



**SME Business Facilitation Center, Multan**



## **Aquaculture Clusters in South Punjab**

### **Opportunities and Challenges**



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## Executive Summary

This study presents an analysis of the potential, barriers, and opportunities associated with developing aquaculture clusters in South Punjab. The region, known for its agricultural heritage, is witnessing a shift towards aquaculture due to changing market dynamics, water scarcity concerns, and governmental backing. The study seeks to evaluate the present condition of aquaculture, delve into the notion of aquaculture clusters, pinpoint challenges, and provide suggestions for fostering sustainable cluster growth.

South Punjab has witnessed significant growth in fish farming, with expanded acreage, increased production levels, and Government initiatives contributing to the sector's development. Major fish species farmed include Rohu, Catla, Mrigal, Tilapia, Grass Carp, and Silver Carp.

The study identifies and characterizes aquaculture clusters in South Punjab, emphasizing their formation through geographical proximity, shared resources, and collaborative networks among stakeholders. Major clusters are located in districts like Dera Ghazi Khan, Muzaffargarh, Multan, Vehari, Bahawalnagar, Bahawalpur, and Rahim Yar Khan.

The aquaculture sector in South Punjab presents significant opportunities driven by market demand, technological advancements, and value addition. These opportunities include employment generation, income diversification, value chain linkages, and community development.

However, the sector faces diverse challenges such as environmental management, socioeconomic disparities, technological adoption, market access, and access to finance. Addressing these challenges is crucial for sustainable development and industry resilience.

The study provides recommendations pertaining to best business practices, capacity building, stakeholder collaboration, policy alignment, regulatory frameworks, incentive mechanisms, and stakeholder engagement to foster the growth and resilience of aquaculture clusters in South Punjab.

The overall regulatory and institutional framework for aquaculture development in Pakistan has also been discussed, highlighting the role of Government entities, policies, funding, and strategic initiatives aimed at promoting and regulating the sector.

In conclusion, the study underscores the importance of aquaculture clusters in South Punjab's economic development, food security, and rural livelihoods, while also emphasizing the need for strategic interventions, collaborative efforts, and policy support to overcome challenges and capitalize on opportunities for sustainable growth.

## 1. Introduction

South Punjab is well defined region in Punjab Province that includes Multan, Dera Ghazi Khan, and the Bahawalpur Civil Divisions. This includes 11 districts: Vehari, Multan, Lodhran, Khanewal, Bahawalpur, Bahawalnagar, Rahim Yar Khan, Rajanpur, Muzaffargarh, Layyah, and D.G. Khan.

**Figure 1: Map of South Punjab**



These districts have 42 sub-district administrative units (tehsils), 1,221 union councils, and 8,907 Mauzas. The population of South Punjab is estimated to be around 34.7 million, while Punjab’s total population is 110 million. Population density in the South Punjab is presently 447 persons per Square Kilometer and population growth rate is 2.32%.<sup>1</sup>

Aquaculture, the farming of aquatic organisms, has emerged as a significant sector in South Punjab, owing to various factors that have shaped its development over time. Historically, the region has been characterized by a strong agricultural economy, with a focus on traditional crops such as wheat, rice, and cotton. However, with changing environmental conditions, water scarcity issues, and evolving market demands, the diversification into aquaculture has become a viable and strategic choice for economic growth and food security.

### 1.1 Background and Context

The background of aquaculture in South Punjab can be attributed to several significant factors:

#### a). Water Resources

South Punjab is blessed with water resources, including rivers, canals, and natural water bodies. The availability of water has been a driving force behind the expansion of aquaculture activities, providing the necessary infrastructure for fish farming and cultivation.

<sup>1</sup> The Bureau of Statistics, Punjab

### **b). Climate Suitability**

The region's climate, characterized by hot summers and moderate winters, is conducive to the growth of various aquatic species. This favorable climate has enabled farmers to engage in aquaculture throughout the year, maximizing production and profitability.

### **c). Market Demand**

The increasing demand for fish products, both domestically and internationally, has created lucrative opportunities for aquaculture entrepreneurs in South Punjab. With a growing population and changing dietary preferences towards healthier protein sources, such as fish, the market for aquaculture products has witnessed steady growth.

### **d). Government Support**

Recognizing the potential of aquaculture for rural development, food security, and export earnings, the Government has implemented various policies and initiatives to promote and support the aquaculture sector. These include subsidies, training programs, infrastructure development, and regulatory frameworks aimed at facilitating sustainable growth.

### **e). Technological Advancements**

Advances in aquaculture technology, including pond management techniques, breeding practices, feed formulations, disease control measures, and water quality management, have enhanced the productivity and efficiency of fish farming operations in South Punjab.

### **f). Community Engagement**

Local communities, including small-scale farmers and fishermen have played an important role in fostering the growth of aquaculture clusters. They have come together to establish cooperative groups, share knowledge, expertise, resources, and collectively tackle various challenges, including access to inputs, marketing channels, and integration within the value chain.

## **1.2 Scope and Objectives**

This study aims to conduct analysis of the potential of aquaculture clusters in South Punjab. Key objectives are following:

- To assess the current status of aquaculture in the region, including production levels, dominant species farmed, and existing opportunities and challenges.
- To analyze the concept of aquaculture clusters and their potential benefits for the sector in South Punjab.
- To identify and characterize existing or potential aquaculture clusters in the region.
- To provide a set of recommendations to stakeholders based on the findings for fostering sustainable and impactful aquaculture cluster development in South Punjab.

