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Dissemination and scaling strategy for genetically improved farmed tilapia (GIFT) in India, 2020–2030



In partnership with



Dissemination and scaling strategy for genetically improved farmed tilapia (GIFT) in India, 2020–2030

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List of abbreviations

BDW	business development wing
BMP	better management practice
CAGR	compound annual growth rate
CGIAR	Consultative Group on International Agriculture Research
DOF	Department of Fisheries
F&ARD	Fisheries and Animal Resources Development
GIFT	genetically improved farmed tilapia
GOI	Government of India
GDP	gross domestic product
HORECA	hotel, restaurant and catering
ICAR	Indian Council of Agricultural Research
ITS	International Tilapia Summit 2014
MPEDA	Marine Products Export Development Authority
NCIEAS	National Committee on Introduction of Exotic Aquatic Species
NFHS	National Family Health Survey
PMMSY	Pradhan Mantri Matsya Sampada Yojana
PPP	public-private partnership
RGCA	Rajiv Gandhi Centre for Aquaculture
RKVY	Rashtriya Krishi Vikas Yojana

Summary

Indian demography, economy, fish production and consumption pattern

India is the second-most populous country in the world, after China, with a population of 1.35 billion people, and it is the fifth-largest economy, with a gross domestic product (GDP) of USD 3 trillion. India is the third-largest fish producer in the world with 13.75 million metric tons of fish production in 2019–2020. Statistics from the National Family Health Survey (NFHS-4) indicate that 69% of Indians consume fish. The average weekly household expenditure on non-vegetarian foods (fish, eggs and meat) is about INR 384 (USD 5.50). The World Economic Forum projects that continued GDP growth of about 7.5% will transform India from a bottom-of-the-pyramid economy to a middle-class-led economy. Such growth will increase consumer spending from USD 1.5 trillion today to nearly USD 6 trillion by 2030. It is projected that nearly 25 million households will exit poverty by 2030, reducing the share of households living below the poverty line to only 5%. Increased per capita income, especially in India's eastern and central states, would increase spending on non-vegetarian foods and raise the frequency of fish consumption. As per the estimates of India's Ministry of Fisheries, Animal Husbandry and Dairying, the demand for fish is expected to reach 22 million metric tons by 2024–2025. Inland aquaculture is expected to play a major role in fish production and supply to both domestic and export markets. For the past few decades, Indian major carps have been the main farmed species in the inland sector, though minor carps, pangasius and other catfish have also contributed significantly to Indian farmed fish production. However, the government is keen to diversify farmed species for increased farm productivity, profitability, farmer resilience and affordability for consumers. Tilapia farming can play an important role in enhancing the availability and affordability of fresh fish by increasing consumption and boosting nutrition outcomes, including for the most vulnerable communities.

Government programs, fish production target, and policy change

The Pradhan Mantri Matsya Sampada Yojana (PMMSY) national plan, which is designed to induce a "blue revolution" in India, has set a national target of 22 million metric tons of fish production by 2024–2025. To reach this target from a baseline production of 13.75 million metric tons in 2019–2020 will require an average annual growth rate of about 8.2%. However, the compound annual growth rate (CAGR) of fish production from 2010–2011 to 2019–2020 was just 6.20%. As a result, the government has put additional efforts through PMMSY to achieve a higher growth rate in the sector. The PMMSY program aims to increase aquaculture farm productivity from 3 t/ha to 5 t/ha through sustainable crop intensification. To achieve this goal, the Department of Fisheries (DOF), within the Ministry of Fisheries, Animal Husbandry and Dairying, anticipates 1 million metric tons of tilapia production with a 5-year CAGR of 68% and a production share of 4.5% by 2024–2025. To reach this target, the ministry instituted suitable amendments to the national policy guidelines on responsible tilapia farming in March 2020. Specifically, the ministry made two major policy changes to encourage tilapia production: (1) a decrease in the minimum size of the tank/pond area required for tilapia farming from 1 acre to 0.05 acres and (2) decentralization of the tilapia hatchery licensing process from the central government to state governments to empower state DOFs to handle licensing.

Resources for achieving the tilapia production target by 2024–2025

India has both the fisheries resources and the capacity to produce 1 million metric tons of tilapia by 2024–2025. This strategy document provides a pathway for tilapia farming within a broad spectrum of systems to achieve this target. Based on a demand and supply analysis, producing 1 million metric tons of tilapia by 2024–2025 requires 33,460 ha under commercial tanks (productivity per tank = 15 t/ha per year) and 20,080 ha under backyard tanks (productivity per tank = 15 t/ha per year). In addition, 100,400 biofloc tanks (diameter = 4 m, water holding capacity = 10,000 L, productivity = 1 t/tank per year) and 20,000 rectangular cages of 96 m³ in reservoirs (productivity = 5 t/cage per year) are also required. Achieving this target will substantially increase productivity. As a result, it will also raise farm income, improve nutrition

through consumption of diversified diets and generate employment through strengthened value chains. This investment will be private sector driven, and the Government of India (GOI) and state governments will play a crucial role in creating an enabling environment for investment. India currently has vast freshwater aquaculture resources, including 2.48 million ha of ponds and tanks, 230,000 ha of derelict water bodies, 3.53 million ha of reservoirs and 550,000 ha of floodplain wetlands (beels, oxbow lakes, jheels, mauns, pats, etc.) spread across the country's numerous river basins, which can readily help in achieving the production target.¹ Currently, tilapia production is 74,000 t from both farms (30,000 t) and wild sources, such as rivers, reservoirs and lakes (44,000 t). However, if tilapia has to be produced through cage culture in reservoirs, GOI guidelines must be followed properly.

Tilapia hatcheries and seed requirements by 2024–2025

In 2017–2018, India produced 52 billion fish fry (mostly Indian major carps), supplying 8.9 million metric tons of freshwater fish. Producing 1 million metric tons of tilapia (average size = 500 g) by 2024–2025 will require 4.18 billion monosex tilapia grower fry. This is achievable based on an annual production capacity from a proposed combination of 991 hatcheries: 841 small hatcheries (2 million monosex fry), 125 medium hatcheries (10 million monosex fry) and 25 large hatcheries (50 million monosex fry). Producing this amount of monosex fry from these hatcheries will require 9.18 million mixed-sex tilapia breeder fry from multiplication centers. Currently, there are about 11 authorized and 25 unauthorized tilapia hatcheries/seed centers in India with an annual production of about 94 million fry in 2019–2020.

Proposed focus states for tilapia production and consumption

Statistics on household income and fish consumption patterns show that promoting tilapia farming and consumption in the eastern and central states of Bihar, Jharkhand, Odisha, Uttar Pradesh, Chhattisgarh, Madhya Pradesh and West Bengal is essential to reaching the target of 1 million metric tons by 2024–2025. The tilapia production estimates are based on the proportion of the total fish production basket, including both domestic and export markets, though it is not known how much of the 1 million metric tons is for exports. These states are home to 640 million people (47% of the population), with 30% living below the poverty line (USD 1.90 per day). Interestingly, more than 90% of the population in the eastern states and more than 60% of people in the central states consume fish, especially freshwater fish, with a paltry weekly budget for non-vegetarian food no higher than INR 374 per household. Although the focus is on the eastern and central states, tilapia promotion in the southern and western states—which are characterized by lower poverty rates, higher purchasing power for food and preferences toward marine fish—are equally important for achieving impacts at scale with genetically improved farmed tilapia (GIFT). It is important for increasing consumer acceptance and market penetration of GIFT through improved dissemination and promotion approaches in Kerala, Tamil Nadu and Maharashtra, where tilapia already enjoys considerably high demand.

Positioning of GIFT in India's tilapia growth story

Developed by WorldFish through selective breeding, GIFT is a fast-growing, hardy and resilient strain of Nile tilapia (*Oreochromis niloticus*) (Pant et al. 2019). India already has a state-of-the-art GIFT breeding nucleus at the Rajiv Gandhi Centre for Aquaculture (RGCA), which is a registered society under the Marine Products Export Development Authority (MPEDA) of the GOI's Ministry of Commerce and Industry. The breeding nucleus was established in 2011 with support from WorldFish, and the RGCA has maintained genetic quality by following a pedigree-based breeding program. GIFT has been shown to perform better on-farm compared with non-GIFT strains in both monoculture and polyculture systems in Bangladesh (Tran et al. 2021), generating greater gains in productivity and profitability. Its adoption and scaling in India could therefore contribute substantially toward sustainable aquaculture growth. Combined with recent policy changes, the vision of the GOI offers an opportunity for scaling GIFT in India. WorldFish has targeted at least a 50% market share for GIFT in India to ensure timely, inclusive and sustainable access for farmers to a resilient, faster-growing and high-yielding fish breed. This in turn will increase incomes, improve food and nutrition security, and reduce poverty. Leveraging strong and strategic partnerships with, among others, the RGCA and the Fisheries and Animal Resources Development (F&ARD) department of the Government

of Odisha, WorldFish has continued to promote widescale adoption of GIFT. Under the Odisha State plan, 136 GIFT demonstration farms have been established since 2017, and there are ongoing efforts to establish new ones on 111 acres. At the same time, there are increased investments to encourage private sector entrepreneurs to establish tilapia hatcheries so that farmers have availability and easy access to GIFT. WorldFish will leverage its existing partnership with the Government of Odisha while creating and strengthening collaboration with other state governments and the private sector in the eastern and central states of Bihar, Jharkhand, Uttar Pradesh, Chhattisgarh, Madhya Pradesh and West Bengal. These efforts will not only ensure sustainable business models for GIFT seed production and dissemination but will also increase demand for tilapia. During 2019–2020, India produced about 10 million GIFT monosex fry and 2000 t of plate-size tilapia out of about 30,000 t of total farmed tilapia production in the country.

Action plan for GIFT promotion

A strategy for GIFT dissemination and scaling in India is imperative to ensuring that the positive changes in policy and the increased efforts and investments in the tilapia industry succeed to scale impacts of GIFT adoption. Therefore, India's GIFT strategy aims at ensuring increased productivity, incomes, food and nutrition security, and reduced poverty through effective dissemination and scaling of GIFT within a sustainable business model. To achieve this aim, the strategy describes the dissemination model with annual milestones and an action plan from March 2020 to March 2030. The strategy further details plans for quality control, demand creation, and monitoring, evaluation and learning. Fundamental to this strategy is to encourage private sector investment and to strengthen public-private partnerships (PPPs). We recognize that successful scaling implies market acceptance. It also requires an enabling environment in the form of favorable policies, access to financing and aquaculture advisory services, links to input and output markets, and quality assurance. The strategy proposes the formation of a business development wing (BDW) or an India innovation hub. The BDW will be jointly supported by the MPEDA-RGCA and WorldFish to meet the commissioner-cum-secretaries of fisheries departments in focal states and convince them to invest in GIFT hatcheries under the freshwater finfish hatchery plan. In addition, the BDW will promote a GIFT farm demonstration program with input support to freshwater aquaculture farms either through state plans or through central government plans, such as PMMSY and Rashtriya Krishi Vikas Yojana (RKVY), as well as through private sector players, like feed companies and hatcheries.



