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Structure, vulnerabilities and policy for fish seed supply system in India

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Abstract Fish seed as a primary input determines the pace of aquaculture development. Traditionally, the fish seed was sourced from natural water bodies, and farmers faced several constraints like the mixed and ununiformed seed of non-targeted species, and uncertain supplies. The development of induced breeding technologies enabled the establishment of large numbers of hatcheries. Since then, remarkable growth has taken place in seed production. Yet, the seed sector suffers from several vulnerabilities like excessive centralisation, seasonal dependence, price fluctuations, and climate shocks. This paper suggests measures to improve governance and reduce vulnerabilities in creating a more resilient and efficient fish seed supply chain.

Keywords Fish seed, seed supply system, vulnerabilities, reliance, seed price, governance

JEL Codes D23, D49

Seed is the primary input in aquaculture. Historically, aquaculture in India started with the use of fish seed for stocking in confined waters. Until the 1970s, the natural rivers, streams and breeding grounds were the only sources of fish seed. A major shift in seed production happened with the artificial propagation of the seed in confined waters. The first breeding success in the carps in 1957 (Choudhury and Alikunhi,1957) initiated the spurt of aquaculture development activities, leading to a dramatic improvement in production and productivity of freshwater aquaculture. Over a period, the induced breeding technology spread throughout the country.

At present, fish seed production is carried out by small and marginal farmers with greater involvement of women. Despite such popularity of the practice, fish seed shortage (in quantity and quality) remains a matter of concern. This paper examines the production and trade of fish seed from the new institutional economics perspectives. It assesses seed production system, its vulnerabilities and suggest measures to improve it.

Materials and Methods

The study is based on data available at the national and state level on the production of the fish seed in India. The data available at the national and states provide information on the state-wise fry production which don't provide information on the production and trade of the spawn in the state. There is no available information on the state-wise volume of the spawn production and trade. State level information on the number of functional hatcheries available in published and unpublished literature are collected. In cases where such information is not available, estimates are prepared based on the discussion with officials and experts. This paper attempts to generate an estimate of deficit or surplus of the spawn in the states on the basis of level of production, seed requirements and available functional hatcheries in the states.

Primary data are collected through interview with the market functionaries, traders, office bearers of trades association from the major markets of seed like Naihati, Bankura, Rangia etc.The focused group discussion with

farmers are made to delineate marketing system, vulnerabilities and other issues relating to the production and marketing of fish seed in India.

Results and Discussion

Evolution of seed production technology

Aquaculture in traditional ways are practised in small ponds, tanks and wetlands in West Bengal, Assam and Bihar and other coastal states of India to meet the growing demand for fish. Small water bodies exist either naturally or created artificially. The traditional aquaculture practices are improvements over the 'trap and hold' system, where stocking of seed in the small water bodies increase production and reduce uncertainties in the harvest. To stock these water bodies a large number of fish seeds are required leading to the development of the market for seed in eastern India.

In the past, a large number of the fishermen were involved in collecting naturally available seeds in rivers and rivulets in the deltaic regions. By the 1960s, the riverine collection of seed and transportation of it across the region was a thriving business in eastern India. Until the late 1970s, riverine seed collection was the main source of the seed of Indian Major Carps for aquaculture, contributing to 91.67% of the total fish seed production in 1964–1965. Bundhs (a special type of tank where riverine conditions were simulated during monsoon and carps bred) accounted for a major share of the fish seed until the 1980s (Basavraju 2007). During this period, research in inland fisheries focused on identification breeding grounds, development of effective and efficient ways of fish seed harvesting and establishment of fish seed marketing networks.