## **1.3 Methodology**

To achieve the above-mentioned objectives, this study employed a mixed-method approach that incorporated the following methods:

### **a). Desk Research**

A detailed review of existing literature, reports, and data on aquaculture in South Punjab was conducted. This involved examining Government publications, research papers from academic institutions, and industry reports to gather relevant information on the subject.

### **b). Field Surveys**

The field surveys were carried out through interviews with fish farmers, sector stakeholders such as input suppliers, processors, and government officials directly involved in the sector to collect important first-hand information.

### **c). Case Studies**

The successful examples of aquaculture clusters in other regions, both within Pakistan and internationally were examined, which provided valuable insights and potential models for adoption in South Punjab. This involved study best practices, identifying key success factors, and understand the challenges faced in established clusters.

Data sources include the Department of Fisheries Punjab, which provides official reports, statistics, policies, and regulatory frameworks. Coordination with educational institutes provides access to scholarly research, academic publications, case studies, and expert opinions. Additionally, direct interaction with fish farmers through interviews to understand their experiences, challenges, practices, perspectives on aquaculture clusters, enhancing the study's depth and breadth. Moreover, market analysis is incorporated to assess market trends, consumer preferences, import-export dynamics, and economic indicators affecting aquaculture clusters. The triangulation of data from multiple sources ensure a comprehensive analysis, and facilitating evidence-based recommendations for sustainable development and growth strategies in the sector.

## **2. Aquaculture in South Punjab: An Overview**

Fish farming has a long and established tradition in South Punjab. Communities for generations have utilized the region's abundant water resources and fertile lands for both household and commercial aquaculture.

### **2.1 Historical Perspective**

Historical records and archaeological evidence suggest fish farming practices have existed in South Punjab for centuries. Traditional methods likely involved small-scale pond culture, with communities raising fish for their own consumption or local trade. Over the years, aquaculture has evolved from traditional-level activities to a thriving industry, driven by advancements in technology, increased knowledge about aquatic species, and growing market demand.

The progress in inland fishery and aquaculture began in 1970s in Pakistan. As mentioned earlier, much of the development observed today has been achieved relatively recently. Inland fisheries have received significant Government assistance over the past decade. On the other hand, the Asian Development Bank (ADB) also had started project in late 1979 for 5-year duration, with an investment of about 22.1 million dollars for aquaculture development. The priority area of the projects was upgradation of existing facilities, technical knowledge, improvement of fish hatcheries, nurseries,

provision of consultancy, foreign training, procurement of nursery equipment, establishment of a pilot project, commercial trout farming, fellowships for foreign training, lake fishery development and cage culture pilot project. As a result, the fish seed capabilities increased to encourage the fish farmers. However, still the adoption and introduction of modern aquaculture technology is far away to reach on fisheries development.<sup>2</sup>

The introduction of modern aquaculture techniques in Pakistan began in the early 20th century, with Government initiatives promoting fish seed production and extension services. In South Punjab, this gradual modernization has led to the adoption of practices like polyculture, integrating fish farming with agriculture, and the use of formulated feeds to enhance productivity.

## 2.2 Importance of Aquaculture in South Punjab

Aquaculture sector plays an important role in the food security and economy of South Punjab.

Its importance stems from several factors, which are given as below;

- **Diversification of Agriculture:** Aquaculture provides a diversification opportunity for farmers, allowing them to supplement income from traditional crops with fish farming. This diversification promotes economic resilience and fosters overall growth in the region.
- **Food Security:** Fish is a rich source of protein and essential nutrients, contributing to dietary diversity and nutritional security, especially in rural areas where access to protein sources may be limited. Therefore, aquaculture helps meet the growing demand for this vital food source. Considering Pakistan's population is anticipated to surpass 275 million by 2050<sup>3</sup>, the implementation of sustainable aquaculture practices can significantly enhance to food security in the region.
- **Employment and Income Generation:** The aquaculture sector creates employment opportunities across the value chain, including pond preparation, stocking, feeding, harvesting etc. This also creates income by generating economic activities such as processing, marketing, and distribution, thus supporting livelihoods and rural development.
- **Foreign Exchange Earnings:** Export-oriented aquaculture activities contribute to foreign exchange earnings through the export of high-value fish products to international markets, enhancing the region's economic resilience.

## 2.3 Current State of Aquaculture

The current state of fish farming in South Punjab is characterized by significant growth and development. The area under fish farms has expanded from 70,000 acres to 80,000 acres of land. Moreover, the total fish production in the province has increased from 90,000 metric tons to 113,000 metric tons, indicating a substantial rise in production levels. Initiatives, such as the launch of a project for prawns' culture over 2,500 acres of land and the installation of 5,000 cage fish farms in natural waters are further enhancing fish production in the region, with an expected addition of 6,000 metric tons annually to the province's total production. These developments underscore the

<sup>2</sup> <https://www.punjabfisheries.gov.pk/>

<sup>3</sup> <https://www.worldometers.info/world-population/>

industry's growth and the Government's efforts to support and expand fish farming in South Punjab.<sup>4</sup>

The average yield of carp farming in South Punjab varies depending on the specific location and farming practices. On average, farmers in the study area harvest about 3,747 kg of fish per farm, with large farms harvesting 6,225 kg, medium farms 4,749 kg, and small farms 1,466 kg. Leased-pond farmers tend to harvest an average of 6,976 kg, which is significantly higher than the average harvest of owned farms. In terms of productivity per acre, medium-scale farmers achieve the highest productivity at 1,214 kg per acre, followed by small-scale farmers at 867 kg per acre and large-scale farmers at 620 kg per acre.<sup>5</sup>

Additionally, the Government is investing in projects worth Rs. 112.4 million to promote fisheries in South Punjab, focusing on capacity building, biofloc fish farming, cage culture, and diagnostic labs to enhance fish production in the region. These efforts underscore the Government's commitment to developing and expanding the fish farming industry in South Punjab.

