Forecasting Catch and Price Dynamics in Coastal Karnataka Fisheries

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Abstract

The Indian peninsular region is blessed with rich coastal areas and a vast Exclusive Economic Zone, endowing it with substantial potential for fisheries development. The coastal region of Karnataka, renowned for its rich marine biodiversity and vibrant fishing industry, plays a pivotal role in the socio-economic fabric of the state. The fluctuating nature of fish catch, influenced by environmental factors such as monsoons and cyclones, significantly impacts the availability of marine resources and, consequently, the livelihoods of fishing communities. These complexities necessitate the development of robust forecasting models for fish catch and prices to enhance the resilience and sustainability of the fishing sector in Coastal Karnataka.

This study aims to analyse variations in catch levels, growth rates, and volatility among the three coastal districts of Karnataka and to forecast fish catch and real prices for the next five years using the Prophet model. Using a decade of district data on catches, nominal prices, and fleet capacity, we constructed consistent series by deflating prices to constant terms. We have then produced district-level forecasts with confidence intervals and assessed differences in projected levels, growth, and volatility. Outputs include tabular and graphical forecasts, a comparative dashboard of district trends. Secondary data on marine catch, market prices, and fuel costs were used for the analysis and forecasting. The results indicate a complex interaction between environmental seasonality, operational costs, and market responses across the districts. While Udupi demonstrates rapid post-pandemic recovery and fleet expansion, Dakshina Kannada shows the highest sensitivity to market shocks, and Uttara Kannada remains relatively stable but slow-growing. Seasonal cycles, such as the 61-day monsoon ban, significantly influence catch recovery, while Prophet-based forecasts predict a 58% increase in catch over five years, stressing the need for adaptive and sustainable fisheries management.

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Keywords - Fisheries Economics; Forecasting; Coastal Karnataka; Comparative Analysis; Prophet model.

Introduction

Fishing has been a fundamental human activity since the dawn of civilisation, serving as a primary source of sustenance and a catalyst for the development of coastal communities (Tarun Kumar & Shivani, 2014). Fisheries, encompassing both the capture of wild fish stocks and the cultivation of aquatic organisms through aquaculture, represent a multifaceted sector with far-reaching implications for global food security, economic stability, and the livelihoods of millions worldwide (Sadekin et al., 2018). The Food and Agriculture Organization provides detailed statistics on trends in fish and aquatic animal production (Suresh & Parappurathu, 2018). The total global fisheries and aquaculture production reached a historic peak of 223.2 million tonnes in 2022, marking significant growth primarily driven by aquaculture (130.9 million tonnes) and capture fisheries (92.3 million tonnes) (FAO, 2024). Diversification of catch and production across stocks, species, or fishing grounds has been shown to stabilise incomes and reduce exposure to natural variability and risk (Anderson et al., 2017; Cline et al., 2017; Kasperski & Holland, 2013; Schindler et al., 2010). Still, climate change and continued fishing pressure are expected to increase fisheries' variability globally (Brander, 2010; Perry et al., 2010), and many communities may have limited alternatives for diversification as over 90% of assessed stocks are currently considered fully- or overfished (Food and Agriculture Organization, 2018).

India's extensive coastline, spanning over 7,500 kilometres, is a crucial resource that significantly contributes to the nation's economy through marine fisheries (Khyat, 2020). The Indian peninsular region is blessed with rich coastal areas and a vast Exclusive Economic Zone, endowing it with substantial potential for fisheries development (Khyat, 2020; Majhi, 2020). India's diverse aquatic habitats foster a wide array of fish species, positioning the country as a prominent global fish producer (Suvarna, 2023). The sector's prominence is underscored by its substantial contribution to the national economy, accounting for 1.1% of India's total GDP (Garg, 2025). Fisheries have gained importance in the State and National economy as a source of nutritious food, foreign exchange and employment. Karnataka State has vast potential for fish production. It has 5.74 lakh ha. of freshwater sources consisting of 3.02 lakh ha. of ponds and tanks and 2.72 lakh ha. of reservoirs. In addition, the State has 8,000 ha. of brackish water resources and 320 Km coastline with a continental shelf area of 27,000 Sq. Km (Government of Karnataka, Department of Fisheries, 2024).