The research in seed production started with the exploration of the ways and means to simulate the natural riverine conditions for seed production. This led to the technology of the 'bundh breeding' in which the riverine conditions were simulated using a large expanse of the land and water with the efficacies remaining for a limited time. A breakthrough occurred in 1957 when the Cuttack station of Central Inland Fisheries Research Institute, Barrackpore (CIFRI) succeeded in breeding major carps in captivity through hyphophysation or inducing the breeding through injection of the pituitary gland extracts. Subsequently, Chinese carps were bred in 1962. With the advent of the technique of induced breeding of Indian major carps by Chaudhuri and Alikunhi (1957) and exotic carps by Alikunhi, Sukumaran and Parameshwaran (1963) through hypophysation, it became possible to obtain quality seed of major carps for aquaculture. This led to the development of dependable methods of pure seed production and which also opened for research in the genetic improvement programme. The breeding technology evolved through cloth happa, glass jar, circular hatchery with hatching response increased from 50% to 90%. Similarly, major research inputs were to improve fry raising from spawn with the improvement of survival from 5-10% to about 30-40% at present (Basavraju 2007). There were possibilities of improvement in the seed quality through genetic improvement programmes (Kumar, et al, 2008).

Concurrent research in the development of composite fish culture technology had demonstrated productivity of 6.0-9.0 per ha at research stations as well as in farmers' fields. The All Indian Coordinated Project on Composite Fish Culture and Seed Production experimented and demonstrated the technology across different agro-climatic zones during 1969-75. The experimental fish culture has been extended to cover large water bodies, varying from 1.48 ha to 2.15 ha under an operational research programme at Krishnanagar with net production of around 2514 – 4143 kg/ha/year (CIFRI 1979a). The Government of West Bengal adopted the technology on large scale and demonstrated gross production of 4.5 to 5.5 tons/ha in 1973-74 which was a quantum jump compared to the reported productivity of 600 kg/ha in the ponds through traditional methods of production. These technologies with modifications and adaptations were adopted across the country (CIFRI 1979b). The enhanced aquaculture productivity with the popularisation of the fish culture technologies created a high and sustained demand for fish seed in the country.

At present, not less than 2500 carp hatcheries are operational in India producing about 52,170 million fry (DAHD&F 2020). In the past four decades, enhancing the availability of quality seed has been a priority. The establishment of a hatchery and nursery is the primary strategy to make seeds available.

Seed production system

The seed production system in aquaculture is organised primarily as a three-stage system. In the first stage, the spawn is produced from broodstock in the hatchery

(hatchery operation), in the second stage spawn are raised to fry in about 3 weeks period (total cropping period including pond preparation and drying is about one month), in the third stage fry is grown for 2 to 3 month to attain the size of about 20 grams called fingerlings. Fingerlings are preferred by farmer as stocking materials as it reduces the time required to attain harvestable size, eases gauging quality standard and reduces mortality of the fish. The large hatcheries operators tend to integrate the first two-stage while large fish farmers integrate the last stage with the grow-out culture. Due to low cost, several small artisanal aquaculture farmers stock large quantities of the seed at the fry stage with the hope that a small percentage of seed will survive and grow to bigger sizes. Most of the large farmers prefer stocking a smaller number of large fingerlings or yearlings. The commercial operations are divided into clearly defined four stages of production from spawn to grow-out culture.

The seed production system is operated as a single integrated market in the country. Except for a few states (e.g., West Bengal and Assam), all of the states depend on interstate trade to meet the demand. Even in West Bengal and Assam, specific types of seeds (i.e., pangasius, magur and tilapia) are brought in from outside India. West Bengal is the hub and largest seed producer with around 1500 hatcheries. Two widely recognised and significant fish seed markets of the country viz, Naihati and Bankura, are functional in the state within a distance of around 200 kilometres catering to the need of the whole country.

The state of Assam and West Bengal start early breeding towards the end of February or 1st week of March reaching a peak by May and ending in June. Whereas in Odisha, Chhattisgarh, Jharkhand, Madhya Pradesh breeding starts in June and continues until August. In Andhra Pradesh July- August is the main season for breeding. Last year, there are reports of Tamil Nadu breeding Indian major carps in the month of December-January as a major technical breakthrough achieved with support from National Fisheries Development Board funded project operated by ICAR-Central Institute of Freshwater Aquaculture (Pers. Communication Dr. S. Nandi, Principal Scientist). Therefore, the early breeding of spawn in the states like West Bengal is the major source of spawn to all the seed growers across the country.

