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Status of Freshwater Aquaculture in Gujarat: A Trend Analysis and Potential

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ABSTRACT

This study was undertaken during 2022 in the Regional Research Center of ICAR-Central Institute of Freshwater Aquaculture, Anand, Gujarat, India to study the present status and potential in the development of freshwater aquaculture in the state of Gujarat. The present seed production (2608.37 million fry) and Inland fish production (0.158 MT) in Gujarat is forecasted to reach 3100 million fry and 0.22 MT in 2030; 4600 million fry and 3.14 MT in 2050, respectively. The Regional Research station of ICAR-CIFA had contributed significantly in promoting aquaculture by imparting skill training and providing technical backup to fish farmers. Authors argue that in order to further develop freshwater aquaculture value chain, concerted efforts are required to disseminate technology packages for fish breeding and seed rearing, semi-intensive culture practices, diversified fish farming, scientific management (fish feed and nutrition, water quality and fish health), ornamental fish farming, pearl production and cluster-based fish farming. However, successful implementation of suggested points will be depending on the sustainable adaptive capacity of the freshwater aquaculture producers, entrepreneurs, strategies and planning of policy makers and line departments of various state departments, input dealers and buyers in the state of Gujarat. Hence, they need to be supported in terms of skill, policy and market towards establishing a vibrant fish value chain. Therefore, adoption of BMPs, nurturing entrepreneurs, aggregating farmers and strengthening extension services are recommended.

KEYWORDS: Aquaculture, freshwater, dissemination, potentials, production, Gujarat

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1. INTRODUCTION

Aquaculture has emerged as a fast-growing sector in the field of fisheries with 7% average annual growth (Inaotombi and Mahanta, 2015, Jayasankar, 2018, Boyd et al., 2020) due to its potential and the stagnation fish production in the capture fisheries in marine as well in inland sector (Ahmed et al., 2019, Naylor et al., 2021). Also, the demand of fish is rising significantly in current times due to the awareness about the health benefits of fish consumption (Chen et al., 2022, Swain and Ferosekhan, 2022, Yerlikaya et al., 2022). The share of aquaculture's production to world fish production has continued to increase, reaching 82.1 mt (46%) out of the estimated 179 mt of world fish production. Moreover, its contribution to worldwide fish production is expected to growing up from the existing 46 to 53% in 2030 (Anonymous, 2020a). Because this sector has provided the food and nutritional security, employment and livelihood directly or indirectly through the various level of aquaculture activities (Subasinghe and Phillips, 2010, Ramakrishna et al., 2013, Nandeesha et al., 2013, Jain et al., 2016, Gephart et al., 2020, Irwin et al., 2021, Cai et al., 2022).

India ranks second in the total aquaculture production in the world next to China (Anonymous, 2020b, Ngasotter et al., 2020) and the freshwater aquaculture contributes major part (>80%) in the aquaculture production in recent years (Anonymous, 2017a) due to the technological interventions of induced breeding, polyculture and composite fish culture in ponds and tanks have brought about significant growth in the freshwater aquaculture production and productivity and turned the sector into a fast growing industry (Jayasankar, 2018, Swain et al., 2021). The freshwater aquaculture comprises the culture of carps, catfishes, prawns, tilapia and ornamental fishes but carps contributes major part (95%) in the total freshwater fish production (Jayasankar et al., 2018). Fisheries sector contributes about 1.24% to the country's GVA and over 7.28% to the agricultural GVA. In terms of employment, the sector supports the livelihood of over 28 million people in India especially the marginalized and vulnerable communities (Anonymous, 2022). Fish production has increased from 4.16 mt (2.45 mt for marine and 1.71 mt for inland fisheries) in 1991–92 to 10.79 mt (3.58 mt for marine and 7.21 mt for inland fisheries) in 2015–16 (Anonymous, 2017a) during 2019–20 it was further increased to 14.16 mt (3.73 mt for marine and 10.44 mt from inland fisheries). During, this financial year (2019–20), India has exported ₹ 46,662.85 crore (Anonymous, 2020a).

