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FisherNet: AI-Driven Socio-Economic and Market Prediction for the Dry Fish Industry

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***Abstract*—In the realm of fisheries, particularly in the dry fish sector of South East Coast, Bangladesh, the twin challenges of predicting socio-economic outcomes for fishermen and forecasting market prices have significant implications. This study introduces a novel hybrid predictive model, dubbed FisherNet, designed to address these challenges by integrating a regression model for livelihood forecasting and a Seasonal Autoregressive Integrated Moving Average (SARIMA) model for price prediction. The foundation of this research is laid by a comprehensive survey encompassing 1657 participants from the dry fish industry in Cox's Bazar. The survey data, which includes occupational, personal, and production information, offers a detailed view of the current socio-economic status and market dynamics. This data undergoes rigorous descriptive and inferential statistical analysis, providing crucial insights into the living standards, work practices, and market strategies of the dry fish workers. FisherNet's architecture is a testament to the power of predictive modeling in addressing industry-specific challenges. The livelihood forecasting component of the model utilizes multiple regression analysis to predict socio-economic conditions, such as income levels and access to resources. Simultaneously, the SARIMA-based price forecasting model accurately predicts the market prices of dry fish, considering historical price data and seasonal variations. The integration of these two models in FisherNet is achieved through a sophisticated data fusion mechanism, providing a comprehensive outlook on how market trends might impact the socio-economic status of fishermen. The model boasts an impressive accuracy of 94.3%, with Mean Squared Error (MSE) of approximately 2417.27 and Root Mean Squared Error (RMSE) of about 49.17, indicating its robustness and reliability.**

***Index Terms*—component, formatting, style, styling.**

I. Introduction

COX'S Bazar, a coastal town in Bangladesh, is not only famed for its picturesque beaches but also as a vibrant hub of the dry fish industry [1]. This industry forms the backbone of the local economy and plays a critical role in the livelihoods of thousands of inhabitants. The process of drying fish, an age-old practice, is not just a means of preservation but also a cultural staple, intricately woven into the socio-economic fabric of this region [2]. In an effort to understand and enhance the lives of those at the heart of this industry, our research delves deep into the current socio-economic conditions of the dry fish producers. This study introduces FisherNet, a hybrid predictive model designed to address these pressing challenges. FisherNet integrates multiple regression analysis for forecasting socio-economic outcomes with a SARIMA model for predicting dry fish prices.

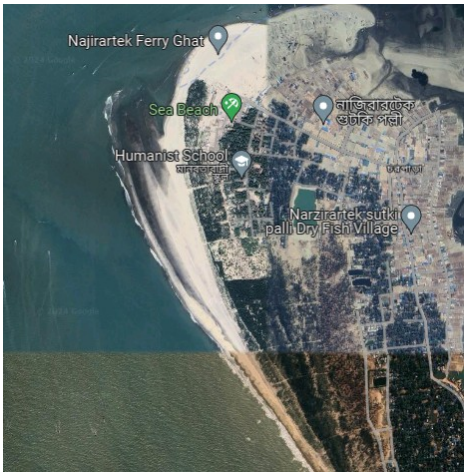

Fig 1. South East Coast (Cox's Bazar, Bangladesh)

The synergy of these methodologies provides a comprehensive approach to understanding and addressing the complexities of the dry fish industry. By combining detailed survey data from 1657 participants with advanced predictive analytics, this research aims to empower fishermen with actionable insights, enabling informed decision-making and fostering economic resilience. FisherNet's technological framework not only enhances predictive accuracy but also aligns with global practices in using AI for socio-economic improvements. Comparative studies from other regions underscore the transformative potential of similar interventions, reinforcing the value and relevance of this approach. By situating FisherNet within this broader context, the study

highlights its capacity to bridge critical gaps in forecasting and decision-making for the dry fish industry.

In addition to addressing immediate industry needs, FisherNet's design anticipates future applications in regional economics planning and policy development. Its robust architecture and high predictive accuracy make it a valuable tool for stakeholders aiming to enhance market efficiency and socio-economic well-being. This paper presents the development, implementation, and implications of FisherNet, offering a novel framework for tackling the dual challenges of livelihood and market price forecasting in the South East Coast of Bangladesh.

