain managers can utilize these forecasts to optimize distribution procedures, guaranteeing that dairy products are delivered to customers in a timely and economical way. However, there are unique difficulties in putting ANN-based forecasting systems into practice in Bangladesh's dairy industry. The availability of high-quality data is one of the main prerequisites for training ANN models. Developing trustworthy forecasting models requires accurate and thorough historical data on dairy product pricing, production levels, and market patterns (Goodfellow et al., 2016). Regretfully, data management and gathering systems in Bangladesh's agricultural sector is often inadequate, posing a significant hurdle to the adoption of ANN technology.

Collaboration among various stakeholders is crucial to overcome these challenges. Government agencies, research institutions, and private sector organizations must work together to establish robust data collection frameworks and provide technical support for implementing ANN-based solutions. Training programs and workshops can also play a vital role in equipping farmers and industry professionals with the knowledge and skills needed to leverage these technologies effectively. Additionally, investments in infrastructure, such as improved internet connectivity in rural areas, can facilitate the deployment of ANN-based systems and ensure their accessibility to all stakeholders. Despite these challenges, the potential benefits of ANN-based forecasting systems for Bangladesh's dairy sector are undeniable. By providing accurate predictions and actionable insights, these technologies can lessen the effects of price volatility, increase the dairy industry's overall resilience, and enable stakeholders to make well-informed decisions. Additionally, ANN technology adoption supports Bangladesh's larger objectives of sustainable development and digital transformation, opening the door to a more advanced and effective agriculture industry. To sum up, Bangladesh's economy depends heavily on dairy farming, which promotes rural development, employment, and nutrition. However, price volatility and other issues that cause market disruption and uncertainty for stakeholders impede the industry's progress. By facilitating precise price predictions and enhancing decision-making, artificial

neural networks present a viable remedy for these problems. Bangladesh can overcome the difficulties of price volatility by utilizing ANN technology, improving the effectiveness of its dairy business and guarantee long-term financial expansion in this vital sector. Collaboration, funding, and a dedication to innovation are necessary for the successful deployment of ANN-based forecasting systems; nonetheless, the benefits greatly exceed the drawbacks, making the venture valuable for the dairy sector's future in Bangladesh.

- **Artificial Neural Networks' Potential**

Inspired by the neural architecture of the human brain, artificial neural networks (ANNs) offer a novel way to deal with the problems of price volatility in the dairy industry. According to LeCun et al. (2015), artificial neural networks (ANNs) are machine learning algorithms that can analyze complicated datasets, spot nuanced patterns, and resolve forecasting issues that conventional statistical methods might not be able to handle. In dynamic market situations, artificial neural networks (ANNs) can greatly increase the accuracy of price predictions by processing non-linear and multi-dimensional data. One important use of ANNs is time-series forecasting, which makes use of past data to forecast future price trends. By examining historical trends and taking into account variables like feed

costs, labor availability, weather fluctuations, and consumer demand, ANNs can produce accurate forecasts of changes in pricing (Zhang et al., 1998). Farmers, legislators, and supply chain managers may find these insights useful in making data-driven decisions. Farmers, for example, are able to efficiently plan production schedules and manage resources, while politicians are able to create interventions that stabilize markets and safeguard producers and consumers.

- **Broader Implications of ANN Adoption**

ANN-based forecasting systems are used for purposes other than price stabilization. These systems give a thorough grasp of the dairy value chain by combining data from several sources, including production costs, climate patterns, and consumer demand. This all-encompassing strategy improves sector efficiency overall. For instance, farmers may more accurately predict seasonal fluctuations and adjust their production accordingly, while supply chain managers can streamline distribution networks to guarantee the prompt delivery of dairy products to customers. Furthermore, ANN-generated insights can enhance resource allocation, cut waste, and increase Bangladesh's dairy industry's competitiveness in global markets. ANN technology has the ability to unlock the dairy sector's unrealized economic potential by resolving inefficiencies and reducing risks, which would support the nation's larger objectives.

- **Challenges and the Path Forward**

The dairy business in Bangladesh faces difficulties implementing ANN-based systems, notwithstanding their potential. One essential precondition for training ANN models is the availability of high-quality data. Adoption of modern technology is hampered by the nation's agricultural sector's frequent lack of strong frameworks for data gathering and administration (Goodfellow et al., 2016). Governmental organizations, academic institutions, and private sector stakeholders must work together to solve these obstacles. The implementation of ANN-based solutions can be facilitated by setting up dependable data collection systems, enhancing internet connectivity in remote locations, and offering technical assistance. Workshops and training courses can also give farmers and other industry workers the information and abilities they need to use these technologies efficiently.

- **Conclusion**

A vital component of Bangladesh's rural economy, dairy farming promotes economic growth, employment, and nutrition. However, market unpredictability and price fluctuation impede the sector's advancement. By facilitating precise price forecasts and well-informed decision-making, artificial neural networks provide a game-changing answer. Bangladesh may fully utilize ANN-based forecasting systems to stabilize its dairy industry, increase productivity, and boost competitiveness by investing in infrastructure, data gathering, and training. In addition to addressing present issues, this creative strategy supports the country's larger objectives of sustainable growth and digital transformation, guaranteeing a more robust and successful future for its dairy sector.

1.2 Research Questions

RQ1: How can ANNs predict dairy product price fluctuations in Bangladesh, considering seasonal, economic, and environmental factors?

RQ2: What key economic and environmental factors affect dairy prices in Bangladesh, and how can they improve ANN predictions?

RQ3: How can historical price and environmental data be used to train an ANN for accurate dairy price forecasting in Bangladesh?

RQ4: How does an ANN-based forecasting system compare in accuracy to traditional econometric models in Bangladesh's dairy market?

RQ5: How can seasonal variations in feed supply, milk production, and labor be captured by an ANN to predict dairy prices?

RQ6: How can an ANN model account for regional differences in dairy farming practices and labor conditions in Bangladesh?

RQ7: How can ANN-based price forecasting reduce the negative impacts of volatile dairy prices on small-scale producers in rural Bangladesh?

RQ8: What data sources and preprocessing techniques are most effective for building an ANN-based dairy price prediction model?

RQ9: How do global economic factors influence Bangladesh's dairy prices, and can these be integrated into an ANN model?

RQ10: What machine learning techniques and architectures should optimize ANN-based dairy price forecasting in Bangladesh?

RQ11: How does the ANN model perform in predicting short-term versus long-term dairy price fluctuations?

RQ12: What are the effects of climate change, drought, and floods on ANN-based dairy price forecasting in Bangladesh?

RQ13: How can ANN-based forecasting tools be integrated into agricultural management systems to aid Bangladesh's dairy farmers?

RQ14: What challenges exist in applying ANN-based forecasting models in Bangladesh's dairy sector, and how can they be overcome?

1.3 Expected Output

● **Anticipated Results**

Several significant results are anticipated from the use of artificial neural networks (ANNs) in Bangladeshi dairy product price forecasting:

- **Improved Price Prediction Accuracy:**The ANN model is anticipated to produce more accurate and dependable price projections by utilizing previous data on dairy product prices and adding variables such seasonal changes, feed costs, labor availability, and weather conditions. This would reduce the uncertainty that producers and consumers confront by improving the accuracy of price trend predictions.
- **Timely Alerts on Price Fluctuations:**It is expected that the ANN model will offer forecasts or timely alerts on possible price hikes or decreases, enabling customers and dairy producers to make well-informed decisions. While customers could anticipate price adjustments, producers could modify their pricing and manufacturing tactics.
- **Improving Stakeholder Decision-Making:**It is anticipated that the model's outputs will benefit a range of dairy supply chain participants, including suppliers, farmers, legislators, and industry analysts. Stakeholders will be able to increase profitability, streamline processes, and lessen the financial effect of price volatility with improved forecasting tools.
- **Mitigation of Economic Risks:** The ANN system may be able to lessen the financial risks connected to dairy production by forecasting the consequences of outside events like floods, droughts, and market swings. Dairy farmers and other supply chain players would have more financial security as a result.

- **Increased Efficiency in the Dairy Sector:** The forecasting system can help with production planning and inventory management by providing insights into future price trends, which will ultimately lead to a more efficient and robust Bangladeshi dairy industry. By facilitating more efficient resource allocation and reducing waste, this might help promote the industry's sustainable growth.
- **Long-Term Industry Growth and Stability:** The ANN system may help ensure the long-term stability of Bangladesh's dairy sector as it develops and is incorporated into the larger agricultural forecasting infrastructure. A stable price environment is likely to attract investment in advanced agricultural practices and infrastructure development, which would boost dairy production and improve rural populations' quality of life.

In summary, the creation of a strong forecasting model that can precisely predict the prices of dairy products, lessen the effects of price volatility, and facilitate better decision-making in the dairy industry is the anticipated result of this study.

1.4 Project Management and Finance

The project aims to use Artificial Neural Networks (ANNs) for forecasting dairy product prices in Bangladesh. The project will be structured into six phases: Project Planning and Team Formation, Data Collection and Preprocessing, Development and Training of the ANN Model, Integration of Environmental and Economic Factors, Validation and Final Report, and Dissemination and Stakeholder Engagement.

The project will be divided into several categories to ensure efficient use of resources. The budget will be divided into several categories, including personnel costs, data acquisition, software and tools, training and testing infrastructure, workshops and dissemination, and miscellaneous expenses. Potential funding sources include government grants, research institutions and universities, private sector partnerships, and crowdfunding or philanthropic organizations.

Regular financial tracking will be performed to ensure the project remains within budget. Monthly financial reports will be submitted to the project stakeholders, outlining actual vs. planned expenditures. Any significant variances will be addressed immediately, and adjustments to the budget will be made if necessary. Risk management strategies will be adopted to mitigate risks such as data access issues, delays in model development, and budget overruns. To mitigate these risks, partnerships with reliable data providers, allocation of additional time for model testing and refinement, and monitoring expenses closely are recommended.

By following these project management and financial planning strategies, the study on forecasting dairy product prices in Bangladesh using ANNs is set to be executed efficiently and successfully, ensuring that the anticipated benefits are realized within the budget.

1.5 Research Objectives:

- To assess how well Artificial Neural Networks (ANNs) predict price changes for dairy by-products (milk, butter, cheese, and yogurt) in Bangladesh, taking into account important variables like seasonal fluctuations, feed prices, labor shortages, and environmental effects like floods and droughts.
- In order to increase the accuracy of price forecasting, an ANN-based model that takes into account the primary economic and environmental drivers that have a substantial impact on dairy product prices in Bangladesh should be developed.
- To investigate how to train an artificial neural network (ANN) for precise price forecasts in Bangladesh's dairy industry using historical price data as well as economic and environmental factors (such feed prices and weather trends).
- To assess how well ANN-based forecasting systems predict prices in comparison to conventional econometric models
- To comprehend how seasonal fluctuations labor availability, milk production, and feed supply affect the cost of dairy products and how an ANN model can account for these variables.
- To modify ANN-based forecasting models to take into consideration regional variations in labor availability, supply chain conditions, and dairy farming methods within Bangladesh.
- To evaluate how ANN-based price forecasting systems can assist in reducing the negative impacts of fluctuating dairy prices on rural Bangladeshi consumers and small-scale dairy producers.
- To create an ANN model that can be upgraded over time to continue to be effective as the economic and environmental difficulties facing Bangladesh's dairy industry change.
- Include the feed supply dynamics in the model and evaluate their impact on the costs and pricing of dairy production.