Gujarat is prime state in the sector of fish production in India particularly in marine and brackish-water fish production because this state is owed with longest coastline (Joshi et al., 2018, Hudda, 2018). The major contribution in freshwater aquaculture in Gujarat is from village ponds which are leased to the farmers (Ail et al., 2019, Ail et al., 2021). However, the freshwater aquaculture production is considerably low in spite of huge freshwater resources the state of Gujarat. Since, establishment of Regional Research Center of ICAR-Central Institute of Freshwater Aquaculture, at Anand, Gujarat during 2011 and it has conducted several workshops, awareness and training programs, field days, celebrated National Fish Farmers days and through precipitations in Agri exhibitions to disseminate the scientific technologies to the fish farmers of Gujarat. Also, this center did the research work with focused on the region-specific problems e.g. growth performance of jayanti rohu, fish breeding by FRP carp hatchery, rearing of fish seed in village ponds, cultivation of freshwater ornamental fishes, fish health etc. (Anonymous, 2017b, 2018, 2019). Considering the water resources available in state of Gujarat, the present investigation was evaluated the prospects and potential in the sector of freshwater aquaculture to help enhance the overall fish production.

2. MATERIALS AND METHODS

The present study was conducted during 2022 at Regional Research Center of ICAR-CIFA, Anand, Gujarat, India based on primary and secondary data relating to freshwater aquaculture of Gujarat and India collected from various reports of Government Gujarat and Government of India. Data pertaining to one decade i.e., from 2007–2008 and 2009–2010 to 2017–2018 and 2019–2020 respectively relating to water resources, fish seed production, inland fish production at the state and district level etc. were collected in the present study from annual reports, scientific communications and other related literature published by scientific community, Gujarat state fisheries Department, Department of Fisheries, Government of India. The information seekers data that were visited to the Regional Research Center of ICAR-CIFA, Anand was collected during 2012–2020. The data collected for fish seed production, fish production and information seekers was applied with Trend analysis using SPSS 16.0 Software then presented in the form of line charts and Pie diagrams.

Besides focused group discussion (FGD) were held with groups of farmers at field level to elicit their views about the current status and what need to be done for further development of fish value chain. Multidisciplinary team of scientists including representatives from Krishi Vigyan Kendra, Anand had conducted six such FGDs during the study.

3. RESULTS AND DISCUSSION

3.1. Freshwater resources of Gujarat

Gujarat is bestowed with vast freshwater resources

comprising of rivers, canals, reservoirs and ponds having a share of 5.29%. Narmada, Tapi, Mahisagar, Sabarmati are major rivers flowing through Gujarat state. The ponds and tanks were contributing about 2.92% of total area of ponds and tanks in India. The state had 6860 village ponds comprising an area of 0.022 mha which need to be utilized in a sustainable manner to enhance the fish production (Ail et al., 2021). There is total 1635 number of reservoirs from which 50 numbers are major, 38 numbers are Medium and 1547 numbers are small reservoirs covering water spread area of 0.229 mha, 0.026 mha and 0.092 mha respectively (Table 1).

Table 1: Freshwater resources of India and Gujarat

	Resources				
	Rivers & canals (kms)	Reservoirs (mha)	Tanks & ponds (mha)	Flood plain lakes & derelict waters (mha)	Total water bodies (mha)
Gujarat	3865	0.243	0.071	0.012	0.326
India	195095	2.9264	2.4328	0.7983	6.1574
Percentage share	1.98	8.30	2.92	1.50	5.29

3.2. Present status of fish production

The inland fish production was doubled over a decade in Gujarat. The freshwater fish production primarily comprise of Indian major carps (catla, rohu and mrigal) and exotic carps (silver carp, grass carp) in the ratio of 9:1. Freshwater aquaculture with a share of 34% in inland fisheries in mid-1980s was increased to about 80% in recent years and this holds true for the state of Gujarat also. The average production per unit freshwater area was 0.764 t ha^{-1} y^{-1} which was far less than the average national average i.e. 3 t ha^{-1} y^{-1} (Anonymous, 2014b). The inland fish production from the state was increased from 0.77 lt in 2007–08 to 1.58 l t in 2019–20 registering 2-fold growth during last decade (Table 2 and Figure 1). On the contrary marine production in the state was reached a plateau and this production trends shows the stagnant growth like India (Figure 1). However, the total fish production was increased over the years from 0.721 mt in 2007–08, the total production raised to 0.835 mt in 2017–18, an increase of over 16% and reached to 0.859 mt during 2019–20. Here, the production trends illustrate steady growth and it can be said that this hike in production has mainly come from freshwater sector in Gujarat. The total fish production in Gujarat (R^2=0.93) highly correlated and significantly contributed to the total fish production of India (R^2=0.96) (Figure 1). Inland fish production in Gujarat is forecasted to reach 0.22 million tonnes in 2030 and 3.14 million tonnes in 2050 (Figure 2). However, the present fish production growth rate of

