



MSSRF

Science for Sustainable Development

2020-2021

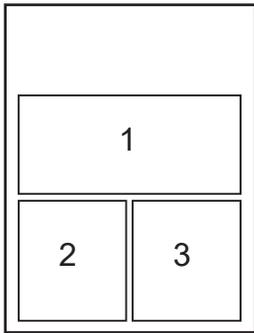
THIRTY-FIRST

ANNUAL REPORT

**CENTRE FOR RESEARCH ON
SUSTAINABLE AGRICULTURAL
AND RURAL DEVELOPMENT**

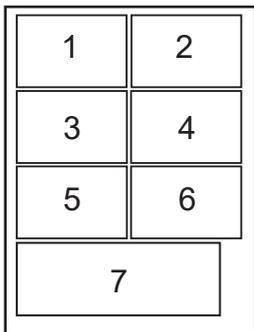
M. S. SWAMINATHAN RESEARCH FOUNDATION





Front Cover

1. Prof. M.S. Swaminathan setting the agenda for the conference titled virtual consultation on “Science for Resilient Food, Nutrition, Livelihoods: Contemporary challenges” on 7th August 2020 in the presence of Hon’ble Shri. M. Venkaiah Naidu, Vice President, Govt. of India.
2. Dr. G.R. Chintala, Chairman, NABARD interacting with Prof. M.S. Swaminathan during his visit to MSSRF on 17th September 2020.
3. Online session on “Gendered impacts of the Covid-19 Crisis” during the virtual consultation on “Science for Resilient Food, Nutrition and Livelihoods: Contemporary Challenges”, 8th August 2020.



Back Cover

1. Release of booklet on establishing Nutri-garden by Dr. Soumya Swaminathan, Chief Scientist, WHO at KVK – Thirur, Thiruvallur District, Tamil Nadu.
2. Community greater yam conservation plot at Madamkunnu tribal settlement in Wayanad District, Kerala.
3. Training to SHG women in Mangalapuram, Challapalli Mandal, Krishna District, on handicrafts using palm leaf.
4. Mr. Vijay Ambruta Kulangey, IAS, District Collector, Ganjam visiting the Plant clinic exhibition organised under Resilience project at Krushi Odisha Agriculture Exhibition at Ganjam District, Odisha.
5. NABARD officials (CGM, GM, DDM) visiting the seabass culture in floating cages in the backwaters of River Krishna at Nagayalanka, Krishna District, Andhra Pradesh.
6. Mrs. Vijayalakshmi, Dindigul District Collector visiting Reddiarchatram Sustainable Agriculture Producer Company (RESAPCOL) stall during Agri expo held at Dindigul.
7. Preparation of enriched farmyard manure and seed treatment of finger millet using beneficial bacteria.

Thirty-First Annual Report

2020 – 2021



M. S. Swaminathan Research Foundation

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and Rural Development
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Chairperson's Foreword

The pandemic year was a challenge for all of us at MSSRF. When the pandemic began, our first efforts were to ensure the health and safety of our workers as well as all the farmers and fishers that we partner. Agriculture and related activities were able to continue in large measure and our efforts shifted towards technological innovations for livelihood enhancement in a period of severe economic distress.

In the Fish for All Centre, Bycatch Reduction devices (BRDs) were introduced and found to be effective in reducing bycatch (or waste) in shrimp trawling. Improved advisories based on the sea current wave rider buoys set up in collaboration with INCOIS led to significant risk-reduction for fishers. Activities were stepped up in the coastal areas of Andhra Pradesh, where we prepared e-People's Biodiversity Registers in 1,251 coastal villages spread over 59 Mandals of nine coastal districts. We are happy to note that two persons trained in the Fish for All Centre were awarded "best traditional organic farmer" by the Government of Tamil Nadu for implementing best practices in integrated fish farming system and a woman leader of the Kadal Muthukul Self Help Group promoted by the Fish for All Centre was selected for "Women Achiever Award" by the Ministry Of Women and Child Development, Puducherry to celebrate International Women's Day 2021.

In the Kolli Hills of Tamil Nadu and Koraput Eastern Ghats of Odisha, income and nutrition enhancement was achieved by the introduction of multi-storey mixed farming. Improved agronomic practices such as the System of Millet Intensification gave a 28 per cent increase in

millet yields and consequent enhancement of incomes for farmers in Koraput district.

The Community Agrobiodiversity Centre at Wayanad took up a range of innovative practices among 6000 families across 50 revenue villages in six districts of Kerala. While promoting salt-tolerant rice varieties, crafts based on screw pine, a Pandanus that grows on the banks of water bodies in the backwaters of Kerala, were revived. The M. S. Swaminathan Botanical Garden (MSSBG) was awarded a Level 1 Accreditation by *The ArbNet* Arboretum Accreditation Program and The Morton Arboretum for achieving standards of professional practice deemed important for arboreta and botanic gardens. MSSBG was one among 15 recipients of the 2020 Global Botanic Garden Fund.

The Biotechnology Programme at MSSRF continued work on characterisation of salt tolerant rice, and in particular, on traditional landraces such as Kagga paddy from the Aghanashini estuary on the west coast of Karnataka. This work has important implications for all lowland rice growing regions in this era of climate change. A big new initiative was setting up of the prestigious Biotech-Krishi Innovation Science Application Network (Biotech-KISAN Hub) in collaboration with the Department of Biotechnology (DBT), Government of India. The MSSRF-Biotech KISAN Hub, is a farmer-centric programme that addresses the technology needs of small and marginal farmers of the aspirational districts of Koraput, Malkangiri and Rayagada in Odisha, and Wayanad, Kerala.

The Ecotechnology programme continued its focus on strengthening collective

institutions, and using modern information and communication tools to address problems of soil and water management so as to enhance incomes sustainably. The Mahatma Gandhi National Rural Employment Guarantee scheme or NREGS has been critical in generating employment for hundreds of millions of workers who lost jobs during the pandemic. MSSRF helped identify over 12 lakh relevant works for NREGS by preparing gram panchayat based composite water resources management plans for over 1200 panchayats in two districts of Tamil Nadu. The Farming Systems for Nutrition approach was further strengthened by applications in multiple locations and disseminated in peer-reviewed research publications.

Over the last year, a notable advance was made by the climate change team in the sphere of policy support to the Ministry of Environment, Forests and Climate Change (MoEFCC) in preparation of India's Third Biennial Update Report (BUR) to the UNFCCC. We are proud to note that MSSRF is listed as a participating institution and our staff as experts in the Third Biennial Update Report. Research on yield gaps for five major crops across different climatic zones has drawn attention to the significant gaps at district level, and hence the potential and need for productivity increase as the first line of defence in the adaptation of agriculture to climate change.

We were very happy to receive Dr. G. R. Chintala, Chairman, NABARD, in MSSRF, a rare personal visit during the pandemic. He spoke of the need for "an active interface between research, credit facilities and the farmer to take agriculture and rural development forward." At the event, Professor Swaminathan highlighted the need to "customize research in laboratories to meet farmers' requirements". It will remain our endeavour to take the latest and best in science and technology to farmers, particularly poor and marginalised farmers, and to take lessons from these experiences back to policy makers.

We made two important additions to our senior staff: M M Hossain, a renowned horticulturist from Orissa University for Agriculture Technology joined as head of the Jeypore centre, and Jitendra Choubey, as head of Communications.

I thank K S Murali, G N Hariharan, V R Prabavathy, R Rengalakshmi, and Jitendra Choubey for coordinating the material presented here, Suni Sebastian for editing the text and AMM Prints for printing the Report. The achievements reported here come from the hard work and commitment of our scientists, development workers, administrative staff and students. I record my appreciation and gratitude to all of them.

COASTAL SYSTEMS RESEARCH

The livelihoods of more than 100 million people along the coastline in India rely on coastal natural resources. The livelihood security of the coastal community is under severe stress due to increase in population leading to overexploitation of resources resulting in degradation of ecologically important ecosystems. Many fisheries-dependent communities are living precariously because of extreme poverty, lack of access to social services and inadequate essential infrastructure. In general, the eastern coast of India is particularly prone to cyclones, storm surges and floods. In recent years the intensity and the frequency of cyclones have been increasing due to global warming. Mangrove forests are the most vital coastal resource for the socioeconomic sustenance of the majority of human population living near estuaries. They sustain more than 70 direct livelihood activities, ranging from fuelwood for the local community to fisheries. The mangrove forests form a thick coastline near estuarine areas and act as a barrier or bioshield against cyclonic winds, storms and rarely occurring tsunamis. The M S Swaminathan Research Foundation (MSSRF) has focused on coastal research primarily for the aforementioned reasons and to study the impending impact of climate change as sea levels continue to rise.

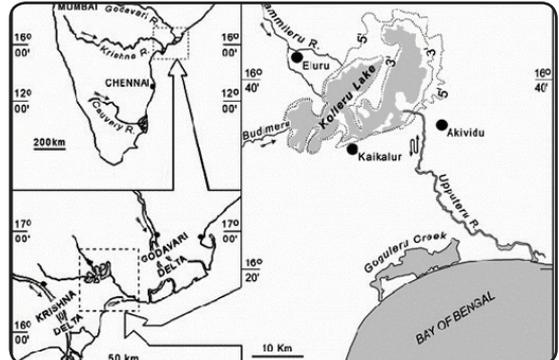
The pioneering work of MSSRF on mangrove conservation and management continued in Andhra Pradesh, Tamil Nadu and Maharashtra. The support from NTPC Tamil Nadu Energy Company Limited (NTECL) has been extended for another 2 years. Electronic People's Biodiversity Registers (e-PBRs) were prepared for 1251 coastal villages across 59 mandals of nine coastal districts for the Andhra Pradesh State Biodiversity Board (APSBB). Our Machilipatnam office

procured with the support of Mitsubishi Corporation, Japan has been renovated. The project also supported the villagers of Mangalapuram, Basavanipalem, Soralgondi and Nali in preparing and distributing 8000 reusable cotton masks via women's self-help groups (SHGs). District-level workshops created awareness in developing adaptation strategies for conservation and management of coastal resources against sea-level rise among district-level government officers and non-government agencies. We are currently carrying out climate risk assessment and adaptation planning for Point Calimere Wildlife and Bird Sanctuary Ramsar site, a technical cooperation project. It is a wetlands management for biodiversity and climate protection project, being implemented by the Ministry of Environment, Forest and Climate Change (MoEFCC), in partnership with International Centre for Environmental Management (ICEM)Asia and German Corporation for International Cooperation GmbH (GIZ). The outcomes on the climate change mitigation and adaptation activities will be part of the Tamil Nadu State Action Plan on Climate Change (SAPCC).

The Fish for All Centre, Poompuhar, Tamil Nadu, was successful in reducing bycatch by the use of bycatch reduction devices (BRDs) in the Palk Bay region. A similar effectiveness was seen in the reduction of bycatch of juvenile fishes using juvenile fish excluder cum shrimp sorting device (JFE-SSD with square mesh). A new Datawell current wave rider buoy deployed near Muttom in Kanyakumari district in collaboration with Indian National Centre for Ocean Information Services (INCOIS) provided real-time sea water current data in the Indian Ocean for validating existing ocean advisories. An evaluation study showed that 67 per cent of beneficiaries improved their income and another 63 per cent experienced reduced risk through the use of our Fisher Friend Mobile Application (FFMA) services. Three community members, trained in the Fish for All Centre, were recognized for their achievements in enterprise development and integrating organic farming in integrated fish farming system (IFFS) and

rewarded by the government. The centre supported 1500 vulnerable fisher families by providing livelihoods and looking after their health and nutrition during the COVID-19 pandemic.

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Sub Programme Area 101

Mangrove and Non-mangrove Coastal Bioshields

MSSRF is implementing mangrove and non-mangrove coastal bioshield programmes to enhance the livelihood security of the coastal communities and ecological security of the coastal areas during disasters such as cyclones. The coastal communities play an important role in planning, implementing and monitoring of the projects jointly with MSSRF. Such programmes have been implemented both in the eastern and western coasts of India.

101.1 Mangrove Restoration

Thiruvallur district, Tamil Nadu: The rate of survival of planted mangrove saplings in 15 ha of mangrove plantation near the NTECL power plant in the Koratallaiyar River estuary, Ennore, is about 85 per cent. About 3000 *Rhizophora* propagules were planted in October 2020 as casualty replacement. The canals were desilted in March 2021 for free flow of tidal water. The average height of *Avicennia* saplings is 90 cm and that of *Rhizophora* saplings about 1.2 m. Pneumatophores were well established in most of the old *Avicennia* saplings, and some of them started fruiting. *Rhizophora* plants have five–seven still roots. Large numbers of *Avicennia* seedlings were established naturally.

Krishna district, Andhra Pradesh: One-day orientation and field training was organized for the 40 officials, including the field officers

of the Panchayat Raj and Rural Development, in Machilipatnam on 2 February 2021 on mangrove restoration techniques. The team was taken to the field for identifying the suitability and demonstrating the designing of canals, their dimensions, canal digging, planting of seeds, collection of seeds and so on. Desiltation and casualty replacement were carried out in mangrove plantation established in 200 ha near Basavanipalem during this year.

East Godavari district, Andhra Pradesh:

The Wildlife Division, Rajahmundry (Forest Department), is maintaining the Mangrove Genetic Resources Conservation Centre (MGRCC) established in Coringa Wildlife Sanctuary, where 25 mangrove species were nurtured by sustaining proper tidal flushing.

Navi Mumbai, Maharashtra: The rate of survival of mangrove saplings in Sarsole and Mandala is about 85 per cent while in Kanjoremarg it is about 70 per cent. As part of village development activities, the fisherfolk of Sarsole requested a semi-permanent shelter near the boat jetty for them to use during monsoon and summer seasons. The fishermen in consultation with the Airoli forest range officer identified the area for the construction of the shed. A tin-roof shed, about 20'x40' with a concrete floor, was constructed. The work was completed in October 2020 and the fisherfolk are finding it very useful.

101.2 Integrated Mangrove Fishery Farming System

We established 50 ha of Integrated Mangrove Fishery Farming System (IMFFS) farms

managed by the farmers. In the past 2 years, the shrimp and crabs grown in the farms were affected by the viral disease outbreak. Hence, many farmers are now culturing sea bass along with shrimp. On an average, a farmer harvests 250 kg of sea bass along with 50 kg of shrimp from a 1 ha pond. About 8000 *Rhizophora* propagules were planted as casualty replacement during March 2021 to maintain the density of the plants.

101.3 Cage Culture

During this year (2020–21) farmers reared sea bass fingerlings using 10 floating cages in the backwaters of the Krishna River, while in the past year (2019–20) 6 floating cages were used. The sea bass fingerlings were sold after 7 months to interested farmers to grow in the ponds. The fingerlings that attained a weight of 100–125 g was sold at Rs 100 apiece. The project has supported the farmers in procuring the machine to macerate the thrash fishes for feeding. During this year, we organized training programmes for 50 farmers on the aquaculture practices in IMFFS and cage culture.

101.4 Integrated Rural Development Programme

We implemented the Integrated Rural Development Programme in three project villages, namely Nali, Sorlagondi and Mangalapuram in Krishna district, Andhra Pradesh, with support from Mitsubishi Corporation, Japan. The Village Resource Centre (VRC) was established in Machilipatnam to provide the real time information for the

coastal fishers on ocean state forecast, potential fishing zone and other livelihood training. The community in the village use potable water, we established reverse osmosis (RO) units in the aforementioned villages. The villagers manage the RO plant and collect Rs 5 for 20 litres towards maintenance. In Muthurasupalem hamlet of Mangalapuram village, a multipurpose community hall was built on common land. Similarly, another community hall was built in Sorlagondi. In Mangalapuram, a concrete road 112 m in length was laid for which the community contributed equally. In Eenaiyapalem hamlet, we renovated a crematorium and built a small bridge over the irrigation canal to provide access to the crematorium. An Anganwadi (creche) centre was renovated and a kitchen included. The area was fenced and learning/playing kits provided for the children.

Improving livelihoods for women and adolescent girls: In Mangalapuram village, livelihood training was organized jointly with the Livelihood Enterprise Development Programme (LEDP) of NABARD. A partner non-profit Praja Pragathi Seva Sangham (PPSS) helped us to provide training in palmyra leaf handicrafts making wherein NABARD bore the training cost and the Mitsubishi Corporation contributed Rs 5,000 to each participant to procure raw materials and to prepare toolkits for handicrafts. We were able to reach 90 trainees of which 60 belonged to the Scheduled Caste. Three training batches of 15 days each were planned and each batch had 30 trainees.

101.5 Greenhouse Gas Fluxes in the Mangrove Ecosystem

We measured greenhouse gas (GHG) fluxes in the Pichavaram mangrove ecosystem using an eddy covariance (EC) tower as part of a collaborative project with Indian Institute of Tropical Meteorology, Pune, under the MetFlux India project of the Ministry of Earth Sciences (MoES), to ascertain whether the mangrove wetland acts as sink or source of GHGs. Parameters such as atmospheric temperature, relative humidity, wind speed, wind direction, precipitation, photosynthetic active radiation and net solar radiation are measured continuously and pCO₂ (partial pressure of carbon dioxide) and air-water CO₂ flux and methane flux data are also collected. We found that the Pichavaram mangroves act as a sink for CO₂ for most part of the year while methane emission was slightly high during wet season.

