# MARINE LITTER: IMPEDING GROWTH IN INDIAN BLUE ECONOMY

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## Introduction

Countries across the world have been witnessing rapid economic growth owing to increased consumption and investment demand to meet the need of the growing population over time. Indian liberalization policies since the New Economic Policy in 1991 have scaled India's growth with more investment, employment, and income for residents in the country. The upward growth indicated more production of goods and services and a steady rise in India's gross domestic product. Growth of production in consumer goods registered a parallel growth in demand for packaging materials. Plastic being suitable as well as a durable material, it was adopted in most of the packaging needs of the products.The non-biodegradable property of plastic demands efficient management of the disposed packaging materials to avoid environmental hazards created by the accumulation of used plastic wastes. However, the inefficient waste management practices in India compounded with the extensive use of plastic over the years have resulted in crowding of the waste either in the dump yards or have been discarded into the open sea causing a serious threat to he marine ecosystem (Awuchi and Awuchi, 2019; Das et al., 2020).The existence of substantial marine plastic litter is a result of a resource-inefficient economy where the plastics, instead of being recycled create environmental degradation (Abalansaetal., 2020). A report by the United Nations Environment Program in 2015 indicated that India ranked 12th among the top 20 countries responsible for marine pollution, dumping 6 million tons of plastic waste annually into the ocean and is responsible for generating 9.46 million tons of plastic waste annually, of which 40% remains uncollected (Bhatia and Bhaskar, 2019). A report from Central Pollution Control Board indicated that 80% of the total plastic produced in India lands in the garbage. Accordingly, the probability ofthe majority of such plastic waste damaging the ecosystem becomes significant. Besides, the poor sanitation in the slums around the coastal regions in Indiafurther aggravates the problem (Duraisamy and Latha, 2011). In March 2019 Government of Japan and the United Nations, Environment Program initiated a joint effort 'Promotion of counter measures against marine plastic litter in Southeast

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Asia and India' to upgrade supportive information to develop measures against plastic pollution.

Marine plastic pollution is the result of a failure in economic markets. The price of making and using things made out of plastic does not reflect the full cost of disposing ofthe used plastic, instead, that cost is passed on to other entities, often coastal municipalities and ocean users (Carr, 2019). This is replicated as a negative externality where the indirect costs associated with the economic activity leading to marine plastic pollution are borne by the population but do not reflect in the calculation of the producer and remain uncovered.The most affected sector due to marine plastic pollution in India remains the fishing sector. The quality and quantity of the fish caught have been declining, impeding the sustainable income in the sector. The vessels and fishing equipment are often damaged by marine litter, leading to high maintenance and repair costs (Kapinga and Chung, 2020).The fisheries sector contributes to about 1% of the gross domestic product and the total fish production during 2017-18 was estimated to be 12.6 millionmetric tons which constituted about 6.3% of global fish production. According to the Central Marine Fisheries Research Institute, in the year 2019, total marine fish landings from the coastal areas were 3.56 million tonnes. India is the 6th largest fishing giant in the world in terms of marine capture. The total fish production from marine fishing constitutes about 35% and fish products account for nearly 10% of the total exports of the country. The pertinent problems of the fishing sector in India compound when along with the other institutional issues, challenges of aquatic pollution, destruction of fishing habitat, and impact on aquatic biodiversity are seen increasing. Also, due to the loss of habitat marine fishing has declined. This results in the loss of fishing produce and inhibits the full potential that the fishing industry can attain. Adding to this, the single-use plastic protective gears are a new threat to aquatic lives that not only disbalances the marine environment but also impedes the contributary blue economy.