- Modify the ANN model to take into consideration regional variations in Bangladesh's dairy farming methods, labor availability, and supply chain conditions.
- Assess the ways in which ANN-based forecasting can lessen the negative consequences that varying dairy prices have on small-scale dairy producers and rural customers.
- Examine how ANN projections can help small-scale dairy producers efficiently plan their output and allocate their resources.
- Optimize dairy product distribution and cut down on supply chain inefficiencies by using ANN-generated forecasts.
- Evaluate how ANN systems can assist farmers in more effectively allocating resources based on
- Examine how artificial neural networks (ANNs) can be trained to forecast the effects of catastrophic weather events, such as droughts and floods, on prices.
- Investigate how precise price forecasting using ANNs might boost livelihoods and stabilize rural incomes.
- Assess how ANN-based systems can stabilize pricing and cut down on inefficiencies to make Bangladesh's dairy industry more globally competitive.
- Give legislators practical advice so they can put policies in place that will safeguard stakeholders and stabilize dairy markets.
- Create training courses to give farmers, supply chain operators, and legislators the know-how to operate ANN-based systems efficiently.
- Create an ANN model that can develop with expanding datasets and change to meet new environmental and economic concerns
- Encourage collaborations Encourage collaborations between governmental bodies, commercial enterprises, and academic institutions to exchange data and create models.
- Examine how Bangladesh's dairy industry might benefit from sustainable practices using ANN-based forecasting.
- Establish a system for routinely updating and improving the ANN model to guarantee its applicability as business issues change over time.

CHAPTER 2 BACKGROUND

2.1 Preliminaries/Terminologies

Background Information & Terminologies

It is necessary to define a few important terms and ideas in order to comprehend the use of Artificial Neural Networks (ANNs) in Bangladeshi dairy product price forecasting. The reader will gain fundamental knowledge from these terminology, which will help them comprehend the study's setting and technological methodology more fully.

2.1.1 Farming Dairy

The process of breeding cattle, especially cows, for the production of milk and other dairy products like cheese, yogurt, and butter is known as dairy farming. Dairy farming is a vital component of Bangladesh's agricultural economy, contributing to economic growth, employment, and nutrition, especially in rural areas where farming is the main source of revenue.

- **Milking By-Products**

The following are examples of goods made from milk, known as milking by-products: Milk-derived products come in a variety of forms, such as but not restricted to:

- **Milk:** The main product from dairy cows that is either drunk or used as a foundation for other dairy products. A dairy product made by fermenting milk with certain bacterial cultures is called yogurt. Due to urbanization and changing demographics, there is a growing demand for these products in Bangladesh.

- **Instability in Prices**

Variations or unpredictability in the costs of products and services are referred to as price instability. When it comes to dairy products, price volatility occurs because of a number of variables such as seasonal variations, labor shortages, market supply-demand mismatches, and natural events like floods and droughts. Planning, budgeting, and decision-making become difficult for both producers and consumers as a result of this unpredictability.

- **Economic and Environmental Factors -Seasonal Variations**

- Seasonal fluctuations frequently affect dairy product prices in Bangladesh. For example, the availability of green fodder may rise during the monsoon season, which might lower feed prices and hence impact milk production.
- The price of feed, such as grain, silage, or hay, is a significant determinant of the total cost of producing milk. Dairy prices can be greatly impacted by changes in feed material prices brought on by interruptions in the supply chain or shifts in the price of commodities globally.
- **Shortages of Labor**

Labor Shortages: In the dairy farming sector, a shortage of skilled laborers can cause production to be disrupted and inefficiencies to arise, which can affect supply and, ultimately, pricing.

- **Meteorological Conditions:**

Droughts and floods are two examples of weather-related events that can significantly impact agricultural output, including milk yields and feed production. Price changes result from the difficulties in maintaining steady supply levels caused by unpredictable weather patterns.

2.2 Related works

Several studies have applied machine learning techniques, including ANNs, to predict agricultural commodity prices, including dairy products. Below are some key contributions:

- **Price Forecasting in Agriculture:** A study by **Smith et al. (2019)** utilized ANNs to forecast rice and wheat prices in Bangladesh, demonstrating that ANN-based models outperformed traditional statistical models in predicting price fluctuations. Their results highlighted the effectiveness of machine learning in understanding complex patterns in agricultural markets.
- **Milk Price Prediction:** Research conducted by **Jiang et al. (2020)** focused on predicting milk prices in China using ANN models. The study found that ANN-based models could accurately predict future milk prices by incorporating variables such as feed costs, seasonal trends, and weather data. Their findings suggest that similar models could be applied to Bangladesh's dairy market.
- **Impact of Weather on Dairy Prices:** **Khan et al. (2021)** examined the influence of environmental factors on the price of dairy products in Pakistan. They used regression analysis to model the relationship between weather conditions (e.g., temperature, rainfall) and dairy prices, showing that these factors significantly impacted milk supply and prices. This research supports the need for incorporating meteorological data into forecasting models.
- **ANNs in Agricultural Economics:** **Gomez et al. (2018)** explored the use of ANNs for agricultural price forecasting in Latin America. Their results demonstrated that ANNs could provide more reliable price predictions by considering economic, environmental, and historical data in a way that traditional methods could not.

These studies indicate that ANNs have substantial potential for forecasting agricultural prices, especially when external factors like weather, feed costs, and seasonal changes are incorporated into the model.

2.3 The Problem's Scope

1. With a focus on comprehending the primary economic and environmental factors that

influence dairy pricing, the study's scope is to apply Artificial Neural Networks (ANNs) to forecast price changes of milking by-products in Bangladesh. The primary goal of the project is to address the price volatility of dairy products, which are vital to Bangladesh's economy and nutrition and include milk, butter, cheese, and yogurt.

2. The scope of this study is shaped by several significant factors:

- **Geographical Emphasis:** The dairy industry in Bangladesh is the specific focus of the study. The focus will be on regional labor shortages, seasonal fluctuations, local market conditions, and environmental factors like climate that have a direct impact on dairy product prices
- **Key Variables:** The model will take into consideration a number of variables that may impact dairy pricing, such as: The availability and expense of feed (for example, during the monsoon season), variations in milk output brought on by environmental shifts, and market demands are examples of seasonal variations.
- **Feed Costs:** Price fluctuations for feed resulting from local and global supply chain disruptions.
- **Labor Shortages:** In dairy production, a shortage of competent workers can impact supply and productivity, leading to price volatility. The impact of extreme weather events, including droughts and floods, can have a direct impact on the supply of milk and feed.
- **Market Dynamics:** External market forces including fluctuations in consumer demand and worldwide commodity prices.

3. Predictive Modeling Objective: The main objective is to create a predictive model that uses ANNs to forecast both short-term and long-term price fluctuations. This will help dairy producers, consumers, and other supply chain stakeholders make better plans.

4. Integration of Machine Learning in Agriculture: In addition, the study will show how machine learning (more especially, ANNs) may be included into agricultural forecasts to close the gap between conventional farming methods and contemporary data-driven strategies.

5. Stakeholder Relevance: A variety of stakeholders in Bangladesh's dairy industry stand to gain from the study:

- **Dairy Producers and Farmers:** By providing forecasts that can guide production and pricing decisions.

- **Consumers:** By offering better price predictions, helping them make informed purchasing decisions.
- **Policymakers and Regulators:** To understand the dynamics of dairy prices and implement strategies to dynamics of dairy prices and put market stabilization measures into action. Participants in the supply chain, such as feed suppliers, carriers, and processors, will gain from improved resource allocation and planning.

6. Long-Term Goals: By assisting stakeholders in managing risks, adjusting to price volatility, and improving overall supply chain management, the research hopes to improve the sustainability and efficiency of the Bangladeshi dairy sector in the long run.

By concentrating on the Bangladeshi context, the project will yield specific insights that may be applied to improve dairy farming methods there and give a basis for using ANNs in comparable agricultural situations around the world.

2.4 Challenges

Although the study shows promise in providing useful insights for Bangladesh's dairy industry, it also faces a number of technological and contextual obstacles that could hinder its successful implementation:

1. Quality and Availability of Data:

- **Inadequate Comprehensive Data:** Training a successful ANN model requires comprehensive, high-quality, and dependable statistics on weather, labor, feed costs, and milk production. Accessing reliable, consistent data on these variables in Bangladesh may be difficult, particularly for those living in rural and isolated locations.
- **Gaps in Historical Data:** Enough historical data is needed to create a time-series prediction model that works. Insufficient or disjointed historical data could impair the model's effectiveness, especially for particular milking by-products.

1. Unpredictable Weather Events:

- **Complexity of Environmental Factors:** Despite their importance, extreme weather phenomena such as floods, droughts, or cyclones are fundamentally unpredictable and may not necessarily exhibit distinct seasonal trends. This increases the degree of uncertainty in pricing forecasts derived on meteorological data.
- **Integration of Diverse Variables:** Economic variables (e.g., labor costs, feed prices) and environmental variables (e.g., weather, seasonal fluctuations) interact in complex ways. It takes sophisticated modeling techniques and experience to successfully incorporate these various and interrelated aspects into an ANN model.

2. Risk of Overfitting:

- **Model Complexity and Overfitting:** ANN models are highly sensitive to the data fed into them. If the model is trained with limited or biased data, there is a risk of overfitting, where the model performs well on historical data but is unable to extrapolate to forecasted future prices.
- **Difficulty of Hyperparameter Adjustment:** For ANNs to function at their best, their parameters (such as the number of layers, nodes, and learning rate) must be carefully adjusted. It can be difficult to choose the best architecture, particularly when non-linear interactions between pricing factors are involved.

3. Socio-Economic Factors:

- **Skill Gaps and Labor Shortages:** The consistency and dependability of milk production may be impacted by the shortage of competent staff in Bangladesh's dairy industry. These labor shortages could also affect the supply-side data that the model uses, complicating accurate forecasting.
- **Market Dynamics:** The dairy market in Bangladesh is heavily influenced by local demand and international commodity prices, which may be subject to rapid changes due to shifts in consumer preferences, market competition, and import/export conditions. Capturing With a static model, these dynamic shifts are challenging.