India is the second-largest fish-producing country with around 8% share in global fish production. Over the past two decades, India's fisheries sector has witnessed significant growth and transformation. From technological advancements to policy reforms, the period from 2004 to 2024 has been marked by milestones that have bolstered India's position in global fisheries and aquaculture (Garg, 2025).

Between 2023 and 2024, India's marine fish landings decreased slightly by 2%, from 3.53 million t to 3.45 million t. This general decline was caused by a downturn on the West Coast. Regional trends exhibited significant variability, with Karnataka, Goa, and Daman & Diu encountering steep decreases of 34%, 50%, and 44%, respectively (ICAR, 2024)

Comparative studies on environmental time series consistently support the Prophet model. Prophet matched or outperformed classical ARIMA/SARIMA on seasonal datasets and delivered lower error and easier calibration in practice (Samal et al., 2019). In ocean–climate contexts, Prophet excelled at capturing long-horizon patterns and seasonality in sea-level forecasting relative to autoregressive baselines, providing tighter short-term confidence and stable long-term trend extraction (Elneel et al., 2024). Against deep learning, Prophet performed competitively with LSTM for temperature series, particularly for maximum temperatures, with minimal tuning burden, an advantage for operational fisheries analytics (Toharudin et al., 2021). Finally, ecosystem evidence that bottom-up environmental variability drives marine production underscores the value of flexible seasonal/trend decomposition with climate regressors, precisely Prophet's design (Piroddi et al., 2017).

Literature Review

Agmata & Guðmundsson (2025) developed the CATCH study, an advanced computer model using Convolutional-LSTM to predict when and where fish are most likely to be caught, based on fishing data and environmental factors like sea temperature, salinity, and depth. By learning seasonal and spatial patterns, it accurately forecasted fishing "hotspots," showing that combining environmental and fishing data can improve the reliability of catch predictions. This approach offers strong insights. Local forecasts could integrate data such as monsoon rainfall, sea surface temperature, and fishing effort to anticipate variations in catch and market supply. These predictions can then be linked with economic indicators like real fish prices, helping policymakers and cooperatives plan for storage, sales, and income stability.

Rajani et al. (2024) studied how India's fish production has changed over several decades and tried to predict future trends. They used a time-series forecasting method called ARIMA, which helps identify growth patterns and seasonal fluctuations. Their analysis showed that both marine and inland fish production are increasing, with inland aquaculture growing faster. The models they used, ARIMA(0,1,3) for marine and ARIMA(0,2,1) for inland and total production, proved accurate for short-term forecasts. The five-year projections (to 2026–27) show continued increases across all three categories, with marine rising modestly and inland driving most aggregate growth.

Layton et al. (2024) paper reviews "genomic forecasting" tools that predict how marine species will respond to climate change and argues they are especially relevant for fisheries. It explains that warming, changing salinity, and oxygen declines can shift species ranges and productivity, often more strongly in the ocean than on land. The authors describe genomic offset methods that estimate how much a population's genetic makeup would need to change to stay adapted under future climates, and they propose validation using historical sampling and hindcasting against long time series. The workflow they outline also supports pairing SARIMAX or ML forecasts with climate-informed risk layers, so cooperatives can plan procurement, storage, and income protection where future maladaptation is most likely.

Zahid & Harikumar (2025) This study explains why Cyclone Tauktae (May 14–19, 2021) intensified so close to India's west coast and quantifies the drivers: very warm sea surface temperatures above 31 °C, high tropical cyclone heat potential over 130 kJ cm^{-2}, moist mid-troposphere, and low wind shear, with ocean and atmosphere contributing roughly 47% and 53% to intensification. It also situates Tauktae within a decade of rapid Arabian Sea warming, La Niña with negative IOD conditions, and an active MJO phase, all factors that raise genesis potential and vorticity and hasten rapid intensification within ~140 km of the coast. For Coastal Karnataka forecasting, these mechanisms matter because cyclones disrupt fishing effort, damage fleets and ports, and temporarily alter productivity and availability, which depresses landings, tightens local supply, and amplifies real price volatility.