Trends in seed production

The estimated annual growth rate in the seed is 5.7% which is equivalent to the growth of inland fish production in India. The spawn production is estimated at 4 times that of fry production. Hence, the estimated spawn production is around 21000 crores (Table 1).

Table 1 Trends of fish seed production in India

Year	Fry (in million)	Estimated Spawn production (Million)
1973-74	409	1636
1978-79	912	3648
1984-85	5639	22556
1989-90	9691	38764
1994-95	14544	58176
1999-00	16589	66356
2004-05	20790	83160
2009-10	29313	117252
2014-15	39350	157400
2019-20	521706	2086824

Source DAHD&F, 2020

Spatial distribution of seed production

The fish seed hatcheries in the private sector started in 1978 with the first circular hatchery in West Bengal. Since then, several hatcheries are established in the state. A large number of hatcheries are concentrated around Naihati and Bankura as seed producing clusters. Similarly, a large number of small and medium-sized hatcheries are established in Assam and Uttar Pradesh. Therefore, these six states contribute a major share of the seed production i.e., 85% of the total seed production in India. West Bengal produced about 80% of the seed in 1985-86, but only 23.8% in 2017-18. Historically, West Bengal dominated the seed supply scenario in the country (Table 2, Figure 1).

Evolution of fish seed marketing

Prior to the induced breeding technology, the seeds were being collected and distributed from a few selected regions in West Bengal, Bihar, Assam and Odisha. West Bengal was the major source of fish seed and a large number of fishermen were involved in collecting seed from natural rivers. Most of the

Table 2 Fish seed production of selected states in million fry

Sl No	States	1985-86	1995-96	2005-06	2017-18
1	West Bengal	79.1	54.5	55.5	23.8
2	Jharkhand	0.0	0.0	0.1	19.8
3	Andhra Pradesh	3.6	4.7	3.9	16.9
4	Assam	0.4	17.0	14.6	15.3
5	Uttar Pradesh	1.9	3.6	4.9	5.2
6	Chhattisgarh	0.0	0.0	2.3	4.2
	Rest of India (RoI)	15.0	20.2	18.7	14.7
	Total	100.0	100.0	100.0	100.0

Source DAHD&F, 2020

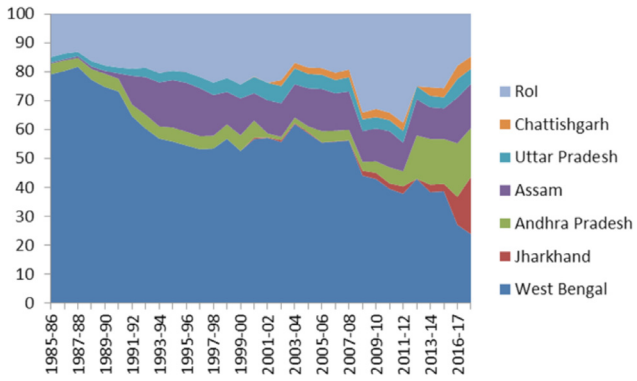

Figure 1 The trend of top six seed-producing states in India (%)

aquaculture areas were dependent on West Bengal for their seed requirements. The fish seed syndicate in Howrah was the first institution for coordination and development of the fish seed market in India established in early sixties. The government of India posted one officer in the syndicate to coordinate seed supply to various states in India during the sixties and seventies.

