

FRESHWATER FISH DEMAND TREND AND ITS ELASTICITY: A CASE STUDY OF SOUTH SUMATRA, INDONESIA

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Abstract: South Sumatra's growing population, alongside increasing public awareness of the health benefits of fish consumption, has raised the need for demand projections. This study estimates the demand for freshwater fish in South Sumatra up to 2035 and analyses the price elasticity of fish relative to other animal protein sources. Demand projections were generated using predictive analysis, while elasticity was assessed as a function of commodity prices, prices of substitute goods, and income. The findings indicated a steady rise in the demand for freshwater fish through 2035. Pangasius (0.51), catfish (1.73), and tilapia (1.62) are classified as elastic and substitute goods while carp (-0.24) is inelastic and functions as a complement. Pangasius, catfish, and tilapia are the most frequently consumed fish species, largely due to their role as staple ingredients in household meals and food stalls. Income elasticity estimates suggest that price fluctuations have little effect on demand for these species. These results provide useful insights for policymakers in planning strategies to meet future freshwater fish demand in South Sumatra.

Keywords: Fish consumption, fisheries, Holt Double Exponential Smoothing, price response, time series forecasting.

Introduction

In developing countries, including Indonesia, the demand for farmed fish is on the rise. This demand is driven by several factors such as increasing incomes, urbanisation, and declining supplies of captured fish. It is projected that by 2030, aquaculture will contribute 62% to global fish demand (Ahmad *et al.*, 2021). The fisheries production sector positively impacts employment in developing countries (Nasr-Allah *et al.*, 2020). Strengthening the fisheries sector, particularly when integrated with other agricultural sectors has been shown to contribute to national economic growth (Victor *et al.*, 2018).

The high nutritional value of fish has contributed to a global increase in fish consumption. However, the world's fish populations face threats from human population growth and changes in resource use (Gordon *et al.*, 2018). In 2023, the global fish consumption

rate is expected to remain at 20.6 kg per capita, the same as in 2022 (FAO, 2023). In Indonesia, the consumption of food derived from both inland and marine waters continues to rise annually. The national fish consumption index for 2020, 2021, and 2022 was 54.56 kg, 55.16 kg, and 57.27 kg per capita per year, respectively (Ministry of Marine Affairs and Fisheries Statistics, 2023). This increasing trend in fish consumption must be addressed with sufficient fish stocks to ensure that people can access quality fish at affordable prices (Susanto *et al.*, 2020).

The water areas in South Sumatra, Indonesia, primarily consist of public lands, including swamps, lowlands, and rivers. According to data from the South Sumatra Central Bureau of Statistics (2024), four main types of freshwater fish commodities are found in the region: Pangasius, catfish, tilapia, and carp. As the

population grows, so too does the demand for animal protein derived from fish. A significant factor contributing to the high fish consumption in South Sumatra is the presence of local specialties such as *pempek*, *pindang*, and *ikan salai*, which all use fish as a primary ingredient, along with a consistent supply of fish. Data from the Ministry of Marine Affairs and Fisheries (2024) indicates that fish consumption rates in South Sumatra have increased annually from 2013 to 2019. However, during the pandemic in 2020, there was a decline in fish consumption, which rebounded in 2021, slightly decreased in 2022, and then increased again in 2023.

The demand for freshwater fish consumption in Indonesia is expected to continue rising in line with the growing population and increasing public awareness of the importance of animal protein. Unfortunately, this rising demand for freshwater fish is not matched by an increase in production, resulting in an insufficient supply. Research by Tran *et al.* (2017) analysed the demand and supply of fish in Indonesia until 2030 and the role of aquaculture using the AsiaFish model. The scenario analysis indicated that the supply and demand for fish in Indonesia will begin to rise from 2012 to 2030, with aquaculture projected to become a major supplier of fish around 2026.

To maintain stability between production and consumption, forecasting can be utilised to project future demand, which determines the required volume of fish to be consumed. Accurate demand forecasting can support the identification of this need (Jefri & Shaadan, 2024). Forecasting relies on historical data and information (Khairina *et al.*, 2021) and can encourage fish farmers to produce in order to meet consumer demand (Sari *et al.*, 2024). It is predicted that the aquaculture sector will surpass the capture fisheries sector as the primary source of fish-based animal food in Indonesia before 2030. Achieving balance between production and consumption is essential for sustainable long-term development (Seda *et al.*, 2021).

Therefore, the sustainability of fish product supply and consumption in the country warrants deeper study to ensure that the demand for animal protein from fish for domestic consumers and overall food security remains stable.