Kwarteng & Andreevich (2024) directly compare ARIMA, SARIMA, and Prophet on a seasonal monthly series and find Prophet delivers the lowest errors across metrics: MAE 0.74 versus 2.18 (SARIMA) and 3.02 (ARIMA), and MAPE 8.2% versus 10.04% and 13.62%, respectively. Beyond accuracy, Prophet's design explains the edge: it models trend + multiple seasonality's with Fourier terms, natively handles yearly/weekly effects and holiday/event regressors and provides calibrated prediction intervals with

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minimal tuning. ARIMA/SARIMA require strict stationarity checks, careful differencing, and expert hyperparameter search; performance is sensitive to mis-specified orders. In contrast, Prophet's decomposable, additive structure is robust to missing data, outliers, and regime changes, and its flexibility to add domain regressors (e.g., monsoon bans, cyclone dummies, fuel prices) makes it well-suited for fisheries. For Coastal Karnataka, where strong seasonality (ban-induced gaps), irregular shocks (cyclones), and multiple cycles coexist, Prophet's accuracy and operational simplicity make it a pragmatic baseline over ARIMA/SARIMA.

The studies show that blending ocean data with fishing patterns can make short-term and district-level forecasts far more effective for sustainable management and pricing of marine resources. And with the help Prophet model delivers the best results compared to ARIMA and SARIMA forecasting models.

Objectives

To compare district trajectories in catch levels, growth rates, and volatility.

To find the correlation of fuel, catch, and price.

To analyse the month-wise catch across years of the Udupi district.

To forecast fish, catch and real prices for the Udupi district for next 5 years with confidence intervals.

Methodology

This study employed a mixed analytical approach combining descriptive trend analysis, correlation modelling, and time-series forecasting to examine marine fish catch and pricing dynamics across the coastal districts of Karnataka, which are Dakshina Kannada (DK), Udupi, and Uttara Kannada (UK), from 2016 to 2024. District-level secondary data on monthly fish landings (catch) and average fish prices were obtained from official fisheries and market records through Right to Information (RTI - Registration No. DOFHO/R/2025/60005), while annual diesel prices were incorporated as a proxy for operating costs. All data were cleaned and standardised to a uniform temporal structure, with monthly records aggregated into annual summaries (fiscal year: April-March) for trend and correlation analysis.

To assess interrelationships among key variables, both Pearson's correlation coefficient (r) and Spearman's rank correlation (ρ) were computed. The Pearson correlation measured linear associations among catch, price, and diesel cost, while the Spearman coefficient identified monotonic relationships resilient to outliers or non-linear effects.

Monthly fish catch and price visualisation was performed to examine seasonal fluctuations and interannual variations across different fishing years in Udupi. The monthly data from 2014–15 to 2024–25 was plotted as multi-line time series to capture temporal dynamics in production and market value. Each line represented one fiscal year, allowing for comparison of seasonal peaks, monsoon closures, and post-monsoon recovery trends. The visualisation highlighted the cyclical nature of the fisheries sector, with pronounced declines during June–July due to fishing bans and rapid rebounds from August onward. These plots also facilitated the identification of anomalous years, showed increases and decreases in both catch and average price. Such graphical exploration provided crucial context for understanding intra-annual variability and guided the selection of suitable forecasting models by revealing strong seasonality patterns inherent in the data.

For forecasting, the study adopted the Prophet model, a decomposable time-series model well-suited for seasonal fisheries data. Separate Prophet models were fitted to monthly catch and price series for Udupi, incorporating yearly and monthly seasonality components to account for cyclical production and market patterns. The model was trained on data up to FY 2023–24 and used to generate five-year forecasts (2024–25 to 2028–29).

Forecast uncertainty was quantified using 95% confidence intervals (CIs) derived from the Prophet model. The upper and lower bounds of these intervals represent the plausible range of outcomes given historical variability and model uncertainty.

