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Land Use Change And Livelihood Transition Under Aquaculture Growth: Evidence From Nandakumar Block Of West Bengal, India

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Abstract: The Nandakumar Block of Purba Medinipur district, West Bengal, has experienced a significant transformation in land use and rural livelihoods over the past three decades, primarily driven by the rapid expansion of aquaculture. This study examines the spatio-temporal dynamics of land use and land cover (LULC) change and its socio-economic implications using a combination of primary and secondary data sources. A household survey of 47 respondents, supplemented by field observations, provides insights into occupational shifts, income patterns, and livelihood transformations, while LULC data for the years 1991, 2001, 2011, and 2021 are analyzed to assess land conversion trends. The findings reveal that aquaculture expansion is a relatively recent phenomenon, intensifying particularly during the period 2011–2021, when large areas of agricultural and fallow land were converted into water bodies. This process reflects a transition from a traditionally agrarian economy to a market-oriented aquaculture system. The occupational structure analysis indicates a sharp decline in agriculture-based livelihoods alongside a substantial increase in aquaculture-dependent households, highlighting a fundamental restructuring of rural employment. Income analysis further demonstrates that aquaculture has emerged as the most economically rewarding activity, with average monthly household income increasing significantly compared to agriculture and other occupations. As a result, aquaculture has contributed to improved living standards, enhanced economic mobility, and diversification of rural livelihoods. However, the study also identifies critical challenges, including the reduction of agricultural land, growing dependence on market forces, and potential socio-economic inequalities.

Overall, the study concludes that aquaculture has become a key driver of rural transformation in Nandakumar Block, offering substantial economic benefits while simultaneously raising concerns regarding environmental sustainability and long-term resilience. The findings underscore the need for integrated policy interventions to promote sustainable and inclusive aquaculture development.

Keywords: Aquaculture, Land Use Change, Socio-economic Transformation, Livelihood Shift, Nandakumar Block, West Bengal

1. INTRODUCTION

Aquaculture has emerged as one of the fastest-growing food production sectors globally, contributing significantly to food security, livelihood diversification, and rural economic development (Food and Agriculture Organization, 2020). In developing countries such as India, the rapid expansion of aquaculture is closely linked with changing land use patterns, where traditional agricultural lands are increasingly being converted into fish and shrimp farming zones due to their higher economic returns (Ahmed & Thompson, 2019; Edwards, 2015). This transition reflects a broader shift in rural economies from subsistence agriculture to market-oriented production systems.

In the eastern coastal regions of India, particularly in West Bengal, aquaculture has gained prominence due to favourable agro-climatic conditions, availability of water resources, and increasing demand for fish and shrimp in both domestic and international markets (Beveridge, 2004). The Purba Medinipur district, characterized by its proximity to coastal ecosystems and riverine networks, has witnessed a substantial rise in aquaculture activities over the past few decades. Among its administrative units, the Nandakumar Block represents a significant case of agrarian transformation, where agricultural land is rapidly being replaced by aquaculture ponds and fisheries.

Land use and land cover (LULC) change associated with aquaculture expansion has important environmental and socio-economic implications. On the one hand, aquaculture contributes to income generation, employment opportunities, and improved living standards among rural households (FAO, 2018). On the other hand, unregulated expansion can lead to ecological degradation, including soil salinization, water pollution, and loss of agricultural biodiversity (Froehlich et al., 2018). Moreover, such transformations often alter traditional livelihood structures, leading to increased dependence on market forces and private sector inputs, particularly in commercial shrimp farming systems (De Silva & Anderson, 2009).

The application of Geographic Information Systems (GIS) and remote sensing techniques has proven to be highly effective in analyzing spatial and temporal changes in land use patterns. These tools enable researchers to identify aquaculture hotspots, assess the extent of land conversion, and evaluate environmental impacts with greater precision (Maity, 2014). Despite the growing body of literature on aquaculture and land use change, there remains a need for localized, micro-level studies that integrate spatial analysis with socio-economic field data.

