



Sustainability Indicators in Pisciculture: A Multi-Criteria Decision Analysis Approach

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DOI - 10.5281/zenodo.15254924

Abstract:

Sustainability in pisciculture (fish farming) has become a critical concern as the industry expands to meet global food demands while addressing environmental, social, and economic challenges. This study explores the application of Multi-Criteria Decision Analysis (MCDA) as a comprehensive framework for assessing sustainability in pisciculture. By integrating environmental, social, and economic indicators, MCDA offers a holistic approach to evaluating fish farming practices. Focusing on the Yavatmal district of Maharashtra, India, as a case study, the research highlights the challenges and opportunities in implementing sustainable pisciculture. The findings reveal significant variations in sustainability performance across talukas. Pusad, Digras and Mahagaon scored the highest in overall sustainability i.e., 25/30, 23/30 and 23/30 respectively, while Zari Jamni, Wani, Ralegaon and Arni scored the lowest i.e., 14/30, 15/30, 15/30 and 15/30 respectively. These results indicate that MCDA effectively guides decision-making by ranking fish farming practices based on their sustainability performance. This approach supports the development of policies and practices that promote long-term ecological balance, socio-economic equity, and economic viability, ensuring the sustainable growth of the pisciculture sector.

Keywords: *Pisciculture, sustainability, Multi-Criteria Decision Analysis (MCDA), Yavatmal*

Introduction:

Pisciculture, or fish farming, has emerged as a vital sector for food security, livelihoods, and economic development, particularly in rural areas. However, the rapid expansion of fish farming has raised concerns about its environmental and social impacts, including habitat degradation, water pollution, and overfishing. To address these challenges, there is a growing need for sustainable practices that balance ecological integrity, economic viability, and social equity. This paper proposes the use of Multi-Criteria Decision Analysis (MCDA) as a tool for assessing sustainability in pisciculture. MCDA allows for the integration of

multiple indicators across environmental, social, and economic dimensions, providing a comprehensive framework for evaluating fish farming practices. The study focuses on the Yavatmal district of Maharashtra, India, where pisciculture plays a significant role in the local economy and food security.

Literature Review:

Sustainability in pisciculture has been widely discussed in the context of environmental impact assessments, social equity, and economic viability. Previous studies have highlighted the importance of indicators such as water quality, biodiversity, livelihoods, and profitability

in evaluating fish farming practices. However, there is a lack of integrated approaches that consider all three dimensions of sustainability simultaneously. MCDA has been increasingly applied in environmental and agricultural studies to address complex decision-making problems. By assigning weights to different criteria and ranking alternatives, MCDA provides a transparent and systematic approach to evaluating sustainability. This paper builds on existing literature by applying MCDA to pisciculture, with a focus on the Yavatmal district.

Methodology:

The study employs a Multi-Criteria Decision Analysis (MCDA) framework to assess sustainability in pisciculture. The following steps were undertaken:

1. **Identification of Indicators:** Key sustainability indicators were identified across three dimensions:
 - Environmental: Water quality, habitat integrity, biodiversity, waste management
 - Social: Livelihoods, community well-being, and social equity.
 - Economic: Profitability, market demand, and contribution to local economies.
2. **Data Collection:** Data were collected from fish farms, local communities, and government records in the Yavatmal district. Surveys and interviews were conducted with stakeholders, including fish farmers, fishermen, and policymakers.
3. **Weighting and Scoring:** Indicators were weighted based on their relative importance, and fish farming practices were scored against each criterion.
4. **Ranking and Analysis:** Using MCDA, fish farming practices were

ranked based on their overall sustainability scores.

Case Study: Yavatmal District, Maharashtra:

Yavatmal district, located in the Vidarbha region of Maharashtra, is characterized by its diverse freshwater ecosystems, including rivers, ponds, and reservoirs. Pisciculture is a significant economic activity in the region, providing livelihoods for local communities. The study analyzed fish farming practices across different talukas in Yavatmal, focusing on indicators such as fish productivity, water quality, and socio-economic impacts. The MCDA framework revealed significant variations in sustainability performance, with some talukas demonstrating better practices in terms of environmental stewardship and economic viability.

Results and Discussion:

The Multi-Criteria Decision Analysis (MCDA) framework was applied to assess the sustainability of pisciculture practices across all talukas in the Yavatmal district. The talukas analyzed include Arni, Babhulgaon, Darwha, Digras, Ghatanji, Kalamb, Kelapur (Pandharkawada), Mahagaon, Maregaon, Ner, Pusad, Ralegaon, Umardhed, Wani, Yavatmal, and Zari Jamni. The sustainability indicators were categorized into environmental, social, and economic dimensions, and each taluka was scored based on these criteria.

