JSDC
Journal of Studies in Dynamics and Change (JSDC);
Vol-13, Issue-1, ISSN: 2348-7038
International Peer Reviewed Quarterly Journal
www.jsdconline.com

Analysis of Marine Fish Production in Odisha with Special Reference to Ganjam District

Ranjan Kumar Nayak[1]

Nispesita Manjari Jena[2]

ABSTRACT

In India, marine fisheries are crucial to the creation of jobs, coastal livelihoods, and regional economic growth. Using 24 years of secondary data (2000–01 to 2023–24), the current study examines the development and trend of marine fish production in Odisha with particular reference to Ganjam district. To investigate production trends by district, the study uses quantitative methods such growth rate analysis, Compound Annual Growth Rate (CAGR), decadal growth analysis, moving averages, ANOVA, and correlation analysis. The findings show that Odisha's overall marine fish production rose by almost 87% throughout the course of the research, demonstrating consistent sectoral growth. The results, with particular reference to Ganjam district, reveal an impressive rise of almost 253%, the greatest of the coastal districts, with a CAGR of 5.64%, far higher than the state average (2.77%). While correlation analysis reveals a close relationship between Ganjam's production trends and those of other major fishing districts, the ANOVA results suggest statistically significant differences in production between districts. The study comes to the conclusion that Ganjam's quick development has been facilitated by advancements in fishing infrastructure, mechanization, institutional support, and fisheries policies. In order to promote sustainable marine fisheries development, the report emphasizes the significance of district-level fisheries planning and recommends specific infrastructure, technology, and cooperative strengthening strategies.

Keywords: Marine fisheries, Fish production, CAGR, District analysis

JEL Classification Codes: Q22

Author Details:
1. Ranjan Kumar Nayak is Assistant Professor in Economics (TE), KSUB CTE, Bhanjanagar, Ganjam, Email: ranjankumarnayak5@gmail.com
2. Nispesita Manjari Jena is Research Scholar in Department of Analytical and Applied Economics, Utkal University, Bhubaneswar, Email: lipijena6@gmail.com

I. INTRODUCTION

A significant part of the global blue economy, marine fisheries are essential to maintaining food security, creating jobs, generating foreign cash, and sustaining

Suggested Citation:
Nayak, R. K. & Jena, N. M. (2026). Analysis of Marine Fish Production in Odisha with Special Reference to Ganjam District, *Journal of Studies in Dynamics and Change (JSDC), 13*(1), 1-21.
DOI: www. https://doi.org/10.5281/zenodo.22069291
Published on: 01 January 2026

livelihoods, especially in developing nations. The worldwide fisheries industry directly and indirectly supports about 120 million people and makes a substantial contribution to nutritional security, according to the Food and Agriculture Organization (FAO, 2022). With an average annual growth rate of about 6–8 percent over the past 20 years, the fishing industry in India has become one of the agricultural economy's fastest-growing sectors (Government of India, 2023). India is the world's second-largest producer of aquaculture and the third-largest producer of fish (FAO, 2022). Employment and coastal economic development are greatly aided by the marine fishing industry (Ayyappan & Diwan, 2006). Nearly 16 million people, including fishermen, processors, merchants, and ancillary workers, depend on this industry for their livelihood (Department of Fisheries, 2021). Due to its 480 km of coastline, rich marine biodiversity, and traditional fishing communities, Odisha holds a significant place in India's marine fisheries (CMFRI, 2020). The improvement of infrastructure, the modernization of fishing vessels, and government programs like the Blue Revolution and Pradhan Mantri Matsya Sampada Yojana have all contributed to the state's consistent increase in marine fish production (Government of India, 2022). The main marine fishing belt of Odisha is made up of the coastal districts of Balasore, Jagatsinghpur, Puri, Kendrapara, Bhadrak, and Ganjam. Marine fish output has historically been dominated by districts like Jagatsinghpur and Puri, but current trends show that districts like Ganjam are becoming significant producers as a result of the quick expansion of fishing operations (Department of Fisheries, Odisha, 2022). Because of better landing facilities, mechanized fishing boats, and institutional backing from fisheries cooperatives, Ganjam district, especially the Gopalpur coast, has seen substantial growth in marine fisheries. Over the past 20 years, the district's marine fish production has grown remarkably, despite beginning with a comparatively smaller production base. Nevertheless, there are very few systematic empirical studies looking at this growth trend.

Relevance of the Study

Studying marine fish production is crucial because it directly affects rural development, coastal livelihoods, and regional economic expansion. In addition to creating jobs, fisheries support value chains that include export, marketing, processing, and transportation (World Bank, 2012). District-level fisheries study is crucial from the standpoint of regional development since growth patterns frequently differ due to variations in infrastructure, institutional support, technological adoption, and resource availability (Kumar & Prakash, 2017). Designing focused fisheries development policies requires an understanding of these distinctions. The current study is especially pertinent since it examines Ganjam district, an example of a fishing region that is expanding quickly. While high-output districts have received the majority of emphasis in prior research, districts exhibiting rapid development despite lower initial production levels have received less attention.

The identification of growth trends can give decision-makers valuable information to improve market connectivity, strengthen fisheries infrastructure, strengthen cooperative societies' institutional capacity, and encourage sustainable management practices in the fishing industry. This makes the study highly relevant to policy. In order to ensure the long-term sustainability of fishery resources and to

promote equitable regional development, such micro-level (district-level) assessments are essential (OECD, 2021).

Economic Theories Underpinning the Study

The current study is grounded in significant economic theories that describe regional economic growth and production expansion. The classical production framework states that important elements including capital investment, human labor, technical innovation, and the function of supportive institutions drive the rise of output (Solow, 1956). These elements might be thought of as fishing vessels and equipment as capital, fishermen as labor, current fishing techniques as technological inputs, and cooperative societies as institutional mechanisms promoting development within the fisheries industry. Additionally, Schumpeter's (1934) innovation theory emphasizes how important technological progression is as a key driver of economic growth. Fish productivity in fisheries is greatly increased by the use of motorized boats, navigation technologies like GPS, and improved preservation and storage methods. Furthermore, the regional development viewpoint contends that, in comparison to less developed regions, locations with more robust infrastructure and efficient institutional arrangements typically experience higher growth rates (Myrdal, 1957).

Differences in institutional support and resource management systems are a major cause of the economic discrepancies in fisheries development among coastal regions. The effectiveness and caliber of institutions have a major impact on the rate and direction of economic development, according to institutional economic theory, especially the research of North (1990). Cooperative societies serve as crucial institutional arrangements in the fishing industry, strengthening marketing channels, facilitating formal credit access, and boosting fishermen's ability to bargain collectively. The Blue Economy concept, which encourages the sustainable and ethical use of marine resources as a route to long-term economic progress, is still relevant today, according to recent research (World Bank, 2017). As a result, any evaluation of the expansion of the fishing industry must also take resource conservation and environmental sustainability into account.

