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Original Article

Assessment of fish consumption behaviour and market forecasts for sustainable fisheries in Manipur, India

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Abstract
This study analysed the socio-economic characteristics, consumption behaviour and expenditure patterns of fish-consuming households in Manipur, India, using data from 450 households across six districts belonging to different social background. Secondary data (2015 – 2025) obtained from government records supported a production-requirement forecast. The regression model demonstrated a moderately strong relationship between the predictors and the dependent variable (R^2 = 0.588; adjusted R^2 = 0.581). A paired *t*-test revealed that monthly expenditure on fish alone ₹5,326.88 (~59.20 $) was much higher than other non-vegetarian foods ₹2,310.44, comprising nearly 70% of the total non-vegetarian expenses. Holt's exponential smoothing model (R^2 = 0.813, MAPE = 2.71%) projected that fish demand will exceed supply from 2024 – 2029, indicating a widening gap. The study concludes that fish holds cultural and nutritional importance in Manipur and calls for enhanced aquaculture, better market infrastructure, and improved consumer awareness for sustainable fish supply and food security.

Keywords: demographic profile; fish consumption; household expenditure; Manipur; socio-economic factors

1 | INTRODUCTION

Fish plays a vital role in Manipur's socio-economic and dietary system, serving as a key source of animal protein and an important cultural food, while the fisheries sector significantly supports livelihoods, food security and nutrition in the state (Dorothy *et al.* 2018). The consumption pattern of fish in the state is shaped by demographic and socio-economic factors such as age, family size, education, income and occupation (Adhikari *et al*. 2025). Similar demographic influences on fish consumption have been reported across several Indian states including Tripura, Assam, Karnataka and Chattisgarh. Studies from those regions consistently show that household income and family structure play a significant role in shaping fish purchasing behaviour (Upadhyay *et al*. 2014; Sen and Roy 2015; Bhuyan *et al*. 2017; Honnananda *et al*. 2022; Kumar *et al*. 2023). In particular, higher-income households tend to purchase fish more frequently, largely because of

greater economic flexibility. Likewise, families with more members often consume larger quantities of fish, indicating that both economic capacity and social consumption pattern influence overall demand.

The growing demand for fish across India, particularly in the northeast region, underscores the importance of accurate production and requirement forecasting to ensure sustainable fisheries management. Forecasting techniques such as Holt's exponential smoothing and ARIMA models have been widely applied in fisheries economics to assess production trends and demand–supply gaps, offering policymakers valuable tools for planning aquaculture and market interventions (Boruah *et al*. 2020; Singh *et al*. 2017; Paramasivam and Malaiarasan 2021). Previous studies have demonstrated that these models can reliably capture short-term trends, enabling effective projections for states with growing consumption demands. The present study therefore adopted Holt's exponential smoothing model to estimate fish production and requirement in Manipur for the period 2025 – 2030, ensuring statistical robustness through validation measures such as R^2, RMSE, and MAPE. In addition to production forecasting, understanding consumer behaviour is critical for formulating demand-oriented strategies.

Integrating these perspectives—demographic analysis, household expenditure behaviour and time series forecasting—provides a comprehensive understanding of fish consumption dynamics in Manipur. The ensuing results and discussion section presents empirical evidence on the socio-economic determinants of fish consumption, compares expenditure on fish and other non-vegetarian foods, projects future production and requirement trends and identifies the most influential market attributes shaping consumer preferences. Such evidence-based insights are essential for enhancing aquaculture production, strengthening fish marketing infrastructure and promoting sustainable fish consumption in Manipur and similar socio-economic contexts across India.

2 | METHODOLOGY

Primary data on fish consumers were gathered from August 2022 to March 2023 while secondary data for time series data covering production and requirement from 2015 to 2025 were obtained in September 2025 from the state department of fisheries. These datasets were analysed using SPSS (version 25), which supports time series modelling techniques suitable for fisheries production trends, such as exponential smoothing and ARIMA. Six districts of Manipur—Churachandpur, Imphal East, Imphal West, Senapati, Thoubal and Ukhrul—were selected to represent both hilly and plain regions based on the 2011 Census. From these districts, 450 fish consumers (75 per district) were randomly chosen. Within each district, 25 respondents were selected from three income groups: below ₹2 lakh ($2,224.17), ₹0.2 – 0.5 million ($2,224.7–$5,561.78), and above ₹0.5 million ($5,561.78). Primary data were collected using a structured and pre-tested survey schedule designed according to the study objectives.