Results and Analysis

District-Level Comparison of Catch, Growth, and Volatility

To understand the spatial dynamics of marine production and pricing, district-wise trajectories of annual fish catch and average prices were compared for Dakshina Kannada, Udupi, and Uttara Kannada. The trends reveal distinct patterns in catch levels, growth rates, and volatility shown in Fig. 1. Dakshina Kannada exhibits the highest volatility, with sharp surges in 2021-22 followed by notable declines, suggesting stronger sensitivity to market or environmental shocks.

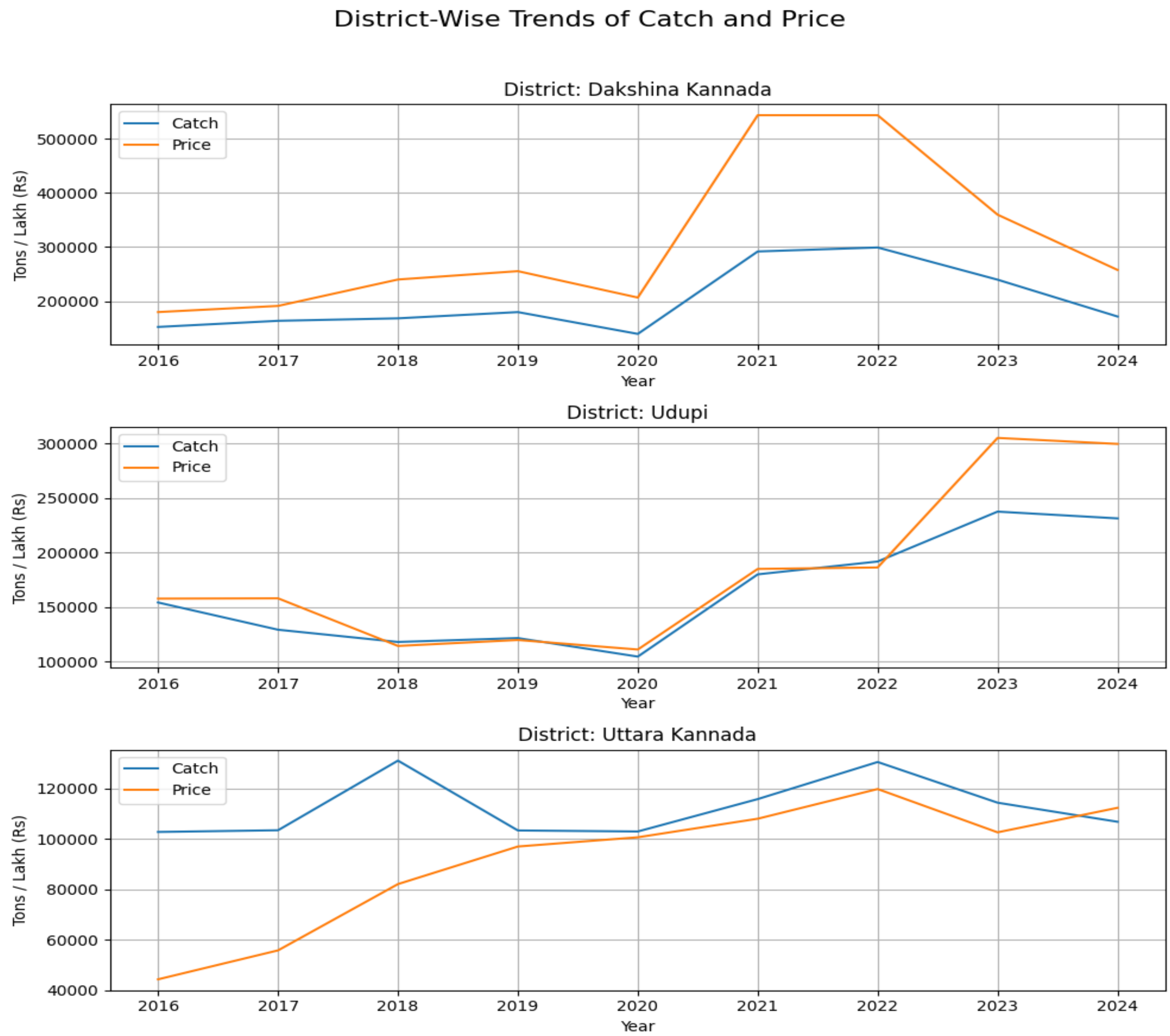

Fig. 1., District-wise trends of catch and price

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Udupi shows the steepest growth in both catch and price since 2020-21, reflecting post-pandemic recovery and capacity expansion. In contrast, Uttara Kannada maintains more stable but slower growth in both indicators, with moderate year-to-year fluctuations. Overall, these contrasting trajectories highlight differences in district-level resilience, productivity, and price responsiveness within the regional fishery sector.

Correlation of fuel, catch, and price.

A correlation analysis was conducted to examine the relationship between annual fish catch, average market price, and diesel cost from 2016 - 2024 across the coastal districts of Dakshina Kannada, Udupi, and Uttara Kannada. The aggregated year-level Pearson correlation matrix showed a strong positive association between catch and price ($r = 0.971$), indicating that years with higher fish landings were generally associated with higher market prices. A moderate to strong correlation was also observed between catch and diesel price ($r = 0.817$) and between price and diesel price ($r = 0.891$), suggesting that operational costs and fuel variations may have influenced both production and market trends. The Spearman rank correlations followed a similar pattern, with catch-price ($\rho = 0.833$) and price-diesel ($\rho = 0.767$) exhibiting monotonic positive relationships.