Theoretical Model Linking Production Growth

The neo-classical production theory, which sees output expansion as the outcome of the combined influence of capital, labor, technological advancement, and institutional arrangements, provides the conceptual foundation for the analysis of marine fish production growth in the current study (Solow, 1956; Gujarati, 2012). The availability of physical assets, such as fishing boats, nets, and landing infrastructure; the contribution of human resources, such as fishermen and support workers; the adoption of contemporary technologies, such as motorization and fish-finding equipment; and the efficacy of institutional mechanisms, such as cooperatives and public policy interventions, can all be considered factors that affect production performance within the fisheries economy (Ayyappan & Diwan, 2006; Kurien, 2005). Schumpeter's theory of innovation (1934), which emphasizes the significance of technological improvement as a catalyst for productivity increase and sectoral expansion, further supports this viewpoint. Furthermore, North's (1990) institutional economics paradigm emphasizes the importance of collective organizations, governance structures, and regulatory frameworks in enhancing economic efficiency. From a modern policy standpoint, the Blue Economy paradigm

also acknowledges that better market access, value chain development, modernization of fisheries infrastructure, and sustainable resource management are important factors that influence fisheries growth (World Bank, 2017; FAO, 2022). Based on these theoretical viewpoints, it is possible to conceptualize the growth of marine fish production in Ganjam district as being influenced by a number of interconnected factors, including the availability of infrastructure, technological modernization, institutional effectiveness, ecological conditions, and market connectivity, all of which work together to shape the long-term trajectory of fisheries production.

The functional relationship may be expressed as:
Fish Production Growth (FP) = f (Capital, Labour, Technology, Institutions, Infrastructure, Market Access, Policy Support, Environment)
This theoretical model suggests that improvements in these determinants are expected to increase marine fish production and explain regional variations in fisheries growth.

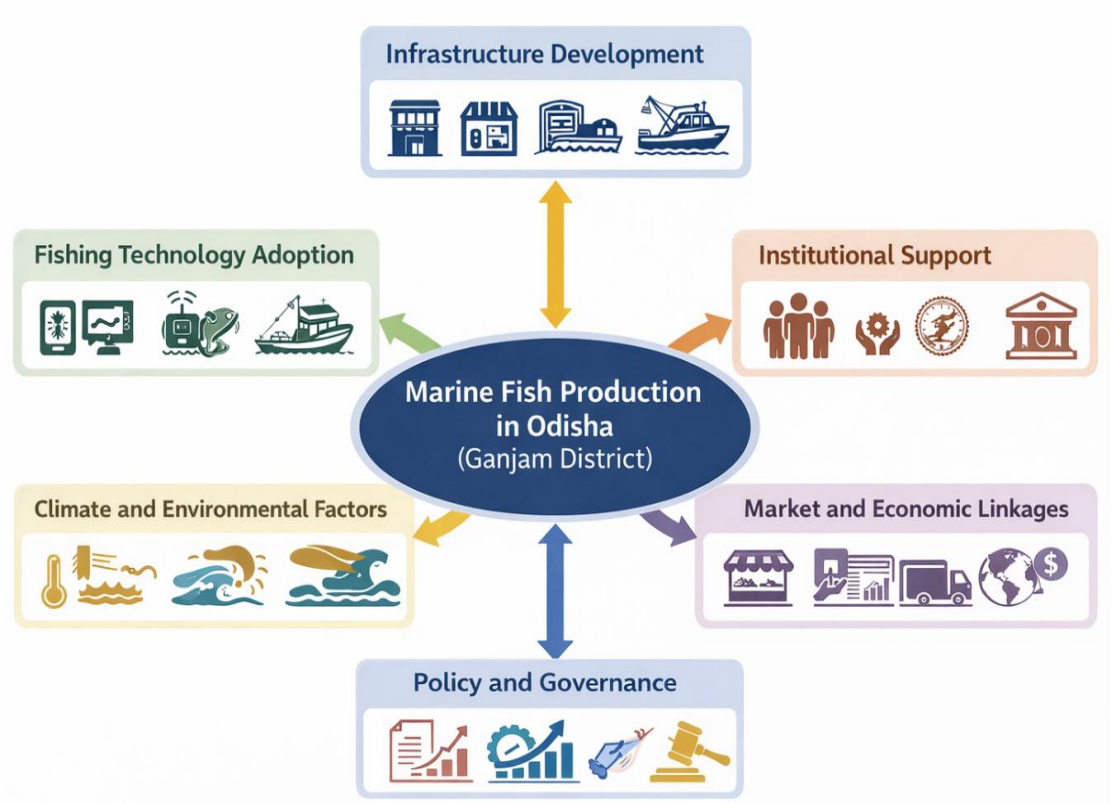
Conceptual Framework

The conceptual framework (Figure-1) shows how a number of interrelated institutional, technological, economic, and environmental factors influence marine fish output in Ganjam district. According to this framework, the production of marine fish is the dependent variable, while the production outcomes are influenced by independent variables like market integration, institutional mechanisms, technological advancements in fishing techniques, environmental conditions, infrastructure facilities, and governance policies. Increasing operational efficiency and productivity is largely dependent on the availability of infrastructure, such as transportation networks, cold storage systems, and fish landing harbors. In a similar vein, institutional mechanisms like financial support systems and fishermen's cooperatives expand marketing opportunities, increase collective bargaining power, and make financing more accessible.

Additionally, the application of advanced fishing technologies—such as mechanized and motorized boats, fish-finding tools, and navigation systems—contributes considerably to raising operational efficacy and output. The sustainability and quantity of fish caught are also directly impacted by environmental and climatic factors, such as water temperature, weather fluctuation, and the health of marine ecosystems. Additionally, improved economic integration and stronger market ties enable fisherman to receive fair pricing, which promotes increased production. By guaranteeing regulatory support, resource management, and developmental aid, policy interventions and fishery governance frameworks also play a significant impact.

Therefore, the framework emphasizes that rather than being determined by a single factor, the production of marine fish in Ganjam district is the outcome of the combined influence of infrastructure expansion, institutional strengthening, technological modernization, environmental sustainability, and effective policy support. The district's growing significance in supporting Odisha's marine fisheries industry is also reflected in this integrated viewpoint.

Figure-1: Conceptual Framework



Source: Authors' own compilation

II. REVIEW OF LITERATURE

Particularly in developing nations like India, marine fisheries are essential to the creation of jobs, the security of livelihoods, and the growth of the coastal economy. FAO (2022) reports that the fishing industry sustains over 120 million livelihoods globally and makes a substantial contribution to global food security. Fisheries have become one of the fastest-growing agricultural sectors in India, making significant contributions to both GDP and export revenue (Government of India, 2023). The contribution of marine fisheries to economic growth and poverty alleviation has been the subject of numerous studies. Kurien (2005) noted that in coastal areas, small-scale fisheries play a major role in employment and social fairness. In a similar vein, Allison and Ellis (2001) emphasized that fisheries are a crucial tool for vulnerable coastal communities to diversify their sources of income. Technology advancements, fishing vessel mechanization, and institutional assistance have all contributed significantly to the growth of marine fish production in India, according to research on the country's fisheries development (Devaraj & Vivekanandan, 1999; CMFRI, 2016). According to research by Bavinck et al. (2018), collective organizations like cooperatives and fisheries governance can enhance resource management and fishermen's income stability.