Multiple regression analysis was employed to assess the influence of socio-economic factors, namely age, family size, education and income on fish purchasing behaviour. In this model, fish expenditure was taken as the dependent variable, while the socio-economic parameters served as independent variables. The linear regression equation used for the analysis is given as:

$$Y = \beta_0+\beta_1X_1+ \beta_2X_2+ \beta_3X_3+ \beta_4X_4$$

where, Y = Fish Expenditure; β_0 = Constant Value; β_1 = regression coefficient; X_1 = Age; X_2 = Family size; X_3 = Education and X_4 = Income (Gujarati and Porter 2009; Montgomery, Peck, and Vining 2012).

To examine the difference in household spending between fish and other non-vegetarian items, a paired sample *t*-test was employed, as both variables represented related samples from the same households. The significance of differences was tested at the 5% probability level and results were interpreted in relation to socio-economic and cultural consumption patterns of the respondents.

The trend analysis of fish production and requirement in Manipur for 2025 – 2030 period was carried out using the Holt's Exponential Smoothing method in SPSS (Version 25). This model was selected as it is appropriate for non-seasonal time series data exhibiting a consistent trend. It incorporates both level and trend components to generate reliable short-term forecasts for fisheries planning and management. The model performance was assessed using the Normalised Bayesian Information Criterion (BIC) and Ljung–Box Q (18) statistics. The normalised BIC values for production (13.613) and requirement (17.107) were found to be low, indicating a good model fit. The Ljung–Box Q (18) statistic revealed no significant autocorrelation in the residuals, confirming that the residuals were random and that the model was statistically adequate. Moreover, no outliers were detected, demonstrating the stability and consistency of the dataset used for the analysis. These results confirm that the Holt exponential smoothing model was suitable for forecasting fish production and requirement in the state for the next five years.

Secondary data on fish production, consumption, and related variables for the period 2015 – 2025 were obtained from official government records, including the Directorate of Fisheries, Government of Manipur. The production requirement gap was determined by comparing the forecasted values for each year. Model accuracy was evaluated using statistical indicators such as R^2 (coefficient of determination) likely indicates strong model fit → supporting accurate representation of production and requirement trends, RMSE (Root Mean Square Error) like-

ly remains low → confirming that deviations between observed and fitted values are minimal, and MAPE (Mean Absolute Percentage Error) likely demonstrates accurate trend estimation → validating the projected production–requirement gap and the upward forecast trends. Together, these measures strengthen the conclusion that Holt's exponential smoothing is an appropriate and statistically robust model for forecasting fish production and requirement in Manipur.

3 | RESULTS AND DISCUSSION

3.1 Socio-economic profile of fish consumers

The social characteristics of the fish consumers reflected that the average age of the respondent fish consumers was 42 (42.74%) years and concentrated in the age group of 31 to 50 years (59.56%). Kumar *et al*. (2023) stated that the majority of respondents (65%) were aged between 20 and 40 years. Around 30% of the consumers visited the fish market occasionally, while approximately one-third (33%) purchased between 0.5 and 1.0 kg of fish per visit. Adhikari *et al*. (2025) stated that in Biratnagar Metropolitan City, the dynamics of fish consumption are shaped by socio-economic and cultural factors. Older adults and males, especially those in higher-income brackets, tend to consume fish more frequently, likely because of a combination of dietary habits and economic freedom.

The socio-economic survey indicates that the majority of the fish consumers in the state were government employees (47.78%), followed by those in the private sector (23.56%), agriculture (16.22%) and business (12.44%). St. Louis *et al*. (2022) analysed the fish consumption habits of 1509 Brazilian consumers. The results indicated that income level was the primary predictor for increasing consumption frequency, with older individuals consuming less frequently. This study highlights the clear pattern that higher socio-economic status is associated with higher fish consumption frequency. While 64.67% of the consumers had more than five family members on average, 35.33% had two to five family members. About 33.33% of the respondents were classified into each of the income groups with an annual income of less than 0.2 million, 0.2 – 0.5 million and more than 0.5 million. Family type indicated that 52.44% of the consumers belonged to the joint family and 47.56% belonged to the nuclear family. Among fish consumers, the marital status is predominantly married (74.22%), with singles accounting for 24.22%, followed by widowed (1.11%) and divorced (0.45%). Bhendarkar *et al*. (2017) revealed that family size is an important socio-economic indicator, as it affects the income, food consumption, and socio-economic well-being of fisherwomen households in the Ratnagiri district, which coincides with the research findings stating that the majority of the reported fish consumers (52.44%) in the study area were in a joint family.