GIFT fingerlings for stocking in a grow-out tank in Khorda District, Odisha, India.

1. Background

Tilapia ranks third in fish production globally, after Chinese carps and Indian major carps (FAO 2020a). Global tilapia production increased from 3.49 million metric tons in 2010 to 6.03 million metric tons in 2018 (FAO 2020a), and the corresponding increase in the share of tilapia in the global fish supply was 8.29% in 2010 to 10.20% in 2018 (FAO 2020a). The increase in tilapia production is significant given that the species supplied only about 379,000 t in 1990 (FAO FishStatJ). The multifold increment in farmed tilapia production over the past three decades is mainly attributed to technological innovations, such as the successful development and dissemination of genetically improved strains since the 1980s, monosex seed production technology since the 2000s and improved farming practices. Changes in consumer preferences toward boneless tilapia fillets and other easy to cook and ready to eat products have also contributed to the rapid growth of tilapia aquaculture. In addition, the affordability of tilapia has stimulated demand from all consumer segments, especially among low-income consumers in developing countries in Asia and Africa.

Genetic improvement through selective breeding has been used for millennia on crops and livestock, but up until the 1980s little had been done to use this process for farmed fish (Gjedrem et al. 2012). In response to the inadequate supply of tilapia seed and the deteriorating performance of the fish in many aquaculture systems in Asia, WorldFish and partners began the GIFT project to develop a faster-growing strain of Nile tilapia that was suitable for both small-scale and commercial aquaculture. Nile tilapia was selected due to its popularity in aquaculture, short generation time of approximately 6 months, naturally high tolerance to variable water quality and diseases, and ability to grow in diverse farming systems. In the 1990s, WorldFish and partners distributed the GIFT strain to the Philippines, Bangladesh, China, Thailand and Vietnam as part of the dissemination plans for an Asian Development Bank project. In 2001, the GIFT strain was transferred from the Philippines to WorldFish headquarters in Malaysia, and WorldFish continues to improve GIFT through

selective breeding at a research station provided by the Malaysian Department of Fisheries in Jitra. The improved strain was made available to research organizations and national governments for continued work on selective breeding and distribution to farmers. WorldFish estimates show that more than 50% of the global tilapia production is from GIFT and GIFT-derived strains.

In India, tilapia is an exotic species. Tilapia (*O. mossambicus*) was first introduced in the country in 1952. However, culturing the species was banned in 1959 because of perceived ecological imbalance resulting from tilapia escaping into natural water bodies. In the 1970s, Nile tilapia was introduced. Then during 1998–2000, the Indian Council of Agricultural Research (ICAR) and the Central Institute of Freshwater Aquaculture jointly imported the GIFT strain from WorldFish and carried out farm trials. Based on the results, commercial introduction of GIFT was then recommended to the GOI.

In 2009, the GOI formulated guidelines for responsible farming of tilapia through the National Committee on Introduction of Exotic Aquatic Species (NCIEAS) in Indian waters. Various state governments were mandated to conduct monitoring, controlling and surveillance of hatchery, nursery and farming facilities. Biosecurity and licensing are the key aspects in the guidelines issued by the GOI's Ministry of Fisheries, Animal Husbandry and Dairying, and it is mandatory for the state governments to issue licenses and register farms. The guidelines for hatchery operations and farming of tilapia are developed by a sub-committee under the NCIEAS. Before a recent policy change, the guidelines only permitted monoculture of monosex tilapia in ponds of 1 acre or more. Under the guidelines, three private hatcheries/companies and the RGCA were initially allowed to import commercially viable tilapia strains from abroad and set up multiplication centers and hatcheries in the country. In 2019–20, about 11 licensed and more than 25 unauthorized tilapia hatcheries produced about 94 million fry. GIFT, Chitralada and Golden are the major strains produced by licensed hatcheries in India.

In 2010, the MPEDA-RGCA approached WorldFish for technical collaboration on GIFT dissemination in India. This culminated in a memorandum of understanding between the two organizations in 2011. During Phase I (2011–2016) of the collaboration, a fully pedigreed genetic improvement program for GIFT was established in India after the transfer of 100 families from Jitra in two batches (August 2011 and March 2016). The program successfully achieved six generations of selection at the MPEDA-RGCA research station in Vijayawada, Andhra Pradesh, resulting in an average genetic improvement for weight at harvest of over 8% per generation. The program has successfully maintained an accumulated rate of inbreeding and effective population size to acceptable levels. The MPEDA-RGCA has also conducted GIFT farm demonstrations in several states for popularizing GIFT among farmers and local markets. Phase II (2019–2023) of WorldFish's collaboration with the MPEDA-RGCA is ongoing. Details are explained in sections 4 and 5.1.1.

The introductory phase of tilapia commercialization in India experienced a significant but sluggish growth in production. A survey conducted by WorldFish in 2016 showed that total tilapia production in the country was about 40,000 t. Of this amount, only 15,000 t was from aquaculture, while the remaining 25,000 t came from natural water bodies. Data from UN Comtrade showed that India exported 2666 t (USD 3.27 million) of tilapia products in 2018, representing 7% of the country's tilapia production and accounting for 0.22% of the world market value (UN Comtrade Database 2020; FAO 2020b). Most of India's total tilapia export value (83.78%) in 2018 went to Asia while the remainder was sold in Africa (13.51%) and Europe (2.51%) (UN Comtrade Database 2020; FAO 2020b). The remaining quantity was used for human consumption (80%) and other purposes, such as poultry and aquafeed (13%).

WorldFish has signed a technical collaboration agreement with F&ARD of the Government of Odisha (July 2016 to March 2022). It has also signed a collaboration agreement with the Assam Agribusiness and Rural Transformation Project, which is funded by the World Bank and implemented under the Assam Rural Infrastructure and Agricultural Services Society of the Government of Assam (August 2018–July 2023) for development of the inland fisheries sector.

The Government of Odisha started GIFT farm demonstrations and local market promotions under a state plan titled, "Implementation of Fishery Policy: Development of Inland Fisheries during 2017–2018 and 2018–2019." In total, 800,000 GIFT monosex fry were procured from the MPEDA-RGCA GIFT breeding center in Vijayawada and distributed to 136 farmers in 17 districts in Odisha. District fisheries officers issued tilapia farm licenses to the demonstration farmers as per the GOI guidelines for responsible tilapia farming. During 2017–2018, 200,000 fry were stocked in tanks covering 33 acres in total and belonging to 36 farmers in 9 districts. During 2018–2019, 600,000 fry were stocked in tanks covering 100 acres in total and belonging to 100 farmers in 17 districts. The program was established based on experiences gained from a semi-intensive GIFT farming demonstration conducted by the MPEDA-RGCA in a private farm in Jagasinghpur District of Odisha during 2016–2017. The farm demonstration was successful, with a total production of 49.65 t during 2017–2018 and 151.54 t during 2018–2019. The average farm yield was about 5000 kg/ha per crop. The farmgate price ranged between INR 85/kg and INR 140/kg, with an average of INR 100/kg. The average cost of production including farm inputs, labor and harvest costs was INR 60/kg during 2018–2019. The net profit margin was about INR 72,000/acre per crop.

In 2019–2020, a government GIFT hatchery with an annual capacity of 5 million monosex GIFT fry was established at a state government fish seed farm in the village of Kausalyaganga in Bhubaneswar Block of Odisha's Khordha District. The establishment was jointly funded by the state plan (hatchery infrastructure cost) and the centrally sponsored RKVY plan (operational costs). The hatchery's production and sale of monosex GIFT fry to farmers started in January 2020. The Kausalyaganga GIFT hatchery obtained mixed-sex GIFT breeder seed from the MPEDA-RGCA breeding center in the city of Vijayawada. Elated with the good success in farm demonstrations and good market responses, the Government of Odisha prepared a state plan for establishing four private GIFT hatcheries with an annual production capacity of 2 million monosex fry per hatchery. This plan is being implemented during 2020–2021. The four private GIFT hatcheries are expected to be established in the zones of Balasore, Sambalpur, Koraput/Kalahandi and Ganjam in Odisha for farmers to have easy access to seed.

Andhra Pradesh is a major hub of aquaculture in India. Grow-out farmers in Andhra Pradesh expect markets to immediately absorb huge volumes of production. However, this is not the situation in the introductory phase of tilapia in India, so tilapia has not yet penetrated the market in Andhra Pradesh. In other states, like West Bengal, Maharashtra, Madhya Pradesh, Chhattisgarh, Bihar, Jharkhand and Kerala, where there is a sizable local fish consumption population, tilapia production is increasing steadily. Furthermore, there is a growing trend of using tilapia in backyard biofloc and reservoir cage culture systems. Experiences and lessons from those states and farmers clearly showed several factors have hindered successful promotion of GIFT in India. Such factors include stringent policy guidelines for tilapia farming, unavailability of seed, lack of awareness and knowledge among farmers, and limited access to markets. Consequently, the introductory phase of commercialization of the species extended to more than a decade, restricting farmed tilapia production to less than 50,000 t—far below the country’s potential.

1.1. Present policy environment

Most recently, stakeholders including the MPEDA-RGCA, WorldFish, state governments, private hatchery operators, and farmers have provided positive feedback and justification for scaling tilapia in India to the Ministry of Fisheries, Animal Husbandry and Dairying. This engagement with the national government brought favorable policy changes in 2020. Under the new policy for responsible tilapia farming in India, DOFs at the state level are authorized to provide the required government approvals for establishing tilapia hatcheries directly. In addition, the permitted size of land for tilapia culture was relaxed from 1 acre to 0.05 acres, allowing smaller grow-out tanks to be stocked. These two important changes in the policy will revitalize tilapia seed production and facilitate increased access for farmers to high-quality seed by decentralizing the licensing process for tilapia hatcheries at the state level. In addition, the favorable policy environment will quickly boost grow-out tilapia production by including smaller tanks, which are common in India but inefficient for carp farming.