Immediately after the partition of India, a large number of fish breeding and seed collection centres located in East Pakistan were not available for the Indian market. Therefore, the syndicate provided incentives and support to collect and produce seed within the Indian side. The seed collectors on the Indian side of the border, with the availability of induced breeding in the later part of eighties, started establishing hatcheries to supply seed to the syndicate. The complementary development of seed production centres and seed market made West Bengal the dominant player in fish seed production and trade, as in 1985-86 around 80% of the seed demand in India was met by West Bengal. States like Andhra Pradesh, Assam, Rajasthan, and Uttar Pradesh have emerged as major seed producing states only since last decades. The fish seed markets in these states are not developed at the dimension of that of West Bengal. The large quantities of the seed in these states are still sold directly by the hatchery operators to the farmers or users to meet local demands.

Networks of fish seed vendors act as last mile connectivity to fish farmers across the country for fish seed. They provide seed at the door step of farmers by collecting seeds from markets or hatcheries. These vendors are connected with one of the seed production cluster in the country. For a small and marginal farmers, vendors are only source of seed in the seed stocking season (i.e. May-September).

In the areas where one or few isolated hatcheries operates, farmers directly buy seed (fry or fingerlings) from the hatcheries to meet their demand. In general, reach of such hatcheries through direct sale in limited to 200-500 farmers.

Market and marketing of fish seed

Hatchery operations in India are mostly carried out to sell spawn to seed growers or transport spawn to longer distances. Only a small proportion of the spawn are reared by hatcheries operators due to lack of sufficient rearing pond available at their disposal. A small scale hatchery produce about 2 million spawn in one cycle (one cycle can be taken at an interval of 1- 3 days as per the availability number of hatching pools. In case of one breeding pool and 3 hatching pools hatcheries can be technically operated every day) which require about 1 ha of the pond area. It require one month to grow fry (including pond preparation and growing period) and in a breeding season one pond can be used about 4 times. Hence, a small scale hatchery with 5 ha

of the pond need to operate the hatchery only for 20 times but, it can operate about 90-120 cycle in a year if available rearing pond area is about 20-30 ha. Most of the hatcheries infrastructures remain underutilised due to lack of such rearing ponds. Hatcheries devise means like contractual arrangements for buy-back of fry from seed growers, annual contract to supply spawn in fixed quantities, shared seed rearing by bearing a part of the cost of production, creation of the nursery networks etc to develop arrangements to dispose spawn in large quantities. One of the prime objective of the hatcheries to sale as much spawn as possible within a short available breeding period of the year. Moreover, the hatcheries could be prepared and initiated into operation within a short time of 2-3 days and can deliver spawn to the buyer within 4-5 days of demand. Therefore, most of the hatcheries operate on-demand basis i.e. the spawn is produced on demand from the seed rearing farms. In an area where seed rearing ponds systems are not well developed and networked, productivity of hatchery operators reduces considerably.

Seed growers access spawn through 3 market channels, (1) The spawn bought by seed rearing groups either directly from the seed markets like Naihati or Ramsagar, (2) Vendors or suppliers buy from the seed market and deliver to the seed grower which involves long-distance transport by rail, air and road, and (3) direct purchase of the seed grower from hatcheries. Channel 1 & 2 is the dominant form of marketing system for hatcheries operators of West Bengal. Spawns are produced by specialised hatcheries in large quantities and large numbers of vendors engaged in long route transportation across the country. In channel 1 & 2 there are very limited interaction between hatcheries and seed grower. However, most of the states in India don't have organised market and hatcheries operators are directly connected with the seed grower in a quasi-market relationship as in channel 3. It is a relationship that is mixed of market exchange and long term clientele relationships. The prices are directly negotiated between seed growers and hatchery operators. This channel offers a lot of flexibility in gauging market demands and fulfilling the need of the market. This channel also offers flexibility in price and quantities as both parties negotiate as per requirements without much pressure of competitions.