The educational profile of the fish consumers indicated that more than half of the respondents (66.00%) had attained a collegiate level of education, followed by secondary level (28.44%) and primary (5.56%) education. It is noteworthy to mention that the majority of the consumers had proper knowledge of fish consumption. Upadhyay *et al*. (2014) studied the socio-economic determinants of fish consumption in Tripura, and the results revealed that the modal age group of fish consumers was 31 – 45 years. Most of the consumers were educated to the graduate level and had occupations like government service or private business, which is similar to the age group of Manipur. According to Sen and Roy (2015), even though the literacy rate among fish farmers and their spouses in the state of Tripura was fairly high (90.00%), the overall level of education was found to be very good, with the majority having a college degree, which is similar to the education level of fish consumers in the neighbouring state of Manipur. According to Shyam *et al*. (2022), within the broader framework of the Pradhan Mantri Matsya Sampada Yojana (PMMSY) initiative, it is essential to strengthen ongoing efforts to raise awareness and promote sustainable consumption in order to build a more robust statistical foundation for evidence-based policymaking.

3.2 Fish consumption behaviour of sample households

The overall frequency of fish purchase was categorised into five groups, with the majority eating fish one to three times a week (27.78%), every day (26.89%), once a week (26.67%), once a month (13.33%), or four to six times a week (5.33%). Celik (2021) examined the fish consumption habits of individuals in Bingol, Turkey, and stated that fish consumption frequency changes based on the economic and social conditions of the individual as well as her palate for food. The consumption frequency had three options: "several times a month," "once in a month" and "several times a year." The highest prior probability belonged to "several times per month" with a ratio of 55.79%. The accuracy rate of the Naive Bayes classification was found to be 59.87%. Considering the analysis results of the C4.5 and C5.0 algorithms, the most important factors that affected the classification prediction for the fish species were monthly food spending income and the reason for preference.

Consumers preferred live fish (93.55%), while only 5.5% preferred smoked and 0.67% canned; none opted for frozen or refrigerated fish. While 27.11% of the consumers preferred buying fish from fish farms, 23.55% opted for street vendors, retail markets (18.00%), wholesalers, retailers, and street vendors (10.67%), farms and street vendors (8.89%), wholesalers, street, and online purchases (6.45%), fishery stores (3.33%), departmental stores (1.33%) and wholesalers (0.67%). Majagi and Somashekar (2020) reported that the majority of fish con-

sumers preferred eating fish once a week rather than daily. They further highlighted that household income strongly influenced the choice of fish species based on cost or price. The study also observed a significant demand and wide potential for supplying fresh, dried and frozen fish, aligning with consumer preferences in Manipur. Because of freshness (99.55%), health benefits (99.33%), availability (98.44%), taste (98.22%), less cholesterol (88.88%) and low price (77.11%), the consumer preferred fish.

The results of the regression analysis show that age, income and family size significantly influence household fish expenditure (Table 1). Among these, income exhibits the strongest effect. In contrast, education is not statistically significant ($p > 0.05$), indicating that educational level does not meaningfully impact fish spending. These findings highlight that demographic and economic factors—especially income and family size—play a key role in determining household expenditure on fish.

TABLE 1 Socio-economic factors influencing household fish expenditure in Manipur, India ($n = 450$).

Factors	Coefficients	Standard error	*t*-value	*p*-value
Age	0.203	0.091	2.233	0.026
Income	0.267	0.037	7.299	<0.001
Family size	0.215	0.081	2.638	0.009
Education	0.115	0.123	0.936	0.350