In this context, the present study focuses on the Nandakumar Block of Purba Medinipur district to examine the dynamics of land use transformation from agriculture to aquaculture and its socio-economic implications. By combining primary household survey data with secondary information and spatial analysis, the study aims to provide a comprehensive understanding of how aquaculture expansion is reshaping rural landscapes and livelihoods. The findings are expected to contribute to the formulation of sustainable aquaculture policies that balance economic development with environmental conservation.

2. OBJECTIVES

i. To analyze temporal changes in land use with special reference to aquaculture expansion in Nandakumar Block.

ii. To examine the socio-economic impacts of aquaculture on local communities.

3. STUDY AREA

The present study is conducted in the Nandakumar Community Development (CD) Block, located in the Purba Medinipur district of the state of West Bengal, India (Figure 1). Geographically, the block lies between 22°11′47″ N latitude and 87°55′15″ E longitude, forming part of the lower Gangetic alluvial plains characterized by fertile soils and a dense drainage network. The region falls under the Tamluk subdivision and occupies a strategically significant position due to its proximity to the Haldi River, which plays a crucial role in shaping the local hydrological and economic landscape.

Nandakumar Block is bounded by Mahishadal Block to the east, Moyna Block to the west, Tamluk and Panskura Blocks to the north, and Bhagwanpur-I and Chandipur Blocks to the south. The total geographical area of the block is approximately 165.70 square kilometers**,** comprising 12 Gram Panchayats, around 100 villages (mouzas), and 243 Gram Sansads. The administrative structure is supported by a Panchayat Samiti, and the area is well connected by National Highway 116, enhancing accessibility and market integration.

Physiographically, the study area is part of the coastal plain with low elevation, making it highly susceptible to seasonal flooding, drainage congestion, and riverbank erosion, particularly during the monsoon season. The presence of numerous canals, ponds, and water bodies creates favorable conditions for aquaculture development. However, these same factors also contribute to waterlogging and salinity intrusion in certain areas, influencing land use decisions (Beveridge, 2004).

Climatically, the region experiences a tropical monsoon climate with hot and humid summers, a pronounced monsoon season, and mild winters. The average annual rainfall exceeds 1500 mm, most of which is concentrated between June and September. Such climatic conditions, coupled with abundant surface water resources, provide a conducive environment for fish and shrimp farming (FAO, 2020).

Socio-economically, the population of Nandakumar Block has traditionally been dependent on agriculture as the primary source of livelihood. However, over the past three decades, there has been a noticeable shift towards aquaculture, particularly commercial shrimp farming, driven by higher profitability and increasing market demand. This transition has led to significant land use changes, with large tracts of agricultural land being converted into fisheries and aquaculture ponds.

Despite the economic advantages, the study area faces several developmental challenges, including inadequate institutional credit support, dependence on private technical assistance, and seasonal transport constraints. These issues, combined with environmental concerns such as soil degradation and changes in water quality, make Nandakumar Block an ideal case for examining the complex interactions between land use transformation, aquaculture expansion, and rural livelihoods.