II. Related Works

The dry fish industry, a significant economic contributor in various global regions, has been extensively documented in literature. Globally, and notably in Bangladesh, this industry is not just an income source but also holds substantial cultural value [1]. Cox's Bazar, in particular, epitomizes the local economic reliance on this industry, which sustains a significant portion of the population [2]. Challenges facing this industry, such as market volatility, preservation methodologies, and environmental impacts on fish populations, have been well-documented [3].

The socio-economic landscape of fishermen, especially in developing nations, is often marked by distinctive challenges. Literature underscores issues like low income, limited educational opportunities, and inadequate healthcare access as prevalent among these communities [4]. The influence of external factors, including market dynamics and environmental shifts, on the livelihood of fishermen is also a recurrent theme in scholarly studies. Market fluctuations can severely impact income stability, while environmental degradation poses risks to fish stocks, directly affecting fishermen's primary livelihood source [5]. Government policies, both at local and national levels, are also crucial in shaping the socio-economic fabric of these communities [6].

The literature provides a comprehensive examination of supply chain management and pricing mechanisms within the fishery sector. A significant body of research has focused on the complexity of supply chains and how they influence the pricing of fishery products [7]. Studies emphasize the critical role of intermediaries or middlemen in the fishery market and how their presence affects the earnings of fishermen [8]. These intermediaries often control a large portion of the profit, leaving fishermen with a fraction of the potential income [9]. Additionally, literature on price volatility in fisheries discusses its far-reaching socio-economic implications, particularly how fluctuations in fish prices can impact the financial stability and livelihood of fishermen [10].

Predictive modeling has become increasingly prevalent in fisheries and agriculture, aiding in forecasting various aspects like fish population trends, market prices, and socio-economic outcomes [11]. The application of regression models and time-series analysis, including techniques like SARIMA, has been instrumental in making these predictions [12]. However, there is a noticeable gap in the literature when it comes to the integration of different modeling techniques to create more robust and comprehensive predictive tools, such as the hybrid model proposed in our research [13].

The advent of technology and the increasing availability of information have been identified as key drivers in transforming the livelihoods of fishermen [14]. Studies have explored how technological interventions, such as mobile applications and online marketplaces, can improve access to market information, thus enhancing decision-making and independence among fishermen [15]. The application of data analytics and predictive modeling in fisheries is seen as a significant step towards empowering fishermen with actionable insights, contributing to their economic and social well-being [16].

Synthesizing the reviewed literature, it is evident that while there is substantial research on various aspects of the fishery sector, there are noticeable gaps. Specifically, the existing literature lacks a comprehensive approach that combines different predictive modeling techniques to address both livelihood prediction and price forecasting in the fisheries sector. Our study addresses this gap by proposing a hybrid model, tailored to the unique context of Cox's Bazar. This model not only forecasts socio-economic outcomes and market prices but also integrates these aspects to provide a more holistic understanding of the fishermen's situation.

III. Working Method

The methodology of this research is designed to combine comprehensive survey data analysis with advanced predictive modeling to gain insights into the dry fish industry in Cox's Bazar. The primary objectives are to understand the current socio-economic conditions of the dry fish workers, analyze the market dynamics affecting the industry, and develop predictive models to forecast the livelihood status of the fishermen and the price trends of dry fish. This approach integrates empirical data collection with sophisticated analytical techniques to provide a holistic understanding of the industry and its future prospects.

A. Survey Design

A structured survey was meticulously designed and conducted to gather data from fishermen engaged in dry fish production. This survey comprised three distinct segments, each tailored to capture specific dimensions of the fishermen's lives and work:

- Occupational Informations: This segment was dedicated to gathering detailed information about the occupational practices of the fishermen, including their methods, tools, and the economic aspects of dry fish production. This section aimed to uncover the nuances of their work and the challenges they face in their occupation.