101.6 Preparation of People's Biodiversity Registers in the Coastal Villages of Andhra Pradesh

Electronic People's Biodiversity Registers were prepared to promote conservation, sustainable use and documentation of biological diversity, including conservation of habitats, land races, folk varieties and cultivars, domesticated stocks and breeds of animals and micro-organisms chronicling the knowledge related to biological diversity. A total of 1251 e-PBRs were prepared for villages spread over 59 mandals of nine coastal districts as per NBA guidelines using the secondary data. The

compiled data has been sent to the APSBB for further updating through the grama sabhas.

Sub Programme Area 102

Fish for All Research and Training Centre, Poompuhar

We introduced path-breaking innovations for sustainable fisheries and received feedback from the local fishermen to improve existing interventions. Successful introduction of BRDs in the Palk Bay region has facilitated the introduction of BRDs for shrimp trawling. We also deployed a new Datawell sea current wave rider buoy off Kanyakumari in collaboration with INCOIS to record sea current in the west coast of the Indian Ocean. This improved efficiency of forecasting and validated the existing ocean advisories from INCOIS. We instituted an evaluation study to understand the impact of FFMA on local communities to learn from our work and strengthen further the existing interventions. It was an absolute moment of pride when three community members trained under the Fish for All Centre were recognized at the district and state levels for their achievement in enterprise development and integrating organic farming in IFFS. We initiated a COVID-19 response programme focusing on the areas of livelihood and health and nutrition for 15000 vulnerable fisherfolk to cope with the pandemic.

102.1 Capture Fisheries Resource Management and Enhancement

Flower shrimp fishery improvement programme in the Palk Bay region: The

flower shrimp fishery improvement programme implemented in the Palk Bay region achieved the Marine Stewardship Council (MSC) certification. Experiments on the effectiveness of three different BRDs (JFE-SSD, square mesh cod end (25 mm) and Turtle Excluder Device (CIFT-TED)) were undertaken using commercial fishing trawlers. The experiments were conducted at three different landing centres, namely Mandapam, Kottaipattanam and Rameswaram. At each location, we used four trawlers: one control trawler without any modifications and the other three trawlers fitted with BRDs on to the trawl net. All the trawling operations were carried out simultaneously in the same fishing ground, as suggested by the fishermen. In total, 173 hauls were carried out in two peak seasons of flower shrimp, that is, February and August 2020, each with a duration of 45 minutes.

We found that introduction of BRDs in shrimp trawling reduces bycatch. The total discards from the different gears indicated that highest discards were observed in the control vessels (6.9 kg/h) and the lowest in the trawl nets fitted with the square mesh and JFE-SSD, at 4.8 and 4.7 kg/h, respectively. The average number of species in the control net were 18 per haul, which was higher ($P < 0.05$) than the average number of species per haul observed in trawl nets with square mesh cod end (13.7 species/haul), JFE-SSD (11.9 species/haul) and TED (10.5 species/haul), respectively. The catch per unit effort (CPUE), expressed in kilograms, showed no significant difference in mean values among the gears ($P = 0.691$), indicating that all gears performed equally well. Thus,

we conclude that the control vessels capture higher biodiversity because of bycatch, which can be avoided by using BRDs. Among the three BRDs tested, square mesh cod ends with a mesh size of 25 mm (12.5 mm bar length) were found to be the most effective in reducing bycatch. On an average, the reduction in the bycatch was about 3–5 kg/h of operation, which is significant considering the fraction that is discarded comprises of juveniles of commercially important species, which when grown can fetch nearly three to four times the price realized from the bycatch. Furthermore, these juveniles will grow and fetch better price in future.

We developed a voluntary code of practice for flower shrimp management in Tamil for sensitizing the fishermen on sustainable harvesting. Legal compliance and sustainable fishing practices form the base for developing the voluntary code of practice. The code complies with all Indian and Tamil Nadu state legal requirements as minimum regulation, but additionally it also emphasizes on formally adopting sustainable fishing practices on a voluntary basis. We oriented 256 fishermen on the code of practice in 22 landing centres with specific training programmes. After several rounds of training, demonstration and dialogues, around 57 fisherfolk have agreed to sign the voluntary code of practice to follow sustainable fishing practices. Additionally, a turtle recovery plan manual was prepared in the local language and distributed among 500 fishermen with proper training. This handbook provides guidance for fishermen to handle the sea turtles effectively while fishing.

Monitoring of wave rider buoys, dissemination of ocean state and marine fish advisory services:

A new Datawell sea current wave rider buoy, which was successfully deployed off Muttom in collaboration with INCOIS, has received notable support from the fishing community and government authorities. It measures ocean conditions such as waves, sea current and sea surface temperature on real-time basis. The ocean data obtained from the buoy will be useful to validate the wave, current and sea surface temperature (SST) forecasts from INCOIS for the oceanic region surrounding the west coast and, in addition, helps in analyzing and tracking the high swell events originating from the Southern Ocean arriving at the southwest coast of India.

The data generated from the wave rider buoys was regularly communicated to INCOIS for validation. The validated advisories from INCOIS further disseminated this data to the fishermen on a regular basis. Around 8240 fisherfolk (7537 men and 703 women) from 210 villages across Tamil Nadu, Puducherry and Andhra Pradesh are aware of the functioning of INCOIS and its scientific services, especially on Ocean State Forecast (OSF), high wave alerts, Potential Fishing Zone (PFZ), Tuna forecast, tsunami warning and other disaster alerts. A total of 83781 fisherfolk from 636 villages received information on OSF and PFZ on a daily basis through mobile-based ICT applications such as FFMA, voice and text messages, district-wise WhatsApp groups and GSM-based public address system. A total of 6337 fisherfolk availed INCOIS–MSSRF 24/7 helpline facility available in Tamil, Telugu and

Malayalam languages. A total of 190 village-level and one-to-one feedback meetings were organized in Tamil Nadu, Puducherry and Andhra Pradesh, and 60 feedbacks and 40 success case studies were collected from fisherfolk from 30 villages on the services provided.

Fisher Friend Mobile Application: During the reporting period, a total of four new versions and one intermediate version of the FFMA were released on the Google Play Store. A total of 11754 new users have downloaded the application in eight coastal states, which has increased the overall number of users to 73440. The total number of screen views for the application is 80.48 lakhs, and the number of screen views during this period was 20.58 lakhs. The average screen view per day for this period was 5511.

Two new features, PFZ feedback and voice-over (Tamil, Telugu and Malayalam), as requested by fisherfolk and fisheries scientists, were integrated into the application. There are 71 fisherfolk identified and promoted as FFMA ambassadors for the promotion of FFMA; they held awareness meetings in 419 villages benefitting more than 20000 fisherfolk. Six district-level advisory committee meetings recommended for a policy advocacy to enhance the network coverage offshore and also shared an idea through policy advocacies with government to increase the use of FFMA.

Scaling up of FFMA to a greater extent needs multi-stakeholder partnership, including public and private players in every state. Therefore,

a district-level consultation was held involving the Fishermen Cooperative Society members for evolving a road map for the scaling up of FFMA in Andhra Pradesh, Tamil Nadu and Puducherry. A total of 12 Fishermen Cooperative Societies with 120 fisherfolk were made aware of FFMA. A broad understanding of FFMA among the members has contributed to its upscaling strategies in the districts. A joint action plan was developed to upscale FFMA at the village level with the support and cooperation of all Cooperative Society leaders.

We documented 240 feedbacks and 59 case studies showcasing the economic and livelihood benefits of the users of FFMA. An evaluation study by an external consultant indicated that the majority of the respondents (67 per cent) agree that they benefited financially from the services of FFMA, while 63 per cent experienced enhanced resilience and reduced risk capacity both on-sea and off-sea. About 58 per cent agree that they are acquiring new knowledge in enhancing their livelihoods. Before accessing FFMA, only 8 per cent of the respondents had higher than adequate income to meet their family requirements, but after using FFMA services, 29 per cent respondents attained additional income. The study also highlighted that fisherfolk attach high social and economic values to the FFMA at individual/personal, family and societal levels. After using information from FFMA, there are changes in the collective decisions and behaviour of the fishing community, particularly as a response to early warnings and disaster alerts. They are able to blend scientific knowledge with their traditional knowledge.

102.2 Post-Harvest Management

Since January 2021, 15 women SHG members have earned Rs 50300 by processing 862 kg of dry fish. A seven-day training programme on Livelihood Development and Enhancement Program on fish processing and post-harvesting technology was conducted with support from NABARD, and it benefitted 90 women from 9 SHGs. We trained them on new products and advanced fish processing techniques. Additionally, an online course on dry fish processing and preservation technology was conducted for the women from Thangachimadam region.

We demonstrated value-addition processes in two villages in Karaikal and Puducherry districts for large-scale production of fish pickles, prawn powder and masala dry fishes. These two groups produced pickles from different fish species and earned a profit of Rs 10500 within a month. The women's group from Panithittu, Puducherry, won the 'women achiever award' from the Ministry of Women and Child Development for their active participation and involvement in the fish-based enterprise activity as a role model for other women in Puducherry.

102.3 Culture Fisheries Enhancement and Management

Promoting Integrated Fish Farming System: During this period, 30 farmers harvested 10.9 metric tonnes (MT) of fish, out of which 5.4 MT were used for self-consumption and 5.5 MT were sold, earning a revenue of Rs 1162000. These 30 farmers

also harvested 5 MT of vegetables, of which 2.2 MT was used for self-consumption and 2.8 MT fetched a revenue of Rs 47950. Similarly, the farmers produced 88 kg of chicken meat for self-consumption and another 551 kg was sold earning a revenue of Rs 97200. Overall, 30 farmers earned a revenue of Rs 1307150 with an average of Rs 42571. Two IFFS farmers who were trained by the project, Mr. V. S. Kannan and Mr. Samuel, received an award for their best practice of organic farming in IFFS from the government of Tamil Nadu through the Department of Agriculture, Mayiladuthurai district, on the occasion of the seventy-second Republic Day 2021.

Brood stock development: ICAR-National Bureau of Fish Genetic Resources (ICAR-NBFG) supported the brood stock development intervention to rejuvenate the lost livelihoods of the people from Thenpathi village. We selected 20 families for orienting brood stock development of indigenous carps for seed production and formed groups

named 'Neithal and Semparuthi Fish Culture Groups' for maintaining community fish ponds in the village. The fish ponds were renovated and stocked with 100 kg of brooders, Catla, Rohu, Mrigal, which the women's groups are now maintaining. In the fish farm bunds, women were encouraged to take up vegetable cultivation to meet their household vegetable requirements.

102.4 Training and Capacity Building

Training centre: During 2020–21, 72 training programmes were conducted on various topics such as marine biodiversity conservation and sustainable fisheries, sustainable gear operation, use of square mesh for responsible fishing, sea safety measures, COVID-19 precautionary measures while fishing, preservation and transportation, fish processing and preservation technology, carp fish culture and IFFS. A total of 4780 fisherfolk and farmers participated in all these training programmes, the details of which are given in Table 1.

Table 1: **Training Programme Organized under Fish for All Centre**

S. No.	Training Topics	No. of Programmes	Participants		Total
			Men	Women	
1	Marine biodiversity conservation and sustainable fisheries	8	350	104	454
2	Square mesh for responsible fishing	3	48	0	48
3	Sea safety measures	8	304	78	382
4	Fish processing and preservation technology	4	46	80	126
5	Fish value-added products	10	0	152	152
6	Quality dry fish production	7	0	208	208
7	Integrated fish farming	15	606	68	674
8	COVID-19 awareness in fishing activities	17	1226	1510	2736
Total		72	2580	2200	4780

Village Resource Centre: During the reporting period, the VRCs developed and disseminated 344 content materials on marine biodiversity conservation and sustainable fishing methods using ICTs. A total of 15 video, audio-conferences and phone-in programmes were conducted through Village Knowledge Centres (VKCs) and VRCs on different topics to create awareness about the regulations for fishing during the COVID-19 pandemic, nursery for horticulture crops, pest management in cotton, selection of better-quality black gram seeds, IFFS, cattle care and management of vegetable cultivation practices which benefitted 738 users.

Table 2: VRC and VKC users

Name of the VRC/VKC	Total Users	Male	Female
Poompuhar	176	85	91
Thangachimadam	276	158	118
Keezhaputhanur	491	221	270
Panithittu	448	131	317
Total	1391	595	796

Workshop on sea safety and risk reduction measures: A one-day programme on 'Sea Safety and Risk Reduction Measures for Small-Scale Marine Fishers' was conducted at Chennai, Puducherry, Nagapattinam, Karaikal,

Mayiladuthurai, Thangachimadam, Nagercoil and Kakinada districts. The workshop was focused on two major objectives: to sensitize the fisherfolk on the importance of sea safety and precautionary measures under changing climatic conditions; and to demonstrate the various sea safety tools and technologies that can be used to minimize their risks. We distributed lifebuoys and sea-safety toolkits from MSSRF and Qualcomm Communications to 184 small-scale fisherfolk.

Internship programme for college students:

In collaboration with Centre of Advanced Study in Marine Biology, Annamalai University, the Fish for All Centre organized an internship programme from 16 February to 2 March 2021 for 55 students. The focus of the programme was to increase students' practical knowledge and exposure on fisheries-related research and livelihood programmes. Students attended interactive lectures on different topics such as marine biodiversity and sustainable fishing practices, fish processing technology, preparation of fish manure, fish amino acids, wildlife management, ornamental fish culture, IFFS, FFMA and VRC/VKC activities by experts in the fields. The organization provided

Table 3: ICT-Based Programmes Conducted through VRCs/VKCs

Theme-wise Programmes	Total users	Male	Female
Health and sanitation	236	113	123
Fisheries	85	23	62
Agriculture	187	96	91
Education	130	78	52
Government schemes and entitlement	100	74	26
COVID-19 precautionary measures in fishing and fish processing unit	217	217	0
Total	955	601	354

the students a unique opportunity to work on field, collaborating with local communities from different walks of life. From the students' point of view, this internship gave them an opportunity to get hands-on experience in fish processing technology, creation of value-added products and IFFS. In addition, they expressed that their field visits were an eye opener for them to learn new strategies to interact with people, which will help them in future research projects.

Efforts of Fish for All Centre to combat the effects of COVID-19: Fish is a key part of our food systems. The COVID-19 situation has heavily affected the fisheries sector and the livelihoods of fishing communities. Fall in production from reduced fishing activities and delayed stocking of aquaculture systems has led to lower supplies, access and thereby consumption of fish-related foods. The pandemic has disrupted the fishery supply chains due to restrictions in transportation, trade and labour. This has severely affected the livelihoods of fisherfolk and fish farmers as well as the nutrition of the population that relies heavily on fish to fulfil its dietary requirements. In order to address some of the key issues, Fish for All Research and Training Centre has initiated a COVID-19 response programme to help the poor and vulnerable fishing communities cope with the pandemic situation and lead a normal life. As part of the programme, 20 fishing villages were identified in Ramanathapuram, Pudukottai and Mayiladuthurai districts of the Tamil Nadu coast and two COVID-19 response packages were introduced: (i) Health package:

Provision of biofortified food rich in minerals and vitamins to 5000 households, focusing on women, elderly fisherfolk and children, and distribution of 55000 double-layered masks and 1000 litres of hand sanitizers to 10300 households. (ii) Livelihood package: Provision of 50-litre ice boxes to 500 women fish vendors and small-craft fisherfolk for the hygienic transportation of fish from the landing centre to the marketplaces to avoid contamination of fish materials. The livelihood and health support provided by Fish for All Centre has benefitted 15000 families and provided them a supporting hand to combat the challenges brought on by the pandemic.

Sub Programme Area 103

Remote Sensing and Geographical Information Systems

103.1 Geographical Information Systems Based Forewarning Model for Pest Management

Training and capacity-building activities were organized in Thennadar, Vanduvancheri, Kathiripulam, Periyakuthahai, Sembodai and Kadinalvayal villages on seed treatment and pest management in which 200 farmers participated. The agro advisories and weather alerts are sent through the voice SMS service to 2500 farmers across the project villages in Vedaranyam block. The farmers interact with the project team through the PANNAI app (Pest-disease Advance Notification and Need-based Agriculture Information) for management of pests and diseases in their

crops. They also receive advice through the virtual mode. The PANNAI app has been a very useful tool for the farmers during the COVID-19 pandemic for receiving advice through voice and video messages easily. During the pandemic, the project team in Vedaranyam facilitated free summer ploughing in Tennadar village by which 74 acres of land have been ploughed benefitting 37 farmers through JFarm Services, an initiative of TAFE (Tractors and Farm Equipment) farmers. During the cyclone periods, the weather alert was constantly given to the farming communities from various authentic sources. The farmer's database was updated for the new project villages in the Vedaranyam block. The cadastral and Field Measurement Book (FMB) have been digitized to be updated in the GeoAgri portal where it will be used as decision support system for pest and disease management and the information given to the individual farmers.

103.2 Quantification of Biomass in Pichavaram Mangroves Using Remote Sensing

'The WEKA' (Waikato Environment for Knowledge Analysis) based machine learning algorithm is tested to quantify the above-ground biomass of mangroves using the optical sentinel 2, LISS IV satellite images with the sentinel Synthetic Aperture Radar (SAR) images. Combinations of spectral bands were computed in the modelling and tested for estimating the above-ground biomass of mangroves accurately. The mangrove canopy height is computed using the cartosat-2 DEM

data, and it is validated with the biophysical data collected in Pichavaram.