The buyers of spawn are either a seed grower or fish farmers, buyer of fry or fingerlings are grow out fish farmers. Fish farmers choose to buy from market, vendors or hatchery operators which seems free and competitive. In a macro perspective, market system for fish seed seems competitive as large number of buyers and sellers simultaneously operated in market across country. But, the micro structure is not as free as it seems. The organised markets like Naihati, Bankura, Neelbagan, Rangia etc are controlled by trade associations. There are restrictions to entry to non-members to trade in these markets. The market practices, price fixing etc are being controlled by group of traders. At the decentralised level, one or few hatcheries operate in geographical locations. Hence, the market structure is either monopoly or oligopoly. Farmers are closely attached to one or few seed growers within a geographical domain. Hence, the fish seed market are not open and competitive. Excessive dependent on the farmers to one or few hatchery operators leads to price disadvantage to the farmers.

Fish seed trade

The fish seed is a nationally traded commodity in the form of spawn, fry and fingerlings. Spawns can be transported long distances with limited cost and hence, are transferred across the country in large quantities. The fry is also transported within short distances but in small numbers but the fingerlings are transported within the localities.

The major interstate trade for spawn is between state of West Bengal and RoI (Rest of India). In the state of West Bengal, out of total spawn production of 12,000 crores around 6000 crores are traded outside the state and reaching out to almost all parts of the country. The spawn is primarily transported by road through smaller vehicles within about 8-10 hours. Train is used to transport to nearby states within 15-18 hours from West Bengal. The air transport is used for transporting the high value fishes like catfish (Pangasius, pabda, magur, tilapia, ornamental fish, singhi, koi, etc) or ornamental fishes for smaller quantities.

The state of Assam is the next most important hatcheries cluster in the country. There are around 500 number of hatcheries in the state and supply seed to the most of the north-eastern part of the country. Each year, around 2000 crores of spawn are produced and additional 1000 crores are brought from West Bengal.

Similarly, there is significant amount of the regional trade. The spawns are supplied by Uttar Pradesh hatcheries to Rajasthan, Punjab, and Haryana. The spawn produced in Chhattisgarh are sent to Madhya Pradesh, Maharashtra and Odisha. The spawn and fry of Andhra Pradesh are flown to Karnataka, Tamilnadu, Kerala.

The summary of the trade is given in Table 3. Around 56% of the total spawn requirements of the all the states as given in the Table 3 are being imported from West Bengal. The dependence on the spawn from outside states varied from about 98.6% to 17%. Table shows dependence of the important aquaculture states on West Bengal to meet the demand of the spawn requirements.

Similarly, fry are also traded across the country to meet local demands. Every year around 1300 crores of fry are traded from one state to other state. West Bengal sent fry across the country while Assam sent fry to other north-eastern states. The state of Andhra Pradesh, Bihar, Gujarat, Kerala, Odisha, Punjab, and Gujarat also receive fry from other states. There are to and fro movement of fry across the state as estimated in Table 4.

Seasonality

Seasonal distribution of spawn production is presented in Table 5 which depicts the spawn production level of West Bengal and Rest of India by month-wise distribution. Out of estimated 20,000 crores of spawn around 12,000 crores are produced by West Bengal while Rest of India produces around 8,000 crores. All of these spawn produced are concentrated in April to

Table 3 The spawn supply by West Bengal to other states estimated for the year 2017-18

States	Imported spawn (Cr)	Share (%)	Total spawn requirements (Cr)	Share of requirements
Andhra Pradesh	655.4	9.3	3705.4	17.7
Assam	1152.0	16.3	3200.0	36.0
Jharkhand	4078.0	57.8	4134.0	98.6
Karnataka	59.2	0.8	99.2	59.7
Madhya Pradesh	286.9	4.1	446.9	64.2
Maharasthra	190.0	2.7	250.0	76.0
Punjab	71.2	1.0	111.2	64.0
Rajasthan	386.1	5.5	426.1	90.6
Tamilnadu	177.9	2.5	222.9	79.8
Total	7056.7	100.0	12595.7	56.0

