Strategic SWOT-SPACE-QSPM-PAR Analysis for Sustainable Shrimp Farming throughout Fluvio-coastal Khejuri of Purba Medinipur District in West Bengal

Rabin Das

Assistant Professor, UG & PG Department of Geography, Bajkul Milani Mahavidyalaya, Purba Medinipur, West Bengal, India. **dasrabin0@gmail.com**

Abstract - Strengths, weaknesses, opportunities and threats (SWOT) analysis indicates a framework for helping the researchers or planners to identify and prioritize the occupation goals, and to further identify the strategies of achieving them. SWOT analysis is a technique used to analyze the strengths, weaknesses, opportunities and threats of the selected economy, ***shrimp farming*** in terms of aquaculture. In the study area, fluvio-coastal Khejuri of Purba Medinipur district in West Bengal shrimp farming practice plays a vital role in not only food security or life earning, but also in the economic growth as well as regional development. Population growth is the major reason for increased food demands and finding out occupational ways. Hence, it puts additional pressure on the natural resource of the region as well as nation. Countries with rapid population growth face especially difficult challenges in ensuring livelihood security. As such, SWOT analysis is used to identify strategies for aquacultural development, especially in shrimp farming systems, and they help the researchers or planners to manage and prioritize them for achieving livelihood security and environmental sustainability. The research area is typically ***fluvio-coastal landscape*** delimited by River Hooghly at the east, River Rasulpur at the west, River Hooghly and Bay of Bengal at the South and Talpati creek/ channel along with Nandigram-I and II CD Blocks at the north. The study area occupationally signifies 10293 people (10.49%) who are directly and indirectly related to domestic and commercial aquaculture and integrated aquaculture whereas 1673 domestic and commercial aqua-farmers including 910 shrimp farmers are related to various aquacultural practices directly and for this study 255 people has been considered as the sampled population included of shrimp farmers, shrimp-agricultural farmers and other relevant characters like trainers, feed traders, transporters, academicians, researchers, environmentalists, etc. The sample size was chosen using systematic and stratified random sampling techniques mainly. But in some cases purposive and chunk sampling techniques have been applied also aiming to fulfill the objectives of the research. Based on the results from ***SWOT, SPACE*** and ***QSPM*** analyses, strategies for shrimp farming management as well as its ***sustainable development*** in time are prioritized on ***PAR*** approach and ***SDGs*** whereas proper policy and strategy framing, institutional support in practice and policy, development of farm and related infrastructure and facilities, emphasizing farm sustainability dimensions and considering quality of materials and methods intensively used in shrimp farming have been estimated as the first five strategic dimension to be introduced and implemented.

Key words: *Shrimp farming, fluvio-coastal landscape, SWOT, SPACE, QSPM. PAR, SDGs and sustainable aquaculture*

I. Introduction and Literature Base

1.1 Understanding the Sustainable Aquaculture:

"Aquaculture is entering new environments; it is moving further offshore into land based facilities. This reduces the environmental pressure from fragile coastal ecosystems but simultaneously presents lots of new challenges to scientists and engineers."

- Alexandra Leeper, Researcher Sustainable Aquaculture, at Matis

Aquaculture is the world's fastest growing industry with huge expansion potential. It plays an important role in global food production, growing more than half of the food produced by humans. FAO's work in the oceans stems from the Blue Transition, a vision that works to build sustainability and resilience, reduce environmental impact, improve bio-security and

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disease control, be supported by technology and innovation, and enhance the ability to deliver justice and thereby improve people, socio-cultural and economic dimensions of aquaculture. [24]

Throughout the time to neutralize the increasing huge demands of the future, aquaculture must tag along the three pillars of sustainability and be economically, socially and environmentally friendly. These pillars are:

P1. Economic: Aquaculture should be a good long term profitable business opportunity

P2. Social: Aquaculture should be socially responsible and contribute to the health and well-being of society.

P3. Environmental: Aquaculture should not cause significant damage to ecosystems or be responsible for biodiversity loss or significant impacts. [23]

Our oceans and rivers are interconnected; therefore, what we do in one place affects the ecosystem in another. We must practice responsible and sustainable agriculture so that everyone can continue to obtain food in this environment. But this can be difficult because the way oceans work is dynamic. Because of all the differences in species, location, social structure, and tools, its development has not been universally measured. [23]

"We need technologies, and we need other solutions to ensure we are doing fishing and aquaculture in a sustainable way and that people aren't left out who do require fish protein in order to survive on a daily basis or even profit from it in terms of industry and their income."

- Dan Watson, Co-founder & CEO, Safety Net Technologies

1.2 Main drivers for aquaculture diversification:

Table 1: Main drivers for aquaculture diversification

Driver	Mechanism
Market demand	As the world becomes more populous, urban and wealthy, more people will need and be able to afford more fish and fish products
Climate change	Changes in the environment will require new species/species or existing species may be moved to new areas
Desire for increased resilience	Aquaculture will need to supply consistent products in spite of external impacts
Consumer demand	Consumers want to continue to eat fish that they are accustomed to eating and at affordable prices; tastes may change in response to new trends or the introduction of new species
Environmental concerns	Government and consumers will want to promote and eat fish raised in a good and friendly environment
Profit	Aquaculture farmers will seek to find fo species, breeds, and systems that are efficient and meet market/consumer demands
Competitive advantage	Developing new species, breeds or farming systems often gives the innovator an initial competitive advantage

Source: [5] & [6]

1.3 Understanding the SDGs, Their Use, and Role for Human and Planetary Health:

Table 2: The five "Ps" representing the aspirations of the 2030 Agenda

5 Ps	Specification of 5 Ps	Aspirations of the 2030's Agenda
P_1	People	1. Ending the poverty and hunger of people and 2. Ensuring the platform for human beings to fulfill their potential in dignity and equality and in a healthy environment.
P_2	Planet	1. Protecting the planet from degradation through: ❖ *Sustainable consumption and production and* ❖ *Sustainably managing of its natural resources* 2. Taking urgent action on climate change supportable for present and future generations.
P_3	Prosperity	1. Ensuring the enjoyment of prosperous and fulfilling the lives of human beings and 2. Functioning the social, economic and technological progress in harmony with nature.
P_4	Place	Fostering peaceful ground and atmosphere reflecting inclusive societies having free from fear and violence. (since the principle is on the way of no sustainable development without peace and no peace without sustainable development)
P_5	Partnership	Mobilizing the means through a revitalized global partnership for sustainable development focusing the needs of poorest and most vulnerable and with the partnership of all countries, all stakeholders and all people.

Source: Author's composition based on [22], [38] and [39]

1.4 Aquaculture's Contribution to the SDGs in terms of "Blue economic growth":

The risks of inequality arising from the development of aquaculture and the seafood sector as a whole must be taken into account, as this will have an impact on the success of sustainable development of groundwater freezing and the achievement of more sustainable development goals. Applying sustainable development goals to aquaculture development can

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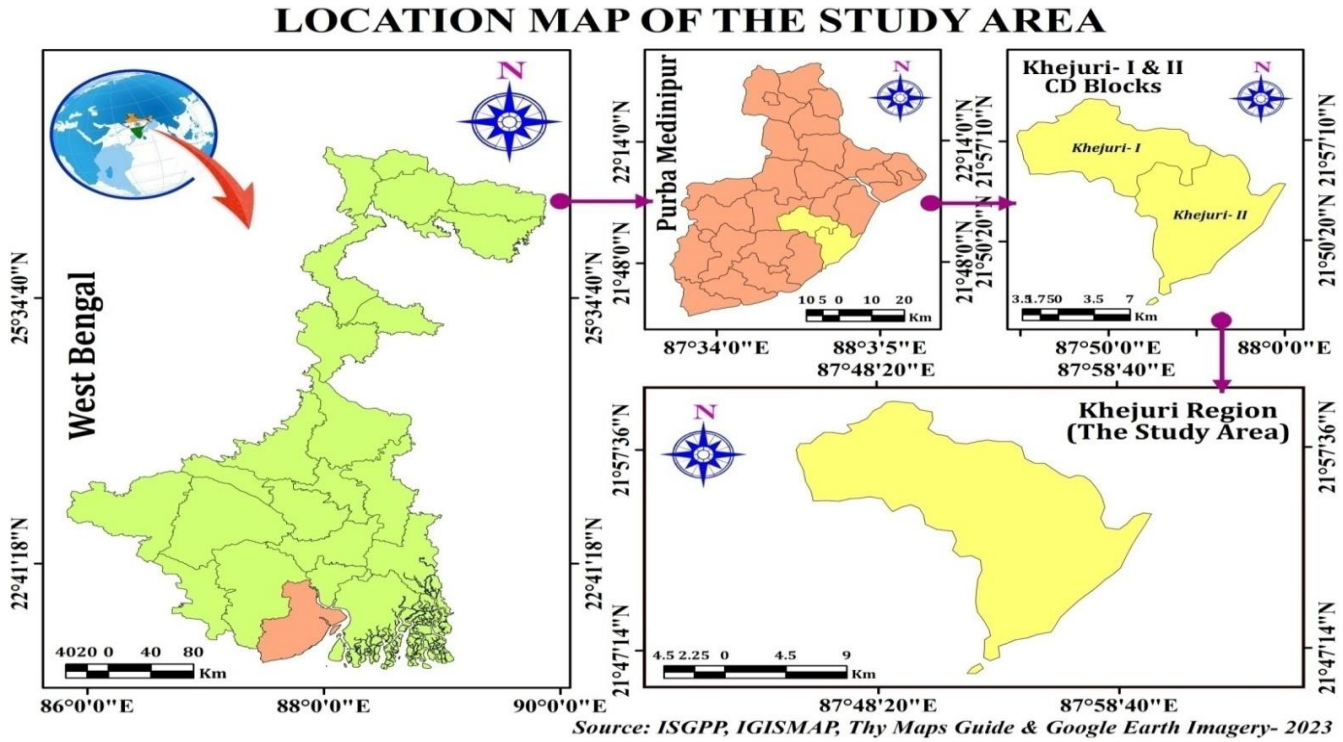
lead to a better understanding of the benefits of social-ecological justice and food justice. For example, marine aquaculture is considered an important part of the "blue economy"-an idea that can reduce ecosystem destruction and increase social contribution while increasing income related to the use of marine resources [18]. Stakeholders have different interpretations of this concept, and the scope and scope of the blue economy in line with the sustainable development goals are blind [7], although controversial, proves that marine aquaculture (fish and shellfish) can increase [3]. However, the current marine industry does not produce as much food as freshwater (73% of all farmed seafood by weight consumed) [17], [29], [30], most of the grown products are sold to the export market. Although the environmental footprint of seafood farming is generally lower than that of other animal-based proteins [34], [38], the contribution of seafood farming to local food security and livelihoods (feed systems) has been questioned [3], [19], [20]. Better integration of marine aquaculture, and the broader blue economy, with sustainable development goals will help ensure sustainable growth and development, as well as protect marine resources.

1.5 Understanding SWOT Framework Analysis:

SWOT analysis is a unique mechanism which aids the owners, entrepreneurs, trainers, planners, administrators, academicians and researchers to appraise the strengths, weaknesses, opportunities and threats involved in any economic practice throughout the anthropogenic world. A SWOT analysis can lend a hand them to grow insights into the history and create the sense of promising recoveries to existing and latent constraints and troubles, either for an existing occupational practice or for an up-to-the-minute undertaking [31] [40] [41]. Distinctively, SWOT is a crucial and forthright replica that evaluates what an economic way can and cannot do, as well as its budding opportunities and threats. The SWOT technique is implemented to catch the information from both environmental and societal analysis of the specific economic activity considering its internal (strengths and weaknesses) and external wings (opportunities and threats). A cautious and complete SWOT examination estimates what may support the occupation cum economy to fulfill its goals and best of benefits and what difficulties must be triumph over or lessened to attain the preferred outcome [36]. Conversely, a SWOT study on any economic dimension is the foremost footstep in strategic planning [36] which helps to identify strategies for communal and environmental development in terms of livelihood and nature [41] [42] [43]. Uniquely this work out and exercises reflect the following five developmental sorts for the sustained livelihood in time:

- Conservation and utilization of natural resources;
- Development of the wasteland, wetland, aquaculture and integrated aqua-agriculture zones.
- Promotion of livelihoods resources and human resource development.
- Promotion of health, cleanliness and education.
- Development of village institutions.