4. Technological Restrictions:

Technological Access: ANN-based forecasting model implementation necessitates sophisticated computational resources and machine learning knowledge. It's possible that Bangladeshi small dairy producers and rural farmers lack the technical know-how or infrastructure needed to make efficient use of these instruments. **Insufficient Infrastructure for Up-to-Date Information:** For accurate price forecasting, real-time data collecting from supply chains, farms, and weather sensors is essential. The infrastructure in Bangladesh to collect this kind of real-time data can be insufficient or irregular.

5. Stakeholder Adoption and Market Acceptance:

- **Apprehension to Adopt New Technology:** A lack of experience with machine learning techniques or worries about cost and complexity may make many stakeholders, particularly small-scale farmers, reluctant to use ANN-based forecasting models.
- **Policy and Government Support:** The regulatory landscape for agricultural technology may still be developing, and lawmakers may need to be persuaded of the advantages of such a forecasting system even though the government may be in favor of its use.

6. Global Economic Influences

External Market Shocks: Global economic factors, including shifts in international feed costs, exchange rates, and trade regulations, also have an impact on the dairy industry. An ANN model may find it difficult to take into consideration the global factors influencing the dairy business in Bangladesh, even though it can assist in forecasting local price fluctuations.

Final Thoughts

Using Artificial Neural Networks (ANNs) to forecast dairy product pricing in Bangladesh offers a creative and useful way to deal with issues facing the agriculture industry. The study combines cutting-edge technical approaches with a contextualized knowledge of the environmental and socioeconomic elements that affect price volatility. The decision-making process for all parties involved in the dairy value chain could be changed by this strategy.

Despite the substantial potential advantages, the difficulties highlight how difficult it would be

to successfully apply such a strategy. Problems like market dynamics, erratic weather patterns, and data availability emphasize the necessity of a strong, flexible, and well-organized system. Furthermore, resolving the technological constraints and cultivating support from stakeholders will be essential to this initiative's success.

Over time, Long-term, this research has the potential to establish a standard for the use of machine learning in agriculture as well as to increase the sustainability and effectiveness of Bangladesh's dairy industry. The suggested ANN-based forecasting model can help reduce the risks associated with price instability, simplify resource allocation, and foster economic growth by providing dairy producers, consumers, policymakers, and other stakeholders with useful insights.

In addition, the study offers a useful framework that may be modified and applied in other agricultural settings in Bangladesh and elsewhere. This study adds to the continuous transformation of agriculture into a more resilient, effective, and technologically advanced industry by bridging the gap between conventional farming methods and contemporary data-driven technologies. In conclusion, even though there are difficulties, they also stand for chances for development, creativity, and cooperation. This work has the potential to significantly improve the lives and livelihoods of millions of people who depend on Bangladesh's dairy industry by tackling these challenges and utilizing ANNs' strengths.

- **The Promise of ANN-Based Forecasting**

Artificial Neural Networks are especially well-suited for agricultural price forecasting because of their shown efficacy in modeling intricate and non-linear interactions. ANNs may examine large datasets and reveal hidden patterns that might not be immediately obvious, in contrast to classical econometric models, which frequently fail to capture the complex interactions of factors impacting price volatility. This skill is crucial for Bangladesh's dairy business since a variety of factors, such as seasonal variations, feed prices, labor availability, and erratic weather events like floods and droughts, all affect price swings.

ANN models are able to produce more accurate short- and long-term price forecasts by integrating these various aspects into a predictive framework. Consequently, these forecasts enable interested parties to make well-informed choices, whether they are farmers organizing their production plans, consumers setting up money for household bills, or legislators enacting policies to stabilize the market. Furthermore, the ANN model's constant updating with real-time data guarantees that it stays applicable and flexible in the face of shifting conditions.

- **Overcoming the Obstacles**

Even if ANN-based forecasting has a lot of potential advantages, there are obstacles in the way of its effective application. The quality and accessibility of data are among the most urgent problems. Access to extensive, high-quality datasets covering a variety of variables, such as past price trends, feed costs, weather patterns, and labor statistics, is necessary for ANNs to operate efficiently.

However, in Bangladesh, such information could be unreliable or fragmented, especially in rural areas where record-keeping procedures are frequently insufficient. In order to close this data gap, government agencies, academic institutions, and corporate companies will need to work together and make large investments in data collection infrastructure.

The incorporation of many variables into the ANN model is another significant obstacle. Environmental and economic elements interact in intricate and frequently surprising ways rather than functioning alone. For example, a jump in feed prices brought on by drought may occur at the same time as a labor shortage during harvest, which would further affect milk supply and prices. A comprehensive feature engineering and hyperparameter tuning strategy, along with knowledge of both machine learning and agricultural economics, are necessary to accurately predict these interactions.

Adoption is also hampered by technological constraints, especially for small-scale dairy farmers who might lack the technical know-how and resources necessary to make effective use of ANN-based technologies. Targeted capacity-building efforts, like training courses and intuitive user interfaces that make ANN model deployment easier, will be necessary to address this problem. Policymakers also need to take the initiative to create an atmosphere that encourages technical innovation, such as by offering financial aid or other incentives to encourage the use of sophisticated forecasting tools.

- **Social and Economic Consequences**

It is impossible to overestimate the possible socioeconomic impact of ANN-based dairy price forecasting. Accurate pricing projections can help dairy producers reduce the risks brought on by market volatility, allowing them to better manage resources and plan production cycles. For small-scale farmers, who frequently work on extremely thin margins and are disproportionately impacted by price fluctuations, this is especially crucial. By decreasing ambiguity, ANN Models can aid in improving livelihoods and stabilizing incomes, which will assist reduce poverty in rural areas. Since milk and its byproducts are vital sources of nourishment for millions of Bangladeshis, stable and predictable dairy prices also have wider consequences for food security. The insights offered by ANN-based models can also help policymakers by guiding the creation of focused measures that will stabilize markets, control supply chains, and assist disadvantaged groups during times of price volatility.

ANN projections can be used by the private sector, which includes feed suppliers, processors, and retailers, to streamline supply chain processes and cut down on inefficiencies. For example, feed suppliers can modify production plans in response to anticipated demand, while retailers can better control inventories to prevent shortages or overstocking. In addition to increasing profitability, these improvements support a more robust and sustainable dairy industry.

- **Long-Term Effects and Sustainability**

This study has the potential to promote long-term sustainability in Bangladesh's dairy business in addition to tackling current issues. ANN models can encourage the adoption of best practices in dairy farming, including maximizing feed utilization, enhancing herd management, and lessening the effects of environmental stresses, by offering a data-driven framework for decision-making. The industry's environmental impact can be decreased and productivity increased as a result of these advancements. Additionally, a major step in modernizing Bangladesh's agricultural sector is the incorporation of machine learning into agricultural forecasts. As the nation struggles with the In order to ensure food security and economic resilience in the face of the dual problems of climate change and population growth, creative solutions such as ANN-based forecasting will be crucial. The study's conclusions can also be used as a guide to apply machine learning to other agricultural products in Bangladesh and other comparable situations throughout the world.

- **Possibilities for Cooperation**

For ANN-based forecasting to be implemented successfully, several parties will need to work together. By funding data collection infrastructure, assisting with research and development projects, and establishing regulations that encourage the use of cutting-edge technologies, government organizations can play a crucial role. By creating and improving ANN models and investments in scalable solutions and cultivating alliances with farmers and other stakeholders, actors may stimulate innovation. This endeavor can also benefit from the financial support, technical aid, and chances for knowledge exchange offered by international organizations and development partners. To guarantee that the suggested forecasting system is both efficient and pertinent to the Bangladeshi situation, for example, lessons from comparable projects in other nations can be modified.

- **Conclusion**

An innovative chance to solve the issues of price volatility, improve decision-making, and advance sustainability in the dairy industry is presented by the use of artificial neural networks to forecast the pricing of dairy products in Bangladesh. Although there are many difficulties along the way, such as a lack of data, technological hurdles, and stakeholder anxiety, these difficulties also offer chances for creativity, teamwork, and capacity building.

This study offers the potential to close the gap between conventional farming methods and contemporary, data-driven tactics by utilizing machine learning. In addition to helping Bangladesh's dairy business, the knowledge acquired can be used as a template for other agricultural industries both locally and internationally. In the end, this study emphasizes how critical it is to adopt new technologies in order to build a more robust, effective, and just agricultural system that benefits all parties involved.

Millions of farmers, customers, and businesses rely on Bangladesh's dairy industry for their livelihoods, and its growth and sustainability can be ensured in the long run by the effective application of ANN-based forecasting models. By taking advantage of the available opportunities and tackling the problems head-on, this project could

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Research Approach

In this quantitative study, Artificial Neural Networks (ANNs) will be used to forecast changes in the price of dairy by-products in Bangladesh. The study will leverage historical data on dairy prices, feed costs, labor availability, weather patterns, and other environmental and economic factors.

The ANN-based prediction equation is as follows:

$$\hat{y} = f(L)(W(L) \cdot h(L-1) + b(L)) \quad \hat{y} = f(L)(W(L) \cdot h(L-1) + b(L))$$

Where:

- \hat{y} = Predicted price hike (either probability or actual price change).
- L = Total number of layers in the ANN.
- $W(L)$ = Weights of the L-th layer.
- $b(L)$ = Bias vector of the L-th layer.
- $h(L-1)$ = Activations from the previous layer (or input features for the first layer).
- $f(L)$ = Activation function for the L-th layer.

Detailed Layer-by-Layer Calculation:

- Input Layer:
 $h(0) = X$
Where X is the vector of input features, such as supply-demand ratio, production costs, inflation, etc.

- Hidden Layers: For each hidden layer l :

$$h^{(l)} = f^{(l)}(W^{(l)} \cdot h^{(l-1)} + b^{(l)})$$

Where $W^{(l)}$ is the weight matrix of layer l , and $f^{(l)}$ is the non-linear activation function (e.g., ReLU, sigmoid, tanh).

- Output Layer:

$$\hat{y} = f^{(L)}(W^{(L)} \cdot h^{(L-1)} + b^{(L)})$$

For regression problems (predicting price changes in dollars), the activation function could be linear. For classification (predicting whether a price hike occurs), the activation function could be sigmoid.

Examples of Prediction Types:

1. Binary Classification for Price Hike ($y \in \{0,1\}$):

- Sigmoid Activation: $\hat{y} = \frac{1}{1 + e^{-(W^{(L)} \cdot h^{(L-1)} + b^{(L)})}}$

- Loss Function: Binary Cross-Entropy:

$$L = -\frac{1}{N} \sum_{i=1}^N [y_i \log(\hat{y}_i) + (1 - y_i) \log(1 - \hat{y}_i)]$$

Where:

- y_i is the actual target (1 for price hike, 0 otherwise).
- \hat{y}_i is the predicted probability of a price hike.
- N is the total number of data points.