Across the study area, consumers exhibited varying levels of awareness regarding the availability of fish and fishery products in the market. Results revealed that 54.89% of the consumers were partially aware, while 45.11% were fully aware of the availability of fish products. The primary source of information identified was producers, accounting for 47.56% of responses, followed by trade fairs (37.56%), advertisements (8.44%), friends (6.00%) and relatives (0.44%). In terms of specific product awareness, 50.89% of consumers were familiar with fish pickles, whereas only 0.45% reported being unaware of them. However, awareness of the cooking procedure remained low, with only 8.22% of consumers indicating knowledge of preparation methods. Approximately 39.11% of the respondents purchased fish pickles from the market for home consumption, while 1.33% made and used them domestically. Regarding prawn pickles, 39.33% of consumers were aware of the product, 36.89% were unaware and only 4% were familiar with its preparation process. Notably, none of the consumers reported preparing prawn pickles at home, while 19.78% purchased them from the market for household consumption. Awareness of dry fish was remarkably high at 99.56%, whereas only 0.44% of consumers bought and consumed dry fish at home. Conversely, awareness of processed fish products such as fish cutlets was minimal, with 96.89% of consumers being unaware of them and only 3.11% reporting awareness. Similarly, 97.33% of those who purchased ngari for consumption lacked knowledge of its preparation. In the case of hendak, 8.89% of consumers prepared it themselves, although 44.67% were unaware of the process. Of those who had awareness, 28.00% prepared hendak at home for personal use. The findings of this study align with previous research by Kavitha (2005), who reported that 26.88% and 14.38% of respondents were aware of fish pickles and prawn pickles respectively. Additionally, 42.50% and 41.52% of respondents were aware of other fishery products such as masmin and fish cutlets. Kavitha (2005) further noted that friends, relatives, cookbooks and mass media were key sources of information related to fish product preparation. Overall, the present study underscores that local sources remain the dominant channel for consumers to obtain information about current market prices, with 78.89% relying primarily on them, followed by 21.11% who obtained such information from other sources. These findings suggest that while awareness of certain traditional fish products remains high, knowledge about preparation methods and processed fish products is relatively limited, indicating potential areas for targeted consumer education and promotion initiatives.

3.3 Household expenditure towards non-vegetarian items and change in fish consumption pattern

The expenditure pattern of households on fish and other non-vegetarian items provides important insights into consumption behaviour across the selected districts of Manipur. Table 2 presents the details of average monthly and yearly household expenditure on fish and other non-vegetarian foods.

TABLE 2 Expenditure details for fish and non-vegetarian items in Manipur ($n = 450$; in Indian Rupee ₹; 1 USD = ~90 ₹).

Particulars	Expenditure (₹)
Monthly expenditure on fish	5,326.88
Yearly expenditure on fish	63,922.13
Average monthly expenditure on non-veg items (excluding fish)	2,310.44

A comparison between the monthly household expenditure on fish and that on other non-vegetarian items revealed a clear dominance of fish in the food budget of consumers. On average, households spent ₹ 5,326.88 per month on fish and ₹ 2,310.44 per month on other non-vegetarian items such as meat, poultry, and eggs. Thus, expenditure on fish constituted nearly 69.7% of the total non-vegetarian food expenditure.

A paired sample *t*-test was applied to test whether

the difference in expenditure between fish and other non-vegetarian items was statistically significant. The results (t = 14.25, p < 0.001) indicated a highly significant difference between the two categories of expenditure. This implies that the households in Manipur spend considerably more on fish than on other non-vegetarian foods.

The predominance of fish expenditure may be attributed to the strong cultural preference and dietary habit of Manipuri people, where fish occupies a central position in both daily meals and festive occasions. The relatively higher market price of fish, frequent consumption, and the local availability of fresh and live fish further contribute to this higher spending pattern.

These findings are in line with earlier reports that emphasized the importance of fish as a major component of the diet in northeast India, where fish consumption is both nutritional and socio-cultural in nature (Dorothy *et al.* 2018). The preference for fish over other non-vegetarian items also reflects the region's rich aquatic resources and the population's traditional association with inland and capture fisheries. According to consumers, fish consumption patterns have changed due to improved nutrition (70.89%), a lower risk of cardiovascular disease (21.78%), and increased income (7.33%). Devadawson *et al*. (2015) investigated the socio-demographic determinants and fish consumption behaviour among communities in eastern Sri Lanka, noting that health-related reasons for eating fish varied: 37% consumed fish to manage heart disease, 23% for stress relief, 15% for stroke, 13% for improving eyesight and 7% during pregnancy. Ayubi and Ara (2017) investigated the awareness of fish's health benefits among residents of Islamnagar village, Dhaka, and reported that 88% of the villagers recognised the nutritional value of fish and its by-products, whereas 12% lacked such awareness.