II. About the Study Area



Map 1: Location Map of the Study Area

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Geoenvironmentally, Khejuri is one fluvio-coastal landscape having various coastal features, habitats and ecosystems over Misnapore coast in West Bengal. From the geomorphological perspectives it is situated at the junction of River Hoogly, River Rasulpur and Bay of Bengal having the segmental reflection of Rasulpur-Pichhaboni Basin declaring the end of Lower Ganga Course [8]. The study area is geometrically existed in between 21°45´N - 22°00´N latitudes and 87°45´E - 88°05´E longitudes. Hence, it is featured by the typical sub-tropical Monsoonal climatic influence and wet deciduous type of vegetation alongwith identical coastal and mangrove vegetations over Indian sub-continent [8]. Geological set up of this region shows mostly recent formation having the sedimentary and lithological characteristics of recent Quarternery formation. Administratively, Khejuri is designated as one of the coastal police stations surrounded by Nandigram at the north, Bhagwanpur at the north-west and west, Uttar Kanthi at the south (seperated by river Rasulpur) and River Hooghly and Bay of Bengal at the east and south-east [8]. Khejuri is with 11-Gram Panchayets named as Haria, Tikashi, Lakshi, Birbandar, Kamarda and Kalagachhia under Khejuri-I CD Block and Baratala, Haludbari, Khejuri, Janka and Nij Kasaba under Khejuri-II CD Block. Democratic cum administrative dignities of the study area indicates it as Khejuri Assembly Constituency (215) under Kanthi Lok Sabha Constituency (216) of Purba Medinipur district in West Bengal, India [8].

III. Specific Objectives

(i) Estimating the growth factors for rapid and massive expansion of shrimp farming throughout the study area;

(ii) Reviewing the cost-benefit of this economic practice in this fluvio-coastal landscape;

(iii) SWOT analysis for justifying the state and status of fate-fortune of this occupation here;

(iv) SPACE-QSPM-PAR analysis for strategic planning and development of shrimp culture in the study area;

(v) Developing the strategic model and approach towards sustainable aquaculture here.

IV. Materials, Methods & Methodology

4.1 Population, Sample and Sampling:

In the study area 10293 people (10.49% of the total working people) are directly and indirectly influenced by domestic and commercial aquaculture including fish farming, shrimp farming, crab farming and integrated aquaculture. In fact 1673 domestic and commercial aqua-farmers are directly related to various aquacultural practices as their lifeline economy and 910 of the aqua-farmers are the commercial shrimp cultivators in this landscape. For this study, 255 people has been considered as the sampled population having shrimp farmers, shrimp-agricultural farmers and other relevant characters like trainers, feed traders, transporters, academicians, researchers, environmentalists, land leasers and owners, money lenders, etc. Mainly systematic and stratified random sampling techniques have been here, although purposive and chunk sampling techniques have been applied also in some cases to execute the the research objectives.

4.2 Literature Review and Background Study:

Intensive literature review at root level for understanding the study area and research problem has been done thoroughly and extensive literature review is broadly considered for more systematic surveys, data collection, analysis, presentation and interpretation to reach at the objectives of the study. Offline library survey and online database and research review have been emphasized together. Hence, the literature review regarding theoretical and practical thoughts (knowledge), tools, techniques and technologies (4-T) has been one of the key methodological component/ way in terms of background study for this paper.

4.3 SWOT Analysis:

Strength-Weakness-Opportunity-Threat (SWOT) analysis technique has been used to indicate the recent constraints or limitations and upcoming possibilities or potentials of the shrimp farming system and its management in the fluvio-coastal Khejuri CD Blocks of Purba Medinipur district in West Bengal.

For the SWOT analysis, the following stages have been used:

- ❖ Designing external and internal factors matrix
- ❖ Analyzing SWOT matrix

4.3.1 Designing external and internal factors evaluation matrix:

At this phase of the research, external (opportunities and threats) and internal (strengths and weaknesses) factors that affected the farming system of wheat farmers were evaluated. Based on the farmers' idea, each item was evaluated. Based on the farmers' idea, each item was ranked and the importance ratio coefficient was identified. More so, based on the results, the score of the external and internal factors was 2.140 and 2.385, respectively.

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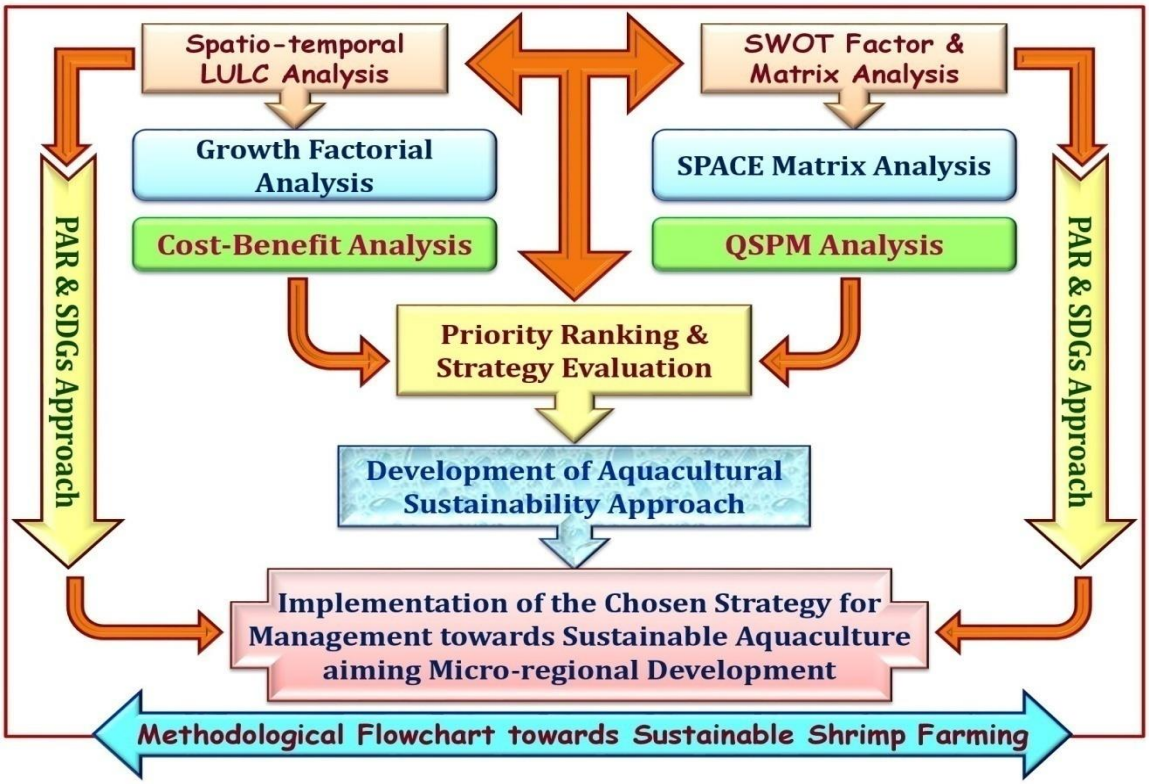

Figure: Methodological Flowchart for the Study

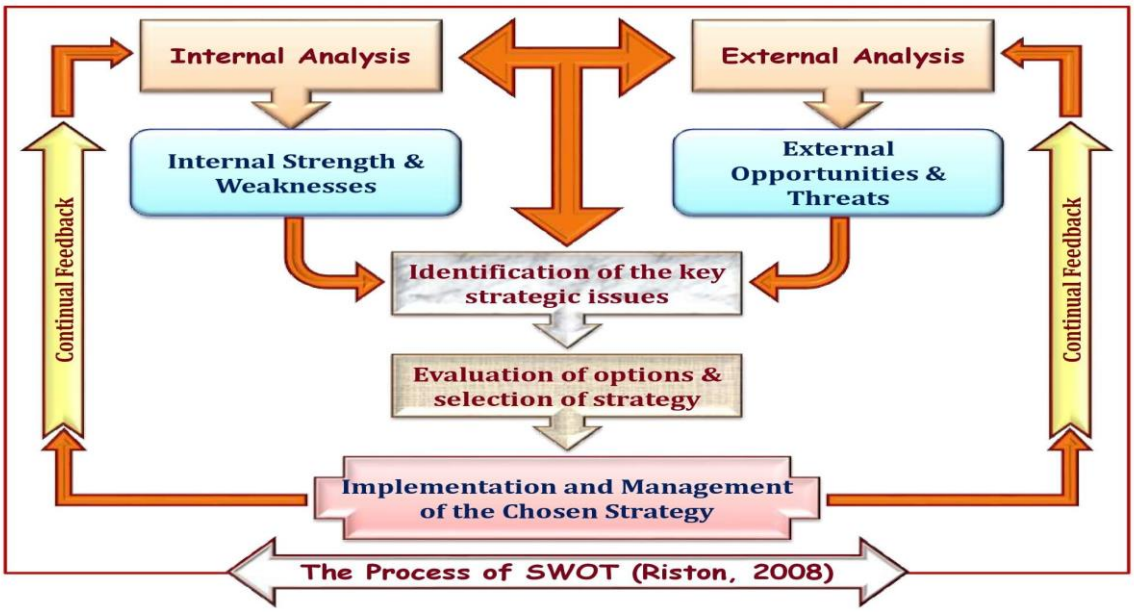

Figure: Methodological Flowchart for SWOT Matrix Analysis [1] [12] [13]

4.3.2 Analyzing the SWOT Matrix:

❖ **External Factor Evaluation (EFE) Matrix:**

The first part of the SWOT analysis requires looking outside our business at issues that we cannot control but can manage to enhance or reduce their impact on our business. External factor evaluation (EFE) matrix is a strategic-management tool often used for assessment of the current business conditions. It is a good tool used to visualize and prioritize the opportunities and threats thata business is facing. Riston (2008) pointed out that the benefits of external analysis include:

- Increasing managerial awareness of environmentalchanges.
- Improving resources' allocation decisions.
- Facilitating risk management

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- Acting as an early warning system.
- Focusing on the primary influences of strategic change.

However, the EFE matrix process uses the following fivesteps:

1. List factors: The first step is to gather a list of external factors and divide them into two groups: opportunities and threats.
2. Assign weights: Weight is assigned to each factor. The value of each weight should be between 0 and 1 (or alternatively between 10 and 100 if the 10 to 100 scale is used). Zero means the factor is not important, while one or hundred means the factor is the most influential and critical. However, the total value of all weights put together should equal 1 or 100.
3. Rate factors: Rating is assigned to each factor, and is between 1 and 4. Rating indicates how effective the firm's current strategies respond to the factor. Rating captures whether the factor represents a major threat (rating = 1), a minor threat (rating = 2), a minor opportunity (rating = 3), or a major opportunity (rating =4). If rating scale 1 to 4 is used, then strengths must receive a 4 or 3 rating and weaknesses must receive a 1 or 2 rating.
4. Multiply weights by ratings: Multiply each factor weight with its rating in order to calculate its weighted score.
5. Total all weighted scores: Add all the weighted scores of each factor, in order to calculate the total weighted score.

❖ **Internal factor evaluation (IFE) matrix:**

Internal factor evaluation (IFE) matrix is a strategic management tool used for evaluating strengths and weaknesses in functional areas of a business. The IFE matrix together with the EFE matrix is a strategy- formulation tool that can be utilized to evaluate the performance of a company with regards to the identified internal strengths and weaknesses of a company. The IFE matrix can be created using the following 3 steps:

1. Key internal factors: The first step is to identify strengths and weaknesses.
2. Weights: IFE matrix assigns a weight that ranges from 0 to 1 for each factor. The weight assigned to a given factor indicates the relative importance of the factor. Zero means not important, while one indicates very important.
3. Rating: Practitioners usually use rating on a scale from1 to 4. Rating captures whether the factor represents a major weakness (rating = 1), a minor weakness (rating = 2), a minor strength (rating = 3), or a major strength(rating = 4).

4.3.3 Strengths, Weaknesses, Opportunities and Threats (SWOT) Matrix:

SWOT is the first step of planning and it helps planners tofocus on key subjects. SWOT method is a key tool used in economies to formulate its strategic plans.

SWOT matrix comprises four strategic groups:

1. How strengths are used to take advantage ofopportunities.
2. How weaknesses are reduced by taking advantage ofopportunities.
3. How strengths are used to reduce the impact ofthreats.
4. How weaknesses that will make these threats a realityare addressed.

