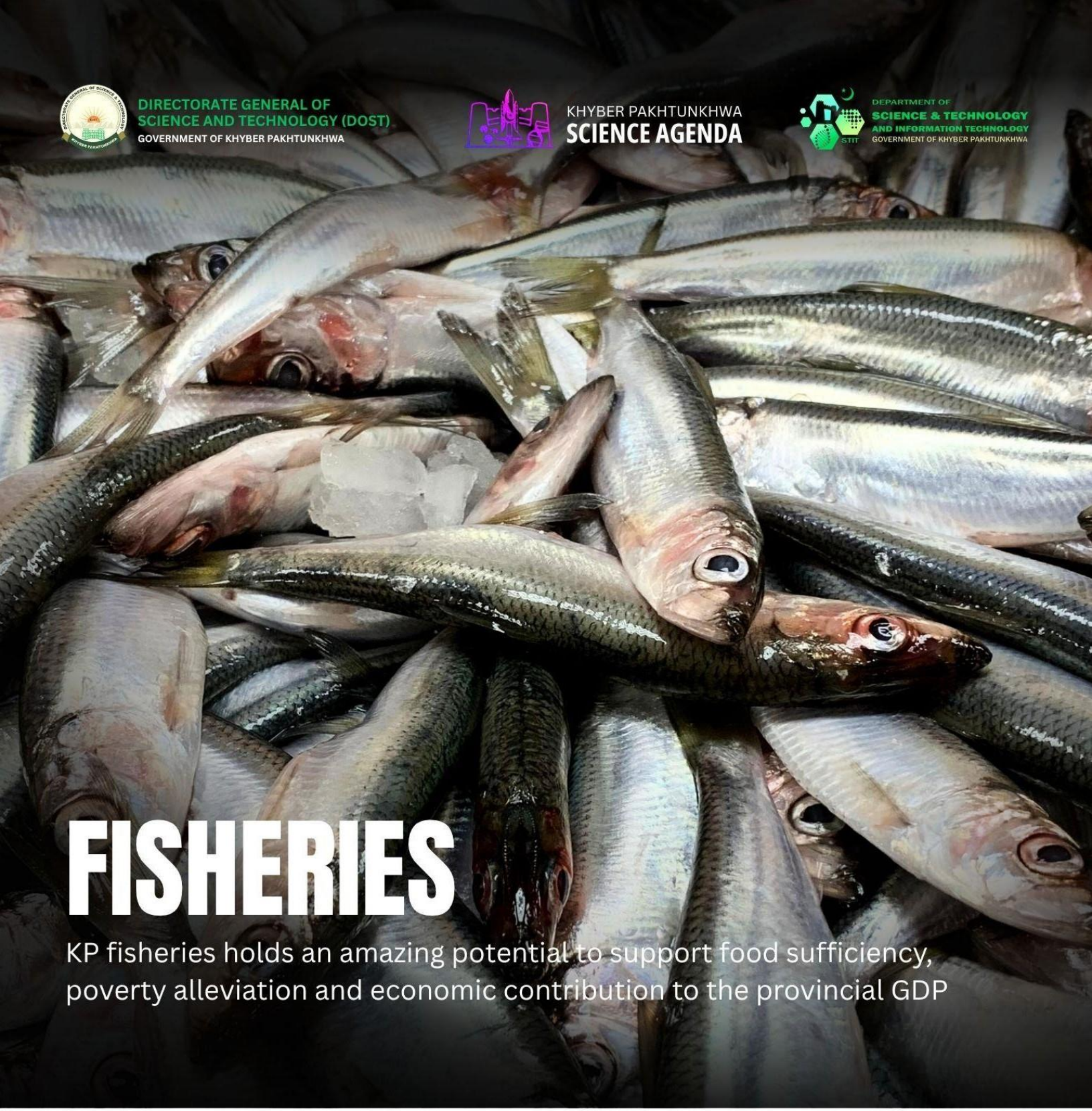
DIRECTORATE GENERAL OF SCIENCE AND TECHNOLOGY (DOST)
GOVERNMENT OF KHYBER PAKHTUNKHWA

KHYBER PAKHTUNKHWA
SCIENCE AGENDA

DEPARTMENT OF SCIENCE & TECHNOLOGY AND INFORMATION TECHNOLOGY
GOVERNMENT OF KHYBER PAKHTUNKHWA



FISHERIES

KP fisheries holds an amazing potential to support food sufficiency, poverty alleviation and economic contribution to the provincial GDP

TASKFORCE REPORT

Fisheries Sector in Khyber Pakhtunkhwa: Sectoral Analysis, Local Challenges, Strategic Insights and Recommendations

2023

FOREWORD

In alignment with the Science Agenda for Khyber Pakhtunkhwa, the Directorate General of Science & Technology initiated a landmark effort to identify and advance priority areas where science, technology, and innovation can meaningfully contribute to the province's socio-economic development. We present to you the sectoral reports in key natural resource areas that are ideally unique to Khyber Pakhtunkhwa and have been identified for R&D investments. Each of these sectoral reports marks an important milestone in advancing scientific understanding and strategic development within Khyber Pakhtunkhwa's natural resource sectors, through focused inquiry and collaborative expertise. These reports, developed by thematic Task Forces constituted under the Directorate General of Science & Technology, are foundational efforts under the broader Science Agenda for Khyber Pakhtunkhwa. This transformative initiative seeks to position the province as a regional leader in science, technology, and innovation as we explore the potential of Khyber Pakhtunkhwa's rich natural resource landscape.

Under the Science Agenda, we hold a bold and pragmatic approach: to build on the province's existing strengths while investing in the future. The identification of eight natural resource areas; from gemstones and herbs to fisheries, fruits and vegetables, bees and honey, micro-hydro power, archaeology, and the urban environment — presents a unique opportunity for science-led value addition and sustainable economic growth. Each thematic area represents not just a resource, but a vibrant ecosystem of challenges and opportunities, waiting to be enhanced through strategic interventions in research, development, and innovation. These reports are the outcome of months of rigorous consultation, deep research, and collaborative ideation by multidisciplinary experts drawn from academia, industry, public sector, and civil society. The Task Forces were entrusted with the mission to map the current landscape, articulate key challenges, and recommend high-impact R&D pathways that can guide smart investment in the sector. This body of work now forms a scientific and strategic blueprint for stakeholders across sectors to drive meaningful change.