According to the household preferences for various fish body parts, the fleshy sections were favoured by 38.22% of the fish consumers, followed by the whole fish (29.11%), the head portion (23.56%), the caudal portion (3.78%), the headless (3.33%) and the bony parts (2.00%). Supartini *et al*. (2018) investigated the change in desire to consume fish and its associated factors in the UK and Singapore. In the UK, higher fish consumption was found to be positively linked with younger age groups, lower prices, perceived health benefits, religious factors and concerns about the safety of meat. In contrast, in Singapore, increased fish consumption was associated with lower prices but showed a negative relationship with sustainability concerns.

3.4 Forecasted fish production

The forecast results indicate a steady increase in fish production in Manipur from 2025 – 26 to 2029 – 30. The model projected production levels of 38397.28 tonnes in 2025 – 26, 39964.1 tonnes in 2026 – 27, 41530.91 tonnes in 2027 – 28, 43097.72 tonnes in 2028 – 29, and 44664.53 tonnes in 2029 – 30 (Table 3). The 95% confidence interval ranged between 38359 and 50969 tonnes, signifying a moderate level of certainty in the forecasted values.

TABLE 3 Trends in fish production and estimated requirement in Manipur during 2015 – 2025.

Year	Fish weight (tonnes)	
	Production	Requirement
2015–16	31,997	42,060
2016–17	32,078	43,950
2017–18	31,354	52,110
2018–19	32,573	53,090
2019–20	32,600	59,410
2020–21	32,874	56,060
2021–22	33,125	57,140
2022–23	34,412	52,000
2023–24	35,772.50	53,000
2024–25	37,125	55,000
Total	**333,911**	**523,820**

The time series plot of fish production presents the historical, fitted, and forecasted trends (Figure 1, Table 4). The continuous upward slope of the fitted and forecast lines reveals a positive and consistent growth trend in fish production. The shaded confidence band around the forecast line widens gradually, representing increasing uncertainty as the forecast horizon extends. This increasing trend in fish output may be attributed to the expansion of aquaculture, improved seed and feed management, and the implementation of government initiatives under the Pradhan Mantri Matsya Sampada Yojana (PMMSY).

TABLE 4 Forecasted fish production, requirement, and projected production-requirement in Manipur for 2025 – 2030 using Holt's Exponential Smoothing Model.

Year	Fish weight (tonnes)		
	Forecasted production	Forecasted requirement	Projected gap
2025–26	38397.28	56061.76	17664.48
2026–27	39964.1	57201.56	17237.46
2027–28	41530.91	58341.37	16810.46
2028-29	43097.72	59481.17	16383.45
2029-30	44664.53	60620.98	15956.45

3.5 Forecasted fish requirement

Similarly, the forecast for fish requirement displayed a continuous upward trend throughout the study period. The estimated demand was 560601.76 tonnes in 2025 – 26, 57201.56 tonnes in 2026 – 27, 58341.37 tonnes in 2027 – 28, 59481.17 tonnes in 2028 – 29, and 60620.98

tonnes in 2029 – 30. The 95% confidence interval ranged from 41054 to 80188 tonnes, suggesting relatively higher variability in demand forecasts compared to production.

The forecast graph for fish requirement (Figure 2, Table 4) shows a consistently rising trend similar to production but with a steeper slope. The widening confidence bands in later years reflect increased uncertainty in demand projections due to dynamic factors such as population growth, dietary changes, and economic development. The upward trend underscores the increasing preference for fish as an affordable and protein-rich food source among Manipur's population.

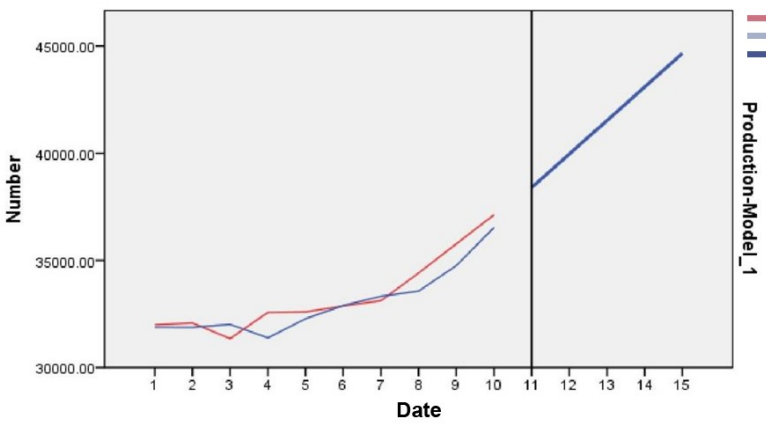

FIGURE 1 Forecasted trend of fish production in Manipur (2025–2030). Source: SPSS Time Series Modeler output. The blue line represents observed data (2015 – 16 to 2024 – 25), while the red line indicates the fitted trend, and the deep blue line denotes forecasted values (2025 – 26 to 2029 – 30).