The covid-19 pandemic, initiated lockdowns across the countries to contain the spread of the virus leading economic activity to a complete halt which made the world economy slip intoa state of quasi-recession. Apart from the essentials, production stopped and the industries were shut. People were confined to their homes restricting their daily activity within their households. This halt reduced the demand for goods and consequently environmental degradation lowered. The world witnessed a drastic fall in the air and local water pollution levels with carbon emission witnessing an estimated fall of 4% in 2020 as compared to 2019. Having environmentalists enthusiastic over the improvements in the environmental quality, the same optimism was not witnessed for marine pollution. It was

the reverse case for marine litter polluting the oceans. Covid-19 triggered an estimated use of 129 billion face masks and 65 billion hand gloves every month. The practical problem associated with such a massive production of face masks and hand gloves was their post-use dumping into the rivers to finally make their way into the oceans which pose serious threats to the marine ecosystem, and fisheries sector in terms of costs of environmental protection and total marine fish landings.

It is imperative to comprehend the vicious cycle that economic development is causing to the marine environment and inturn to the economic health of the country. Peninsular India contributes not only to the gross domestic product but also assists in serving the employment needs of the workforce, especially the informal type. Any disturbances here will impede the assistance offered by this sector in the developmental process affecting the workers associated with it. An understanding of matters concerning this issue is relevant to the man-induced disturbance of the ecosystem that interferes with the habitat of aquatic organisms. Though the effect of such interference may not be seen instantaneously but will become substantial concerning the offerings the blue ecosystem has for the growing economy and human development. The hazard created by the use of plastic litter and its constant addition through man-made forces is a key factor that may suppress associated business and employment opportunities in the future. Making this a matter of concern, the correctional impetus is considered to optimize the habitual processand find ways to minimize it. The present study longs to ascertain this and focuses on enticing authorities to weigh the incidence on the consumers to restrict the use of substances that create an imbalance in the marine ecosystem. One of the ways to do so is to impose a monetary burden on consumers for creating their share of pollution which will act as a restrictive behavior in terms of the usage of substances that harms the environment. Though this aspect has been introduced in the Indian transport sector concerning aged vehicles, however, a similar mandate is essentially required on the consumer as well as the producer level to adequately restrict such usages of materials that cause marine pollution. With this argument, the present study analyses the economic cost of pollution of the marine eco-system and focuses on the willingness to pay measures on consumers to contain increasing pollution in the marine environment.

**OBJECTIVES OF THE STUDY**

1. To measure the effect of constant environmental degradation of the marine ecosystem on the fishing sector in the Indian blue economy.
2. To explain the impact of low opportunity cost on the price to be paid by the consumers

to contain pollution in the marine ecosystem by incorporating the concept of demand elasticity for marine resources.

## DATA AND METHODOLOGY

The study is based on data obtained from both secondary and primary sources. Secondary data has been procured from Central Marine Fisheries Research Institute and Central Pollution Board in India to determine the percent change in Indian marine fish landings and the accumulation of covid-19 biomedical waste in the marine ecosystem respectively. To develop a framework for marine environmental protection, the concept of calculus is adopted into the study. An econometric tool of time series analysis and regression has been incorporated into this study. Based on the marine fish landings data, a trend projection is estimated using time series analysis to measure the incidence of marine litter on fish landings on the Indian peninsular coast. Primary data is used to analyze the willingness to pay for marine pollution abatement and the information is analyzed using the statistical technique of regression. Finally, the concept of elasticity of demand for marine products is used to analyze the opportunity cost associated with the agenda of sustainable development.

## RESULTS AND DISCUSSION

### Framework for marine environmental protection

The assessment that indicates the level of marine environmental pollution is based on the dynamics of important environmental variables and the influence of multiple factors on the marine environment. Considering one of the main variables of marine environmental pollution, i.e., $\delta_t$ the concentration of marine litter $\delta$ in the marine ecosystem at time $t$, then the rate of change of pollution due to the concentration of litter in the marine ecosystem is given by the differential equation:

$$\frac{d\delta_t}{dt} = \varepsilon_t \quad \pi_t \ldots (1)$$

here,$\varepsilon_t$ is the rate of increase of marine litter at time $t$ and $\pi_t$ is the rate of pollution abatement in the marine ecosystem as a consequence of prudent environmental protection measures. Cumulating the marine pollution level at a specific time by integrating the rate of change expression (equation 1) over a time interval 0 & $t$:

$$\int_t^0 \frac{d\delta_t}{dt} = \int_t^0 (\varepsilon_t \quad \pi_t) dt \ldots (2)$$

where $\int_t^0 \frac{d\delta_t}{dt}$ represents the total change in the marine pollution level from time 0 to $t$ and