When analysed at the district level across years (Table. 1), Dakshina Kannada demonstrated a near-perfect correlation between catch and price ($r = 0.984$; $\rho = 0.929$), reflecting the district's consistent market response to production volume. Udupi also showed a strong association ($r = 0.960$; $\rho = 0.983$), indicating synchronised fluctuations in catch and price, particularly after 2021. In contrast, Uttara Kannada displayed a weaker catch–price relationship ($r = 0.393$; $\rho = 0.500$), though price–diesel correlation remained high ($r = 0.861$; $\rho = 0.867$), suggesting that fuel costs influenced pricing more than catch quantity in that region.

Table. 1., District-wise Pearson and Spearman Correlation Coefficients between Fish Catch, Market Price, and Diesel Cost (2016-2024)

District	Pair	Pearsons	Spearman's
Dakshina Kannada	Catch vs Diesel	0.661	0.550
	Catch vs Price	0.984	0.929
	Price vs Diesel	0.693	0.778
Udupi	Catch vs Diesel	0.785	0.633
	Catch vs Price	0.960	0.983
	Price vs Diesel	0.728	0.650
Uttara Kannada	Catch vs Diesel	0.416	0.483
	Catch vs Price	0.393	0.500
	Price vs Diesel	0.861	0.867

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Fish catch and price trends in Udupi

The visual analysis of the monthly fish catches and price trends in Udupi reveals clear seasonal and interannual variability patterns. Across the decade (2014-2024), fish catch, and prices exhibit a cyclical pattern, with the lowest activity during June-July corresponding to the monsoon ban period and a sharp recovery starting from August, peaking around October–November. (Fig. 2)

While earlier years (2015–2019) show moderate fluctuations with relatively stable mid-range prices, the post-2021 trend reflects increased volatility driven by climatic variability and intensified fishing capacity. COVID-era constraints (2020–21 to 2021–22) depressed effort, market access, and thus landings, which explains the visibly lower curves in those years. In 2023–24 the record October spike followed by a quick fall suggests a short-lived aggregation (often small pelagic right after the ban) met by an "effort surge." When many vessels crowd productive grounds simultaneously, landings can overshoot for a month and then sag if recruitment is weak or schools move, consistent with localised overfishing plus shifting ocean conditions. Overall, the curves capture how policy (ban), shocks (COVID/weather), and fleet behaviour interact: a predictable post-ban lift, occasional boom-and-bust peaks, and interannual swings driven by environment and effort.