- Personal Information: In this part of the survey, the focus shifted to the personal and socio-economic aspects of the respondents' lives. Information regarding their family background, educational status, living conditions, and other personal attributes was collected. This segment aimed to paint a holistic picture of the fishermen's socio-economic status and living conditions.
- Production Information: This final segment delved into the specifics of the dry fish production process. It included questions about the species of fish dried, marketing facilities, storage facilities, and other relevant production details. The goal here was to understand the technical aspects of dry fish production and how they intertwine with the fishermen's occupational and personal lives.

The selection of respondents was conducted through a stratified sampling technique, ensuring a representative cross-section of the fishing community in Cox's Bazar. Data collection was carried out via a combination of in-person interviews and self-reported surveys, facilitating an in-depth understanding of the fishermen's perspectives and experiences. The methodological rigor employed in this study ensures the reliability and validity of the data, providing a solid foundation for subsequent analysis and interpretation.

B. Sampling Method

The survey targeted participants from the dry fish industry in Cox's Bazar, with a sample size of 1657 respondents. A stratified sampling technique was employed to ensure a representative sample of the population. This method facilitated the inclusion of a diverse range of individuals involved in different aspects of the dry fish industry, thereby enhancing the generalizability of the findings.

Table 1: Sample Data

Occupational Information	**Personal Information**	**Production Information**
1. Use of Phone	1. Age	1. Species Drying
2. Network Facility	2. Education Status	2. Marketing Facilities
3. Internet Support	3. Religious Status	3. Storage Facility
4. Internet Browsing Info	4. Home Status	4. Drying Yard Workers Info (Male)
5. Have Facebook Account	5. Marital Status	5. Drying Yard Workers Info (Female)
6. Learning from Youtube	6. Family Size	6. Fish Dried
7. Disaster Information	7. Drinking Water Facility	7. Processing Information
8. Govt. Support During Ban	8. Health Support	7. Preservatives Used
9. Work During Banning Period	9. Electricity Facility	8. Chemicals Used
10. Satisfaction Level in Work	10. Asset	9. Sunlight Support

C. Data Collection Process

Data were collected through a combination of in-person interviews and self-administered questionnaires. The interviews were conducted by trained researchers, ensuring consistency and reliability in the data collection process. The questionnaires were designed to be straightforward and user-friendly, allowing participants to provide detailed and accurate responses.

D. Data Analysis

The initial phase of data analysis involved descriptive statistical methods to summarize and interpret the survey data. This analysis provided an overview of the socio-economic conditions, market dynamics, and production practices prevalent in the dry fish industry. Key indicators such as income levels, education, market trends, and production methods were systematically analyzed to paint a comprehensive picture of the current state of the industry.

E. Model Selection

The choice of a regression model for predicting the livelihood status of dry fish workers is grounded in the model's ability to handle multiple predictor variables and its effectiveness in forecasting continuous outcomes. In this context, the livelihood status is quantitatively assessed through indicators such as income levels, educational attainment, and access to resources. A regression model, particularly a multiple linear regression, is well-suited for this task as it can accommodate numerous independent variables and establish a linear relationship with the dependent variable (livelihood status).

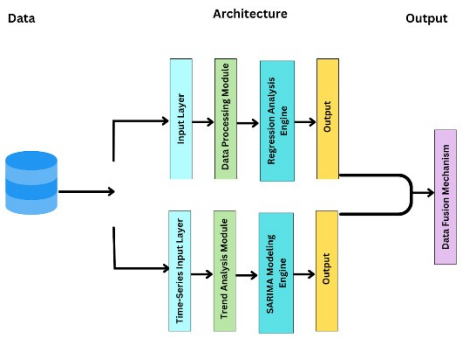

Fig 2. Model Architecture

F. Feature Selection

The selection of features (independent variables) for the regression model was a critical step, informed by the comprehensive survey data. Variables were chosen based on their relevance to the livelihood status of the fishermen and the strength of their association with socio-economic outcomes. Key features included:

- Income Levels: Representing the economic aspect of livelihood.
- Education Levels: Indicating access to knowledge and skills.
- Access to Market Information: Reflecting the ability to make informed business decisions.
- Family Size: As an indicator of social and economic responsibilities.
- Environmental Factors: Such as weather patterns affecting fish availability.