$\int_t^0(\varepsilon_t \quad \pi_t)dt$ expresses the integral of the inflow of marine litter and pollution-containing policies over the same time interval. Equation (2) will assist to explore the level of litter in the marine ecosystem and aid in evaluating the overall effect of pollution influx and reduction efforts on the maritime ecosystem throughout the specified time frame.

### The economic cost of marine litter in India: Marine fishing industry

The entire Indian peninsular region abounds in fishing as a major economic activity. The Indian states of West Bengal, Odisha, Andhra Pradesh, Tamil Nadu, Kerala, Karnataka, Maharashtra, Gujrat, and the union territory of Puducherry, Goa, Daman, and Diu along the coasts follow fishing. Table 1 compares the marine fish landings of these states and union territories between the years 2018 and 2019. In 2018, West Bengal, Andhra Pradesh, Odisha, Karnataka, Goa, Maharashtra, and Gujarat showed a decline in marine fish landing as compared to the year 2017. The marine fish landing in 2019 did show improvements in West Bengal, Odisha, Andhra Pradesh, Daman, and Diu and was reduced in Puducherry, Kerala, Goa, and Maharashtra as compared to 2018. This decline has been steep in Maharashtra on India's west coast registering the lowest catch in 45 years and the decline in the fish landings along the western coast of India was attributed to the causes of increasing environmental pollution, global warming, and a decrease in phytoplankton population (Kajal, 2020).

**Table 1:** State-wise percent change in Indian Marine Fish Landings

| **States** | **Year** | | | |
|---|---|---|---|---|
| | **2019** | | **2018** | |
| | **MFL*** | **% Change from 2018** | **MFL*** | **% Change from 2017** |
| West Bengal | 2.49 | +56 | 1.6 | -56 |
| Odisha | 1.02 | +15 | 0.89 | -30 |
| Andhra Pradesh | 2.59 | +34 | 1.93 | -3 |
| Tamil Nadu | 7.75 | +10 | 7.02 | +7 |
| Puducherry | 0.37 | -19 | 0.45 | +68 |
| Kerala | 5.44 | -15 | 6.43 | +10 |
| Karnataka | 5.01 | +11 | 4.52 | -17 |
| Goa | 0.33 | -44 | 0.59 | -41 |
| Maharashtra | 2.01 | -32 | 2.95 | -22 |
| Gujarat | 7.49 | -4 | 7.8 | -1 |
| Daman and Diu | 1.12 | +64 | 0.68 | +6 |

**Note.** MFL* is marine fish landings in lakh tonnes
**Source:** Central Marine Fisheries Research Institute (CMFR), 2018 & 2019.

In India, fisheries have transformed into commercial enterprises. The share of the fisheries sector in the total gross domestic product (at current prices) increased from 0.40% in 1950-51 to 1.03% in 2017-18, recording an increase of 157%. The sector has been showing steady growth in the total Gross Value Added and accounts for about 6.58

percent share of Agricultural gross domestic product. Furthermore,the fishery sector has been a major contributor to foreign exchange, where marine exports stand at about 5 percent of total exports. This growth in the fisheries sector is also assisting the informal workforce in the primary sector to find ways of earning and sustaining employment. Considering the increasing size of fisheries business in India, this sector secures strategic national importance,especially in the Indian states of the peninsular region and accordingly, it becomes more pertinent to reduce the obstacles in the Indian marine fish landings. One of the major challenges associated with marine landings includes the degradation of the marine ecosystem which again is the major cause of factors affecting these landings. As the existing pollutant in the marine ecosystem has already affected the fish landing, any further addition in this regard will worsen the situation directly and will affect the entire socioeconomic structure of the informal workforce in the fisheries sector. It then becomes imperative to measure the intensity of marine litter affecting the marine fish landing in India.