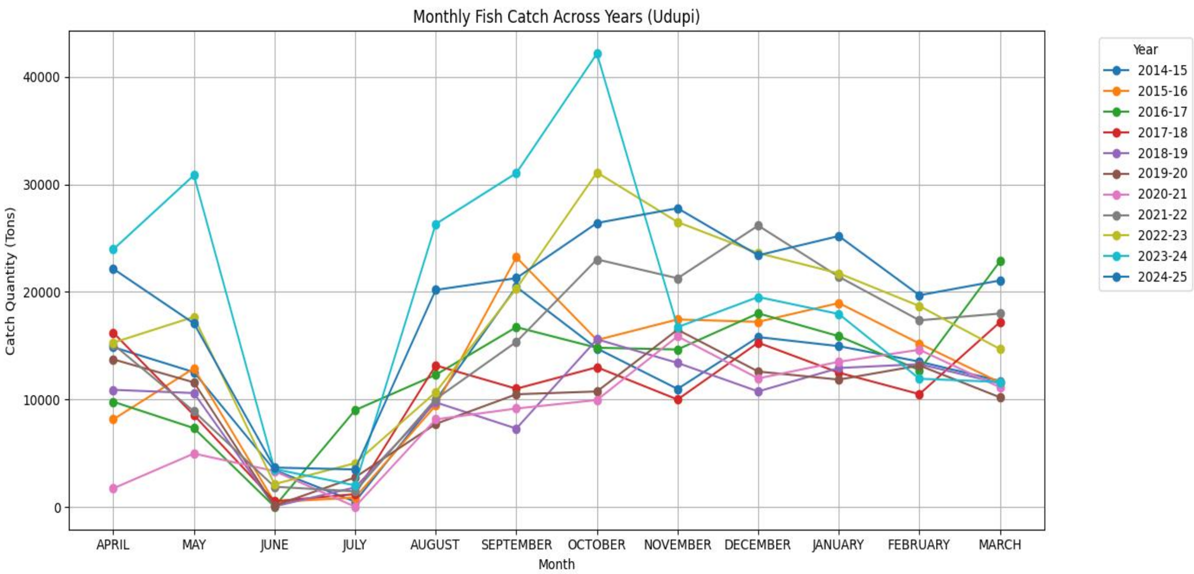

Fig. 2., Month-wise Catch across years of the Udupi district.

Forecasted Annual Fish Catch and Real Fish

The Prophet models with yearly and monthly seasonality yield a coherent central path and transparent uncertainty for Udupi. As depicted in Fig. 3 aggregating monthly predictions shows catches rising from about 255,000 tonnes in 2024–25 to roughly 375,000 tonnes by 2028–29, compared with 238,000 tonnes observed in 2023–24, a modest first-year gain (~7%) and a strong five-year increase (~58%).

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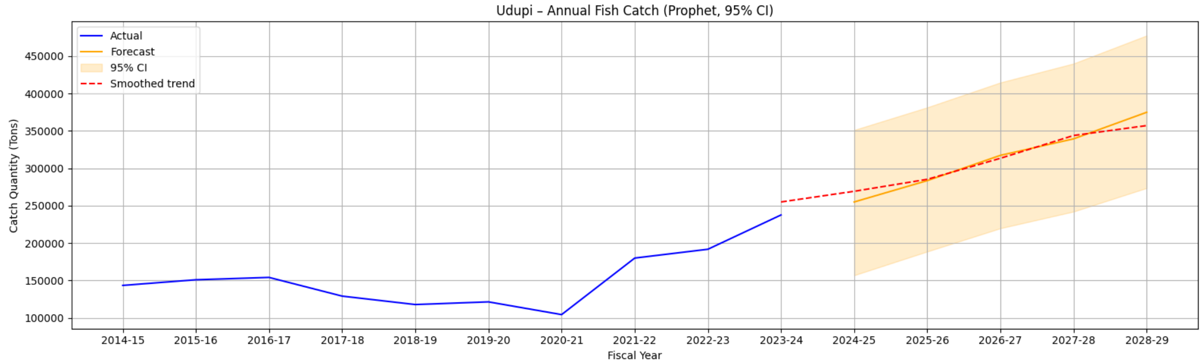