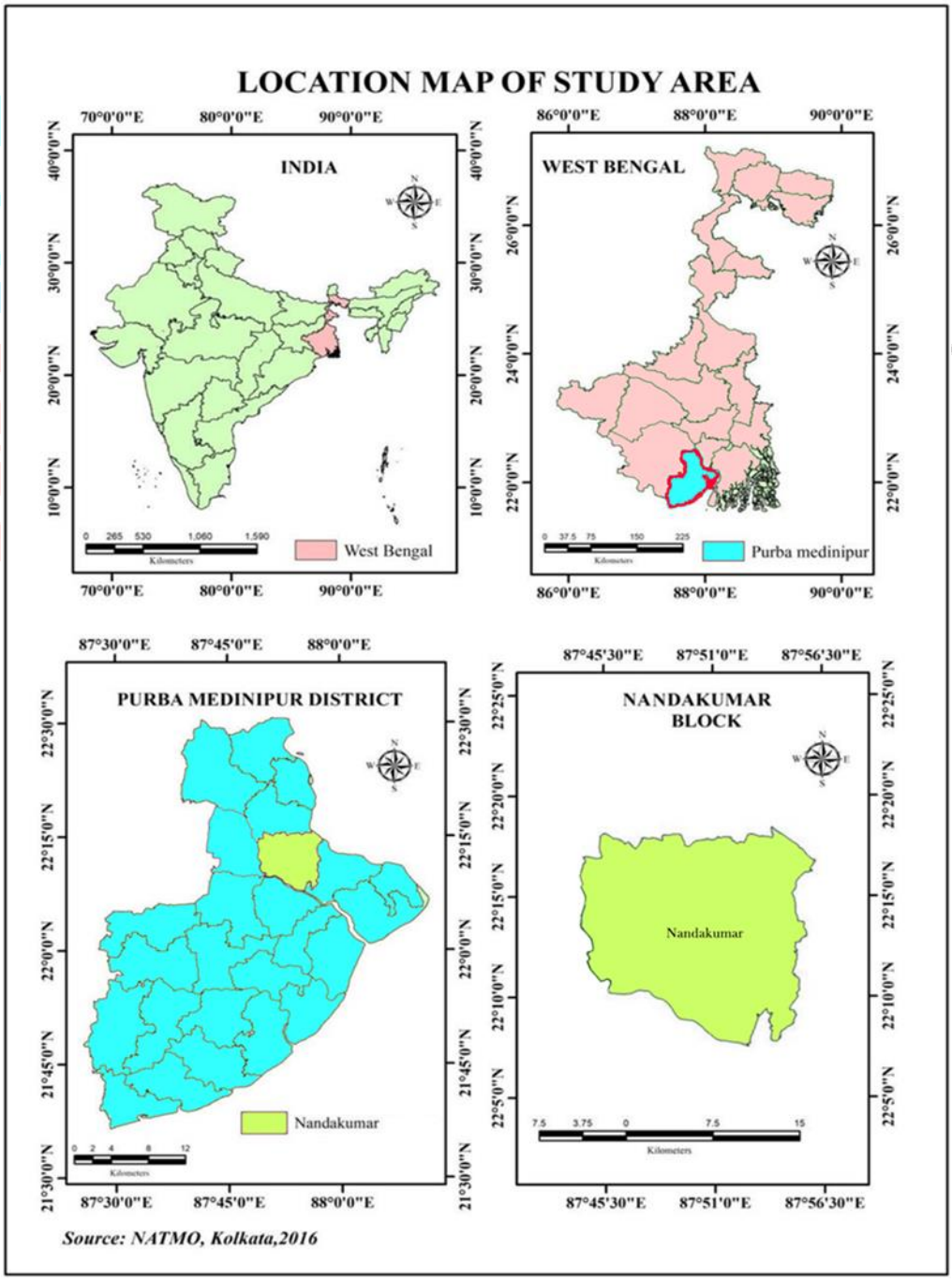


Figure 1: Location Map of Study Area

4. DATABASE & METHODOLOGY

The present study is based on a combination of primary and secondary data sources to examine land use transformation and the socio-economic impacts of aquaculture in Nandakumar Block of Purba Medinipur district. Primary data were collected through a field-based household survey conducted in 2023, covering a total of 47 households selected using purposive sampling techniques (Figure 2). The sample was designed to include households engaged in agriculture, aquaculture, and other livelihood activities to capture the diversity of occupational structures. A structured questionnaire was used to gather information on occupation, income levels, land use practices, and socio-economic conditions. In addition, informal interviews and field observations were conducted to validate and supplement the survey findings.