**Measuring the incidence of marine litter in the Indian marine fishing industry**

The environment ministry in the year 2020, stated that India generates 9.46 million tons of plastic waste annually and about 40% of this waste remains uncollected as most cities and towns are unable to efficiently implement plastic waste management rules. The volume of waste swells up in landfills, drains, and rivers which flows into the sea and creates a serious threat to the entire marine ecosystem which estimates India's contribution to marine litterat 3.78 million tons per year. In addition to this covid-19 biomedical waste escalates this figure. Table 2 indicates the overall generation of covid-19 biomedical waste in the period ranging from June to September 2020. The overall covid-19 biomedical waste in India during the same period was estimated to be 18,006 tons. In July 2020 Central Pollution Control Board revised the guidelines on the management of bio-medical waste of covid-19 patients, along with this revision there was an extension to the Bio-Medical Waste Management Rules 2016 (Singh and Saha, 2020). However, there is an alarming concern over the effective implementation of these guidelines making the entire Covid-19 waste management, an inefficient exercise. If the waste in India remain suncollected it raises the risk of further adding covid-19 biomedical waste that finds its way into the ocean adversely affecting the marine ecosystem and the fishing industry.

**Table 2:** Covid-19 biomedical waste in India (in tons)

| State | June 2020 to September 2020 |
|---|---|
| Maharashtra | 3587 |
| Tamil Nadu | 1737 |
| Gujarat | 1638 |
| Kerala | 1516 |
| Uttar Pradesh | 1432 |
| Delhi | 1400 |
| Karnataka | 1380 |
| West Bengal | 1000 |
| Total (India) | 18006 |

**Source:** Central Pollution Control Board, India

**Table 3: Indian Marine fish landings from 2013 - 2019**

| | Year (MFL) | | | | | | |
|---|---|---|---|---|---|---|---|
| **States** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** |
| West Bengal | 2.62 | 0.77 | 1.18 | 2.72 | 3.61 | 1.60 | 2.49 |
| Odisha | 1.24 | 1.39 | 1.41 | 1.17 | 1.27 | 0.89 | 1.02 |
| Andhra Pradesh | 2.66 | 3.42 | 2.95 | 1.92 | 2.0 | 1.93 | 2.59 |
| Tamil Nadu | 6.88 | 6.65 | 7.09 | 7.07 | 6.55 | 7.02 | 7.75 |
| Puducherry | 0.69 | 0.65 | 0.79 | 0.45 | 0.27 | 0.45 | 0.37 |
| Kerala | 6.71 | 5.76 | 4.82 | 5.23 | 5.85 | 6.43 | 5.44 |
| Karnataka | 4.37 | 4.74 | 4.43 | 5.29 | 5.48 | 4.52 | 5.01 |
| Goa | 1.04 | 1.53 | 0.68 | 0.61 | 1.0 | 0.59 | 0.33 |
| Maharashtra | 3.64 | 3.45 | 2.65 | 2.92 | 3.81 | 2.95 | 2.01 |
| Gujarat | 7.17 | 7.12 | 7.22 | 7.74 | 7.86 | 7.80 | 7.49 |
| Daman and Diu | 0.79 | 0.46 | 0.81 | 1.16 | 0.64 | 0.68 | 1.12 |

Note: MFL is marine fish landings in lakh tones

Source: Retrieved from Central Marine Fisheries Research Institute (MFL Report): 2013 to 2019