It is within this renewed and favorable policy environment for tilapia aquaculture in India that WorldFish desires to position GIFT as the most preferred strain for production and consumption

across the country. Increased availability of GIFT seed will contribute toward a sustainable growth in productivity and incomes, improved nutrition and reduced poverty among farmers. Increased tilapia production in India will contribute to improved availability and access to diverse and nutritious diets, which will increase food and nutrition security, especially among the poor and vulnerable populations. In addition, disseminating and scaling GIFT will contribute to the development of the entire tilapia value chain through sustained businesses for different actors along the value chain, which will further create employment and increase incomes. To achieve this aim and these impacts, it is necessary to develop a clear dissemination and scaling strategy as well as an action plan for GIFT in India. With this mind, this document explains various steps to be taken for time-bound and verifiable actions and results.

1.2. Objectives of the dissemination and scaling strategy

The purpose of this dissemination and scaling strategy is to ensure increased productivity, incomes, food and nutrition security and reduced poverty in India through effective, accelerated, sustainable and inclusive dissemination and scaling of GIFT. The intermediate goal is to contribute to the achievement of the national government’s target of 1 million metric tons of tilapia by 2025. In the longer term, the strategy aims to achieve annual tilapia production of 2.4 million metric tons by 2030. As shown in Table 1, reaching this overarching objective will require the following outcomes, outputs and activities.

1.3. Strategy outline

This document outlines the strategy for March 2020 to December 2030. The strategy addresses the following:

- identification of the main beneficiaries and key stakeholders
- description of the dissemination model and approach
- strategic partnerships required
- tilapia health management
- plan for quality control
- marketing and demand creation
- capacity building
- monitoring, evaluation and learning

The strategy was prepared with insights from the Dalberg (2020) report. It also draws from several others sources. These include (a) previous and current memorandums of understanding with the MPEDA-RGCA, (b) the comprehensive tilapia seed systems evaluation research conducted in Bangladesh and Malawi under the Scaling Systems and Partnerships for Accelerated

Adoption of Improved Tilapia Strains project, (c) the dissemination strategy for improved carps in Bangladesh (WorldFish 2020), (d) consultations with colleagues at WorldFish and in-country partners, (e) and experiences from previous and ongoing projects in India. The strategy has been designed to align with One CGIAR's seed systems development strategy initiative.

Outcome	Outputs	Activities
<ul style="list-style-type: none"> Sustainable business models are established for GIFT hatcheries and grow-out producers around the dissemination of GIFT. 	<ul style="list-style-type: none"> Evidence about the benefits of GIFT to hatcheries and grow-out producers is generated. A sustained increase in demand for GIFT is achieved. 	<ul style="list-style-type: none"> Intensify the efforts to promote GIFT in the eastern and central states, which have the largest population of fish consumers and poor people in India. Establish demonstration farms. Conduct an on-farm performance assessment and ex-ante evaluation of impacts. Establish a BDW supported by the MPEDA-RGCA and WorldFish.
<ul style="list-style-type: none"> Partnerships with both the private and public sectors are strengthened to support and maintain the production, multiplication and widescale dissemination of GIFT. 	<ul style="list-style-type: none"> Wider market acceptance of GIFT is achieved. The number of private sector GIFT hatcheries is increased. The number of small and medium enterprises supplying feed and other inputs required for GIFT production increases. Favorable policies are formulated to promote GIFT adoption and scaling. 	<ul style="list-style-type: none"> State-level DOFs form and launch plans in respective states to invite applications from interested private entrepreneurs to establish GIFT hatcheries. Create awareness and multistakeholder platforms for dialogues on GIFT across India especially in the eastern and central states. Hold advocacy and policy dialogue with policymakers in both national and state governments.
<ul style="list-style-type: none"> A hatchery accreditation and seed certification program is established for continuous quality control of GIFT mixed-sex breeder seeds in multiplication centers and monosex grower seeds in hatcheries. 		<ul style="list-style-type: none"> Collaborate with the MPEDA-RGCA and GOI to standardize the seed certification process for GIFT hatcheries that includes the purpose of the certification, the certifying authority or agency, and the eligibility requirements for the certification.

Table 1. Outcomes, outputs and activities required to achieve impacts at scale with GIFT in India.

2. Target beneficiaries

The main target beneficiaries are aquaculture producers, including both men and women and across different age and wealth categories. These producers will have increased availability and access to GIFT seed, which is expected to increase aquaculture productivity and profitability. Increased income is important to ensure effective demand for nutritious diets, which enhances food security and nutrition. Secondary beneficiaries comprise all actors in the tilapia value chain across India, especially in the eastern and central states, including large-scale

producers, hatchery operators, feed dealers and companies, transporters, processors, wholesalers, retailers and consumers. About 60% of all food supply chain activities in India are post-farmgate, involving firms and workers in the midstream wholesale, processing and logistics segments, and downstream in retail and food service (Reardon et al. 2020). Increased adoption of GIFT by grow-out producers is expected to generate spillover impacts to other value chain actors through important backward and forward links.



Photo credit: Anura Padhyar/WorldFish

Mr. Pradosh Kumar Acharya, a pioneer GIFT farmer in Odisha receiving his first batch of GIFT fry from the MPEDA-RGCA GIFT hatchery in Vijayawada under the state government plan.

3. Geographical focus of GIFT dissemination and scaling

The NFHS-4 (2015–2016), conducted by the national Ministry of Health and Family Welfare, showed that 68.8% of the Indian population consumes fish, while about 36.3% does so at least once a week. Statistics from the household consumer expenditure survey conducted in 2011–2012 by the Ministry of Statistics and Program Implementation showed that a typical household spends 47.8% of its income on food, of which 7.3% is spent on non-vegetarian foods (fish, eggs and meat). Figure 1 shows the regions of India where consumption of non-vegetarian foods is common.

This strategy document categorizes the Indian population into five zones: (1) northeastern, (2) eastern, (3) central, (4) southern and western zone (excluding Gujarat), and (5) northern (including Gujarat). Focus for GIFT dissemination and scaling will be placed on the eastern and central Indian states of Bihar, Jharkhand, Odisha, Uttar Pradesh, Chattishgarh, Madhya Pradesh and West Bengal. Fish is an important source of animal protein to the people who live there. More than 90% of people in the eastern states consume fish, and 55% of households eat it at least once a week. The proportion of the food budget spent on non-vegetarian foods by households in the eastern states is 9.6%. Out of an average weekly household food budget of INR 3583, non-vegetarian foods make up only 10% (INR 374) of expenditures (10%). In the central zone, fish is consumed by 61% of the population, but only 21.5% of households eat it at least once a week. Households in the central zone spend about 4% of their food budget on non-vegetarian items. Out of INR 3492 spent on food in a week, household expenditures on non-vegetarian foods are only INR 146. Generally, households in the eastern, central and northeastern zones have favorable preferences for freshwater fish due to their proximity to large riverine basins.²

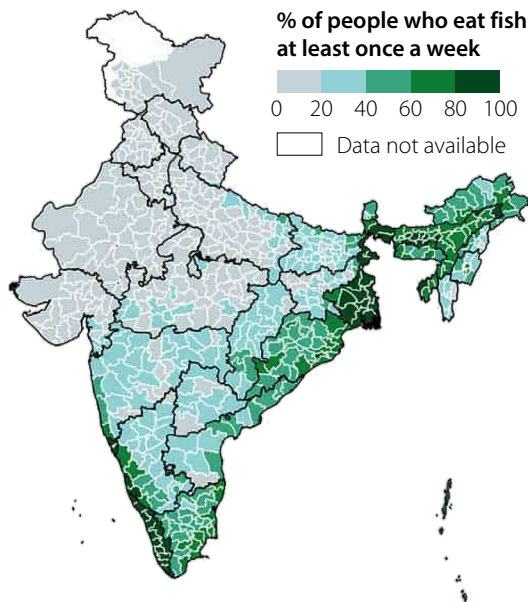
The eastern and central zones are highly populated, accounting for 47% of India's population (640 million people). Although a high proportion of the population in these zones consume fish, 30% live below the poverty line.

Consequently, weekly budgetary allocation on non-vegetarian foods is very low, at less than INR 374 per household. Furthermore, both zones are net importers of fish from neighboring states, especially Andhra Pradesh, which exports about 3 million metric tons of freshwater fish to other parts of India. Thus, availability of fish and its freshness greatly influences consumer choices in non-vegetarian food purchases. Increased availability of affordable and locally produced fresh fish as an alternative to the popular but more expensive carps, which cost INR 150–250/kg at retail, will increase the frequency of consumption of fish and so improve nutrition outcomes. In addition, smaller tilapia could stimulate increased demand among consumers because they may be able to buy entire fish (less than 200–300 g) in smaller quantities (under 1 kg per purchase per household) to meet their budget.

India is one of the world's fastest-growing economies. Current and projected annual GDP growth is 7.5%. World Economic Forum projections indicate that growth in income will transform India from a bottom-of-the-pyramid economy to a middle-class economy by 2030. Consumer spending is expected to grow from USD 1.5 trillion today to nearly USD 6 trillion by 2030. The vision for the future of consumption in India is anchored in the growth of the upper middle income and high income segments, which will grow from being one in four households today to one in two households by 2030. Economic growth in India is expected to lift nearly 25 million households out of poverty, reducing the share of households below the poverty line to 5%. This means that eastern and central Indian states will be among the biggest beneficiaries of India's growth success. Increased per capita income in these states would lead to more spending on non-vegetarian food and more frequent consumption of fish. As a result, promoting localized fish farming, especially tilapia, in these states would quickly help increase consumption.

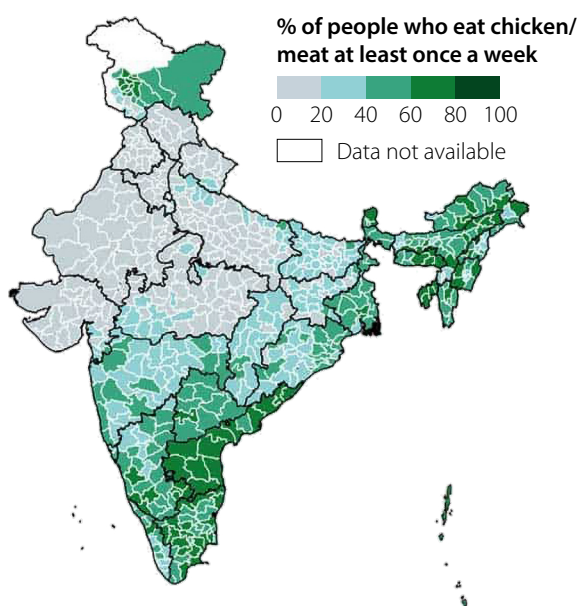
Where do people eat fish the most?

People in Kerala eat the most fish, with 62% of Keralites eating fish on a daily basis. Along with Kerala, Lakshadweep, the Andaman and Nicobar Islands and West Bengal are the highest fish-eating states, where more than 90% of people eat fish at least once a week. This is expected since consumption of fish increases with proximity to India's coastline.