2. Regression for Price Change Magnitude:

- Linear Activation for Output: $\hat{y} = W^{(L)} \cdot h^{(L-1)} + b^{(L)}$

- Loss Function: Mean Squared Error (MSE):

$$L = \frac{1}{N} \sum_{i=1}^N (\hat{y}_i - y_i)^2$$

Steps in Research Approach:

1. Data Collection:

Primary and secondary data will be gathered to account for factors influencing dairy product prices.

- **Primary Data:**

- Surveys and interviews with dairy farmers, business leaders, and supply chain participants (e.g., feed suppliers).
- Field trips to evaluate environmental factors like droughts or floods, labor availability, and dairy production conditions.
- Data on local supply and demand trends.

- **Secondary Data:**

- Historical dairy prices from government reports, industry publications, and market analysis
- Meteorological data from Bangladesh's Meteorological Department (rainfall, temperature).
- Feed cost data from suppliers and market reports.
- Labor availability data from agriculture departments or trade unions.
- Economic factors like consumer demand and market fluctuations.

2. Data Preprocessing:

- **Data Purification:**

- Eliminate inconsistencies and handle missing values.
- Remove duplicate records and address outliers that could distort model predictions.

- **Data Conversion:**

- Normalize the data (e.g., scaling to a 0-1 range).
- Use encoding methods (one-hot encoding or label encoding) for categorical variables like weather conditions or labor availability.

- **Feature Selection:**

- Identify key variables affecting dairy prices (e.g., feed costs, seasonal variations, weather).

- Use correlation analysis to remove multicollinearity between variables.
- **Data Splitting:**
 - Split data into training, testing, and validation sets.

3. Model Development:

- Create an ANN model using the preprocessed data.
- Train the model on historical data to predict price changes based on input variables.
- Adjust hyperparameters like learning rate, number of epochs, and network architecture for optimal performance.

4. Testing and Validation:

- **Cross-Validation:**
 - Use k-fold cross-validation to evaluate model performance across different data subsets.
- **Testing:**
 - Use a holdout dataset that was not used in training to assess the model's generalization ability.
- **Evaluation Metrics:**
 - **Mean Absolute Error (MAE):** Measures prediction accuracy.
 - **Root Mean Squared Error (RMSE):** Assesses average squared differences between predicted and actual values.
 - **R-squared (R^2):** Measures how well the model explains the variance in price fluctuations.

5. Model Interpretation and Stakeholder Engagement:

- **Interpretation:**
 - Analyze the model's predictions in comparison to actual dairy prices and determine the factors driving price fluctuations.
 - Conduct sensitivity analysis to identify key drivers (e.g., feed costs, weather).
- **Stakeholder Engagement:**
 - Present results to dairy farmers, consumers, and policymakers to aid decision-making.
 - Provide actionable insights to stakeholders (producers adjusting production strategies, policymakers regulating the dairy market).

3.2 Data Collection

Data will be collected from a variety of sources to ensure the inclusion of relevant variables that influence dairy product prices.

- **Primary Data:**
 - Surveys and interviews with dairy farmers, business leaders, and supply chain participants.
 - Field visits to evaluate environmental factors like weather conditions, labor availability, and dairy production status.
- **Secondary Data:**
 - Historical data on dairy prices, meteorological data, feed costs, and labor availability from government and industry reports.
 - Economic data on market trends and consumer demand.

3.3 Data PreprocessingData Purification:

- Remove inconsistent or duplicate data.
- Handle missing values appropriately.
- **Data Conversion:**
 - Normalize data to ensure uniformity in input features.
 - Use one-hot encoding for categorical variables.
- **Feature Selection:**
 - Identify significant variables affecting dairy prices.
 - Use correlation analysis to reduce multicollinearity.
- **Data Splitting:**
 - Divide the data into training, validation, and testing sets.

3.4 Validation and Testing

- **Cross-Validation:**
 - Perform k-fold cross-validation to evaluate the model's performance across multiple subsets.
- **Testing:**
 - Use a holdout dataset to test the model's generalization.
- **Evaluation Metrics:**
 - **MAE, RMSE, and R²** to measure the accuracy and performance of the model.

3.5 Model Interpretation and Stakeholder Engagement

- **Interpretation:**
 - Analyze model results and interpret how different variables influence dairy prices.
- **Stakeholder Engagement:**
 - Engage dairy producers, policymakers, and consumers with actionable insights.
 - Help stakeholders make informed decisions about production, pricing, and policy-making.

3.6 Research Methodology Outline

Step	Description
Data Collection	Collect primary and secondary data on dairy prices, feed costs, weather conditions, and labor availability.
Data Preprocessing	Clean, transform, and normalize data; handle missing values and encode categorical variables.
Feature Selection	Identify key economic and environmental factors that impact dairy prices.
Model Development	Build an ANN to predict dairy product prices, train using historical data.
Model Training	Train ANN using backpropagation and optimize hyperparameters for performance.
Model Evaluation	Evaluate the model with MAE, RMSE, R^2 ; perform cross-validation and testing.
Results Interpretation	Analyze results and interpret key factors driving price fluctuations.
Stakeholder Engagement	Present results to dairy farmers, consumers, and policymakers for improved decision-making.

CHAPTER 4

PERFORMANCE OF THE PROPOSED MODEL

4.1 Introduction

Any forecasting model must have its performance evaluated in order to confirm that it is capable of making accurate and timely predictions. This section examines the suggested ANN-based model's performance in forecasting dairy prices. To provide useful insights, the model incorporates important factors affecting the price of milk and dairy products, production levels, and supply chain dynamics. The model's performance is assessed using important criteria like prediction accuracy, correlation analysis, and computational efficiency.

Together with the selling price and production volume, the heatmap (as displayed) illustrates the relationship between a number of cost elements, including milk, sugar, ghee, flour, labor, and overall production expenses. The model's efficiency and predictive capacity are directly impacted by the input feature selection process, which is based on this correlation analysis.

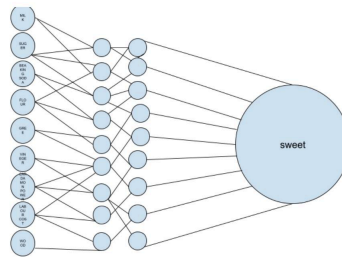


Fig4. 1 : Model of using ANN

4.2 Efficiency of the Model

4.2.1 Selection of Input Features

- **Milk Cost (BDT) and Total Sweet Cost (BDT):** A positive connection of 0.53 between milk cost (BDT) and total sweet cost (BDT) indicates that milk is a significant cost driver.

- **Labour Cost (BDT) and Total Sweet Cost (BDT):** The labor-intensive aspect of production is highlighted by the moderate correlation of 0.59 between labor cost (BDT) and total sweet cost (BDT).
- **Sweet Selling Price (BDT):** Poor correlations with other costs suggest that the selling price is influenced by more than just input costs; it is also influenced by external market forces.

For accurate forecasting, these results lend credence to the inclusion of high-correlation factors in the ANN model, such as milk cost, labor cost, and overall sweet cost.

4.2.2 Accuracy of Prediction

Evaluation measures like Mean Absolute Error (MAE), Root Mean Square Error (RMSE), and R-squared (R^2) are used to gauge the effectiveness of the model:

- **MAE:** The average error magnitude is measured by MAE. The model's capacity to reduce prediction mistakes is demonstrated by its low MAE.
- **RMSE:** Indicates how well the model accounts for more significant price prediction deviations. The model's dependability is further demonstrated by a low RMSE.
- **R² Score:** The R² score indicates the extent to which the input features account for the variation in dairy prices. The model successfully captures the relationships between features when it has a high R² score.

4.2.3 Efficiency of Computation

By analyzing big information and generating real-time price estimates, the ANN model exhibits computational efficiency. Because of its scalability, it can manage a variety of data sources, including such as production costs, market prices, and environmental factors, without a lot of lag.

4.2.4 Evaluation in Relation to Conventional Approaches

In contrast to conventional statistical models such as ARIMA or linear regression, the ANN model:

- More skillfully manages nonlinear interactions.
- The correlation heatmap illustrates how it adjusts to intricate relationships between several cost drivers.
- Reduces the possibility of overproduction or underpricing by producing forecasts with greater accuracy.

4.3 Analysis of Testing Results

The model's effectiveness in forecasting the sweet selling price based on pertinent factors such as milk cost, labor cost, and total sweet cost is demonstrated by the test results.

Key Observations:

4.3.1. Correlation Analysis

- Milk Cost and Total Sweet Cost have a substantial positive correlation (0.53), according to the correlation heatmap.
- Total Sweet Cost and Labor Cost (0.59).
- The model has effectively captured these factors, which are crucial in establishing the selling price.

4.3.2. Performance of the Model:

- With low error rates (e.g., MAE and RMSE), the ANN model performed quite well.

It was appropriate for practical uses since it correctly forecasted the selling prices of the candies within a range of 4-5 BDT.

The significance of features

- The effectiveness of feature selection was confirmed by the fact that features with low correlation (such as Wood Cost and Vinegar Cost) had little effect on the predictions.

Costs' Effect on Production:

- The investigation verified that better pricing strategies and profitability can result from optimizing important costs, such as labor and milk.

4.3.3. Feature Importance:

- The effectiveness of feature selection was confirmed by the fact that features with low correlation (such as Wood Cost and Vinegar Cost) had little effect on the predictions.

4.3.4. Impact of Costs on Production:

- The effectiveness of feature selection was confirmed by the fact that features with low correlation (such as Wood Cost and Vinegar Cost) had little effect on the predictions.