103.3 Mangrove Community Zonation and Biophysical Characterization of the Tamil Nadu Coast

The national mangrove atlas is being updated for Tamil Nadu and Puducherry on a 1:25000 scale with the support of Space Applications Centre (SAC), ISRO, Ahmadabad. The LISS IV, L3 satellite images are used to classify the mangroves. Ground verification was carried out along the coast to validate the classified satellite images. The changes in the mangrove communities have been studied for the years 2005 and 2020 from the ISRO database. It shows that there has been a substantial increase in mangrove extent, except in Muthupet, where the extent has decreased due to the Gaja cyclone in 2018.

103.4 Water Security and Climate Adaptation (WASCA) in Rural India: Geographical Information Systems Component

The detailed Geographical Information System (GIS) based plan and thematic maps were prepared for the 860 gram panchayats (GPs) of Thiruvannamalai and 429 GPs of Ramanathapuram districts. The ground verification was initiated to verify the plans and understand the current status (exact location using the latitude and longitude of the activity) in the field with the help of rural department engineers. Such plans and actual progress will be uploaded in the The Mahatma Gandhi

National Rural Employment Guarantee Act (MGNREGA) website for the approval of the work by the engineers. Various thematic maps and analysis of the spatial data were carried out to support the climate resilience model in Ramanathapuram and Thiruvannamalai districts. The GIS based decision support system is being prepared for greening of hillock in Thiruvannamalai and cascade of tanks in Ramanathapuram districts. The GIS WASCA resource centre is utilized effectively by the engineers of the Rural Department for

their day-to-day activities in both districts. The training and capacity building has been carried out in GIS related works in the resource centre. GIS maps will be used to monitor the planned activities in the MGNERGA and will be updated in their site. The WASCA web portal has been developed by the team wherein different spatial and non-spatial data are used for the planning and monitoring of the project which will be accessed by the villagers and decision-makers.

BIODIVERSITY

The project team continued its focus on agroforestry development in Kolli Hills on millet promotion with the objective of increasing income, enhancing nutrition supply for Malayali tribal farm families and ensuring livelihoods and environmental sustainability. Promotion of millet cultivation under Odisha Millet Mission (OMM), production of foundation seeds of millet and value-added products, integrated farming system, every village a biovillage, sustainable livelihood enhancement through empowering tribal women, DBT KISAN Hub, biodiversity conservation on campus and preparation of People's Biodiversity Register were some of the activities undertaken in Biju Patnaik Tribal Agro-biodiversity Centre (BPTAbC), Koraput during the year 2020–21. Community agrobiodiversity conservation activities in Wayanad are categorized under three major subheads: biodiversity conservation; education and capacity-building programmes for conservation and sustainable utilization of biodiversity; and biodiversity-based food and nutrition security. The interventions encompass 6000 families across 50 revenue villages in 6 districts of Kerala.

201 Community Conservation Programme in Kolli Hills	25
202 Biju Patnaik Tribal Agro-biodiversity Centre (BPTAbC), Koraput	28
203 Community Agrobiodiversity Centre, Wayanad	36



Sub Programme Area 201

Community Conservation Programme in Kolli Hills

During this year, multistory mixed farm (MSMF) development, millet-based farming systems research, processing and value-addition activities and value chain development, nutrition and health awareness actions and training programmes were also taken up.

201.1 Integrated Tribal Livelihood Enhancement through Agroforestry

Second-year phase activities were carried out for the MSMF in over 500 acres, such as procurement and distribution of plant saplings for Batch II farmers, maintenance of WADI - Mini Orchard farms, training on application of organic manure, biopesticides, insecticides and biofungicides ploughing, layout designing, pegging and digging of pits, filling of pits and planting, basin weeding, fertilizer application and spraying, shading, staking, mulching and irrigation. Over 15000 saplings of main crops (jackfruit, mango and acid lime); 6259 of nutri-dense plants such as sapota, pomegranate, amla, guava and moringa; 15000 of border crops such as silver oak; and 104000 of CO4 grass slips fodder were planted by tribal families on their farms. About 300 metric tonnes (MT) of farmyard manure, 8.50 MT of neem cake and 250 litres of oil were used by the farmers in 500 acres as part of soil nutrient management and plant protection. Several best practices in agroforestry development were imparted such

as ploughing for intercropping of nutri-dense crops, layout and pegging of pits, digging of pits, filling of pits and planting, basin weeding, fertilizer application and spraying, shading, staking, mulching and life-saving irrigation that covered over 15250 person-days of work. Participants maintained a higher survival rate (80 per cent or more) of crops such as jackfruit, mango and acid lime. Millet cultivation promoted as intercrop in the WADI farms ensured food security of the families. About 180 families who adopted intercropping of millets in WADI harvested 15500 kg of millets. Seventy per cent of this was consumed and the remaining sold at Rs 30/kg. This provided additional income to the families. Significant effort was made to conserve soil and water through development of compartmental bunds, trenches and V bunds in 250 acres. Mini percolation ponds dug over 110 locations in common wells created in six tribal settlements helped in the water supply for crops and villages. Nutritional awareness along with supply of seeds of tomato, chilli, green leafy vegetables, lady's finger, ribbed gourd and bitter gourd has helped tribal farm families to grow vegetables in their immediate vicinity and has led to increased consumption. Sanitation awareness campaigns were extended to villages to bring about behavioural change. Eighteen producer groups were formed this year, and they held 16 training programmes benefitting about 1056 tribal men and women farmers. Eight community nursery units were successfully established, and they initiated sale of 8700 pepper cuttings at the rate of Rs 10 each and 850 coffee seedlings at the rate of Rs 8 each.

201.2 Enhancing Farmers' Income and Livelihoods through Millet-Based Farming Systems

A National Agricultural Science Fund (NASF) - ICAR supported project on farmer-led extension strategy for enhancing farmers' income through millet-based farming systems in hilly and tribal areas is being implemented in Kolli Hills in Tamil Nadu and in the Koraput Eastern Ghats of Odisha. In Kolli Hills, among Malayali tribes, around 75 per cent of farmers are marginal, 15 per cent small, 5 per cent medium and large and the remaining 5 per cent landless. Koraput district in Odisha was notified as an aspirational district having more than 70 per cent small and marginal farmers, and with 83 per cent of its population living below the poverty line. The dominant tribes here are Paroja and Bhumia.

Millet farmer facilitators: Selection of millet farmer facilitators (MFFs) was one of the core activities to render extension services effectively. For this, fellow farmers in each village were asked to nominate three or four farmers as leaders who supported them voluntarily in adopting good agricultural practices. Thereafter, each group member was asked to offer his opinion on two such nominated volunteers by writing their names in a folded piece of paper, in confidence. Their opinions were considered, and the person who got the higher number of positive opinions from the group members was selected. In this manner, a total of ten MFFs from both sites (five from each) were selected. Every volunteer farmer has their own special attributes such as

leadership quality, which attracts and motivates fellow farmers towards development activities. Therefore, attributes of the selected MFF were studied based on the group members' perception. These attributes were ranked on the basis of their relevancy coefficient estimated by quantifying the opinion of the fellow group members. It is revealed that the information-seeking behaviour of an MFF was ranked first followed by their innovativeness coupled with motivating nature ranked second and their good communication coupled with practical advice ranked third. These activities can be taken into consideration while selecting such volunteer farmers.

Improved millet technology and allied farming through MFFs

To assess farmer-led extension services of the selected MFFs, a total of six millet-based technology interventions were selected involving MFFs. These are as follows:

1. *Varietal demonstration:* Results of 25 demonstration plots show that the average grain yield of the traditional variety (Suruttai Kelvaragu) was 11.38 quintal/ha and that of CO15 (an improved variety) was 13.40 quintal/ha. This has resulted in 34 per cent additional net income from cultivating the improved variety.

2. *Technological interventions using a system of millet intensification:* Results of 25 demonstrations indicate that the average grain yield was 16.66 quintal/ha following the system of millet intensification (SMI) method compared with 13.4 quintal/ha using farmers'

practices, which was 24 per cent higher resulting in 28 per cent additional income.

3. *Line transplanting method*: The farmers received an average yield of 16.03 quintal/ha, which was 20 per cent higher compared with 13.4 quintal/ha with farmers' practices. This resulted in 10 per cent additional income.

4. *Intercropping*: Intercropping millet with pulses in a 4:2 ratio resulted in a grain yield of 17.20 quintal/ha of millet and 4.54 quintal/ha of pulses enabling a net additional income of Rs 11960/ha compared with monocropping of millets. Farmers, especially women, found intercropping with millet most useful as it increases yield in millets and provides pulses for family consumption. This needs to be compared with income from two monocrops.

5. *Dairying*: To enhance income through agriculture-allied enterprises, dairying was introduced. An average increase of 53 per cent in net family income across families was seen, which validates the combined effect of dairying and millet farming in addition to providing employment.

6. *Primary processing unit*: Four millet processing units were established at both the sites comprising of a thresher, destoner, pulverizer, utensils set and micro-oven. Threshing, destoning and flouring can also be done in addition to the preparation of value-added products such as ragi flour, bread, rusk and ragi malt. A few farm equipment such as power sprayers, weeders, seeders and small farm tools were allotted to the farmers to ease farming operations. The millet producer group

is enthusiastic and happy to establish the units in the vicinity of the villages as these facilities will be helpful in their farming and will reduce drudgery in processing millets, especially for women.

201.3 Millet Promotion and Value Chain Development

Establishment of Community Seed Bank:

The Community Seed Bank was established at Sundakadu village, Chiturnadu, of Kolli Hills, and managed by Sri Mariyaman women's farmers' club, to cater to the needs of 250 tribal farm families. This helps farmers access millets seed varieties such as the improved GPU 28, 48, 67 and ML365 and traditional varieties of Surutaikeelvaraku, Sataikeelvaraku and Sundankikeelvaraku. Three improved varieties of finger millets (GPU 67, GPU 28 and GPU 48) were sourced from taluk agriculture departments, and three traditional varieties of finger millets were sourced from millet farmers in Alathrnadu and Gundaninadu of Kolli Hills and distributed to community seed banks after viability tests.

Distribution of farm equipment: Farm equipment such as spade, hoe and sickles were distributed to millet farmers who cultivated millets in the 2020 Kharif season. In Sundakadu, 50 farmers received a set of spade, a hoe and two sickles each.

Establishment of millet processing centre and production and marketing of Kolli Hills Natural Foods: A millet pulverizer was installed in Sundakadu, which is being managed by Sri Mariyaman women farmers'

club. About 250 tribal families from six villages now have access to this processing unit. Millet value-addition training was provided to 25 tribal women farmers to prepare thinai laddu, samai-bajji mix, thinai-payasam mix and samai-uppama mix at Kuchakiraipatti, Kolli Hills. Across Kolli Hills, ten community pulverizer units were installed, and they are managed by women's self-help groups (SHGs) and farmers' clubs at Padasolai, Navakadu, Thirupuliorpuram, Thuvrapallm, Vandalapadi, Semputhuvalavu, Puliampatty, Olaiyaru, Periyakovilur and Kuchakirai patti villages. These facilities resulted in a reduction of travel distance by at least 10–15 km. About 9.3 MT of millets were processed for local consumption. For women, the drudgery involved in manual processing of ragi has been minimized due to this intervention.

Kolli Hills Agro Biodiversity Conservers Federation (KHABCOFED) members are producing and marketing millet valued-added products under the brand name 'Kolli Hills Natural Products' since 2001. About 16 value-added products such as little millet flour, Italian

millet flour, kodo millet, barnyard millet, ragi malt, Italian little millet upma mix, little millet bajji mix, Italian millet payasam mix, Italian millet laddu, ragimurukku and flour and pearl millet flour are being produced and marketed across Tamil Nadu. During the reporting year, 2.430 tons of millets and value-added products were sold.

Sub Programme Area 202

Biju Patnaik Tribal Agro-biodiversity Centre (BPTAbC), Koraput

Promotion of millet cultivation under Odisha Millet Mission (OMM), production of foundation seeds of millet and value-added products, integrated farming system, every village a biovillage, sustainable livelihood enhancement through empowering tribal women, DBT KISAN Hub, biodiversity conservation on campus and preparation of People's Biodiversity Register were some of the activities undertaken during the year 2020–21.

Table 1. *Cost and returns of seed production in Finger millet*

Variety	No. of farmers engaged in seed production		Average Grain Yield (q/acre)		Total seeds produced & Sold (quintal)		Total Production cost (Rs./ Per acre)		Gross return (Rs.ac ⁻¹)		Net return (Rs.ac ⁻¹)		% Increase over local variety	Per acre additional benefit over farmer's practice (Rs)
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020		
KMR-204	129	191	6.75	8.98	110	344	10680	12515	27439	37429	16759	24914	70.47	18096
Arjun	22	40	6.42	7.56	46	56	10468	12042	26097	31511	15629	19468	43.18	12650
Local	48	27	4.46	5.28	--	--	10374	10580	14250	17398	3876	6818	--	--

202.1 Alternative Seed System Model for Production and Supply of Improved Seed Varieties of Millets and Pulses

The project initiated in April 2018 continues production and supply of improved seed varieties of millets and pulses to farmers. Farmers were trained on improved seed production technologies and sustainable livelihood security as economic empowerment was one of the objectives of the project. Koraput and Ganjam districts were selected for certified seed production of finger millet and green gram, respectively. Ten villages of four gram panchayats (GPs) were covered under the project which extended over an area of 196 acres and involved 231 farmers. Foundation seeds of Arjun and KMR-204 were provided to the farmers. The variety KMR-204 recorded an average yield of 8.98 quintal/acre whereas for the variety Arjun it was 7.56 quintal/acre. A total of 426 quintals of certified seeds of finger millet cv. KMR-204 and Arjun varieties were produced, of which 232 quintals were procured by State Seed Production Corporation, Jeypore, at Rs 4168/quintal and the rest was sold locally and to other agencies. The

farmer by growing certified seeds would get an additional income of Rs 800–1000/quintal. The cost and returns per acre in finger millet seed production is shown in Table-1.

Green gram seed production programme was carried out in five villages of two GPs under the Chikiti block of Ganjam district covering an area of 230 acres. The highest yield of 4.4 quintal/acre of IPM 2-14 was recorded in a farmer's field where the average yield obtained was 3.37 quintal/acre. A total of 413.7 quintals of quality seeds of green gram (of which 8.70 quintals were Foundation seeds and 405 quintals certified seeds) were produced. The seeds were procured at Rs. 118/kg for Foundation seeds and Rs. 87/kg for certified seeds by Odisha State Seed Corporation and Siddha Barahi Seed Agency. It has been observed that the yield is significantly increased and pest and disease occurrence is reduced. It has also been observed that KMR-204 is drought resistant. The germination percentage for KMR-204 was 96 per cent and for Arjun it was 93 per cent. The cost and returns per acre in green gram seed production over a period of two years is shown in Table-2.

Table 2. *Cost and returns of seed production in Green gram*

Variety	No. of farmers engaged in seed production		Average Grain Yield (q/acre)		Total seeds produced & Sold (quintal)		Total Production cost (Rs./ Per acre)		Gross return (Rs.ac ⁻¹)		Net return (Rs.ac ⁻¹)		% Increase over local variety	Per acre additional benefit over farmer's practice
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2020	
IPM: 02-14	92	173	4.3	3.37	292	489	10374	11574	35432	29319	25058	17745	31.7	12527
IPM: 02-03	68	--	4.1	--	209	--	9865	10933	33784	--	23919	--	86	--
Local	22	34	2.2	2.3	--	--	8354	8582	12760	13800	4406	5218	--	--

202.2 Every Village a Bio-Village Programme

Every Village a Bio-Village by 2030 programme is structured to achieve UN Sustainable Development Goals (SDGs) 1–8 and 12–15, especially the ZERO HUNGER challenge. The project is funded by Bajaj CSR project and has been implemented in 20 villages of Koraput district. We are pursuing three integrated pathways in this programme: research innovations that are participatory in nature with multidisciplinary scientists and communities; capacity development of 100 youths to function as SDG/bio-village champions; and livelihood innovations to generate employment at grassroots-level institutions such as SHGs and farmer producer organizations (FPOs).

Crop demonstration on sustainable agricultural practices: As a component of bio-village, we introduced sustainable agricultural practices among five promising popular landraces of rice (*Asamchudi*, *Hirakhandi*, *Machhakanta*, *Kalajeera* and *Muktabali*) and demonstrated a yield improvement with 47 farmers cultivating in 9.47 acres during Kharif 2020. Farmers benefited from improved yield cultivating landraces with an average yield of 27.23 quintal/ha and received a net return of Rs 33234/ha following low-input-based sustainable agricultural practices with a B:C ratio of 2:41. This showcases enormous potential to popularize landraces of paddy using sustainable agricultural practices. Similarly, some of the popular landraces of millets were cultivated by the same 47 farmers who cultivated paddy. It was observed that

farmers received an average yield of 18.05 quintal/ha with a net return of Rs 26624/ha following low-input-based sustainable agricultural practices with a B:C ratio of 1:95.

Freshwater aquaculture: This programme was initiated in nine farmers' ponds covering an area of 5.9 acres in a participatory mode. The adjacent pond and dyke areas were used for paddy and vegetable cultivation during the Kharif season and green gram, black gram and vegetable cultivation during the Rabi season. In August 2020, a total of 10000 fingerlings of Catla, Rohu and Mrigal fishes were reared as a composite pisciculture. Farmers were also provided with lime, fish feed, seedlings of papaya, drumstick, banana, amla, custard apple and vegetable seeds for plantation in the pond dyke and adjacent land for the demonstration of integrated aquaculture. The first phase of harvest was completed in all the ponds, and the farmers harvested 412kg of fish as on 10 April 2021. Of this, 20 kg were consumed by the farmer's family, 54 kg were shared with neighbours/relatives and the remaining 338kg were sold within the village. At an average rate of Rs 160/kg, the farmers received a gross benefit of Rs65920. They also undertook integrated farming system and received economic returns from vegetables, green gram and black gram cultivation.