Fisheries have been acknowledged as a significant industry in Odisha that supports coastal lives. According to Mohanty (2015), government initiatives, the development

of fishing infrastructure, and the growing use of robotic fishing methods have all contributed to the continuous growth of Odisha's marine fisheries. Similarly, coastal areas like Jagatsinghpur, Puri, and Ganjam are crucial for the production of marine fish, according to Sahoo and Mishra (2018). The literature has also extensively addressed the function of fisheries cooperatives. According to Jentoft (2000), cooperative organizations support fair benefit distribution and strengthen fishermen's negotiating position. Fisheries cooperatives are crucial institutional tools for putting welfare programs into place and enhancing market access, according to Salagrama (2012). Growth rate analysis and CAGR techniques have been applied in a number of empirical studies to investigate changes in fisheries production. When Tripathy and Barik (2019) examined fish production trends in eastern India using CAGR analysis, they discovered notable regional differences. In a similar vein, Dash et al. (2020) used trend analysis and moving averages to examine the growth of fisheries in Odisha and discovered steady long-term increases in spite of short-term swings.

Fisheries research has also made extensive use of statistical techniques like correlation analysis and ANOVA. Wooldridge (2016) and Gujarati (2012) stressed the value of econometric methods in examining regional differences in production. District-wise variance in fisheries productivity was examined using ANOVA methodologies in studies like Panda and Sahu (2021), who discovered statistically significant differences. Additionally, studies show that the development of infrastructure, including transportation facilities, cold storage facilities, and fish landing centers, has a significant impact on the expansion of marine fisheries (World Bank, 2012; Ayyappan & Diwan, 2006). The expansion of maritime fisheries in Ganjam district of Odisha has been facilitated by the building of landing centers like Gopalpur (Department of Fisheries, Odisha, 2022). Time-series analysis is crucial for fisheries research, according to a number of studies. While Harvey (1990) talked about the significance of trend analysis for comprehending long-term sectoral growth, Box and Jenkins (1976) highlighted the value of time-series techniques in analyzing production trends. Fisheries economics has used these techniques extensively to study production dynamics (Rao et al., 2018). Districts with lower initial output frequently show higher growth rates as a result of infrastructure expansion and technological adoption, according to studies on fisheries performance at the district level (Kumar & Prakash, 2017). The Ganjam district, which has experienced significant expansion while having a comparatively smaller manufacturing base, is consistent with this conclusion. The significance of institutional involvement is further highlighted by research on livelihood sustainability and fisheries. According to FAO (2020), cooperative involvement enhances market access and income stability. In a similar vein, ICSF (2019) found that resilience in small-scale fisheries is improved by bolstering community institutions. The production of marine fish is also influenced by environmental conditions. Pauly and Zeller (2016) emphasized how the availability of marine resources and climate variability affect fisheries production. Vivekanandan et al. (2009) examined how environmental changes affect trends in marine fish catches in the Indian context. The significance of sustainable fisheries development is also emphasized in recent research. Hilborn et al. (2020) highlighted the necessity of striking a balance between sustainability and output expansion. In a similar vein, the OECD (2021) emphasized the significance of institutional reforms and governmental support in the growth of fisheries. It is clear from the examination of

the literature that the majority of studies concentrate on the expansion of fisheries at the national or state level, whereas there is little research on comparative analysis at the district level with a focus on developing districts like Ganjam. Additionally, few studies look at fisheries development at the district level using growth analysis, CAGR, ANOVA, and correlation approaches. Thus, by offering a district-level statistical analysis of marine fish production with particular reference to Ganjam district, the current study aims to close this research gap.

Research Gap

Although there is a wealth of literature on the development of marine fisheries in Odisha and India, there are still a number of significant research gaps that need to be filled. While district-level empirical evaluations are still scarce, especially for developing fisheries districts like Ganjam, the majority of current research concentrate mostly on national or state-level changes in marine fish output (FAO, 2022; Government of India, 2023; CMFRI, 2020). Despite discussing fisheries growth in Odisha, research like Mohanty (2015) and Sahoo and Mishra (2018) mostly offer descriptive insights without doing in-depth comparative statistical analysis across coastal districts. Additionally, only a small number of studies have used a combination of quantitative tools like CAGR, moving averages, ANOVA, correlation matrices, and decadal growth analysis to understand regional disparities in marine fish production. Prior research has typically looked at fisheries growth using basic trend analysis. The dearth of targeted research on how comparatively low-production districts like Ganjam have developed into high-growth areas within the marine fishing industry is another significant gap. Furthermore, little study has been done utilizing long-term time-series data to examine the relative performance and convergence of district-level production trends. Additionally, the majority of research do not adequately investigate whether variations in district production levels are structurally or statistically significant. In order to close these gaps, the current study uses 24 years of time-series data to provide a thorough district-level quantitative analysis of marine fish production in Odisha, with a focus on Ganjam district. The study adds to the literature by identifying Ganjam as a rapidly developing marine fisheries district and offering a more thorough statistical understanding of regional fisheries development in Odisha through the integration of growth analysis, econometric tools, and comparative district performance assessment.

Research Questions

The current study aims to address the following research topics in light of the debate and literature review mentioned above: What is Odisha's marine fish production's long-term trend? In terms of the increase of marine fish production, how does Ganjam district stack up against other coastal districts? Has the growth of Ganjam district been noticeably greater than that of other districts? Are district-to-district variations in marine fish production statistically significant? What might be causing the marine fisheries in Ganjam district to flourish so quickly? Does Ganjam district exhibit convergence with Odisha's main marine fishing districts? What policy ramifications result from production analysis at the district level? The study aims to provide empirical insights into the growth dynamics of emerging marine fisheries districts and advance knowledge of regional fisheries development by addressing these topics.

III. OBJECTIVES

With particular reference to Ganjam district, the current study attempts to analyze the growth, trend, and district-wise performance of marine fish production in Odisha. The study specifically looks at the long-term growth pattern of marine fish production in Odisha, compares Ganjam district's production performance with that of other coastal districts, measures the growth rate and Compound Annual Growth Rate (CAGR) of marine fish production, analyzes decadal and moving average trends in production, and uses statistical tools like ANOVA and correlation analysis to determine whether there are significant differences in production levels across districts.

Hypotheses

The study develops the following theories in light of these goals.

H_0 (Null Hypothesis): The production of marine fish does not differ considerably amongst Odisha's coastal districts, and Ganjam district's growth in production is not significantly different from that of other districts.

H_1 (Alternative Hypothesis): The production of marine fish varies greatly among the coastal districts, with Ganjam district exhibiting noticeably greater growth than other districts.

In order to determine if Ganjam district has become an important and quickly expanding contributor to Odisha's marine fisheries sector, the study analyzes these hypotheses utilizing growth analysis, CAGR, ANOVA, and correlation methodologies.