This initiative is aligned with our core vision to move Khyber Pakhtunkhwa from being a consumer of technologies to a creator of solutions , driven by our local talent, informed by global best practices, and anchored in our unique natural endowments. Through this endeavor, we reaffirm our commitment to building a culture of science that is inclusive, collaborative, and forward-looking.

I extend my deepest appreciation to all members of the Task Forces, as well as the wider science and innovation ecosystem that supported this effort. We look forward to translating the insights from these reports into tangible programs, R&D investments, and partnerships that uplift livelihoods, enhance competitiveness, and leave a lasting impact on the province's development trajectory.

Sajid Hussain Shah

Director General
Directorate General of Science & Technology
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ACKNOWLEDGMENT

This policy report has been developed by the Directorate General of Science & Technology, Government of Khyber Pakhtunkhwa, as part of the Annual Development Program initiative, which focuses on strategic natural resource development.

The report is the outcome of a time-bound effort by a dedicated Task Force constituted for this thematic area, comprising local experts from diverse institutional backgrounds, including academia, government, industry, and the development sector. The Task Force worked collaboratively through multiple rounds of consultations to undertake a deep-dive analysis, identify context-specific challenges, and offer actionable insights to guide future scientific, technological, and policy interventions. The Directorate General of Science & Technology gratefully acknowledges the Directorate of Fisheries, Government of Khyber Pakhtunkhwa, for their valuable insights and contributions in compiling this report on the Fisheries subsector of the provincial economy

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1. THE SUBSECTOR LANDSCAPE

1.1 GLOBAL

Over the last two decades, the fisheries and aquaculture sectors have been increasingly recognized for their essential contribution to global food security and nutrition. Expanding this role requires scaling up transformative changes in policy, management, innovation, and investment to achieve sustainable, inclusive and equitable global fisheries and aquaculture.

Total fisheries and aquaculture production reached an all-time record of **214 million tonnes in 2020**, comprising 178 million tonnes of aquatic animals and 36 million tonnes of algae, a slight increase (3 percent) from the **previous 2018 record (213 million tonnes)**. The limited growth is mainly caused by a 4.4 percent decline in capture fisheries due to reduced catches of pelagic species, particularly anchoveta, a reduction in China's catches, and the impacts of the COVID-19 pandemic in 2020.

This decline was compensated for by a continued growth of aquaculture, albeit at a slower yearly rate in the last two years. For aquatic animal production, this general trend masks significant variations between continents, regions, and countries. In 2020, Asian countries were the main producers accounting for **70 percent of the total**, followed by the Americas, Europe, Africa and Oceania. China remained the first major producer with a share of **35 percent** of the total. The expansion of aquaculture in recent decades has boosted the overall growth of aquatic animal production in inland waters, from 12 percent of total production in the late 1980s to 37 percent in 2020.

In 2020, global capture fisheries production (excluding algae) was 90.3 million tonnes, with an estimated value of USD 141 billion, including 78.8 million tonnes from marine waters and 11.5 million tonnes from inland waters – a fall of 4.0 percent compared with the average of the previous three years (FAO, 2022).

TABLE 1: WORLD FISHERIES AND AQUACULTURE PRODUCTION, UTILIZATION AND TRADE

	1990s	2000s	2010s	2018	2019	2020
	Average per year					
	Million tonnes (live weight equivalent)					
Production						
Capture:						
Inland	7.1	9.3	11.3	12.0	12.1	11.5
Marine	81.9	81.6	79.8	84.5	80.1	78.8
Total capture	**88.9**	**90.9**	**91.0**	**96.5**	**92.2**	**90.3**
Aquaculture:						
Inland	12.6	25.6	44.7	**51.6**	**53.3**	**54.4**
Marine	9.2	17.9	26.8	**30.9**	**31.9**	**33.1**
Total aquaculture	**21.8**	**43.4**	**71.5**	**82.5**	**85.2**	**87.5**
Total world fisheries and aquaculture	**110.7**	**134.3**	**162.6**	**178.9**	**177.4**	**177.8**
Utilization[2]						
Human consumption	81.6	109.3	143.2	156.8	158.1	157.4
Non-food uses	29.1	25.0	19.3	22.2	19.3	20.4
Population (billions)[3]	5.7	6.5	7.3	7.6	7.7	7.8
Per capita apparent consumption (kg)	14.3	16.8	19.5	20.5	20.5	20.2
Trade						
Exports – in quantity	39.6	51.6	61.4	66.8	66.6	59.8
Share of exports in total production	*35.8%*	*38.5%*	*37.7%*	*37.3%*	*37.5%*	*33.7%*
Exports – in value (USD 1 billion)	46.6	76.4	141.8	165.3	161.8	150.5

[1] Excluding aquatic mammals, crocodiles, alligators and caimans and algae. Totals may not match due to rounding.
[2] Utilization data for 2018–2020 are provisional estimates.
[3] Source of population figures: United Nations. 2019. 2019 Revision of World Population Prospects. In: *UN*. New York. Cited 22 April 2022. https://population.un.org/wpp
SOURCE: FAO.

To be more relevant to the subject, we will discuss global **aquaculture** production, that in 2020, reached a record **122.6 million tonnes**, including 87.5 million tonnes of aquatic animals worth USD 264.8 billion and

35.1 million tonnes of algae worth USD 16.5 billion. Around **54.4 million tonnes** were farmed in inland waters and **68.1 million tonnes** came from marine and coastal aquaculture. All regions, except Africa, experienced continued aquaculture growth in 2020, driven by expansion in Chile, China and Norway –

the top producers in their respective regions. Africa experienced a decrease in the two major producing countries, Egypt and Nigeria, while the rest of Africa enjoyed 14.5 percent growth from 2019. **Asia continued to dominate world aquaculture, producing over 90 percent of the total**. The contribution of aquaculture to the global production of aquatic animals reached a record **49.2 percent** in 2020 (FAO, 2022).