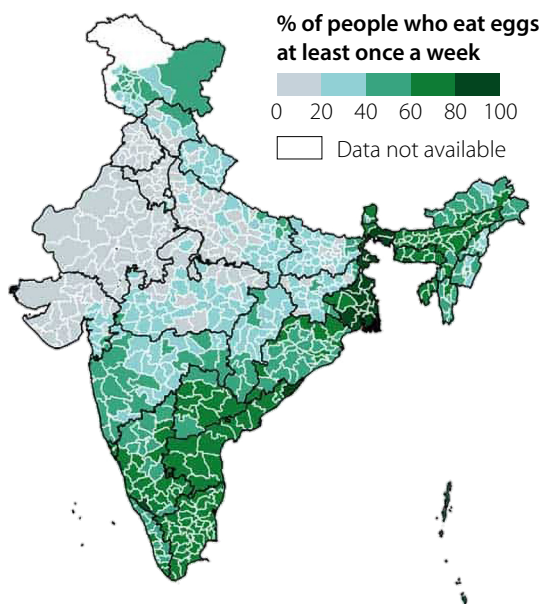
Where people eat chicken and meat

There is a clear regional pattern in chicken and meat eating: In most parts of South and East India, more than half of the population eat chicken or meat at least once a week. But in the Hindi heartland, you would be a minority if you ate these items that frequently. For instance, in Haryana, Rajasthan and Punjab, less than 10% eat chicken/meat at least once a week. In Sikkim, around 70% do.



Where people eat eggs

More than 80% of the population in the Andaman and Nicobar Islands, West Bengal and Puducherry eat eggs at least weekly. In Haryana, Punjab and Rajasthan, less than 15% do. In all states except J&K, Nagaland, Arunachal Pradesh and Sikkim, more people eat eggs compared to chicken/meat.



Source: *The Hindustan Times* 2018.

Figure 1. Non-vegetarianism and fish consumption in India.

4. Dissemination model and approach

4.1. Seed supply

Dissemination of GIFT in India currently follows a pyramid model. In the model, dissemination starts at the MPEDA-RGCA GIFT satellite breeding nucleus. The MPEDA-RGCA is presently the sole source of GIFT breeder seed in India. Its GIFT breeding program is pedigree-based, meaning all fish are tagged and can be traced back to their pedigree. The selection method used is a combined-family selection based on estimated breeding values. WorldFish supplied GIFT germplasm to the MPEDA-RGCA in 2011 and 2016. Considering 2011 as G0, the RGCA had 62 unique families of G7 in 2019. Based on WorldFish's analysis of G7 data, the mating list and mating design for the production of G8 were provided to the MPEDA-RGCA in February 2020. Using the mating list and design, the MPEDA-RGCA will produce G8 families, rear them following its standard operating procedures and collect the relevant data to enable selection of G8 fish for future selection and breeding of G9 in 2021. Improved GIFT broodstock is multiplied at the MPEDA-RGCA and disseminated to other hatcheries as mixed-sex fry. The MPEDA-RGCA also supplies quality monosex GIFT fry to fish farmers holding tilapia farming permits from the

state fisheries departments. These fry are free from tilapia lake virus and are regularly screened and certified by the RGCA's NABL accredited pathology laboratory. From initiation until November 2020, the MPEDA-RGCA distributed about 22,248 mixed-sex broodstock to five public sector and four private sector multiplication centers in India (Table 2). In addition, a total of 30.8 million monosex fry were disseminated to farmers in 18 states (Table 3).

Hatcheries receiving mixed-sex breeder fry of improved broodstock from the MPEDA-RGCA in turn produce monosex grower fry following technical protocols that the MPEDA-RGCA and WorldFish provided in order to ensure that high-quality seed is sold to farmers. These hatcheries are expected to replace the broodstock every 2 years by sourcing them from the MPEDA-RGCA.

From experience both in India and other countries, such as Bangladesh, WorldFish has shown that achieving sustained impacts of GIFT dissemination and scaling requires active participation of the private sector. This strategy, therefore, proposes a private sector-led model of GIFT dissemination and scaling across India combined with strengthened PPPs. The ongoing efforts by state fisheries

Si No	State	Party	Total number	State total	Total consignment
1	Karnataka	University	48	48	1
2	Kerala	Private hatchery	2000	4600	1
3		MPEDA-RGCA-multi-species aquaculture complex	2600		2
4	Maharashtra	Private hatchery	6500	6500	3
5	Odisha	DOF, Odisha	6000	6000	1
6	Rajasthan	National Federation of Fishers Co-Operative Ltd. (FISHCOPFED), under the DOF	2000	2000	1
7	Tamil Nadu	DOF, Tamil Nadu	900	3100	2
8		Private hatchery	2200		2
Total			22,248	22,248	13

Source: MPEDA-RGCA through personal communication with the authors.

Table 2. GIFT mixed-sex brood fry supplied by the MPEDA-RGCA (2012–2020).

S.No	State	Category	Number of seeds	State total	Number of consignments
1	Andhra Pradesh	Andhra Pradesh farmer	992,900	2,001,100	21
2		Andhra Pradesh University	10,200		2
3		DOF Andhra Pradesh	993,000		9
4		KVK Andhra Pradesh	5000		2
5	Bihar	Bihar University	4000	4000	1
6	Chatisgadh	Chatisgadh farmer	467,225	477,225	5
7		DOF Chatisgadh	10,000		1
8	Gujarat	Gujarat University	2000	2000	1
9	Jharkhand	Jharkhand University	5000	5000	1
10	ICAR	ICAR	100,000	100,000	12
11	Karnataka	DOF Karnataka	122,500	319,580	2
12		Karnataka farmer	195,080		7
13		Karnataka University	2000		1
14	Kerala	DOF Kerala	6,447,410	7,657,661	42
15		Kerala farmer	1,188,651		78
16		Kerala University	15,600		4
17		KVK Kerala	6000		1
18	Madhya Pradesh	DOF Madhya Pradesh	15,000	15,000	1
19	Maharastra	DOF Maharastra	1,000,000	8,550,547	3
20		Maharastra farmer	7,540,123		78
21		Maharastra University	10,424		4
22	Meghalaya	DOF Meghalaya	10,000	10,000	1
23	Odisha	DOF Odisha	800,000	840,830	13
24		Odisha farmer	38,330		3
25		KVK Odisha	2500		1
26	Tamilnadu	DOF Tamilnadu	930,822	1,643,272	31
27		Tamilnadu farmer	651,750		19
28		Tamilnadu university	60,700		5

S.No	State	Category	Number of seeds	State total	Number of consignments
29	Telangana	DOF Telangana	1000	142,850	1
30		Telangana farmer	137,850		14
31		Telangana University	4000		1
32	Tripura	DOF Tripura	50,000	50,000	2
33	West Bengal	DOF West Bengal	35,000	44,000	1
34		West Bengal University	9000		
35	MPEDA	MPEDA (SSP)	863,725	863,725	30
36	NFDB	NFDB	4000	4000	2
37	NIRD	NIRD	2000	2000	1
38	Punjab	Punjab University	5500	5500	1
39	RGCA	RGCA-MPEDA-MAC	7,825,084	7,825,084	34
40	Uttar Pradesh	Uttar Pradesh farmer	200,000	200,000	1
41	Utharkhand	Utharakhand farmer	15,000	15,000	2
TOTAL			3,0778,374	30,778,374	439

Source: MPEDA-RGCA through personal communication with the authors.

Table 3. GIFT monosex fry supplied by the MPEDA-RGCA (2012–2020).

departments encouraging private entrepreneurs to invest in GIFT hatcheries under the state plan and other centrally supported plans, such as the RKVY and PMMSY, are a good entry point for increasing private sector participation. In Odisha, there are ongoing plans to establish four private sector GIFT hatcheries under the state's plan for monosex seed production and dissemination. The annual production capacity of each hatchery is 2 million monosex fry. Private sector GIFT hatcheries will be established in four zones in Odisha (Balasore, Sambalpur, Koraput/ Kalahandi and Ganjam) to increase farmers' access to quality GIFT seed. For now, the MPEDA-RGCA has the capacity to produce and supply improved broodstock to both existing and new hatcheries.

Beyond Odisha, the dissemination strategy identifies three possible private sector hatchery models for promotion by other states.

1. Model 1 (small hatchery): with an annual capacity of 2 million monosex fry per hatchery

2. Model 2 (medium hatchery): with an annual capacity of 10 million monosex fry per hatchery
3. Model 3 (large hatchery): with an annual capacity of 50 million monosex fry per hatchery.

It is expected that construction of the private sector hatcheries will be done under either the state or centrally supported plans with an estimated unit cost of INR 2.5 million for Model 1, INR 1 million for Model 2 and INR 50 million for Model 3, with financial support at 40% of the unit cost (as per the government financial assistance pattern). Provision of technical support and financial assistance is expected to encourage investment by private sector hatcheries. The activity plan for establishing private sector GIFT hatcheries in India under the state plan is presented in Table 4.

Based on a WorldFish demand and supply forecast analysis, the GOI's target of 22 million metric tons of total fish production and 1 million metric tons of tilapia production can be achieved by 2024–2025

Activity	2020		2021–2030			
	Q3	Q4	Q1	Q2	Q3	Q4
1 Meetings are held with state fisheries departments across India.						
2 State fisheries departments form plans (scheme) and then launch them to invite applications from interested private entrepreneurs to establish GIFT hatcheries. The plans should include the following: 1. application for a tilapia hatchery license 2. modalities of implementation by the department 3. model hatchery design and technical specifications 4. unit cost for construction and operations 5. hatchery accreditation and seed certification criteria and checklists						
3 Private entrepreneurs apply for both the plan and the hatchery license at the same time.						
4 The DOF provides the hatchery license, approves the plan and gives the entrepreneur the go-ahead for construction.						
5 Entrepreneurs and their technical staff undergo training on GIFT hatchery monosex fry production.						
6 Outdoor tanks (broodstock rearing tank, breeding tank, sex reversal and nursing tanks, effluent treatment tanks) and the indoor hatchery unit are constructed.						
7 GIFT breeder fry (mixed sex) are procured, quarantined and stocked from the MPEDA-RGCA. After 24 months, the broodstock is retired and culled. The hatchery has to buy new breeder fry from the MPEDA-RGCA once every 2 years.						
8 GIFT breeder fry are grown out into broodstock (6–8 months).						
9 Hatchery fry (monosex) are produced and sold to farmers.						
10 A traceability system is established.						
11 The hatchery is audited annually under the hatchery accreditation and seed certification program.						

Table 4. Activity plan for establishing private GIFT hatcheries in India (2020–2030).

with a 5-year CAGR of 8.3% and 68% for total fish production and tilapia, respectively (Figures 2 and 3). In such a scenario, tilapia is expected to make up 4.55% of total fish production in India by 2024–25.