Based on SPACE matrix, group III strategies (defensive) are the suggested strategies for agricultural development.

4.4 Strategic Position and Action Evaluation (SPACE) Matrix:

The strategic position and action evaluation (SPACE) matrix is a management tool used to analyze a company's business. It is used to determine what type of strategy a business should undertake. The SPACE matrix is broken down into four quadrants, where each quadrant suggests a different type or nature of strategy: aggressive, conservative, defensive and competitive. However, the SPACE matrix analysis functions upon two internal and two external strategic dimensions.

4.5 Quantitative Strategic Planning Matrix (QSPM):

A basic principle of the quantitative strategic planning matrix (QSPM) is that occupations or economies need to systematically assess their external and internal environments, conduct research, carefully evaluate the pros and cons of various alternatives, perform analyses, and then decide upon a particular course of action [13].

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The QSPM approach attempts to objectively select the best strategy for an economy. Although, the left column ofa QSPM consists of external and internal key factors, the left column of a QSPM lists factors is obtained directly from the EFE and IFE matrixes. The top row consists of feasible alternative strategies derived from the SWOTanalysis and SPACE matrix. However, the first column with numbers includes weights assigned to factors.

Attractiveness scores (AS) in the QSPM indicate how each factor is important or attractive to each alternative strategy. The range for attractiveness scores is 1 = not attractive, 2 = somewhat attractive, 3 = reasonably attractive and 4 = highly attractive.

Total attractiveness scores (TAS) indicate the relative attractiveness of each key factor and the related individual strategy. However, the sum of the total attractiveness score (STAS) is calculated by adding the total attractiveness scores in each strategy column of the QSPM.

4.6 PAR Approach towards Sustainability:

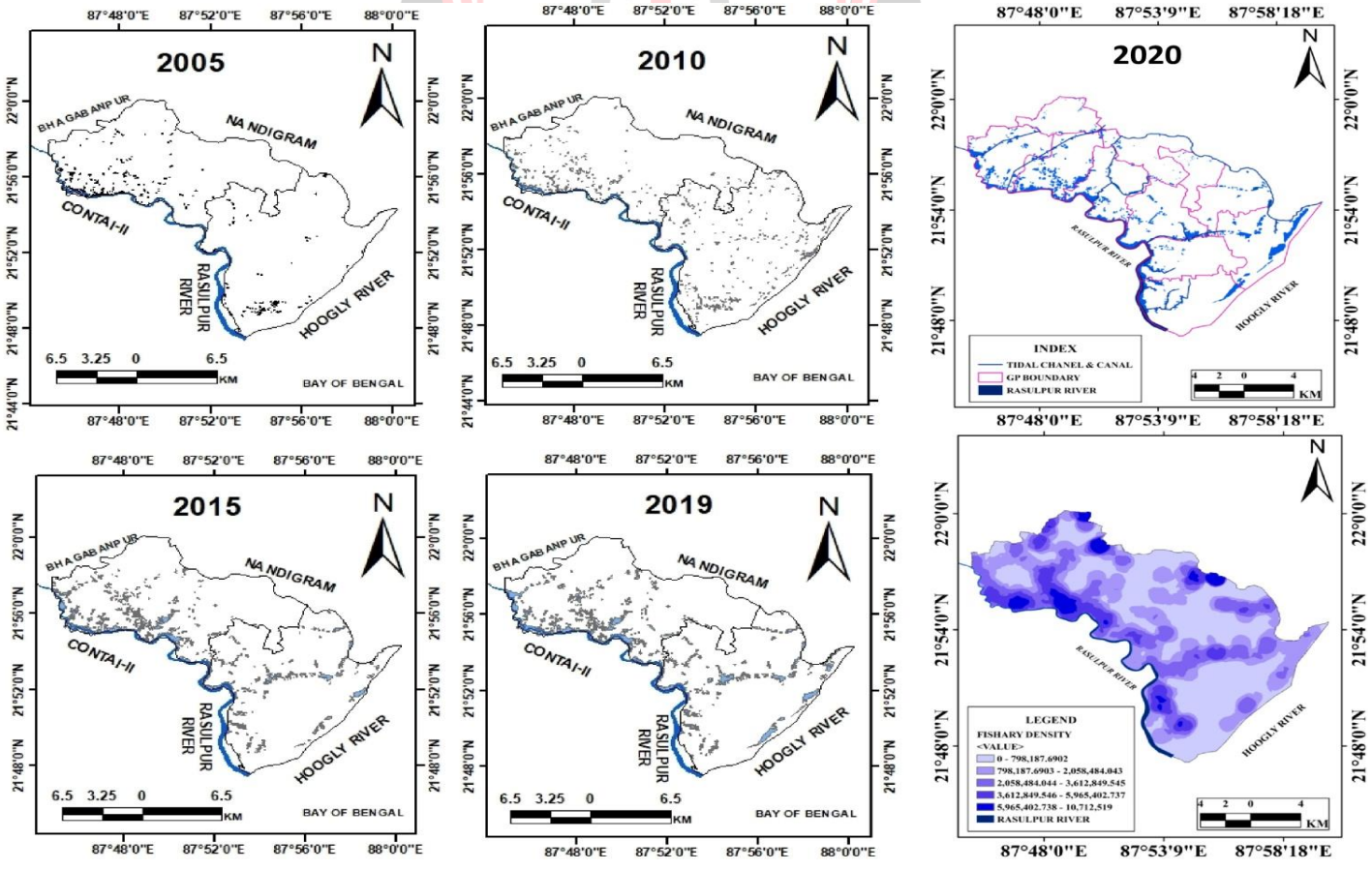
Strategic Prediction-Adaptation-Resilience or PAR approach supports the achievement of development goals by linking local population growth to life-livelihood-infrastructural development, traditional small scale life earning ways to modern economic and occupational human adaptation, and ability and adjustment to mitigate all the environmental impacts and changes with strong psychological and mental health. Thus, the PAR approach connects the present with future ensuring both socio-economic and environmental health aiming towards sustainable development. In this paper, this approach has been considered not to stop the practiced blue economy, but to run up it through sustainable envelop whereas growing population of this fluvio-coastal landscape can find out their life earning roots sustaining their future.

4.7 Justification of the Contribution of Aquaculture towards Sustainable Development:

All the 17 SDGs have been considered to justify the contributions of aquaculture in the study area and strategic development of shrimp farming has been configured aiming its sustainability in this potential landscape. Here conceptual frameworks of blue economy and sustainable aquaculture have been considered for making the blueprint of strategic plans towards sustainability of shrimp farming.

V. Results and Discussion

5.1 Spatio-temporal Change in Aquaculture with respect to the Other LULCs of the Study Area:



Map Plate 2: Spatio-temporal Change in Shrimp Culture from 2005 to 2022 in the Study Area

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Table 1: Spatio-temporal Change in LULC of the Study Area (From 1911 to 2022)										
Years	**Aquaculture**	**Settlement**	**Agriculture**	**Brick Kiln**	**Forest**	**Social Forestry**	**Inland Natural**	**Sandy Area**	**River**	**Ponds/ Tanks/ Canals**
1911	0.95	7.894	224.66	0	22.466	0	1.508	1.341	4.365	0.475
1971	1.12	15.982	214.38	0	13.068	0	1.012	0.625	4.015	0.544
1996	1.467	42.734	210.21	0.087	3.183	0.112	1.154	0.404	3.992	0.561
2000	1.87	54.3	198.7	0.194	2.14	0.25	0.92	0.39	3.99	0.63
2004	1.889	54.386	198.58	0.198	2.123	0.232	1.425	0.426	3.987	0.659
2008	1.964	54.446	198.2	0.327	2.002	0.216	1.389	0.412	3.995	0.708
2012	2.12	54.732	198.47	0.341	2.083	0.245	1.45	0.39	3.99	0.712
2015	4.32	57.33	193.49	0.435	2.092	0.315	1.54	0.39	3.99	0.698
2016	13.055	57.89	184.18	0.454	2.093	0.305	1.54	0.39	3.99	0.687
2020	17.637	59.485	176.91	0.752	2.093	0.403	1.54	0.39	3.99	0.703
2022	28.373	65.122	159.85	0.854	2.138	0.645	1.642	0.426	4.023	0.834
Source: District Gazettes, Historical Records, District & Block Level Census Handbooks & Image Analysis [2] [9] [14] [15] [16] [25] [26] [27] [28] [32]										

Table 1 shows the database of spatio-temporal changes in various land uses and land covers of this fluvio-coastal landscape throughout the time. The statistical database and mapping analysis reflects the huge change in aquaculture from 1911 to 2022 whereas only 0.95% of the aquaculture of 1911 has been enormously converted into 28.37% in 2022 massively affecting the agricultural lands and wetlands of the study area.

In table 2 the multi-correlational analysis reveals the significant inversely proportional or negative correlation (-0.89) between aquaculture and agriculture which indicates the huge affection of agricultural land and also local food security by this blue economic practices here. Table 3 indicates the multi-regression model showing the significant F and P-values signifying the correlation and regression between aquaculture and agriculture in the study area.

Table 2: Multi-correlation among different LULCs with years											
	years	Aquaculture	Settlement	Agriculture	Brick Kiln	Forest	Social Forestry	Inland Natural	Sandy Area	River	Ponds / Canals
Years	1										
Aquaculture	0.463962	1									
Settlement	0.936154	0.5084962	1								
Agriculture	-0.78014	-0.8967719	-0.8216733	1							
Brick Kiln	0.697715	0.8955133	0.7563795	-0.9608432	1						
Forest	-0.96701	-0.3101899	-0.9444244	0.66865642	-0.56894724	1					
Social Forestry	0.738054	0.8655661	0.8301666	-0.9768727	0.94791352	-0.651733	1				
Inland Natural	0.197086	0.5676886	0.34297791	-0.517581	0.646388226	-0.095564	0.545709342	1			
Sandy Area	-0.95662	-0.2516454	-0.8394928	0.59701104	-0.47693516	0.960068 4	-0.54426669	0.074353	1		
River	-0.90137	-0.162553	-0.7296536	0.49877855	-0.36640337	0.892698 6	-0.42341956	0.185188 5	0.981025 4	1	
Ponds/ Canals	0.845645	0.6994317	0.8848919 3	-0.9173394	0.88088786	-0.763289	0.923566351	0.518327 2	-0.681369	-0.584679 6	1
Source: Statistical Analysis of LULC Database, 2022-'23											

Table 3: Multi-regression Analysis								
Regression Statistics								
Multiple R	0.99985							
R Square	0.999699							
Adjusted R Square	0.996994							
Standard Error	0.495482							
Observations	11							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	9	816.5026	90.72251	369.5381	0.040351			
Residual	1	0.245502	0.245502					

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Total	10	816.7481						
Regression Justification Report								
	Coefficients	***Standard Error***	***t Stat***	***P-value***	***Lower 95%***	***Upper 95%***	***Lower 95.0%***	***Upper 95.0%***
Intercept	-133.924	88.56524	-1.51215	0.371967	-1259.25	991.4042	-1259.25	991.4042
Settlement	-0.84718	0.117038	-7.23852	0.087396	-2.33428	0.639925	-2.33428	0.639925
Agriculture	-0.94715	0.071453	-13.2555	0.047936	-1.85504	-0.03925	-1.85504	-0.03925
Brick Kiln	-2.02359	2.965564	-0.68236	0.618798	-39.7047	35.65747	-39.7047	35.65747
Forest	-1.54127	0.547814	-2.81349	0.217408	-8.50191	5.419368	-8.50191	5.419368
Social Forestry	-1.55733	6.748421	-0.23077	0.855616	-87.3041	84.18949	-87.3041	84.18949
Inland Natural	3.422311	1.471403	2.325883	0.2585	-15.2736	22.11826	-15.2736	22.11826
Sandy Area	-28.4562	16.25481	-1.75063	0.330399	-234.993	178.0807	-234.993	178.0807
River	98.7281	23.98632	4.116018	0.151729	-206.047	403.5031	-206.047	403.5031
Ponds/ Tanks/ Canals	-18.9082	6.303812	-2.99949	0.204865	-99.0058	61.18928	-99.0058	61.18928

Source: Data Compilation and Analysis, 2022-'23

5.2 Factorial or Causal Assessment for the Massive Growth of Shrimp Aquaculture throughout the Study Area:

Table 4: Causal/ Factor Specific Assessment for the Massive Growth of Shrimp Culture in the Study Area