## 2.4 Key Categories / Types

The most commonly farmed fish species in South Punjab, include Rohu, Catla, Mrigal, Tilapia, Grass Carp, and Silver Carp. These species are extensively cultivated in the region, contributing significantly to aquaculture activities. South Punjab encompasses a range of species and production systems, including:

- a. **Pond Culture:** Traditional pond culture of freshwater species such as carp (e.g., rohu, catla, mrigal), tilapia, and prawns/shrimp, using extensive, semi-intensive, or intensive farming methods.
- b. **Cage Culture:** Floating or submerged cages in natural or man-made water bodies for species like tilapia, pangasius, and catfish, providing higher stocking densities and controlled feeding.



<sup>4</sup> Directorate of Fisheries & Wildlife South Punjab

<sup>5</sup> Directorate of Fisheries & Wildlife South Punjab

## 2.5 Production

The overall fish production in Punjab has shown a gradual increase from 942,000 quintals in 2016-17 to 1,146,000 quintals in 2020-21. Within South Punjab, fish production has fluctuated slightly over the years, ranging from 410,000 quintals in 2016-17 to 455,000 quintals in 2020-21.<sup>6</sup> South Punjab's contribution to Punjab's total fish production has varied between approximately 43% and 40% during this period, indicating a stable but not dominant share of fish production in the region. In the South Punjab region, the D.G. Khan division consistently yields the highest quantity of fish among these divisions.

**Table 1: Fish Production in South Punjab (Quantity, '000' Quintals)**

Division	2016-17	2017-18	2018-19	2019-20	2020-21
<b>Punjab</b>	<b>942</b>	<b>1,050</b>	<b>1,090</b>	<b>1,135</b>	<b>1,146</b>
<b>South Punjab</b>	<b>410</b>	<b>457</b>	<b>474</b>	<b>496</b>	<b>455</b>
Bahawalpur	78	87	94	102	104
D.G.Khan	198	221	224	227	228
Multan	134	149	156	167	123

The value of fish production in Punjab has shown a steady increase from 15,072 million rupees in 2016-17 to 20,057 million rupees in 2020-21. The value of fish production in South Punjab has also experienced growth over the years, ranging from 6,560 million rupees in 2016-17 to 7,963 million rupees in 2020-21.<sup>7</sup> South Punjab's share of the total value of fish production in Punjab has remained relatively consistent, hovering around 43% to 39% over the years, indicating a significant contribution to the overall value of fish production in the region.

**Table 2: Fish Production in South Punjab (Value, Million Rupees)**

Division	2016-17	2017-18	2018-19	2019-20	2020-21
<b>Punjab</b>	<b>15,072</b>	<b>16,799</b>	<b>17,987</b>	<b>19,295</b>	<b>20,057</b>
<b>South Punjab</b>	<b>6,560</b>	<b>7,312</b>	<b>7,821</b>	<b>8,432</b>	<b>7,963</b>
Bahawalpur	1,248	1,391	1,551	1,734	1,820
D.G.Khan	3,168	3,531	3,696	3,859	3,990
Multan	2,144	2,390	2,574	2,839	2,153

Source: The Bureau of Statistics, Punjab

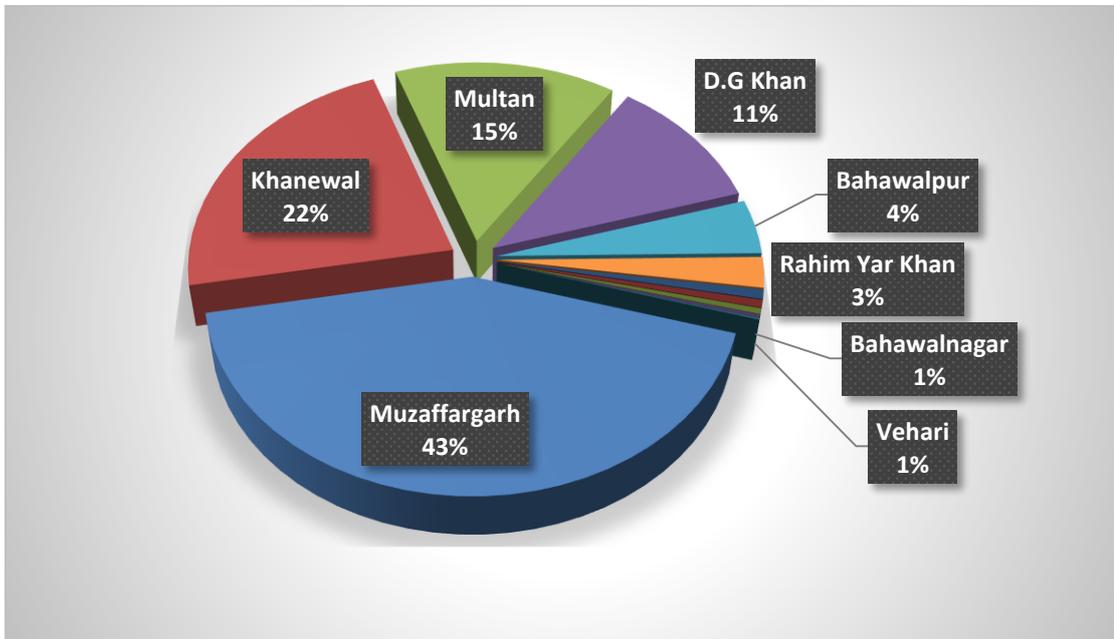
In South Punjab region mainly Rohu and Thaila, Mori, Grass Carp, Silver Carp, Big Head, Gulfam, and Tilapia fish is being cultured in farms. Most common types being produced by fish farms are Rahu, Thaila and Tilapia. The fish is supplied to local fish markets of Multan, Bahawalpur, Dera Ghazi Khan, Head Islam, Head Panjnad, Head Taunsa, Head Sidhnai etc. District Muzaffargarh is the largest fish producing district in South Punjab with total share of 43% within South Punjab region. Likewise, Khanewal has 22%, Multan 15% and D.G Khan 11% share in total fish production of the region. In other district like Bahawalpur, Rahim Yar Khan, Bahawalnagar, Vehari,