The marine fisheries sector is dominated by the socio-economically backward artisanal and small-scale fishers whose lives are closely intertwined with the oceans and seas. However, 75 percent of the total marine fish production comes from the mechanized sector, 23 percent from the motorized sector, and only 2 percent from the artisanal sector. National Fisheries Policy, 2020 indicated that despite stagnation in the growth of marine capture fish production over the years, the dependency of traditional marine fishers on marine capture fisheries for livelihoods has been increasing. As such this sector has been a source of employment in the coastal areas of the country. Employment inthese areas depends on the fish landings, better ladings will lead to better business and good income.To measure

the incidence of marine litter on fish landings in the Indian peninsular coast, trend values are computed by applying time series analysis to the data in Table 3 to estimate the trend projection of marine fish landings for the years 2023 to 2026.The equation of the fitted trend line and its estimation are given by equations 3 and 4 respectively:

$$\hat{y}_t = \bar{y} + \hat{b}(t \quad \bar{t}) \ldots (3)$$

$$= 36.126 + \{ \quad 0.16\,(\mathrm{t} - 2016)\} \ldots (4)$$

where$\hat{y}_t$ is the estimated fitted trend line, $\bar{y}$and$\hat{b}$ are the least square estimates and $\bar{t}$ is given as the mean of all times t.With this fitted trend line, the trend values for 2013 to 2019 and trend projection for 2023 to 2026 is estimated in Table 4.

**Table 4:** Trend estimation for Marine Fish Landings (MFL) in India

| **Trend Values** | | **Trend Projection** | |
|---|---|---|---|
| **Year** | **Trend** | **Year** | **Projection** |
| 2013 | 36.606 | 2023 | 35.006 |
| 2014 | 36.446 | | |
| 2015 | 36.286 | 2024 | 34.846 |
| 2016 | 36.126 | | |
| 2017 | 35.966 | 2025 | 34.686 |
| 2018 | 35.806 | | |
| 2019 | 35.646 | 2026 | 34.526 |

**Note:** MFL in lakh tones

**Source:** Author's estimation using time series analysis.

The repercussion of sustained marine environmental degradation is evident from the trend analysis of the marine fish landing which indicates a declining trend that continues for the complete period of assessment.

**Willingness to pay and Indian blue economy**

Assuming that a tax equivalent to the consumer's willingness to pay through the government's intervention towards protecting the marine environment exists, an analysis is sought to substantiate the effect of such a tax on the productive marine fishing industry in India. The divergence from a state of higher pollution to a state of low marine pollution is dependent on the role government plays to affect that divergence. With an agenda to test a choice between conditional access to plastic pollutants or inducement of organic change in the mindset towards environmental degradation either by coercion or by legislation, a survey was administered among the daily users of plastic andits variants with people having at least a tertiary level of education and regular monthly income. An attempt was deliberated to interpret their results using the probabilistic regression model.

The survey was administered to 60 respondents who were asked if they are prepared to support the cause or willing to pay voluntarily. Table 5 gives the survey data for 60 families. In Table 5, if $P_i$ = probability that $Y = 1$ (that is, the family is willing to pay) and 1 - $P_i$ = probability that Y = 0 (that is, the family is not willing to pay), the variable Y has the probability distribution:

$$\begin{array}{cc} Y_i & Probability \\ 0 & 1 \quad P_i \\ 1 & P_i \end{array}$$