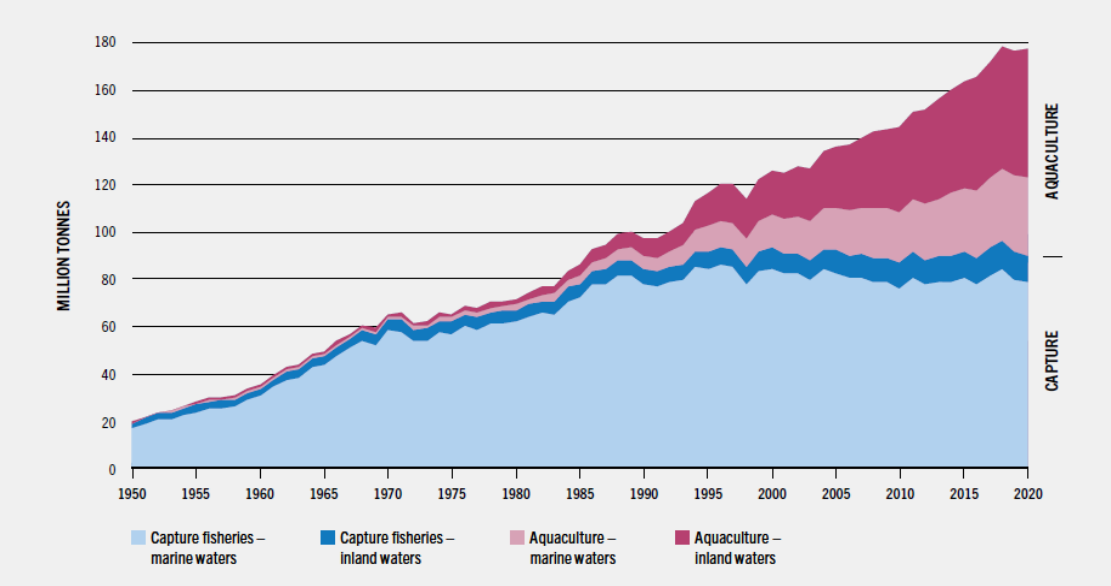


FIGURE 1: WORLD CAPTURE FISHERIES AND AQUACULTURE PRODUCTION

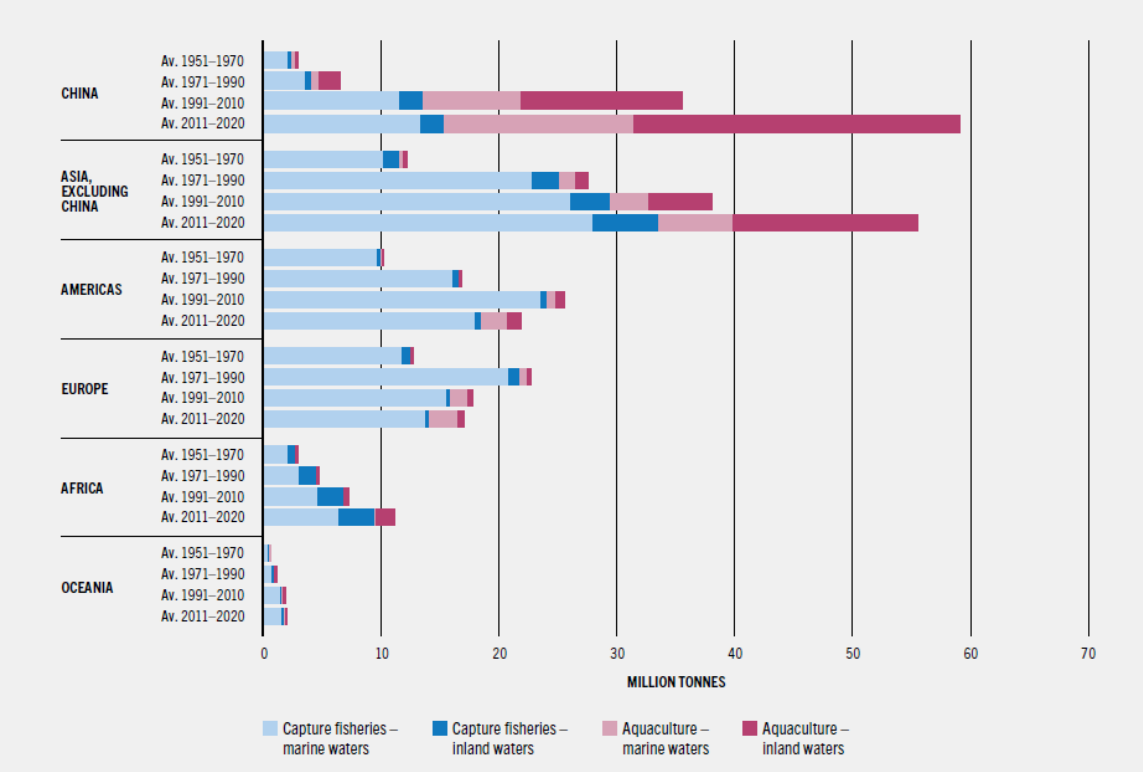
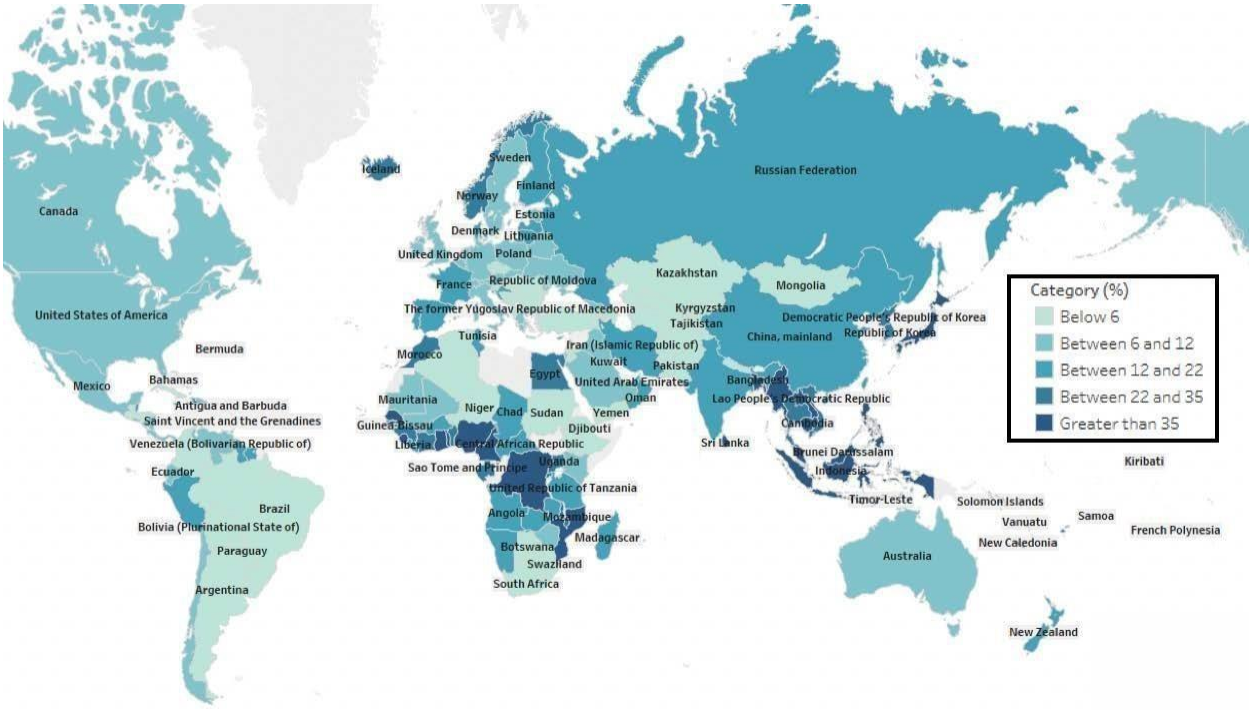