<sup>6</sup> The Bureau of Statistics, Punjab

<sup>7</sup> South Punjab Development Statistics

Lodhran, Ranajpur and Layyah fish farming is being carried out and the number is increasing with the time.<sup>8</sup>

**Figure 2: District wise Share of Fish Production in South Punjab (in Percentage)**



### 3. Characteristics of Aquaculture Clusters

The concept of aquaculture clusters holds immense potential for enhancing the efficiency and competitiveness of the sector in South Punjab. Understanding the characteristics and formation process of these clusters is crucial for promoting their successful development.

#### 3.1 Definition and Concept of Aquaculture Clusters

Aquaculture clusters are geographically concentrated groups of interconnected businesses and institutions involved in various stages of fish production, processing, and marketing. These clusters foster collaboration, knowledge sharing, resource optimization, and value creation within the aquaculture value chain. A cluster approach enables synergies among input suppliers, fish farmers, processors, marketers, and support services, leading to enhanced competitiveness, sustainability, and innovation in the aquaculture sector.<sup>9</sup> These clusters create several benefits including but not limited such as;

- **Economies of Scale:** Clusters enable businesses to leverage bulk purchasing power for inputs like feed and fingerlings, reducing costs and improving access to resources.
- **Knowledge Sharing:** The close proximity of actors within a cluster facilitates knowledge sharing and technology transfer between farmers, researchers, and

<sup>8</sup> Punjab Fisheries Department - South Punjab

<sup>9</sup> <https://www.britannica.com/topic/aquaculture>

other stakeholders. This can lead to improved farming practices, better disease management, and innovation within the cluster.

- **Improved Market Access:** Clusters can strengthen market linkages by connecting producers with processors, distributors, and retailers more efficiently. This can reduce transaction costs for farmers and ensure their products reach consumers faster and in better condition.

### 3.2 Formation and Structure of Aquaculture Clusters in South Punjab

Aquaculture clusters in South Punjab are formed through a combination of geographical proximity, shared resources, common market access, and collaborative networks among aquaculture stakeholders. The formation and structure of successful aquaculture clusters in South Punjab depend on several key factors:

- **Proximity to Water Resources:** Availability of freshwater resources like canals, ponds, and lakes is essential for fish farming. Clusters are likely to emerge in areas with a reliable and abundant water supply.
- **Presence of Hatcheries and Feed Suppliers:** Easy access to high-quality fish seed and formulated feeds is crucial for efficient aquaculture. Clusters are more likely to develop near established hatcheries and feed manufacturing facilities.
- **Infrastructure for Transportation and Processing:** Efficient transportation networks are essential for moving live fish or processed products to markets. Similarly, the presence of processing facilities within or near the cluster can add value to the product and improve marketability.

### 3.3 Identification of Clusters

The identification of aquaculture clusters in South Punjab involves geographic mapping, stakeholder surveys, value chain analysis, and market linkage assessments. Geographic mapping using GIS helps pinpoint areas with high concentrations of aquaculture activities. Stakeholder surveys gather data on production, infrastructure, market access, and challenges. Value chain analysis examines the flow of goods and services, while market linkage assessments assess connections to local and international markets. Cluster-specific strengths and challenges are identified, leading to the development of detailed cluster profiles that guide targeted interventions and development strategies for sustainable growth.

The major aquaculture clusters in South Punjab include districts like Dera Ghazi Khan, Muzaffargarh, Multan, Vehari, Bahawalnagar, Bahawalpur, and Rahim Yar Khan.<sup>10</sup> These areas have a significant presence of fish farming activities, with a focus on species like carp, tilapia, trout, shrimp, and catfish. The region's diverse geography and climate support aquaculture, with a population primarily engaged in agriculture, livestock, and other related activities.