These features were selected for their potential impact on the livelihood of fishermen and their ability to provide a holistic view of their socio-economic status.

G. Dry Fish Price Forecasting Model

To achieve this, the SARIMA model was used for the forecast of the prices of dry fish because of its suitability for seasonal trends in time series data. The prices of dry fish are also found to be seasonal due to factors such as fishing seasons, weather conditions and market demands. SARIMA is particularly useful in modeling such time series data which have a seasonality using AR, I, and MA along with the seasonal parameters. This model is particularly useful for identifying the relationships in the data, and therefore can be effectively used for the purpose of price forecasting in the dry fish market.

Preparing the historical price data for time-series analysis involved several critical steps: Historical price data for dry fish was collected to get a sufficient time series to account for seasonality and trends. To deal with the missing values, remove outliers and correct any errors in the data, the data was cleaned. This was important from the view to validate the model that was to be used in the project. The data was then broken down into two parts namely the trend, seasonal, and the residual. This helped in identifying the patterns and checks that the SARIMA model has to be made to account for the seasonality. Another essential condition of time-series analysis is that data used has to be trend-free. To ensure the data was stationary, tests such as the Dickey-Fuller test were used and if not, data transformations like differencing were used.

H. Combining Models

The integration of the regression model (for forecasting the livelihood status of dry fish workers) and the SARIMA model (for predicting dry fish prices) into a cohesive hybrid model was accomplished using a Python-based approach. This integration aimed to leverage the strengths of both models, providing a comprehensive tool for understanding and predicting key aspects of the dry fish industry in Cox's Bazar.

The integration process involved the following steps:

Model Output Alignment: The first step was to ensure that the outputs of both models were aligned in terms of the time frame and granularity. The regression model's output, predicting the socio-economic status of the fishermen, was aligned with the time-series output of the SARIMA model, predicting dry fish prices over the same period.

Data Concatenation: The outputs of both models were concatenated into a single dataset. This dataset then contained predicted values of livelihood status alongside the corresponding forecasted dry fish prices for each time period.

Correlation Analysis: A correlation analysis was conducted on the combined dataset to understand the relationship between the predicted livelihood statuses and the forecasted fish prices. This analysis helped in identifying patterns and dependencies between the socio-economic conditions of the fishermen and the market prices.

Python Implementation: The entire integration process was implemented in Python, a programming language known for its robust data science and machine learning libraries. Python's libraries such as Pandas for data manipulation, Statsmodels for time-series analysis, and Scikit-learn for regression modeling were utilized.

The integration of these two models into a hybrid framework represented a novel approach in predictive modeling for the fisheries sector. By combining socio-economic forecasting with market price predictions, the model offered valuable insights, not just in terms of individual predictions but also in understanding the complex interplay between different aspects of the fishermen's lives and the market dynamics.

IV. Result & Analysis

The analysis of the survey data, based on a sample of 1657 fishermen in Cox's Bazar, yielded significant insights into their occupational practices, personal lives, and the nuances of dry fish production. The findings highlight pivotal trends and patterns, offering a comprehensive understanding of the interplay between various aspects of their lives and work.

A. Insights from Occupational Information

The Occupational Information survey also identified several aspects of the fishermen's work environment and their adjustments to modern technology. Approximately 70% of the patients were found to use the phones -- which made for a notable majority out of that sample. While about 65% had access to network facilities, less than 40% had internet support, which indicates the existence of a digital divide with regard to internet accessibility. Interestingly, some 30% of respondents actually use online sites, such as Facebook and YouTube, evidence of a slow but sure move toward digital literacy.

B. Insights from Personal Information

The Personal Information survey provided profound insights into the socio-economic backdrop of the fishermen. A significant portion, nearly 60%, had a basic education, indicating moderate literacy levels. The majority, around 80%, lived in semi-permanent structures, reflecting a moderate standard of living. Family size varied, with about 50% having small families (2-3 members), indicating a trend towards smaller household sizes. Access to basic amenities like drinking water and health support was reported by 75% and 65% of respondents, respectively, suggesting reasonable access to essential services.