Demonstration of model nutrition garden: Keeping in view the low intake of plant-based diversified food and prevailing high malnutrition in the region, six model nutritional gardens (Swaminathan Poshan Bagicha) were demonstrated in six operational villages with

an average land area of 0.09 acre. Each garden had diversity of crops such as brinjal, tomato, chilli, cauliflower, cabbage, bean, pea, carrot, radish, green leafy vegetables, lady's finger, pumpkin, cucumber, coriander, bitter gourd, ridge gourd, papaya, drumstick and banana. The gardens were established during October 2020–31 March 2021 and were protected by fencing with shade net. The total harvest from all the gardens obtained was 10.13 quintal out of which the farmer families consumed 3.61 quintal and the surplus of 6.52 quintal was sold in the local market with a gross benefit of Rs 35400 over a period of 6 months. About 236 progressive farmers from different parts of Odisha visited the model nutritional gardens. Initial support of vegetable seeds amounting Rs 2750/garden and fruit-bearing plants such as papaya, banana, drumstick, lemon and guava (10 plants each) was provided.

Group-based income-generation activities: Nineteen women SHGs having 10 members each were involved in group-based income-generation activities. Training and demonstrations were organized to build capacity on oyster and straw mushroom cultivation. Inputs such as spawn, polythene, bavistin, lime and so on were provided to initiate the activity. Farm families obtained 1841 kg of oyster mushroom from 808 beds and got a total income of Rs 276150. About 190 women members were engaged in this activity, and the average income per person was Rs 1453 within a period of 3 months. The groups were also involved in value addition to tamarind. Ten pressing machines were provided to support in the making of seedless

tamarind briquettes. The process of value addition is in progress.

202.3 Odisha Millet Mission

A special programme for promotion of millets, 'Reviving Millets in Farms and on Plates', is being implemented since 2017–18. During this year, 1142 farmers covering 114 villages under 14 GPs were mobilized to cultivate finger millet in 596.15 ha during Kharif 2020 and 99 farmers in 12 villages in an area of 18.22 ha cultivated during Rabi 2021 by adopting improved agronomic practices such as SMI and line transplanting (LT) through a series of capacity-building training programmes and exposure visits. The farmers received incentives from the government as prescribed for adoption of different practices, such as Rs. 5000/ha under SMI and Rs. 2500/ha under LT in the first year; Rs 3000/ha and Rs 1500/ha, respectively, in the second year; and Rs 1500/ha and Rs 1000/ha in the third year for adopting the prescribed practices. An amount of Rs 22.67 lakhs was provided to the farmers under this programme during the reporting period. The incentives encourage farmers in adapting new technologies such as SMI and LT in millets. They are preparing and applying biological formulations such as Jibamrita, Handikhata and so on. Use of cycle weeders is also helping in reduction of drudgery, lowering cost of production and producing more tillers per plant. Use of threshers in millet harvesting reduces drudgery in post-harvest processing. The farmers are satisfied as they are getting better income by adopting new technologies. As the average yield increased by 3.54 quintal/

acre, the average income per acre also increased by Rs. 11664.

Crop-cutting experiment: A total of 23 samples were randomly selected from the 1142 farmers for evaluating yield performances. The highest dry grain weight of 6.90 kg/25m² was recorded in the SMI field of Mr Jagatram Bhumia of Gorahandi village amongst all the samples. This worked out to an estimated yield of 27.59quintal/ha. The average yield from all the samples showed 21.09 quintal/ha.

Farmer producer organization: Bamandei Producer Company Ltd (BPCL) was formed with 79 members under the OMM programme in June 2019with a total share capital and membership fees of Rs 24460. It was entrusted with the responsibility of farmers' registration, creating M Pass and facilitating the procurement of finger millet in Kundra block for the first time. A total of 3816 quintals of finger millet were procured through *mandi* from 452farmers. BPCL received Rs 245970 as commission for undertaking the activity.

Custom Hiring Centre and Community Seed Centre: The Custom Hiring Centre (CHC) managed by BPCL is equipped with 10 ragi thresher-cum-pearlers, 47 cycle weeders, 42 tarpaulin sheets, 6 moisture metres, 6 weighing balances, 2 sieves, 1 water pump and so on. The CHC coordinated with many farmers to access the agricultural gadgets in an easy way, which helped in enhancing crop production and reducing drudgery. The Community Seed Centre managed by BPCL got pure seeds of 8 quintals of *Batimandia*, one of the promising local varieties selected

through Participatory Varietal Trial (PVT) which is accessed by the needy farmers. It has been observed that most of the farmers (2859out of 3188) are now aware of improved technologies and the adoption rate of improved technologies in the region has increased by around 90 per cent over a period of 4 years. People have now shifted from subsistence agricultural practices to improved agricultural practices.

202.4 Integrated Farming Systems Model for Income Enhancement of Small and Marginal Farmers

The overall objective of the project is to design and develop land- and aquaculture-based integrated farming system models comprising both crop and non-crop components suitable to the location. This project is being implemented in Boipariguda and Kundra blocks of Koraput district covering around 2000 households.

Aqua-based interventions: A total of 10 aquaculture models (7 individual and 3 community level) involving 37 households were developed during the year covering an area of 8 ha. In each model of 0.80 ha, the pond area is 0.1 ha, and the remaining area is used for paddy and vegetable cultivation during the Kharif season and green gram, black gram and vegetable cultivation during the Rabi season. In August 2020, 14740 yearlings of Catla, Rohu and Mrigal fish were stocked. Farmers were also provided with lime, fish feed and seedlings of papaya, drumstick, banana, amla, custard apple and yam and vegetable seeds for plantation in the pond dyke and adjacent land as demonstration of Integrated Farming System Model (IFSM). The

first round of harvest has been completed in 5 ponds. A total of 255 kg of fish were harvested till 31 March in 5 villages, out of which 99 kg (39 per cent) were used for self-consumption, 19 kg (7 per cent) distributed to neighbours and relatives and the remaining 137 kg (54 per cent) sold within the village at an average rate of Rs. 180/kg. A total of 10 farmers of 10 aquaculture ponds from 9 villages had grown leafy vegetables such as amaranthus, coriander and spinach and seasonal vegetable such as lady's finger, tomato, bush bean, cowpea, cucumber as dyke yard intervention in aqua-model ponds. Green shade nets were supplied for the protection of ponds. The testimonial regarding the benefits of the aquaculture model attracted and inspired 8 more farmers from 8 villages to adopt the same model towards building sustainable livelihoods.

Agriculture-based interventions

Crop-cutting and harvest data collection of paddy: In non-aquatic intervention 190 farmers from 30 villages of 2 blocks were involved in paddy cultivation. In this intervention, cultivation of three high-yielding varieties, namely, MTU-1001, MTU-1010 and Pratikshya, were undertaken with improved agronomic practices. Of the 190 farmers, 116 cultivated MTU-1001, 61 went for MTU-1010 and 13 for Pratikshya. Crop-cutting data were collected from a random sample of 50 farmers (25 interventions and 25 non-interventions) from 19 villages of both blocks. Grain yield was recorded after sun drying for 36 hours.

It was observed that under improved agronomic practices grain yield increased by 16 per cent,

8.5 per cent and 24 per cent for MTU-1001, MTU-1010 and Pratikshya, respectively. The highest yield recorded was 69.70 quintal/ha for MTU-1001. The same farmers were also involved in finger millet cultivation in LT covering an area of 100 acres. KMR-204, an improved variety of finger millet, was selected for this intervention. Harvest data was collected randomly from five quadrates of 2 x 2 m² each in fields of 20 farmers. To compare the data with that of farmers' varieties and using farmers' practices, another data set following the same method was collected from 20 farmers' field of same/other farmers. It was observed that there is increment of 22 per cent yield for KMR-204 as compared with traditional varieties with a highest yield of 28.75 quintal/ha. The same 190 farmers were involved in maize and pigeon pea intercropping covering an area of 47 acres. In this intervention cultivation of NMH-51, a variety of maize, and NTL-30 (Durga), a variety of pigeon pea, was undertaken. Usually, maize was harvested as green cob and pigeon pea is in the process of being harvested. A random sample of harvest data from 20 farmers' plots has been collected in a quadrate of 25 m². It was observed that the majority of the portion (89 per cent) was sold in the local market at Rs. 15/kg. Hence, it has been concluded that maize cultivation is used for economic benefit rather than for household consumption. A total of 127 farmers from 27 villages were involved in green gram and 87 farmers involved in black gram cultivation in rice fallow covering an area of 72.75 acres and 32.75 acres, respectively. Harvesting of both the crop is underway.

Landless families and group activities: As part of livelihood support, 19 women's SHGs with a total of 210 women were engaged in oyster mushroom cultivation. Altogether, 880 mushroom beds were prepared and 2024 kg mushroom were obtained in just 45 days with an average yield of 106.5 kg/group. Out of the total production, 39per cent was used for home consumption and the remaining 61per cent sold within the village at Rs 130/kg. Moreover, 128 straw mushroom beds were also prepared by 34 members from 4 women's SHGs and the process of production is ongoing. As part of sustainable livelihood support to landless families, 1140 rainbow rooster birds were supported to 114 landless households with 10 birds to each household. To enhance the large-scale production and collective marketing of the product through producer groups, six producer groups have been formed with 190 women farmers from 6 villages.

202.5 Sustainable Livelihood Enhancement by Empowering Tribal Women

The project is supported by National Academy of Science, India (NASI), Gol, and has been implemented in four villages in Koraput block of Koraput district. Around 500 tribal women households of the four villages were covered under the project, the objective of which is to empower them through enhancement of sustainable livelihoods.

Improved agronomic practices to enhance productivity in millets and paddy: Demonstrations of SMI and LT trials were

conducted during Kharif 2020 involving 116 farmers for cultivation of four landraces of finger millet in 95.8 acres using improved agronomic practices. The SMI method yielded 6.62 quintal/acre, followed by 5.89quintal/acre under LT and 2.7quintal/acre under broadcasting.

Paddy trials of System of Rice Intensification (SRI) and LT were conducted using three landraces viz. Kalajeera, Machhakanta and Sapur Dhan, in 2.3acres involving 24 farmers. Training on improved agricultural practices was conducted for the participating farmers. Crop-cutting experiments were conducted by marking a plot of 25 m². Biometric observations were recorded in 12 demonstration fields and 12 traditional practice fields. Paddy cultivated using the LT method showed a higher yield of 18.01quintal/acre compared with 13.15quintal/acre using farmers' practice. Machhakanta performed well with 20.9quintal/acre when compared with other varieties.

Capacity building (training and exposure visits): A total of 16 capacity-building training programmes on seed treatment, application of bioinput, demonstration of SMI and LT, use of cycle weeders and integrated pest and disease management were conducted for 603 farmers (male: 302; women: 301). Exposure visits to various demonstration fields of finger millet and paddy were organized for 38 farmers (18 men and 20 women).

Mushroom cultivation as an off-farm group activity: As the project aims at addition of nutri-rich food in their daily diet, 55 members from five women's SHGs were advised to

undertake mushroom cultivation. The SHG members showed keen interest and were trained on oyster mushroom cultivation. They harvested 238 kg of mushroom from 80 beds, of which 192 kg was used for family consumption and rest sold at Rs 120/kg. Members gave priority for family consumption than sale of the mushroom. They expressed their desire to undertake mushroom cultivation on a large scale in the following years.

Convergence with Orissa Rural Development and Marketing Society and other government departments: The project could also merge to achieve the common goal of community development and women empowerment by convergence with government line departments such as the Orissa Rural Development and Marketing Society (ORMAS). It supported the Shabari Producer Group both financially and technically in implementing different livelihood activities. It extended its technical support for value-added jackfruit products such as chips and supported in the marketing of the products. Shabari Producer Group is now processing various millet- and rice-based products and supplying them to Special Jail Authority, Bhubaneswar, on a regular basis.

The ORMAS has been very supportive in livelihood-generating activities. It has also helped in the establishment of a multipurpose building at Machhara. The NASI project, in collaboration with the ORMAS and ICAR - Indian Institute of Soil and water Conservation (IISWC), supported livelihood activities such as providing 750 Japanese quail chicks to

Dangardei women's SHG, Machhara. There is a good demand of such birds in the local market with a high sale rate of Rs 350/kg.

202.6 Conservation Action in the Biju Patnaik Tribal Agro-biodiversity Centre

The Biju Patnaik Tribal Agro-biodiversity Centre (BPTAbC) is a unique garden which is attracting local communities, students and researchers. It has nine subgardens named after the nine major tribes of undivided Koraput district where 384 ethno-medicinal plants have been conserved. The garden is also embedded with in situ conservation of 141 landraces of paddy, 39 landraces of millet and a wild food garden consisting of 62 species of wild fruits, leaf and tuber plants of this region. During this year about 5000 plants of 32 species were propagated and supplied to schools, the forest department, NGOs, traditional healers and individual plant lovers. The garden is well equipped with three poly houses, two shade net houses and a hardening-off centre for propagation of planting materials of local medicinal plants and other genetic resources for community needs. In addition, 50000 saplings of different horticultural species were prepared and supplied to 20 villages of Koraput, Boipariguda, Kundra and Jeypore blocks. Germplasm was collected from different sources under Biotechnology Industry Research Assistance Council (BIRAC) supported nutri-garden project which represents 92 species of 225 varieties of different vegetables, fruit plants, tubers and rhizomes rich in nutritive properties. There are around 4000 medicinal plants

saplings available in the nursery representing 58 species and 3000 fruit-bearing plants of 22 species.

202.7 Grassroot Institution

Panchabati Grama Unnayan Samiti (PGUS), formed in 2002 and a recipient of Equator Initiative Award, has its presence in 16 villages reaching 5000 people of 1086 households covering 65 per cent of the tribal population. It undertook biodiversity conservation activity with 76 varieties of paddy landraces and 18 millet landraces in 6 villages. Besides conservation, it focused on bringing nutritional security in the region by promoting 250 backyard nutrition gardens in 12 villages. The members of PGUS participated in various training programmes organized by the M S Swaminathan Research Foundation (MSSRF) and were also actively involved in plantation activities in collaboration with the Jeypore Forest Division. A total of 7000 trees were planted on the road sides and barren lands around Jholaguda, Nuaguda and Santaliaguda villages.

Sub Programme Area 203

Community Agrobiodiversity Centre, Wayanad

Community agrobiodiversity conservation activities are categorized under three major subheads: biodiversity conservation; education and capacity-building programmes for conservation and sustainable utilization of biodiversity; and biodiversity-based food and nutrition security. The interventions

encompass 6000 families across 50 revenue villages in 6 districts of Kerala.

203.1 Biodiversity Conservation

The Community Agrobiodiversity Centre (CABC) initiated 'Rice Seed Village Programme' for conserving medicinal and aromatic rice varieties. We established 22 seed villages that distributed 925 kg of traditional paddy seeds to 25 farmers. A 10 per cent increase in yield helped the farmers, who preferred to consume the local varieties because of cooking quality, aroma and some perceived health benefits. There is potential for farmers to earn premium price if it is marketed as organic rice with various benefits.

The Centre has conducted in silico characterization of the selected genes responsible for drought and flood tolerance and identified the expression level of it in the traditional rice varieties of Wayanad. The study helped to segregate the genomic data of drought-responsive calcium sensor genes through in silico analysis. This study also identified the level of gene expression of flood-tolerant genes SUB1 A and SUB1 C in traditional rice varieties such as *Chenthadi* and *Veliyan*. The nutritional analysis of eight traditional rice varieties showed that there was significant difference in proximate composition and mineral content in varieties such as *Adukkan*, *Kalladiyaryan*, *Marathondi*, *Chennellu*, *Chomala*, *Chenthadi*, *Mullan Kaima* and *Veliyan*.

Kerala State Council for Science, Technology and Environment (KSCSTE) recognized

Community Agrobiodiversity Centre (CAbC) as a grant-in-aid institution for strengthening the research and extension activities for the conservation and sustainable utilization of bioresources. The Centre has engaged in documenting the homestead agrobiodiversity across Malabar region; chronicled wild food consumed by ethnic communities; and collected germplasms of cultivated and wild species of tubers, pepper, ginger, cardamom and so on. Study of the conservation and sustainable utilization of non-timber forest products (NTFPs) indicates lack of procurement of many NTFP species by co-operative societies and that spread of invasive species and forest degradation have affected the scope of collection of NTFPs in general, thereby severely affecting livelihood security of the Kattunaikka community in Wayanad. M S Swaminathan Botanical Garden (MSSBG) was awarded with Level 1 Accreditation by the ArbNet Arboretum Accreditation Program sponsored by the Morton Arboretum in Lisle, Illinois, in cooperation with American Public Gardens Association and Botanic Gardens Conservation International.

203.2 Education, Communication and Training

The Rural Agricultural Innovators Meet was conducted for promoting rural innovations in agriculture and sustainable development. The potential innovations demonstrated in the event included the technique to produce nutritious microgreens in mud vessels, wooden paddy threshing machines, modified grafting technique in coffee and machines for scaring wild animals to keep them away from

agricultural fields. The meet provided the innovators with an opportunity to showcase their innovations and to interact with scientists and fellow innovators.