To achieve such an optimistic growth rate in tilapia production by 2024–2025 will require 4.18 billion monosex tilapia grower fry. These will come from the combined annual monosex fry production capacity of 991 hatcheries: 2 million fry from 841 small hatcheries, 10 million fry from 125 medium hatcheries and 50 million fry from 25 large hatcheries. To achieve this amount of monosex fry,

9.18 million mixed-sex tilapia breeder fry will be required from tilapia multiplication centers. Tilapia farming should be taken up in a combination of 33,460 ha of large commercial tanks as well as 20,080 ha of small household backyard tanks. Also required are 100,390 biofloc tanks and 20,080 rectangular cages (Tables 5, 6 and 7).

4.2. Feed supply and tilapia better management practices

Achieving optimal productivity and profitability gains with the adoption of GIFT requires improved

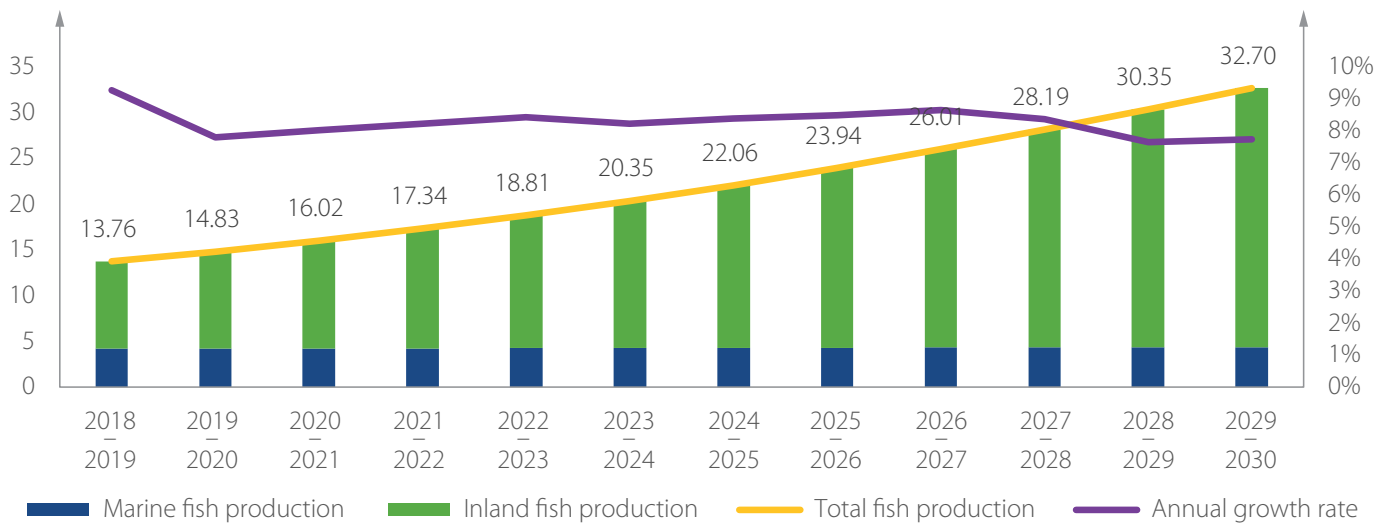


Figure 2. Projected fish production in India (2020–2030).

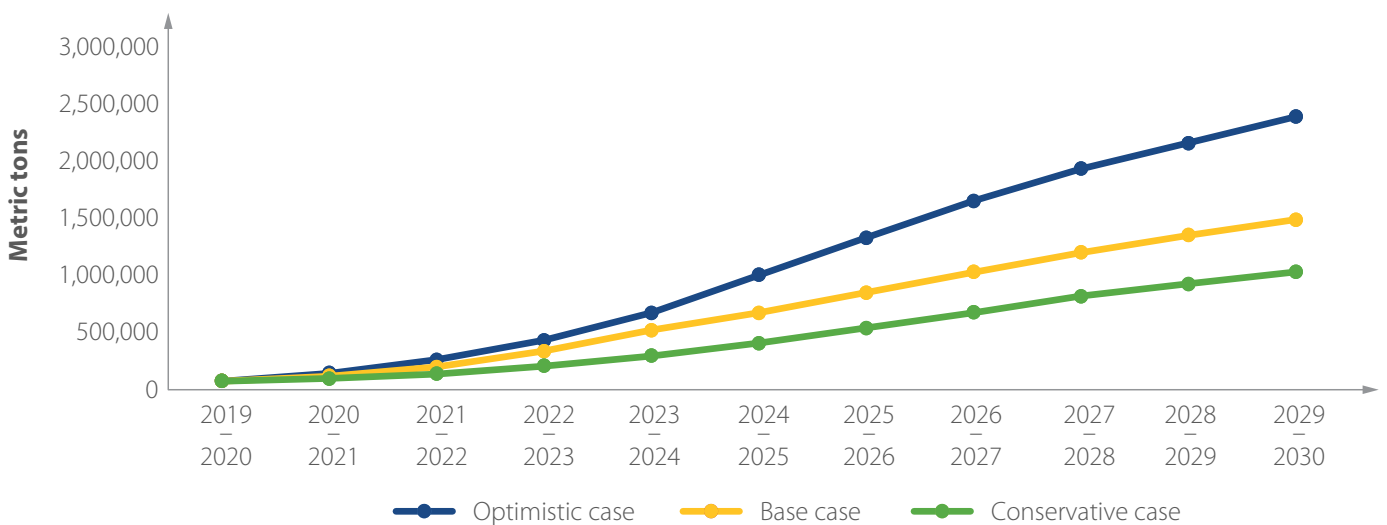


Figure 3. Projected tilapia production in India (2020–2030).

fish feeding and complementary implementation of BMPs. Shikuku et al. (2021) found that limited access to good quality feed interacted with other binding constraints, creating systemic lock-ins in the dissemination of GIFT seed in Bangladesh. Increased access to quality feed will require promoting small and medium enterprises to engage in feed production and supply. Ensuring quality feed also requires stronger regulatory frameworks for quality control. In Bangladesh, weak regulatory frameworks are the main reason for quality adulteration. WorldFish will provide the knowledge required to support the strengthening of the institutional capacity of both national and state governments in enforcing the quality of inputs. Growth in tilapia aquaculture productivity is expected to trigger a “quiet revolution” characterized by increased private sector investment in feed supply upstream (Rashid and Zhang 2019). This means that providing

incentives for increased investment in the supply of GIFT seed can crowd-in investment in the feed supply by providing an expanded market for feed. In other words, investment in GIFT seed production and dissemination can generate important multiplier effects in the feed supply with overall positive impacts on productivity. A decentralized feed supply will reduce transportation costs, giving farmers better access to affordable feed. Evidence from Malawi, for example, shows that proximity to input markets is a major factor influencing the choice of suppliers and use of aquaculture inputs (Shikuku et al. 2021). Adoption of BMPs will be promoted at both the hatchery and grow-out producer level. Diffusion of BMPs will combine different approaches in a pluralistic manner, including training of trainers (TOT), lead farmers, formal extension, digital extension, and information products, such as leaflets and posters.

Description	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Total fish production (million metric tons)	14.83	16.02	17.34	18.81	20.35	22.06	23.94	26.01	28.19	30.35	32.70
Annual growth rate in fish production (%)	7.81	8.03	8.24	8.43	8.23	8.40	8.50	8.65	8.38	7.65	7.75
Market share of tilapia (%)	0.50	0.75	1.15	1.80	2.55	3.05	3.55	3.95	4.25	4.45	4.55
Tilapia production (t)	74,000	120,000	199,000	339,000	519,000	673,000	850,000	1,027,000	1,198,000	1,351,000	1,488,000
GIFT production (50%) (t)	37,000	60,000	100,000	169,000	260,000	336,000	425,000	514,000	599,000	675,000	744,000
Monosex grower fry (#)	309 million	501 million	831 million	1.41 billion	2.163 billion	2.804 billion	3.541 billion	4.281 billion	4.992 billion	5.627 billion	6.199 billion
Mixed-sex breeder fry (#)	678,000	1.99 million	1.824 million	3.096 million	4.747 million	6.154 million	7.772 million	9.396 million	10.957 million	12.35 million	13.606 million
Small hatcheries (#)	60	100	166	295	431	557	716	851	996	1119	1245
Medium hatcheries (#)	9	15	25	42	65	84	106	128	150	169	186
Large hatcheries (#)	2	3	5	8	13	17	21	26	30	34	37
Large commercial grow-out farms* (ha)	4940	4010	6650	11,280	17,300	22,430	28,330	34,250	39,940	45,020	49,590
Small backyard household tanks** (ha)	-	2400	3990	6770	10,380	13,460	17,000	20,550	23,960	27,010	29,760
Biofloc tanks*** (#)	-	12,020	19,950	33,850	51,910	67,300	84,990	102,740	119,810	135,050	148,780
Cage culture**** (#)	-	2400	3990	6770	10,380	13,460	17,000	20,550	23,960	27,010	29,760

* > 1 acre at 15 t/ha per year (50% of production)

** < 1 acre at 15 t/ha per year (30% of production)

*** 4 m in diameter with a 10 t water holding capacity at 1 t fish/tank per year (10% of production)

**** rectangular 96 m³ at 5 t/cage per year (10% of production)

Table 5. Projected demand for tilapia in India and milestones for production for 10 years under the baseline scenario.

Description	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Total fish production (million metric tons)	14.83	16.02	17.34	18.81	20.35	22.06	23.94	26.01	28.19	30.35	32.7
Annual growth rate in fish production (%)	7.81	8.03	8.24	8.43	8.23	8.40	8.50	8.65	8.38	7.65	7.75
Market share of tilapia (%)	0.50	0.90	1.50	2.30	3.30	4.55	5.55	6.35	6.85	7.10	7.30
Tilapia production (all strains) (t)	74,000	144,000	260,000	433,000	672,000	1,004,000	1,329,000	1,652,000	1,931,000	2,155,000	2,387,000
GIFT production (50%) (t)	37,000	72,000	130,000	216,000	336,000	502,000	664,000	826,000	966,000	1,077,000	1,194,000
Monosex grower fry (all strains) (#)	309 million	601 million	1.084 billion	1.802 billion	2.799 billion	4.183 billion	5.536 billion	6.882 billion	8.046 billion	8.978 billion	9.946 billion
Mixed-sex breeder fry (all strains) (#)	678,000	1.319 million	2.379 million	3.956 million	6.143 million	9.181 million	12.15 million	15.105 million	17.66 million	19.705 million	21.83 million
Small hatcheries (all strains) (#)	60	110	202	356	554	841	1113	1386	1618	1794	1983
Medium hatcheries (all strains) (#)	9	18	33	54	84	125	166	206	241	269	298
Large hatcheries (all strains) (#)	2	4	7	11	17	25	33	41	48	54	60
Large commercial grow-out farms* (ha)	4940	4810	8670	14,420	22,390	33,460	44,290	55,060	64,370	71,830	79,570
Small backyard household tanks** (ha)	-	2880	5200	8650	13,430	20,080	26,570	33,030	38,620	43,100	47,740
Biofloc tanks***	-	14,420	26,020	43,250	67,170	100,390	132,870	165,170	193,110	215,480	238,710
Cage culture****	-	2880	5200	8650	13,430	20,080	26,570	33,030	38,620	43,100	47,740

* > 1 acre at 15 t/ha per year (50% of production)

** < 1 acre at 15 t/ha per year (30% of production)

*** 4 m in diameter with a 10 t water holding capacity at 1 t fish/tank per year (10% of production)

**** rectangular 96 m³ at 5 t/cage per year (10% of production)

Table 6. Projected demand for tilapia in India and milestones for production for 10 years under an optimistic scenario.