Additionally, the major aquaculture clusters in South Punjab include the installation of fish cage clusters in different rivers to promote fish production. Specifically, in South Punjab, there are 400 cage clusters operational to boost fish production in which 200 fish cages were installed at Ghazi Ghat in river Sindh. Similarly, 100 are operational at

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<sup>10</sup> Directorate of Fisheries & Wildlife South Punjab

Mailsi Siphon. These clusters are part of a modern concept of fish farming where cages are installed in freshwater bodies. The Fisheries Department in South Punjab has facilitated fish farmers in setting up these cage clusters, with subsidies support provided by both the Federal and Punjab Government to promote this modern approach to fish farming.<sup>11</sup>



### 3.4 Key Features and Components of Aquaculture Clusters

The key features and components for formation of successful aquaculture clusters may include the following:

- **Infrastructure:** Availability of ponds, cages, hatcheries, processing units, cold storage facilities, and transport networks supporting aquaculture activities.
- **Market Access:** Access to local, regional, and international markets through established supply chains, marketing channels, and market information systems.
- **Knowledge Exchange:** Collaboration among stakeholders for knowledge sharing, capacity building, technology transfer, best practices dissemination, and innovation in aquaculture techniques.
- **Support Services:** Provision of extension services, training programs, financial assistance, and regulatory guidance to promote sustainable and profitable aquaculture practices.
- **Cluster Governance:** Establishment of cluster-based organizations, cooperatives, or associations to facilitate coordination, collective decision-making, advocacy, and representation of cluster interests.

### 3.5 Value Chain of Key Fish Types Production

The major species of fish farmed in South Punjab include grass carp, silver carp, common carp, tilapia, trout, and shrimp. These species are commonly cultivated in

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<sup>11</sup> Directorate of Fisheries & Wildlife South Punjab

aquaculture operations in the region, contributing to the overall fish production and economic development of South Punjab.

The value chain of key fish types production in South Punjab encompasses a series of interconnected stages that add value to fish products and bring them to consumers effectively. These stages include<sup>12</sup>:

**a). Input Supply**

The value chain begins with the procurement of essential inputs such as quality feed, fingerlings, and equipment from reliable suppliers. Feed suppliers provide nutritionally balanced feeds tailored to the specific requirements of different fish species, ensuring optimal growth, health, and productivity. Fingerlings are sourced from hatcheries or breeding centers, ensuring genetic quality and disease-free stock. Equipment suppliers offer tools, machinery, and infrastructure for pond management, water quality control, and harvesting operations.

**b). Production**

The production stage involves the actual cultivation of key fish species, including carp (e.g., rohu, catla, mrigal), tilapia, and prawns. Farmers employ various farming techniques based on the species, pond type (extensive, semi-intensive, intensive), and market demand. This includes pond preparation, stocking of fingerlings, water quality management, feeding regimes, disease prevention, and growth monitoring. Sustainable practices such as integrated farming systems, biosecurity measures, and environmentally friendly approaches are increasingly integrated into production processes.

**c). Harvesting**

Once fish reach marketable size and maturity, they are harvested using appropriate methods to ensure product quality and freshness. Harvesting techniques vary depending on the species and farming system, including pond draining, netting, seining, or mechanical harvesting. Timely and efficient harvesting is crucial to avoid stress, maintain product integrity, and meet market demands.

**d). Processing**

After harvesting, fish undergo processing steps to prepare them for consumption or further value addition. Processing includes cleaning, gutting, scaling, filleting, and removing the head to eliminate undesirable parts and maintain food safety standards. Processing facilities equipped with hygiene standards, cold storage, and quality control measures play a vital role in maintaining product freshness, shelf life, and market acceptance. Value-added processes such as smoking, curing, marinating, packaging, and branding enhance the product's value, differentiation, and market appeal.

**e). Marketing**

The marketing stage involves the distribution, promotion, and sale of fish products to target consumers and markets. Marketing channels include wholesale markets, retail outlets, supermarkets, restaurants, hotels, online platforms, and export channels. Effective marketing strategies focus on product differentiation, branding, packaging innovation, pricing strategies, market segmentation, and customer engagement. Market

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<sup>12</sup> Fisheries Development Board (FDB)

research, consumer preferences analysis, and market intelligence inform marketing decisions and strategies to maximize sales and market penetration.

**f). Value Addition**

Value addition activities occur throughout the value chain, including processing stages and marketing strategies. Value-added products such as smoked fish, fish fillets, marinated seafood, ready-to-cook products, and fish-based snacks command higher prices and cater to diverse consumer preferences. Innovation in product development, packaging design, labeling, and branding enhances product competitiveness, market share, and profitability.



**4. Cluster Actors**

**4.1 Input Suppliers**

Input suppliers play a crucial role in aquaculture clusters by providing essential resources and services to fish farmers. These suppliers encompass a range of entities, including feed manufacturers, hatcheries, equipment suppliers, agrochemical suppliers, and technical service providers. Feed manufacturers supply high-quality feeds formulated with balanced nutrition for different fish species, promoting growth and health. Hatcheries supply quality fingerlings and juveniles, ensuring genetic diversity, disease resistance, and growth potential in fish stocks. Equipment suppliers offer a range of tools, machinery, and infrastructure for pond preparation, aeration, water quality management, feeding automation, and harvesting operations. Agrochemical suppliers provide inputs such as fertilizers, pesticides, and disinfectants for pond management and disease control. Technical service providers offer expertise in aquaculture practices, training programs, consultancy services, and research support, enhancing the efficiency, productivity, and sustainability of fish farming operations within aquaculture clusters.

**4.2 Fish Farmers**

Fish farmers are the primary producers within aquaculture clusters, responsible for cultivating and managing fish stocks to meet market demand. These farmers operate various farming systems, including pond culture, cage culture, and integrated farming systems, depending on species, scale, and resources. Fish farmers undertake activities

such as pond preparation, stocking of fingerlings, water quality monitoring, feeding, disease management, growth monitoring, and harvesting. They adopt best practices in aquaculture, including biosecurity measures, sustainable resource use, environmental stewardship, and compliance with regulatory standards. Fish farmers within aquaculture clusters benefit from collective actions, knowledge sharing, access to inputs, market linkages, and capacity-building initiatives, contributing to the overall growth and resilience of the aquaculture sector.