Price and income elasticities are crucial parameters in analysing fish demand (Koeshendrajana *et al.*, 2021). Demand elasticity plays a significant role in price policy analysis, pricing, and marketing planning (Saptho *et al.*, 2024). The concept of elasticity is employed to assess the magnitude of changes in fish demand (Yusela, 2019). Many previous studies have treated fish as a homogeneous commodity, despite the existence of various types of fish with differing attributes (Firmansyah *et al.*, 2020; Shankar Kumar *et al.*, 2021; Aung *et al.*, 2022).

In recent decades, research on fish consumption patterns globally has revealed a negative relationship between the preferences of younger consumers and fish consumption, with fish-based menus becoming less desirable. It is thus pertinent to investigate how the current pattern of fish consumption in South Sumatra is associated with future trends and its sensitivity (elasticity).

This study is the first to analyse the demand for four types of freshwater fish in South Sumatra using secondary data. The article aims to estimate the demand for freshwater fish (pangasius, catfish, tilapia, and carp) in South Sumatra through to 2035, along with the price elasticity of these fish relative to other animal proteins as alternative food sources. The findings of this study are crucial as they provide an overview and estimation of freshwater fish demand, as well as insights into consumption behaviour regarding fish and its substitutes. This information can assist policymakers in designing strategies that not only meet the needs of local communities but also open export opportunities beyond the region, thereby supporting food security and sustainability, particularly in aquaculture fishery products.

Materials and Methods

Research Design and Data Collection

This research was conducted in Palembang City, South Sumatra Province, Indonesia. The research location was selected by gathering time series data for 2000-2022 from the Ministry of Fisheries and Maritime Affairs, the Fisheries and Maritime Affairs Office of South Sumatra Province, and the Central Bureau of Statistics of South Sumatra Province.

Secondary data sources were carefully considered to support the research objectives. The fish species under study were chosen based on the dominant freshwater fish production data published by the South Sumatra Statistics Agency, specifically pangasius, catfish, tilapia, and carp. The variables used to measure price elasticity, cross elasticity, and income elasticity include the consumption rates of freshwater fish, prices of freshwater fish, chicken meat, beef, eggs, sea fish, and per capita income. Projections of demand for freshwater fish in South Sumatra were made using trend/predictive analysis, an analytical method designed to estimate or forecast future outcomes.

Variables and Data Sources

This study employs regression analysis to assess the demand elasticity for freshwater fish using the Excel 2019 programme. Additionally, forecasting is conducted through the Double Smoothing Method (Holt) with the R Studio 4.3.3 application. The analysis utilises a time series dataset comprising 23 years of annual data, spanning from 2000 to 2022. This data was sourced from the Ministry of Fisheries and Maritime Affairs, the South Sumatra Provincial Fisheries and Maritime Affairs Office, and the Central Bureau of Statistics of South Sumatra Province. The fish demand data is secondary information processed from various variables related to fish demand in South Sumatra.

Data Analysis

The elasticity value can be assessed through three types of demand models, as outlined by Yusela (2019):

Price Elasticity

The degree of price elasticity can be determined using the following formula:

$$Ep = \frac{\% \Delta Qx}{\% \Delta Px} \quad (1)$$

where

- Ep : Price elasticity
- Px : Price of item X
- ΔQx : Change in quantity of X
- ΔPx : Change in the price of good

Cross Elasticity

The degree of cross-elasticity can be determined using the formula:

$$Ec = \frac{\% \Delta Qx}{\% \Delta Py} \quad (2)$$

where

- Ec : Cross elasticity
- Py : Price of good
- Qx : Quantity of good
- ΔQx : Change in quantity demanded of good X
- ΔPy : Change in price of goods Y

Income Elasticity

The level of income elasticity can be determined using the following formula:

$$Ei = \frac{\% \Delta Qx}{\% \Delta I} \quad (3)$$

where

- Ei : Income elasticity
- I : Consumer income
- Qx : Number of X items requested
- ΔQx : Change in quantity demanded of good X
- ΔI : Change in consumer income

Exponential smoothing is one of the most widely used methods in time series analysis, valued for its simplicity, computational efficiency, predictive capabilities, and reasonable accuracy (Montgomery *et al.*, 2008). The Double Exponential Smoothing (DES) method is specifically employed when the data exhibits a trend. Within DES, there are two approaches: Brown DES and Holt DES (Febrian *et al.*, 2020). Holt's method is applied when demand is influenced by trends but not

by seasonality. The Holt method, also known as Holt’s linear exponential smoothing (HDES) method is particularly suitable for trend data (Booranawong & Booranawong, 2018).