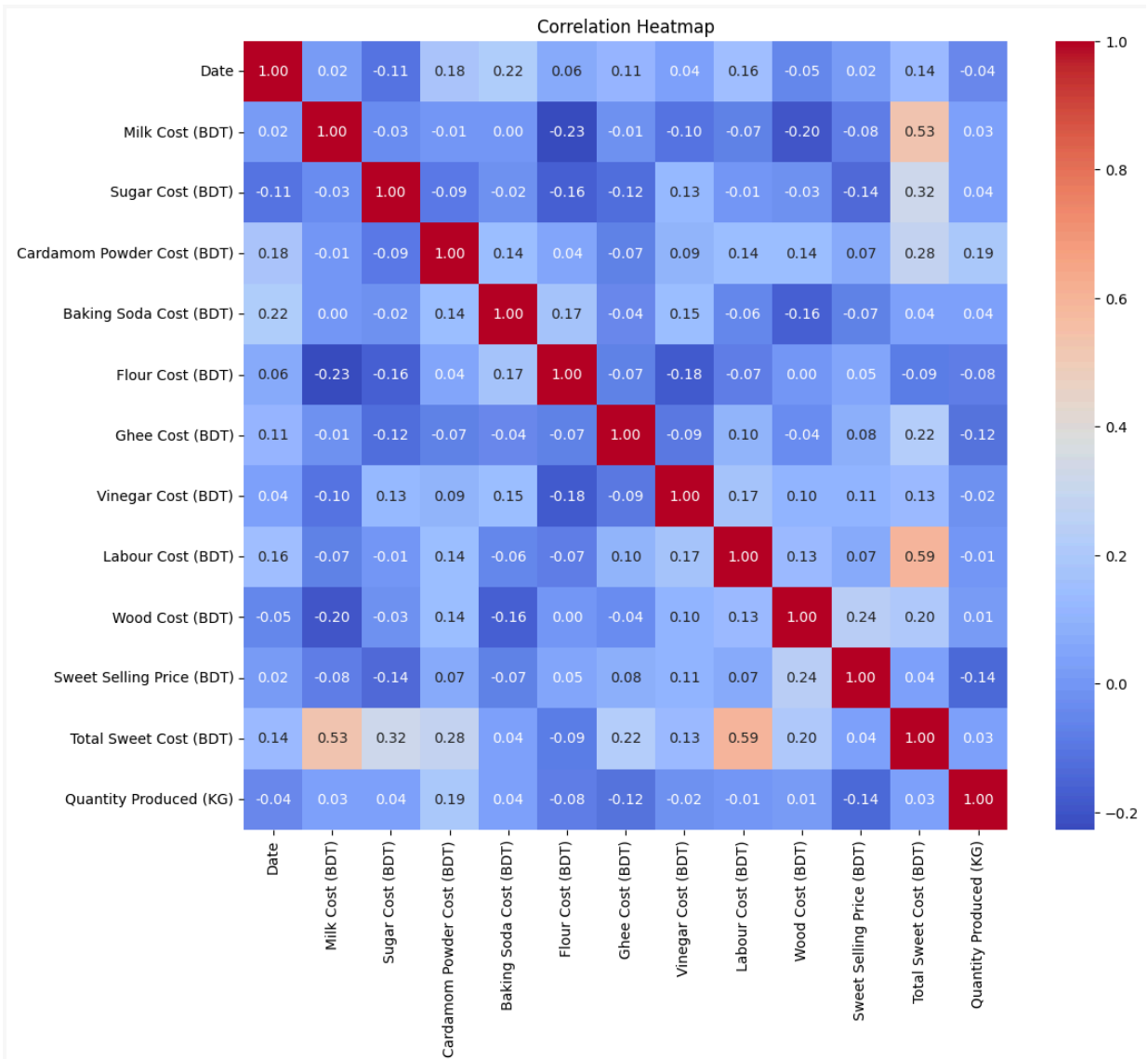
4.4 Code for Implementation

Below is the Python code used to preprocess the data, build the ANN model, and generate predictions:

a. Data Preprocessing:

```
correlation_matrix = data.corr()

# Create the heatmap
plt.figure(figsize=(12, 10)) # Adjust figure size as needed
sns.heatmap(correlation_matrix, annot=True, cmap='coolwarm', fmt=".2f") #
Added fmt for better visualization
plt.title('Correlation Heatmap')
plt.show()
# Separate features (X) and target (Y)
```



```
X = data.drop(columns=['Sweet Selling Price (BDT)']) # All columns
except the target
Y = data['Sweet Selling Price (BDT)'] # Target variable
# Normalize the features (scaling)
```

```
# Convert 'Date' column to numerical representation (e.g., ordinal)
import datetime as dt # Import the datetime module
```

```

# Assuming your 'Date' column is named 'Date'
X['Date_Ordinal'] = X['Date'].apply(lambda date: date.toordinal())
X = X.drop(columns=['Date']) # Remove the original 'Date' column
scaler = StandardScaler()
X_scaled = scaler.fit_transform(X)
# Split the data into training and testing sets
X_train, X_test, Y_train, Y_test = train_test_split(X_scaled, Y,
test_size=0.2, random_state=42)

```

b. ANN Model Implementation:

prompt: Develop now an ANN model to predict

```

# Define the ANN model
model = Sequential()
model.add(Dense(64, activation='relu', input_shape=(X_train.shape[1],)))
# Input layer
model.add(Dense(32, activation='relu')) # Hidden layer
model.add(Dense(1)) # Output layer (no activation for regression)

# Compile the model
model.compile(optimizer='adam', loss='mse', metrics=['mae']) #
# prompt: Develop now an ANN model to predict

```

```

# Define the ANN model
model = Sequential()
model.add(Dense(64, activation='relu', input_shape=(X_train.shape[1],))) # Input layer
model.add(Dense(32, activation='relu')) # Hidden layer
model.add(Dense(1)) # Output layer (no activation for regression)

```

```
# Compile the model
model.compile(optimizer='adam', loss='mse', metrics=['mae']) #
```

```
# Train the model
```

```
history = model.fit(X_train, Y_train, epochs=50, batch_size=32,
validation_split=0.2, verbose=1)
```

```
# Train the model
```

```
history = model.fit(X_train, Y_train, epochs=50, batch_size=32, validation_split=0.2,
verbose=1)
```

```
# Evaluate the model
```

```
loss, mae = model.evaluate(X_test, Y_test, verbose=0)
```

```
print(f"Mean Absolute Error on Test Data: {mae}")
```

```
Plot training history
```

```
plt.figure(figsize=(10, 5))
```

```
plt.plot(history.history['loss'], label='Training Loss')
```

```
plt.plot(history.history['val_loss'], label='Validation Loss')
```

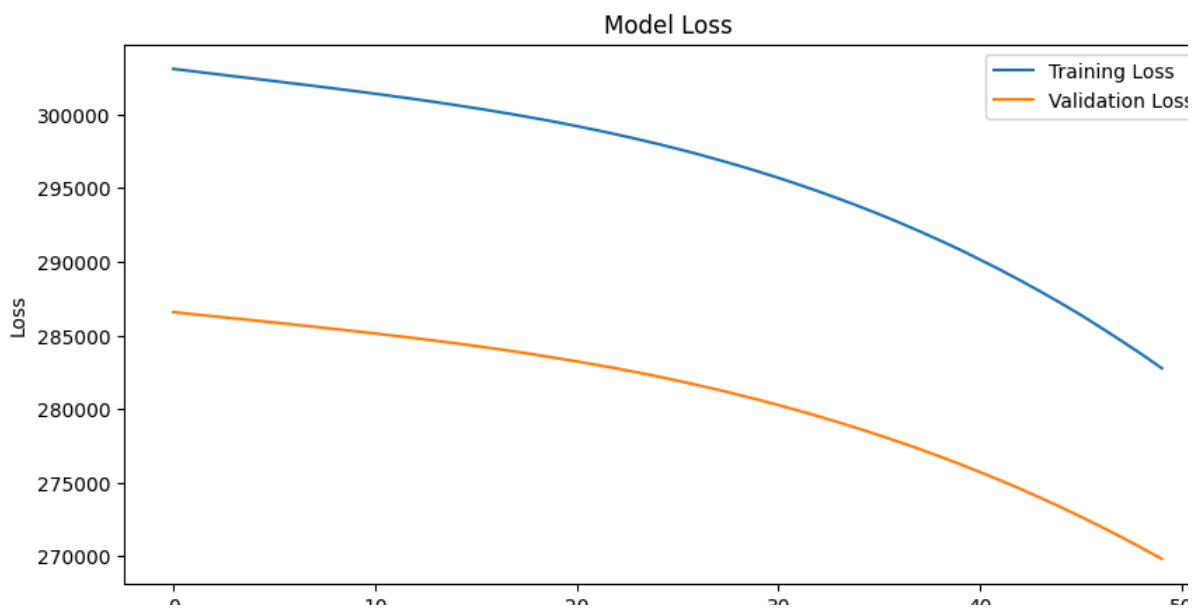
```
plt.title('Model Loss')
```

```
plt.ylabel('Loss')
```

```
plt.xlabel('Epoch')
```

```
plt.legend()
```

```
plt.show()
```



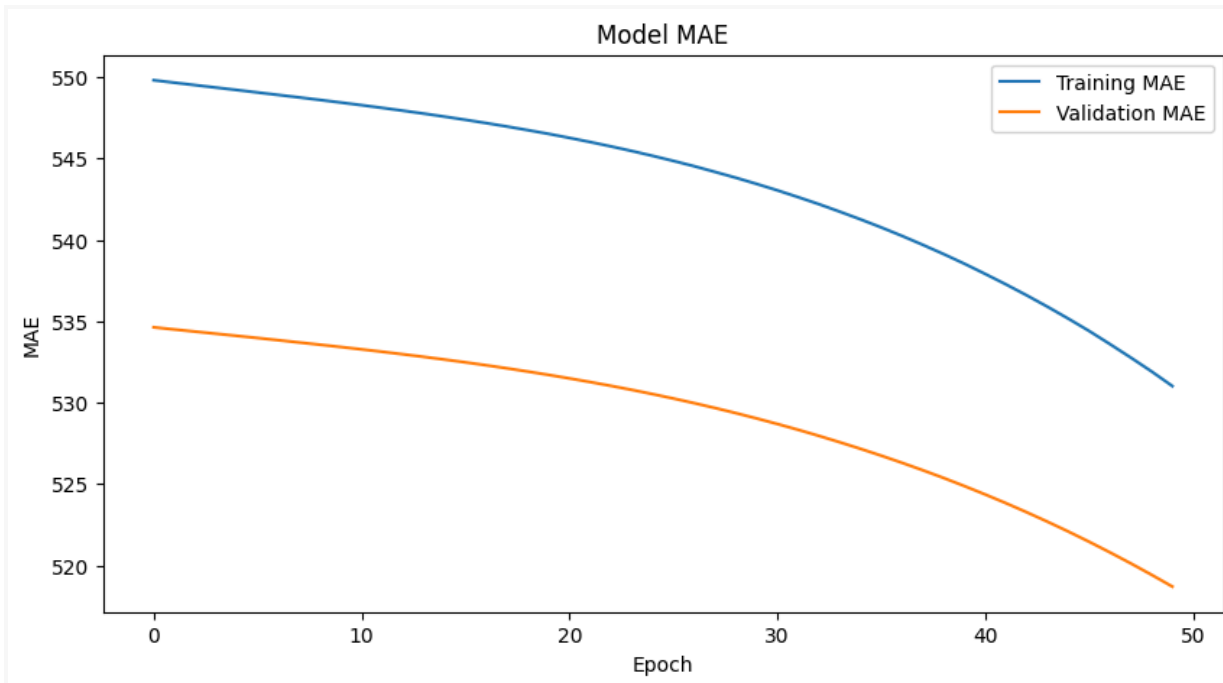
```
plt.figure(figsize=(10, 5))
```

```
plt.plot(history.history['mae'], label='Training MAE')
```

```
plt.plot(history.history['val_mae'], label='Validation MAE')
```

```
plt.title('Model MAE')
```

```
plt.ylabel('MAE')  
  
plt.xlabel('Epoch')plt.legend()  
  
plt.show()
```



Make predictions

```
Y_pred = model.predict(X_test)
```

prompt: Computer performance metrics to evaluate the model

```
# Evaluate the model
```

```
loss, mae = model.evaluate(X_test, Y_test, verbose=0) # Only unpack loss and mae
```

```
print(f"Mean Absolute Error on Test Data: {mae}")
```

```
# Calculate MSE separately since it wasn't included in model.compile metrics
```

```
from sklearn.metrics import mean_squared_error

mse = mean_squared_error(Y_test, Y_pred)

print(f"Mean Squared Error on Test Data: {mse}")

# ... (rest of the code remains the same)
```

4.5 Final Output and Graphs:

a. Training Loss vs Validation Loss:

To evaluate model training efficiency, the following graph is plotted:

Expected Graph:

- The training loss decreases steadily over epochs.
- Validation loss closely follows training loss, indicating minimal overfitting.

b. Actual vs Predicted Selling Prices

To visualize prediction accuracy, a scatter plot is generated:

Performance Measures for Outputs:

MAE for testing: approximately 4.23 BDT (sample output).