### **4.3 Contractors**

Contractors are service providers who offer specialized services to fish farmers within aquaculture clusters on a contractual basis. These services include pond preparation, stocking of fingerlings, water quality management, disease diagnosis and treatment, aeration system installation, harvesting assistance, and post-harvest handling. Contractors may also provide technical advice, training, and support in implementing best practices and technologies for efficient fish farming operations. Their role is crucial in ensuring timely and effective delivery of services, optimizing production outcomes, and enhancing farmer capabilities in aquaculture management.

### **4.4 Intermediaries**

Intermediaries play a significant role in connecting fish farmers with processors, wholesalers, retailers, and end consumers within aquaculture clusters. These intermediaries include traders, brokers, wholesalers, and cooperatives operating in local markets or regional trade networks. They facilitate the buying, selling, and distribution of fish products, negotiate prices, manage logistics, and provide market information and intelligence. Intermediaries act as market aggregators, bridging supply and demand dynamics, ensuring market access for farmers, and promoting market efficiency and transparency within aquaculture clusters.

### **4.5 Processors**

Processors are entities engaged in the processing, value addition, and packaging of fish products within aquaculture clusters. These processors operate facilities such as fish processing plants, cold storage units, packaging units, and quality control laboratories. They undertake processing activities such as cleaning, gutting, filleting, freezing, smoking, curing, and packaging to prepare fish products for domestic consumption or export markets. Processors adhere to food safety standards, hygiene practices, and quality assurance protocols, ensuring product integrity, shelf life, and market acceptability. Value-added processing techniques enhance the market value, diversify product offerings, and cater to consumer preferences, contributing to the economic value and competitiveness of aquaculture clusters.

### **4.6 End Consumer Markets**

End consumer markets represent the final destination for fish products from aquaculture clusters, encompassing a wide range of consumers, including households, restaurants, hotels, supermarkets, and export markets. Consumer markets may be local, regional, national, or international, depending on the scale and scope of aquaculture production. Consumers demand high-quality, safe, and nutritious fish products, driving market preferences, trends, and product differentiation. Aquaculture clusters focus on meeting consumer expectations through product innovation, branding, packaging, marketing

strategies, and customer engagement initiatives. Sustainable sourcing, traceability, and certification of fish products enhance consumer trust, loyalty, and market competitiveness, ensuring long-term market viability and growth for aquaculture clusters.

## 5. Opportunities for Aquaculture Clusters in South Punjab

### 5.1 Market Potential and Demand

The aquaculture sector in South Punjab presents significant opportunities driven by market potential and demand factors. Market potential refers to the capacity of aquaculture clusters to meet existing and emerging market demands for fish products. Key factors contributing to market potential include;

- **Growing Population:** The region's increasing population, coupled with rising income levels and urbanization trends, drive demand for high-quality protein sources, including fish. Aquaculture clusters can capitalize on this demographic shift by supplying diverse fish products to meet consumer preferences.
- **Changing Consumer Preferences:** Shifts in consumer preferences towards healthy, nutritious, and sustainably sourced food options create opportunities for aquaculture clusters to offer a wide range of fish species, value-added products, and certified sustainable practices, catering to niche markets and premium segments.
- **Export Market Opportunities:** Aquaculture clusters in South Punjab have the potential to tap into export markets, leveraging their competitive advantage in terms of product quality, cost efficiency, compliance with international standards, and access to trade networks. Targeting export markets can enhance revenue streams, foreign exchange earnings, and global market presence.
- **Technology Adoption:** Adoption of modern aquaculture technologies, precision farming techniques, digital solutions, and data-driven decision-making processes can enhance production efficiency, quality control, supply chain management, and market responsiveness within aquaculture clusters, aligning with market demands and trends.
- **Value Addition:** Value addition strategies such as product diversification, branding, packaging innovation, processing capabilities, and product differentiation can create added value for fish products, attract premium prices, capture new market segments, and enhance market competitiveness for aquaculture clusters of South Punjab.

### 5.2 Economic and Social Benefits

Aquaculture clusters in South Punjab offer a range of economic and social benefits, contributing to rural development, livelihoods, food security, and economic growth. These benefits include:

- **Employment Generation:** The aquaculture sector generates employment opportunities across the value chain, including input suppliers, fish farmers, processors, traders, marketers, and support services. Job creation benefits rural communities, minimizes unemployment rates, and supports income generation for households in South Punjab.
- **Income Diversification:** Fish farming provides an additional income source for agricultural communities, diversifying income streams, reducing income

volatility, and enhancing financial resilience. Income from aquaculture activities supports household expenses, education, healthcare, and savings.

- **Value Chain Linkages:** Aquaculture clusters create linkages and synergies within the value chain, fostering collaboration, knowledge sharing, technology transfer, and market access. Value chain integration enhances efficiency, productivity, profitability, and sustainability for all actors involved.
- **Community Development:** Aquaculture clusters contribute to community development through infrastructure development, social investments, capacity-building programs, vocational training, women's empowerment initiatives, and community-based organizations. Social benefits include improved access to education, healthcare, sanitation, and social services.
- **Food Security:** Aquaculture clusters play a critical role in enhancing food security and nutrition by providing affordable, protein-rich fish products to local communities. Fish consumption contributes to dietary diversity, micronutrient intake, and nutritional well-being, especially for vulnerable populations such as children and pregnant women.