Table 4 Interstate trade of fish fry in 2017-18

Interstate import		Interstate export	
States/UTs	Fry (cr)	States/UTs	Fry (cr)
Andhra Pradesh (Including Telengana)	554.3	Assam	412.5
Bihar	212.0	Jharkhand	287.7
Gujarat	36.0	West Bengal	585.1
Haryana	15.5	Total	1350.6
Karnataka	67.4		
Kerala	100.2		
Maharashtra	66.3		
Orissa	69.4		
Punjab	49.4		
Tamil Nadu	38.5		
Uttar Pradesh (Including Uttarakhand)	111.6		
Total	1320.8		

Table 5 Seasonal distribution of spawn production of carps (000 crores) in 2017-18

Months	West Bengal	Rest of India	Total	Cumulative (West Bengal in %)	Cumulative (Rest of India in %)	Cumulative (All India in %)
March	1	0.5	1.5	8.3	6.3	7.5
April	4	0.5	4.5	41.7	12.5	30.0
May	4	1.5	5.5	75.0	31.3	57.5
June	2	3.5	5.5	91.7	75.0	85.0
July	0.5	1.5	2.0	95.8	93.8	95.0
August	0.5	0.5	1.0	100.0	100.0	100.0
Total	12	8	20.0			

July months but provide major source for seed availability throughout the years.

As has been given in the Fig 2, the spawn production is concentred and depended on trade within short span of time for supplying seed throughout the year. Any disruption in the seed movement during this period affected overall availability across the country. As a case of such disruption in 2020 covid-19 lock down period March-May, 2020. Due to lack of movement seed in air, train and road, hatcheries in the West Bengal did not produce sufficient quantity of seed. The farmers across the country faced shortage of seed as vendors and traders were not able to supply seed to many parts of the country.

Cluster and Decentralized development

Since last four decades, aquaculture development progressed in every part of the country. National as well as state governments encourage farmers to grow fish in the available water bodies as well as land based activities though creation of ponds, tanks, water harvesting structures, farm ponds etc. Therefore, the demand for the fish seed is highly decentralised. On the other hand, the seed production system are developed in clusters and hatcheries are placed within a specified geographical area or cluster to take advantage of market and economics of scale. Within the specific clusters, it is easier to exchange knowledge, train and hire manpower, and transport products etc. Hence, seed production is being developed as successful business enterprises within specified clusters in the country. Some of the examples of such clusters are Ramsagar, Naihati in West Bengal, Khordha in Odisha, Rangia and Nilbagan in Assam etc.

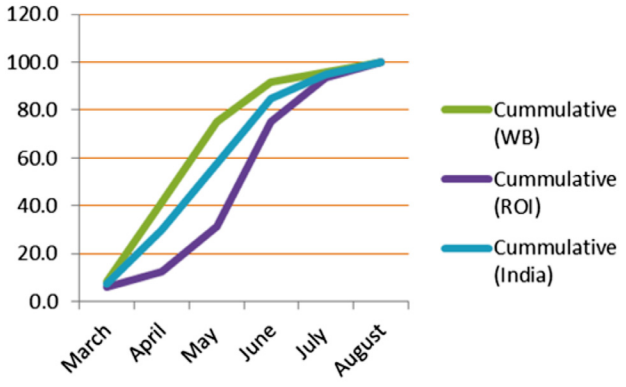

Figure 2 Cumulative distribution of spawn production

Long distance transport of seeds from the cluster add to the cost of seed to the farmers. There is a trade-off between cost of transportation and economics of scale for seed production in the clusters. Farmers prefer to reduce cost of transportation and opt for seed from nearby areas leading to more and more hatcheries development in a decentralised manner. The centralisation and decentralisation seed production system operate as a trade-off and determined through economic forces of cost and prices. With the present level of centralisation, it is disadvantage for the farmers to obtain seed from long distances since high cost due to mortality, transportation and quality reduction is borne by them.

