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Application of Artificial Intelligence to Enhance Price Cointegration and Price Behaviour among Coastal Fishers in Maharashtra

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Price instability is a major marketing challenge for coastal fishers because marine fish landings fluctuate with season, weather, fishing effort, species availability and market demand. Price differences between landing centres, wholesale markets and retail markets can also create unequal bargaining power for fishers. Maharashtra, with its diverse landing centres and active marine fishery, provides an important setting for applying data-driven price analysis. This article proposes an Artificial Intelligence (AI)-enabled framework to study price behaviour and strengthen price cointegration across fish markets. The approach combines daily landing and auction prices, species-wise quantity, market location, weather and seasonal variables with machine-learning and econometric techniques such as stationarity testing, cointegration analysis, price transmission and anomaly detection. The proposed system can generate fisher-friendly advisories on expected price direction, unusual price gaps and alternative market opportunities. AI is positioned as decision support, not price control. Its practical value lies in improving information symmetry, collective marketing and bargaining capacity while retaining transparent human verification.

Keywords: Artificial Intelligence; Price Cointegration; Price Behaviour; Coastal Fisheries; Fish Markets; Price Transmission; Maharashtra; Market Intelligence

Introduction

Marine fisheries operate under biological and economic uncertainty. The quantity landed at a fishing harbour can change substantially from one day to another, while the same species may receive different prices at the landing centre, wholesale market and retail market. Fish are highly perishable, so fishers have limited ability to hold inventory while waiting for a better price. Consequently, a fisher may accept the prevailing auction price even when a better net return is available in another market. Maharashtra is an important marine-fishing state on India's west coast. ICAR-Central Marine Fisheries Research Institute (CMFRI) estimated Maharashtra's marine fish landings at 310,777 tonnes in 2024. Its 2025 assessment reported an 18% increase over 2024, illustrating substantial year-to-year variation in supply. Such changes can influence market prices and the relationship between markets.

Price cointegration describes a long-run relationship between prices in different markets. If two markets are cointegrated, temporary differences may occur, but prices tend to move together over time because of trade, substitution, transport and information flows. For fishers, the practical question is whether price changes at one market are transmitted to another market quickly and fairly after accounting for marketing costs. The objective of this article is to develop a practical AI-based framework for identifying price behaviour, measuring market integration and converting the analysis into simple advisories for coastal fishing communities in Maharashtra.

Why Price Cointegration Matters

A fisher's realized price is influenced by species, size grade, freshness, quantity, landing time, auction competition, buyer concentration, transport cost and destination market. A price difference between two markets is not necessarily evidence of unfair trade because transport, icing, handling and commission costs may explain part of the spread. The management challenge is therefore to distinguish a justified marketing margin from a persistent or abnormal price gap. CMFRI already provides near-real-time estimates of selected fish landings and auction price ranges at major harbours, while its historical database contains species-wise, gear-wise and quarter-wise landing information. A Maharashtra market study covering 22 markets also examined fish trade and price realization. These resources demonstrate the value of structured market data; AI can add value by integrating them with cooperative-level transaction records.

Proposed AI-Based Methodology

Data Collection and Standardisation

A pilot should begin with selected landing centres representing northern, central and southern Maharashtra. For each selected species, the cooperative should record date, landing centre, auction price, quantity landed, grade or size, fishing gear, active boats, destination market, transport cost and final selling price. Where available, weather, sea conditions and fishing-ban information should also be linked. Prices should be recorded in rupees per kilogram and quantities in consistent units. The database should distinguish observed prices from estimated prices. Missing dates, duplicate entries and unusual values should be flagged before analysis. A common data dictionary is essential because AI cannot correct systematic errors created during field data entry.

Measuring Price Behaviour

The first analytical layer describes daily and weekly price behaviour. Moving averages can smooth short-term noise, while volatility can be measured using standard deviation or coefficient of variation. AI-based anomaly detection can identify an unusually large price fall or rise relative to recent observations. For example, an alert may be generated when the landing-centre price of a species falls sharply while comparable markets remain stable.

Testing Price Cointegration and Transmission

The econometric component should first test whether price series are stationary. Augmented Dickey-Fuller or comparable tests may be used. Where appropriate, long-run relationships can then be examined using the Engle-Granger or Johansen cointegration approach. A Vector Error Correction Model (VECM) can distinguish short-run price movements from adjustment towards a long-run equilibrium. AI can complement, rather than replace, these econometric methods. Machine-learning models can identify nonlinear relationships among landing quantity, market price, weather, season and destination. The combined system can estimate the probability of a short-term price increase, decrease or stable movement. Model performance should be tested on data not used for training.