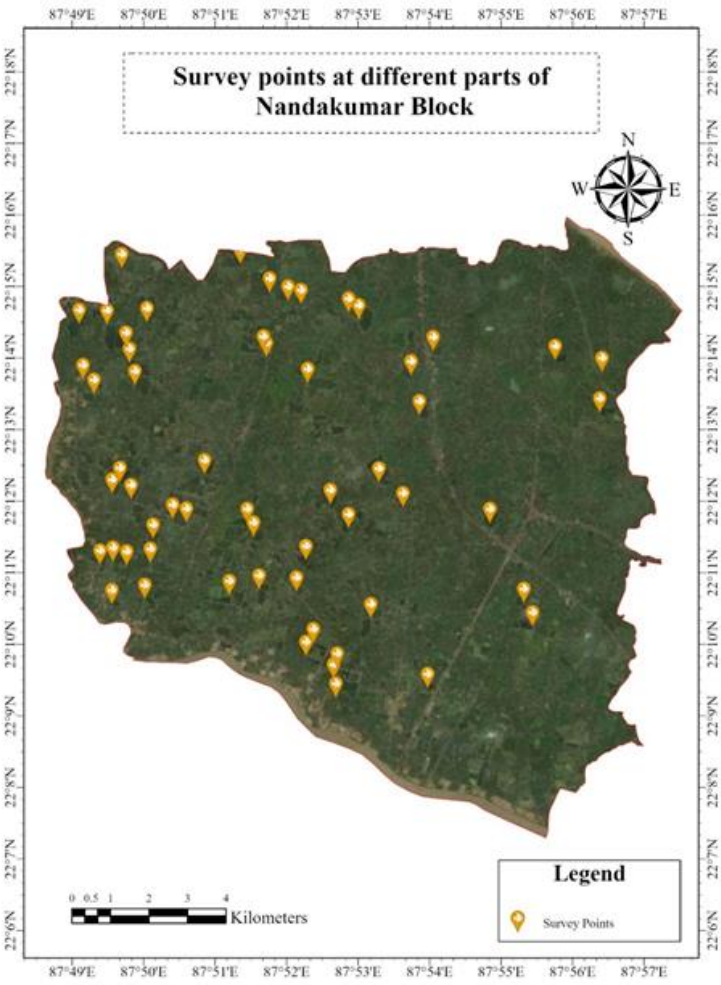


Figure 2: Sample Points of Nandakumar Block

Secondary data were obtained from multiple sources, including District Census Handbooks, Statistical Abstracts, government reports, and published literature**.** Furthermore, land use and land cover (LULC) data for the years 1991, 2001, 2011, and 2021 were compiled and analyzed to understand temporal changes, particularly in relation to aquaculture expansion. The dataset includes major land use categories such as agriculture, vegetation, fallow land, water bodies, and settlements.

The study adopts a mixed-method approach, integrating both quantitative and qualitative techniques. Quantitative analysis was performed using simple statistical tools such as percentage, ratio, and comparative trend analysis to interpret changes in occupational structure and income levels over time. The LULC changes were analyzed using a comparative temporal framework, focusing on the conversion of agricultural and fallow land into water bodies as a proxy for aquaculture expansion. Qualitative insights from field observations were used to interpret the underlying drivers and socio-economic implications of these changes.

Overall, this integrated methodological framework provides a comprehensive understanding of the spatio-temporal dynamics of land use change and its socio-economic impacts in the study area.

5. RESULT AND DISCUSSION

5.1. Aquaculture Expansion in Nandakumar Block (1991–2021)

The temporal analysis of land use and land cover (LULC) transformation in Nandakumar Block reveals that aquaculture expansion, represented by the growth of water bodies, is a relatively recent yet rapidly intensifying phenomenon. The dataset indicates that while earlier decades were dominated by agricultural expansion, the last decade (2011–2021) marks a decisive shift toward aquaculture-driven land conversion.

5.1.1 Temporal Dynamics of Aquaculture Expansion

During the period 1991–2001, aquaculture did not constitute a major component of land use transformation in Nandakumar Block. The dataset shows that this phase was primarily characterized by large-scale conversion of vegetation into agricultural land, with negligible expansion of water bodies. This suggests that aquaculture practices remained largely traditional, confined to small-scale, subsistence-oriented pond systems without significant spatial expansion (Table 1).

In the subsequent decade (2001–2011), although other blocks within the Tamluk subdivision experienced notable increases in water bodies, Nandakumar Block exhibited only a limited transition toward aquaculture. The persistence of agricultural land expansion and relatively modest growth of water bodies indicate that aquaculture had not yet emerged as a dominant land use strategy. However, this period may be interpreted as a transitional phase, during which structural conditions for future aquaculture expansion were gradually developing.

A significant transformation becomes evident in the period 2011–2021, where the dataset records a substantial increase in water bodies. Specifically, 3017 hectares of agricultural land and 117 hectares of fallow land were converted into water bodies, indicating large-scale expansion of aquaculture (Table 1). This magnitude of conversion within a single decade reflects a rapid intensification of aquaculture activities, marking a clear departure from earlier land use trends.