Table 2: Fish production of India and Gujarat (mt)

	2007–2008			2009–2010			2017–2018			2019–2020		
	Inland	Marine	Total	Inland	Marine	Total	Inland	Marine	Total	Inland	Marine	Total
Gujarat	0.077	0.644	0.721	0.084	0.687	0.771	0.134	0.701	0.835	0.158	0.701	0.859
India	4.207	2.919	7.126	4.894	3.104	7.998	8.902	3.688	12.590	10.437	3.727	14.164
Percentage share	1.83	21.20	10.12	1.72	22.13	9.64	1.50	19.00	6.63	1.51	18.81	6.06

Source: Anonymous , 2018, 2020a

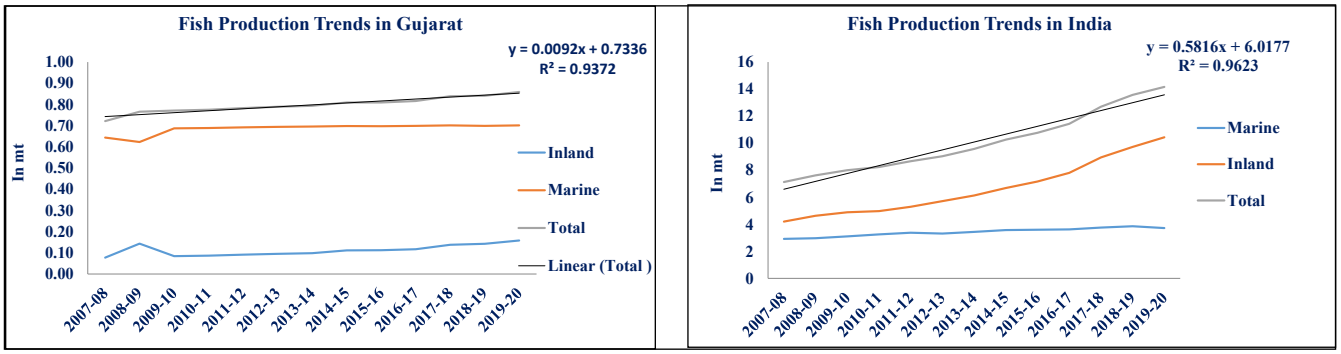

Figure 1: Fish production trends in Gujarat and India, Source: Anonymous, 2018, 2020a

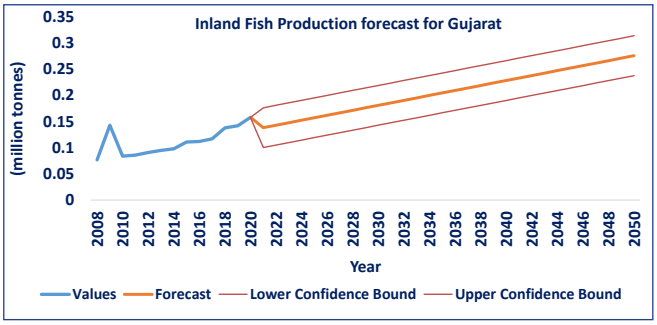

Figure 2: Inland fish production forecast for Gujarat

State Gujarat was much lesser than India's growth rate (Anonymous, 2018, 2020a).

At present aquaculture was practiced in village ponds include carp polyculture, capture based prawn farming and negligible progressive farmers indulged in cage farming. Few farmers were indulged in combination of major carps with *Labeo calbasu*, *L. fimbriatus*, *Puntius gonionotus* etc. Prawn seed were collected from wild, mainly from Narmada and Mahisagar rivers during September to December are cultured. Pangasius culture was also trending as this fish grows to marketable size within 6–8 months.