Fig. 3., Forecasted Annual Fish Catch and Real Fish Prices for Udupi District (Prophet Model, FY 2024–25 to 2028–29, with 95% Confidence Intervals)

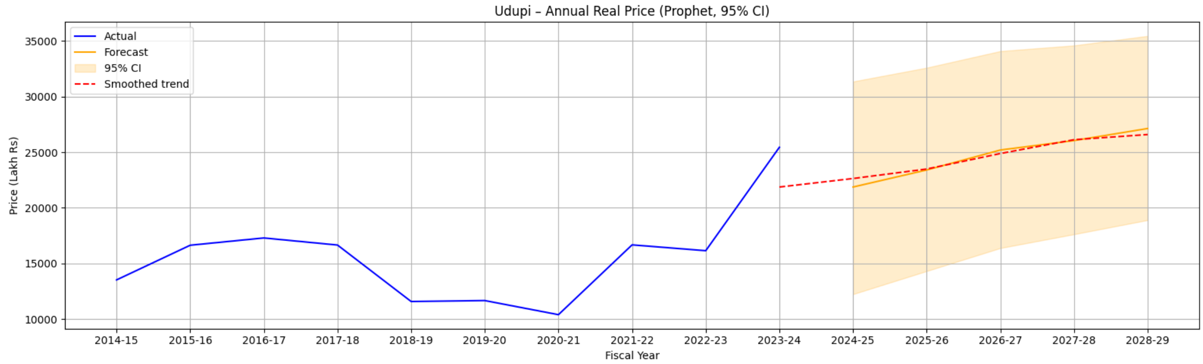

Fig. 4., Forecasted Annual Real Fish Prices for Udupi District (Prophet Model, FY 2024–25 to 2028–29, with 95% Confidence Intervals)

As shown in Fig. 4 Real (inflation-adjusted) prices are expected to soften in the near term about ₹25,400 lakh to ₹21,900 lakh in 2024–25, before recovering to ~₹27,100 lakh by 2028–29, implying a net real improvement of ~6–7% over the base year. Importantly, the interval bands indicate material risk around these point paths. For catch, the 95% CI spans 160–352 thousand tonnes in 2024–25 and 277–478 thousand tonnes by 2028–29; the relative width narrows from ~75% to ~53%, suggesting trajectories become better identified with horizon but remain susceptible to shocks. For real price, the 95% CI ranges from ₹12,500–₹31,300 lakh in 2024–25 to ₹19,000–₹35,000 lakh in 2028–29; the relative width eases from ~86% to ~60%, indicating persistent market variability even as uncertainty declines. Practically, this means planning should not be anchored on the mean alone. On the sustainability side, a rising central catch after the monsoon ban calls for vigilant CPUE monitoring and effort management to prevent boom-and-bust dynamics; if indicators such as weak post-ban recruitment, or repeated cyclone alerts emerge, managers should tighten trips, adjust gear deployment, and deploy storage price-stabilisation tools. In short, the outlook is constructive, higher catches with prices recovering after a one-year dip, but policy and business decisions should be calibrated to the interval bounds, especially in 2024–26 when uncertainty is widest.

Discussion

The comparative and predictive analyses collectively reveal a complex interplay between environmental seasonality, operational costs, and market responses in the coastal fisheries of

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Karnataka. District-level contrasts show that while Udupi leads in post-pandemic recovery and capacity expansion, Dakshina Kannada remains highly sensitive to both climatic and market shocks, and Uttara Kannada maintains stability at lower intensity. These differences underscore how localised ecosystem dynamics and fleet structures drive varying resilience and productivity across the region.

Dakshina Kannada saw the strongest storm surges in 2024, while Udupi and Uttara Kannada suffered the greatest wind damage. Casualties occurred in every district, more than 1,000 people were injured in total, and fishing households recorded substantial income losses as boats and nets were damaged across all three districts. Access to essentials was strained: transport networks were disrupted, and there were widespread shortages of electricity and fuel, although food insecurity was comparatively limited because of relief deliveries (ICAR, 2024). The strong positive correlations between catch, price, and fuel costs suggest a cyclical relationship; when fuel prices rise, fishing effort and operational costs increase, often followed by higher market prices to offset expenditures. However, the weaker catch-price relationship in Uttara Kannada implies that external market factors and fuel dependency play a stronger role there than catch volume itself. Such interdependencies highlight the economic vulnerability of coastal fisheries to fuel price fluctuations.