To predict the demand in the next period, we need to know the new estimated refinement rate/value and estimate the trend. Below is the formula for the HDES method:

$$Lt = \alpha Yt + (1 - \alpha)(F_{t-1} + T_{t-1}) \tag{4}$$

$$Tt = \beta(Ft - F_{t-1}) + (1 - \beta)T_{t-1} \tag{5}$$

$$\widehat{Yt} = Lt + T_{t-1} \tag{6}$$

where

- Lt : Exponential smoothing value
- Tt : Period t trend smoothing
- : Period t-1 trend smoothing
- Ft : Forecast for time period t
- F_{t-1} : Forecast for the previous period
- α : Level smoothing constant (0 < α < 1)
- β : Trend smoothing constant (0 < β < 1)
- Yt : Actual value of period t
- Ŷt : Predicted value of period t

The HDES method is used to predict future product demand based on time series data. This method can significantly reduce forecasting errors. There are two main types of double exponential smoothing: The Holt and Brown methods, both of which are typically applied to trend-patterned data. The key distinction between the two lies in the smoothing parameters employed in their calculations. The Brown method is often referred to as the one-parameter linear method while the Holt method is known as the two-parameter method. The Holt method is generally regarded as more accurate, as it yields a smaller Mean Squared Error (MSE) value (Fauziah & Gunaryati, 2017).

In forecasting using the Holt DES method, both alpha (α) and beta (β) parameters are tested simultaneously. The constant α is used to smooth the overall data while β smooths the trend value (Alfinatuzzahro *et al.*, 2024). The values of α and β in Holt DES are selected to minimise the Mean Absolute Percentage Error (MAPE) (Santosa *et al.*, 2024). When data processing is performed using Microsoft Excel, the selection

of alpha and beta values is done through trial and error (Febrian *et al.*, 2020). In contrast, forecasting with the Holt method using the R Studio application automatically identifies the most accurate pair of alpha and beta parameters that yield the smallest MAPE value, which is a notable advantage of R Studio.

The accuracy of forecasting results obtained through the double exponential smoothing method is highly reliant on the chosen smoothing constants. The selected values for the smoothing constants (Alpha and Beta) are those that minimise forecasting error, as assessed by the Mean Squared Error (MSE), Root Mean Squared Error (RMSE), and MAPE criteria. The equations for calculating MSE, RSME, and MAPE are outlined in the works of Maulana and Mulyantika (2020), Dharmawan and Indradewi (2021), Pamungkas *et al.* (2021), and Syafwan *et al.* (2021). In more detail for the MAPE value category can be seen in Table 1.

$$MSE = \frac{\sum_{t=1}^n (Xt - \widehat{Xt})^2}{n} \tag{7}$$

$$RSME = \sqrt{\frac{1}{n} \sum_{t=1}^n (Xt - \widehat{Xt})^2} \tag{8}$$

$$MAPE = \frac{\sum_{t=1}^n \left| \frac{Xt - \widehat{Xt}}{Xt} \right|}{n} \times 100 \tag{9}$$

where

- MSE : Mean Square Error
- RMSE : Root Mean Squared Error
- MAPE : Mean Absolute Percent Error
- n : number of samples
- t : forecasting time
- Xt : actual value
- Ŷt : forecast value

Results and Discussion

Agricultural products often experience instability due to an imbalance between supply and demand (Basnayake *et al.*, 2022). Demand is influenced by both the level of consumption and the population in a region; it tends to rise as the population or the number of individuals needing the product, increases. The fish consumption rate represents the public’s consumption of

Table 1: MAPE value criteria

No.	MAPE Value	Criteria
1.	< 10%	Very good
2.	10% - 20%	Good
3.	20% - 50%	Good enough
4.	> 50%	Bad

Source: Febrian et al. (2020)

fish commodities, measured in kg per capita per year (Ermasari et al., 2022). This level of fish consumption varies across different regions (Djunaidah, 2017). Previous studies by Septiadi and Joka (2019) and Sujiono et al. (2021) indicate that the population variable significantly impacts product demand. Population growth is a key driver of per capita consumption growth, which in turn influences food demand growth (Fukase & Martin, 2020). Fish and its derivative products offer extensive research opportunities and play a crucial role in meeting nutritional needs and strengthening the economy of a country (Hossain & Shikha, 2021).

This study utilises time series data from four freshwater fish species in South Sumatra: Pangasius, catfish, tilapia, and carp, covering the period from 2000 to 2022, as illustrated in Figure 1.