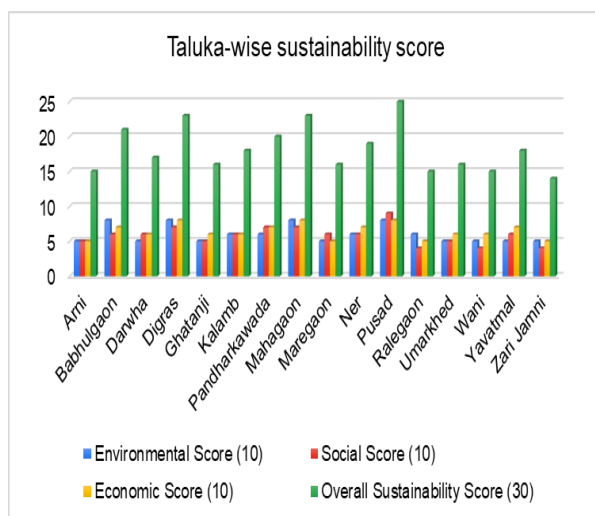
1. Data and Analysis:

The following table presents the sustainability scores for each taluka across the three dimensions (Environmental, Social, and Economic). Each dimension is scored out of 10, with 10 being the highest level of sustainability.

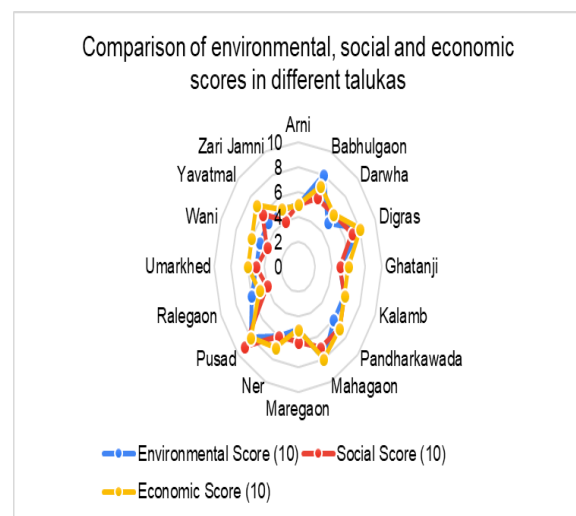
Table 1. Sustainability scores for each taluka across the three dimensions

Taluka	Environmental Score (10)	Social Score (10)	Economic Score (10)	Overall Sustainability Score (30)
Arni	5	5	5	15
Babhulgaon	8	6	7	21
Darwaha	5	6	6	17
Digras	8	7	8	23
Ghatanji	5	5	6	16
Kalamb	6	6	6	18
Pandharkawada	6	7	7	20
Mahagaon	8	7	8	23
Maregaon	5	6	5	16
Ner	6	6	7	19
Pusad	8	9	8	25
Ralegaon	6	4	5	15
Umarkhed	5	5	6	16
Wani	5	4	6	15
Yavatmal	5	6	7	18
Zari Jamni	5	4	5	14

Graph 1. Taluka-wise Sustainability Scores



Graph 2. Comparison of environmental, social and economic scores in different talukas



Discussion of Results:

1. Environmental Sustainability:

The environmental scores reflect the impact of fish farming practices on water quality, habitat integrity, and biodiversity. Talukas such as Pusad, Digras, Mahagaon and Babhulgaon scored the highest (8/10) due to their effective waste management practices and lower

environmental degradation. In contrast, Maregaon, Zari Jamni, Arni, Darwaha, Ghatanji, Umarkhed, Wani and Yavatmal scored the lowest (5/10), indicating issues such as water pollution, habitat degradation, and poor waste management. These talukas require immediate interventions to improve their environmental sustainability.

2. Social Sustainability:

Social sustainability scores were based on the impact of fish farming on local livelihoods, community well-being, and social equity. Pusad scored the highest (9/10), reflecting strong community involvement, equitable distribution of benefits, and support for local livelihoods. Wani, Ralegaon and Zari Jamni scored lower (4/10), indicating disparities in income distribution and limited community engagement in fish farming activities.