Transaction cost in marketing

Fish seed is not a uniform commodity. It composed of seed of wide range of species, size and quality. Farmers demand and hence price of seed is specific to species, size and quality in the market. Quality of the seed is dependent on many factors like source of broodstock, feeding, genetic quality, breeding practices and nursing care etc. The buyer of the seed need to invest on time and energy in gathering information in availability,

quality of the seed, price etc. Actual quality is difficult to ascertain from appearance. Since seeds are available within a short season, buyers need to take a quick decision on the quantity and quality of seed. Actual quality of seed can only be realised after substantial period of growing in farmers pond. Therefore, it is costly in identifying, measuring and enforcing contract in market transactions. High transaction cost is a major bottleneck is creation of competitive market for fish seed in India.

Vulnerabilities

The seed production system is vulnerable to fluctuation, shock and collapse. Some of the weaknesses and vulnerabilities are presented as below.

Seasonality of production

The technological progress so far have been successful in producing seed during monsoon season. With the efforts of farmers and scientists, breeding window has been widened for a period of March to September for carps. Beyond this period, the spawn production is not possible. Hence, there are scarcity of seed during most part of the year. Since aquaculture activities are carried out throughout year seed is demanded in whole year. But, seed is not available in the lean season, aquaculture operations need to make adjustments or ponds remains fallow during this period. The glut season followed by lean season makes facilities and large number of trained manpower unemployed. Seasonal availability of seed is a major vulnerability of the sector and challenge to increase productivity to meet rising demand for aquaculture products. The efforts to make seed available throughout the year is a way out to reduce this vulnerability.

Centralised production

The national demand for the fish seed is primarily met from the selected fish seed cluster in the country. These clusters dominate the market by transporting seed all across the country. There are losses of seed through mortalities and diseases during transportations leading to increase in the cost of seed. The solution to these problems lies in decentralised development of hatcheries across country. Typically, in a district with around 2500-3000 ha of aquaculture ponds, around 4-5 hatcheries would be able to supply adequate quantities of seed to the district. It would reduce the cost and loss of seed to the advantages of fish farmers.

Monopolistic market structure

Fish seed market is seller market and market is controlled by trader group or group of hatcheries or individual hatcheries as per market structure. Monopolistic competition is a predominantly occur when only few hatcheries operate within a specific geographical area. The terms of trade in fish seed is asymmetrically favoured the hatchery operators. This an inefficient system of market governance leading to poor market performance especially in delivering seed to farmers best quality at lower possible price is a major vulnerability of the seed production system in India.

Non-standardised weights and measurements

The seeds are being sold from one-day old hatchlings to yearlings. Size of fish seed varies with species, days of culture and condition of culture. The seeds are measured initially in volume (litres/ml), then weight (kg) and then count (number). The measures are not standardised. The cups (or *bati*) used in spawn trade vary from place to place. Due to non-standardization, farmers end up paying different prices for same commodities. It also hinders fair market integration across the country.

Price fluctuations

Seasonal price fluctuation is very high in fish seed. Price is dependent upon date of arrival, species, size and location. The price of carps spawn is as high as Rs 1800 per *bati* (25000 number) in March to about Rs 200 per *bati* in July-August every year. Similarly, the price of spawn is as high as Rs 800 per *bati* for catla to about Rs 200 per *bati* for rohu on the same day. These fluctuation is due to high degree of demand for early bred seed compared to late. Similarly, some of species preferred higher than other species.

Climate shocks

Climatic conditions determine success and failure of breeding operations. Most of the carps breed within a specific temperature range of 18-36^{o}C with matured condition of fish. In many years, there are climatic shocks especially with prevailing high temperature when fish is in mature condition. Under such conditions, there are often breeding failures. Similarly, low temperature affects maturity of brood fish and

breeding performance. The fish seed production is vulnerable to prevailing high or very low temperatures.