‘Every Child a Scientist’ in tribal hamlets:

‘Every Child a Scientist’ (ECAS) is a programme initiated to develop creative learning and to improve inquisitiveness among tribal students and also expose the other student community to biodiversity and environmental concerns. Children belonging to the tribal communities and economically disadvantaged sections are expected to benefit from this programme. To address the increased dropout rates among the Paniya community, an education support programme was initiated and extended to three selected tribal hamlets, with support from Cochin Shipyard. Trained community teachers and tribal education experts interacted with students and offered intensive training sessions. The tribal language based learning system introduced generated considerable interests among educators, academicians and administrators involved in tribal education. A direct target group consisting of 100 tribal students of different hamlets attending the alternate classroom sessions showed interest and enthusiasm towards the learning process. A different pedagogy integrating performing arts such as folk songs, dance forms, drama and theatre with classroom lectures attracted students and created and retained the interest for learning and schooling. This new approach has caught the attention of both educators and administrators of the Wayanad district and other districts with a tribal population. Considering the interest of tribal children in

football, professional football coaching was provided for those children attending school, with the aim to reduce dropout rates; thus, the 'No School, No Football' programme could bring dropouts back to school.

Plant clinics to support farmers: Six plant clinics were established in Wayanad and other districts to support farmers in identifying the diseases and pests causing damage to their crops. This extension service introduced farmers to knowledge and technologies that could improve their production, income and welfare. A total of 30 plant clinics across 6 districts were conducted during the year with expert advice and recommendations to the farmers. The plant clinics helped 200 farmers in the identification of major issues related to pests, diseases and soil fertility. The major diseases noted during the sessions were fungal diseases such as fusarium rots, powdery mildew, Anthracnose, Rhizoctonia roots and so on. The major diseases found in pepper were quick wilt and slow wilt, and the major pests noticed in rice were brown plant hopper (BPH), leaf folder and stem borer, and fall army worm in banana and vegetables. During the lockdown period, plant clinics continued the support to farmers through the online mode. This brought farmers closer to digital technologies and created awareness and knowledge of such technologies in farming.

203.3 Food, Nutrition and Livelihood Interventions

MSSRF started the implementation of a participatory action research programme for

doubling farmers' income through appropriate agro-technologies and market interventions. Increasing costs of production of major crops such as paddy and coffee and declining crop yield due to pest and disease attack (pepper and ginger) have tempted farmers to invest in farming. The project addresses low productivity in agriculture, transfer of innovative farming technologies for enhancing crop (rice, tubers, coffee, pepper) yield, reducing the cost of production, encouraging group farming by women, enhancing the nutritional status of low-income families and promoting farmer collectives for market interventions.

Participatory research in enhancing the yield of major crops: This exercise facilitates the working of farmers with agriculture experts and conducts field-level trials for enhancing crop yield. Yield enhancement interventions cover major field crops such as paddy, tubers, ginger, pepper and so on. Yield enhancement trials in rice were initiated in traditional paddy varieties such as *Valichoori* and *Thondi*. The preliminary result shows an increased yield of up to 20 per cent by adopting new agronomic practices (early transplantation, lower rate of seedlings per hill, increased spacing between plants and lower rate of fertilizers compared with conventional practice) and reduced production cost by 10 per cent with an overall income in the range of Rs 9000–12300/acre. CAbC-MSSRF supplied 1000 high-yielding and disease-resistant varieties of ginger (IISR Varada and local variety Maran) and turmeric (IISR Pratibha and Wayanadan) and 1000 quality pepper vines (IISR Thevam and Panchami) to 200 farmers. An area of 1000

acres was used for the plantation of ginger, turmeric and pepper for yield enhancement. Intensive training was imparted to 300 smallholder farmers in spice cultivation. Awareness on soil health and sustainable management was created among the farmers, and 400 of them received soil health cards issued with recommendations on soil health management. Successful demonstrations on spice cultivation were carried out on 20 selected farmers' fields covering an area of 40 acres. Biofertilizers such as *Trichoderma* and *Pseudomonas* were distributed among the farmers to promote eco-friendly fertilizer methods and the importance of bioinputs for long-term soil health management replacing conventional chemical inputs was emphasized. Biotech KISAN Hub brought together smallholder farmers, agricultural scientists and experts as members. A total of 300 smallholder farmers with 50 per cent tribal farmers as direct and another 3000 farmers as indirect beneficiaries benefited from the Hub learning latest technologies developed in premier national research institutes.

HDFC Bank Parivartan Program on improvement of smallholder farmers' livelihoods: In the context of frequently occurring and large-scale natural disasters in Kerala, the state government is trying hard to bring back the tradition of rice cultivation for climate adaptation and mitigation. CAB-C-MSSRF played a lead role, along with the Department of Agriculture and Farmers' Welfare, in promoting rice cultivation over 100 ha in Alappuzha and Ernakulam districts ensuring physical infrastructure, inputs and

technology and facilitating financial support. Also, a traditional method of rice cultivation named 'Pokkali' was revived in 12 ha of fallow land. The farmers could convert fallow land for paddy cultivation, and it ensured employment and income for them. Fifteen rainwater harvesting systems (10000 litres capacity each) were established in intervention villages, where people faced severe shortage of potable water, and it could cater to the requirements of 15 households throughout the year. Infrastructure facilities for Community Resources Centres (CRC) cum Plant Clinics have been established at Ernakulam, Idukki and Kuttanad and plant clinic sessions conducted across intervention villages. Rural livelihood strengthened by establishing rural enterprises across 5 districts (Table 3)

On-farm and non-farm livelihood support activities in flood affected villages

In order to ensure sustainable livelihoods, on-farm enterprises were promoted across 5 districts. Thirteen families were supported with quail rearing units. A poly-house vegetable nursery facility created for a group of 10 landless women daily wagers as an additional income generating enterprise, which ensured quality planting material for small holder farmers at affordable price. Ten vegetable farming units initiated with women collectives for income generation and ensuring food and nutrition security. Goatery established benefitting 19 families as an income generating farm activity.

As a part of Non farm enterprises, Screw pine handicraft as a rural enterprise provided with

Table 3: *Livelihood Support Activities in Flood-Affected Regions*

Livelihood Activities	Unit	People/Family Benefited	Impact
Raising quails	100	13 families	Additional income for the households, household nutrition
Meat/fish/egg outlet	1	7 women	Market outlet, fair price, additional income, household food and nutrition
Poly house nursery	1	10 women	Additional income, quality planting materials
Vegetable farming	10	105 women	Additional income, household food and nutrition
Goat rearing	2	19 families	Additional income
Cattle feed mixing unit	1	20 women	Additional income, quality fodder
Screw pine handicraft	1	30 women	Employment and income
Stitching studio cum sewing classroom	1	10 women	Skills training, employment and income

a prefab building as common facility centre, infrastructure, training, and market linkages supporting a group of 30 women. A stitching studio and tailoring classroom established for a group of 10 women beneficiaries. Established an outlet for fresh and value added produce of fish/meat to support a 7 member women SHG as an alternate livelihood venture. A group of 20 women supported with infrastructure and machinery required for establishing a cattle feed making unit, ensured income and quality cattle feed to local farmers at affordable price for increasing milk production.

The centre established over 2000 home-nutrition gardens to address malnutrition among vulnerable tribal communities. Home gardening consisted of a package for cultivating leafy greens, other vegetables, pulses, tubers (yam, colocacia and dioscorea) and locally available fruit trees. The study on the impact of home nutrition gardens reveals that tribal households with such gardens were able to consume diverse nutritious foods and

achieve household food security. The Centre provided technology and handholding support for production and marketing of seven herbal and six ginger-based products. A herbal production unit at Pozhuthana has produced and marketed a total of 92 kg of different value-added herbal products and earned Rs 55760, while a ginger value-addition unit marketed 85 kg of ginger-based products and earned Rs 52000 during the reporting year.

203.4 Grassroots Initiatives, Farmer Producer Organization, Wayanad

Wayanad Agri Marketing Producer Company (WAMPCO), with its outlet for 'safe to eat/ organic product' at Kalpetta, procured diverse organic produces namely, coffee, spices, vegetables, minor forest produce, traditional rice varieties, tubers and pulses. During the current year, FPO procured 30000 kg of vegetables, 5500 kg of traditional rice varieties, 400 kg of honey and various value-added products of coffee and spices with a

turnover of over Rs2829559. The activities of FPO directly benefited 350 farmers, including 125 shareholders and over 1000 indirect beneficiaries such as customers. The farmers received a premium price for their produce and ensured a market for their produce even during the COVID-19 pandemic.

203.5 Initiatives Taken to Address Healthcare and Economic Crisis Due to COVID-19

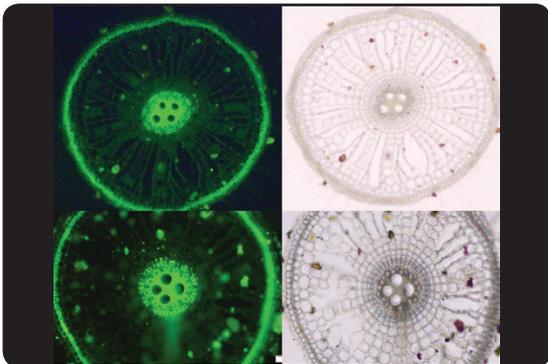
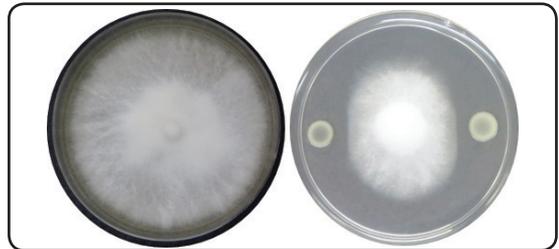
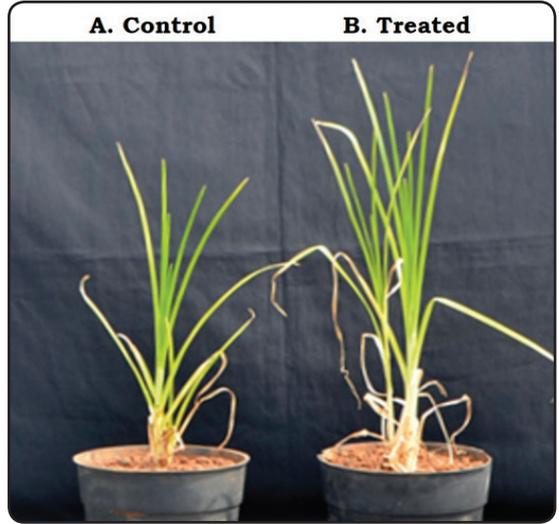
A modified pedal-operated hand sanitizer dispenser (low cost and easily manufactured

using PVC pipes) was developed and distributed (12 in number) for institutional/public use. The Centre conducted a series of awareness campaigns on the COVID-19 pandemic and produced and distributed hand sanitizers, hand wash, face mask and face shields for the benefit of frontline workers of COVID-19 and the general public. It also supported two women's groups consisting of 21 members in the making of double-layered, reusable cotton masks (with a thread count of 240) and distributed 10,000 such masks.

BIOTECHNOLOGY

*The Biotechnology Programme at MSSRF uses cutting-edge biotechnological tools for crop improvement to achieve abiotic stress tolerance, improving nutrition, developing microbial products for promoting crop yield and maintaining soil health and bioprospecting secondary compounds from lichens for suitable applications. The molecular biology research focuses on cell and molecular mechanisms governing the salinity tolerance in halophytic wild rice *Oryza coarctata*. Transcriptomics and Gene Ontology analysis identified differentially expressed genes in leaf and root tissues under salinity. Phenotypic and molecular characterization aspects conferring salinity tolerance to cultivated rice landraces (*Oryza sativa* L.), including the traditional Kagga paddy from the Aghanashini estuary in the west coast, have also been carried out. Lichen diversity was enumerated for assessing ecosystem health and understanding the commercial pressure on non-timber forest product (NTFP) lichens by the Paliyan tribes of lower Palani Hills. Lichen cultures were established to safeguard vulnerable lichen species as well as for the biosynthesis of flavour-conferring secondary compounds of NTFP lichens. The micronutrient mobilizing and plant growth promoting (PGPR) microbial diversity were assessed. The survival of the key PGPR *Pseudomonas* sp. MSSRFD4 was monitored using gene-specific marker-assisted tracer tool. A novel sulfur and nitrogen-fixing saline-tolerant bacteria from mangrove ecosystem has been characterized. The prestigious Biotech-Krishi Innovation Science Application Network (Biotech-KISAN Hub), a mission programme of the Department of Biotechnology (DBT), government of India, New Delhi, has been implemented at MSSRF.*

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Sub Programme Area 301

Genetic Enhancement

Salinity tolerance is a complex and multigenic trait in plant species. Rice, among cereals, is most sensitive to salinity. In this subtheme, mechanisms of tolerance in the naturally halophytic wild rice species *Oryza coarctata* were examined. In addition, the natural variation in salinity tolerance seen in coastal cultivated rice landraces (*Oryza sativa* L.) is being analyzed.

301.1 Studies Related to Salinity Tolerance in *O. coarctata*

Analysis of salt-secretory microhairs of *O. coarctata*: Salt-tolerant wild rice *O. coarctata* leaves show prominent undulations and the presence of salt-secreting microhairs in furrows on the lower surface of the leaf. A method to enrich microhair tissue was developed previously. This was used to generate a transcriptome of the microhair tissue under salinity. A total of 551484 unique transcript sequences with an average length of 631 bp were obtained. The transcriptome data validation by qRT-PCR for both upregulated (10) and downregulated (12) transcripts were completed and found to correlate with RNAseq data. Using the previously established in vitro leaf secretion protocol for *O. coarctata*, the effect of hormones (gibberellic acid (GA₃), its inhibitor (paclobutrazol) and methyl jasmonate) in the presence or absence of salt was examined. Transmission electron microscopy of *O. coarctata* leaf tissues

showed the presence of plasmodesmatal connections between mesophyll cells as well as between mesophyll and bundle sheath cells. Plastoglobuli were observed in chloroplasts.

Transcriptomics (RNAseq) of *O. coarctata* leaf and root tissues: *Oryza coarctata* leaf and root tissue specific transcriptomes (RNAseq) were analyzed previously. Gene ontology (GO) analysis identified 'response to stress' and 'response to chemicals' related terms enriched in differentially expressed genes in leaf and root tissues under salinity.

Examining apoplastic barriers in *O. coarctata* roots under salinity: Microscopic examination of freshly emerged *O. coarctata* roots has previously shown development of strong apoplastic lignified/suberized exodermal and endodermal layers in maturation and elongation zones. This was utilized to examine Na⁺ distribution using the fluorescent dye CoroNa Green. Na⁺ accumulation in the exodermal region of the root was higher in the cytosol in the elongation zone under salinity. In the maturation zone, Na⁺ accumulation was higher in the cell periphery relative to the elongation zone.

Analysis of transporter genes and their regulation in wild rice *O. coarctata*: The cation-chloride-cotransporter (CCC) cDNA was cloned from *O. coarctata* (*OcCCC1*). The open reading frame (ORF) of *OcCCC1* was cloned in the yeast expression vector pYES2 and expressed in the sodium extrusion deficient strain G19. Expression of *OcCCC1* in the presence of either sodium or potassium in the medium was found to confer growth

sensitivity due to accumulation of sodium or potassium within cells.

301.2 Genetic Diversity of Rice Landraces from Saline Coastal Regions of India

We had previously reported about genotyping rice landraces (*O. sativa* L.) from saline coastal regions of India. The relative salinity tolerance of 43 rice landraces at seedling stage, using 13 unbiased morpho-physiological and biochemical parameters related to salinity tolerance, was assessed. Among the 43 rice varieties, 25 were tolerant, 15 were moderately tolerant, 1 was moderately susceptible and 2 sensitive checks were found to be highly susceptible based on standard salinity scoring methods. While salinity significantly reduced growth and physiological traits in all genotypes, lowest reductions were observed in tolerant genotypes landraces such as Katrangi, Orkyma, Pokkali 2, FL478, Hoogla and Talmugur 2. Based on tissue Na^+ , K^+ estimations as well as Na^+/K^+ ratios, Pokkali 2, Orkyma, Nona Bokra 1, Aduisen 1 and Orumundakan 1 were identified as potential novel donors of salinity tolerant genes. Four marker trait associations (RM455-Root Na^+ ; RM161 – shoot and root Na^+/K^+ ratios; RM237-salinity tolerance index) accounted for phenotypic variations in the range of 20.97–39.82 per cent.

301.3 Phenotypic and Molecular Characterization of Saline-Tolerant Kagga Paddy

During 2020–21, the biochemical and nutritional profiling were carried out on the

saline-tolerant 'Kagga' rice. Measurement of length and breadth of brown rice shows 7.4 and 2.8 mm, respectively, and the ratio is 2.64. Intermediate amylose type was observed with 21.95 per cent amylose. The rice grain shows 98 per cent chalkiness with the index value 4. Cooking test indicates that the rice is non-sticky with mild aroma and normal taste and the optimal cooking time is 32 minutes. The rice displayed satisfactory cooked rice volume (390 ml/100g). The texture of cooked rice shows 276.57 g hardness and 10.07 g.sec adhesiveness. Gel consistency measures 82 mm with soft gel. The calculated gelatinization temperature is 71.74°C and the alkali score indicates 2. Other nutritional analyses, such as moisture, fat, protein, fibre, ash, carbohydrate, energy and so on, are yet to be carried out.