Based on the data in Table 5 the probabilistic regression was estimated by ordinary least square as:

$$\hat{Y} = 0.1546 + 0.0038\,X$$

**Table 5:** Survey data on willingness to pay for an individual.

| Family | Y | X | Family | Y | X | Family | Y | X |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 40 | 21 | 0 | 45 | 41 | 0 | 65 |
| 2 | 0 | 45 | 22 | 1 | 60 | 42 | 1 | 15 |
| 3 | 0 | 55 | 23 | 0 | 85 | 43 | 0 | 50 |
| 4 | 1 | 50 | 24 | 0 | 50 | 44 | 1 | 90 |
| 5 | 0 | 25 | 25 | 0 | 70 | 45 | 0 | 35 |
| 6 | 0 | 35 | 26 | 1 | 80 | 46 | 0 | 45 |
| 7 | 0 | 35 | 27 | 0 | 50 | 47 | 1 | 60 |
| 8 | 1 | 50 | 28 | 0 | 60 | 48 | 1 | 35 |
| 9 | 0 | 35 | 29 | 0 | 45 | 49 | 1 | 25 |
| 10 | 0 | 37 | 30 | 1 | 25 | 50 | 0 | 65 |
| 11 | 0 | 37 | 31 | 0 | 50 | 51 | 1 | 55 |
| 12 | 0 | 70 | 32 | 1 | 50 | 52 | 0 | 25 |
| 13 | 0 | 75 | 33 | 0 | 80 | 53 | 0 | 25 |
| 14 | 1 | 100 | 34 | 1 | 75 | 54 | 0 | 35 |
| 15 | 0 | 15 | 35 | 0 | 45 | 55 | 1 | 40 |
| 16 | 1 | 125 | 36 | 0 | 65 | 56 | 0 | 35 |
| 17 | 1 | 50 | 37 | 0 | 75 | 57 | 1 | 110 |
| 18 | 0 | 75 | 38 | 1 | 35 | 58 | 0 | 35 |
| 19 | 0 | 40 | 39 | 1 | 23 | 59 | 0 | 45 |
| 20 | 1 | 35 | 40 | 0 | 45 | 60 | 0 | 30 |

**Note:** X = income and Y = individual's willingness to pay where 1 = yes, 0 = no, income (X) is shown in '000
**Source:** Author's survey

where $\hat{Y}$ is the estimated value of Y. The intercept of 0.1546 gives the probability that a family with zero income will be willing to pay for marine environmental degradation caused due to its consumption process. The slope value of 0.0038 suggests that for a unit change in income, i.e., 1000 as per the survey, the probability of willingness to pay increases by 0.0038 which is almost insignificant. Estimates of the actual probability of willingness to pay for the survey data concerning the various level of income is given by the expression:

$$E\,(Y_i \quad X_i) = 0.1546 + 0.0038\,X_i = \; P_i$$

where $i$ is the *ith* family in the survey and $P_i$ is the estimated probability of willingness to pay with $X_i$income, then $Y_i$. The estimated values for all the families under the survey are shown in Table6 which suggests that families with a higher level of income havea higher probability to pay.

**Table 6:** Estimates of probabilities for WTP concerning the families under the survey

| F. No | Pi | X | F. No | Pi | X | F. No | Pi | X | F. No | Pi | X |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.3066 | 40 | 16 | 0.6296 | 125 | 31 | 0.3446 | 50 | 46 | 0.3256 | 45 |
| 2 | 0.3256 | 45 | 17 | 0.3446 | 50 | 32 | 0.3446 | 50 | 47 | 0.3826 | 60 |
| 3 | 0.3636 | 55 | 18 | 0.4396 | 75 | 33 | 0.4586 | 80 | 48 | 0.2876 | 35 |
| 4 | 0.3446 | 50 | 19 | 0.3066 | 40 | 34 | 0.4396 | 75 | 49 | 0.2496 | 25 |
| 5 | 0.2496 | 25 | 20 | 0.2876 | 35 | 35 | 0.3256 | 45 | 50 | 0.4016 | 65 |
| 6 | 0.2876 | 35 | 21 | 0.3256 | 45 | 36 | 0.4016 | 65 | 51 | 0.3636 | 55 |
| 7 | 0.2876 | 35 | 22 | 0.3826 | 60 | 37 | 0.4396 | 75 | 52 | 0.2496 | 25 |
| 8 | 0.3446 | 50 | 23 | 0.4776 | 85 | 38 | 0.2876 | 35 | 53 | 0.2496 | 25 |
| 9 | 0.2876 | 35 | 24 | 0.3446 | 50 | 39 | 0.242 | 23 | 54 | 0.2876 | 35 |
| 10 | 0.2952 | 37 | 25 | 0.4206 | 70 | 40 | 0.3256 | 45 | 55 | 0.3066 | 40 |
| 11 | 0.2952 | 37 | 26 | 0.4586 | 80 | 41 | 0.4016 | 65 | 56 | 0.2876 | 35 |
| 12 | 0.4206 | 70 | 27 | 0.3446 | 50 | 42 | 0.2116 | 15 | 57 | 0.5726 | 110 |
| 13 | 0.4396 | 75 | 28 | 0.3826 | 60 | 43 | 0.3446 | 50 | 58 | 0.2876 | 35 |
| 14 | 0.5346 | 100 | 29 | 0.3256 | 45 | 44 | 0.4966 | 90 | 59 | 0.3256 | 45 |
| 15 | 0.2116 | 15 | 30 | 0.2496 | 25 | 45 | 0.2876 | 35 | 60 | 0.2686 | 30 |