3. Economic Sustainability:

Economic sustainability scores were determined by factors such as profitability, market access, and contribution to the local economy. Pusad, Mahagaon and Digras scored the highest (8/10), demonstrating high profitability and strong market linkages. In contrast, Zari Jamni, Arni, Maregaon and Ralegaon scored the lowest (5/10), suggesting low productivity and limited economic benefits from fish farming.

4. Overall Sustainability:

The overall sustainability scores (sum of environmental, social, and economic scores) reveal that Pusad, Digras and Mahagaon are the most sustainable talukas scored 25/30, 23/30 and 23/30 respectively, followed by Babhulgaon (21/30), Pandharkawada (Kelapur) (20/30), Ner (19/30), Kalam (18/30) and Yavatmal (18/30). These talukas demonstrate a balanced approach to environmental, social, and economic sustainability, while Zari Jamni, Wani, Ralegaon and Arni scored the lowest i.e., 14/30, 15/30, 15/30 and 15/30 respectively., indicating significant challenges in achieving sustainable pisciculture.

5. Key Findings

1. Top-Performing Talukas: Pusad, Digras and Mahagaon are the most sustainable talukas, with high scores across all three dimensions. Their success can be attributed to effective waste management, strong community involvement, and high profitability.
2. Mid-Performing Talukas: Talukas like Babhulgaon, Pandharkawada (Kelapur), Ner, Kalam and Yavatmal show moderate sustainability, with room for improvement in areas such as environmental management and social equity.
3. Low-Performing Talukas: Zari Jamni, Wani, Ralegaon and Arni require urgent interventions to address environmental degradation, low productivity, and social disparities.

Recommendations

Based on the findings, the following recommendations are proposed:

1. Environmental Interventions: Low-performing talukas should adopt better waste management practices, restore degraded habitats, and monitor water quality regularly.
2. Social Interventions: Community engagement programs should be implemented to ensure equitable distribution of benefits and support for local livelihoods.
3. Economic Interventions: Efforts should be made to improve market access, increase productivity, and provide training to fish farmers in low-performing talukas.
4. Policy Support: Policymakers should prioritize interventions in low-performing talukas and promote sustainable practices through incentives and regulations.

Conclusion:

This study demonstrates the effectiveness of Multi-Criteria Decision Analysis (MCDA) in assessing sustainability in pisciculture. By integrating environmental, social, and economic indicators, MCDA provides a comprehensive framework for evaluating fish farming practices and guiding decision-making. The MCDA framework provides a comprehensive approach to assessing sustainability in pisciculture, highlighting the strengths and weaknesses of fish farming practices across the Yavatmal district. By addressing the identified challenges and building on the successes of top-performing talukas, the district can achieve a more sustainable and equitable pisciculture sector. Future research should explore the application of MCDA in other regions and contexts, as well as the development of standardized sustainability indicators for pisciculture. By adopting a holistic approach to sustainability, the pisciculture sector can contribute to global food security while preserving the health of aquatic ecosystems and supporting local communities.

References:

1. Food and Agriculture Organization (FAO). 'The State of World Fisheries and Aquaculture', 2020
2. Government of Maharashtra's report on Fisheries' 'Performance Budget 2022-23'
3. Kumar, G., & Engle, C. R., 'Sustainability in Aquaculture: A Multi-Criteria Approach', 2016

4. Saaty, T. L., 'Decision Making with the Analytic Hierarchy Process'. International Journal of Services Sciences, 2008
5. Tumsare K.A., Joshi P.P., 'Current Status Of Pisciculture In Yavatmal Taluka: To Check The Sustainability', Vidyabharati International Interdisciplinary Research Journal, 24 Sept, 2022, 1157-1162
6. Tumsare K.A., Joshi P.P., 'Comparative study on sustainability of Pisciculture in Ghatanji and Yavatmal taluka of Maharashtra', International Journal for Multidisciplinary Research, 2023
7. Tumsare K.A., Joshi P.P., 'Sustainability of Pisciculture in Digras Taluka of Yavatmal District: Assessment Year 2021-22', The Rubrics Journal of Interdisciplinary Studies, Vol 6, Issue 2, March 2024, 915-921
8. Tumsare K.A., Joshi P.P., 'Economic Viability and Market Analysis of Sustainable Fish Farming in Yavatmal Taluka', B. Aadhar Multidisciplinary International Research Journal, 2024
9. United Nations General Assembly. (1987). 'Report of the World Commission on Environment and Development: Our Common Future'.
10. Yavatmal District Fisheries Department. 'Annual Report on Fish Production and Sustainability Practices', 2023