3.3. Present status of fish seed production

Most of the fish seed production in the state was by Government fish seed hatcheries and the fish seed requirement of the state is not fulfilled by these existing hatcheries due to their limited production capacity. Fish seed produced in Gujarat was only of Indian major carps like catla, rohu and mrigal and it falls short of the demand. The fish seed production was 610.20 (2007–08) and 689.89 (2009–10) million fry and it has drastically reduced to 185.23 million fry in 2017–18. However, in 2019–20 the seed production increased significantly to 2608.37 million fry in Gujarat and it is positively correlated (R^2=0.78) implies that the state has huge scope and potential for fish seed production (Table 3 and Figure 3). It shows the fish seed production trends of Gujarat is growing up very slothfully as compare to India's fish seed production trends over the years (Figure 3). This is mainly because of the presence of less number of fish hatcheries in the state and most of them are belongs to Government sector. Hence, farmers were

Table 3: Fish seed of India and Gujarat (In Million Fry)

	2007–2008	2009–2010	2017–2018	2019–2020
Gujarat	610.20	689.89	185.23	2608.37
India	24,143.57	29,313.17	44,420.77	52,170.61
Percentage share	2.53	2.35	0.42	5.0

Source: Anonymous, 2018, 2020a

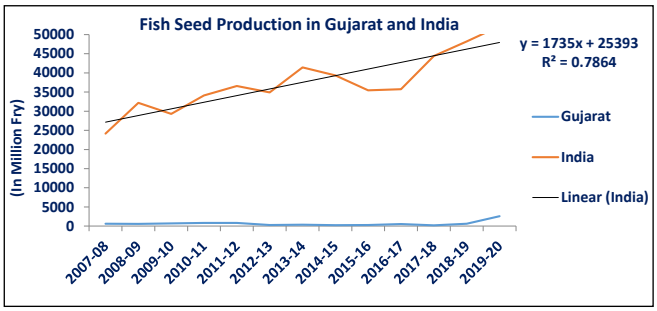

Figure 3: Fish seed production trends in Gujarat and India, Source: Anonymous, 2018, 2020a

still procured carp spawn from Kolkata (Naihatti Fish Seed Market) raising them in their nursery ponds up to fry and then to fingerlings and selling it to local grow out culture farmers. Farmers were owned village ponds of <1ha area raised this seed for a year into yearling (200-300 g) and were stocked them in larger grow-out pond or sell them to leased farmers of larger village ponds and reservoirs. Seeds of exotic carps, minor carps, tilapia and pangasius were supplied by vendors from other Kolkata, Andhra Pradesh, etc. Aquaculture in India is in growth phase with introduction of new species and recent technologies aiming higher fish production. With this present phase seed production in Gujarat is forecasted to reach 3100 million fry in 2030 and 4600 million fry in 2050 (Figure 4).

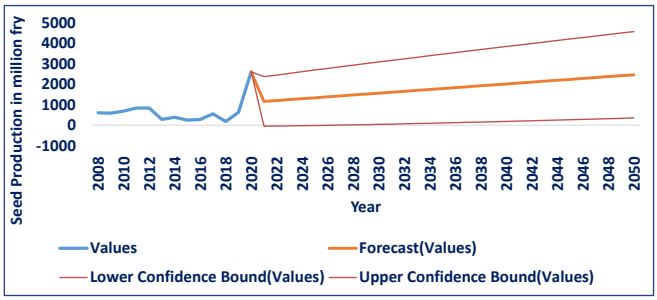

Figure 4: Fish seed production forecast for Gujarat

Prawn seed was collected from rivers like Narmada, Mahisagar and Tapti during September–December month of the year. The seeds will be of mixed nature with several species of *Macrobracium* spp. This was resulting in poor performance of production. *M. rosenbergii* and *M. malcomsonii* fetched higher market price than the mixed one.

3.4. Challenges for increasing fish production

In Gujarat the freshwater aquaculture production was low in spite of the availability of vast resources under freshwater sector in this region; although the state of Gujarat was leading in marine fish production. Many aspects of the freshwater aquaculture sector in were Gujarat remain less explored. Many a times problems were arised like poor productivity of freshwater fish from ponds due to poor

adoption of scientific freshwater carp polyculture, less availability of good quality seed of desirable fish species, improper feeding, poor health management practices etc. Water scarcity was a major problem because the users and demand for water resources have gone upright. In this connection, there is a need for modifying the existing aquaculture practices and also substituting with modern technologies of fish farming like aquaponics, recirculatory aquaculture system (RAS), biofloc etc. Entrepreneurs, farmers and educated youths were keen in entering the aquaculture sector as evident from number of units coming up for freshwater pearl technology and shrimp farming. Interest for ornamental fish breeding and culture was also increasing among youths and hobbyists. Skill training and financial assistance by state fisheries department must be geared up to motivate youths and farmers in aquaculture sector.