IV. METHODOLOGY

Data Sources

The current analysis is solely based on secondary data about Odisha's marine fish output, with a focus on the Ganjam district. For the six coastal districts of Odisha—Balasore, Bhadrak, Jagatsinghpur, Kendrapara, Puri, and Ganjam—district-by-district data on marine fish output were gathered during a 24-year period, from 2000–01 to 2023–24. The information was gathered from official publications of the Government of Odisha's Department of Fisheries, reports from the Marine Fisheries Census, and relevant statistics manuals. These districts were chosen because they comprise the state's entire maritime fishing belt and serve as the foundation of Odisha's marine fisheries economy. The dataset is used to analyze long-term production trends, district-wise growth patterns, and Ganjam district's relative performance. It contains annual marine fish production measured in metric tons (MT). In order to investigate the dynamics of marine fisheries development, the study also makes use of derived statistical indicators such growth rates, moving averages, compound annual growth rates, and correlation coefficients.

Analytical Landscape

The study examines trends and growth patterns in marine fish production using a quantitative and descriptive analytical methodology. The data was analyzed using a variety of statistical methods.

The basic growth rate calculation was applied to analyze the overall increase in marine fish production:

$$\text{Growth Rate}(\%)=\frac{\text{Final}-\text{Initial}}{\text{Initial}} \times 100$$

This approach aids in comprehending the production growth % during the research era. Ganjam district's growth performance was compared to those of other coastal districts using this method.

The Compound Annual Growth Rate (CAGR) was computed using the following formula in order to more precisely measure long-term growth trends:

$$\text{CAGR}=\left(\frac{\text{Final Value}}{\text{Initial Value}}\right)^{1/n}-1$$

Where:

- Production in 2023–2024 is represented by Final Value.
- Production in 2000–01 is represented by the first value.
- n is the number of years. By eliminating short-term swings and displaying the average yearly growth rate, CAGR offers a more accurate indicator of long-term growth.

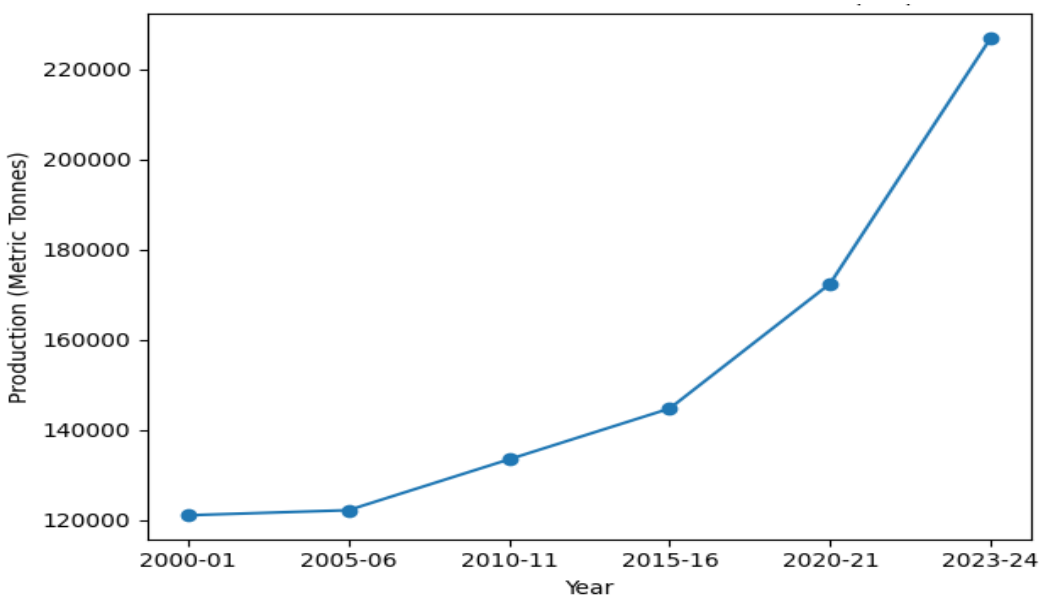
A five-year moving average was computed to smooth out short-term swings and spot long-term patterns. By lessening the influence of year-to-year fluctuations brought on by market and environmental factors, this approach aids in determining the underlying growth pattern.To determine the relative performance of coastal districts, a district-wise comparative growth analysis was carried out. Despite having a comparatively smaller production base, Ganjam was found to be the district with the quickest rate of growth. A one-way ANOVA test was used to determine whether variations in marine fish production between districts were statistically significant. The ANOVA method aids in identifying whether differences in production between districts are caused by structural changes like infrastructure, technology, and fishing resources, or by random fluctuations. The relationship between production patterns across districts was investigated using a Pearson correlation matrix. This made it easier to determine if Ganjam district's growth patterns are consistent with those of other coastal districts and represent shared technology and policy impacts. Production patterns and district contributions were graphically represented using techniques including correlation heatmaps, trend graphs, and district share diagrams. These graphical methods enhance comprehension and offer lucid insights into the dynamics of marine fisheries growth. Ganjam district received special attention in order to comprehend its growth performance, output patterns, and relative standing among coastal districts. The report highlights Ganjam's growing significance in Odisha's marine fishing sector by comparing its performance with state averages and other districts utilizing growth rates, CAGR, and decadal analysis.

V. ANALYSIS AND FINDINGS

Trend of Fish Production in Odisha

Figure-2 demonstrates a distinct and steady increase in marine fish output from 2000–01 to 2023–24. Production rose from over 121086 metric tonnes in 2000–01 to roughly 226953 metric tonnes in 2023–2024, demonstrating the marine fisheries industry's significant long-term expansion. Production only slightly increased during the first few years (2000–01 to 2005–06). However, starting in 2010–11, the growth became more noticeable due to advancements in fisheries infrastructure, mechanization of fishing vessels, and government support for the fishing industry. There is a moderate growth between 2015–16 and 2020–21, but the biggest increase is between 2020–21 and 2023–24. This suggests that marine fishing operations are expanding quickly, probably due to improved technology, market demand, and cooperative engagement. Overall, the graph shows a consistent and quickening growth trajectory, indicating the growing economic significance of marine fishing in Odisha's coastal economy.

Figure-2: Trends of Fish Production



Source: Authors' own compilation from mentioned data sources

Growth Trend of Marine Fish Production in Odisha

The entire expansion of the state's marine fisheries industry is reflected in the trajectory of total marine fish output in Odisha from 2000–01 to 2023–24, which shows a consistent and notable increase (Table-1). Over the course of the study, total production grew by around 87%, from 121086 MT in 2000–01 to 226953 MT in 2023–24. Between 2000–01 and 2015–16, the rise seems to have been slow. However, after 2015–16, it increased more quickly, especially between 2020–21 and 2023–24. This suggests that marine fishing activities have accelerated, fishing

technologies have improved, and fisheries management techniques have improved. The performance of Ganjam district, whose marine fish production rose significantly from 6777 MT to 23948 MT during the same time, likewise reflects this general state-level growth tendency. Notably, Ganjam's growth rate (about 253%) is significantly greater than the state average, suggesting that the district is expanding more quickly than Odisha's marine fishing industry as a whole. This implies that fisheries development projects like motorizing fishing boats, building fish landing facilities like Gopalpur, bolstering fisher cooperatives, and enhancing market connections are helping Ganjam more and more. As a result, the table shows that although marine fish output in Odisha has increased significantly overall, Ganjam district has become one of the fastest-growing producers.