Based on data from 2000 to 2022, the demand for freshwater fish in South Sumatra

fluctuates annually. Pangasius is the most consumed type of fish, primarily because it serves as a key ingredient in local South Sumatra specialties such as *pindang*, *ikan salai*, and *brengek*. Catfish and tilapia are also highly sought after by consumers in various regions of South Sumatra (Suryati, 2023; Sakina & A. Haidar Mirza, 2024). In contrast, the demand for carp in South Sumatra is minimal, as its processing is largely limited to frying. This is different from North Sumatra, where carp is a staple ingredient in traditional events (Sari et al., 2023). South Sumatra exceeds the national calorie consumption adequacy standard (Maiyanti et al., 2024).

In 2017, the consumption of pangasius and tilapia rose compared to the previous year, and there was a significant increase in catfish consumption in 2021. Notably, carp consumption peaked in 2015. These variations in consumption rates can be attributed to

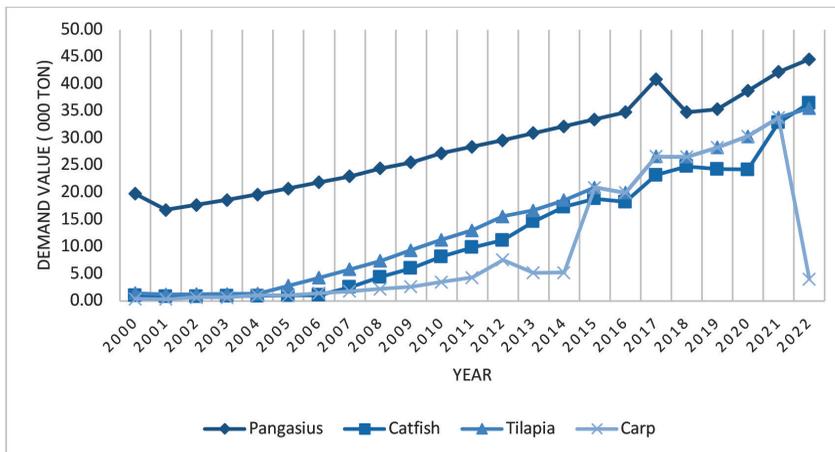


Figure 1: Actual demand for freshwater fish in South Sumatra

differences in consumer preferences and the frequency of consumption for certain types of fish (Temesi *et al.*, 2020). Population growth contributes to increased food demand (Rusli *et al.*, 2024). Other studies, such as those by Haque *et al.* (2019) identify additional factors influencing increased fish consumption, including age, education level, gender, annual income, and religious beliefs. Moreover, rising awareness of the health benefits of fish, the appealing taste of fishery products, and price factors also play a role (Rahman & Islam, 2020; Widiastuti & Arthatian, 2020).

The fisheries sector has not been immune to the impacts of the COVID-19 pandemic, which has affected all parts of the world. During the pandemic, production and consumption activities were delayed, yet Indonesia’s agricultural commodity exports showed positive

growth, driven by increased demand from other countries for Indonesian farmers’ products (Siregar *et al.*, 2024). The recovery of global fish production in 2021 is anticipated to continue, bolstered by a surge in demand for fish. As the world gradually recovers from the COVID-19 pandemic, the dynamics of the fisheries sector are returning to normal, although not entirely. According to FAO data (2022), the aquaculture sector experienced a growth of 2.9% in 2022.

Forecasting models have been developed for the next ten years. Using freshwater fish demand data from South Sumatra for 2000 to 2022, the smoothing method (Holt DES) generates predictions extending to 2035. Table 2 presents the forecasted values for freshwater fish demand in South Sumatra until 2035, along with 80% and 95% confidence limits, as calculated using the R Studio application.

Table 2: Predicted demand for freshwater fish in South Sumatra (kg/year)