Factorial Dimension		**Different Force/ Factors**	**Rating Grade on 5-Point Likert Scale (R_5)**	**Weight (W)**		**Weighted Score (WSc)**		**Factorial/ Causal Dimension Specific Index**
In-site Forces/ Factors	**Situational Factors**	Fluvio-coastal site suitability	**4.5**	0.050	**0.185**	0.225	**0.721**	**Situational Factor Specific Index (SFSI) = 0.21 (21.02%)**
		Environmental & micro-climatic favourability	**4.0**	0.045		0.180		
		Local resource base	**3.5**	0.045		0.158		
		Proper and sufficient water and land availability	**3.5**	0.045		0.158		
	Factors regarding Infrastructure & Facilities	Development in rural transport and communication system after 2010	**3.0**	0.040	**0.150**	0.120	**0.453**	**Infrastructure & Facilities Specific Index (IFSI) = 0.13 (13.21%)**
		Regional market & opportunity to export the products easily	**2.5**	0.035		0.088		
		Local market with sufficient aqua-shops for drawing the feeds, nutrients and medicines	**3.5**	0.040		0.140		
		Facilities of a lot of aqua-shops with farm doctors and trainers	**3.0**	0.035		0.105		
	Demographic & Socio-economic Factors	Increasing population and driving trend to more and more life earning ways	**4.0**	0.040	**0.360**	0.160	**1.348**	**Demographic & Socio-economic Factor Specific Index (DSEFSI) = 0.39 (39.30%)**
		Availability of sufficient youth and experienced labour force	**4.5**	0.040		0.180		
		Higher productivity & better labour weighted production	**4.0**	0.040		0.160		
		Remarkable short term economic gain and higher profits than other economies	**4.0**	0.045		0.180		
		Very low/ marginal production and income from agriculture and livestock & trend to replace these by profitable aquaculture	**4.0**	0.045		0.180		
		Emergence as the good supportive or alternative economy for strengthening the socio-economic base and status	**3.5**	0.040		0.140		
		Domestic and local employment opportunity absorbing the regional emigration	**3.5**	0.035		0.123		
		Provision to distinguished status in livelihood and on socio-cultural background	**3.0**	0.035		0.105		
		Better savings and deposit opportunity aiming the secured life and comfort livelihood	**3.0**	0.040		0.120		
			3.588	**0.695**	**0.695**	**2.494**	**2.522**	**0.73 (73.53%)**
Ex-site Forces/ Factors	**Institutional and Organizational**	Rural development by govt. providing better transport-communication and electrification	**3.0**	0.045	**0.190**	0.135	**0.555**	**Institutional & Organizational Factor Specific**

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		Developing legislative framework and taking incentives by the govt. for regional aquacultural development	**3.0**	0.040		0.120		**Index (IOFSI) = 0.16 (16.18%)**
		Training prgrammes for upgrading thoughts-tools-techniques-technologies in aquaculture by different govt. and non-govt. organizations	**3.0**	0.035		0.105		
		Banking support through term loan and credit facilities	**3.0**	0.040		0.120		
		Recently govt. support providing fewer subsidiaries and schemes	**2.5**	0.030		0.075		
	Others	Expanding the regional and global demand and new market opportunity	**3.5**	0.045	**0.115**	0.158	**0.353**	**Other Factor Specific Index (OFSI) = 0.10 (10.29%)**
		Developing a competitive demand, production and marketizing environment stimulating regional aquaculture	**3.0**	0.040		0.120		
		Popularizing through education, training, meetings, workshops, etc. in favor of investors and shrimp farmers for establishment and growth of aquaculture	**2.5**	0.030		0.075		
				0.305	**0.305**		**0.908**	**0.26 (26.47%)**
					1.000		**3.430**	**1.00 (100%)**
Source: Field Survey and Data Analysis, 2018-2022								

`Table 4 shows the causal or factorial scenario to assess the massive growth of shrimp culture throughout the study area. The survey and data analysis reveals that there are two types of causal or factorial dimensions in terms of in-situ or internal factors and external factors which are responsible for rapid extensive growth of aquaculture in the study area. Major internal factors like Situational factors, factors regarding infrastructure and facilities and demographic and socio-economic factors and external factors like institutional and organizational factors, etc. are the driving forces to expand the occupancy of aquaculture here rapidly. Among those different socio-economic factors are mostly responsible (39.30%) as the internal causes followed by the roles situational dimension (21.02%), institutional and organizational factors (16.18%), infrastructure and facilities (13.21%), and others (10.29%) respectively. Hence, analysis of causal assessment reflects that in-situ or internal factors are mostly liable (73.53%) rather than ex-situ or internal factors (26.47%) for such type of growth in the study area.

5.3 Costs-Benefits Analysis of the Shrimp Culture in the Study Area:

5.3.1 Aquaculture Cost Index (CI_{AQ}) Analysis:

Table 5: Aquaculture Cost Index (CI_{AQ}) Analysis

Types of Costs	Major Dimensions	Indicators/ Variables/ Attributes	Weighted Values (5)	Total Weighted Values	Dimension Specific Indices	Cost Specific Index	Aquaculture Cost Index
Environmental Costs	Resource Dimension	Unfortunate Resource Generation & Utilization	3.5	21.5/ 25	**Resource based Environment Cost Index (ECI_R)** = 0.86	**Environment Cost Index (ECI)** (ECI_R + ECI_E)/ 2 = (0.86 + 0.86)/ 2 = **0.86**	**Shrimp Farming Cost Index (CI_{AQ})** = (ECI + HCI)/ 2 = (0.86 + 0.79)/ 2 = **0.825 (82.5%)**
		Resource Abuse, Misuse & Overuse	4.5				
		Resource (Soil, Water, Biotic, etc.) Degradation	4.5				
		Lack in Resource Reuse, Renewability & Recycling	4.5				
		Poor Resource Management & Conservation	4.5				
	Ecological Dimension	Ecosystem: Change & Modification	5.0	21.5/ 25	**Ecology based Environment Cost Index (ECI_E)** = 0.86		
		Biomass & Productivity Loss	3.5				
		Habitat Loss	4.5				
		Species Declination	4.5				
		Mining Landscape Ecology	4.0				
Human Costs	Socio-economic Dimension	Agricultural Land Loss, Degradation & Defertilization	4.0	15/ 20	**Socio-economic Human Cost Index (HCI_{SE})** = 0.75	(HCI_{SE} + HCI_{SC} + HCI_I)/ 3 = (0.75 +	
		Livestock Dilution & Fate on	3.5				
		Pseudo and Part-time Employment	3.5				

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		& Emigration					
		Uncertain & Unsecured Economy	4.0				
	Socio-cultural Dimension	Alcoholism, Smoking & Drug Trending	4.5	12/ 15	**Socio-cultural Human Cost Index (HCI_{SC}) = 0.80**		
		Educational Turndown	4.0				
		Socio-cultural Disruption leading Behavioural Change	3.5				
	Institutional/ Organizational Dimension	Politics rather than Policy	4.0	12.5/ 15	**Institutional Human Cost Index (HCI_I) = 0.83**		
		Impassivity in Administrative Liability for Illegal Spread of Economy	4.5				
		Incoherence in Land use Policy	4.0				

Cost Index Categories:
(1) CI = 0-0.20: Low Cost, (2) CI = 0.20-0.40: Low to Moderate, (3) CI = 0.40-0.60: Moderate Cost, (4) CI = 0.60 – 0.80: Moderate to High Cost, (5) CI = 0.80 – 1.00: Very High Cost, (7) CI = 0: No Cost and (8) CI = 1.00: Absolute Cost

Source: Compilation of Collected Primary Data, Experimented Result of Collected Sample, Categorical Impact Observation, Survey and Assessment and Perception Study, 2018-2022 & **[10] [11]**

The Table No.-5 reflects the Aquaculture Cost Index (CI_{AQ}) analysis where the dimension specific and cost specific indices have been assessed from the weighted values on different dimension specific accountable variables. In case of the dimension specific indices, the values are greater than 0.80 excluding socio-economic human cost index (HCI_{SE} = 0.75) only which indicates the high to very high magnitude of aquacultural cost impacts. The analysis significantly shows, Environmental Cost Index (ECI) is higher (0.86) than Human Cost Index (HCI) (0.79) whereas ECI indicates very high impact on environment and HCI imprints the higher impacts on human dimensions. Hence, the comprehensive Shrimp Farming Cost Index (CI_{AQ}) is 0.825 (82.5%) which provide the alarm as the acute cost to society and environment influenced by this rapid and massive shrimp culture in the study area.

5.3.2 Aquaculture Benefit Index (BI_{AG}) Analysis

Table 6: Aquaculture Benefit Index (BI_{AG}) Analysis

Types of Costs	Major Dimensions	Indicators/ Variables/ Attributes	Weighted Values (5)	Total Weighted Values	Dimension Specific Indices	Benefit Specific Index	Aquaculture Benefit Index
Environmental Benefit	Resource & Ecological Dimension	Functionalized Use of Fluvio-coastal Site Suitability/ Environment	3.0	11.5/ 20	**Resource & Ecology based Environment Benefit Index (EBI_{RE}) = 0.57**	**Environment Benefit Index (EBI) = 0.57**	**Shrimp Farming Benefit Index (BI_{AQ})** = (EBI + HBI)/ 2 = (0.57 + 0.71)/ 2 = **0.64 (64%)**
		Effective Use of Unused, Rejected & Waste lands	3.0				
		Proper Utilization of Low Productive Wetlands, Lowlands & Agricultural Land	3.0				
		Effective use of Low Productive Ecosystem	2.5				
Human Benefit	Socio-economic Dimension	Large Scale Economic Return and Profit	4.0	23/30	**Socio-economic Human Benefit Index (HBI_{SE}) = 0.77**	**Human Benefit Index (HBI)** (HBI_{SE} + HBI_{SC} + HBI_I)/ 3 = (0.77 + 0.75 + 0.60)/ 3 = **0.71**	
		Short Term Economic Gain, Higher Income, Saving Opportunity & Quick Growth	4.0				
		Domestic & Local Employment Opportunity	3.5				
		Developing Market Facilities & Infrastructure	3.5				
		Increasing Living Standard & Upgrading Livelihood	4.0				
		Strengthening Supported Economy and Economic Security	4.0				
	Socio-cultural Dimension	Promoting Socio-cultural Status like Education, Health & Consumption of Different Modern Amenities	4.0	15/ 20	**Socio-cultural Human Benefit Index HBI_{SC}) = 0.75**		
		Developing housing, sanitation, demand and consumption	4.0				
		Dignifying Socio-cultural Position in the Society	3.5				
		Change in Food, Nutrition, Clothing and Behavioural Cases	3.5				
	Institutional/	Strengthening Policy and Providing	3.0	6/ 10	**Human Benefi**		

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	Organizational Dimension	Training, Education, Loan Facility & Emergent Subsidy from Govt. Horizon					
		Strengthening Owners' and Labours' Organization in Self of Their Livelihood & Economy	3.0				

Benefit Index Categories:
(1) BI = 0-0.20: Low Cost, (2) BI = 0.20-0.40: Low to Moderate, (3) BI = 0.40-0.60: Moderate Cost, (4) BI = 0.60 – 0.80: Moderate to High Cost, (5) BI = 0.80 – 1.00: Very High Cost, (7) BI = 0: No Cost and (8) BI = 1.00: Absolute Cost

Source: Compilation of Collected Primary Data, Experimented Result of Collected Sample, Categorical Impact Observation, Survey and Assessment and Perception Study, 2018-2021 and **[10] [11]**

`Table 6 aiming Shrimp Farming Benefit Index (BI_{AQ}) analysis provides the idea regarding positive returns as well as benefits from local shrimp culture. This quantitative and qualitative survey and its analysis exhibits the low to moderate environmental benefits (EBI = 0.57) from aqua-practice where aquacultural human benefits is considerably higher (HBI = 0.71). The comprehensive Benefit Index (BI) shows the nearly moderate to higher extent and magnitude of benefits (BI_{AQ} = 0.64) from this blue economic way throughout the region.