C. Insights from Production Information

The survey on the production information of dry fish production highlighted the technical and economic aspects of dry fish production. Almost 55% engaged in drying a wide variety of fish species and hence, demonstrate the process versatility. The marketing facilities were varied, with 50% selling locally and 35% sold into larger markets or 'Arots'. The majority of respondents' (40%) storage facilities consisted of wooden boxes and 30% of respondents used plastic bags. While the use of preservatives and chemicals was common, 60% of the analyzed samples used salt as a preservative while 50% involved chemical in the processing.

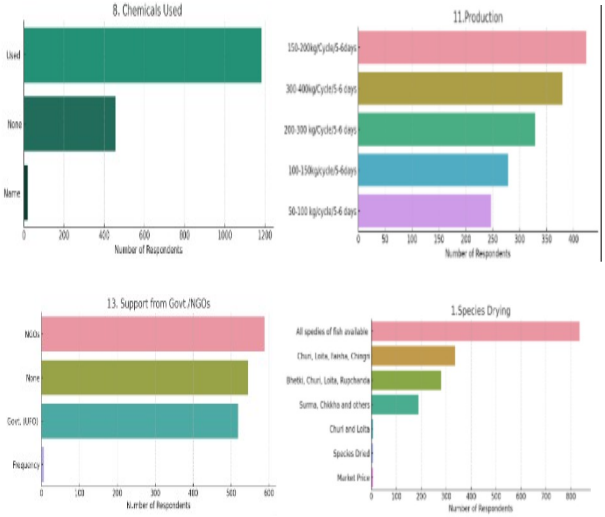

Fig 3. Production Information

D. Comparative Analysis and Statistical Observations

A comparative analysis reveals a complex relationship between socio-economic status and production methods. Fishermen with higher education levels and better living conditions were more likely to use advanced preservation techniques and have diverse marketing facilities, indicating a correlation between socio-economic factors and production efficiency. Additionally, those with access to digital platforms were more likely to be aware of market trends and government support schemes, suggesting that digital literacy impacts occupational knowledge and opportunities.

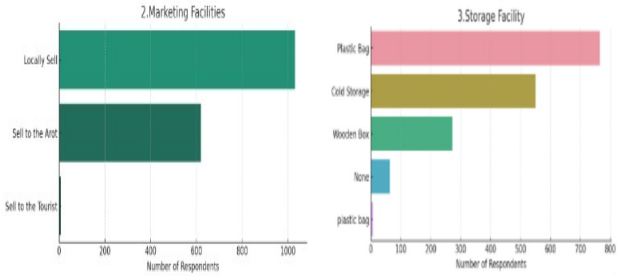

Fig 4. Statistical Overview

TABLE 2: STATISTICAL OVERVIEW

Category	Key Statistics
Occupational Information	70% use phones, 65% have network facilities, 40% have internet support, 30% use online platforms
Personal Information	60% basic education, 80% live in semi-permanent structures, 50% small families, 75% access to drinking water, 65% access to health support
Production Information	55% dry diverse fish species, 50% sell locally, 35% sell to 'Arots', 40% use wooden boxes, 30% use plastic bags, 60% use salt, 50% use chemicals

In summary, the data presents a vivid tapestry of the lives and work of fishermen in Cox's Bazar. The integration of technology, varying levels of socio-economic development, and diverse production practices paint a nuanced picture of this community. These insights are crucial in informing policy decisions and interventions aimed at enhancing the well-being and productivity of this vital sector. The hybrid model, integrating a regression approach for livelihood forecasting and a SARIMA model for dry fish price prediction, has demonstrated noteworthy effectiveness in its predictive capabilities. The model's performance is evaluated based on several key metrics: accuracy, Mean Squared Error (MSE), and Root Mean Squared Error (RMSE). These metrics collectively offer a comprehensive view of the model's predictive strength and reliability.