3.5. Scope of the freshwater aquaculture development in the Gujarat

3.5.1. Assured supply of quality fish seed

The fish seed demand in Gujarat is increasing day by day (every year) and therefore, achieving self-sufficiency in seed production is of paramount importance. To meet this demand, Public-private partnership or privately-owned hatcheries may be promoted to enhance fish seed production. Along with this (availability of fish seed) there is need to emphasize on quality of seed also, so that grow-out farmers purchase seed from local hatcheries on the assurance of growth performance. For producing good quality seed, collection and selection of brooders (male 3 years and female 2 years age), their diet (28–30% protein) and husbandry practices are the key factors. ICAR-CIFA had demonstrated nursery seed rearing practices from spawn to fry and then to fingerlings in hapa and pens respectively in village ponds. Also, it had given improved rohu (Jayanti) seed to several progressive fish farmers and tribal groups (Anonymous, 2020). This improved strain of rohu had assured the 18% gain generation^{-1} and yield 55–60% more than the control rohu. To increase the fish production in the state, required 3000 million carp fry and 363 million pangas fish fry annum^{-1} (Swain et al., 2021).

3.5.2. Extensive to semi-intensive culture practice

Fish farmers in Gujarat mostly practice extensive mode of farming in village ponds and small reservoirs. Community water bodies were leased to farmers under Village pond Fisheries Policy-2003 and Reservoir Leasing Policy-2004 for a period of 10 years. Village ponds were auctioned by District Development Officer and the revenue generated was allotted to concerned village panchayat. Water bodies are divided based on area among village, taluka and district panchayat. Many fish farmers from other states also take part in tenders. Most of the village ponds were connected with domestic sewage pipes and therefore the ponds are fairly productive. During 2010, Andhra Pradesh was supplied 19,440 t (Ramakrishna et al., 2013) table fish to Gujarat state. Also, the fish consumption of Gujarat state was 9.55 kg capita^{-1} y^{-1} during 2019–20 (Anonymous, 2020). This indicated the gap between demand and supply. This is due to the mode of practice followed by the farmers and they are not able to exploit the existing water resources at par with its production potential resulting in import of fishes from other state to fulfill the demand. However, increasing stocking density, maintaining pond water quality with application of supplementary feed and following Good Management Practice (GMPs) farmers can double the fish production from existing water bodies which can go a long way in ensuring self-sufficiency in fish.

3.5.3. Species diversification

In general, species diversification is increasing number of farmed species and more even distribution of production among species in aquaculture. It is associated with various factors including consumer preference, technical innovations such as breeding, rearing and grow-out potential, economies of scale, risk diversification, over dependency on few cultivable species, market demand, etc. (Cai et al., 2022, Inaotombi and Mahanta, 2015). Most of the fish farmers in the state are farming Indian Major Carps (Catla, Rohu and Mrigal) and to some extent exotic carps viz., Silver carps, Grass carps and common carps because seed were easily available from Government sector and private sector. Farmers were interested to culture high valued fish species along with carps or separately to increase the income viz., scampi, snakehead, amur, knifefish, pabda etc. Main constraints to culture these species are seed availability. However, the few entrepreneurs were started procuring their seed from West Bengal, raising them in the village ponds and getting better production and returns.

3.5.4. Fish feed and nutrition management

Farmers were stocked advanced fingerlings or yearling in ponds and do not pay much attention in feeding and other management practices. Because of the productivity of the pond to nutrient inflow from domestic sewage pipes and its effects on fish production. Carp farmers of Thanjavur district of Tamil Nadu were obtained yield around 3, 4.5 and 4.4 t ha^{-1} y^{-1} while respectively using mixture of ingredient, floating pellet and mash-sinking pellet feed with average 4 t ha^{-1} y^{-1} fish production (Nandeesha et al., 2013) Whereas, Andhra Pradesh carp farmers were obtaining more than 6.6–8.4 t ha^{-1} y^{-1} yield followed with typical semi-intensive culture system (Ramakrishna et al., 2013). Therefore, to increase the fish production from the ponds, need to provide supplementary feed in to the village ponds to boost the

growth of the culture species. Farmers can apply different feeding methods viz., bag feeding with rope or pole, check tray feeding, frame feeding, feeding with demand feeder etc., for the smooth feed management to reduce the feed wastage and increase the feed conversion ratio.