5.3.3 Cost-Benefit Index (CBI_{SF}) or Benefit-Cost Ratio (BCR_{AQ}) Analysis for Aquaculture:

Table 7: Cost-Benefit Index (CBI_{SF}) or Benefit-Cost Ratio (BCR_{AQ}) Analysis for Aquaculture

Cost Index		Benefit Index		Environmental Cost-Benefit Index (ECBI)	Human Cost-Benefit Index (HCBI)	Cost-Benefit Index (CBI_{AQ})
ECI	HCI	EBI	HBI			
0.86	0.79	0.57	0.71	EBI/ECI = 0.66	HBI/ HCI = 0.90	$\{(EBI + HBI)/2 \mid (ECI + BCI)/2\}$
Average CI = 0.83		Average BI = 0.64				$= 0.64/0.83 =$ **0.77**

CBI_{AQ}: <0.60 = acute costs over benefits, CBI_{AQ}: 0.60 – 0.70 = very high costs over benefits, CBI_{AQ}: 0. 70-0.80 = higher costs over benefits, CBI_{AQ}: 0.80-0.90 = moderate costs over benefits and CBI_{AQ}: >0.90 = low to very low costs over benefits,

Source: Analysis of Compiled Data and **[10] [11]**

Table 7 indicates the Cost-Benefit Index or Ratio (**CBI_{SF}/ BCR_{AQ}**) of the shrimp farming in the study area. Here, the benefits of both environment and human beings from aquaculture have been justified with respect to its corresponding costs. Hence, Human Cost-Benefit Index (HCBI) is higher (0.90>0.66) than Environmental Cost-Benefit Index (ECBI) i.e., overall cost is higher than the drawn benefits from aquaculture. Since the lower value of ratio indicates the higher deviation between costs and benefits, assessed **Cost-Benefit Index (CBI_{AQ})** shows the low to moderate index value signifying the remarkable costs from the growing blue economy here.

5.4 SWOT Factorial Analysis for Shrimp Cultivation in the Study Area:

Table 8: External Factor Analysis of SWOT

Dimension	Internal Factors	Rating Grade on 5-Point Likert Scale (R_5)	Weight (W)		Weighted Score (WSc)	
Opportunities	Expanding demand and new market opportunity rather than China	3.0	0.045	0.460	0.135	1.500
	Occupational alternative against marginal agro-economy and others encouraging job opportunity and mitigating emigration	3.5	0.050		0.175	
	Existence of a legislative framework that governs aquaculture activity and its operators	3.0	0.040		0.120	
	Institutional encouragement of aquaculture projects within the framework of the blue economy	3.0	0.045		0.135	
	State aid measures for the development of aquaculture	3.0	0.045		0.135	
	Popularizing through education, training, meetings, workshops, etc. in favor of investors and shrimp farmers for establishment and growth of aquaculture	3.5	0.040		0.140	
	Increasing connectivity with new locations, new markets through new supply chain	3.0	0.050		0.150	
	Decrease in fish production encourages the consumption of aquaculture products	3.0	0.045		0.135	
	Application of upgraded thoughts-tools-techniques-technologies (T-T-T-T/ T_4) in regional aquaculture	4.0	0.050		0.200	
	Stimulating practice and profession for local economic growth and regional development	3.5	0.050		0.175	
Threats	Absence of hatchery and feed factory or manufacturing units on a local/ regional scale.	1.0	0.055	0.54	0.055	0.640
	Health crisis (COVID 19) Threatens imports of fingerlings (raw material), floating cages (work tool), food (primary	1.0	0.055		0.055	

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	input)					
	Conflicts of use in the use of marine space and potentiality (fishing, tourism, etc.)	2.0	0.050		0.100	
	Too much dependency on Vannamei shrimp	1.0	0.055		0.055	
	Absence of a regional structured market for aquaculture products, and of a marketing network	1.0	0.055		0.055	
	Institutional heaviness and complexity in policy and practice alongwith local/ regional politico-administrative complexity and instability	1.0	0.060		0.060	
	Lack of a laboratory for the analysis and control of fishery and aquaculture products and lack of commissions for monitoring the healthiness of aquaculture areas	1.0	0.055		0.055	
	Climate Change along with morphological and functional change in landscape ecology	1.5	0.050		0.075	
	Diluting the importance and mining the potentialities of agriculture and fishing throughout the region	1.5	0.050		0.075	
	Huge environmental and human costs and questionable journey with sustainable landmark	1.0	0.055		0.055	
				1.00		2.140

Source: Data Analysis, 2022-'23

Table 8 shows the external factor analysis of SWOT where weighted score of opportunity is higher than that of threats from shrimp farming in the study area. Further, from table 9 for internal factor analysis it is seen that weighted score of strength is higher than weakness. But it's clear that weight of both strengths and opportunities are lower than the weights of weakness and threats of shrimp culture in the study area. Hence, it is alarming that negativeness of this aquaculture is prominent here.

Table 9: Internal Factor Analysis of SWOT

Dimension	Internal Factors	Rating Grade on 5-Point Likert Scale (R_5)	Weight (W)		Weighted Score (WSc)	
Strength	Fluvio-coastal site suitability with neuro-drainage network	4.0	0.050		0.200	
	Increasing investors/ owners having effective adult age groups and functional education favorable to entrepreneurship and cultivation	3.5	0.050		0.175	
	The availability of experienced labors	3.0	0.050		0.150	
	Mastery of cultivating techniques by the different regional technical team for treatment and operation	3.0	0.050		0.150	
	Banking support through term loan and credit facilities and govt. support by fewer subsidiaries and schemes	3.5	0.045		0.158	
	Increasing global demand cum market and well established supply chain structure	3.5	0.045	0.49	0.158	1.700
	Species farmed are partially autochthonous and mostly imported from neighbourhood regions	3.0	0.045		0.135	
	Fish farms are equipped with all the necessary materials and equipment	3.0	0.045		0.135	
	Emergence as the best supportive or alternative economy of traditional agriculture adjusted with regional landscape and environment	4.0	0.055		0.220	
	Higher productivity, better labour weighted production and remarkable short term economic gain than other economies	4.0	0.055		0.220	
Weakness	Abuse of fluvio-coastal site and situation in a lot of farm development not considering the environmental costs rather than economic benefits	1.0	0.050		0.050	
	A large number of Investors/ owners having no previous experience are not trained in aquaculture	1.5	0.050		0.075	
	Absence of hatchery and feed factory at farm level	1.5	0.055		0.083	
	The investment and fish processing costs are very high	1.5	0.055		0.083	
	Too much dependent on bank loans and usury money from lenders	1.0	0.060	0.51	0.060	0685
	Lack of hygienic process, low quality testing procedure and insufficient testing lab.	1.0	0.050		0.050	
	Autochthonous species are mostly at crisis phase dwindling regional habitats, ecosystem and environment	1.5	0.050		0.075	
	Interrupted drainage creates the regional water logging as well as flood prone situation	1.5	0.045		0.068	
	The lack of market and manufacturing space and scope and intensive dependency on external market and economy	1.5	0.050		0.075	

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	Local Politico-administrative complexity and obstacles in policy and practice	1.5	0.045		0.068	
				1.00		2.385

Source: Source: Data Analysis, 2022-'23

5.5 Analyzing the Strategic Position and Action Evaluation (SPACE) Matrix for Proper Strategic Applicability in the Shrimp Culture of Study Area:

From the factorial analysis of SWOT, SPACE matrix has been justified. The evaluated SPACE matrix (figure 5) suggests the defensive strategic type rather than conservative, aggressive and competitive others. Hence, the planners, strategy makers, policy makers, administrators and also shrimp farmers should be careful in the implementation of defensive strategy for sustainable aquaculture in this fluvio-coastal rural landscape.

Table 10 shows the SWOT matrix analysis where 10 defensive suggested strategies have been formulated as per evaluation of existed weaknesses and estimated threats from shrimp culture in the study area.

5.6 SWOT Matrix Analysis for Shrimp Cultivation in the Study Area:

Table 10: SWOT Matrix Analysis

			Internal Factors	
			Strength	**Weakness**
External Factors	**Opportunity**	**O1.** Expanding demand and new market opportunity rather than China **O2.** Occupational alternative against marginal agro-economy and others encouraging job opportunity and mitigating emigration **O3.** Existence of a legislative framework that governs aquaculture activity and its operators **O4.** Institutional encouragement of aquaculture projects within the framework of the blue economy **O5.** State aid measures for the development of aquaculture **O6.** Popularizing through education, training, meetings, workshops, etc. in favor of investors and shrimp farmers for establishment and growth of aquaculture **O7.** Increasing connectivity with new locations, new markets through new supply chain **O8.** Decrease in fish production encourages the consumption of aquaculture products **O9.** Application of upgraded thoughts-tools-techniques-technologies (T-T-T-T/ T_4) in regional aquaculture **O10.** Stimulating practice and profession for local economic growth and regional development	**S1.** Fluvio-coastal site suitability with neuro-drainage network **S2.** Increasing investors/ owners having effective adult age groups and functional education favorable to entrepreneurship and cultivation **S3.** The availability of experienced labors **S4.** Mastery of cultivating techniques by the different regional technical team for treatment and operation **S5.** Banking support through term loan and credit facilities and govt. support by fewer subsidiaries and schemes **S6.** Increasing global demand cum market and well established supply chai structure **S7.** Species farmed are partially autochthonous and mostly imported from neighbourhood regions **S8.** Fish farms are equipped with all the necessary materials and equipment **S9.** Emergence as the best supportive or alternative economy of traditional agriculture adjusted with regional landscape and environment **S10.** Higher productivity, better labour weighted production and remarkable short term economic gain than other economies	**W1.** Abuse of fluvio-coastal site and situation in a lot of farm development not considering the environmental costs rather than economic benefits **W2.** A large number of Investors/ owners having no previous experience are not trained in aquaculture **W3.** Absence of hatchery and feed factory at farm level **W4.** The investment and fish processing costs are very high **W5.** Too much dependent on bank loans and usury money from lenders **W6.** Lack of hygienic process, low quality testing procedure and insufficient testing lab. **W7.** Autochthonous species are mostly at crisis phase dwindling regional habitats, ecosystem and environment **W8.** Interrupted drainage creates the regional water logging as well as flood prone situation **W9.** The lack of market and manufacturing space and scope and intensive dependency on external market and economy **W10.** Local Politico-administrative complexity and obstacles in policy and practice
	Threat	**T1.** Absence of hatchery and feed factory or manufacturing units on a local/ regional scale. **T2.** Health crisis (COVID 19) threatens imports of fingerlings (raw material), floating cages (work tool), food (primary input) **T3.** Conflicts of use in the use of marine space and potentiality (fishing, tourism, etc.) **T4.** Too much dependency on Vannamei shrimp **T5.** Absence of a regional structured market for aquaculture products, and of a marketing network **T6.** Institutional heaviness and complexity in policy and practice alongwith local/ regional politico-administrative complexity and instability **T7.** Lack of a laboratory for the analysis and control of fishery and aquaculture	**Defensive Suggested Strategies**	**W** **O**
			T➲	**Suggested WT Strategies** ***WT1.*** *Development of hatchery and feed factory at local level and well structured market opportunities and infrastructure* ***WT2.*** *Development of extension programs based on farmers needs* ***WT3.*** *Development of proper institutional policy and strategy framework for sustained shrimp farming as well as aquaculture* ***WT4.*** *Provision of sufficient govt. supports in production, marketing, trading and emergent situations* ***WT5.*** *Preparing strategic plans to development integrated aqua-farming as well as sustainable shrimp farming* ***WT6.*** *Development of land reclamation or effective reproductive policy and strategy for rejected or unproductive aqua-farms* ***WT7.*** *Using sustainable water, soil, land and biotic resources management.* ***WT8.*** *Considering farm sustainability indexes* ***WT9.*** *Considering quality of seeds, methods, tools, techniques and technologies* **WT10.** *Proper LULC and environmental policy implementation in aqua-*

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		products and lack of commissions for monitoring the healthiness of aquaculture areas **T8.** Climate Change along with morphological and functional change in landscape ecology **T9.** Diluting the importance and mining the potentialities of agriculture and fishing throughout the region **T10.** Huge environmental and human costs and questionable journey with sustainable landmark		*practice through proper thoughts, teaching and training*