**Note:** Pi = probability of WTP, F.No = family number and X = income (in '000)

**Source:** Author's estimation

As the probability of paying any amount is high at higher levels of income as per the survey, the willingness to pay among the community under the survey will be dependent on the household income, the higher the income, the higher will be the probability for WTP. Considering this assessment and comparing with the average income of an individual against the cost of living in India, the WTP for a consumer depends not only on the consumer's willingness but also on compulsive governmental regulations and its effectiveness to initiate taxation that affects the consumer's willingness to pay.The significance of any intervention by the government for aparticipatory role of an individual towards lowering the marine environmental degradation requires a comprehensive understanding of the community development concerning regional economic inequality and related administrative policies else societal inducement to suppress the use of substances that aggravate marine pollution will not take effect. Moreover, with the escalated disturbances in the marine ecosystem combined with man-made marine environmental degradation, the fishing industry in India will be further stressed as the marine fish landings will follow the trend line (Table 4) to register a dip in business and related matters.

**Adjusting the rate of marine environmental degradation**

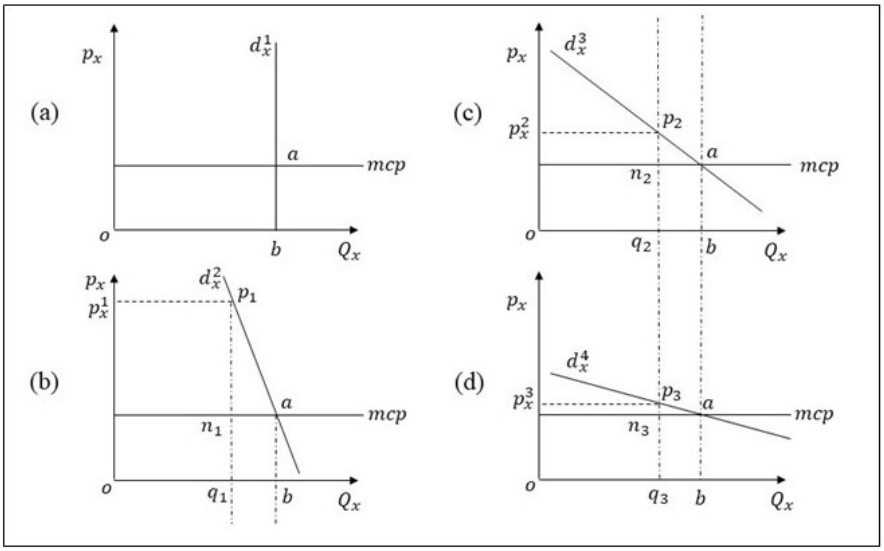
The speeding marine environmental degradation involves an opportunity cost. The