Description	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Total fish production (million metric tons)	14.83	16.02	17.34	18.81	20.35	22.06	23.94	26.01	28.19	30.35	32.70
Annual growth rate in fish production (%)	7.81	8.03	8.24	8.43	8.23	8.40	8.50	8.65	8.38	7.65	7.75
Market share of tilapia (%)	0.50	0.60	0.80	1.10	1.45	1.85	2.25	2.60	2.90	3.05	3.15
Tilapia production (all strains) (t)	74,000	96,000	139,000	207,000	295,000	408,000	539,000	676,000	818,000	926,000	1,030,000
GIFT production (50%) (t)	37,000	48,000	69,000	103,000	148,000	204,000	269,000	338,000	409,000	463,000	515,000
Monosex grower fry (all strains) (#)	309 million	401 million	578 million	862 million	1.23 billion	1.701 billion	2.244 billion	2.818 billion	3.406 billion	3.857 billion	4.292 billion
Mixed-sex breeder fry (all strains) (#)	678,000	879 million	1.269 billion	1.892 billion	2.699 billion	3.733 billion	4.926 billion	6.185 billion	7.476 billion	8.465 billion	9.42 billion
Small hatcheries (all strains) (#)	60	90	129	176	255	345	462	559	693	773	851
Medium hatcheries (all strains) (#)	9	12	17	26	37	51	67	85	102	116	129
Large hatcheries (all strains) (#)	2	2	3	5	7	10	13	17	20	23	26
Large commercial grow-out farms* (ha)	4904	3200	4620	6900	9840	13,610	17,950	22,540	27,250	30,850	34,330
Small backyard household tanks* (ha)		1920	2770	4140	5900	8160	10,770	13,530	16,350	18,510	20,600
Biofloc tanks*** (#)		9610	13,870	20,690	29,510	40,820	53,860	67,630	81,750	92,560	103,000
Cage culture**** (#)		1920	2770	4140	5900	8160	10,770	13,530	16,350	18,510	20,600

* > 1 acre at 15 t/ha per year (50% of production)

** < 1 acre at 15 t/ha per year (30% of production)

*** 4 m in diameter with a 10 t water holding capacity at 1 t fish/tank per year (10% of production)

**** rectangular 96 m³ at 5 t/cage per year (10% of production)

Table 7. Projected demand for tilapia in India and milestones for production for 10 years under a conservative scenario.

5. Strategic partnerships and engagement framework

5.1. Collaboration strategy

5.1.1. MPEDA-RGCA GIFT Satellite Breeding Program

The MPEDA-RGCA has excellent pond facilities, equipment, laboratories and experimental infrastructure. The RGCA, specifically, has highly skilled staff in both biology and aquaculture, as well as a good network of extension service providers in India, who are crucial for disseminating and scaling GIFT to farmers. In 2019, the 5-year collaboration between WorldFish and the MPEDA-RGCA for the GIFT breeding program in India was renewed. This provided an opportunity to promote GIFT on a wider scale by conducting national multistakeholder workshops and through advocacy and policy dialogues with various state governments. The purpose was to encourage private sector investments in state plans while creating a conducive enabling environment for scaling.

Phase II (2019–2023) of the collaboration aims at continued improvement of the breeding program (fully pedigreed population) that was initiated in Phase I (2011–2016). It also seeks to further develop viable dissemination models that can facilitate the long-term delivery of high-quality GIFT seeds to India's aquaculture sector. In collaboration with world renowned scientists, the project has published a valuable research paper in a high impact international journal (Agha et al. 2018). The collaboration further targets improved genetic performance of the GIFT strain through continuation of the following:

- developing a logical breeding structure
- establishing a system for recording and monitoring the dissemination of GIFT to farmers and hatcheries throughout the country
- conducting an on-farm performance assessment of GIFT in various zones and across farming systems.

Under the new policy guidelines, there will be increased demand for mixed-sex brood seed. As the principal source of quality GIFT germplasm

the MPEDA-RGCA needs to gear up to meet this unique demand. Analysis of demand and supply presented in sections 3 and 4.1 suggests that the RGCA has the capacity to satisfy the demand for quality mixed-sex brood seed to all the envisaged categories of hatcheries in India over the coming years. This guarantees a sustainable business model for the RGCA as the sole supplier of GIFT germplasm to all multiplication centers across the country. The RGCA could even consider stopping production of monosex seed for supplying to farmers. In its place, it could augment its resources and efforts to ensure a consistent supply of GIFT germplasm and facilitate the establishment of an accreditation system for GIFT hatcheries and GIFT seed in India in close collaboration with WorldFish.

5.1.2. Government of India and state governments

The dissemination and scaling strategy proposes establishing a BDW for GIFT in India, with performance incentives. Supported by the MPEDA-RGCA and WorldFish, the BDW will organize and facilitate meetings with the commissioners-secretaries of the fisheries departments in priority states aimed at demonstrating a clear value proposition and encouraging investment in GIFT hatcheries. The BDW will also convince state governments to promote the GIFT farm demonstration program implemented through either the state plan or central plan (PMMSY, RKVY). Each state will be encouraged to promote at least 100 ha of private demonstration farms per year. The GIFT BDW should hire dedicated extension staff in each state to assist the state governments in implementing the plans.

WorldFish will work with both national and state governments to jointly develop proposals about GIFT farming in India. Building on the already effected changes in policy, further policy dialogue with both the GOI and state governments will create a favorable policy environment for the tilapia industry to thrive. WorldFish will generate the knowledge and evidence necessary to inform sound policy and investment decisions to scale GIFT. An enabling

policy environment is crucial to incentivize the private sector to invest in GIFT seed production and dissemination as well as the development of other segments of the tilapia value chain. Close collaboration with both national and state governments is also important to facilitate imports of germplasm of GIFT for breeder seed (mixed-sex) production in two or three private multiplication centers across India, if found necessary.

In India, so far only five GIFT hatcheries have been established in the public sector: (1) at the MPEDA-RGCA in Vijayawada, Andhra Pradesh, which is a multiplication center and hatchery for producing mixed-sex breeder seeds and monosex grower seeds), (2) at the DOF in Tamil Nadu, (3) at the University of Agricultural Sciences in Bangalore, Karnataka, (4) the recently established Kausalyaganga government farm in Odisha, which is a hatchery for producing only monosex grower seeds, and (5) at Fishcopfed, DOF, MOFA, GOI in Banswada, Rajasthan. WorldFish will strengthen its collaboration with public hatcheries in quality seed production and effective dissemination. Establishment of the government GIFT hatchery at the Kausalyaganga fish farm and demonstration program has ignited interest among farmers

in Odisha because of successful harvests and increasing local market demand for tilapia. These milestone achievements have set a good example in India for opening up dialogue with various state governments in the eastern part of the country to take up GIFT and make appropriate investments through state development plans.

Through the joint project with the MPEDA-RGCA, WorldFish will work with the GOI and state governments to implement a seed quality assurance system for tilapia hatcheries that includes certification, the certifying authority or agency, and the eligibility requirements for accreditation.

5.1.3. Private sector hatcheries

The private sector is crucial for achieving impacts at scale with GIFT. There are currently seven private sector tilapia hatcheries: one GIFT hatchery, two hatcheries that produce both GIFT and non-GIFT strains, and four producing and disseminating non-GIFT strains across India. In total, more than 25 unauthorized hatcheries/seed rearing centers are operating in the state of West Bengal, where a lot of uncertified tilapia



GIFT haul from a demonstration farm in Kalahandi District, Odisha, India.

seed is imported from Bangladesh through the border and then distributed to other states in India (Figure 4). Table 8 shows the list of licensed GIFT and non-GIFT hatcheries across India. To enhance the capacity of both existing and new private sector GIFT hatcheries in quality seed production and dissemination, WorldFish will maintain close collaboration, providing technical support where needed. Non-GIFT hatcheries will be encouraged to adopt GIFT through the demand creation strategies.

5.1.4. Other private sector partners, including feed companies and other intermediaries

Individual small-scale tilapia farmers face serious constraints in accessing input and output markets. In most cases, individual farmers rely on local feed suppliers and fish traders. Although these intermediaries create an important link to markets, purchasing feed from local suppliers sometimes reduces the profit margin and may compromise the quality of feed in a context where regulatory frameworks are weak. Recognizing the role of intermediaries in GIFT seed dissemination, including information diffusion, the GIFT BDW,

with support from WorldFish, the MPEDA-RGCA and state governments, will strengthen the capacity of the intermediaries to promote the supply of quality inputs. At the same time, the BDW, in collaboration with WorldFish, the MPEDA-RGCA, state governments and other stakeholders, will support the formation of networks and partnerships between farmers and other actors within the supply chain, such as feed companies and fish markets. This will help increase farmers' access to high quality inputs and ensure they receive better prices for their fish and thus increase profitability. In addition, introducing the cluster farmer approach will help farmers pool resources and share information within social networks, which in turn will increase the adoption of advanced technologies, practices and systems. Furthermore, cluster farmers are likely to experience greater bargaining power on pricing or to make agreements with feed companies and fish buyers. Increased adoption of GIFT is expected to induce demand for complementary inputs, including improved feed (Emerick et al. 2016). Combined with favorable policies, this will generate incentives for investment by the private sector.