3.5.5. Water quality management

Water quality is the first most important limiting factor in pond fish production. Water quality determines the various physical, chemical and biological factors where they directly or indirectly effect on growth and survival of fish in an aquaculture operation (Buttner et al., 1993, Boyd, 1998, Boyd et al., 2020). The major water quality includes pH, Dissolved oxygen, alkalinity, plankton, nutrients and toxic metabolites. In Gujarat, major source of water to the village ponds are domestic sewage water which is enriched with nutrients leads to higher pond productivity. But excess inflow can cause on bad water quality viz., DO, pH, ammonia level, BOD level, COD level, etc. lead to fish mortality. Hence, need to maintain the water quality parameters at optimum level while applying suitable remedial measures viz., lime, zeolite, alum, water exchange, medicines, aeration, etc.

3.5.6. Fish health management

Disease is one of the major constrains to aquaculture and limiting factor for economic and socio-economic development. Different stress factors such as non-optimal water quality, higher microbial load, poor nutritional status, and high stocking density can trigger the chances of infection by opportunistic pathogens in aquatic environment. In village pond-based aquaculture generally parasitic, bacterial and ulcerative diseases were encountered because of high organic inflow from domestic water. Major economic loss to the fish farmers of state was due to the occurrence of Argulus and EUS infection during hot season and winter season respectively (Anonymous, 2019). Since, inception of ICAR-CIFA center it has provided services of fish disease diagnosis and their control measures in state at Anand to the fish farmers. For preventing and controlling disease outbreaks to take suitable steps viz., maintain water quality parameter in optimum level, provide nutritionally balanced feed, avoid overcrowding, stock disease free seed, apply lime at regular interval, disinfect farm appliances regularly and use immunostimulants/probiotics/bioremediator in culture systems., Hence, implementation of Better Management Practices (BMP) is important to prevent frequent occurrence of disease and production loss in aquaculture.

3.5.7. Ornamental fish breeding and culture

Ornamental fishes provides aesthetic pleasure; brings peace, harmony and relaxation; rinses of the tension and stress. Keeping Ornamental fishes, its farming and trading had showing increasing trend due to the demand for aquaria and accessories, ornamental fish, formulated fish, formulated and live feeds and aquarium service providers. The total domestic aquarium trade of our country was 300 crores with potential to grow to 1200 crore while only 0.32% contribution to the world export (Jain et al., 2016). Therefore, ornamental fish industry has huge domestic as well as international market potential. In our country, North-East states, West Bengal, Kerala, Tamil Nadu and Maharashtra states are leading in ornamental fish breeding, culture and trading. In spite of having huge domestic demand and suitable environment for ornamental fish breeding and culture negligible contribution from Gujarat state. Therefore, the great scope for development of ornamental fisheries sector in the state along with establishing public aquaria in major cities and tourists spot in Public Private Partnership mode will create awareness and provide the employment opportunities (Swain and Misra, 2017).

3.5.8. Freshwater pearl production

Next to the ornamental fish farming, pearl culture is also a non-food farming sector in aquaculture. In our country three pearl producing species are available and among these *Lamellidens corrianus* species was reported and found in the open water bodies of state (Anonymous, 2010). Pearl can be produced from freshwater mussel followed with technology developed by ICAR-CIFA (Anonymous, 2019). Presently, a few pearl producing units were established in Gujarat with limited production capacity. However, an increasing number of entrepreneurs from the state are showing interest to start the pearl production business. This would generate the additional employment opportunities and at the same time can increase the pearl production in the state.

3.5.9. Cluster fish farming approach

Aquaculture is dominated by small-scale producers who are generally facing challenges pertaining to input materials viz., fish seed, feed, medicines and trading of their produce and also how to avail the new opportunities to expand and sustained in competitive market. To overcome these challenges through the establishment of small-scale farmers' organizations using "cluster management". Clustering of smaller producers can improve the aquaculture governance and management of small-scale producers to work together, improve production, develop sufficient economies of scale and enhance knowledge that allows participation in modern market chains (Subasinghe and Phillips, 2010). Formation of Fish Farmers Producers Organizations (FPO) can strengthen both backward as well as forward linkage and thereby contribute to strengthening fish value chain.