FIGURE 2: REGIONAL CONTRIBUTION TO WORLD CAPTURE FISHERIES AND AQUACULTURE PRODUCTION

FIGURE 3: FISH DEPENDENCY AROUND THE WORLD



Source: FAOSTAT Food Balance Sheets, http://www.fao.org/faostat/en/#data/FBS (accessed September 21, 2017).

Note: Fish dependence is defined here as percent of animal source protein from fish.

Fish and seafood stands only second to Milk as a primary protein of animal source globally (*Source: FAO Food Balance Sheets*) and this contribution (graphically explained in Fig: 1, 2 and 3) reveals the importance of this sector both nationally and globally, with major concern to Pakistan that stands below 6% of the total animal source protein on the global fish dependency chart.

1.2 NATIONAL

Pakistan has plenty of natural water resources as fresh, marine waters and brackish waters. Pakistan has inland water covered area about **79,200 square km**. The length of coastline is about **990 km** with Economical Exclusive Zone of **350 nautical miles**, that covers an about **290,270 square km**. Fisheries sector provides employment to about **400,000 fishermen or fish farmers** and about 600,000 people

in allied industries. Pakistan has **193 freshwater** fish species and about **800 marine** fish species. Only **31 freshwater** fish species are considered as commercially important while, **120 marine** species are commercially important. The consumption of fish is about **1.9 kg per capita per year** as compared to global average of **17 kg**. Currently fisheries sector contributes about **0.4%** to the national GDP (Fisheries Development Board, 2020).

As per estimate, the total area covered by fishponds across all provinces is about **80,000 ha**, mainly in Sindh and Punjab and few in other provinces (Baluchistan, Khyber Pakhtunkhwa, Azad Kashmir, and Northern Area). The size of these farms varies considerably, however, the average farm size ranges form **5-10 ha**. No direct data on the number of fish farmers employed in this sector is available as fish farming in most parts of the country is carried out as an integral part of crop farming. According to a best estimate, nearly **50,000** persons are either directly or indirectly employed in the sector (Fisheries Development Board, 2020).

Pakistan lags behind globally in fish production, however the sector is emerging with some promising developments going on board nationally. Till date, the total annual fish production accounts for **0.810 million tonnes,** including **0.306 million tonnes** and **0.504 million tonnes** from inland and marine fisheries, respectively (details in Table 2), while the total annual fisheries export accounts for **0.19 million tonnes,** resulting in **national revenue of 452 million US$** (details in Table 3) (Fisheries Development Board, 2020).

TABLE 2: FISH PRODUCTION OF PAKISTAN

ITEMS	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014 - 15**	**2015 - 16**	**2016 - 17**	**2017-18**	**2018 - 19**	**2019-20**
Marine Fish Production (In million Tons)	0.425	0.425	0.430	0.450	0.465	0.467	0.470	0.480	0.493	0.498	0.502	0.498	0.504
Inland Fish Production (In million Tons)	0.220	0.225	0.240	0.250	0.260	0.262	0.265	0.285	0.295	0.299	0.305	0.301	0.306
TOTAL (In million Tons)	0.645	0.650	0.670	0.700	0.725	0.729	0.735	0.765	0.788	0.797	0.807	0.799	0.810

TABLE 3: EXPORT OF FISHERY PRODUCTS FROM PAKISTAN

ITEMS	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2016-17	2017-18	2018-19	2019-20
Export Earnings (Quantity in tons)	135,112	127,246	113,212	133,926	131,624	144,148	155,671	152,858	196,927	195,532	199,000
Export Earnings (Value in million US$)	212	233	227	296	319	317	369	394	451	439	452

In a broader spectrum, Punjab offers a success story in terms of inland aquaculture and has achieved some worth considering milestones when it comes to meet national market demand as well as international market, such as Tawakkal Tilapia Hatchery in Multan, being on top of the list in inland fisheries besides many others, contributing fast towards the market needs. Sindh has some promising news in terms of shrimp and crab culture, with Tilapia dominating the market with carp species following the chart along with Catfish, Sole and others being on the list.

1.3 PROVINCIAL

1.3.1 KEY STATISTICS

Fisheries as a subsector represent an organization of fish production, processing and market interlinked with each other. Presently the situation is not that convincing in the province, however some promising developments are on board, in terms of dissemination of farming practices to the farmer community, game fishing and conservation. Fish catch from the wild is diminishing due to

climate change and human intervention by construction of Dam reservoirs and Weirs for diversion of water for Agricultural purposes.

TABLE 4: AQUATIC RESOURCES OF THE PROVINCE

Water Bodies	Unit	Cold Water	Semi-Cold Water	Warm Water	Total
Rivers/Streams	Km	1718	2757	1627	**6102**
Natural Lakes	Hectare	2216	402	3744	**6362**
Dams/Reservoirs	Hectare	N/A	N/A	54604.86	**54604.86**

These aquatic resources contribute to the sector through game fishing (angling etc.) under controlled and legal provision by issuing licenses (producing 2.2 M revenue in financial year 2021-22) promoting tourism that results in creating eco-friendly income sources. Dams are being regularly leased out to potential fish contractors for three years (generating 260 M in the current round) creating a sound market space for potential fish catch farmers.