5.1.2 Nature of Land Conversion to Aquaculture

The dataset highlights that aquaculture expansion in Nandakumar Block is predominantly conversion-driven, relying heavily on the transformation of pre-existing land use categories. The conversion of productive agricultural land into water bodies underscores the economic prioritization of aquaculture over traditional farming systems. Additionally, the incorporation of fallow land into aquaculture suggests an effort to optimize underutilized land resources for higher economic returns.

The scale and speed of these transformations indicate a shift from subsistence-based aquaculture to commercially oriented production systems. Such systems are typically associated with higher capital investment, market integration, and the cultivation of high-value species, particularly shrimp.

Table 1: Land Use and Land Cover Conversion Table of Nandakumar Block (1991 – 2021)

Name of Block	Year	(1991-2021)					
	2001						
Nandakumar	1991	Settlement	1891	0	3	0	6
		Vegetation	16	2625	243	157	2203
		Water body	126	8	1001	64	70
		Fallow land	35	30	58	810	114
		Agricultural land	708	304	476	9	5508
	2011						
	2001	Settlement	2759	1	1	4	11
		Vegetation	28	2027	53	222	837
		Water body	26	4	1599	40	112
		Fallow land	38	67	225	579	131
		Agricultural land	211	236	943	94	6441
	2021						
	2011	Settlement	3043	1	5	2	11
		Vegetation	7	1572	14	286	456

		Water body	18	15	2448	182	159
		Fallow land	46	23	117	534	107
		Agricultural land	133	172	3017	269	3931

Source: Prepared by Author

5.2 The socio-economic assessment of aquaculture in Nandakumar Block

Based on a household survey of 47 respondents, reveals that the expansion of aquaculture has significantly reshaped local livelihood structures, income patterns, and socio-economic conditions.

5.2.1 Livelihood Transformation

The occupational structure of the sampled 47 households in Nandakumar Block between 1991 and 2021 reveals a profound socio-economic transformation driven by the expansion of aquaculture. The data indicate that prior to 1991, the local economy was overwhelmingly agrarian, with 32 households primarily dependent on agriculture, while only 4 households were engaged in aquaculture and 11 in other occupations. Over time, this structure underwent a systematic shift, marked by a steady decline in agricultural dependence and a corresponding rise in aquaculture-based livelihoods. By 2001, the number of agricultural households had reduced to 26, while aquaculture participation increased to 12 households, indicating the early stages of occupational diversification. This trend intensified in the subsequent decade, with agricultural households declining sharply to 13 by 2011, whereas aquaculture expanded significantly to 23 households, reflecting growing economic preference for fishery-based activities (Figure 3).

The most striking transformation is observed by 2021, when only 5 households remained dependent on agriculture, in contrast to 37 households engaged in aquaculture. This dramatic reversal clearly establishes aquaculture as the dominant occupation in the study area, surpassing traditional agriculture. The relatively stable yet marginal presence of the "other" occupational category, which fluctuated between 5 and 11 households over the study period, suggests that the primary structural shift occurred specifically between agriculture and aquaculture rather than through broader sectoral diversification.