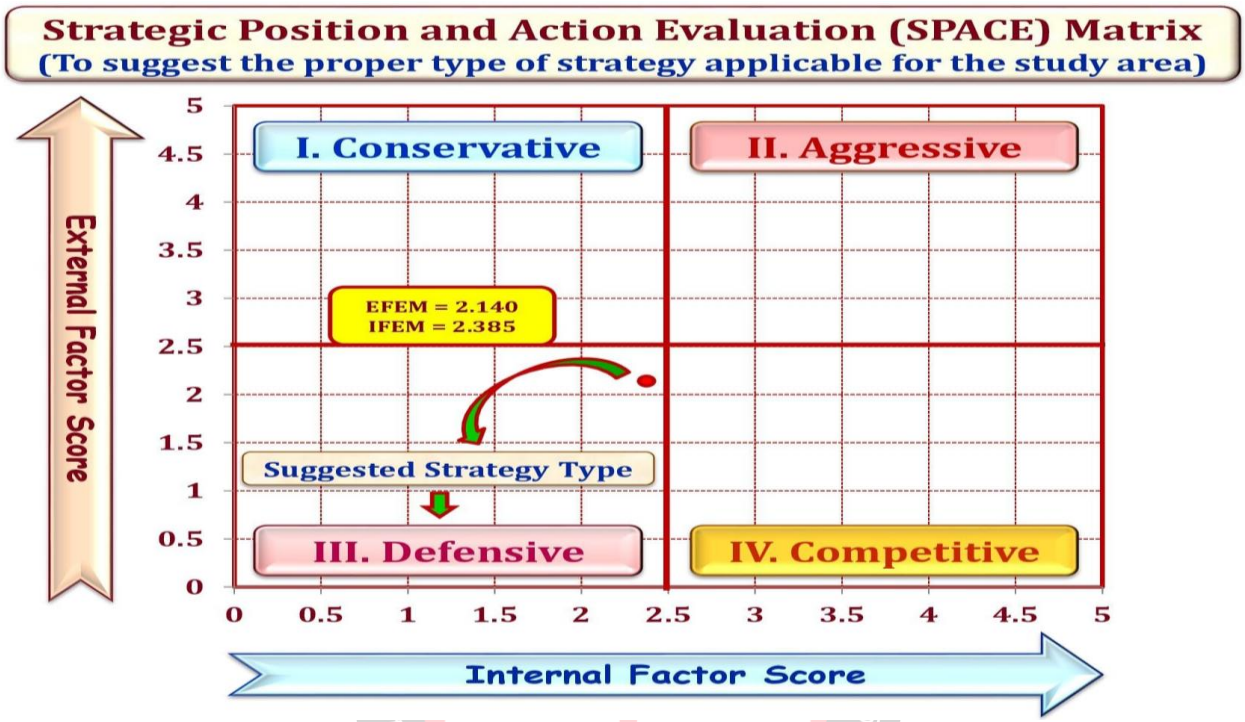

Figure 5: Strategic Position and Action Evaluation (SPACE) Matrix for Prior Strategic Planning

5.7 Quantitative Strategic Planning Matrix (QSPM):

Table 11: QSPM Analysis for Best Strategic Assessment

Key Factors	Weights	WT_1		WT_2		WT_3		WT_4		WT_5		WT_6		WT_7		WT_8		WT_9		WT_{10}	
		AS	TAS	AS	TAS	AS	TAS	AS	TAS	AS	TAS	AS	TAS	AS	TAS	AS	TAS	AS	TAS	AS	TAS
S_1	0.050	1	0.05	2	0.10	2	0.10	1	0.05	2	0.10	1	0.05	2	0.10	2	0.10	1	0.05	2	0.10
S_2	0.050	2	0.10	2	0.10	2	0.10	2	0.10	1	0.05	1	0.05	2	0.10	2	0.10	2	0.10	2	0.10
S_3	0.050	2	0.10	3	0.15	1	0.05	2	0.10	2	0.10	1	0.05	1	0.05	1	0.05	2	0.10	2	0.10
S_4	0.050	2	0.10	1	0.05	2	0.10	2	0.10	2	0.10	2	0.10	2	0.10	2	0.10	3	0.15	2	0.10
S_5	0.045	3	0.14	3	0.14	3	0.14	3	0.14	2	0.09	1	0.05	1	0.05	2	0.09	3	0.14	2	0.09
S_6	0.045	3	0.14	3	0.14	3	0.14	3	0.14	2	0.09	2	0.09	2	0.09	2	0.09	3	0.14	1	0.05
S_7	0.045	1	0.05	1	0.05	2	0.09	1	0.05	2	0.09	2	0.09	3	0.14	3	0.14	3	0.14	3	0.14
S_8	0.045	2	0.09	2	0.09	2	0.09	2	0.09	2	0.09	1	0.05	1	0.05	2	0.09	3	0.14	1	0.05
S_9	0.055	2	0.11	2	0.11	2	0.11	1	0.06	2	0.11	2	0.11	2	0.11	2	0.11	2	0.11	2	0.11
S_{10}	0.055	2	0.11	3	0.17	2	0.11	2	0.11	2	0.11	1	0.06	1	0.06	2	0.11	3	0.17	2	0.11
W_1	0.050	2	0.10	2	0.10	3	0.15	1	0.05	2	0.10	2	0.10	3	0.15	3	0.15	3	0.15	3	0.15
W_2	0.050	2	0.10	2	0.10	2	0.10	2	0.10	2	0.10	2	0.10	2	0.10	2	0.10	2	0.10	2	0.10
W_3	0.055	4	0.22	3	0.17	3	0.17	3	0.17	2	0.11	1	0.06	1	0.06	1	0.06	2	0.11	1	0.06
W_4	0.055	3	0.17	2	0.11	2	0.11	3	0.17	2	0.11	1	0.06	1	0.06	1	0.06	2	0.11	1	0.06
W_5	0.060	3	0.18	2	0.12	3	0.18	3	0.18	1	0.06	1	0.06	1	0.06	1	0.06	2	0.12	1	0.06
W_6	0.050	3	0.15	3	0.15	3	0.15	3	0.15	2	0.10	2	0.10	2	0.10	3	0.15	3	0.15	2	0.10
W_7	0.050	2	0.10	2	0.10	3	0.15	3	0.15	3	0.15	3	0.15	3	0.15	3	0.15	2	0.10	4	0.20
W_8	0.045	1	0.05	1	0.05	3	0.14	2	0.09	2	0.09	3	0.14	3	0.14	2	0.09	2	0.09	4	0.18
W_9	0.050	3	0.15	2	0.10	3	0.15	3	0.15	2	0.10	1	0.05	1	0.05	1	0.05	1	0.05	1	0.05
W_{10}	0.045	3	0.14	2	0.09	4	0.18	3	0.14	2	0.09	2	0.09	3	0.14	3	0.14	2	0.09	3	0.14

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O_1	0.045	2	0.09	2	0.09	3	0.14	3	0.14	1	0.05	1	0.05	1	0.05	1	0.05	1	0.05	1	0.05
O_2	0.050	2	0.10	2	0.10	2	0.10	2	0.10	3	0.15	1	0.05	2	0.10	2	0.10	1	0.05	2	0.10
O_3	0.040	3	0.12	2	0.08	4	0.16	3	0.12	3	0.12	3	0.12	3	0.12	3	0.12	3	0.12	4	0.16
O_4	0.045	3	0.14	3	0.14	4	0.18	4	0.18	3	0.14	2	0.09	3	0.14	3	0.14	3	0.14	4	0.18
O_5	0.045	3	0.14	3	0.14	4	0.18	4	0.18	3	0.14	2	0.09	2	0.09	3	0.14	3	0.14	2	0.09
O_6	0.040	3	0.12	3	0.12	4	0.16	3	0.12	3	0.12	2	0.08	3	0.12	3	0.12	3	0.12	3	0.12
O_7	0.050	3	0.15	3	0.15	3	0.15	3	0.15	2	0.10	1	0.05	1	0.05	2	0.10	1	0.05	1	0.05
O_8	0.045	2	0.09	1	0.05	2	0.09	2	0.09	1	0.05	2	0.09	2	0.09	2	0.09	2	0.09	2	0.09
O_9	0.050	3	0.15	3	0.15	4	0.20	3	0.15	3	0.15	3	0.15	3	0.15	3	0.15	3	0.15	3	0.15
O_{10}	0.050	3	0.15	2	0.10	3	0.15	3	0.15	3	0.15	3	0.15	3	0.15	2	0.10	2	0.10	2	0.10
T_1	0.055	4	0.22	3	0.17	3	0.17	3	0.17	2	0.11	1	0.06	1	0.06	2	0.11	2	0.11	1	0.06
T_2	0.055	3	0.17	2	0.11	2	0.11	3	0.17	1	0.06	1	0.06	1	0.06	2	0.11	2	0.11	1	0.06
T_3	0.050	1	0.05	1	0.05	1	0.05	1	0.05	2	0.10	2	0.10	3	0.15	3	0.15	1	0.05	2	0.10
T_4	0.055	2	0.11	2	0.11	2	0.11	2	0.11	1	0.06	1	0.06	2	0.11	2	0.11	3	0.17	1	0.06
T_5	0.055	3	0.17	3	0.17	3	0.17	3	0.17	2	0.11	1	0.06	1	0.06	2	0.11	1	0.06	1	0.06
T_6	0.060	3	0.18	2	0.12	3	0.18	3	0.18	2	0.12	2	0.12	3	0.18	3	0.18	2	0.12	2	0.12
T_7	0.055	3	0.17	3	0.17	3	0.17	3	0.17	2	0.11	2	0.11	2	0.11	3	0.17	3	0.17	2	0.11
T_8	0.050	1	0.05	1	0.05	1	0.05	1	0.05	2	0.10	2	0.10	3	0.15	3	0.15	2	0.10	3	0.15
T_9	0.050	1	0.05	1	0.05	2	0.10	1	0.05	3	0.15	2	0.10	3	0.15	2	0.10	1	0.05	3	0.15
T_{10}	0.055	2	0.11	1	0.06	3	0.17	2	0.11	3	0.17	3	0.17	3	0.17	3	0.17	3	0.17	3	0.17
STAS			4.83		4.31		5.26		4.84		4.17		3.41		4.05		4.42		4.37		4.12
Priority			**3**		**6**		**1**		**2**		**7**		**10**		**9**		**4**		**5**		**8**

N.B.:

- *Attractiveness Scores (AS) is: 1 = not attractive, 2 = somewhat attractive, 3 = reasonably attractive, and 4 = highly attractive*
- *Total Attractiveness Scores (TAS) & Sum of the Total Attractiveness Score (STAS)*

5.8 Priority Ranking and Strategy Evaluation:

Table 12: Priority Ranking and Strategy Evaluation

Strategy Order	WT Strategies	Priority Rank as per QSPM	Remarks on Strategy
WT_1	Development of hatchery and feed factory at local level and well structured market opportunities and infrastructure	3	Development of farm and related infrastructure and facilities
WT_2	Development of extension programs based on farmers needs	6	Farmer specific development
WT_3	Development of proper institutional policy and strategy framework for sustained shrimp farming as well as aquaculture	1	Proper policy and strategy framing
WT_4	Provision of sufficient govt. supports in production, marketing, trading and emergent situations	2	Institutional support in practice and policy
WT_5	Preparing strategic plans to development integrated aqua-farming as well as sustainable shrimp farming	7	Strategy making for integrated aqua-farming
WT_6	Development of land reclamation or effective reproductive policy and strategy for rejected or unproductive aqua-farms	10	Land reclamation policy and strategy making
WT_7	Using sustainablewater, soil, land and biotic resources management.	9	Sustainable resource management
WT_8	Considering farm sustainability indexes	4	Emphasizing farm sustainability
WT_9	Considering quality of seeds, methods, tools, techniques and technologies	5	Considering quality of materials and methods
WT_{10}	Proper LULC and environmental policy implementation in aqua-practice through proper thoughts, teaching and training	8	Maintaining LULC and environmental policies in practice

Source: QSPM Analysis

The QSPM sum total attractiveness scores which shows the most attractive strategy for sustainable practice of aquaculture throughout the study area. Higher scores point ata more attractive strategy, considering all the relevant external and internal critical factors that could affect the strategic decision (Table 4). The range for attractiveness scores is 1 = not attractive, 2 = somewhat attractive, 3 = reasonably attractive, and 4 = highly attractive. Based on the results of QSPM, the WT strategies are prioritized as follows:

1. **WT_3:** Development of proper institutional policy and strategy framework for sustained shrimp farming as well as aquaculture.
2. **WT_4:** Provision of sufficient govt. supports in production, marketing, trading and emergent situations.
3. **WT_1:** Development of hatchery and feed factory at local level and well structured market opportunities and infrastructure