Pangasius					
Year	F	Lo 80	Hi 80	Lo 95	Hi 95
2023	43,526,399	40,521,124	46,531,674	38,930,227	48,122,570
2024	44,316,699	41,025,800	47,607,598	39,283,704	49,349,695
2025	45,091,194	41,537,445	48,644,942	39,656,204	50,526,183
2026	45,850,198	42,051,646	49,648,750	40,040,814	51,659,582
2027	46,594,023	42,565,423	50,622,622	40,432,812	52,755,233
2028	47,322,971	43,076,683	51,569,258	40,828,835	53,817,107
2029	48,037,340	43,583,912	52,490,767	41,226,410	54,848,269
2030	48,737,421	44,085,994	53,388,848	41,623,678	55,851,165
2031	49,423,501	44,582,095	54,264,908	42,019,209	56,827,794
2032	50,095,860	45,071,585	55,120,134	42,411,894	57,779,825
2033	50,754,771	45,553,991	55,955,551	42,800,864	58,708,678
2034	51,400,504	46,028,955	56,772,053	43,185,428	59,615,580
2035	52,033,322	46,496,211	57,570,433	43,565,041	60,501,603
Catfish					
Year	F	Lo 80	Hi 80	Lo 95	Hi 95
2023	39,041,547	35,991,122	42,091,971	34,376,325	43,706,768
2024	41,568,358	36,844,958	46,291,757	34,344,541	48,792,174
2025	44,044,632	37,756,204	50,333,060	34,427,311	53,661,953
2026	46,471,381	38,629,284	54,313,478	34,477,929	58,464,833
2027	48,849,595	39,435,127	58,264,063	34,451,409	63,247,781

2028	51,180,245	40,163,274	62,197,215	34,331,243	68,029,247
2029	53,464,281	40,810,377	66,118,185	34,111,805	72,816,757
2030	55,702,637	41,376,246	70,029,028	33,792,313	77,612,961
2031	57,896,226	41,862,209	73,930,243	33,374,313	82,418,138
2032	60,045,943	42,270,343	77,821,542	32,860,509	87,231,376
2033	62,152,665	42,603,090	81,702,240	32,254,170	92,051,160
2034	64,217,253	42,863,046	85,571,460	31,558,812	96,875,694
2035	66,240,549	43,052,849	89,428,249	30,778,022	101,703,077

Tilapia

Year	F	Lo 80	Hi 80	Lo 95	Hi 95
2023	37,634,561	35,549,315	39,719,808	34,445,452	40,823,670
2024	39,786,925	37,138,740	42,435,110	35,736,875	43,836,975
2025	41,896,241	38,517,819	45,274,664	36,729,390	47,063,092
2026	43,963,371	39,728,225	48,198,518	37,486,274	50,440,469
2027	45,989,159	40,798,556	51,179,762	38,050,816	53,927,501
2028	47,974,430	41,747,914	54,200,946	38,451,796	57,497,064
2029	49,919,996	42,589,659	57,250,334	38,709,212	61,130,780
2030	51,826,651	43,333,695	60,319,607	38,837,795	64,815,506
2031	53,695,172	43,987,768	63,402,577	38,848,979	68,541,366
2032	55,526,324	44,558,198	66,494,449	38,752,023	72,300,624
2033	57,320,852	45,050,314	69,591,389	38,554,684	76,087,020
2034	59,079,489	45,468,724	72,690,254	38,263,621	79,895,357
2035	60,802,954	45,817,493	75,788,415	37,884,668	83,721,239

Carp

Year	F	Lo 80	Hi 80	Lo 95	Hi 95
2023	11,311,458	283,574	22,339,342	-5,554,235	28,177,151
2024	11,478,246	-2,343,153.7	25,299,646	-9,659,761	32,616,253
2025	11,641,699	-4,497,249.5	27,780,647	-13,040,693	36,324,090
2026	11,801,882	-6,361,750.1	29,965,514	-15,976,996	39,580,760
2027	11,958,861	-8,025,792.4	31,943,515	-18,605,029	42,522,752
2028	12,112,701	-9,540,748.6	33,766,151	-21,003,393	45,228,796
2029	12,263,465	-10,939,417.2	35,466,346	-23,222,281	47,749,210
2030	12,411,212	-12,244,244.2	37,066,669	-25,296,054	50,118,479
2031	12,556,005	-13,471,384.7	38,583,395	-27,249,453	52,361,463
2032	12,697,902	-14,632,920.6	40,028,725	-29,100,984	54,496,788
2033	12,836,961	-15,738,164.0	41,412,086	-30,864,921	56,538,843
2034	12,973,239	-16,794,469.0	42,740,946	-32,552,542	58,499,019
2035	13,106,791	-17,807,761.4	44,021,343	-34,172,937	60,386,518

(F: Point Forecast); Lo 80 and Hi 80 are (respectively) the lower and higher bounds of predictive interval for an error term $\alpha = 0.2$; Lo 95 and Hi 95 are (respectively) the lower and higher bounds of predictive interval for an error term $\alpha = 0.05$.

Figure 2 shows the predicted demand for aquatic fish in South Sumatra. Table 3 shows the parameter values (α and β) generated by Holt DES with the smallest MAPE value.