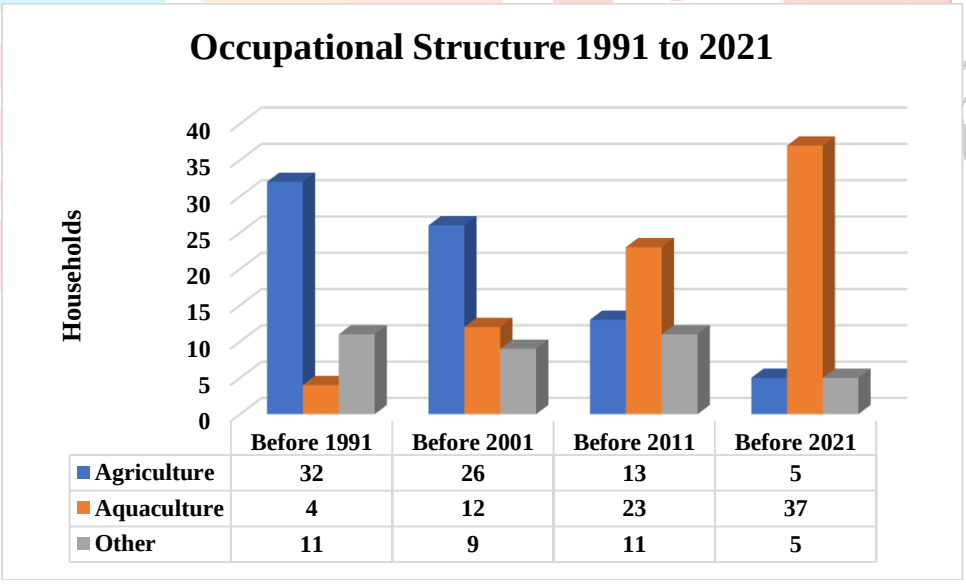


Figure 3: Occupational Structure of Nandakumar Block (1991 to 2021)

From a socio-economic perspective, this occupational transition signifies a shift from subsistence-oriented agricultural practices to more market-driven and commercially viable aquaculture systems. The rapid increase in aquaculture participation, particularly after 2011, reflects its higher economic returns and growing market demand, which have incentivized households to reallocate labour and land resources. Consequently, aquaculture has contributed to enhanced income levels, improved living standards, and greater economic mobility among local communities. At the same time, this transformation has restructured rural labour dynamics, replacing traditional family-based farming with more specialized and sometimes wage-based work associated with aquaculture production cycles.

Overall, the occupational structure analysis demonstrates that aquaculture has played a pivotal role in reshaping the socio-economic landscape of Nandakumar Block. The transition from 32 agricultural households in 1991 to only 5 in 2021, alongside the rise of aquaculture households from 4 to 37, reflects a fundamental reorientation of livelihood strategies. While this shift underscores the economic potential

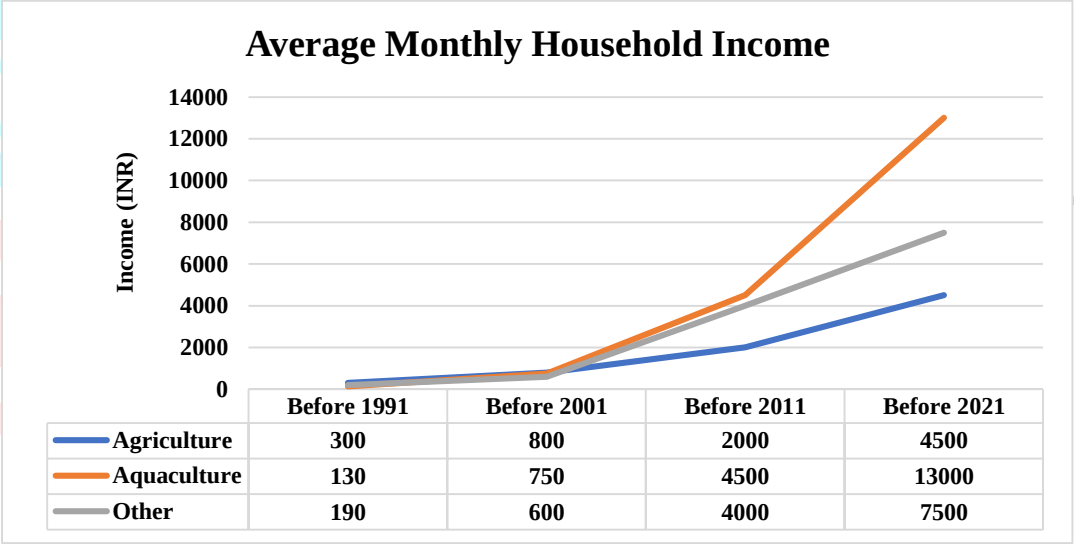
of aquaculture as a driver of rural development, it also highlights the need for sustainable and inclusive planning to ensure long-term socio-economic and environmental stability.

5.2.2 Income Enhancement and Economic Mobility

The analysis of average monthly household income clearly demonstrates the significant socio-economic impact of aquaculture on local communities in Nandakumar Block, aligning closely with the second research objective. The data indicate that prior to 1991, income levels across all occupational categories were relatively low, with agriculture-based households earning around ₹300 per month, while aquaculture households earned even less (₹130), reflecting its marginal and subsistence nature during the early period. Households engaged in other occupations earned slightly higher incomes (₹190), suggesting limited diversification but overall low economic productivity (Figure 4).