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4. **WT_8:** Considering farm sustainability indexes.
5. **WT_9:** Considering quality of seeds, methods, tools, techniques and technologies.
6. **WT_2:** Development of extension programs based on farmers needs.
7. **WT_5:** Preparing strategic plans to development integrated aqua-farming as well as sustainable shrimp farming.
8. **WT_{10}:** Proper LULC and environmental policy implementation in aqua-practice through proper thoughts, teaching and training.
9. **WT_7:** Using sustainable water, soil, land and biotic resources management.
10. **WT_6:** Development of land reclamation or effective reproductive policy and strategy for rejected or unproductive aqua-farms

5.9 General Framework of SDGs and Contribution of Aquaculture in Sustainable Development:

Sustainable development was defined in the World Commission on Environment and Development's 1987 Brundtland report ´Our Common Future` after the commission's chair, then-Norwegian Prime Minister Gro Harlem Brundtland as *'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. Some basic features of Sustainable Development Goals are:*

- *Sustainable Development Goals (SDGs) are the United Nations global development goals.*
- *These are bold universal agreements to end poverty in all its dimensions and craft an equal, just and secure world.*
- *SDG has 17 goals and 169 targets and it covers multiple aspects of growth and development.*
- *It is also known as a successor of MDGs (Millennium Development Goals)*
- *It was adopted by 193 countries of United Nations General Assembly on 25th September 2015*
- *SDG is officially known as "Transforming our world: the 2030 Agenda for Sustainable Development."*
- *It is built on the principle agreed upon under resolution, "The Future We Want".*
- *The United Nations Sustainable Development Goals (SDGs) are 17 goals with 169 targets that all 191 UN Member States have agreed to try to achieve by the year 2030.*

Figure 6: SDGs

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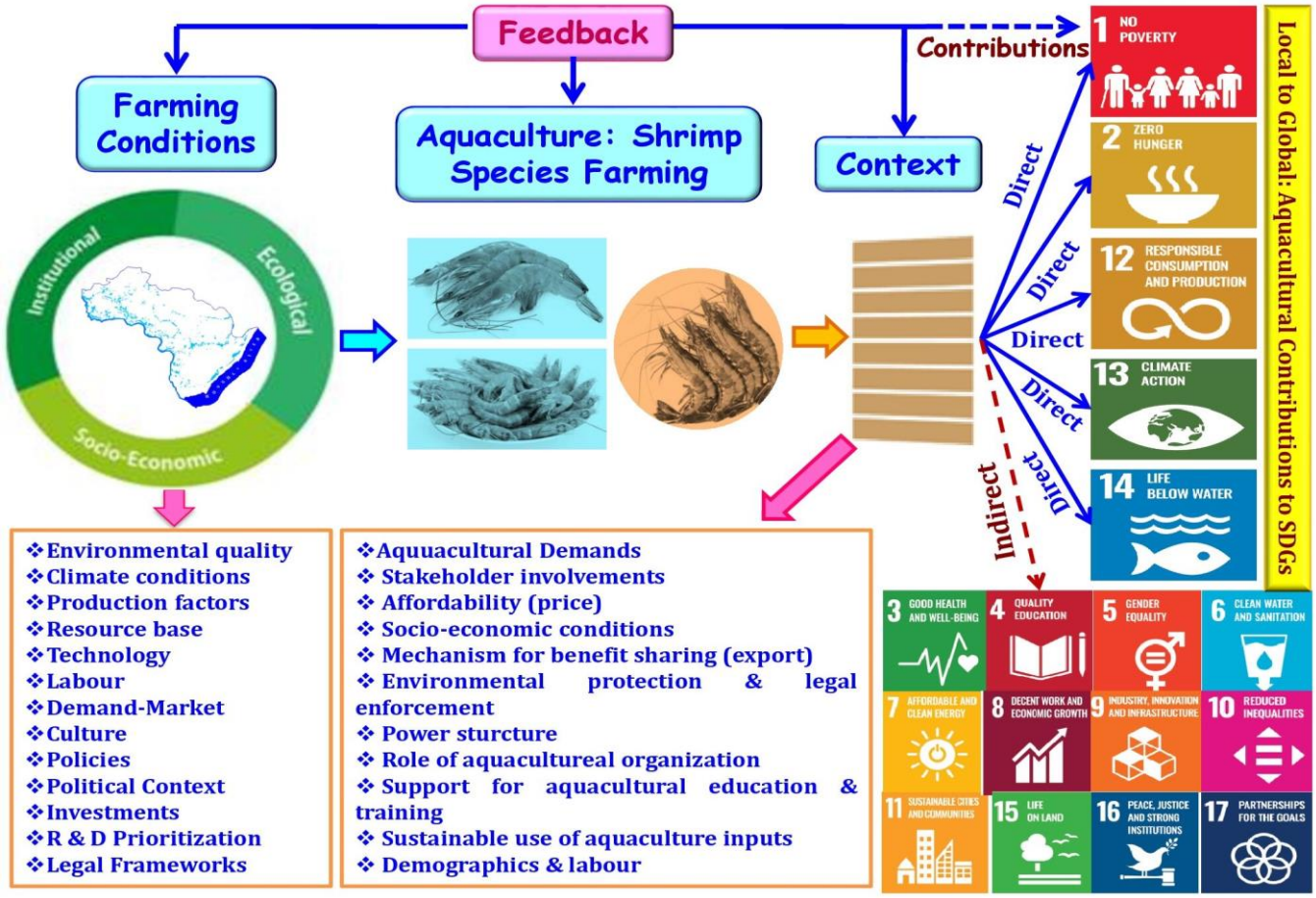

Figure 7: Conceptual figure illustrating what is "shaping" aquaculture's contribution to the Sustainable Development Goals ("rule of the game") and also the feedback enabling adjustments for reaching desired targets/ outcomes (Rebuilt from [39])

Table 13: Suggested actions for the aquaculture sector to continue contributing positively to Agenda 2030
❖ To more explicitly consider aquaculture's role for 2030 Agenda's 17 goals, 169 targets and 230 indicators
❖ Identify aquaculture's role in the global food system, in rural and urban redevelopment, in diets, and overall, in human health and wellness, and recognize the value of indigenous knowledge and traditional aquaculture farming systems as an integral part of intangible heritage and foundation for future sustainability
❖ National aquaculture policies should better integrate aquaculture in national food strategies and sustainable livelihood programs
❖ Influence government long-term strategic plans so that the narrative about aquaculture explains economic prosperity in context of environmental and social responsibility
❖ Incorporate the changing roles of international seafood trade into future contributions of regional aquaculture developments (identifying and acknowledging trade-offs related to the many SDGs)
❖ Establish greater transparency and cooperation between countries under bilateral aid projects involving aquaculture and build on existing experience and knowledge. Different partnerships could make aquaculture's contributions to the SDGs more clear, particularly around addressing displacing impacts
❖ Facilitate for broader integrative thinking/planning: Integrate land and ocean-based aquaculture with emerging renewable energy systems, existing agricultural systems, and other sectors of the economy (e.g., fisheries, tourism)
❖ Develop aquaculture sustainability credits to incentivize investments and participation and incorporate ecosystem services more broadly into the "aquaculture discussion"
❖ Better linkages/integration between coastal aquaculture development and broader marine management, and development of tools such as carrying capacity modeling to help assess these through integrated use of indicators
❖ Better use/implementation of the Ecosystem Approach to Aquaculture; as done with "The Code of Conduct for Responsible Fisheries"—that is, making it more operational
❖ Involving key stakeholders when monitoring aquaculture's progrss towards the SDGs—thus enabling broad stakeholder participation and also developing tools and mapping of SDGs to localized or downscaled meaningful indicators for tracking/ monitoring progress
❖ Enhance/incentivize aquatic farming's role for conservation of biodiversity—policy/industry integration, adoption of ecological aquaculture (novel investment like blue bonds of greener finance and natural capital approaches
❖ Accelerated education for local decision makers and the public related to aquacultures potential role for achieving the SDGs, such as Ireland's Aquaculture Remote Classroom
❖ Making the SDGs more visible in the private aquaculture sectors sustainability reporting and improve our understanding about what's in the SDGs for private companies/aquaculture producers and how they deal with trade-offs in their SDG reporting
❖ Embed social and environmental responsibility into economic goals for the industry to better link to the SDGs
❖ Highlight often neglected cultural and social values in aquaculture and explore opportunities for synergies
Source: [39]

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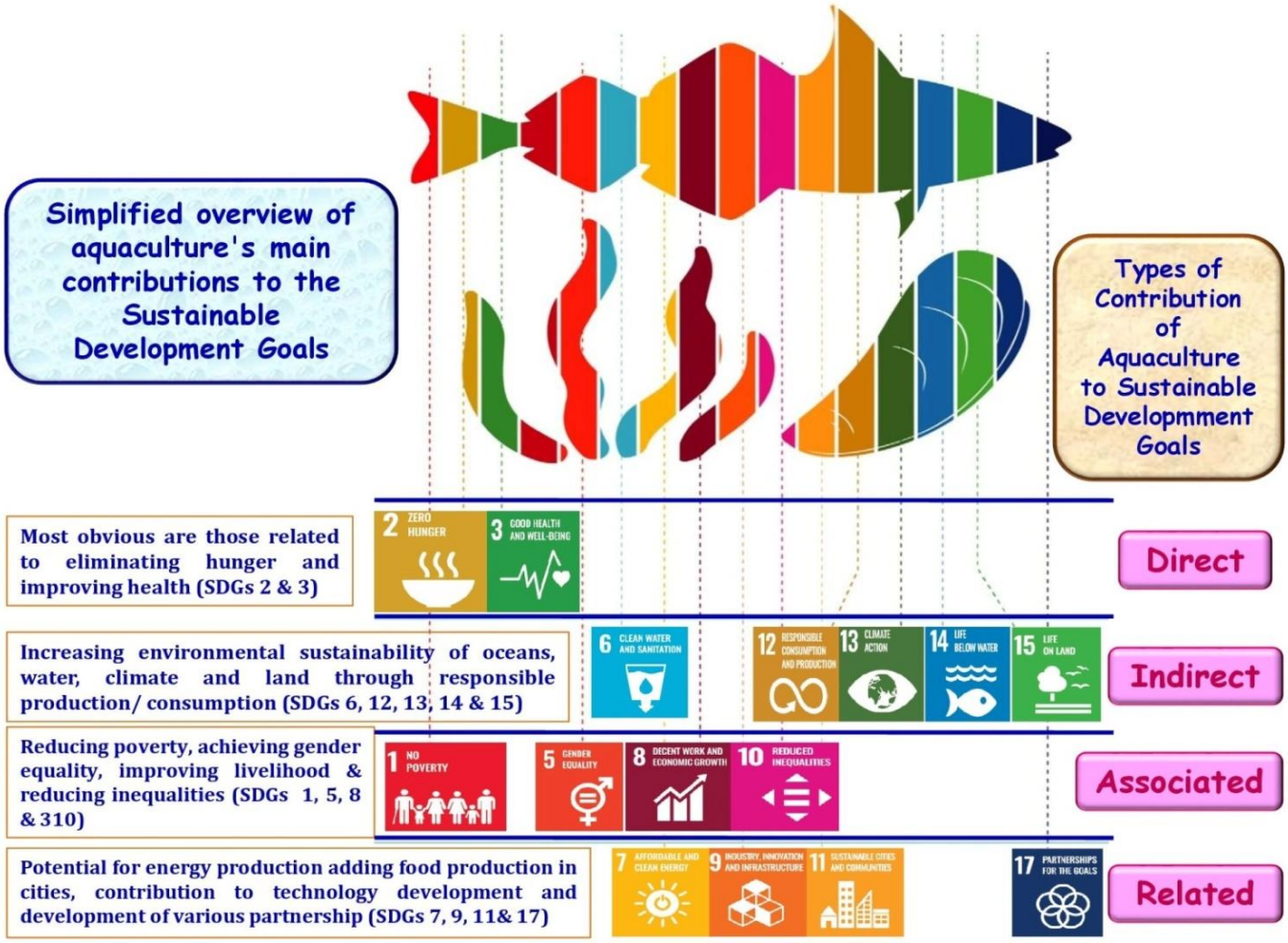

Figure 8: Simplified overview of aquaculture's main contributions to the Sustainable Development Goals (Rebuilt from [39])

5.9 Strategic Prediction-Adaptation-Resilience (PAR) Approach towards Sustainable Aquaculture:

Figure 9 and 10 shows the strategic PAR approach considering three dimensions like shrimp farming growth, demand-supply chain and landscape resilience in the study area. 14 measurable indicators have been selected under the mentioned three dimensions to formulate three PAR keys like Prediction, Adaptation and Resilience and to outline six applicable ways towards sustainable development of the shrimp farming here.