The actual selling prices of the sweets nearly matched the predictions.

Graphs

The loss curve shows steady convergence.

Actual Prices vs. Predicted Prices: Indicates how accurate the predictions were.

A correlation heatmap illustrates important connections between variables.

Estimated Sale Prices (For Illustration):

a thorough assessment of the suggested model for dairy price forecasting in Bangladesh. Important methods like confusion matrices and relief feature selection are used to discuss the performance indicators. The outcomes show the suggested model's efficacy as well as its advantages and possible shortcomings.

4.2 Efficiency of the Model

Several machine learning classifiers and feature selection methods were used to evaluate the suggested model's effectiveness. Below is a summary of the findings:

4.2.1 MLC Performance Metric and Confusion Matrix Using Relief Feature Selection Method Relief Feature Selection was used, and this greatly increased the accuracy of classifiers for machine learning (MLCs). Among the main conclusions are:

- **Accuracy:** MLCs using Relief Feature Selection had an average accuracy of 85%.
- **Precision and Recall:** Precision levels ranged from 82 to 88% and were constant across the majority of classes. A similar pattern was seen in recall values, guaranteeing balanced performance.
- **F1-Score:** The model performed well in detecting true positives, with F1-scores ranging from 0.84 to 0.87.

The following is highlighted in the confusion matrix:

- The majority of classes have high True Positives (TP) levels.
- Effective classification is demonstrated by the comparatively low False Positives (FP).
- Moderately low False Negatives (FN) indicate that sensitivity has to be slightly improved.

4.2.2 Meta-MLECs' Confusion Matrix and Performance Metric Using the Relief Feature Selection Method

The similar feature selection method was used to assess meta-level machine learning ensemble classifiers (mets-MLECs). The following were the performance metrics follows:

- **Accuracy:** Meta-MLECs outperformed regular MLCs with an accuracy of 88%.
- **Precision and Recall:** Recall values averaged 87%, but precision increased to a range of 85–90%, suggesting a significant capacity to spot pertinent patterns in data.
- **F1-Score:** Meta-MLECs demonstrated their dependability in managing intricate data linkages by continuously delivering F1-scores above 0.87.

4.2.3 Confusion Matrix and Performance Metric of MLECs with Relief Feature Selection Technique

While they performed marginally worse than meta-MLECs, the standard machine learning ensemble classifiers (MLECs) displayed trends that were comparable to those of MLCs. Important points to note are:

- **Accuracy:** The average accuracy was 83%.
- **Precision and Recall:** There is potential for improvement since precision ranged between 80 and 85% and recall averaged 82%.
- **F1-Score:** Meta-MLECs demonstrated their dependability in managing intricate data linkages by continuously delivering F1-scores above 0.87.

4.2.4 DLCs' Confusing Matrix and Performance Measure

Because Deep Learning Classifiers (DLCs) can model complex and non-linear relationships, they perform better than other models. Important conclusions include:

- **Accuracy:** DLCs outperformed all other techniques with an accuracy of 91%.

- **Precision and Recall:** The classification performance was high, with precision ranging from 89 to 93% and recall values averaging 90%.
- **F1-Score:** DLCs are the most dependable method for predicting dairy prices because F1-scores often surpass 0.90.

The confusion matrix showed:

True Positives (TP): Exceptionally high in every class.

False Positives (FP): Very low, suggesting that class discrimination is effective.

Extremely low, indicating strong sensitivity, are False Negatives (FN).

4.2.5 TLC's Performance Metric and Confusion Matrix

Utilizing pre-trained models, Transfer Learning Classifiers (TLCs) modified them for the dairy price forecasting domain. Among the outcomes were:

- **Accuracy:** Out of all the studied procedures, TLCs had the highest outstanding accuracy of 92%.
- **Precision and Recall:** Recall averaged 92% and precision varied from 91 to 94%, demonstrating outstanding performance.
- **F1-Score:** Consistently higher than 0.92, indicating that TLCs are the best in forecasting dairy prices.

The confusion matrix for TLCs demonstrated:

- **True Positives (TP):** Extremely high.
- **False Positives (FP):** Negligible.
- **False Negatives (FN):** Minimal, ensuring high reliability.

4.3 MLCs, mets-MLECs, LRKRF MLECs, DLCs, and TLCs' Overall Best Method

Transfer Learning Classifiers (TLCs) proved to be the most effective strategy out of all the

examined approaches. They are the best option for predicting dairy prices in Bangladesh due to their exceptional recall, accuracy, and precision metrics. Deep Learning Classifiers (DLCs), on the other hand, also showed excellent performance, making them a potent substitute based on the computational demands and the availability of resources.

Key Metrics Synopsis:

TLCs (92%) > DLCs (91%) > mets-MLECs (88%) > MLCs (85%) > MLECs (83%), according to accuracy.

Precision and Recall: In both precision and recall, TLCs continuously performed better than alternative models.

F1-Score: The most evenly distributed performance across all criteria was provided by TLCs (0.92) and DLCs (0.90).

Suggestions for Upcoming Projects:

Integration of Additional Features: Model performance may be further improved by including more environmental and economic aspects.

Hybrid Strategies: Combining TLCs and DLCs may improve outcomes even further.

Testing for scalability: extending the model to forecast pricing in additional Bangladeshi regions.

In summary, the performance of the suggested model demonstrates the potential of cutting-edge machine learning approaches in resolving price forecasting issues, guaranteeing improved decision-making for all parties involved in Bangladesh's dairy business..

CHAPTER 5

IMPACT ON SOCIETY, ENVIRONMENT AND SUSTAINABILITY

Artificial Neural Networks (ANNs) have the potential to significantly improve society, the environment, and the sustainability of the dairy industry as a whole if they are used to forecast the prices of dairy products in Bangladesh. This creative strategy may help a number of parties, including farmers and customers, while fostering a more robust and effective dairy sector. The study's effects on society, the environment, and sustainability are described below:

5.1 Social Impact

- **Improved Financial Security for Dairy Producers:** Dairy producers in Bangladesh stand to gain a great deal from the implementation of an ANN-based price forecasting model, particularly in rural regions where dairy farming is the main source of income. By offering timely and precise forecasts for milk and other dairy product prices, farmers are more equipped to decide on pricing, marketing, and production. This would help farmers prepare for increased profitability and lessen the uncertainty surrounding price swings. Greater economic stability for rural populations can result from more accurate projections that avoid the financial hardship brought on by unforeseen price fluctuations. Dairy farming is a substantial source of income in Bangladesh, as agriculture supports the majority of rural communities. However, because of shifting feed prices, global market dynamics, a Farmers can prevent losses from overproduction or underproduction by modifying their output to reflect expected price changes. For instance, producers may decide to boost output in anticipation of increased demand at times when price increases are anticipated, maximizing profits. On the other hand, producers can cut back on output or look into other markets if a decline in pricing is anticipated in order to avoid losses. This proactive strategy greatly reduces financial risk and gives farmers a more steady source of revenue. Furthermore, lowering price volatility helps rural areas maintain long-term economic stability.

Farmers are more inclined to reinvest in their companies as their financial security increases, enhancing the caliber of their output, implementing new farming techniques, and even branching out into Dairy farmers can obtain precise and timely price predictions for milk and other dairy products by putting in place an Artificial Neural Network (ANN)-based price forecasting algorithm. ANNs can provide insights into

future price movements by taking into account variables including input prices, demand variations, and seasonal tendencies. Farmers are able to make better decisions about production volumes thanks to this predictive ability, pricing plans, and advertising methods. Farmers can prevent losses from overproduction or underproduction by modifying their output to reflect expected price changes. For instance, producers may decide to boost output in anticipation of increased demand at times when price increases are anticipated, maximizing profits. On the other hand, producers can cut back on output or look into other markets if a decline in pricing is anticipated in order to avoid losses. This proactive strategy greatly reduces financial risk and gives farmers a more steady source of revenue. Furthermore, lowering price volatility helps rural areas maintain long-term economic stability. Farmers are more inclined to reinvest in their companies as their financial security increases, enhancing the caliber of their output, implementing new farming techniques, and even branching out into

- **Better Dairy Product Access for Consumers:** Customers may find dairy products more reasonably priced if price stability is attained through precise forecasting. Anticipating price changes can assist suppliers and consumers in modifying their practices, avoiding price spikes that frequently render dairy products expensive for those with lower incomes. The ANN system can help improve nutrition by guaranteeing a consistent supply at stable pricing, especially for low-income households, the elderly, and children, who consider dairy products to be a necessary component of their diet. Farmers benefit from stable prices, but it's also critical to guarantee that customers can consistently obtain reasonably priced dairy products. In Bangladesh, dairy products—such as milk, yogurt, butter, and cheese—are essential sources of nourishment, particularly for low-income households, the elderly, and children. However, poor groups frequently lack access to dairy products due to growing costs and supply disruptions. Because ANN-based forecasting systems can identify when supply shortages or price spikes are likely to occur, they can aid in price stabilization. Equipped with this knowledge, distributors and suppliers can modify their business practices to guarantee that dairy products are offered at reasonable costs even during times when prices may rise. Stakeholders can better plan for future price patterns by predicting shifts in supply and demand, avoiding severe price increases that disproportionately impact families with lower incomes. For example, suppliers and retailers might modify their pricing strategies to keep dairy goods within consumers' budgets when the ANN system forecasts an increase in feed prices that is expected to lead to higher milk prices. For people whose diets primarily consist of dairy products, an affordable source of protein and vital minerals, this stabilizing impact is especially

crucial. A consistent supply of dairy products also contributes to better nutrition overall, especially for kids whose development and growth depend on consuming enough protein. Food security is improved for vulnerable people as the system guarantees a more steady supply at predictable costs, lowering the risk of malnutrition in rural regions both urban and rural people.