After obtaining the forecasting results for each alpha and beta, an evaluation calculation process is conducted using three accuracy methods: Mean Square Error (MSE), Root Mean Square Error (RMSE), and Mean Absolute Percentage Error (MAPE), as shown in Table 4.

Figure 2 graphically illustrates the projected demand for freshwater fish (pangasius, catfish, tilapia, and carp) in South Sumatra over the next

10 years, using R software. Figure 3 visualises the potential deviations in the predicted demand for these four fish species. The dark blue shading represents a forecasting confidence interval of 80% while the light blue shading indicates a confidence interval of 95%.

Demand elasticity refers to the sensitivity of demand changes in response to a 1% change in an independent variable. Compensating cross-price elasticity or elasticity of substitution measures how the demand for one commodity responds to changes in the price of another related product. If the cross-price elasticity between two products is positive, it indicates

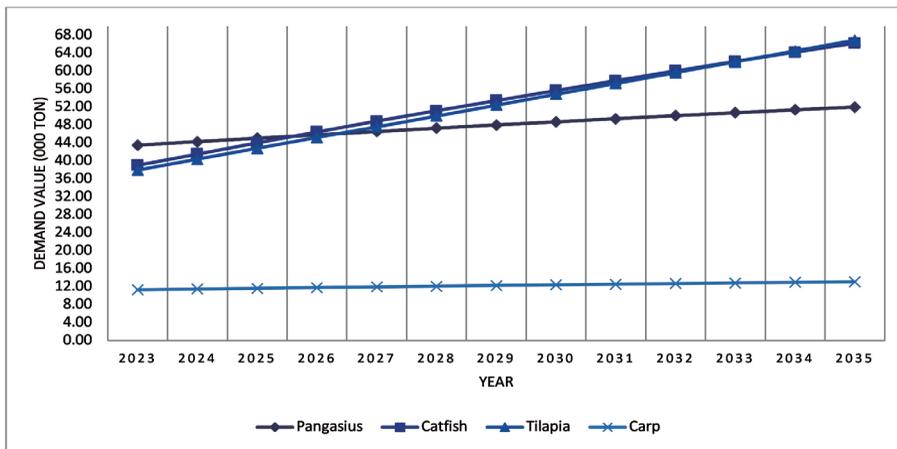


Figure 2: Predicted demand for freshwater fish in South Sumatra

Table 3: Alpha and beta parameter values on MAPE

Parameter	Types of Fish			
	Pangasius	Catfish	Tilapia	Carp
α	0.4461	0.9999	0.5551	0.7554
β	0.0001	0.1861	0.2324	0.0001

Source: Primary data processed (2024)

Table 4: Forecasting accuracy of total demand for freshwater fish in South Sumatra

Accuracy Measure	Pangasius	Catfish	Tilapia	Carp
MSE	4.30369E+12	4.43397E+12	1.69047E+12	5.101259E+13
RSME	2,074,534.00	2,105,700.00	1,300,180.00	7,612,520
MAPE (%)	5.36	26.83	11.89	53.11

Source: Primary data processed (2024)