Table-1: Total Marine Fish Production Growth

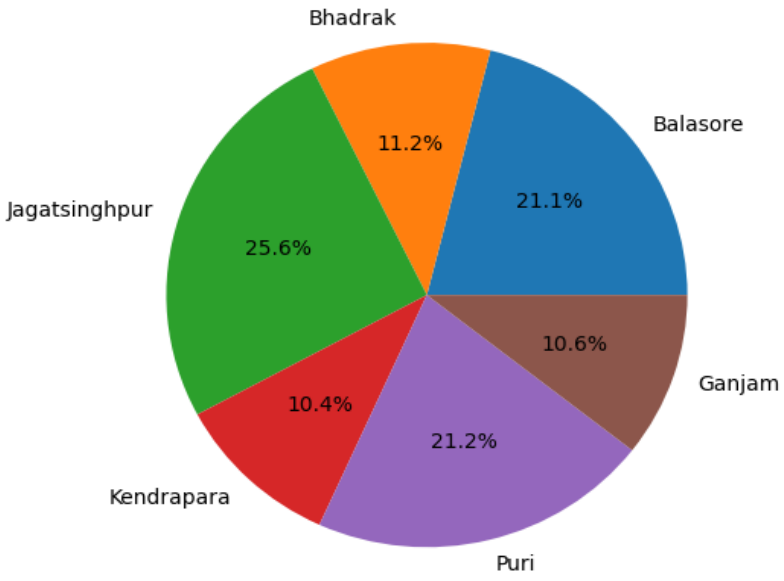
Year	Total Production (MT)
2000–01	121086
2005–06	122213
2010–11	133479
2015–16	144754
2020–21	172469
2023–24	226953

Source: Authors' own calculation from mentioned data sources

District Production in 2023–24

There is a noticeable fluctuation in the contribution of coastal districts in Figure-3 that depicts the district-wise percentage of marine fish production in Odisha for 2023–2024.

Figure-3: District Share of Marine Fish Production



Source: Authors' own compilation from mentioned data sources

The districts that contribute most to the state's marine fisheries production are Jagatsinghpur (25.6%), Puri (21.2%), and Balasore (21.1%). Kendrapara produces roughly 10.4% of the overall production, while Bhadrak contributes roughly 11.2%. According to the figure, Ganjam district specifically provides about 10.6% of Odisha's total marine fish production, which is comparatively less than the top districts. A smaller fishing fleet, fewer landing sites, or a historically lower output base could all be contributing factors to this relatively reduced percentage. However, Ganjam has shown impressive growth throughout the years, as evidenced by its high CAGR and decadal growth rates, despite its little share of overall production. This indicates that Ganjam is becoming a rapidly developing marine fisheries region, even though it is not yet one of the top-producing districts. Growing fishing activity, better infrastructure, and an increase in the involvement of fisher cooperatives are all contributing to Ganjam's growing role in Odisha's coastal fisheries economy.

Trend Analysis of Marine Fish Production in Ganjam

According to the trend research (Table-2), the production of marine fish in the Ganjam district increased significantly and steadily between 2000–01 and 2023–2024. From 6777 metric tons in 2000–01 to 10034 metric tonnes in 2005–06, the production rose, suggesting an early stage of marine fishing activity expansion. The following years saw a small increase, reaching 11276 metric tons in 2010–11 and 11881 metric tonnes in 2015–16, which is indicative of steady advancements in infrastructure and fishing methods. After 2015–16, there is a more pronounced increase, with production rising to 15091 metric tonnes in 2020–21 and then sharply climbing to 23948 metric tonnes in 2023–24. Overall, Ganjam's marine fish production grew by over 253% throughout the course of the study, which is significantly more than the state's average growth. The motorization of fishing vessels, the growth of fishing infrastructure, the improvement of fish landing sites like Gopalpur, and the increased involvement of fisher cooperatives and government fisheries development programs are some of the reasons for this notable increase. The pattern makes it evident that Ganjam district is becoming a significant contributor to Odisha's marine fisheries output.

Table-2: Marine Fish Production in Ganjam

Year	Production (MT)
2000–01	6777
2005–06	10034
2010–11	11276
2015–16	11881
2020–21	15091
2023–24	23948

Source: Authors' own calculation from mentioned data sources

Comparative Growth among Districts

There are notable differences in the growth of marine fish production between 2000–01 and 2023–24, according to a comparative growth analysis of the coastal districts of Odisha (Table-3). In comparison to other districts, Balasore's production

grew steadily but more slowly, from 34915 MT to 47820 MT, a rather moderate 36.9% increase. Bhadrak demonstrated a significant increase from 9350 MT to 25381 MT, representing a gain of 171.4%, indicating a significant improvement in fishing operations and infrastructure. One of the main marine fishing districts, Jagatsinghpur, saw a 71.4% increase in production from 33899 MT to 58101 MT, demonstrating the consistent growth of marine fisheries. With an overall growth rate of 78.4%, Kendrapara also saw significant increase, going from 13206 MT to 23559 MT. Puri also performed well, with production rising from 22939 MT to 48143 MT, a gain of 109.9%, demonstrating the district's important contribution to the development of marine fisheries. But of all the coastal districts, Ganjam district had the fastest growth rate, with production jumping from 6777 MT in 2000–01 to 23948 MT in 2023–24—an astounding 253.4% rise. This impressive growth indicates that the district's marine fishing operations are expanding quickly, perhaps as a result of better fishing infrastructure, mechanized fishing boats, the creation of fish landing facilities, and more fisher cooperative participation. Overall, the table shows that Ganjam is becoming the fastest-growing marine fisheries district in Odisha, but traditional high-production districts like Jagatsinghpur and Puri continue to contribute considerably to marine fisheries.

Table-3: Initial and Final Production

District	2000–01	2023–24	Growth (%)
Balasore	34915	47820	36.9
Bhadrak	9350	25381	171.4
Jagatsinghpur	33899	58101	71.4
Kendrapara	13206	23559	78.4
Puri	22939	48143	109.9
Ganjam	6777	23948	253.4

Source: Authors' own calculation from mentioned data sources

Five-Year Moving Average Trend

To smooth short-term fluctuations, a five-year moving average was calculated (Table-4). Despite significant short-term swings, the five-year moving average trend of Odisha's total marine fish output clearly demonstrates an upward long-term tendency. The average production rose gradually in the first part of the study period, from roughly 117000 MT in 2000–2004 to about 129000 MT in 2005–2009. Between 2010 and 2014, there was a minor stability (about 128000 MT), indicating brief fluctuations that might have been caused by market or environmental variables. However, there is a noticeable rising tendency from 2015 to 2019 (about 152000 MT), which picks up even more speed between 2020 and 2024 (around 202000 MT). This indicates that marine fisheries have significantly expanded thanks to improved technology, mechanization, and fisheries development initiatives. The production performance of the Ganjam district, where marine fish production exhibits consistent rise over the same time periods, likewise reflects this rising trend. The district has profited from the general rise of the fishing industry, as seen by Ganjam's output increase, which is higher than the state average in percentage terms. The development of fishing infrastructure, the fortification of fisher cooperatives, the growth of motorized fishing vessels, and enhanced fish landing facilities like Gopalpur could all be contributing factors to the steady increase. As a result, the moving average trend shows that Ganjam is becoming a

quickly rising fisheries district and actively contributing to the larger growth momentum of Odisha's marine fisheries.