Aquaculture and farming in the province are dependent entirely on government sector hatcheries for quality fish seed production round the year, through summers and winters for warm and cold-water species respectively (Table 5). This is the thematic area where we actually are actually lagging in terms of innovation and research (discussed in the problem statements). However, with copious resources in hand, the department is striving hard to meet the needs of fish farmers and the market.

TABLE 5: FISH SEED PRODUCTION BY THE GOVERNMENT SECTOR

S. No	Area	Fish Seed Production (M)	Total
1	Cold Water (Trout) Sector	1.400	**4.55 million**
2	Semi-Cold Water	0.10	
3	Warm Water (Carp) Sector	3.050	

Fish production by the private sector to meet the provincial market is yet another challenge (Table 6) but given the potential offered by the landscape, resources and climate, we can foresee a great deal of production success. This area is hard hit by the lack of scientific capacity building of both the small

scale and progressive farmers, and the problem once again accounts for the lack of emphasis to the sector on provincial level. Hence, it proves to be the immediate community to be taken on board after intervention in government sector.

TABLE 6: FISH PRODUCTION BY PRIVATE SECTOR

S. No	Particulars	Number	Area (Acres)	Production (Metric Tons)
1	Trout Fish Farms (cold water)	355	88	720
2	Carp Fish Farms (warm water)	1321	1840	4600
TOTAL PRODUCTION				**5320**

1.3.2 CHALLENGES

The sub sector, however, is growing slowly in Khyber Pakhtunkhwa because of constraints on private-sector investments, lack of awareness and unavailability of (cost effective) operational tools on local scale. Slow growth is a product of private sector uncertainty due to the lack of a sector specific research strategy; spatial planning, bio-security and value chain constraints. (Further details in problem statement)

1.3.3 POTENTIAL

The Fisheries sub sector supports a lot more jobs indirectly in retailing, transportation and distribution. Khyber Pakhtunkhwa is home to important fisheries supporting ecosystems comprising of spring water, streams, rivers and including Indus River with numerous man-made water bodies.

Capture fisheries is one of the major aspects of inland fisheries, coupled with eco-tourism and providing a benchmark for ethical and scientific revenue generation. Ecological modeling techniques such as Species Distribution Modeling (SDMs) and riverscape ecology researches should play the trump card in the matter, by demarcating the potential sites and subsequently the potential threats our fresh waters are prone to. We can foresee a tremendous growth as more or less 40 wild species of freshwater fish are reported and about 80 species estimated from our part of the Indus belt and peripheral aquatic reservoirs. (Hagler Bailey Pakistan)

Commercial aquaculture has strong growth potential in short to medium term, which will provide jobs and export revenues. Small-scale aquaculture techniques using both indigenous and exotic fish species can support communities' nutrition and incomes through scientific interventions particularly in areas of introducing novel techniques. With that in hand, provincial export is an uphill yet a very

doable task and no so distant a dream.

2. PROBLEM STATEMENTS

This section will deal with problems currently faced by the subsector, that has compromised the output of the sector in a multifaceted picture of the whole scenario in hand. The problems enlisted in brief are followed by proposed solutions to each, in the same numerical order.

PROBLEMS

1. **Stagnation of the breeding techniques** over the same set of species repeatedly, has resulted in both fish market stagnation, low consumer value and inbreeding depression among the species. Lack of diverse breeding techniques prevailing across the globe, with diversification of novel species has left the sector's production capacity compromised, and farmers discouraged to take new farming initiatives and/or expand the existing ones.

2. **Mostly farmers rely on extensive farming** (natural pond feed instead of supplementary) because they cannot afford cost expensive feed from the market, hence the unavailability of low- cost formulated feed is a big challenge in the way of intensive farming that leads to faster growth and higher value.

3. **Unavailability of ample amount of quality seed** to the farmers round the year is yet another challenge as government hatcheries are the only sources to look up to, for quality seed. Hatchery equipment are not manufactured on local scale, leaving import the only option in hand with farmers, making it impossible for them to develop their farms into hatcheries and assist the sector in meeting the gaps of high demand of fish seed. Therefore, purchase from other provinces (mainly Punjab) becomes the only option, with high prices, transportation costs and mortality risks.

4. **Quality seed and cost-effective feed preparation** both need extensive applied research and the sector is deprived of innovative and equipped laboratories, with infrastructure however present, need to be considered for basic modern tools.

5. **Disease diagnosis and treatment** is one of the many hard-hit issues of the sector where there is not a single diagnostic lab with basic modern tools to cope with the disease outbreaks, hence make the sector vulnerable to the challenge of mass mortality of fish stocks.

6. **Lack of efficient harvesting and marketing strategies** that includes: Fish processing, filleting, cold chain and packaging for value addition and other shipment and marketing strategies has left the production at the altar of local fish dealers that offers disappointingly copious market value to the local farmers, hence creating disparity among them to consider farming as a long-term business plan.

7. **Lack of extensive and regular capacity building trainings** due to unavailability of required monitory inputs and technical human resources, has left the modern research unable to trickle down the line of researchers to the farmers, and must be taken on promptly if we are to look into the future of this closer to life sector of fisheries and aquaculture.

3. PROPOSED SOLUTIONS

3.1. INSTIGATION OF NOVEL BREEDING AND FARMING TECHNIQUES AND INTRODUCTION OF NEW FARMED SPECIES TO MEET THE EMERGING MARKET TRENDS.

- Introduction of Genetically Improved Farmed Tilapia (GIFT) through sex reversal.

This African origin fish is not merely an addition to the farming pool, but a revolution in fisheries sector with its unmatched advantages over every warm water species with its fast growth, high market value, high stocking density (double per acre yield), low oxygen demand, higher disease resistance and what not. From a poor man's fish, Tilapia is now taking it to everyone's fish.

Genetically improved species called GIFT (Blue and Red Strains) developed and commercialized for the first time in Thailand, is now the story of every fish-eating nation and is only second to grass carp globally, which soon will be surpassed by its diverse climatic outreach. We as a province, are still to instigate breeding and sex reversal (production of all-male progeny) of tilapia that only need a slightly modified system of hatching jars contrary to the Chinese circular tanks used for carp or the trays (heath incubators) used for trout.