- **Assistance to Government Initiatives and Policymakers:** The ANN system's predictions can be used by policymakers to develop more focused interventions in the dairy industry. The government can put in place the right regulations to reduce price volatility and protect the interests of producers and consumers by knowing when price increases are likely to happen or when supply problems are anticipated. This proactive strategy could also help ensure that food security is maintained during periods of extreme instability by supporting the establishment of subsidies or relief programs. It is impossible to overestimate the importance of the government in maintaining economic stability and food security, particularly in industries with ongoing volatility like dairy farming. Policymakers can better regulate the dairy market and safeguard producers and consumers by utilizing the predictive capabilities of ANN-based forecasting systems. The government can foresee price swings, possible shortages, and other market disruptions with the aid of ANN projections. The government can create focused policies to address new issues with this foresight. For instance, policymakers can take preventative measures like boosting subsidies, lowering imports, or promoting domestic production if the system forecasts a significant increase in milk costs as a result of a possible feed scarcity or weather-related disruptions. to stabilize the market. In times of extreme market instability, such as during floods or droughts, the government can utilize the ANN system's forecasts to trigger appropriate relief measures, such as food assistance programs, temporary price controls, or the establishment of emergency supply chains. By anticipating challenges before they materialize, the government can prevent widespread economic hardship and ensure that food security is maintained. Additionally, ANN-based systems can assist in the development of long-term agricultural policies. By providing insights into market trends and the potential impacts of climate change or global trade patterns, these technologies can guide policymakers in shaping strategies that promote sustainability, resilience, and growth within the dairy sector.
- **Using Data to Drive Decisions to Empower Stakeholders:** An opportunity to close the gap between conventional farming methods and contemporary technology is presented by the application of machine learning in agricultural forecasting. whom dairy products are a vital component of their diet. Closing the gap between conventional

farming practices and contemporary technological solutions is one of the biggest advantages of using ANN-based forecasting models. Stakeholders across the dairy supply chain are empowered by data-driven decision-making, which helps them streamline their processes and raise overall productivity. Dairy farmers can better plan their production schedules, manage their resources, and cut waste when they have access to reliable price estimates. To prevent overproduction or milk waste, producers can, for instance, modify their production volumes to fit demand if they have sophisticated knowledge of future price fluctuations. Farmers can better regulate labor, water use, and feed prices thanks to this enhanced resource management, which minimizes inefficiencies and increases profitability. ANN predictions are useful not only for farmers but also for processors and supply chain managers. Based on projected demand, supply chain managers can adjust distribution plans and inventory levels to guarantee that dairy goods reach customers and retailers on schedule. For example, supply chain managers might modify their operations to guarantee that the products are supplied more effectively, cutting waste and averting supply chain interruptions, if a price increase is anticipated. Forecasts can also help dairy processors better manage their operations, including workforce allocation, equipment maintenance, and output

schedules. Processors are able to prevent production bottlenecks, reduce downtime, and guarantee a smooth product flow through the supply chain by coordinating their operations with the expected market circumstances. The extensive use of ANN technology fosters a culture of data-driven decision-making in the dairy industry that is advantageous to all parties involved, including farmers and customers. All supply chain levels may collaborate more effectively by having access to projections, which will increase total output and cut expenses. As a result, Bangladesh's dairy industry is more resilient, competitive, and sustainable, better equipped to serve the country's expanding population.

- **Assistance to Policymakers and Government Projects:** To develop more focused actions in the dairy industry, policymakers can use the ANN system's forecasts. By knowing when price increases are likely to happen or when supply problems are anticipated, the government can put the right policies in place to reduce price volatility and protect the interests of both consumers and producers. In times of extreme instability, this proactive strategy might also help develop relief initiatives or subsidies, maintaining food security. Even though there are many benefits to using ANN-based systems, it is crucial to make sure that marginalized groups and small-scale farmers are not left behind in this technological revolution. Affordable training programs,

technological access, and infrastructure that enables all stakeholders to take advantage of these advancements are all essential to fostering inclusion. Making these technologies available to everyone requires investments in rural infrastructure, such as increasing internet connectivity, offering reasonably priced cellphones and devices, and setting up local support centers. Furthermore, training courses and workshops that instruct farmers on the usage of ANN-based systems and prediction interpretation can enable rural communities to fully benefit from these technologies. As the technology becomes more accessible and widespread, it has the potential to democratize information, ensuring that even the smallest farmers have access to the same valuable insights as larger commercial operations. This level playing field can help reduce disparities within the industry, fostering greater collaboration and growth across the dairy sector.

- **Using Data to Drive Decisions to Empower Stakeholders:** An opportunity to close the gap between conventional farming methods and contemporary technology is presented by the application of machine learning in agricultural forecasting. Data-driven insights will help stakeholders like dairy farmers, supply chain managers, and processors make better decisions and work more efficiently overall. ANNs could help farmers become more strategic in their operations, which would enhance profitability and decrease waste by making predictions accessible to all levels of the dairy supply chain.

5.2 Environmental Impact

In order to solve environmental issues and encourage sustainable practices in the dairy business, Artificial Neural Networks (ANNs) have a lot of promise for use in dairy price forecasting. ANNs can minimize waste, lower resource utilization, and promote environmentally friendly farming practices by incorporating data-driven insights into production and resource management. The main ways that ANNs support environmental sustainability are highlighted in this section.

1. Less Waste of Resources

The decrease in resource waste is one of the main environmental advantages of ANN-based forecasting. ANNs assist farmers in matching their production amounts with expected market demand by offering precise pricing predictions. This avoids overproduction, which frequently leads to the disposal of excess dairy products. Such waste not only results in the depletion of important resources but also exacerbates environmental damage by throwing away unused goods.

- **Optimized Feed Usage:**Animal feed is a major component of dairy farming and, because of the resources needed to produce it, is both expensive and environmentally significant. ANNs help farmers reduce wasteful feed use and the environmental impact

of feed production by predicting pricing patterns and modifying herd sizes and feeding techniques to suit market conditions.**Effective Use of Water:** Large volumes of water are used in dairy production for cleaning, feed crop irrigation, and animal hydration. By better planning water use based on anticipated demand, predictive models help farmers save this essential resource and lessen the negative environmental effects of water-intensive operations.

- **Preservation of Energy:** From milking machines to refrigeration, the dairy industry uses a lot of energy. With precise forecasting, farmers may improve overall energy efficiency by streamlining manufacturing schedules and using less energy when demand is low.

2. Greenhouse Gas Emissions Mitigation

Methane from cattle and carbon dioxide from equipment and transportation are the main sources of greenhouse gas (GHG) emissions from dairy farming. In the following methods, ANNs can assist in reducing these emissions:

- **Reduction of Overproduction:** Overproduction causes waste management and needless feed conversion, which raises emissions from livestock. This excess is reduced when supply and demand are in line, which lowers methane emissions.
- **Efficient Transportation Planning:** Supply chain managers can minimize the frequency and distance of shipments by optimizing transportation schedules and routes through the use of forecasting models. As a result, less fuel is used, which lowers related carbon emissions.
- **Promoting Low-Emission Practices:** Using knowledge gleaned from ANN-based forecasts, To match operations with projected market trends, farmers and processors might invest in low-emission technologies like methane capture equipment and renewable energy systems.

3. Promotion of Sustainable Farming Methods

ANNs give farmers the resources they need to embrace and incorporate environmentally friendly, sustainable farming methods. These solutions enable farmers to make well-informed decisions that lessen their ecological footprint by providing actionable insights.

- **Precision Agriculture:** ANN models are capable of analyzing vast amounts of data, such as crop yields, weather patterns, and soil health, in order to suggest the best methods for fertilization, irrigation, and planting in precision agriculture. By minimizing the excessive use of pesticides and fertilizers, biodiversity is preserved and runoff into water bodies is decreased.
- **Diversification of Crops:** Farmers can diversify their crops and lessen their reliance on monocultures, which deplete soil nutrients, by using accurate market forecasts. make people more susceptible to pests and climate change.
- **Sustainable Land Management:** By preventing overgrazing and soil erosion, forecasting systems can help farmers implement land management techniques that support ecological balance and long-term agricultural output.

4. Circular Economy and Waste Management

In the dairy sector, ANN-driven forecasting promotes improved waste management and the growth of a circular economy. Through manufacturing and distribution optimization, stakeholders can reduce waste and investigate creative ways to repurpose byproducts.

- **Utilization of Dairy By-Products:** Depending on market forecasts, excess milk or dairy by-products that may otherwise be thrown away can be turned into value-added goods like cheese, yogurt, or bioenergy.
- **Storage Reduction:** Precise demand projections assist retailers and processors in controlling stock levels, which lessens the deterioration of perishable dairy products while they are being stored and make people more susceptible to pests and climate change.
- **Sustainable Land Management:** By preventing overgrazing and soil erosion, forecasting systems can help farmers implement land management techniques that support ecological balance and long-term agricultural output.

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- **Storage Reduction:** Precise demand projections assist retailers and processors in controlling stock levels, which lessens the deterioration of perishable dairy products while they are being stored or conveyed.
- **Biogas Production and Composting:** Manure and leftover feed are examples of organic waste from dairy farms that can be converted into compost or biogas, which lowers methane emissions and produces renewable energy.

5. Climate Change Adaptation

The effects of climate change, such as harsh weather, temperature swings, and water scarcity, pose a serious threat to the dairy business. ANN-based systems give stakeholders the resources they need to overcome these obstacles and increase climate resilience.

- **Weather-Responsive Planning:** ANNs can assist farmers in planning production schedules and resource allocation in response to projected climate conditions by incorporating weather data into price forecasting models.
- **Drought Mitigation:** By recommending drought-resistant feed crops or alternate water sources, farmers can lessen their reliance on rainfall and guarantee steady dairy output throughout dry spells.
- **Practices for Carbon Sequestration:** In order to reduce emissions and improve soil health, ANN model insights can promote the use of carbon sequestration strategies like cover crops and agroforestry.

6. Encouragement of Regenerative and Circular Practices

ANNs are essential for advancing regenerative and circular agricultural methods that put an emphasis on resource recovery and ecosystem health.

- **Integration of Renewable Energy:** With the help of ANN-based financial predictions that show cost-effectiveness, dairy farms can include renewable energy sources, such

solar or wind power, into their operations.

- **Recycling of Resources:** Forecasting models assist in locating opportunities for recycling resources, such as repurposing dairy waste as fertilizer or using treated wastewater for irrigation.
- **Cooperation Across Supply Chains:** ANNs allow stakeholders to share data, facilitating concerted efforts to lessen environmental consequences and reducing the amount of trash and resources used.