Table-4: Moving Average of Total Production

Period	Average Production (MT)
2000–2004	117000
2005–2009	129000
2010–2014	128000
2015–2019	152000
2020–2024	202000

Source: Authors' own calculation from mentioned data sources

District Wise Compound Annual Growth Rate (CAGR) Analysis

Significant differences in long-term growth patterns are revealed by the Compound Annual Growth Rate (CAGR) analysis of marine fish production throughout Odisha's coastal districts from 2000–01 to 2023–24 (Table-5). With a CAGR of 1.37%, Balasore's growth was comparatively slow, suggesting a steady but constrained increase in marine fish output during the research period. With CAGR values of 2.37% and 2.55%, respectively, Jagatsinghpur and Kendrapara demonstrated moderate growth, whereas Puri performed significantly better with a CAGR of 3.27%, indicating advancements in fishing infrastructure and marine activities. With a CAGR of 4.43%, Bhadrak showed significant growth, suggesting noteworthy advancements in the fishing industry. Ganjam district, on the other hand, has the highest CAGR of 5.64%, which is far higher than the state average of 2.77%. Over the course of the study, Ganjam's marine fish production grew by 3.53 times, from 6777 MT in 2000–01 to 23,948 MT in 2023–24. This impressive growth indicates that the district's marine fisheries are expanding quickly. This is probably due to a number of causes, including greater market access, increased participation from fisher cooperatives, the construction of fishing infrastructure and landing sites like Gopalpur, and the motorization of fishing vessels. Ganjam began with a lesser production base than other coastal districts, but its strong CAGR shows that it is becoming one of Odisha's fastest-growing marine fisheries districts.

Table-5: Compound Annual Growth Rate (CAGR) of Marine Fish Production

District	Production 2000–01 (MT)	Production 2023–24 (MT)	Growth Multiple	CAGR (%)
Balasore	34,915	47,820	1.37	1.37%
Bhadrak	9,350	25,381	2.72	4.43%
Jagatsinghpur	33,899	58,101	1.71	2.37%
Kendrapara	13,206	23,559	1.78	2.55%
Puri	22,939	48,143	2.1	3.27%
Ganjam	6,777	23,948	3.53	5.64%
Total Odisha	1,21,086	2,26,953	1.87	2.77%

Source: Authors' own calculation from mentioned data sources

Decadal Growth of Marine Fish Production

The decadal growth analysis of Odisha's marine fish production from 2000–01 to 2023–24 (Table-6) shows significant differences between coastal districts, with Ganjam district consistently exhibiting robust development throughout. Ganjam's production rose from 6777 MT to 11276 MT over the first ten years (2000–2010), a notable rise of 66.39% and the greatest of the coastal districts during that time. This suggests that the district's maritime fishing operations are only getting started. Production rose to 15091 MT in the second decade (2010–2020), representing a growth of 33.83%, and continued to outpace the state's general growth during that time. Production increased significantly to 23948 MT in the most recent era (2020–2024), representing a gain of 58.71%. Ganjam shows a steady upward trend across all decades, in contrast to other districts like Balasore and Jagatsinghpur, which saw comparatively sluggish growth. Even though districts like Kendrapara saw strong development in the most recent time frame, their prior performance was erratic, including negative growth in the first ten years. On the other hand, Ganjam's consistent growth indicates that the district's marine fisheries are still developing. The expansion of fish landing sites like Gopalpur, increasing mechanization of fishing vessels, strengthening of fisher cooperatives and government fisheries development initiatives, and improvements in fishing infrastructure could all be responsible for this impressive growth. Overall, the data shows that throughout the past 20 years, Ganjam has become one of Odisha's most dynamic and quickly expanding marine fishing districts.

Table-6: Decadal Growth of Marine Fish Production in Odisha (MT)

District	2000–01	2010–11	Growth % (2000–10)	2020–21	Growth % (2010–20)	2023–24	Growth % (2020–24)
Balasore	34915	35183	0.77	45085	28.14	47820	6.07
Bhadrak	9350	12631	35.09	15583	23.37	25381	62.88
Jagatsinghpur	33899	35656	5.18	43634	22.38	58101	33.16
Kendrapara	13206	6853	-48.11	11076	61.63	23559	112.7
Puri	22939	31880	38.98	42000	31.74	48143	14.63
Ganjam	6777	11276	66.39	15091	33.83	23948	58.71
Total Odisha	121086	133479	10.23	172469	29.2	226953	31.59

Source: Authors' own calculation from mentioned data sources

Linkages and Variations in Marine Fish Production

The production levels of marine fish vary significantly amongst Odisha's six coastal districts, according to the ANOVA summary table (Table-7). It is evident that the variations in marine fish output between the districts are statistically significant because the calculated F-value (118.59) is significantly greater than the essential F-value (2.28) at the 5% level of significance and the p-value (3.59×10^{-48}) is significantly below 0.05. This indicates that the production of marine fish is not consistent throughout the coastal districts and that district-specific elements like fishing infrastructure, the quantity of mechanized boats, the strength of fisher cooperatives, and the availability of marine resources all have a significant impact on production levels. Even if Ganjam district's average output level is lower than that of top districts like Jagatsinghpur, Balasore, and Puri, the ANOVA test's

statistical significance indicates that these disparities are genuine and not the result of chance. Simultaneously, Ganjam's robust economic performance over the years indicates that it is progressively closing this disparity by expanding marine fishing operations, strengthening institutional support through fisher cooperatives, and upgrading fisheries infrastructure. Because of its rapid growth trajectory, Ganjam has a considerable potential to enhance its relative position in the future, even though it now belongs to the moderate production group, according to the ANOVA results.

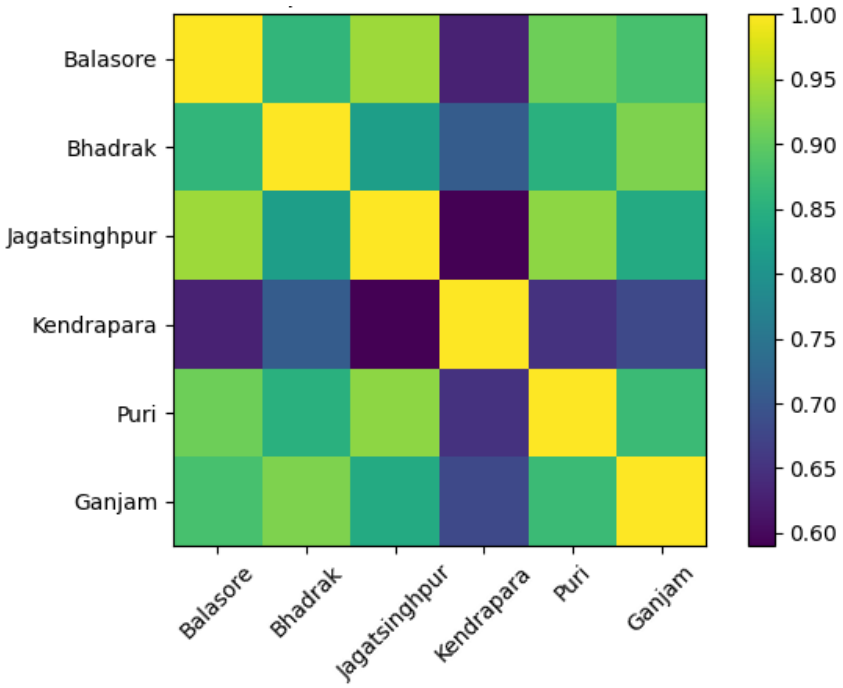
Table-7: ANOVA Summary Marine Fish Production across Coastal Districts