## 6. Major Challenges Faced by Aquaculture Clusters in South Punjab

### 6.1 Environmental Challenges

Aquaculture clusters in South Punjab encounter various environmental challenges that impact sustainability and ecosystem health. These challenges include:

- **Water Quality Management:** Ensuring optimal water quality parameters such as oxygen levels, pH balance, temperature, and nutrient levels is crucial for fish health and productivity. Pollution, eutrophication, sedimentation, and chemical runoff from agricultural activities degrade water quality and pose risks to aquatic ecosystems.
- **Disease Management:** Disease outbreaks, parasites, and pathogens affect fish stocks, leading to economic losses and production disruptions. Timely disease prevention, biosecurity measures, vaccination programs, and health monitoring are essential but challenging tasks for aquaculture clusters in South Punjab.
- **Resource Use Efficiency:** Efficient use of resources such as land, water, energy, and feed is essential for sustainable aquaculture. Overuse of resources, inefficient production practices, and environmental degradation strain natural ecosystems, exacerbate resource scarcity, and impact long-term viability within clusters.
- **Waste Management:** Proper management of aquaculture waste, including uneaten feed, excreta, and sediment buildup, is critical to minimize environmental impact. Nutrient runoff, algal blooms, and water pollution from waste discharge degrade water quality, harm aquatic biodiversity, could lead to ecosystem imbalances.

### 6.2 Socioeconomic Challenges

Aquaculture clusters in South Punjab face socioeconomic challenges that affect industry growth, community well-being, and stakeholder engagement. These challenges include:

- **Market Access and Market Linkages:** Limited market access, price fluctuations, market volatility, and lack of market information hinder profitability and market competitiveness for fish farmers and processors within clusters.
- **Income Disparities:** Income disparities among stakeholders within aquaculture clusters, including input suppliers, farmers, processors, and traders, affect economic equity, social cohesion, and livelihood sustainability affecting overall performance of the sector.
- **Labor Issues:** Labor shortages, skill gaps, seasonal employment patterns, and migrant labor issues impact production continuity, labor productivity, and human resource management within aquaculture clusters in South Punjab.

### 6.3 Technological Challenges

Technological challenges in aquaculture clusters relate to innovation adoption, digitalization, and infrastructure development. These challenges include:

- **Technological Adoption:** Adoption of modern aquaculture technologies, digital solutions, automation, and data analytics can improve productivity, efficiency, and sustainability. However, barriers such as initial investment costs, technical expertise requirements, and technology integration challenges impede widespread adoption in aquaculture clusters in South Punjab.
- **Infrastructure Development:** Infrastructure gaps, inadequate facilities, limited access to electricity, water scarcity, and transport logistics constraints hinder the development of efficient aquaculture operations within aquaculture clusters in South Punjab.
- **Research and Development:** Continuous research, innovation, and development efforts are essential to address emerging challenges, improve production practices, develop new technologies, and enhance competitiveness. Limited funding, research capacity, lack of collaboration between academia, industry, and government limit R&D progress aquaculture clusters in South Punjab.

### 6.4 Marketing and Trade Challenges

Marketing and trade challenges impact market access, product competitiveness, and export opportunities for aquaculture clusters in South Punjab. These challenges include:

- **Market Diversification:** Diversifying market channels, exploring new market segments, and accessing export markets require strategic marketing efforts, product differentiation, branding, and market intelligence. Lack of market information, trade barriers, and market entry challenges restrict market diversification in aquaculture clusters in South Punjab.
- **Quality Standards and Certifications:** Meeting national and international quality standards, certifications, and regulatory requirements is essential for market acceptance and consumer trust. Compliance costs, certification processes, and quality assurance measures pose challenges for small-scale producers within clusters.
- **Trade Regulations:** Trade regulations, tariffs, quotas, sanitary and phytosanitary measures, and import-export procedures impact market access, trade competitiveness, and export performance. Addressing trade barriers,

market access constraints, and trade facilitation issues requires coordination between Government agencies and industry stakeholders.

## 6.5 Access to Finance

Access to finance is one of the key challenges for aquaculture clusters in South Punjab, affecting investment, expansion, and sustainability. The key instances are given as below:

- **Capital Investment:** Securing initial capital investment for pond development, infrastructure upgrades, technology adoption, and expansion projects is challenging for small-scale farmers and processors within aquaculture clusters in South Punjab. Limited access to credit, high interest rates, collateral requirements, and financial literacy barriers constrain investment opportunities.
- **Risk Management:** Managing financial risks such as production risks, market risks, price volatility, climate risks, and policy risks is essential for long-term viability. Lack of access to risk management tools, insurance products, and financial planning support harms the aquaculture clusters in South Punjab.

## 7. Recommendations

### 7.1 Sustainable Practices and Technologies

To promote sustainability in aquaculture clusters in South Punjab, the following recommendations are proposed:

- **Adopt Best Management Practices:** Encourage fish farmers to adopt best management practices (BMPs) for water quality management, disease prevention, waste management, and resource use efficiency. Provide training, technical support, and incentives for BMP implementation.
- **Promote Eco-friendly Technologies:** Encourage the adoption of eco-friendly technologies such as re-circulating aquaculture systems (RAS), biofloc technology, integrated multitrophic aquaculture (IMTA), and solar-powered aquaculture systems. These technologies reduce environmental footprints, improve resource utilization, and enhance production efficiency in aquaculture clusters in South Punjab
- **Encourage Sustainable Feed Practices:** Promote the use of sustainable and locally sourced feed ingredients, alternative protein sources, and low-impact feed formulations. Collaborate with feed manufacturers to develop eco-friendly feeds with reduced reliance on wild-caught fishmeal and fish oil.
- **Invest in Renewable Energy:** Explore opportunities for renewable energy adoption, such as solar energy, wind turbines, and biogas systems, to power aquaculture operations and reduce reliance on fossil fuels. Implement energy-efficient practices and technologies for water pumping, aeration, and heating.