A 61-day uniform fishing ban during the monsoon season in the EEZ to allow fish stocks to replenish (PIB, 2025). Seasonal visualisation for Udupi further demonstrates predictable monsoon-induced troughs (June–July) and post-ban rebounds (August–October), consistent with resource recovery and renewed fleet activity. The 2023–24 record October spike, followed by a decline, reflects overfishing tendencies and rapid exploitation of small pelagic aggregations immediately after the ban. This boom-bust pattern emphasises the need for adaptive management and regulated effort to sustain long-term productivity (Piroddi et al., 2017).

Forecasting outcomes from the Prophet model (Samal et al., 2019) reveals a favourable medium-term trajectory, with catches projected to rise by nearly 58% and prices recovering after a brief dip. The model's 95% confidence intervals capture realistic uncertainty, underscoring that early-year variability (2024–26) remains high due to climatic and market volatility. Integrating these projections with district-level insights suggests that Udupi may continue to drive regional growth, but sustainable outcomes depend on monitoring catch-per-unit-effort (CPUE), managing post-ban surges, and cushioning fuel-related cost shocks. Overall, the study highlights the importance of coupling economic forecasting with ecological prudence to ensure resilience in Karnataka's coastal fisheries.

Conclusion

The study highlights the intricate relationship between environmental variability, operational costs, and market forces shaping the marine fisheries of Coastal Karnataka. By integrating catch, price, and fuel data across Dakshina Kannada, Udupi, and Uttara Kannada, the analysis revealed strong correlations between production and pricing trends, underscoring how fuel fluctuations and climatic disruptions directly influence fishing activity and market outcomes. Udupi emerged as the most dynamic district, demonstrating robust post-pandemic recovery and fleet expansion, while Dakshina Kannada displayed the highest volatility, and Uttara Kannada maintained steady but slower growth. The Prophet model, with its ability to handle multiple seasonality components and irregular events, proved particularly effective in forecasting fisheries data compared to ARIMA and SARIMA. It captured both short-term fluctuations and long-term growth trajectories with transparent uncertainty intervals, projecting a steady increase in catch and gradual recovery in real fish prices over the next five years. These forecasts provide critical insights for sustainable policy planning, including fuel subsidy management, fleet regulation, and market stabilisation measures. Importantly, the study emphasises that economic planning in the fisheries sector must integrate ecological considerations such as seasonal bans, post-monsoon recruitment, and environmental shocks like cyclones. Ultimately, the findings reinforce that predictive modelling using Prophet can serve as a reliable decision-support tool for fisheries management and resilience planning in Karnataka's coastal economy.

Scope for Further Study

Future research can expand upon this study by incorporating a wider range of environmental, economic, and policy variables to enhance the accuracy and applicability of fisheries forecasting in Coastal Karnataka. Integrating real-time satellite data such as sea surface temperature, chlorophyll concentration, and ocean current patterns could improve the predictive power of catch models.

Economically, the inclusion of demand elasticity, export trends, and subsidy structures could refine price projections and reveal the economic resilience of coastal markets. The integration of machine learning and hybrid deep learning models could also be explored to capture non-linear interactions between biological and market factors.

To align forecasts with operational reality, outcomes should be effort-standardised (CPUE) using each district's fleet mix (boat class, gear, engine HP, trip days). Given that Udupi and Uttara Kannada currently have zero deep-sea vessels, a phased expansion of offshore/deep-sea boats can diversify target species and reduce pressure on nearshore small pelagic right after the monsoon ban.

Finally, expanding the analysis to include socioeconomic dimensions, such as employment, gender roles, and fisher community livelihoods, would provide a holistic understanding of how environmental variability and market changes affect local well-being. Such interdisciplinary approaches can strengthen policy interventions aimed at achieving sustainable fisheries management, income stability, and climate resilience in India's coastal economy.

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