Sub Programme Area 302

Bioprospecting

Lichen secondary compounds are considered as potential molecules for future pharmaceutical, agriculture and cosmetological applications. The rich lichen diversity and their secondary compounds and screening them for their potentials form a global research thrust area. MSSRF is currently working on the lichen bioindicators for assessing ecosystem health as well as the pressure on NTFP lichens collected by the Paliyan tribes of lower Palani Hills. Lichen cultures were established to safeguard vulnerable NTFP lichen species. In addition, the biosynthesis of flavour-conferring secondary compounds was triggered in the lichen cultures.

302.1 Bioprospecting of Secondary Compounds

Establishment of lichen mycobiont cultures from vulnerable lichens during NTFP lichen collection: *Diorygma junghuhnii*, *Glyphis cicatricosa*, *Graphis caesiella*, *Graphis scripta*, *Opegrapha submurilosa*, *Phaeographis submaculata* and *Pyrenula astroidea* mycobiont cultures were successfully established. These microlichens are vulnerable to NTFP lichen collection. The molecular identity of these cultures was confirmed by PCR amplification and sequencing of conserved regions of the mitochondrial small subunit (mtSSU) rDNA and nuclear ribosomal internal transcribed spacer (ITS) DNA. The sequence data were confirmed by comparing the existing sequence available at the National Centre for Biotechnology Information (NCBI). These mycobionts are cultured in different media for the biosynthesis of secondary compounds.

302.2 Conservation of NTFP Lichens and Dependent Tribal Livelihoods

The Paliyan tribes of the lower Palani Hills collect certain lichen species as a food-flavouring agent, and this non-timber forest produce provides them a livelihood. This extensive lichen collection impacts lichen diversity as well as associated biodiversity. It also severely hampers ecological functions such as nitrogen fixation by certain lichens. Against this backdrop, the extent of dependency on lichen species for livelihoods by the Paliyan tribes and the impact on lichen diversity because of the collection were assessed. Based on the

results, cultures were established to safeguard the vulnerable species and for the biosynthesis of food-flavour-conferring compounds.

Assessment of the extent of lichen species dependency for livelihoods and its impact on lichen biodiversity: During this year, MSSRF evaluated the intensity of NTFP lichen harvesting in different natural landscapes such as tropical dry evergreen forest (TDEF), plantation area (coffee organic plantation (COP) and non-organic plantation (NOP)), shola forest (SF), riparian forest (RF) and rocky mountain area (RMA) of Kodaikanal block, Dindigul district, Tamil Nadu.

The study highlighted 58 major NTFP lichen species identified from the collections of lichen collectors. The majority of NTFP lichens belong to genus *Parmotrema* with 17 species, and *P. tinctorum* is the major constituent in all the collections. The COP showed highest diversity with 34 species coming under 19 genera followed by TDEF which exhibits diversity with 13 genera and 29 species, also reflected in vegetation indices.

This study established the mycobiont cultures of four NTFP lichens – *P. tinctorum*, *P. reticulatum*, *Heterodermia leucomela* and *Physcia integrata* – and eight vulnerable microlichen species, such as *D. junghuhnii*, *G. cicatricosa*, *G. caesiella*, *G. scripta*, *O. submurilosa*, *P. submaculata* and *P. astroidea*. The High Performance Liquid Chromatography HPLC fingerprint profiles of *P. tinctorum* mycobiont were generated under different media compositions, and the large-

scale biomass production for the extraction and identification of secondary compounds of *P. tinctorum* is under way.

Sub Programme Area 303

Microbial Diversity

Diversity assessment of mangrove-associated dimethylsulfoniopropionate (DMSP) synthesizing and catabolizing bacterial communities contributing to the sulfur cycle is continuing. A molecular marker tracing tool to detect the survival of the *Pseudomonas* sp. MSSRFD41 in field conditions has been developed by targeting the functional marker gene *phIF* of this strain. Microbe-mediated micronutrient biofortification in rice is being evaluated.

303.1 Microbial Community Profiling of Mangrove Ecosystem

Diversity of halophilic dimethylsulfoniopropionate cycling and nitrogen-fixing bacterial communities of South Indian mangrove ecosystem: The study on exploring the DMSP-synthesizing and -degrading bacterial communities of the Pichavaram mangroves of South India continued. Of the total 950 culturable bacterial isolates obtained using selective medium, 110 showed positive amplification of *dsyB*, a marker gene involved in DMSP synthesis. These isolates were further tested for their tolerance to salinity, and ~105 were found to be halophilic in nature, of which 21 isolates that grew at 0.3–0.8 M (or 1.7 per cent) conc. of NaCl were categorized

as slightly halophilic, 82 isolates that grew at 0.8–3.4 M (4.7–20 per cent) conc. of NaCl were categorized as moderate halophiles and 2 isolates were categorized as extreme halophiles as they grew at 3.4–5.1 M (20–30 per cent) conc. of NaCl. Based on 16S rRNA sequence analysis, 11 DMSP-synthesizing isolates were identified as *Labrenzia aggregata*; among the *L. aggregata* the isolate MSSRFCCM36 was slightly halophilic; isolates MSSRFCCM1, MSSRFCCM2, MSSRFCCM3, MSSRFCCM12, MSSRFCCM64, MSSRFCCM65, MSSRFCCM66, MSSRFCCM67 and MSSRFCCM87 were moderately halophilic; and MSSRFCCM84 and MSSRFCCM86 were extremely halophilic. The other moderately halophilic isolates harbouring *dsyB* gene such as MSSRFCCM69, MSSRFCCM74, MSSRFCCM75, MSSRFCCM76, MSSRFCCM77 and MSSRFCCM79 were identified as *Yangia pacifica*, and it was also involved in nitrogen fixation as indicated by the presence of *nifH* gene. This study is the first evidence of nitrogen-fixing gene in DMSP-synthesizing *Y. pacifica* isolated from *A. marina* rhizosphere of Pichavaram mangroves. This particular strain has the potential to fix nitrogen under saline conditions. Another moderately halophile isolate MSSRFCCM21 with *dsyB* gene was identified as *Pseudoceanicola nitratireducens*. The presence of *dsyB* gene, a marker gene in halophilic isolates indicates that DMSP may act as osmoprotectant and help these organisms to survive in extreme saline conditions.

303.2 Bioinoculants for sustainable agriculture

Molecular tracer tool for detecting inoculated Pseudomonas sp. MSSRFD41:

A *Pseudomonas* sp. MSSRFD41 isolated from finger millet rhizosphere and tested extensively for its PGPR and biocontrol activity at field level was evaluated for its survival using a marker gene. A molecular marker tracer tool was developed to detect the strain by targeting the functional gene *phlF* involved in the production of antibiotic 2,4-diacetylphloroglucinol (2,4-DAPG) and reported for the first time in this strain. A newly designed primer pair *phlF41F4/phlF41R* used to amplify the *phlF* gene yielded an amplified product of 240 bp in *Pseudomonas* sp. MSSRFD41 strain but failed to produce any amplification in other pseudomonads as well as other groups of soil bacteria and fungus. Sequence analysis of the amplified product and blast analysis confirmed its identity as *phlF* gene sequence. RT-PCR analysis of soil inoculated with MSSRFD41 showed a single melting curve, similar to the control MSSRFD41 strain, thus indicating the efficiency of the primer to detect the inoculated isolate from the soil DNA. Thus, this tracer molecular marker can be used to detect the colonization efficiency, population density, persistence and survival of the introduced *Pseudomonas* sp. MSSRFD41 in the field based on which the dosage and the time interval of application can be designed.

Isolation and characterization of biocontrol *Bacillus* sp. associated with rice rhizosphere: Parallel to *Pseudomonas*, the *Bacillus* spp.

are also well known for their plant growth promotion and biocontrol potential of soil-borne pathogens. Around 140 Gram-positive bacterial isolates were isolated from 12 rhizosphere soil samples collected from the Villupuram districts of Tamil Nadu by dry and heat treatment method. Based on the morphology and growth pattern they were identified as *Bacillus* sp. Among the total 140 isolates, 24 showed antagonistic activity against fungal phytopathogens *Fusarium oxysporum*. Screening for antibiotic coding synthetase genes involved in production of secondary metabolites such as Bacillomycin (BAMC-F1/BAMC-R1) and Fengycin (FENDF/FENDR) indicated positive amplification in five isolates with product sizes of 957 bp and 269 bp in three isolates, respectively. The presence of AHL-lactonase (Lac F/Lac R) gene in five isolates indicated its quorum-quenching activity. In addition, these isolates exhibited plant growth promoting traits such as solubilizing of macro- and micronutrients, for example, iron (25), phosphate (11), potassium (10) and zinc (2), and production of phytohormone IAA (22).

Biofortification of iron and zinc in rice by using plant growth promoting rhizobacteria:

We continue to undertake research on PGPR-mediated biofortification of micronutrients Fe and Zn in rice, a cost-effective approach to overcome low dietary intake and micronutrient deficiency. Siderophore-mediated iron uptake by micro-organisms has been shown to contribute to plant nutrition under limiting conditions. These low molecular weight biomolecules secreted by iron mobilizing

bacteria chelate iron and convert them to soluble forms. Screening 18 potential iron mobilizing bacterial isolates for siderophore production and type of siderophore indicated that 15 isolates produced hydroxamate-type and 3 isolates produced catechol-type of siderophores. Based on 16S rRNA sequencing analysis, the isolates were identified as follows: MSSRFCCAD1 (*Pseudomonas aeruginosa*), MSSRFCCAD2 (*Stenotrophomonas maltophilia*), MSSRFCCAD7 (*Acinetobacter junii*), MSSRFCCIR1 (*Tsukamurella inchonensis*), MSSRFCCIR31 (*Enterobacter mori*), MSSRFCCCO1 (*Enterobacter cloacae*) and MSSRFCCAS1 (*Bacillus* spp). In the future, we will pilot test for the potential of these isolates to upscale.

303.3 Biotech-Krishi Innovation Science Application Network (Biotech-KISAN Hub)

MSSRF initiated the prestigious ‘Biotech-Krishi Innovation Science Application Network’ (Biotech-KISAN) – a mission programme by the Department of Biotechnology (DBT), government of India, New Delhi – known as the MSSRF Biotech-KISAN Hub. This hub is farmer-centric and addresses the technology needs of small and marginal farmers to generate agriculture and bioresource based livelihoods at the local level by linking them with hi-tech scientific laboratories and institutions in the aspirational districts of the country.

The main Biotech-KISAN Hub at MSSRF, Chennai, is linked with two sub-hubs: sub-hub I at MSSRF-Tribal Agrobiodiversity Centre,

Odisha, and sub-hub II at MSSRF-Community Agrobiodiversity Centre, Kerala. MSSRF is implementing this programme in partnership with ICAR-Indian Institute of Soil and Water Conservation (IISWC), Sunebada, Odisha, and ICAR-Indian Institute of Spices Research (IISR), Kozhikode, Kerala.

This MSSRF Biotech-KISAN Hub mainly focuses on improving farming practices, promoting sustainable use of soil and water and creating access to rural processing technologies, value addition and markets. The project envisages promoting location-specific improved agronomic packages and eco-friendly technologies such as integrated pest management (IPM), integrated nutrient management (INM), soil and water conservation for cultivation of millets in Odisha and pepper, ginger and turmeric in Wayanad, Kerala; promoting post-harvest processing technologies of millet, ginger and pepper; value addition, products preparation, packaging and marketing, record maintenance through Farmer Producer Organization (FPO)/ Self Help Groups (SHGs) and so on. This is achieved through demonstration trials, training and awareness programmes and convergence with hi-tech laboratories, which create a platform for knowledge sharing between farmers and scientist to address location-specific problems. Furthermore, it identifies the leading progressive farmers to participate in developing science-based solutions and for transfer of knowledge to the fellow farmers.

The main Biotech-KISAN Hub, Chennai: A tinkering lab was established at our premises

in Chennai. This pilot facility produces biofertilizers using fermentors and is involved in mass production of arbuscular mycorrhizal fungi (AMF). It will serve as a production cum training unit for farmers and young entrepreneurs. An independent web portal (www.mssrfbiotechkisanhub.org) with updated information on the MSSRF-KISAN Hub, activities and news is being maintained, and the logo for the MSSRF-KISAN Hub has been designed. The main hub serves as the resource centre in coordinating the activities of sub-hub I and sub-hub II implemented in coordination with the partnering institutes.

Due to the surge of the COVID-19 pandemic, online training and workshops on plant and soil health, pest and disease management and use of inoculants were organized for young professionals (YPs) and scientists by the main hub. A physical training session cum workshop on the benefits of biofertilizers and biopesticides and application of bioinoculants as seed treatment, soil drenching and so on was organized for the farmers of aspirational districts of the sub-hub I.

Sub-hub I in three aspirational districts of Odisha: The sub-hub I at Odisha is operating in three aspirational districts: Koraput (K), Malkangiri (M) and Rayagada (R). The project activities have been implemented in a total of 16 villages. Koraput (6 villages): Janiguda, Bariguda, Dangri Maliguda, Sundhiguda, Gurumaiguda and Ektaguda; Malkangiri (6 villages): Amalabhata, Kadaguda, Karadabadi, K. Atalguda, Kandhaguda and Badapa; and Rayagada (4 villages): Tulasichapar,

Haridabhata, Phatagada and Ghatiguda. The baseline survey conducted in these villages indicates soil erosion as a major challenge with nearly 68.55 per cent of the agricultural fields affected by sheet erosion followed by sheet erosion + small gullies (26.29 per cent). We will take up studies to reduce erosion by adopting specific agronomic practices.

During the reporting period demonstration trials using improved variety of finger millet KMR-204, adopting improved agronomic technologies of line transplanting, system of millet intensification (SMI) and intercropping, were conducted. Seed treatment using biofertilizer and biopesticide inputs was demonstrated in 109 farmers' fields (K, 36; M, 58; and R, 15), covering 62.7 acres. The introduction of improved finger millet KMR-204 variety and line transplanting resulted in increased yield by 27.99 per cent in Koraput, 14.62 per cent in Malkangiri and 21.90 per cent in Rayagada and increase in farmers' income by 142.8 per cent, 159.2 per cent and 289.2 per cent, respectively. Awareness on in situ moisture cultivation practices has been created among 716 farmers (K, 264; M, 206; and R, 246). Overall, 1445 tribal farmers (668 women (K, 211; M, 262; and R, 195) and 777 men (K, 246; M, 294; and R, 237)) were oriented to adopt the improved cultivation practices of millet by creating awareness, conducting capacity-building training programmes and initiating exposure visits to the demonstration trial fields.

The following training programmes were organized in sub-hub I. A two-day exposure

visit for 45 progressive farmers (men: 35; women: 10) from the three aspirational districts to the demonstration field at Koraput was organized. One-day training on 'In-situ Moisture Conservation Technology for Enhancing Productivity' was conducted at ICAR-IISWC. Training cum workshop on Soil Health Card scheme was organized for the farmers and YPs. Around nine scientist-farmer interface training programmes on plant health, soil health, use of bioinputs and so on were organized. Around seventeen scientist immersion programmes were organized, and YPs and scientists from MSSRF and IISWC visited the villages and interacted with the farmers to understand their problems and provide viable solutions.

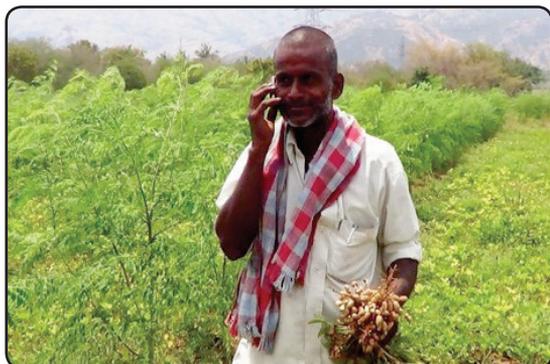
Sub-hub II in aspirational district of Wayanad, Kerala: Sub-hub II in the aspirational district of Wayanad is working in five villages, namely Noolpuzha, Pozhuthana, Pulpally, Panamaram and Padichira, and is focusing on the promotion of improved varieties of pepper, ginger and turmeric. Overall, 300

farmers covering an area of 1000 acres were trained on improved cultivation practices of pepper, soil nutrient analysis, pest and disease management, soil sample collection and so on organized by the MSSRF-CAbC Centre, Wayanad, in collaboration with ICAR-IISR. Primary surveys were conducted at selected villages to understand the problems in pepper, ginger, coffee and fruit cropping system. During the reporting period, 1000 kg each of improved varieties of ginger and turmeric rhizomes were distributed to 80 farmers. Around 895 improved pepper cuttings of IISR-Thevam and IISR-Panchami were distributed to 60 farmers; 110 *Trichoderma* biocapsule and 102 kg of black pepper micronutrient mix were also distributed. The application of bioinputs reduces chemical fertilizers inputs by 20–30 per cent. Training on pest and disease management in coffee for 40 coffee farmers from Padichira village was conducted in collaboration with Regional Coffee Research Station, Chundale. A total of 50 field visit and 5 scientist–farmer interaction programmes on plant clinic, IPM, INM and soil testing were conducted.