FIGURE 4: HATCHING JARS FOR BREEDING AND SEX- REVERSAL OF TILAPIA

- Induced Spawning of Novel Species like Channel Catfish, Sole and Pangasius.

Repeated culture of the same species over decades has brought the local fish market to economic stagnation, reducing the market value (per kg of a species) and dropping the turn over for fish farmers. Changing market trends require innovation in every possible way, and instigation of new farmed species, that has been genetically selected over decades, yet not been introduced in our aquaculture systems, is one of the key factors to cope with market stagnation, per acre yield, and increased market value of species.

Species like American Channel Catfish, Sole and Pangasius are the new talk of the town, as their adaptability to local culture systems instead of being carnivorous in nature, are a good addition to the pool. However, their culture system is a bit more intensive as compared to carps, but the market value sets all the odds apart to make it a revolution in warm water fisheries. We need to shift our farmers towards these species to be cultured in parallel to our Indian and Chinese carps while keeping the balance through genetic selection studies such as hybridization, by our research and academia sectors.

FIGURE 5: AMERICAN CHANNEL CATFISH (A HIGH VALUE WARM WATER FISH)

- Recirculating Aquaculture System (RAS)

Perpetual water consumption is thought to be the biggest challenge to foresee when it comes to aquaculture. Recirculation aquaculture is essentially a technology for farming fish or other aquatic organisms by reusing the water in the production. The technology is based on the use of mechanical and biological filters, and the method can in principle be used for any species grown in aquaculture such as fish, shrimps, clams, etc. Recirculation technology is however primarily used in fish farming.

Traditional fish farming is totally dependent on external conditions such as the water temperature of the river, cleanliness of the water, oxygen levels, or weed and leaves drifting downstream and blocking the inlet screens, etc. In a recirculated system these external factors are eliminated either completely or partly, depending on the degree of recirculation and the construction of the plant.

Recirculation enables the fish farmer to completely control all the parameters in the production, and the skills of the farmer to operate the recirculation system itself becomes just as important as his ability to take care of the fish. Controlling parameters such as water temperature, oxygen levels, or daylight for that matter, gives stable and optimal conditions for the fish, which again gives less stress and better growth. These stable conditions result in a steady and foreseeable growth pattern that enables the farmer to precisely predict when the fish will have reached a certain stage or size. The major advantage of this feature is that a precise production plan can be drawn up and that the exact

time the fish will be ready for sale can be predicted. This favors the overall management of the farm and strengthens the ability to market the fish in a competitive way.

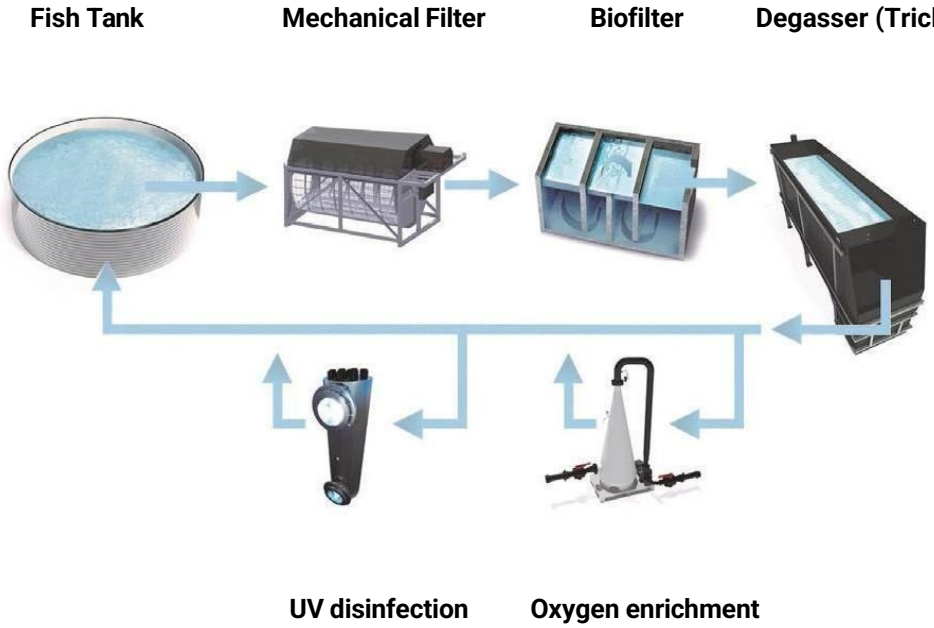


Figure 6: Principle drawing of a recirculation system. The basic water treatment system consists of mechanical filtration, biological treatment and aeration/stripping. Further installations, such as oxygen enrichment or UV disinfection, can be added depending on the requirements.

- Cage Culture System

Cage farming in Asia is practiced in fresh, brackish and inshore coastal waters. Freshwater cage farming is a very old tradition that is thought to have originated in some of the Mekong Basin countries. Currently occurs in all freshwater habitats and is extremely diverse in nature, varying in cage design, and intensity of practice, husbandry methods and the species farmed.

Brackish water and marine cage farming is relatively new in Asia, having first been developed in Japan for marine cage culture for species such as the Japanese amberjack or yellowtail (*Seriola quinqueradiata*) and red sea bream (*Pagrus major*). Over the last 20 years, marine finfish aquaculture, predominantly cage farming, has spread throughout Asia. The predominant countries engaged in this activity are China, Indonesia, Taiwan and Vietnam.

Pakistan has lot of large size water bodies, including dams, barrages, lakes, running canals, rivers, sheltered bays and lagoons, etc. these water bodies can be used to grow fish in cages. The cage farming technology was introduced by the Fisheries Development Board in 2010 at an experimental level.

Keeping in view the results of the initial pilot, there is a need to practice / upscale the cage farming technology to produce fish at commercial level through cluster development approach. Our province is equally bestowed with such reservoirs and is capable to host such projects and must be drawn to consideration for maximum utilization of natural water reservoirs instead of depending solely on already challenged reserves of ground water.

FIGURE 7: MODEL CAGE SETUP INSTALLED AT VARIOUS RESERVOIRS ACROSS PUNJAB AND SINDH BY FDB

- Bio-Floc Technology (BFT)

Bio Floc Technology (BFT) is considered as new “blue revolution” since nutrients can be continuously recycled and reused in the culture medium, benefited by the minimum or zero-water exchange. BFT is an environment friendly aquaculture technique based on in-situ microorganism production. Bio- floc is the suspended growth in ponds/tanks which is the aggregates of living and dead particulate organic matter, phytoplankton, bacteria and grazers of the bacteria. It is the utilization of microbial processes within the pond/tank itself to provide food resources for cultured organism while at the same time acts as a remedy for water treatment. Thus, this system is also called active suspension ponds or heterotrophic ponds or even green soup ponds.