A gradual increase in income is observed by 2001 across all sectors; however, the differences between occupations remained relatively narrow. Agriculture recorded an increase to ₹800, aquaculture to ₹750, and other occupations to ₹600 per month, indicating that aquaculture had not yet emerged as a significantly more profitable activity. This phase represents a transitional stage where economic gains were modest and relatively uniform.

A major shift becomes evident after 2011, where aquaculture begins to outperform other sectors substantially. The average monthly income from aquaculture rose sharply to ₹4500, compared to ₹2000 in agriculture and ₹4000 in other occupations. This divergence highlights the growing economic advantage of aquaculture**,** marking its transition into a commercially viable and high-return livelihood option. The trend intensifies further by 2021, where aquaculture income surged dramatically to ₹13,000 per month, far exceeding agriculture (₹4500) and other occupations (₹7500).



	Before 1991	Before 2001	Before 2011	Before 2021
Agriculture	300	800	2000	4500
Aquaculture	130	750	4500	13000
Other	190	600	4000	7500

Figure 4: Average Monthly Household Income generated from different occupation in Nandakumar block (1991 – 2021)

This sharp rise in aquaculture income indicates that it has become the most economically rewarding activity in the region, driving a large-scale occupational shift as observed in the previous analysis. The widening income gap between aquaculture and agriculture underscores the declining economic viability of traditional farming and explains the rapid transition of households toward aquaculture-based livelihoods.

From a socio-economic perspective, this transformation reflects improved income levels, enhanced purchasing power, and better living standards among households engaged in aquaculture. At the same time, it suggests increasing economic differentiation, as those unable to shift to aquaculture may remain in relatively lower-income agricultural sectors. Overall, the income trends strongly confirm that aquaculture has acted as a key driver of rural economic transformation and livelihood improvement in Nandakumar Block, while also introducing new dimensions of inequality and market dependence.

6. CONCLUSION

The present study provides a comprehensive assessment of land use transformation and its socio-economic implications in Nandakumar Block of Purba Medinipur district, with particular emphasis on the expansion of aquaculture. The findings reveal that the region has undergone a profound structural transformation over the past three decades, shifting from a predominantly agriculture-based economy to one increasingly dominated by aquaculture activities.

The analysis of land use and land cover (LULC) dynamics indicates that aquaculture expansion is a recent yet rapidly intensifying process, especially during the period 2011–2021. This transformation has been largely driven by the conversion of agricultural and fallow land into water bodies, highlighting the growing economic significance of aquaculture in the region. The shift reflects a broader trend of resource reallocation toward more profitable and market-oriented activities, with shrimp and fish farming emerging as key drivers of land use change.

The socio-economic assessment, based on a household survey of 47 respondents, further underscores the transformative role of aquaculture in reshaping rural livelihoods. The occupational structure demonstrates a clear transition from agriculture to aquaculture, with the number of households engaged in aquaculture increasing dramatically over time. This shift is strongly supported by income data, which show that aquaculture has become the most economically rewarding livelihood option, significantly outperforming traditional agriculture in terms of average monthly income. Consequently, aquaculture has contributed to enhanced income levels, improved living standards, and greater economic mobility among local communities.

However, the study also highlights several emerging challenges associated with this transition. The rapid and largely unregulated expansion of aquaculture raises concerns regarding environmental sustainability, reduction of agricultural land, and long-term food security. Moreover, the increasing dependence on market forces, private inputs, and capital-intensive practices may lead to economic vulnerability and social inequality, particularly for small and marginal farmers who may lack the resources to participate in aquaculture.

In conclusion, aquaculture in Nandakumar Block represents a double-edged transformation—while it serves as a powerful engine of rural economic development, it simultaneously poses risks to ecological balance and socio-economic equity. Therefore, there is an urgent need for integrated and sustainable policy interventions that promote responsible aquaculture practices, ensure equitable access to resources, and balance economic growth with environmental conservation. Such an approach is essential to secure the long-term resilience and sustainability of the region's rural economy.

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