ECOTECHNOLOGY

The programme aims at strengthening rural livelihoods using advancements in science and technology and promoting collective institutions. Last year, we directly reached 15,760 farmers through collective institutions and 37,583 farmers through modern information and communication tools. We facilitated the preparation of Composite Water Resources Management plans across 1,289 gram panchayats and identified 12,02,243 planned work that needs to be implemented as part of Mahatma Gandhi National Rural Employment Guarantee Scheme through convergence with other line departments. In addition, we promoted 30 climate-resilient agriculture models in Ramanathapuram and Thiruvannamalai districts. The study on evergreen revolution continued with its focus on five critical research questions in Tamil Nadu along with an action research for developing a soil management decision tool in Odisha. The International Network of Emerging Libraries (INELI) consolidated its activities, and a final report is being prepared. Five new interventions have been initiated: boosting of pollinator services through ecological intensification, facilitation of bioirrigation by mycorrhiza, development of community of practice for plant health information and practice, capacity building of producer collectives and studying the factors influencing the land-use systems in the Cauvery delta region of Tamil Nadu. The following sections provide a detailed report on the work progress and results.

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Sub Programme Area 401

Sustainable livelihoods and grassroots institutions

401.1 Coastal Agroecosystem: Mannadipet Region, Puducherry

In continuation of the nutri-garden intervention as part of the 'Nutrition Secure Puducherry 2019' programme, a nutrition literacy drive was initiated, which involved 3500 women members. The Innuyir Grama Sangham, a women's collective, has sustained its membership of 315 self-help groups (SHGs). We formed 56 joint liability groups (JLGs) and linked them with local commercial Bank so that they could access credit, and they have now accessed Rs 1.22 crores for economic activities. Of these, 25 JLGs were involved in on-farm livelihoods activities, 13 in non-farm activities and 18 in off-farm activities. The Innuyir Grama Sangham Women Farmer Producer Organization (FPO) empowered the board of directors and its members through capacity building on business plan, marketing strategies and financial analysis. The FPO achieved an annual turnover of Rs 21.86 lakhs in 2019-20. Out of 611 shareholders, 84 per cent of credit was linked to promote livelihoods. The Pasumai Farmer Producer Co. Ltd developed a business plan to increase the business turnover from Rs 18 lakhs in 2019-20 to Rs 1 crore in 2022-23. Recently, it received a grant of Rs 10 lakhs from Agriculture Marketing and Business Centre, Puducherry, to upscale its agribusiness activities.

As a part of the action research to test location-specific sustainable agriculture technology, we completed a study on improving pest regulation and pollination services by adopting the principles of ecological intensification in paddy and okra in Puducherry. The preliminary findings showed that cultivating black gram on the borders of paddy fields reduced yellow stem borer pest incidence by 35 per cent. This was attributed to the enhanced population of lady bird beetles and spiders.

401.2 Semi-arid Agroecosystems: Kannivadi Region, Dindigul District, Tamil Nadu

Capacity building, technology demonstrations, enabling access to financial resources, agribusiness in input and output markets were aimed at strengthening on-farm and off-farm livelihoods using existing financial, social and human capital in the form of farmers'/producers' collectives. The Kulumai Producers Federation (KPF), using a credit support of Rs 265 lakhs, initiated livelihoods such as dairying, goat rearing, agriculture and country chicken rearing. The beneficiaries were primarily agricultural labourers and marginal land-holding women farmers. Four women's SHG eco-enterprises started producing biofertilizers (*Azospirillum*, Phosphobacteria, Potash Bacteria and *Arbuscular Mycorrhizae*), biofungicides (*Trichoderma viride*, *Pseudomonas fluorescens* and *Bacillus subtilis*) and biopesticides (*Beauveria bassiana*, *Metarhizium anisopliae* and *Verticillium lecani*) during the year. They produced and marketed 10 tonnes and 100 litres of bioproducts in solid and liquid forms

respectively, worth Rs 6 lakhs. It generated 900 employment days for women farmers and 1500 farmers applied these products in their fields.

Kulumai Milk Producer Co. Ltd, a subsidiary of KPF, reached an annual transaction of Rs 174 lakhs, providing 35 per cent higher price for its members than local milk vendors. It supplied 65 tonnes of good quality cattle feed concentrate at 7 per cent lesser cost than the products available in the market, thus achieving a 15 per cent reduced production cost. Another FPO, Reddiarchatram Sustainable Agriculture Producer Co. Ltd, working with land-owning farmers, strengthened its input and output market services, credit linkages with formal financial banks and technical advisory support systems by adopting an empowerment approach. It provided cotton and maize seeds, bioinputs and pesticides worth Rs 72.2 lakhs and has collectively marketed products worth Rs 108.05 lakhs. Human capital was built by creating awareness among 15 FPOs in Mobi-MOOC in Dindigul and Karur districts; by initiating a courses on corporate literacy and water management with 3000 enrolled learners; and by developing and disseminating 220 voice mails through mobile networks.

We developed sustainable agriculture models adopting participatory research. In the process of enhancing pollination services in mango and moringa, we employed an ecological intensification approach in partnership with the University of Reading, United Kingdom. A consultative workshop was held with farmers to understand gendered traditional knowledge and practices that enhance or

hinder pollinators. In this process, we identified nine potential associated crops that can be co-cultivated to boost pollinators. We conducted a pollinator survey during the flowering season in 16 mango orchards and moringa fields over February–April 2021 and found that the important insect pollinators for mango and moringa are honey bee, hover fly, stingless bees, housefly and carpenter bees.

401.3 Semi-arid Agroecosystems: Mailam Region, Villupuram District

Pulse-based farming system was institutionalized through the Nallavur Farmer Producer Co. Ltd, which brought in 428 acres and 312 acres of additional land for the cultivation of black gram and groundnut, respectively. The key services facilitated were access to quality seeds and fertilizers and other inputs with timely credit through banks for pulses cultivation and its value addition. The annual turnover for 2019–20 was Rs 55.26 lakh. The FPO has partnered with Tamil Nadu Small Farmers Agribusiness Consortium to build a seed value chain for black gram and groundnut. A seed processing unit and a warehouse with a storage capacity of 500 metric tonnes (MT) was also established.

401.4 Transforming India's Green Revolution by Research and Empowerment for Sustainable Food Supply

A study to understand the drivers, impacts and possible actions for transforming the production

systems from multiple dimensions was undertaken. Parameters such as increasing soil salinity, environmental degradation, changes in land-use patterns, migration of men to non-farm livelihoods and changing aspirations of farm parents are the key drivers for the changing food systems. We observed changes in gender roles and relations; shift to animal husbandry among smallholders; shift to horticulture crops; and changes in agronomic practices to organic methods. We prepared four research manuscripts and policy briefs for publication.

401.5 Capacity Building for the Producer Collectives

M S Swaminathan Research Foundation is serving as the technical support agency for the Tamil Nadu Rural Transformation Project funded by the World Bank. We are working in six districts, namely, Theni, Madurai, Dindigul, Karur, Tiruchirappalli and Namakkal. The district teams facilitated for the COVID-19 assistance package for the 28 producer collectives, producer groups and enterprise groups. We developed training manuals and posters to facilitate producer and enterprise groups, and their field testing and translation to Tamil language has been completed. In addition, nine focus crops and products were finalized along with the value chain to promote producer collectives.

401.6 Study on Causal Factors Influencing Agricultural Land-Use Patterns

The main objective of the study is to understand causal factors for conversion of agricultural

land to non-agriculture use and its impact on food security in Karur, Pudukottai and Tiruchirappalli districts of Tamil Nadu during 2020–21. The survey revealed that 158.4 Ha of land belonging to 300 sample farmers had been converted to non-agricultural uses since 2002 in the sample villages. It further revealed that 17 per cent of the farmers had become landless and 70 per cent were marginal farmers. The driving factors for conversion are scarcity of water for irrigation, increasing climatic risks, water pollution, land degradation, low returns from agriculture, labour scarcity, conversion of adjoining land to non-agriculture purpose and forced sale due to personal reasons.

Sub Programme Area 402

Climate Change and Agriculture

Vulnerability assessment of food production to climate change impacts and a policy analysis in the states of Tamil Nadu and Maharashtra was done based on the state action plan on climate change. A consolidated report was submitted to the Ministry of Environment and Forest and Climate Change. Climate Information Services, medium-range agro-advisories based on weather forecast, were sent to 1,23,806 farmers belonging to six districts. Feedback from these farmers indicated that 72 per cent of them are adopting the given advisories. Case studies with selected farmers showed increased income between 38 and 46 per cent in maize, cotton and vegetables. Furthermore, 16–18 per

cent farmers experienced reduced risks by changing the agronomic practices in sowing, pest management and harvesting.

Building climate resilience through sustainable intensification and agroecological approach was adopted through farmer field schools (FFSs) and field demonstrations for climate smart agricultural (CSA) technologies; farmer-to-farmer linkages for diffusion of technologies; farmer producer collectives for market value chains; and digital tools through Village Knowledge Centres (VKCs) for both continuous capacity building and knowledge management. A horizontal diffusion of knowledge and technologies through 300 champion farmers was promoted. Five VKCs were established with the support of the local partners and panchayati raj institutions. In addition, 10 virtual VKCs were promoted in 10 villages connecting farmers through the information and communication technology (ICT) platform. During the reporting period, we conducted 259 programmes in Assam and Odisha reaching 17251 farmers (men: 12241; women: 5010) employing different digital tools (audio advisories, helplines, social media, phone-in programmes, video conferences, audio conferences, video-based learning, plant clinics and VKC users).

A seed village concept has been promoted to improve the value chain for grains by developing a private sector partnership with farmers, two seed companies and the Assam Agricultural University. During Kharif 2020, farmers produced and marketed 500 tonnes

of paddy seeds. Furthermore, two new FPOs are being promoted in Odisha. About 126 men and women farmers were mobilized and organized into a FPO in October 2020 in Chikrada panchayat, Ganjam district.

A study conducted to assess women's control over decisions regarding household agricultural production with 200 women in Assam and Odisha revealed 62 per cent increase in decision-making by women in agricultural activities after participating in these programmes. Similarly, farmers adopting CSA interventions had increased by 31 per cent in Assam and 61 per cent in Odisha. Surprisingly, the farmers who did not participate in our programme also adopted CSA interventions in Odisha (26 per cent) and Assam (31 per cent). These changes could be due to the intervention of other programmes or due to demonstration effect.

Another study on Water Security and Climate Adaptation in rural India (WASCA), an Indo-German partnership programme, completed the Composite Water Resources Management planning in 1289 gram panchayats in Ramanathapuram and Tiruvannamalai districts. The main objective of the project is 'Climate-Proofing for Future Livelihoods'. We identified a total of 12,02,243 works under public and common lands, agricultural and allied sector development and rural infrastructure to strengthen the water security systems. These projects were executed through the Mahatma Gandhi National Rural Employment Guarantee Scheme in convergence with relevant line departments.

Sub Programme Area 403

Jamsetji Tata National Virtual Academy for Rural Prosperity

The strength and advantage of the modern ICTs that have been appropriately harnessed and facilitated to enable agriculture extension services to smallholders in the pandemic period are discussed in this section.

403.1 Transforming Public Libraries to Lifelong Learning Centres

The library initiative, first of its kind, has been scaled up and implemented in South Asian region by harnessing science and technology development in the sector of public libraries. There are 84 library professionals as part of the International Network of Emerging Library Innovators (INELI) and mentors from 22 states, including Union Territories in India. Out of these, 17 are from six South Asian countries. Also, there are 16 experiential innovators, who are also part of INELI, undertaking the online course.

Leadership building: A total of 22 states in India with 41 public librarians of Cohort 1 and 2 (INELI India) have successfully participated in the online innovative librarian leadership course. Furthermore, 15 public librarians from six South Asian countries, namely, Bangladesh, Maldives, Myanmar, Nepal, India and Sri Lanka, have successfully participated in the online innovative leadership course delivered through the MOOC platform.

Among them, 8 experiential innovators have successfully participated in the online innovative leadership course orientation. In the online curriculum, 13 modules have been hosted in Moodle version 3.1 and delivered on the concept of attitude, skill and knowledge building among the learners.

A total of 13 innovators were recognized in the 'Wall of Fame' of the International Federation of Library Association, and 37 have undertaken 1236 services from April 2017 to March 2021. On the whole, a total of 3,44,893 community members benefitted over a period of 3 years encompassing 9 themes, and 15 public librarians are facilitating a self-sustaining model through their libraries by evolving a dynamic localized network of diverse stakeholders. As part of expanding linkages, the Asia Network of Library Innovators' Foundation has delivered four webinars and evolved state-based children's network for promoting cultural activities and learnings. An impact assessment study was completed on how the community benefitted from the services, and a policy recommendation has been drafted for sharing with the State Department Directors of Public Libraries.

403.2 Village Resource Centres and Village Knowledge Centres

The Village Resource Centres (VRCs) and VKCs are crucial in enabling access to demand-based agro-advisories, information, capacity building and diffusion of technologies. Currently, 3 VRCs and 14 VKCs are functioning at the study sites. Further, the VKCs virtually

connect 415 villages through different ICT tools. These tools, namely, farmers' helplines, audio conferences, video conferences, phone-in programmes, mobile-based audio advisories, video-based learning and advisories through social media have been effectively used to address the queries of the farmers and disseminate appropriate content to users. In total, 436 programmes have been conducted, and these have benefited 20,322 farmers (men: 14,239; women: 6,083).

Online meeting platforms such as Zoom and Goto meetings were found very useful during the COVID-19 lockdown to build the capacity of field-level intermediaries and farmers to ensure their effective access to agriculture extension services. Now, about 1000 farmers can connect to these apps on their own. During this period, 63 online programmes were organized and 2,700 farmers (22 per cent women) participated in them. In addition, the WhatsApp advisories were useful to farmers having android phones. Two WhatsApp groups connecting 364 farmers on a daily basis were created. In the past year, 1209 queries were received from the farmers, who were provided with advisories, and this was effective in helping them create a farmer learning platform.

Soil health management: We tested 350 soil samples, of which 148 (42.8 per cent) showed salinity, alkalinity, acidity and high calcium carbonate content. Of the total samples, 73 per cent showed low available nitrogen, 18.5 per cent showed low available phosphorus and 12.5 per cent had low potassium. We educated 12,560 farmers on balanced application of

nutrients and amendments to improve soil organic matter and biological activities.

Farm schools: At Pasupathikovil village in Thanjavur district, a farm school that facilitates farmer-to-farmer learning is operational. The school trained 1,317 farmers (men: 87; women: 1230) on advanced agriculture practices. Impact assessment has shown that 45 per cent of the farmers who regularly participated in the farm school training harvested higher grain yield of 6.5 MT/ha when compared with farmers who did not participate and who harvested only 5.7 MT/ha in a neighbouring village of the same block. Besides, 30 farmers field tested a new variety, ADT 54, suitable for Samba season with technical inputs from the Tamil Nadu Rice Research Institute, Aduthurai. This variety is resistant to lodging and has good grain quality which is essential to combat the effects of the changing rainfall pattern.

Videos for farmers to promote video-based learning: Two new videos on managing rice leaf folder and organic growth promoter in sustainable agriculture has been produced and shared with farmers. Besides, twelve video clips based on the request of farmers were translated to local languages and shared. The videos were shared in Assam, Tamil Nadu and Odisha through VKCs. We organized 231 video-based learning programmes, and 5,691 farmers (34 per cent women) watched them. An evaluation study shows that 72 per cent of the farmers felt the video was useful, 61 per cent expressed that their knowledge on the particular subject has improved and 42 per cent adopted the technologies and

management practices learnt from the videos in their field.

Plant clinics: During the reporting period, 272 plant clinics were organized; it reached 4,350 farmers (men: 3,357; women: 993) and received recommendations for 4,392 crop samples. During the COVID-19 lockdown, there was a good response among the farmers for the online plant clinics. A total of 120 online plant clinics were conducted, and the farmers could find solutions to their crop problems from their fields. The feedback from the farmers revealed that timely diagnosis and advisories helped them in reducing input costs by 55–65 per cent and enhancing productivity by 12–15 per cent with a net gain in income ranging from 12.5 to 16 per cent.

Picture-Based Insurance Bundled with Picture-Based Advisories for Sustainable and Scalable Risk Management Services

These services were tested across 70 villages in Pudukottai and Thanjavur districts; they involved 350 farmers (~5 farmers/village) and covered paddy and groundnut cultivation. About 60 of the farmers from previous seasons (Seasons 1 and 2) were part of Season 3. The pilot followed agent-led model to ensure quality

images during the season which are critical for insurance payouts. Of the 350 farmers, 155 cultivated paddy and 195 cultivated groundnut. Table 1 provides the details of farmers’ participation in images submitted and advisories provided.

A higher percentage of advisories were issued for paddy at the maturity stage, while for groundnut, it was at the flowering stage. The top 10 samples diagnosed showed bacterial leaf blight in paddy and micronutrient deficiency in groundnut.

The abiotic risks recorded are unseasonal, and heavy rainfall in July–August 2020 and water logging in the groundnut field led to decaying and germination of the pods. Owing to heavy rainfall during the flowering stage, the paddy grain setting was severely affected in Thanjavur. The biotic risks recorded were insect pests, namely, stem borer, leaf folder, horned caterpillar, brown plant hopper and ear head bug, and major diseases included leaf blast, leaf spot, sheath blight, sheath rot, grain discoloration and smut. For groundnut, the major insect pests were spodoptera, thrips, termites, tobacco caterpillar and leaf miner and major diseases were tikka leaf spot, rust

Table 1: *Farmers’ Participation in the Picture-Based Insurance Initiatives*

Location	Total Registered Farmers	No. of Sites	No. of Overview Images Received	No. of Damaged Images Received	No. of Advisory Images Received	No. of Advisories Disseminated	No. of Close-Up Images Sent by Farmers
Pudukottai	250	250	2288	1039	680	975	182
Thanjavur	100	100	1110	159	362	296	94
Total	350	350	3398	1198	1042	1271	276

and root rot. Based on the images received during different stages of crop growth and the percentage of damage, loss assessment was carried out for insurance payouts to the farmers. Of the registered 176 farmers, about 80 per cent received compensation based on the crop damage captured through

images. The learning from the empirical field experiences on picture-based advisories (PBAs) and picture-based insurance (PBI) has potential to extend policy inputs to shift the crop insurance to farmer field scale and cover both biotic and abiotic risks.