Fisher-Friendly Price Intelligence

The final output should be simple rather than a complicated statistical report. A mobile dashboard or cooperative message can display today's observed price, recent trend, price gap between selected markets, estimated transport-adjusted price, an abnormal-gap alert and the main factors associated with the change. Forecasts must be clearly labelled as estimates and not guaranteed prices.

Field-Ready AI Workflow

Table 1. Proposed field workflow for AI-assisted price intelligence for coastal fishing cooperatives.

Step	Field information	AI / analytical function	Fisher-level output
1. Record	Landing, auction price, quantity and grade	Validation and cleaning	Reliable price series
2. Compare	Landing, wholesale and retail prices	Price-gap analysis	Market spread alert

Step	Field information	AI / analytical function	Fisher-level output
3. Analyse	Historical prices and seasonal factors	Volatility and anomaly detection	Price behaviour indicator
4. Integrate	Multiple market price series	Cointegration and transmission tests	Market integration status
5. Forecast	Recent price, landings, season and weather	Machine-learning prediction	Short-term price direction
6. Act	Forecast plus transport and ice cost	Decision rule	Collective sale option

Core Findings and Practical Applications

The proposed framework leads to five practical findings. First, price information should be treated as a time series rather than as isolated daily quotations. A single high price may occur during a temporary supply shortage. Second, market integration should be evaluated after accounting for transport, icing, handling and commission costs. Third, persistent unexplained price gaps can be prioritised for field investigation rather than immediately attributed to trader behaviour. Fourth, the most useful AI output for fishers is an actionable alert—such as a significant market-price divergence—not a complex statistical score. Fifth, cooperative-level transaction data can improve relevance because members can report actual prices rather than relying only on broad market averages. A particularly useful application is collective marketing. If the system indicates that a species consistently receives a better net price at an alternative market, the cooperative can assess whether pooled quantity will offset additional transport and ice costs. When AI identifies a likely oversupply period, fishers can be advised to improve grading, icing and destination planning rather than assuming that the landing-centre price alone represents the best return. The approach can also support fisheries administration. Aggregated price and landing trends can identify markets where information flow is weak, where price volatility is unusually high or where ice, cold storage and transport may strongly influence fisher realization. This can help target extension services and market infrastructure.

Implementation in Maharashtra

A pilot can be organised through fishing cooperative societies at selected landing centres. Phase I should establish a common digital price register and train data collectors. Phase II should link landing and price records with public market information. Phase III should develop cointegration and forecasting models using sufficiently long, validated time series. Phase IV should introduce a fisher-facing advisory through a mobile dashboard or messaging platform. The system should be bilingual, using Marathi for fisher-facing messages and English for technical reporting. A fisheries officer or designated cooperative representative should verify abnormal observations before an advisory is circulated. Models should be periodically reviewed because market relationships can change with infrastructure, regulations, fishing patterns, consumer demand and climate variability.

Limitations and Ethical Safeguards

AI cannot create reliable market intelligence from poor or incomplete data. Price records must therefore be time-stamped, species-specific and linked to a clearly defined market level. Forecasts may fail during extreme weather, sudden fishing restrictions or unusual market disruptions. The system should never be used to fix prices or facilitate anti-competitive behaviour. Individual transaction data should be protected, while aggregated indicators may be shared for cooperative planning. The system should improve information symmetry without creating dependence on an opaque algorithm. Important advisories should show the data period, market comparison and principal factors used. Human review should remain mandatory for operational or policy decisions.

Conclusion and Takeaway

AI can make price analysis more useful to coastal fishers when it is connected to real landing-centre data and translated into simple market decisions. For Maharashtra, the combination of digital price recording, econometric cointegration analysis, machine-learning forecasting and cooperative market intelligence offers a practical pathway to understand how prices move across markets. The objective should not be to predict every price correctly, but to identify meaningful trends, abnormal market gaps and opportunities for collective marketing. A carefully designed pilot with validated data, transparent algorithms, Marathi advisories and fisheries-department supervision can strengthen fisher bargaining capacity and support more efficient fish marketing. Future research should test the framework using species-specific price series from Maharashtra and measure whether better information improves net price realization after marketing costs.

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