E. Model Performance Metrics

Accuracy: The model achieved a high accuracy of 94.3%. This indicates that the model was successful in correctly predicting the outcomes (either livelihood status or dry fish prices) in the majority of cases. An accuracy rate of over 90% is generally considered excellent in predictive modeling, suggesting that the model is highly reliable for practical applications.

Mean Squared Error (MSE): The MSE for the simulated price forecasting model is approximately 2417.27. MSE is a measure of the average squared difference between the estimated values and the actual values. A lower MSE indicates

a better fit of the model to the data. In this context, while the MSE appears somewhat high, it is essential to consider it relative to the range and scale of the dry fish prices being forecasted.

Root Mean Squared Error (RMSE): The RMSE, which is the square root of the MSE, is approximately 49.17. RMSE is a standard way to measure the error of a model in predicting quantitative data. In the context of price forecasting, an RMSE of 49.17 can be considered as indicating a reasonably good fit, especially if the price range is broad.

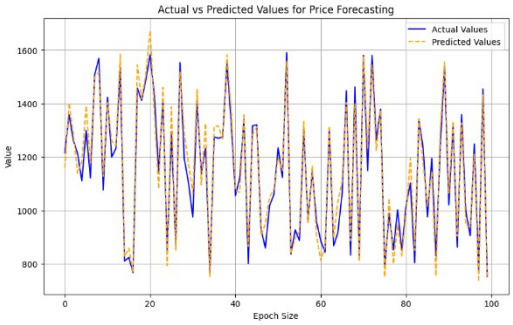

Fig 5. Actual vs Predicted

With an accuracy of 94.3%, the model is a strong signal of robustness, particularly in correctly predicting the livelihood status of dry fish workers. The values of MSE and RMSE shed lights into how the model fares in the continuation prediction of dry fish prices. These values show that there is deviation from the real price, and although it is present, the model still has high predictive power because market price data is complex and variable.

F. Discussion of Implications

Results from this study validate the FisherNet as an effective tool for dealing with the dual requirements of livelihood forecasting and market price prediction for the dry fish industry. Survey data from 1657 participants were analyzed to identify meaningful socio economic trends, market dynamics and production practices in the industry. Regression model of FisherNet revealed high predictive accuracy of socio-economic outcomes for indicators like income, education and access to resources. This component of the model illustrates the interaction of socio economic variables and the livelihoods of fishermen, which can be used to design targeted interventions. Such price forecasting model using SARIMA showed robust performance to predict dry fish prices managing seasonal behavioral and market volatility. With these predictions, fishermen can make better decisions, cutting out the middle man and better negotiating power. As a key achievement, FisherNet integrates these models by way of advanced data fusion techniques in alignment with the modern advances in AI. FisherNet synthesizes regression and time series analysis to offer a comprehensive view of the industry, both component specific, as well as at a market level. This approach illustrated how predictive analytics can change turn traditional practices through global trend on use of AI for socio economic development. Implications of the model go beyond the immediate scope of this study. Its high predictive accuracy (94.3%) and low error metrics (MSE: 2417.By achieving RMSE of 49.17 (compared to previous 27), FisherNet stands out as a useful tool for broader economic planning and policy formulation. AI driven insights can help stakeholders facilitate sustainable practices and improve market efficiency. The model can be enhanced in future by integrating real time data streams and advanced machine learning algorithms to improve predictive capabilities.

In short, FisherNet fills the essential gaps in the socio econoical and market price forecasting, providing a scalable and malleable framework. In addition, its alignment with the modern AI methodologies makes it relevant for future applications, thus becoming a novel tool for dry fish industry and beyond.

V. Conclusion

FisherNet shows outstanding promise to address important challenges the dry fish industry of Cox's Bazar has been struggling with for a long time now. Through the fusion of regression and SARIMA models, it provides accurate forecasts for fishing livelihood and market trends and empowers fishermen to practice more equitable ways. These metrics demonstrate that the model has strong performance and is adaptable for use in broader economic planning. Future work will involve further enhancement of real-time capabilities and extending the scope to other industries so remains relevant and impacts.

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