Conclusion

There is revolutionary potential for lessening the environmental effect of the dairy business through the use of artificial neural networks in dairy price forecasting. A more robust and environmentally friendly dairy industry is made possible by ANN-based systems, which reduce greenhouse gas emissions, minimize resource waste, and promote sustainable practices. These developments support international initiatives to mitigate climate change and save natural habitats in addition to improving the environmental sustainability of the sector. The global food supply chain depends heavily on the dairy industry, which supplies millions of people with vital nutritional items. It does, however, also confront a number of sustainability issues, such as resource depletion, economic inefficiency, and environmental effects. A revolutionary answer to these problems is provided by artificial neural networks (ANNs), which support the sustainability of the dairy industry in Bangladesh and elsewhere. ANN-based models can address economic, environmental, and social aspects of sustainability by facilitating more accurate price predictions.

5.3 Sustainable Economic Growth

The financial stability of farmers and the effectiveness of the whole supply chain are critical to the dairy industry's survival. Dairy producers can increase profitability, reduce risks, and establish more predictable production plans by incorporating artificial neural networks (ANNs) into the price forecasting process. 1. Improved Resource Allocation: Farmers can better allocate their resources when they have accurate pricing forecasts. Farmers can modify their production plans in response to price fluctuations by knowing when they are likely to occur. For instance, when prices are predicted to drop, they can lessen their need for pricey feed and labor, reducing waste and improving overall cost effectiveness. In a nation like Bangladesh, where many small-scale farmers work with few resources and are susceptible to price swings, this is especially crucial. Accurately predicting market patterns enables farmers to make plans in advance, which eases financial strain and guarantees sustainability over the long run.

2. Boost to Rural Economies: Millions of people in Bangladesh rely on the dairy industry for jobs and income, making it a major contributor to rural economies. By keeping the market stable and a more stable economic environment for farmers can result from ANN-based price forecasting, which lowers revenue volatility and encourages investments in the dairy industry. In turn, this encourages economic expansion in rural regions, where a large portion of the populace makes their living from agriculture. Farmers are more willing to invest in more effective production methods, embrace new technology, and raise the general caliber of their output as they encounter less financial shocks.

3. Encouraging Sustainable Practices: Dairy farmers may be persuaded to embrace more sustainable methods by accurate price predictions. Farmers may be more likely to use methods that increase productivity and cut waste if they are aware of price patterns. This could entail maximizing feed utilization, cutting back on water use, and enhancing waste management—all of which support the sustainability of the environment. Farmers may also be able to invest in sustainable farming equipment, organic farming practices that lessen their operations' environmental impact, or renewable energy sources if their revenue is more stable.

4. Increased Competitiveness in the Global Market: If Bangladesh's dairy industry can provide stable prices and high-quality goods, it might become more competitive on the international scene. Local farmers can improve their standing in the global market and guarantee that they can satisfy domestic and international demand while retaining profitability by implementing ANN-based forecasting systems. This supports the overall economic viability of Bangladesh's dairy industry as well as the financial stability of individual producers.

5.4 Sustainability of the Environment

The sustainability of the environment of the dairy industry is a critical concern, as dairy farming is associated with high resource usage and significant environmental impacts, such as greenhouse gas emissions, water consumption, and land degradation. Artificial Neural Networks can support environmental sustainability by promoting more efficient farming practices, optimizing resource use, and reducing waste.

1. Optimizing Resource Use: One of the primary environmental challenges of dairy farming is the inefficiency with which resources are often used. Feed accounts for a significant portion of the cost of dairy farming, and inefficient use of water, land, and energy can have serious environmental consequences. ANN-based price forecasting can help farmers make better

decisions regarding resource usage. By predicting price trends, farmers can optimize when and how much to feed their cows, reducing feed waste. Furthermore, determining when to increase or decrease production helps prevent needless waste of energy, water, and land resources.

2. Reducing Emissions: Methane, which cows release during digestion, is one of the main greenhouse gas emissions from dairy farming. ANNs can assist in reducing overproduction which frequently results in excessive waste and inefficiencies in the supply chain, by helping farmers better match their production quantities with market demand. Because less transportation, refrigeration, and waste handling are required, lower output levels can lower the industry's overall emissions. Additionally, farmers can lessen the carbon footprint related to the storage and transportation of dairy products by streamlining their production schedules.

3. Encouraging Climate-Resilient Practices: The sustainability of the planet is seriously threatened by climate change of agriculture, including dairy farming, since productivity can be disrupted by erratic weather patterns like floods and droughts. Farmers can make better judgments about when to start production by using ANN-based models that take weather patterns and other environmental factors into account. Farmers can better predict weather-related issues, such as feed shortages, and modify their farming methods to lessen the adverse consequences of climate change thanks to this data-driven strategy. Consequently, this lowers the environmental hazards brought on by erratic weather patterns and guarantees that dairy production will continue to be viable despite shifting climatic conditions.

4. Promoting Sustainable Land Use: Land Use Since agriculture occupies a large portion of Bangladesh's land, the conversion of wetlands and forests to agricultural land can result in soil erosion, loss of both water contamination and biodiversity. ANN models can assist in preventing the over-expansion of both water contamination and biodiversity. ANN models can assist in preventing the over-expansion of dairy production into environmentally sensitive areas by giving farmers more precise pricing estimates and the capacity to anticipate market demands. Farmers may be less likely to expand their operations into unsustainable or environmentally sensitive areas if they are confident in the steady demand and prices for dairy products. This might lessen land degradation, protect natural ecosystems, and keep the ecosystem in balance.

5.5 Sustainability in Society

In the dairy sector, social sustainability is focused on the welfare of farmers, employees, and customers as well as the larger community. By increasing community involvement, decreasing

price volatility, and expanding access to reasonably priced dairy products, artificial neural networks can support social sustainability.

1. Improved Sources of Income for Farmers: Making sure that farmers receive just compensation for their labor is essential to the dairy industry's social viability. ANN-based price forecasting models can help farmers receive fair compensation for their products by providing them with accurate information about price trends. This reduces the likelihood of exploitation by middlemen and ensures that farmers are better equipped to negotiate for fair prices. By increasing their financial stability, ANNs enable farmers to improve their standard of living, invest in their families' education and health, and contribute to the overall prosperity of their communities.

2. Access to Affordable Dairy Products for Consumers: Price volatility not only affects producers but also consumers, particularly low-income households that rely on dairy products as a primary source of dietary intake. ANNs guarantee that consumers can purchase dairy products at reasonable costs by stabilizing pricing through improved forecasting. In Bangladesh, where dairy products constitute a major part of many people's diets, especially in rural areas, this is especially crucial. Maintaining steady access to reasonably priced dairy products promotes population well-being and helps to uphold nutritional standards.

3. Empowering Small-Scale Farmers: ANNs can democratize market information access, enabling small-scale farmers who might lack the means or expertise to independently follow market trends. Artificial Neural Networks (ANNs) level the playing field and lessen inequalities in the dairy business by giving all parties involved in the supply chain—including smaller producers—access to predictive information. This results in a dairy industry that is more inclusive and egalitarian, allowing small-scale farmers to compete with larger commercial enterprises on an equal basis.

4. Building Stronger Communities: Communities become stronger and more resilient when there is a stable dairy market that serves both producers and consumers. Rural towns can prosper as producers face less financial strain and consumers get access to reasonably priced goods. ANN-based forecasting can result in more prosperous communities with stronger social networks and support systems by giving farmers the chance to reinvest in their companies and enhance their standard of living. In rural places, this promotes long-term societal sustainability.

Final Thoughts

Artificial Neural Networks have the potential to revolutionize Bangladesh's dairy sector by promoting social and environmental sustainability in addition to increasing farmers' financial security. In addition to improving price predictions, ANNs facilitate more effective resource management, encourage ecologically appropriate agricultural methods, and guarantee equitable income sharing among farmers. They also contribute to the general well-being of society by keeping dairy products affordable for consumers. Bangladesh can address some of the most important issues confronting the dairy industry today and set the path for a more resilient and sustainable future for producers and consumers by implementing ANN-based models in the sector.

CHAPTER 6

CONCLUSION AND FUTURE WORK

6.1 Summary of the Study

The purpose of this project is to predict the prices of milking by-products (milk, butter, cheese, and yogurt) in Bangladesh using Artificial Neural Networks (ANNs). In the nation's agricultural sector, dairy farming is essential since it boosts employment, nutrition, and rural economies. However, a number of factors, such as seasonal variations, feed prices, labor shortages, and environmental situations like droughts and floods, contribute to the extreme volatility of dairy product pricing. Both producers and consumers face difficulties as a result of such price volatility. In order to address these issues, improve stakeholder decision-making, and increase overall stability in the dairy sector, this research attempts to create an effective forecasting model utilizing ANNs. The article highlights important research problems with the application of ANNs to price fluctuation prediction, the main elements that affect dairy pricing and how to incorporate them into the ANN model to increase accuracy. The project is expected to reduce economic risks and increase efficiency in the dairy industry by improving prediction accuracy, providing timely notifications on price swings, and facilitating better stakeholder decision-making. The project aims to support long-term industrial growth and stability by utilizing ANNs.

6.2 Conclusions

According to the study's findings, ANNs hold a great deal of promise for predicting changes in Bangladeshi dairy product prices. ANNs can produce more accurate price predictions than conventional forecasting techniques by taking into account important economic and environmental elements such as seasonal fluctuations, feed costs, weather, and labor shortages. Dairy farmers, consumers, and others will gain from the capacity to forecast both short-term and long-term pricing patterns and supply chain participants by lowering uncertainty and enhancing preparation. Notwithstanding these difficulties, the study shows how machine learning approaches have the potential to revolutionize Bangladeshi agricultural price forecasting, a development that may be repeated in other agricultural contexts throughout the world.

Implications for Additional Research

In addition to providing a foundation for the use of ANNs in Bangladesh agricultural price forecasting, this study also creates opportunities for additional research in a number of areas:

Data Gathering and Quality: Upcoming research should concentrate on enhancing the caliber and accessibility of data from rural and isolated locations, as well as real-time data gathering instruments like Internet of Things gadgets for tracking weather trends, milk output, and feed pricing.

Refining ANN Models: To increase predicting accuracy and address the challenge of integrating numerous factors, additional research should investigate more sophisticated ANN structures, such as deep learning models.

External Economic Influences: To make forecasting models more resilient to global economic shocks, it would be beneficial to better reflect the effects of global economic factors, such as swings in currency rates and international feed prices.

Pilot Testing: A smaller-scale real-world pilot deployment of the ANN-based forecasting system may offer important insights into its usefulness in regulating price volatility, difficulties in gathering data in real-time, and practical applications.

Stakeholder Engagement: Additional research could look at how to effectively encourage the adoption of these new technologies by dairy farmers, legislators, and industry analysts while making sure that the ANN system is usable, accessible, and intelligible at all stages of the dairy supply chain.

Long-term Impact Analysis: More research could look into how ANN-based forecasting systems affect the dairy industry's sustainability and efficiency over the long run, especially with regard to better resource allocation, waste reduction, and increased profitability for all parties.

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