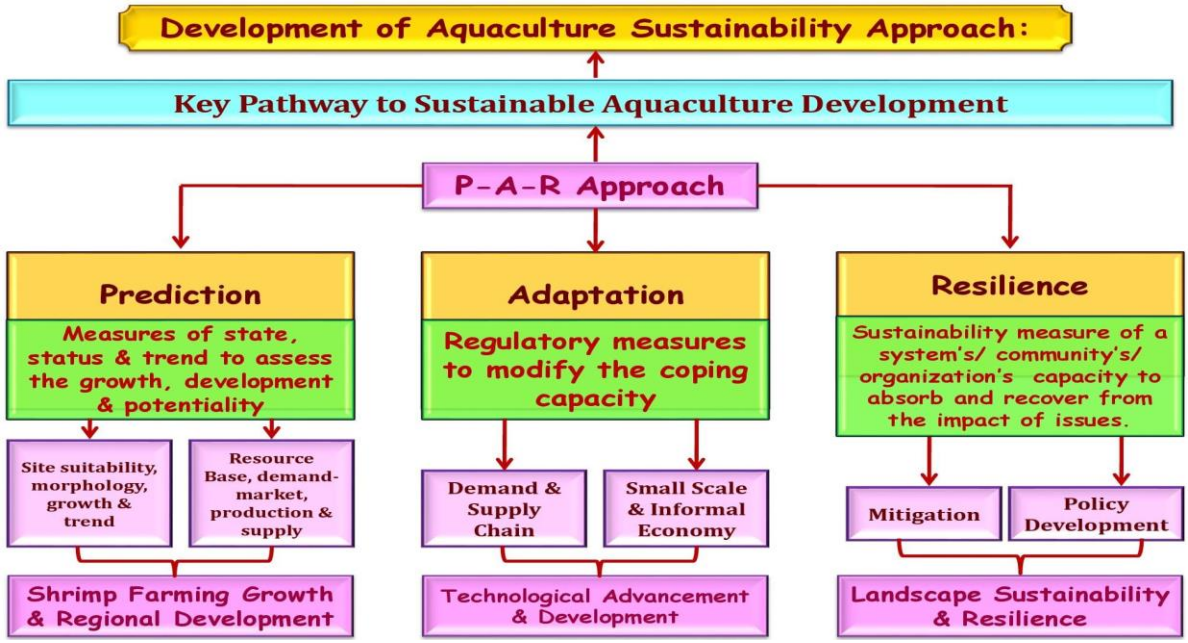

Figure 9: Conceptual Framework as per PAR Approach and UN's SDGs for Sustainable Aquaculture in the Study Area

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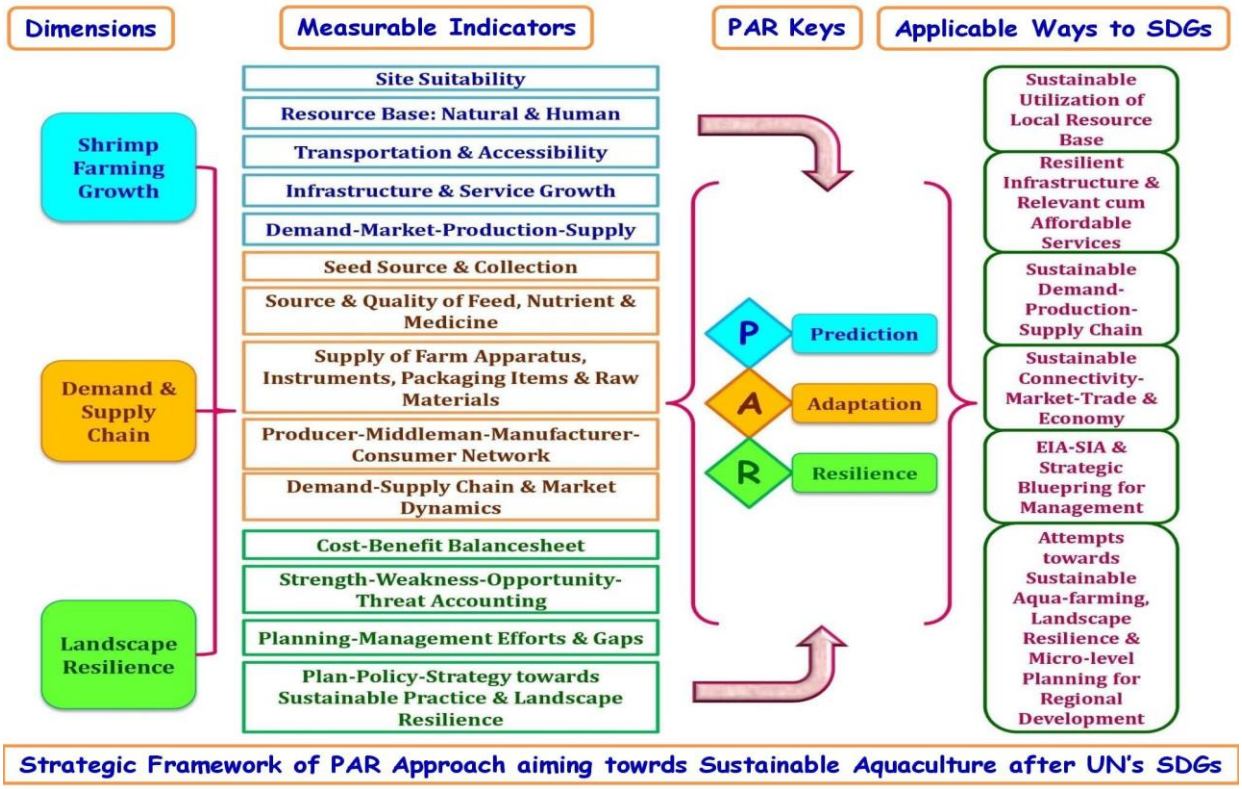

Figure 10: Strategic PAR Approach for Sustainable Shrimp Farming as well as Aquaculture in the Study Area

VI. Messages for the Proper Practicing of Shrimp Farming in terms of Blue Economy aiming the SDGs:

M1. Aquaculture contributes to all 17 Sustainable Development Goals, but the areas where data shows impact are (i) ending hunger and improving health (SDGs 2 and 3); (ii) from responsible production/use to improve the environmental stability of the sea and water. , security and land (SDGs 6, 12, 13, 14 and 15) and (iii) reducing poverty, achieving gender equality, improving livelihoods and reducing inequality (SDGs 1, 5, 8 and 10).

M2. Aquaculture is an important activity that contributes to human well-being, but a better link between aquaculture, health, better nutrition and responsible practices is needed to play a greater role in efforts to maintain natural control and human well-being which are essential in terms of Sustainable Development Goals for this generation and also the next.

M3. Greater recognition and appreciation of aquaculture's current and future role in the world's food supply, including rural and urban development (and innovation), sanitation, sanitation, human health and wellness, will enable us to understand this in depth creating the ability to contribute positively towards multiple sustainable development goals and influence policy effectiveness and impact.

M4. Integrating land and sea with renewable energy systems, existing agricultural systems, and other industries (including trade) should be further explored to facilitate the development of destinations and create meaningful communities with shared goals.

M5. Institutions, from the international to the regional level, need to monitor aquaculture's contribution to the range of sustainable development goals from the current model, while continuing to build on this foundation and develop new tools to achieve the broader benefits of aquaculture. Such analyzes are important to compare and demonstrate the impacts and trade-offs of aquaculture on other food and livelihood resources.

M6. Having a broad overview is essential for a deep understanding of aquaculture for all sustainable development goals and the benefits of action, investment and change, especially in the context of supply chains and diversified livelihoods.

M7. To understand how aquaculture can achieve sustainable development goals (local and global), the specific context of aquaculture development needs to be understood. Different contexts determine how ocean productivity and benefits benefit (and impact) people and the environment, driven by local characteristics and international

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connections (e.g. distant resources (such as feed supplies) and trade relationships). Exports benefit consumers elsewhere, etc.). To support sustainable management, it is important to identify and consider trade-offs at local and global scales (i.e., local impacts and distant benefits).

M8. The inequalities created by some aquaculture structures threaten the realization of sustainable aquaculture and the achievement of development goals. Applying the Sustainable Development Goals perspective to aquaculture development can lead to a better understanding of social-ecological justice and the benefits of food, thereby improving self-management.

M9. Gender should be considered in more detail in data representing cost/benefit in the aquaculture industry. The specific contribution of aquaculture to sustainable development goals is often unrealized due to the lack of information on livelihoods in the fisheries and aquaculture sectors. Better disaggregation of various indicators, including at the household level, will allow measuring the specific benefits and dependency of aquaculture. This information is often not available.

M10. To improve the ability to gain a social license to work in the marine/aquaculture food industry, particularly aquaculture, there is a need for faster training to help people make local decisions and citizens to make informed choices and understand the wider benefits. It is important that consumers understand the role of aquaculture in achieving development goals. New evidence is needed to prevent the negative image of the economy from influencing politics.

M11. There is an urgent need to understand the relationship between global risks and emerging climate challenges and the effectiveness of various aquaculture systems to develop future prevention strategies. A better recovery continuing understanding will be important for national and international development processes (food, livelihoods, water conservation and restoration, etc.). Aquaculture strategies that build on past and future global shocks and increase the sustainability of the sector will be important. [39]

VII. Conclusion

Aquaculture has the potential to benefit the health of people and the planet when its results are aligned with sustainable development goals. However, aside from policy changes, the evidence is still mixed and weak [4]. The potential for business to contribute to sustainable development goals by using mechanisms such as those developed for the United Nations Sustainable Development Goals seems high. Aquaculture has already contributed to many SDGs, but different cultures/systems, along with different contexts, will result in different SDG outcomes being achieved or not achieved. This needs to be evaluated carefully. Our review concludes that the United Nations Sustainable Development Goals framework is useful and necessary to support the future global transformation of aquaculture [22] [37]. But unless action is taken to change policy and recognize the potential of groundwater in all sustainable development goals, the economy will remain stagnant and unaffected by many countries' (food) regulations. By law, aquaculture is regulated differently in different countries; For example, in some countries aquaculture falls within the scope of agricultural law, while in other countries aquaculture is lost in fisheries or natural resource policy. This is just part of management, i.e. private sector, social policies, standards etc. It is the result of the interaction between The full potential of aquaculture to achieve sustainable development goals can only be realized if it is integrated into the broader food and natural resource landscape. Because of the importance of dependence on water and soil nutrients (and others), a clear link between the planning process is necessary. One way to break down sectoral/policy silos is to leverage key concepts such as net zero or the triple challenge of people, planet and climate. This requires the integration of aquaculture management and its integration into the policy development process. Significant changes in how many people think about cultivating land can be improved and better linked to broader interests and the basis of highway goals, according to the statement. Furthermore, policy still needs to be improved to develop a deeper understanding of how aquaculture (systems and species) is linked to more sustainable goals and to improve understanding of its potential as current indicators allow (or not) to monitor change. The application of two assessment methods, the Impact Pathway and the Sustainability Wheel, shows that laypeople can better understand and see the connections between groundwater and sustainability collaboration. However, as this article points out, the scientific literature also shows that understanding how the characteristics of the environment affect the aquatic environment is important in contributing to development goals. The next step is to test the model described in this article on other aquaculture systems and find ways to simplify the analysis. Existing indicators published for different levels should be evaluated and monitored (and approved if new indicators are needed). This requires careful analysis of statistics from different countries and assessing their performance to understand how they are achieving outcomes towards the Sustainable Development Goals. This article shows why new explanations of the complexity of the direct and indirect benefits of different aquaculture products are important and rely on different contexts and regulations to achieve safety goals in this generation. Such clarifications can facilitate the growth of

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the economy and improve the management of the agreement on aquaculture, which can meet many indicators and targets. This will lead to context-specific recommendations to improve the extension and integration of practice across space and body boundaries. It is important to know that aquaculture is not a panacea for achieving global food security or sustainable development goals; however, if it is planned and done correctly, it can provide significant benefits. Finally it may be said that the study area should be habituated with sustainable shrimp farming in terms of aquaculture practices for optimum utilization of this fluvio-coastal landscape and its resources and better livelihood through proper regional planning and micro-level development.

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