Case of Disruption due to covid19 during 2020

There was a complete shutdown on the market and marketing of the spawn of West Bengal as traders were not able to operate during March-May of 2020. There was disruption in the road, rail an air connectivity. There was no scope for the interstate trade of spawn in the month of March, April and May as expected in normal year. Due to uncertainties of the market and transportation and non-availability of the labour, the largest hatcheries operators of west Bengal were not able to start the operations and resume spawn production.

As described previously, 70% of the spawn are produced by end of May and most of these spawns are transported to other states. The disruption reduced spawn in the country by about 30% due to lock down. Similar disruption has been affected across the state and net production loss of spawn till end of May was around 50%. A restricted breeding window for West Bengal and Assam at the end of May and hence recovery was very limited in West Bengal. The other states like Bihar, Uttar Pradesh, Odisha, Andhra Pradesh, and Chhattisgarh were partially affected. States other than West Bengal were not able to fully recover as hatchery capacity was limited and could not fully match loss of seed otherwise sourced from West Bengal.

Policy options and way forwards

Looking at the strength, weaknesses and vulnerabilities of the seed production system, following policy options and way forward is proposed.

- **Creation of competitive markets:** Creation of competitive market require increase in number of players in the market. When large number of buyers and sellers participate in the market, performance of market in delivery of fish seed shall improve. Competitive market requires increase in the suppliers of fish seed by establishment of more number of fish seed producers across country.
- **Participatory governance:** Till now, governance of market is dominated by the sellers. The trader association, group of hatchery operators determine the price and quality of fish seed. This asymmetric control can be improved upon by engaging fish farmers and consumers of fish seed in the governance. The market committee formed should be equally participated by sellers and buyers of seed. New measures for market reforms need to be carried out.
- **Year-round breeding**: Technology need be developed and applied to achieve year-round seed production especially of carps. Some the early trends in application of broodstock diet, environmental control. RAS etc has given encouraging results. Applications of such technologies are imperative to achieve all season availability of seed.
- **Standardisation of measures and weights**: Government needs to undertake measures to standardise system of measures of fish seed. The cups, weights etc used for measuring seed need to be standardised so that market development can takes place.
- **Regulation of market practices**: At present, the fish seed market is beyond ambit of government regulations. Appropriate regulations on the practices, qualities, price etc will help in improving performance of market system.
- **Decentralised development:** Decentralised development of fish seed production is key to holistic development of fish seed scenario in India. Excessive dependent on few clusters for seed is reducing efficiency in market performance. It is both costly and resulting low quality of seed due to long distance travel of fish seed. Establishment of large number of hatcheries across the country will reduce pressure on few cluster and improve market performance.
- **Seed certification:** Seed certification as per the guidelines developed by Government of India in 2010 (DAHD&F, 2010) is a key policy option to ensure production of quality seed in India. Measures needs to be taken at the state government level to fully implement the policy.

Conclusions

Performance of the fish seed sector can be measured in terms of effectiveness and efficiency in delivering best quality of seed at lower price across the country.

The performance is dependent upon techno-social structure of production and marketing. Technology determines efficiency of production, but effective delivery of fish seed at reasonable price is determined by market and quasi-market structure. The operation of market is dependent on the governance structure of market. It has been seen that the micro structure of the fish seed is not perfectly competitive. Traders association, group of hatchery operators, individual hatcheries within geographical regions are three main types of governance mechanisms of fish seed market in India. These lead to higher price of fish seed, high degree of price fluctuations and net loss to the fish farmers across the countries. Typical market structure creates vulnerability of fish seed supply system for very high fluctuations of price, delivery of bad quality seed at higher prices, seasonal glut and scarcity, climatic shock etc. There is need for change in the governance structure and socio-economic conditions under which fish seed marketing system operates to make it less vulnerable. Some of the measures for developing robust marketing system are decentralised development, creation of regulatory framework, seed certification, participatory market governance, etc.

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