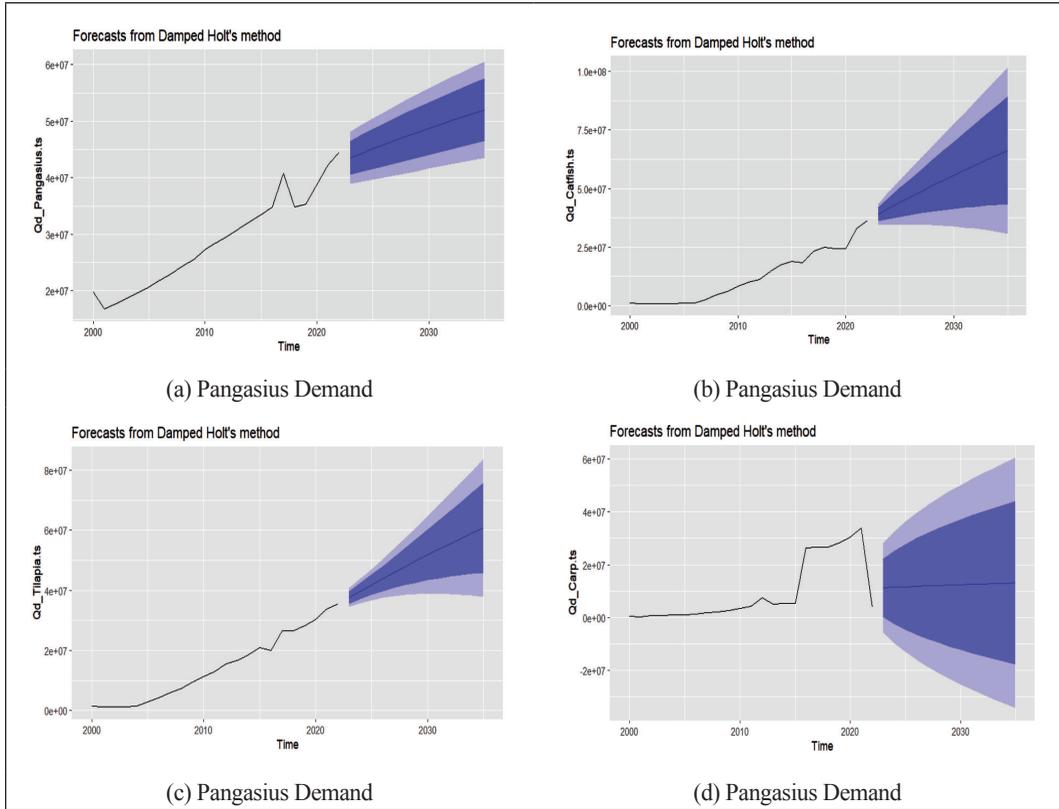


Figure 3: Plot of forecasted freshwater fish demand in South Sumatera

that the products are substitutes. Conversely, a negative cross-price elasticity suggests that the products are complementary. The results of the price elasticity analysis for freshwater fish (pangasius, catfish, tilapia, and carp) in South Sumatra are presented in Table 5.

The own-price elasticities for the four fish species (pangasius, catfish, tilapia, and carp) are 0.51, 1.73, 1.62, and -0.24, respectively. The elasticity values for pangasius and carp are less than 1, indicating that demand for these fish is

not sensitive to price changes. In contrast, the elasticity values for catfish and tilapia are greater than one, suggesting that demand for these fish is sensitive to price fluctuations. This means that changes in the prices of catfish and tilapia significantly affect the quantity demanded. For pangasius and carp, however, price changes have a minimal impact on demand. Consumer preferences for pangasius and carp are influenced by their prices while the inelastic nature of demand for these sources of animal protein can

Table 5: Price elasticity values

Demand	Price							
	Pangasius	Catfish	Tilapia	Carp	Chicken	Beef	Egg	Marine Fish
Pangasius	0.51	0.55	0.58	0.63	0.48	0.20	0.38	0.43
Catfish	1.68	1.73	1.80	1.93	1.60	1.35	1.21	0.84
Tilapia	1.45	1.54	1.62	1.73	1.19	1.02	0.85	1.17
Carp	-0.35	-0.21	-0.22	-0.24	-0.18	-0.16	-0.13	-0.15

be attributed to their classification as essential products necessary to meet consumer needs. As a result, consumers do not significantly adjust their demand in response to price changes (Wahyuni *et al.*, 2016).

As shown in Table 5, the cross-elasticity values indicate whether freshwater fish and other animal protein products are substitutes or complementary goods. The analysis reveals that consumers view pangasius, catfish, tilapia, chicken, beef, chicken eggs, and seafood as substitutes for one another. The negative elasticity for carp suggests that consumers consider carp primarily as a complementary item in fulfilling their animal protein needs. Cross-price elasticity indicates that when the price of fish rises, households will substitute other sources of animal protein such as eggs, poultry, and beef (Khoiriyah *et al.*, 2023).

During the pandemic, as seen in Bangladesh, the availability of fish species such as carp, tilapia, catfish, pangasius, and crawfish remained high, but prices for these fish increased during COVID-19. Consequently, 80% of household consumers opted for eggs as their main source of protein (Mandal *et al.*, 2021). Tilapia has also been identified as an important fish species in Egypt. Cross-price elasticities have shown that tilapia and bayad serve as substitutes for catfish (Al-Mahish *et al.*, 2021). Fish species classified as substitutes are considered superior products by consumers (Yusela, 2019).

In developing countries, particularly in Asia, studies have found high negative own-price elasticities. Most cross-price elasticities for fish species are positive, indicating a substitution relationship, although some are negative, particularly for low-value fish (Lancker & Bronnmann, 2022). In South Sumatra, pangasius, catfish, and tilapia rank as the top three in terms of production and demand.