Source of Variation	Sum of Squares (SS)	df	Mean Square (MS)	F-value	P-value	F Critical (α = 0.05)
Between Districts	1.59×10^{10}	5	3.18×10^{9}	118.59	3.59×10^{-48}	2.28
Within Districts	3.78×10^{9}	138	2.74×10^{7}			
Total	1.97×10^{10}	143				

Source: Authors' own calculation from mentioned data sources

The majority of Odisha's coastal districts have substantial positive correlations with one another in of marine fish production, suggesting that their production trends follow a similar path over time (Figure-4).

Figure-4: Correlation Heatmap of Marine Fish Production across Districts



Source: Authors' own compilation from mentioned data sources

With regard to Ganjam district specifically, the heatmap shows strong positive correlations with the majority of other coastal districts, especially Bhadrak (≈0.92), Balasore (≈0.88), and Puri (≈0.87), indicating that changes in marine fish production in these districts typically coincide with changes in Ganjam. This strong correlation suggests that production patterns are influenced similarly across districts by common factors like state fisheries policies, technological advancements in fishing, mechanization of fishing vessels, development of fish landing centers, and environmental conditions along the Odisha coast. Additionally, Ganjam exhibits a comparatively high correlation (≈0.84) with Jagatsinghpur, another significant marine fishing district, suggesting similar growth tendencies in the development of marine fisheries. However, the correlation between Ganjam and Kendrapara (≈0.68) is somewhat lower, indicating some variation in production patterns that may be caused by variations in resource availability, fishing infrastructure, or shoreline characteristics. Overall, the heatmap indicates that even though Ganjam's production level is comparatively low when compared to some of the state's top districts, its growth trend closely corresponds with Odisha's overall marine fisheries development, underscoring its growing integration and growing significance in the state's coastal fisheries economy.

Discussion

The structural expansion of the marine fisheries sector is confirmed by the empirical analysis of marine fish output in Odisha, which shows a distinct long-term rising trend during the research period (2000–01 to 2023–24). The total amount of marine fish produced rose by approximately 87%, from 1,21,086 MT to 2,26,953 MT. This result is in line with previous research (Devaraj & Vivekanandan, 1999; Ayyappan & Diwan, 2006; Government of India, 2023) that found steady growth in Indian fisheries as a result of mechanization, infrastructure expansion, and policy support. The findings of Dash et al. (2020), who noted a consistent rise in fisheries production in Odisha as a result of technological advancements and fisheries development initiatives, are also supported by the observed growth pattern.

The findings unequivocally show that Ganjam district has become one of Odisha's fastest-growing marine fishing zones. Ganjam's marine fish production grew at a pace of almost 253 percent from 6,777 MT in 2000–01 to 23,948 MT in 2023–2024, which is far greater than the state average. This result bolsters the claim made by Kumar and Prakash (2017) that areas with lower baseline production frequently see stronger development as a result of technological diffusion and infrastructure expansion. The findings also support the findings of Sahoo and Mishra (2018) and Mohanty (2015), who observed the growing significance of coastal areas like Ganjam in Odisha's fisheries industry.

This finding is further supported by the Compound Annual Growth Rate (CAGR) research, which reveals that Ganjam had the highest CAGR (5.64%) of any coastal district in comparison to the state average of 2.77 percent. This implies that compared to typical high-production districts, Ganjam's fisheries industry has grown far more quickly. Schumpeter's innovation theory (1934), which highlights that technical adoption propels output development, is consistent with this pattern. This faster rise could be explained by the proliferation of mechanized fishing vessels, enhanced landing facilities like Gopalpur, and greater market connectivity.

Kurien (2005) and Bavinck et al. (2018) reached similar outcomes, highlighting the need of modernization and institutional assistance in raising fisheries productivity.

Ganjam maintained consistently high growth over all decades (66.39% during 2000–2010, 33.83% during 2010–2020, and 58.71% during 2020–2024), according to the decadal growth study, indicating continuous structural improvement rather than transient variations. This result corroborates the time-series growth observations of Rao et al. (2018), who contended that cumulative advancements in infrastructure, capital formation, and fisheries governance are the main drivers of long-term fisheries growth. The results also support Solow's (1956) production growth theory, which highlights the significance of capital accumulation and technological advancement in output increase.

Because the computed F-value (118.59) is significantly higher than the critical value and the p-value is statistically significant, the ANOVA findings show statistically significant differences in marine fish output among the six coastal districts. This demonstrates that production variations at the district level are structural rather than random. This result is in line with that of Panda and Sahu (2021), who also discovered notable regional differences in fisheries productivity as a result of variations in institutional strength, infrastructure, and fishing capability. The findings also corroborate Myrdal's (1957) theory of regional development, which contends that unequal access to institutional resources and infrastructure leads to regional differences in growth.

Strong positive correlations between Ganjam and other significant fishing districts like Bhadrak (0.92), Balasore (0.88), and Puri (0.87) are revealed by the correlation study, indicating that production trends move in tandem as a result of shared environmental, technological, and policy factors. The results of Pauly and Zeller (2016) and Vivekanandan et al. (2009), who emphasized the impact of climatic and environmental factors on marine fish production patterns, are supported by this. The findings corroborate FAO's (2020) assertion that the expansion of fisheries frequently reflects more significant structural shifts that impact the entire coastal economy.

The results also show that Ganjam's high growth rate indicates tremendous future potential, even though its percentage of overall production (about 10.6%) is still smaller than that of leading districts like Jagatsinghpur and Puri. The Blue Economy framework (World Bank, 2017; OECD, 2021), which emphasizes the significance of developing coastal regions in attaining sustainable marine economic development, is in line with this statement.

Overall, the findings show that improvements in infrastructure, institutional involvement, technology adoption, and policy support are strongly correlated with the rise of marine fish output in Ganjam district. The institutional economic perspective of North (1990), which highlights the role of institutions in fostering economic growth, is substantially supported by this study. The findings of Jentoft (2000) and Salagrama (2012), who emphasized the significance of collective institutions in fisheries development, are further supported by the growing influence of fisher cooperatives and government fisheries programs.

As a result, the current study's findings both support and add to previous empirical findings by showing that the Ganjam district is an example of a fisheries that has grown quickly due to structural advancements. Thus, the study demonstrates the growing significance of Ganjam in Odisha's marine fisheries economy and closes a significant gap in district-level fisheries studies.