How does BFT work?

- Bio-floc system is a wastewater treatment which has gained vital importance as an approach in aquaculture.
- The principle of the technique is to maintain the higher C-N ratio by adding carbohydrate source and the water quality is improved through the production of high-quality single cell microbial protein.
- In such condition, heterotrophic microbial growth occurs which assimilates the nitrogenous waste that can be exploited by the cultured species as a feed and also works as bioreactor controlling of water quality.
- Immobilization of toxic nitrogen species occurs more rapidly in Bio-floc because of the growth rate and microbial production per unit substrate of heterotrophs are ten-times greater than that of the autotrophic nitrifying bacteria.

FIGURE 8: MODEL OF BIO-FLOC FARMING SYSTEM

3.2. QUALITY ENHANCEMENT OF THE CURRENT FARMING SYSTEMS USING CUTTING EDGE TECHNOLOGY

Shifting from extensive to semi-intensive and intensive farming systems in warm water fisheries to increase high per acre yield, fast growth and high value.

Intensive farming refers to higher input of (formulated feed) to the culture system, contrary to the obsolete extensive system with no external inputs, resulting in fast growth (by time) and more yield (by volume) in the same growth period and higher carcass value (bone to flesh ratio).

This intensive farming approach, however, is slightly undesirable only because of cost input, mainly resulting from high crude protein cost that constitute most of the proportion (23 – 40%) in formulated feed, but once managed, in terms of profit are way higher. Therefore, we need to emphasize producing cost-effective feed without reducing the feed conversion efficiency (FCE) of the existing formulation.

Establishment of Feed mills

Commercial feed is almost unbearable for the poor farmers; therefore, feed formulation mills should be established in potential district hatcheries of the department (districts with high farming trends) in order to make quality and cost-effective formulated feed available at nearest distance possible to avoid high purchase and shipment costs on farmers.

This will also allow our researchers to target the intensely needed domain of research on fish nutrition, where they will be able to play around with feed formulation, conduct growth trials in the same hatcheries and help produce a desirable low-cost feed for commercial purpose.

FIGURE 9: MODEL ILLUSTRATION OF A FISH FEED MILL

Technology transfer on making breeding and operational tools on local scale.

Use of mechanical technologies for producing breeding and operational tools such as Aerators, Heath incubators/Hatching trays for trout, hatching jars and fanning tubs for Tilapia and Catfish breeding respectively. This will enable us to disseminate fish breeding techniques on larger scale and lower cost to avoid havoc of custom duty charges on these tools that make them unbearably expensive for the local fish farmers who wish to extend their farms to hatcheries and become independent in producing seed, resulting in a stronger and sustainable infrastructure.

Therefore, technical departments may be taken on board to brainstorm the possibility and design a lay out for the said purpose and collaborate with both academia and the department for further specific inputs such as resource and knowledge sharing.

3.3. ESTABLISHMENT OF RESEARCH LABORATORIES IN MAJOR DISTRICTS

1. NUTRITION LAB

Nutrition is surely the punchline of the story and all that matters at the end. Having said that, intensification can only be made reasonably affordable for poor farmers, by conducting extensive research on formulated fish feed to enhance both early survival and post survival growth, by using advancements of nano-technology (nano particles like

semi-digested coenzymes) and replacement of expensive crude protein sources with that of low-cost proteins for a cost-effective feed production.

2. GENETIC IMPROVEMENT LABS

Extensive studies on fish strain development through *Genetic Selection* and *Hybridization* to cope with the challenge of inbreeding depression, that will need provision of the relevant equipment such as *Gene Tagging Apparatus* and other laboratory tools.

3. PATHOLOGY LABS

Disease diagnosis in fish has always been a challenge globally, however the recent advances in pathology has made it possible to a considerable level and we are in a position to diagnose and treat most of the infections that our culture systems are prone to. Establishment of specialized diagnostic facilities and portable diagnostic kits are need of the hour, to counter the threat imposed by disease outbreaks followed by proper treatment and precautionary measures with proper dispensation of knowledge on fish pathology to the farmers.

4. WATER AND SOIL TESTING LABS

Water quality management (limnology) plays a pivotal role in aquaculture and is very crucial for a healthy pond ecosystem. Routine water testing and maintenance of all the required water parameters at an optimum level is the key to maximized productivity and a backbone of any aquaculture system. Modern limnology kits (both disposable and consumable) are the order of the day.

Soil testing is yet another unavoidable parameter to be taken care of and we are lagging on this front as well. Proper soil texture leads to a productive pond system with good planktonic growth and water holding capacity, resulting into low costs and higher growth.

3.4. FISH PROCESSING UNITS, COLD CHAIN AND VALUE ADDITION

As a simple rule of thumb in consumer behavior, it sells when it attracts. Fish is no different a commodity when it comes to aesthetic value besides its nutritional value, and hence consumers are way more hygiene conscious when it comes to fish as compared to any other animal source of protein, because of its shelf life.

Well processed fish, that includes proper beheading, descaling, deskinning and conversion into fillets offers more to the market value of the fish (almost 75% per kg increase as compared to unprocessed fish as recorded at NARC Islamabad).

This processing is coupled with cold chain and other marketing strategies resulting in a whole new substance to the farming that otherwise would be simply a caricature of the typical obsolete market standards that are prevailing and must be abandoned for a better and robust growth of fisheries as a sector.

Therefore, Fish Processing Units, need to be established at potential sites and made accessible for the farmers through a defined mechanism. This is yet another side of the story that can be a successful end to tale of the sector and would end up like icing on the cake for this emerging sub-sector, and must be on the wish list of the commercial stakeholders of the fish market in future.

FIGURE 10: A MODEL FISH PROCESSING UNIT

3.5. SCIENTIFIC, CAPACITY BUILDING AND MARKETING TRAININGS TO THE FISHERIES COMMUNITY

All we have discussed through the course of this report, ranging from basic understandings to current statistics and through to the problems and plausible solutions, are entirely dependent on how well can we disseminate our understanding of the matter to the community concerned

including students, researchers, academia, progressive farmers and every single individual associated with the sector in one way or the other.