No.	Hatchery	Status of license	Strain	Fry production (2019–2020)
1	MPEDA-RGCA tilapia hatchery, monosex seed production facility, Vijayawada	Licensed	GIFT	8 million
2	University of Agricultural Sciences, Bangalore, Karnataka	Licensed	GIFT	<1 million
3	DOF, Tamil Nadu	Licensed	GIFT	<1 million
4	Arsen Bio-Tech and Farms (India) Pvt. Ltd. (C/O Growel Feeds), Vijayawada, Andhra Pradesh	Licensed	Chitralada, red tilapia	5 million
5	Svara Biotechnovations, Madurai, Tamil Nadu	Licensed	GIFT, Chitralada, red tilapia	3 million
6	MM hatcheries, Raipur, Chhatishgarh	Licensed	Chitralada	10 million
7	Indepesca Pvt. Ltd., Mumbai, Maharashtra	Licensed	Chitralada and GIFT	5 million
8	West Coast Group, Maharashtra	Licensed	GIFT	1 million
9	Ananda Seafoods Group, Bhimavaram, Andhra Pradesh	Licensed	Not producing	-
10	CP Aqua (India) Pvt. Ltd., Chennai	Licensed	Not producing	-
11	DOF, government fish seed farm, Kausalyaganga, Bhubaneswar, Odisha	Licensed	GIFT	340,000
12	More than 25 unauthorized tilapia hatcheries/seed rearing centers (mostly receiving early fry from Bangladesh)	Unauthorized	Unknown	60 million
TOTAL				94.34 million

Source: Authors from their direct communications with various hatcheries and industry interaction.

Table 8. Tilapia hatcheries across India.

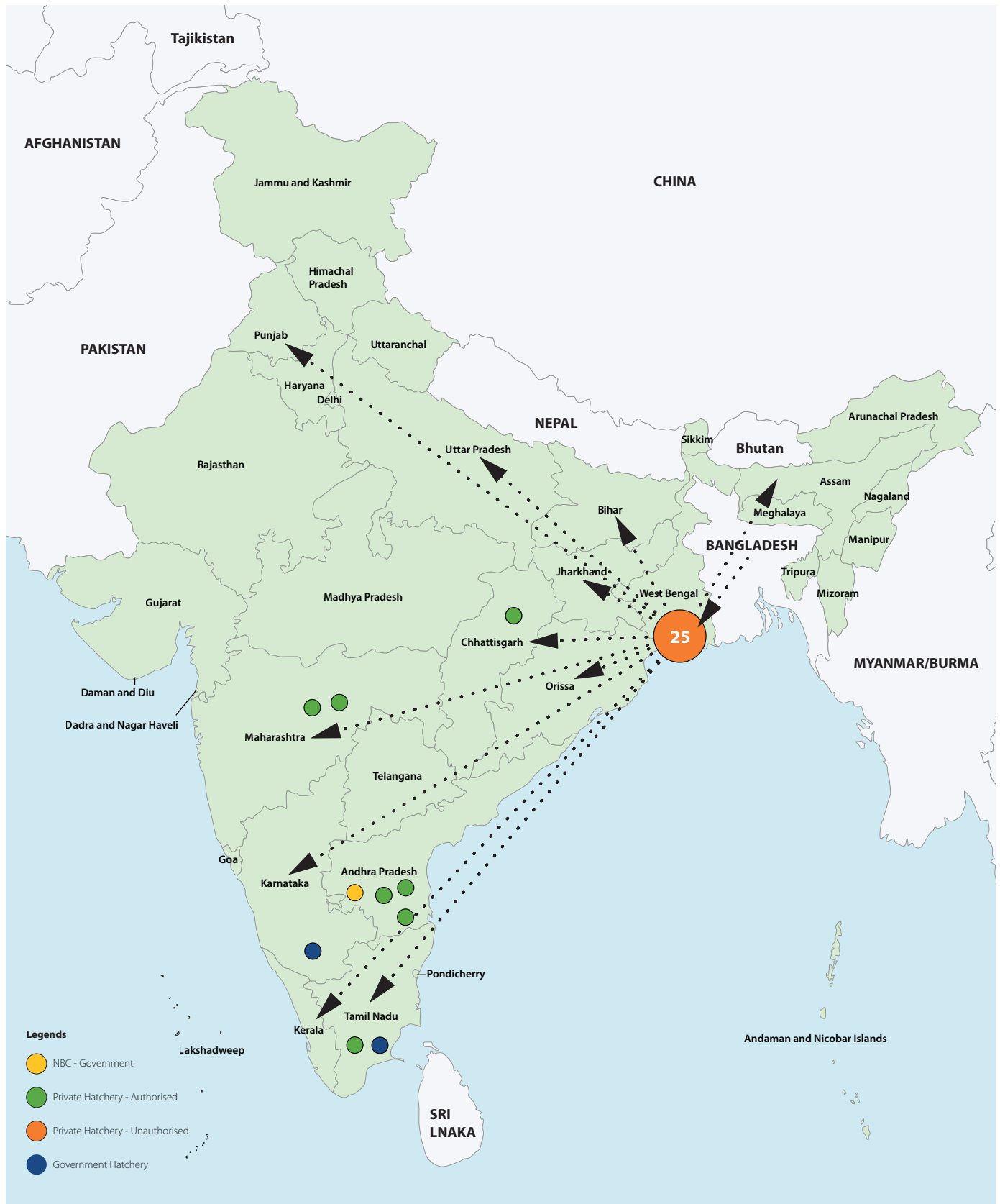


Figure 4. Tilapia hatcheries and seed distribution in India.

6. Marketing and demand creation

Several activities have been undertaken to create demand for GIFT. In 2014, the MPEDA-RGCA and WorldFish organized the India Tilapia Summit 2014 (ITS 2014) at Vijayawada. At the one-day international seminar, many eminent international tilapia and technology experts from the Asian Institute of Technology (Thailand), WorldFish (Malaysia), Technion (Israel) and the Philippines made impressive presentations. Several other experts from India also made presentations, including Dr. E.G. Silas, former director of the Central Marine Fisheries Research Institute and former vice chancellor of Kerala Agricultural University, as well as Dr. M. Vijaya Gupta, former assistant director general at World Fish. This event was organized to check the pulse of Indian aquafarmers and entrepreneurs toward accepting tilapia as an important species for diversification. Over 300 delegates registered for the event. Earlier, Ms. Leena Nair of the Indian Administrative Service, as well as chairperson of the MPEDA and president of the RGCA, inaugurated the event. Dr. Manmohan Singh, secretary to the state government of Andhra Pradesh for the Indian Administrative Service, presided over the event. The ITS 2014 also had a concluding plenary session with panel discussions. The panel

included eminent tilapia scientist Dr. Ambekar E. Eknath, former director general of the Network of Aquaculture Centres in Bangkok, Thailand. The summit provided several recommendations for future propagation of GIFT in India.

Marketing and demand creation activities will be enhanced through on-farm demonstrations about how to produce market size fish combined with creation of market links, as well as workshops and seminars. Table 9 presents a schedule of marketing and demand creation activities in India.

6.1. Marketing and demand creation for elite GIFT germplasm by public and private hatcheries

Evidence from Bangladesh, where the GIFT dissemination system is more developed, shows that one of the main reasons for the declining quality of GIFT seed is multiplier hatcheries relying on their own seed for broodstock production instead of purchasing elite broodstock from the breeding nucleus at the BFRI or hatcheries using the cohort breeding system. As a result, this has caused increased inbreeding, diminished quality

Activity	Q1	Q2	Q3	Q4
1. Multistakeholder workshops in eastern and central states				
<ul style="list-style-type: none"> Create awareness about GOI guidelines on tilapia and changes in policy. Spread knowledge about GIFT grow-out farmer BMPs. Spread knowledge about GIFT hatchery BMPs. Spread knowledge about GIFT production in recirculating aquaculture system (RAS), biofloc and cage culture. Share success stories of GIFT in Odisha. 	■	■	■	■
2. Certification and health management	■			
3. Meetings (DOFs, farmers, hatcheries and feed companies, etc.)	■	■	■	■
4. Seminars		■	■	■
5. Publications (story/blog/case study/papers)	■	■	■	■

Table 9. A schedule of GIFT demand creation activities from 2020 to 2030.

and sub-optimal on-farm performance of GIFT. Therefore, it is important to create and sustain demand for elite broodstock. Demand will be created through several activities, including increased advocacy and knowledge creation among hatcheries about the benefits and sources of elite broodstock as well as the GIFT hatchery accreditation and seed certification program.

6.2. Marketing and demand creation for GIFT among grow-out producers

Demand creation at the level of grow-out farmers targets the following:

- Provide on-farm training and technical support to small- and medium-scale farmers to produce GIFT following BMPs.

- Facilitate market links for GIFT in local wet fish markets and input markets through local service providers.
- Increase awareness among consumers on the nutritional and health benefits of eating tilapia.
- Promote GIFT in the hotel, restaurant and catering sector (HORECA) sector. Conduct campaigns such as recipe competitions among chefs of HORECA to promote GIFT as a menu item in the sector.

Demand creation activities will be conducted in the respective states by forming farming clusters. The specific planned annual demand creation activities for grow-out farmers are further presented in Table 10.

Activity	Q1	Q2	Q3	Q4
1. Meet with state fisheries departments.				
2. Conduct TOT for field staff of DOFs.				
3. Form farmer clusters.				
4. Lead farmer training.				
5. Support farmers to obtain licenses from state fisheries departments.				
6. Support farmers with GIFT marketing by linking them to traders and local service providers.				
7. Promote GIFT in the HORECA sector.				

Table 10. Demand creation activities for grow-out farmers.

7. Plan for quality control

Major producers and distributors of tilapia seed come from the state of West Bengal, where there are more than 25 unregistered private hatcheries. There is also tilapia seed imported (illegally) from Bangladesh. It is important to establish a hatchery accreditation and seed certification system through the GIFT BDW to ensure a supply

of disease-free, high-quality seeds and to minimize inbreeding. This will ensure (a) a system of health screening, (b) a traceable system of supply to multiplication centers and hatcheries, (c) health certificates for seed batches going to farmers and (d) a system for gathering key performance data from farmers.



Photo credit: Khurshed Chandra Nayak/WorlFish

Collection of GIFT fingerlings from a captive hapa nursery at a farm in Khorda District, Odisha, India.

8. Capacity building strategy

The capacity building strategy will focus on the aspects presented in Table 11. In terms of developing skilled labor required for GIFT dissemination, the RGCA has been conducting regular training (breeding, seed production and grow-out farming of GIFT) since July 2014. This 5-day program is a comprehensive

hands-on package that would guide tilapia farmers/breeders to start seed production/farming activities. So far, 47 training programs have been conducted, benefitting a total of 604 trainees, including DOF officials, farmers, entrepreneurs, students and academics.