### 7.2 Capacity Building and Training

To enhance capacity and skills within aquaculture clusters, the following recommendations are proposed:

- **Provide Technical Training:** Offer regular training programs, workshops, and field demonstrations on aquaculture best practices, disease management, water

quality monitoring, feed management, and farm management. Collaborate with agricultural extension services, universities, and research institutions for training delivery.

- **Entrepreneurship Development:** Provide entrepreneurship development trainings, business management skills, and financial literacy workshops to fish farmers, processors, and other stakeholders. Empower entrepreneurs to develop business plans, access credit, market their products, and navigate regulatory requirements.
- **Youth Engagement:** Encourage youth participation in aquaculture through vocational training, internship programs, and youth entrepreneurship initiatives. Foster innovation, creativity, and technology adoption among young aquaculture professionals.
- **Gender Inclusivity:** Promote gender inclusivity by providing training and support for women in aquaculture, including access to resources, training in fish farming techniques, and leadership opportunities. Empower women to actively participate in decision-making and value chain activities.

### 7.3 Stakeholder Collaboration and Networking

To enhance collaboration and networking among stakeholders, the following recommendations are proposed:

- **Establish Cluster Organizations:** Facilitate the formation of aquaculture cluster organizations, cooperatives, or associations to promote collaboration, knowledge sharing, collective bargaining, and advocacy. These organizations can address common challenges, represent cluster interests, and facilitate dialogue with government agencies and industry partners.
- **Networking Events:** Organize networking events, stakeholder forums, industry conferences, and trade fairs to facilitate interactions, partnerships, and business opportunities within aquaculture clusters. Encourage knowledge exchange, technology transfer, and market linkages among stakeholders.
- **Public-Private Partnerships:** Foster public-private partnerships (PPPs) to leverage resources, expertise, and investment for aquaculture development. Collaborate with private sector entities, financial institutions, NGOs, and research organizations to implement joint projects, innovation initiatives, and capacity-building programs.

### 7.4 Potential for Growth and Expansion

To unlock the growth potential and facilitate expansion within aquaculture clusters, the following recommendations are proposed:

- **Market Diversification:** Support market diversification strategies, product differentiation, branding, and value addition to capture new market segments, enhance product competitiveness, and increase market share. Explore export opportunities and international market access for high-value fish products.
- **Infrastructure Development:** Invest in infrastructure development projects, including pond construction, hatcheries, processing facilities, cold storage units, transportation networks, and market infrastructure. Improve access to utilities such as electricity, water, and sanitation for aquaculture operations.

- **Promote Investment:** Facilitate access to finance, investment incentives, and credit facilities for aquaculture stakeholders. Develop financing mechanisms, venture capital funds, and risk-sharing arrangements to support small-scale farmers, startups, and expansion projects.

## 7.5 Policy Recommendations

To create an enabling policy environment for aquaculture clusters, the following recommendations are proposed:

- **Policy Alignment:** Align aquaculture policies with national development goals, sustainable development targets, and international best practices. Develop integrated policies that consider economic, social, environmental, and technological dimensions of aquaculture development.
- **Regulatory Framework:** Establish clear and transparent regulatory frameworks for aquaculture operations, including licensing, environmental standards, food safety regulations, and aquaculture zoning. Ensure compliance with national and international quality standards to enhance market access and consumer confidence.
- **Incentive Mechanisms:** Implement incentive mechanisms such as tax incentives, subsidies, grants, and investment promotion schemes to attract investment, stimulate innovation, and support sustainable aquaculture practices. Target incentives towards environmentally friendly technologies, value addition, and market-driven initiatives.
- **Stakeholder Engagement:** Foster multi-stakeholder dialogue, consultation processes, and participatory decision-making in policy formulation. Engage with industry associations, community representatives, academia, research institutions, and civil society organizations to solicit input, address concerns, and build consensus on policy priorities.

## 8. Regulatory and Institutional Framework

The regulatory and institutional framework for aquaculture development in Pakistan involves various entities and policies aimed at promoting and regulating the sector. The Ministry of National Food Security & Research plays a crucial role in overseeing fisheries and aquaculture development in the country. The Government of Pakistan has allocated significant funds to the fisheries sector, with a focus on aquaculture development, as evidenced by the implementation of Aquaculture Development Projects in provinces like Sindh and Punjab.<sup>13</sup> These projects aim to enhance fish production through initiatives such as upgrading extension services, establishing model demonstration farms, improving seed production facilities, and setting up training centers for farmers. Additionally, the Government's policy emphasizes the importance of aquaculture development, with a specific focus on boosting fish production and quality through strategic investments and capacity-building efforts. The framework also addresses aspects like environmental impact assessment, control of fish movements, health regulations, product quality control, and the promotion of sustainable practices within the aquaculture industry in Pakistan.

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<sup>13</sup> Ministry of National Food Security & Research

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