3.6. Role of regional research center of ICAR-CIFA in promoting freshwater aquaculture

ICAR-CIFA played a pivotal role in dissemination of freshwater technologies in Gujarat district. It gave information, need based training and hand holding support to fish farmers and worked relentlessly towards resoluteness of the issues in freshwater aquaculture (Anonymous, 2017b, 2018, 2019).

Since, establishment of Regional Research Center of ICAR-CIFA at Anand the visit of fish farmers had significantly increased over the years (Figure 5) to seek information on fish farming (47%), scampi farming (3%), ornamental fishes (3%), pearl farming (5%), fish breeding and seed production (3%), fish feed and nutrition (1%), fish disease diagnosis and treatment (10%), water and soil testing (6%), training (19%) and other (3%) purposes related to fish culture (Figure 6). The location of research center was in middle region of the state hence majority of fish farmers (84%) were visiting from the nearby districts viz., Anand, Kheda, Vadodara, Bharuch, Ahmedabad and Panchmahal while only 16% farmers visited the centre from far off districts and rest of India (Figure 7).

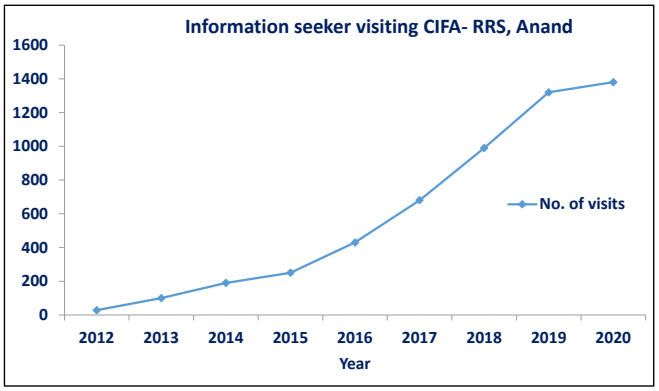

Figure 5: Cumulative numbers of information seekers visiting ICAR-CIFA Center, Anand

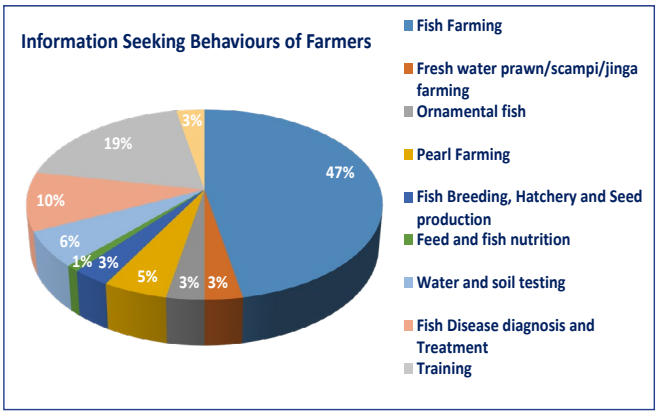

Figure 6: Information seeking behaviours of farmers visiting to center

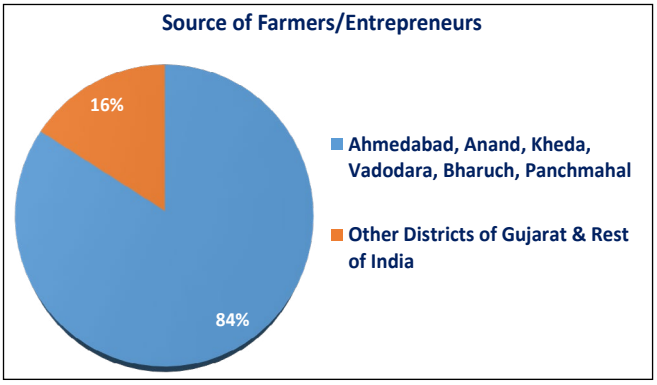

Figure 7: Source of farmers/entrepreneurs visiting to ICAR-CIFA, Center, Anand

4. CONCLUSION

Fish farming practices viz., good quality and desired sized seed stocking, optimum supplementary feeding, water quality and health management, species diversification, etc. holds the key to increase the fish production of the Gujarat state from the existing resources. With enabling policy, entrepreneurial interest, collectivization of farmers in the form of FPOs and technical backup, freshwater aquaculture in Gujarat is slated for quantum growth contributing immensely to make the state self-sufficient in fish production.

5. ACKNOWLEDGEMENT

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