No.	Activity	Level
1	On-farm training/seminar	Farmers
2	Hatchery BMP management	Private entrepreneurs, government farms
3	TOT on farm BMP management	Department officials
4	Seminar by international experts	Department officials, farmers
5	External visitors	National and international
6	Provide technical advice and support for the implementation of the breeding program and dissemination of GIFT in India	
7	Facilitate and assist the RGCA in exchanging scientific information with RGCA approved experts in the field of tilapia genetics in the region	
8	Assist the RGCA in preparing specifications for equipment required for implementing the program	
9	Train personnel in quantitative genetics, selective breeding and statistical analysis	

Table 11. Capacity building activity plan.

9. Monitoring, evaluation and learning

Continuous monitoring is important throughout the process of disseminating and scaling aquaculture innovations. Dissemination will be monitored within the wider seed delivery system using both quantitative and qualitative indicators of performance. WorldFish and the MPEDA-RGCA will monitor the implementation of the breeding program. WorldFish India will conduct an independent national survey on the status of tilapia production (both wild and farmed), seed production, domestic and export markets, tilapia consumer profiling, farmer needs and preferences, and constraints for effective functioning of the seed system. A forecast for tilapia production and demand over next 10 years will also be prepared. Quantitative indicators will reflect the amount, number or percentage of the target reached and will evaluate the level of satisfaction of the target beneficiaries reached through the dissemination and scaling strategy.

9.1. On-farm performance assessment

An improved understanding of GIFT productivity and profitability across a range of agro-ecological zones and systems will provide good benchmarking information required for GIFT promotion now and in the future. An on-farm performance assessment will be conducted through close partnership with the private sector to assess, among other outcomes, the productivity and profitability of GIFT under the management of farmers. This is important to inform areas that require intervention to ensure optimal GIFT yields and achieve impacts at scale. Understanding the performance of improved strains is a prerequisite for scaling. In 2021, an on-farm performance assessment will be conducted among farmers who already received GIFT seed through previous and ongoing projects in Odisha. The assessment will combine quantitative and qualitative approaches.

9.2. Monitoring demand and supply

Monitoring the demand and supply situation is important to understand how the market for fish seed is performing. A foresight analysis for tilapia will be conducted in selected states or for the entire country using a supply/demand

approach and WorldFish foresight models. Digital innovations will be used to track dissemination and collect high-frequency data on demand and supply, including prices. This will further help track the dissemination of GIFT and is, therefore, important to ensure traceability. Monitoring will be achieved through close collaboration with the MPEDA-RGCA and other hatcheries. An accurate and complete database of hatcheries will be maintained and routinely updated. Important drivers of demand (adoption) and supply will also be monitored.

9.3. Assessing drivers of adoption

Understanding drivers of GIFT adoption is important to inform the design of appropriate interventions and the creation of strategic partnerships to achieve wide-scale dissemination. An adoption analysis will be conducted following a robust framework developed by WorldFish and anchored by empirical and theoretical literature on diffusion of innovations. The framework focuses on five important drivers of adoption:

- individual characteristics
- capital, including natural, physical, financial, human and social capital
- context, including transaction costs, infrastructure, policies and regulations, and effective demand
- transfers, such as social protection and social assistance
- behavior, including inconsistent preferences, informational constraints and risk aversion.

Important areas of focus include the following questions:

- How do women's and men's preferences, needs and experiences with GIFT differ?
- How do their needs and capacities in relation to fish nutrition and disease prevention differ?
- What are the implications for effective priority setting in breeding programs and fish feed and disease and innovation development?

9.4. Seed system assessment

Future improvement of the dissemination model will require rigorous and systematic evaluation of the fish seed system in India. This evaluation will look at how the seed system functions to sustainably disseminate adequate amounts of quality fish seed in a timely and inclusive manner. The evaluation will, therefore, identify important

areas of intervention to strengthen the national seed system for GIFT. In addition, insights from this evaluation will be used to inform the One CGIAR seed systems development strategy.

9.5. Suitability analysis

As a priority, GIS and suitability analysis models will be used to delineate areas for GIFT culture.



Photo credit: Anum Padhyar/WorldFish

GIFT mating hapas in the government fish seed farm in Kausalyaganga, Bhubaneswar, Odisha, India.

Notes

¹ It is important to mention that we are not suggesting GIFT in open water bodies.

² Detailed state-wise statistics for all zones in India are presented in the Appendix.

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Appendix

State	Population in million (2018)	% of people below the poverty line in 2011–2012 with a monthly per capita consumption of INR 816 in rural areas and INR 1000 in urban areas (Planning Commission 2013)	Per capita income (INR) in 2017–2018 (Reserve Bank of India)	Average weekly household spending (INR) on food (five people per household)	Average weekly household spending (INR) on fish, eggs and meat (five people per household)	% of per capita income spent on fish, eggs and meat	Frequency of fish consumption among people (%) NFHS 4 (2015–2016)				
							YES	Daily	Weekly	Occasionally	
All-India	1350	21.92	114,958	5278	385	7.3	68.8	5.2	31.1	32.55	
Eastern states											
1	West Bengal	98	19.98	93,711	4613	783	17.2	98.95	22.25	69.1	7.65
2	Odisha	45	32.59	84,854	4186	357	8.6	94.4	2.9	59.6	31.9
3	Jharkhand	37	36.96	69,265	3493	238	6.8	90.45	0.8	32.1	57.65
4	Bihar	120	33.74	38,631	2039	118	5.8	86.8	1.25	31.45	54.1
	TOTAL/Avg	300	30.82	71,615	3583	374	9.6	92.65	6.8	48.1	
Central states											
5	Chattisgarh	29	39.93	89,813	4098	229	5.6	79.05	0.85	29.75	48.5
6	Uttar Pradesh	229	19.43	55,456	2586	100	3.9	54.35	0.4	16.35	37.6
7	Madhya Pradesh	82	31.65	82,941	3792	110	2.9	48.4	0.7	16.35	31.4
	TOTAL/Avg	340	30.34	76,070	3492	146	4.1	60.6	0.65	20.82	

	State	Population in million (2018)	% of people below the poverty line in 2011–2012 with a monthly per capita consumption of INR 816 in rural areas and INR 1000 in urban areas (Planning Commission 2013)	Per capita income (INR) in 2017–2018 (Reserve Bank of India)	Average weekly household spending (INR) on food (five people per household)	Average weekly household spending (INR) on fish, eggs and meat (five people per household)	% of per capita income spent on fish, eggs and meat	Frequency of fish consumption among people (%) NFHS 4 (2015–2016)			
								YES	Daily	Weekly	Occasionally
Northeastern states											
8	Sikkim	1	8.19	317,134	14,698	1496	10.1	90.15	1.65	43.3	45.05
9	Arunachal Pradesh	2	34.67	127,748	5835	990	17	97.7	4.65	61.05	32
10	Mizoram	1	20.4	141,210	6959	1389	20.1	96.2	2.45	28.8	64.9
11	Nagaland	2	18.88	102,581	5129	942	18.4	98.5	2.2	43.45	52.9
12	Tripura	4	14.05	105,044	5459	1,264	23.2	99.4	8.2	76.4	14.8
13	Meghalaya	3	11.87	81,098	3720	781	20.9	98.6	9.05	56.45	33.1
14	Assam	35	31.98	74,204	3889	685	17.6	98.6	11.65	66.8	20.2
15	Manipur	3	36.89	65,411	3359	520	15.5	99.55	18.55	52.3	28.65
	TOTAL/Avg	51	22.12	126,804	6131	1008	17.9	97.34	7.3	53.6	
Southern and western states excluding Gujarat											
16	Kerala	35	7.05	184,000	7077	1,381	19.5	97.85	56.3	33.3	8.25
17	Tamil Nadu	77	11.28	171,583	7771	800	10.3	93.7	4.55	55.5	33.7
18	Goa	2	5.9	422,149	19,524	4,021	20.6	92	34.3	50.5	10.45
19	Andhra Pradesh	53	9.2	143,935	6484	647	9.9	89.5	1.45	43.65	44.45
20	Telangana	38	-	180,697	-	-	-	84.6	0.6	32.85	51.15

	State	Population in million (2018)	% of people below the poverty line in 2011–2012 with a monthly per capita consumption of INR 816 in rural areas and INR 1000 in urban areas (Planning Commission 2013)	Per capita income (INR) in 2017–2018 (Reserve Bank of India)	Average weekly household spending (INR) on food (five people per household)	Average weekly household spending (INR) on fish, eggs and meat (five people per household)	% of per capita income spent on fish, eggs and meat	Frequency of fish consumption among people (%) NFHS 4 (2015–2016)			
								YES	Daily	Weekly	Occasionally
21	Karnataka	66	20.91	187,649	8255	641	7.8	75.95	6.1	36.35	33.5
22	Maharashtra	121	20.35	176,102	7958	458	5.8	67.25	2	29.8	35.45
TOTAL/Avg		392	12.45	209,445	9512	1325	12.3	85.83	15	40.3	
Northern states including Gujarat											
23	Jammu and Kashmir	14	10.31	83,717	4150	343	8.3	72.3	0.5	11.4	60.35
24	Uttarakhand	11	11.26	182,320	8406	344	4.1	63.35	0.85	14.3	48.2
25	Himachal Pradesh	7	8.06	167,044	7204	300	4.2	35.85	0.35	5.75	29.7
26	Gujarat	64	16.63	174,652	8405	197	2.4	31.7	1.2	9.95	20.6
27	Rajasthan	78	14.71	99,487	4558	99	2.2	22.25	0.1	4.45	17.7
28	Delhi	19	-	328,985	13,065	379	2.9	22	-	-	-
29	Punjab	30	8.26	142,644	5836	75	1.3	20.65	0.2	2.75	17.7
30	Haryana	27	11.16	203,340	8925	108	1.3	17.95	0.35	5.85	11.75
TOTAL/Avg		250	11.48	172,774	7569	231	3.3	35.76	0.51	7.78	

Table 12. State-wise pattern of fish consumption and per capita income.

About WorldFish

WorldFish is a nonprofit research and innovation institution that creates, advances and translates scientific research on aquatic food systems into scalable solutions with transformational impact on human well-being and the environment. Our research data, evidence and insights shape better practices, policies and investment decisions for sustainable development in low- and middle-income countries.

We have a global presence across 20 countries in Asia, Africa and the Pacific with 460 staff of 30 nationalities deployed where the greatest sustainable development challenges can be addressed through holistic aquatic food systems solutions.

Our research and innovation work spans climate change, food security and nutrition, sustainable fisheries and aquaculture, the blue economy and ocean governance, One Health, genetics and AgriTech, and it integrates evidence and perspectives on gender, youth and social inclusion. Our approach empowers people for change over the long term: research excellence and engagement with national and international partners are at the heart of our efforts to set new agendas, build capacities and support better decision-making on the critical issues of our times.

WorldFish is part of One CGIAR, the world's largest agricultural innovation network.