Based on freshwater fish production and consumption data in South Sumatra from 2000 to 2022, catfish, pangasius, tilapia, and carp are produced in the largest quantities, in that order. The average consumption levels among the people of South Sumatra are highest for pangasius (3.73 kg/capita/year), followed by tilapia (1.80 kg/capita/year), catfish (1.51 kg/capita/year), and carp (1.32 kg/capita/year). Pangasius is widely consumed in local specialties such as *Pindang*, *Brengkes*, and *Ikan Salai*. Catfish and tilapia are commonly featured in household meals and restaurant dishes.

In provinces outside South Sumatra such as Bengkulu, fish is the most elastic animal food, with a demand elasticity of 4.44%. This is followed by beef (2.78%), milk (1.94%), broiler chicken meat (1.54%), and eggs (0.82%). Fish serves as a substitute for beef, chicken, and eggs when prices rise, but complements milk (Khoiriyah *et al.*, 2023). Research by Al-Mahish *et al.* (2021) concluded that fish demand in Egypt is price inelastic, indicating that price changes have little impact on the demand for fish.

Consumption patterns of fish are largely shaped by consumer habits and traditions. To boost demand and increase fish consumption in diets, it is essential to promote the nutritional and health benefits of fish (Jalić *et al.*, 2022). With rising population density and growing awareness of the health benefits of fish, an increase in fish consumption is anticipated in the future (Shankar Kumar *et al.*, 2021). Previous research by Faharuddin *et al.* (2015) on the consumption patterns of the people of South Sumatra found that household food consumption is more elastic to changes in income than to changes in food commodity prices. The results of this study indicate a shift in food consumption patterns over the past decade, with price elasticity now being greater than income elasticity.

Table 6: Income elasticity of demand for freshwater fish in South Sumatra

Variable	Demand			
	Pangasius	Catfish	Tilapia	Carp
Income elasticity	0.31	1.01	0.87	-0.12

In line with Supartini *et al.* (2018), the primary factor influencing the increase in fish demand is price. Stable fish prices and a consistent supply will encourage consumers to enhance their consumption (Fiandari *et al.*, 2019).

An elasticity value of less than one (inelastic) indicates that the demand for these commodities is a basic need, increasing at a rate that is less than the proportionate increase in income. Generally, as income rises, the elasticity of demand for animal food commodities diminishes (Suryana *et al.*, 2021). The positive and negative signs of income elasticity reflect the consumption preferences for goods influenced by income levels. A positive sign indicates that demand will rise with increasing income while a negative sign suggests the opposite.

Table 6 reveals that income elasticity is positive for pangasius (0.31), catfish (1.01), and tilapia (0.87), signifying that these fish types are normal goods. This finding aligns with the reports by Adah and Eleche (2017) and Jubran and Al Sawaie (2023), which also classify fish as normal goods. Notably, the elasticity value for catfish (1.01) is higher than that of the other fish species. This is consistent with Rizal *et al.* (2018), who regard catfish as a common food item that is less responsive to changes in economic factors. In contrast, the income elasticity of demand for carp (-0.12) is negative, suggesting that carp is an inferior good.

Over the past 25 years, the real price of fish in the global market has steadily increased. Nguyen and Kinnucan (2018) identified income and population growth as the main contributors to this price rise. Income is one of the key factors driving changes in fish consumption across various consumer demographics (Can *et al.*, 2015). Income growth is estimated to have raised fish prices by an average of 1.2% per year while population growth has contributed an average of 0.9% per year, resulting in a combined effect of 2.1% per year. Banda *et al.* (2024) emphasised the need for policymakers to

ensure that individuals have adequate income to budget for purchasing more fish while also preventing significant increases in fish prices.

Conclusions

Demand for freshwater fish in South Sumatra is expected to continue rising until 2035. This trend is driven by two main factors: The region's growing population and the increasing recognition of fish as an essential component of a healthy diet. The most commonly consumed fish species in South Sumatra are catfish, tilapia, and pangasius, which are prevalent in local culinary traditions and easily accessible as ingredients for various dishes found in households and food stalls.

The findings of this study indicate that the demand for pangasius, catfish, and tilapia is classified as elastic and these species are considered substitute goods. In contrast, carp is classified as inelastic and a complementary good. Consumer preferences for fish species among the people of South Sumatra have not changed significantly over the past few decades. Conversely, carp is viewed as an inferior good, as consumers do not show a tendency to increase their purchases of carp as a source of protein.

The results of this forecasting effort are expected to assist policymakers in addressing the freshwater fish needs of the population in South Sumatra, as well as identifying opportunities to increase freshwater fish farming production and boost national income. The government's role is crucial in stabilising fish prices through intervention.

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Conflict of Interest Statement

The authors declare that they have no conflict of interest.

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