use of the environment in a callous manner leading to its degradation today reduces the availability of a pollution-free environment in the future. The increasing marine litter will shrink the habitat of marine animals which will further reduce the level of marine fish landings in the future. The agents degrading the marine environment must considerthe cost of giving up the opportunity of the plausible returns that could have been procured with the use of a flourishing marine environment in the future. The initial condition of optimal environmental depletion is:

$$p = mc + uc$$

where $p$ is the price, $mc$ is the marginal cost for the use of the environment, and $uc$ is the user cost or the opportunity cost (Bhattacharya, 2017). This optimal depletion can be used to implement the control system for marine environmental degradation.The depletion of the environment needs to be optimized to understand the context in marine environmental settings. Figure 1 represents different demand elasticities for marine environmental goods where the optimal depletion level is *ob* consumption of resources. Here $d_x^1, d_x^2, d_x^3, d_x^4$ are the demand curve for marine environmental goods showing perfectly inelastic, inelastic, unit elastic,and elastic demand elasticity respectivelyand *mcp* is the marginal cost of polluting the marine environment which is assumed to be constant in the study. $P_x$ in Figure 1 represents the price to be paid by

**Figure 1:** Demand elasticities for marine environmental goods




**Source:**Author's assessment based on the concept of elasticity of demand.

the consumer for controlling pollution and *ob* is the quantity demanded for the environmental goods.The perfectly inelastic demand ($d_x^1$) in section (a) of Figure 1 shows that for marine environmental goods, there will be infinite opportunity cost suggesting that economizing its usage will not be possible and will lead to aggravating the environmental pollution. Subsequent sections of Figure 1 show that the opportunity cost ($p_1n_1$ in section b) goes on diminishing as the elasticity of demand for marine environmental goods changes from perfectly inelastic demand to relatively elastic demand:

$$p_1n_1 > p_2n_2 > p_3n_3$$

This indicates exercising control over the pollution in the marine ecosystem. Under such circumstances, the higher the elasticity of demand for marine environmental goods, the lower the opportunity cost which assists the cause of sustainable development. This also suggests that with higher elasticity the price to be paid by the consumer for aggravating pollution diminishes, i.e.,

$$op_x^3 < op_x^2 < op_x^1$$

**CONCLUSION**

A significant implication of this study is that consumerism practices concerning the disposal of non-biodegradable waste leading to unsustainable development are affecting the marine ecosystem and eventually creating a negative impact on the Indian blue economy. With the disequilibrium between per capita income and average monthly cost of living in India, there is no urgency in willingness to contribute to the process of reducing the marine environmental degradation by the agents i.e. consumers responsible for marine pollution. This is intensified by the absence of compulsive environmental legislation that creates accountability for amassing marine plastic litter on the individual level. The present consumption activities generating massive litter in the oceans are not consistent with the health of the economy concerning the primary economic activity of marine fishing. The declining trend in marine fish landings is attributed to the distortion of the marine ecosystem and is indicative of two conditions in the long run if significant pollution suppressive measures are not adopted, firstly it may lead to restrictive national and international trade which in turn will create a low-level income trap among the informal workforce in the marine fishing sector, and secondly, the prevalence of disguised unemployment will grow more profound unless the informal fishermen incorporate additional income generating measures to meet the daily exigencies of life.The contributory willingness on the part of the consumers will inculcate a responsive view towards minimizing such uses of materials that they can avoid. With an assumption of similar responsive views on the national level and interventional governmental regulation, the producers will then be compelled to adopt biodegradable and environment-friendly materials which can be recycled. The producer sector in the

contemporary world is following a primitive classical view of supply creating its demand by continuously employing plastic materials for almost every consumer good which the consumers are readily using in the consumption process. Relative key to this issue of marine plastic litter shall originate from the manufacturers venturing into designing such consumer products which can promote sustainability in the overall development process.

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