Scientific understandings that underpin the science of fisheries and aquaculture, all the relevant and core subjects, technical and operational principles such as biomass assessment, record keeping, harvesting protocols, market trends, consumer behavior and every thing that connects to the chain of a successful business, should be extended down to the communities by extensive training programs.

Given the existing infrastructure, this goal, with its on-ground feasibility, is the most cost effective of all yet so important, as we have training centers already present in government sector. All we need is, to upgraded and innovated these centers to modern day requirements such as digital libraries, online scientific databases, technical and research related training programs that should be incorporated in the regular domain of the sector, where the communities will get benefitted on perpetual basis. Such long-term gaps that must be bridged by taking multiple sectors on board such as academia, industry and the department.

In a nutshell, awareness and technical trainings are the need of the hour if we really are to get the strings together for a promising tomorrow out of these challenges faced by the sector.

Figure 11: Training on Cage Culture farming initiated by Fisheries Development Board, Islamabad

4. ACTION MATRIX FOR IMPLEMENTATION

Action - I

Target Public and Private funds towards value-creating investments in Aquaculture

1.1	**Incentivize more investments in efficient and sustainable aquaculture technologies and solutions;** • Support to private sector for Improvement of Engineering design of Aquaculture systems i.e., Reverse Engineering. • Technical Support to private sector in improvement of Water Quality Management such as Limiting factors of Fish Production through the same reverse engineering i.e., Aeration tools, Feeding equipment etc.
1.2	**Support investments in larger production capacities with higher profit capabilities;** • Support Research through scientific intervention to improve Fish Seed production quality. • Sex reversal for producing mono-sex progeny, such all-female seed in Trout, and all-male seed in Tilapia. • Improve vigor of the existing strains by phenotypic and genetic selection of brood fish through genetic programs like hybridization etc.
1.3	**Stimulate the development of new aquaculture products with higher added value;** • Species diversification according to suitable culture environment in the private sector on pilot basis would do the needed benchmark for future.

Action – II

Facilitate the Development and inclusive Aquaculture Value Chains

2.1	**Improve support mechanisms for producers of fish to comply with public and private food safety and quality standards;** • Global Gap Certification of aquaculture production. • Applying Codex Alimentarius (FAO) criteria in Aquaculture Value Chain. • Improved processing methods and development of Cold Chain on pilot basis.
2.2	**Support innovative women, youth entrepreneurs in starting new businesses in aquaculture Value Chain;** • Scientific processing of fish (Degutting, filleting preparations, cold chain) • Scientific transportation of fish (Mounted Vehicles/ Live Haulers) • Improvement in quality of fish handling at Marketing outlets.

Action – III

Foster strong and integrated support systems for knowledge-based aquaculture systems

3.1	**Research key issues affecting the production and marketing of aquaculture products;** • Production of fish species (Infrastructure, Seed, Feed and other factors). • Processing for value addition. • Marketing of Fish and Fish products.

3.2	**Develop Aquaculture Information System and Knowledge Hub in the province;** • Web site with relevant updated information in Urdu on Aquaculture Value Chains.
3.3	**Provide support to innovative partnership between producers and Scientific institutions i.e., Academia;** • Evaluation of fish strain development. • Evaluation of fish feed for growth (Feed Conversion Ratio) and environmental waste generation. • Improvement in production methods at the farm level. • Economic evaluation of the fish farm production.

Action – IV

Strengthen the capacity of Aquaculture producers to manage Climate Change and protect the environment

4.1	**Support Reach for promotion and application of efficient health management practices at the Farm Level;** • *Documentation of diseases of Economic Value Fishes of the Province.* • *Preventive and Prophylactic measures at the farm level.*
4.2	**Develop various risk management instruments supporting aquaculture investments;** • *Flood Risks* • *Disease Risks* • *Other Risks to be identified by Academia.*
4.3	**Strengthen educational and vocational training program in the field of aquaculture,**

	particularly for youth, women and progressive farmers.

Action – V

Support will be required to the Fisheries Department Khyber Pakhtunkhwa for streamlining the public and private sector on proper basis for which the following actions are needed;

1. *Fisheries and Aquaculture Policy and Strategy to be prepared, followed by approval from the provincial government and enacted.*
2. *Setting up focal person for coordination with Academia and potential stakeholders on novel researched and development.*

5. CASE STUDIES

1. SHRIMP CULTURE AND CAGE CULTURE CLUSTER DEVELOPMENT PROJECTS INITIATED BY FDB, ISLAMABAD.

A remarkable development towards diversification of aquaculture techniques and species, under the umbrella of projects initiated by the Fisheries Development Board, Pakistan. Details can be obtained and literature to be sought on https://fdb.org.pk/

Shrimp culture however, being already done in Sindh, has been initially extended to Punjab and coastal areas of Baluchistan under this project. Khyber Pakhtunkhwa however, do not have considerable region for shrimp farming therefore not a candidate for the project.

Cage culture cluster development project is the new talk of the town, with our national landscape bestowed with plenty of water reservoirs and dams. Under this five years project, a total of 5000 cages would be installed across the three provinces with 1500 cages already been installed. Khyber Pakhtunkhwa, although not a part of this project, but equally capable in terms of resources must be considered in future.

2. INSTIGATION OF NOVEL SPECIES BY NARC, ISLAMABAD.

Aquaculture & Fisheries Program, National Agricultural Research Center, Islamabad offers a success story in terms of species diversification with holding the privilege of instigating novel species projects like American Channel Catfish (successfully completed) and Sole fish (currently initiated) offering a new dimension to the cause by setting an example of being the first in government sector.

3. FIRST SUCCESSFUL BREEDING TRIAL OF PANGASIUS BY TAWAKKAL HATCHERY, MUZAFFARGARH, PUNJAB.

Tawakkal Fish Hatchery started Pangasius breeding in 2021. They hired Vietnamese Consultant, Mr. Minh Phu, for its breeding and supplied about 5 million pangasius seed to fish farmers at affordable price. They have got Pangasius Hatchery training from Aqua Centre, Asian Institute of Technology, Thailand. They successfully cultured Pangasius at their farms and now Tawakkal Foods is the first company that has started producing Pangasius fillet in Pakistan this year (2022). Such examples are some of the promising sides that we can fall back on, in future.

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