VI. CONCLUSION

The current study suggests that over the past 20 years, Odisha's marine fish production has grown steadily and significantly, showing the growing economic significance of the fishing industry in coastal development and the creation of livelihoods. The empirical findings show that Ganjam district has become the fastest-growing marine fisheries district, with a remarkable growth of roughly 253 percent and the highest CAGR among all coastal districts, while traditional marine fishing districts like Jagatsinghpur and Puri continue to dominate in terms of total production. This expansion is structural and supported by advancements in fisheries infrastructure, mechanization of fishing vessels, institutional participation, and supporting government policies, according to statistical findings from growth analysis, decadal trends, ANOVA, and correlation analysis. Ganjam's overall output share is still small, but its steady development pattern points to significant future potential and growing integration with Odisha's larger marine fishing economy. As a result, the study indicates that Ganjam is an emerging hub for the growth of marine fisheries and shows how institutional strengthening, technology adoption, and infrastructural development may turn comparatively low-production areas into high-growth districts. All things considered, the study underscores the significance of district-level empirical analysis for comprehending regional differences and stresses the role of focused fisheries development policies in fostering inclusive and sustainable coastal economic growth.

Policy Implications

The current study's conclusions point to a number of significant policy implications for bolstering Odisha's marine fisheries development, especially in districts with growing growth like Ganjam. In order to lower post-harvest losses and increase value realization, Ganjam's high growth rate highlights the need for focused district-level fisheries policies that emphasize infrastructure development, such as contemporary fish landing centers, cold storage facilities, and enhanced transportation networks (World Bank, 2012; Department of Fisheries, Odisha, 2022). Through the promotion of motorized boats, navigation systems, and scientific fishing techniques, which are known to increase output, the results further emphasize the significance of technical modernization (Devaraj & Vivekanandan, 1999; Ayyappan & Diwan, 2006). Fishermen's market access and economic security can be further improved by bolstering fisher cooperatives and enhancing institutional credit assistance (Jentoft, 2000; Kurien, 2005). To strengthen the fisheries value chain, the report also highlights the necessity of better market connections, fish processing facilities, and export promotion (OECD, 2021). In keeping with the Blue Economy concept, sustainable fisheries management techniques must be encouraged in order to guarantee long-term resource conservation (FAO, 2022; World Bank, 2017). Overall, the study indicates that a well-rounded approach that incorporates institutional strengthening, technology diffusion, infrastructure investment, and sustainability-focused governance can

further boost the growth of marine fish production in Ganjam district and promote inclusive coastal economic development.

Limitations of the Study

The study mostly concentrates on production trends and is based on secondary data. Due to inconsistent time-series data, variables like fishing effort, capital investment, labor involvement, and cooperative performance could not be included. For a more thorough socioeconomic analysis, primary survey data may be included in future research.

VII. REFERENCES

Allison, E. H., & Ellis, F. (2001). The livelihoods approach and management of small-scale fisheries. *Marine Policy, 25*(5), 377–388.

Ayyappan, S., & Diwan, A. D. (2006). Fisheries development in India. *Fishing Chimes, 26*(1), 10–17.

Bavinck, M., Jentoft, S., & Scholtens, J. (2018). Fisheries as social struggle: A reinvigorated social science research agenda. *Marine Policy, 94*, 46–52.

Box, G. E. P., & Jenkins, G. M. (1976). *Time series analysis: Forecasting and control*. Holden-Day.

Central Marine Fisheries Research Institute (CMFRI). (2016). *Marine fisheries census*. CMFRI.

Central Marine Fisheries Research Institute (CMFRI). (2020). *Annual marine fish landings in India*. CMFRI.

Central Marine Fisheries Research Institute (CMFRI). (2022). *Marine fish landings report*. CMFRI.

Dash, M., Pradhan, B., & Sethi, N. (2020). Growth trends in the fisheries sector of Odisha. *Indian Journal of Fisheries Economics, 12*(2), 45–58.

Department of Animal Husbandry & Fisheries. (2021). *Annual fisheries report*. Government of India.

Department of Fisheries, Government of Odisha. (2022). *Fisheries statistics of Odisha*. Government of Odisha.

Devaraj, M., & Vivekanandan, E. (1999). Marine fish production trends in India. *CMFRI Bulletin, 45*.

FAO. (2020). *The state of world fisheries and aquaculture*. Food and Agriculture Organization.

FAO. (2022). *The state of world fisheries and aquaculture 2022*. Food and Agriculture Organization.

Government of India. (2022). *Pradhan Mantri Matsya Sampada Yojana report*. Ministry of Fisheries.

Government of India. (2023). *Handbook on fisheries statistics*. Ministry of Fisheries.

Gujarati, D. N. (2012). *Basic econometrics* (5th ed.). McGraw Hill.

Harvey, A. C. (1990). *Forecasting, structural time series models and the Kalman filter*. Cambridge University Press.

Hilborn, R., et al. (2020). Effective fisheries management instrumental in improving fish stock status. *Proceedings of the National Academy of Sciences, 117*(4).

ICSF. (2019). *Small-scale fisheries report*. International Collective in Support of Fishworkers.

Jentoft, S. (2000). Legitimacy and fisheries management. *Marine Policy, 24*(2), 141–148.

Kumar, R., & Prakash, S. (2017). Fisheries development and regional growth. *Economic Affairs, 62*(3), 473–480.

Kurien, J. (2005). *Responsible fish trade and food security*. FAO Fisheries Technical Paper.

Mohanty, B. (2015). Fisheries development in Odisha. *Orissa Economic Journal, 47*(1).

Myrdal, G. (1957). *Economic theory and underdeveloped regions*. Duckworth.

National Fisheries Development Board. (2020). *Fisheries development in India*. NFDB.

North, D. C. (1990). *Institutions, institutional change and economic performance*. Cambridge University Press.

OECD. (2021). *Rebuilding fisheries: The way forward*. OECD Publishing.

Panda, S., & Sahu, N. (2021). District-wise fisheries growth analysis. *Indian Economic Review, 56*(2).

Pauly, D., & Zeller, D. (2016). Catch reconstructions reveal global fisheries trends. *Nature Communications*.

Rao, K., Sathiadhas, R., & Najmudeen, T. (2018). Fisheries economics in India. *Indian Journal of Fisheries*.

Sahoo, D., & Mishra, P. (2018). Marine fisheries of Odisha. *Journal of Coastal Development*.

Salagrama, V. (2012). *Climate change and fisheries*. FAO.

Schumpeter, J. A. (1934). *The theory of economic development*. Harvard University Press.

Solow, R. M. (1956). A contribution to the theory of economic growth. *Quarterly Journal of Economics, 70*(1), 65–94.

Tripathy, S., & Barik, R. (2019). Growth analysis of the fisheries sector. *Agricultural Economics Research Review*.

Vivekanandan, E., et al. (2009). Climate change impacts on marine fisheries. *Current Science*.

World Bank. (2012). *Hidden harvest: The global contribution of fisheries to development*. World Bank.

World Bank. (2017). *The blue economy: Sustainable development of ocean resources*. World Bank.