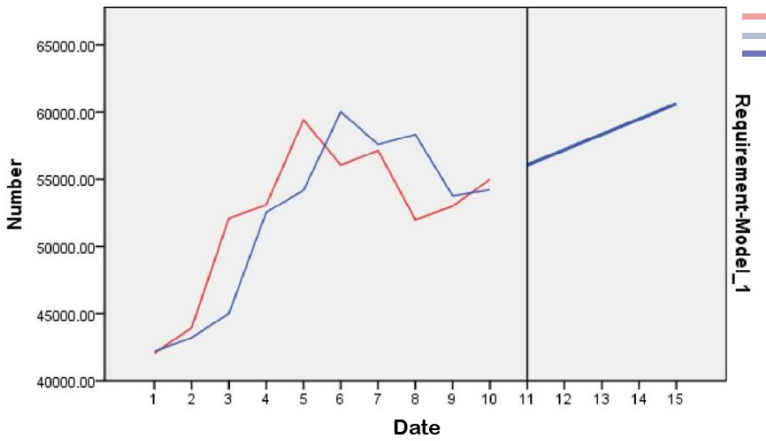

FIGURE 2 Forecasted trend of fish requirement in Manipur (2025–2030). Source: SPSS Time Series Modeler output. The deep blue forecast line remains above the production trend line, indicating a persistent supply–demand gap over time.

3.6 Comparative outlook and implications

A comparison between the forecasted fish production and requirement reveals a consistent deficit in supply across the forecast period. By 2029 – 30, the projected fish production (44664.53 tonnes) falls short of the estimated requirement (60620.98 tonnes) by approximately 15956.45 tonnes. This supply–demand gap highlights the urgent need to strengthen fish production systems in Manipur through enhanced aquaculture practices, capacity building, improved hatchery infrastructure, and the introduction of high-yield fish varieties.

Bridging this gap will be essential to ensure fish self-sufficiency, improve local livelihoods and reduce dependency on imports from neighbouring states. The findings also emphasize the importance of developing sustainable fishery management strategies aligned with the state's nutritional and economic goals.

4 | CONCLUSIONS

The study of fish consumption patterns in Manipur has revealed several key insights that can inform future interventions and strategies to enhance fish consumption and marketing in the state. One of the notable findings is that the majority of fish consumers are concentrated in the 31 – 50 age group, with an average literacy level up to the collegiate level. This information can help target specific demographic groups through tailored awareness campaigns and marketing strategies. By educating consumers about the health benefits of fish consumption and providing them with practical knowledge of preparation methods, the demand for fish can be further stimulated. To meet the growing demand for fish in Manipur, it is crucial for the respective departments to take measures to increase local fish production. This will not only ensure food security but also reduce the state's reliance on other

states for fish supply. Ensuring the quality and safety of the fish sold in the market is another key priority. The installation of proper fish markets, coupled with regular quality checks and the establishment of hygienic fish stalls, can help provide consumers with safe and healthy fish products. By addressing these key areas, the state can work towards achieving a healthier and more sustainable fish consumption landscape.

CONFLICT OF INTEREST

The authors declare that there are no potential conflicts of interest to disclose.

AUTHORS' CONTRIBUTION

N.K. Sonanla: Collection of primary data and preparation of the first version of the manuscript. Dr. M. Rajakumar: Critical reviewer for research work, data analysis, and technical assistance. Dr. T. Umamaheswari: Validated the results and proofread the manuscript. Dr. N.V Sujathkumar, Dr. S. Athithan, and Dr. Wanglar Chimwar provided valuable suggestions for the manuscript and reviewed the paper.

DATA AVAILABILITY STATEMENT

All data generated and analysed in this study are presented within this research article.

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