Agriculture, Nutrition, Health

This programme focus has been on leveraging agriculture for nutrition and health through research; implementing and demonstrating models at the community level; and advocating with different stakeholder groups. Monitoring of the promotion of nutrition-sensitive fisheries in Odisha by WorldFish was done, and a learning exchange project on the school meal programme in the country was started.

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Sub Programme Area 501

Leveraging Agriculture for Nutrition

This year, we published three papers on our work on mainstreaming the nutrition dimension in agriculture through a Farming System for Nutrition (FSN) approach in international peer-reviewed journals. These papers are: 'The COVID-19 Pandemic Crisis and the Relevance of a Farm-System for Nutrition Approach',¹ 'Nutrient Intake of Rural Households That Participated in a Farming System for Nutrition Study in India'² and 'Farming System for Nutrition – a Pathway to Dietary Diversity: Evidence from India'.³ A review of our programme on the demonstration of FSN approach models by Krishi Vigyan Kendras (KVKs) in Andhra Pradesh and Maharashtra revealed home scientists in all the KVKs used FSN models for nutrition literacy. The KVKs further stated that the nutri-gardens received good response; however, seasonal models are required for nutritional gardens, as suggested by KVKs in Andhra Pradesh.

Sub Programme Area 502

Strengthening Livelihoods and Enhancing Food and Nutrition Security of Small and Marginal Farmers

The project's focus is to promote an FSN approach to improve the livelihood and nutrition

1. <https://doi.org/10.1007/s12571-020-01071-6>.

2. <https://doi.org/10.4236/fns.2021.123022>.

3. <https://doi.org/10.1371/journal.pone.0248698>.

status of small farm households. Covering 1575 households, it is being implemented in all 39 villages of Mathapada gram panchayat (GP) and 8 hamlets of Doraguda GP in Boipariguda block of Koraput district. The FSN interventions promoted in 2019–20 were upscaled during the year.

Crop interventions: The area under the nutrient-dense crops promoted, namely, finger millet, pigeon pea, biofortified rice, maize and orange flesh sweet potato (OFSP), increased during the 2020 Kharif season. The interventions are discussed in the following sections.

Finger millet: We tried five improved varieties of finger millet during 2019, of which KMR-204 and Chilika were preferred by farmers. These two varieties were adopted by 980 farmers and cultivated over 435 acres. We provided seeds for sowing (5 kg/ha) and fertilizers (40 kg N, 20 kg P and 20 kg K per hectare) apart from guidance on improved agricultural practices of nursery raising and line transplanting with proper spacing. A sample harvest was collected from four plots of 2 x 2m from 20 farmers for each variety. Similarly, data was collected from the fields of 20 farmers who cultivated local varieties (Dasara mandia and Bada mandia) using traditional practices. The area and yield data of two improved and local varieties are shown in Table 1.

The average yield of KMR-204 was 61 per cent higher and that of Chilika 69 per cent higher than that of farmers' varieties. Around 70 per cent of the produce was retained by farmers for home consumption, 3–5 per cent kept for

Table 1: **Number of Farmers, Area and Grain Yield**

S. No	Varieties	No. of Farmers	Area (acre)	Average Yield (kg/ha)
1	KMR-204	883	93	1807 ± 290
2	Chilika	97	342	1900 ± 335
3	Farmers' varieties	–	–	1123 ± 468
Total		980	435	

seed purposes and remaining 25–27 per cent sold either in the local market at Rs 25–30/kg or in the open market at Rs 32.95/kg. Sale at the *mandi* was done by a few farmers who had surplus production.

Intercropping of pigeon pea with maize:

Intercropping of pigeon pea with maize in a 1:1 ratio was introduced to increase the availability of pulses. We involved 910 farmers in this experiment which covered an area of 150 acres. Pigeon pea seed NTL-30 (Durga) was provided to farmers at 4 kg/acre and maize seed NMH-51 at 8 kg/acre. We suggested line sowing at 60 x 30 cm for maize and at 60 x 60 cm for pigeon pea with intercultural operations. We also recommended the application of NPK in the ratio of 50 kg:40 kg:30 kg per hectare, that is, half the recommended dosage for each crop with basal application and at different phases of the crop. Harvest data was collected

from 20 farmers. Average production of maize green cob was 3627 kg/ha while that of maize (seed yield from matured cob) was 654 kg/ha; yield of pigeon pea tender pod was 452 kg/ha and seed yield from matured pod was 356 kg/ha. Like in the previous year, the bulk of maize green cob and pigeon pea, both as tender pod and grain, was used for home consumption. Details of the utilization of the produce are given in Table 2.

Biofortified rice cultivation: Following the past year's demonstration of high-protein rice varieties developed by Indian Council of Agricultural Research – National Rice Research Institute (ICAR-NRRI), Cuttack (CR Dhan-310 and CR Dhan-311) and high-zinc variety developed by ICAR-Indian Institute of Rice Research (IIRR), Hyderabad (DRR Dhan-45), 215 farmers cultivated the three varieties in an area of 55 acres. Seeds and technical guidance were provided by the project. Other costs on inputs, such as farmyard manure, fertilizer, pesticides and labour for land preparation, nursery preparation, transplanting, weeding and harvesting, were invested by the farmer. Improved agronomic practices such as line transplanting at 20 x 10 cm with 1–2 seedlings/hill planted at a depth of 3–4 cm, and fertilizer application

Table 2: **Utilization of Produce (in %)**

Crop Type	Household Consumption	Distribution to Neighbours and Relatives	Saved for Seed Purpose	Sale
Maize green cob	70	10	0	20
Maize grain	30	10	0	60
Pigeon pea tender pod	55	10	0	35
Pigeon pea grain	90	0	10	0

of NPK (80 kg:40kg:40 kg per hectare), recommended by the Odisha University of Agriculture and Technology (OUAT), were promoted. *Pratikshya*, a non-fortified and preferred high-yielding rice variety cultivated by farmers, was taken for comparison. Grain yield data from five plots (measuring 2 x 2m each) of each variety was recorded from fields of 20, 10, 5 and 20 farmers for CR Dhan-310, CR Dhan-311, DRR Dhan-45 and *Pratikshya*, respectively, after sun drying for 36 h. Details are given in Table 3.

CR Dhan-310 and CR Dhan-311 had better grain yield compared with *Pratikshya*. Farmers were made aware of the nutritional importance of the biofortified varieties, and seeds have been kept aside for the next cropping season.

OFSP cultivation: Five of the six OFSP nurseries established on farmers' fields in the past year continue to be maintained. Planting materials were supplied to 156 households at Rs0.30 per cutting to grow either in the nutrition garden or on the farm land. Harvest data of 15 farmers from four quadrates (2x2m) were recorded, and the average yield of OFSP tuber was 7.36 metric tonne/ha. Utilization data has also been collected from 50 farmers: around

64 per cent of the produce was used for home consumption, 5 per cent distributed to relatives and neighbours and the remaining 31 per cent sold in the local market.

Pre-Rabi and Rabi crop interventions: Area under horse gram (a high-protein local variety pulse crop of 100–110 days), promoted in fallow land as a pre-Rabi crop, increased to 221 acres from 136 acres in the past year and involved 618 farmers. Each farmer on average cultivated 0.35acre; the yield, however, was not satisfactory as the moisture content in soil went down due to less rainfall in August and September. Green gram cultivation with *Nayagarh local* variety was undertaken on rice fallow land and covered an area of 80 acres and involved 95 farmers, an increase from 60 acres with 77 farmers in the past year. Harvesting has just begun.

Nutrition garden: One of the core interventions of the project is natural fortified vegetable cultivation in nutrition gardens for household consumption. Keeping this in view, 1433 households were supplied with fruit-bearing plants such as lemon, guava, custard apple, pomegranate, banana and amla; and seeds of seasonal vegetables, such as amaranthus,

Table 3: **Number of Farmers, Area and Grain Yield**

S.No.	Varieties	No. of Farmers	Area (acre)	No. of Farmers' Fields Taken under Crop Cutting	Average Yield (kg/ha)
1	CR Dhan-310	132	33	20	4517 ±654
2	CR Dhan-311	61	16	10	3723 ±631
3	DRR Dhan-45	22	06	05	3280 ±280
4	Pratikshya	–	–	20	3654 ±760
Total		215	55		

spinach, coriander, Indian spinach, bitter gourd, broad bean, pumpkin, cluster bean, ridge gourd, tomato, brinjal and cucumber, in the Kharif season. It was observed that the bulk of the produce was retained for home consumption. Data is being collected regularly for a sample set of households from January 2021 onwards. Due to water scarcity, Rabi season vegetable cultivation was restricted to 444 households who have some life-saving irrigation facilities either in the backyard garden or in the field; the number, however, was an increase from 150 households supported in the previous year. Seeds of seasonal vegetables such as beans, cucumber, bitter gourd, pumpkin, bottle gourd, cluster bean, radish, carrot, ridge gourd, lady's finger, tomato, brinjal, spinach, amaranthus and coriander were supplied to these households. Of these, 220 households were also supported in the first phase with agro-shade net for fencing and water cans for life-saving irrigation. Farmers were trained to practise non-pesticide management by applying two eco-friendly formulations, namely, Handikhata (pot manure) and Jibamrita (miracle microbilculture) for soil and plant health, to grow chemical-free vegetables in the nutrition garden. By using these effective and low-cost formulations, farmers could keep their crops free from pest attack and disease; so far 44 farmers have established bioformulation manufacturing units in their nutrition gardens; more will be established in the future.

According to the farmers, the nutrition garden is making access to fresh vegetables for household consumption easier. During the

COVID-19 lockdown, it was difficult to access the market, but the vegetable requirements could be fulfilled from the nutrition gardens and micronutrient deficiency addressed. Moreover, the farmers are saving money by reducing the expenditure ear-marked for vegetable procurement. They grow chemical-free vegetables as they are using bioformulations instead of chemical fertilizer; it reduces pest and disease incidence and enhances productivity. Besides, the bioformulations can be prepared by farmers at a very low cost and are eco-friendly; therefore, the vegetables grown are suitable for human consumption as they do not contain any toxic substances.

Saba Khillo from Musapadar village stated, 'We have received different vegetable seeds from MSSRF along with other technical guidance and agricultural equipment. Now, we can grow and access fresh vegetables for household consumption. "Makar Murjia from Similiguda village said, 'We are quite happy as we were supported with establishment of the bioinputs, including Handikhata, Jibamrita and vermicompost pits. We are using this in our nutrition garden and access organic vegetables for household consumption. The shade net support makes us motivated to establish nutrition garden across the year as we do not fear open grazing anymore."

Fish farming: The number of freshwater fish ponds increased from 78 (68 individual and 10 community ponds involving 265 farmers) in the previous year to 86 this year (74 individual and 12 community ponds involving 397 farmers). Apart from technical support, lime, fish

yearlings and floating fish were supplied to the farmers. The community ponds involving 323 households are managed by groups such as women's self-help groups (SHGs) and youth clubs in the villages. From the first round of fish harvest in 36 ponds (29 individual and 7 community ponds), farmers harvested 1258 kg out of which 452 kg (35 per cent) was used for home consumption, 45 kg (4 per cent) distributed to relatives and neighbours and 761 kg (61 per cent) sold within the village at Rs 150–160/kg.

Backyard poultry support for the landless:

To enable landless farmers to access nutrient-dense food and for income generation, backyard poultry farming was promoted among 234 landless households. Each household was supported with 10 rainbow rooster poultry birds, a net, feed for a fortnight and medicines along with technical knowledge. Training camps on poultry management, in collaboration with the Block Veterinary Department, were organized before the poultry birds were given.

Nutrition awareness and community hunger fighters:

Nutrition awareness and building community capacity are core components of the project. During the reporting period, several cluster-level awareness programmes were organized. A wall-hanging calendar on balanced diet was developed and distributed to all 1575 HHs. Thirteen cluster-level meetings were held to observe National Nutrition Month during September 2020 in the project villages, and 369 farmers (31 men and 338 women) participated in the programme. The meetings

culminated with a block-level valedictory programme convened in collaboration with the Integrated Child Development Services (ICDS) Project, Boipariguda, at Musapadar village on 29 September 2020. A total of 79 participants (18 men and 16 women) from 35 villages of Doraguda and Mathapada GPs showed active participation. Another 21 participants from ICDS and Odisha Livelihood Mission (OLM) were also involved. The chief attendees were Child Development Programme Officer (CDPO), Boipariguda, as chief guest; ICDS supervisor; and block livelihood coordinator, OLM, Boipariguda. Mrs Ghasamani Dalei, Community Hunger Fighter (CHF), Banuaguda village, attended the programme as guest of honour. Due to the COVID-19 pandemic, the importance of proper understanding of nutrition has increased, particularly in regions dominated by tribal populations as the prevalence of malnutrition was higher there than in urban areas. It was emphasized that nutrition knowledge has to be translated into practice.

To spread the message of nutrition and to reduce hunger, we trained 108 CHFs (59 men and 49 women) on nutrition literacy with three messages including four or five food groups in daily diet for diversity; not leaving a long gap between two meals; and supporting women by sharing household chores to reduce drudgery. A follow-up survey revealed 75 per cent CHFs shared all the three messages with others while 16 per cent shared two messages and 9 per cent shared one message. The messages were shared by both informal and formal

means. We followed and recorded changes in food intake and production by CHF in their households, and their evidence of leadership. Eight focus group discussions (FGDs) with the CHFs revealed 77 CHFs (men: 46; women: 31) participated in the FGDs. A total of 52 CHFs shared information through 66 formal meetings. Approximately 1483 persons were reached by formal and informal means. Focus group discussions revealed that 55 households increased their meal frequency by the members carrying food to their place of work, thereby increasing their number of meals from two to three.

Farmers' field day: A farmers' meet was organized in Musapadar village on 25 March 2021 to obtain feedback from farmers regarding the interventions promoted during the past 2 years and their future needs. A total of 145 farm men, women, CHFs and government functionaries from Agriculture and Block Administration participated in the programme. The chief district agriculture officer (CDAO), Koraput, conveyed his appreciation for the introduction of biofortified rice varieties in the district. Vegetables cultivated for commercial purposes tend to use chemical fertilizer for increasing yield and income, which may have adverse health effects. Therefore, everyone should establish a nutrition garden for household consumption. The block development officer, Boipariguda, appreciated the initiative of the M S Swaminathan Research Foundation to improve the nutrition status of the community. Furthermore, he drew attention to the fact that farmers can avail "*Mo Upakari*

Bagicha" or nutrition garden scheme under the OLM. Mr Dasarath Kirshani, CHF, said that the capacity-building training had helped the farmers with knowledge on the nutritional value of different foods and that an adult should consume half a kilogram of vegetables, including roots, tubers and leafy vegetables, daily, which can be availed from the nutrition garden. Now they can access even pulses for household consumption as they have started maize-pigeon pea intercropping.

Technology support and infrastructure development: An FSN model was established at our Jeypore centre over an area of 0.75 acre as a demonstration plot for awareness purposes. Over 700 farmers, other institute researchers and Community Based Organisations visited the site. Furthermore, to meet the objective of reducing postharvest losses, community drying-cum-threshing yards of size 40.5 x 40.0 feet were constructed in 16 project villages. It is expected that grain loss during drying and threshing will be reduced to some extent and the village community members will benefit from access to a common place for threshing and drying. Twelve mini flour mills were installed in as many village clusters to reduce the drudgery of women in ragi processing and are now being managed and operated by women SHGs. A total of 96 sprayer machines are in use in 47 villages. Support for construction of vermicompost pits was provided to convert a wide range of agricultural residues, such as straw, husk, leaves, stalks, weeds, food processing waste and so on, into compost by earthworms.

Sub Programme Area 503

Promotion of Nutrition-Sensitive Fishery

We monitored a project to promote fishery for nutrition security in Odisha led by WorldFish in seven blocks across three districts: Jagatsinghpur and Naugaon blocks in Jagatsinghpur district; Khaira and Soro blocks in Balasore district; and Gopabandhu Nagar, Khunta and Kaptipada in Mayurbhanj district. Endline survey with 155 households (20 per cent of 774 households of intervention) were undertaken for impact assessment of the programme. The intervention focused on promotion of carp and mola fish culture, accompanied by promotion of cultivation of vegetables and fruits and nutrition awareness. Focus group discussions were conducted with members of two community ponds in each district selected randomly from the 16 community ponds across the three districts. We observed increased production of total quantity of fish per household when compared with baseline across all pond sizes. This demonstrates that better management of fish ponds leads to better fish production and consumption by smallholder farmers,

essentially achieving the main objective of the project.

Sub Programme Area 504

Learning Exchange of School Meal Programme

Global Child Nutrition Foundation (GCNF) is supporting a project on 'Learning Exchange of School Meal Programme in India'. The aim of this initiative is to generate robust momentum among key government stakeholders engaged in delivering the Mid-Day Meals Scheme (MDMS), foster cooperative approach and experiential learning for the school meal programmes and promote peer learning through interactive digital platforms. The project was started in January 2021, and currently we are listing innovations and initiatives in school feeding programmes related to food varieties in the menu undertaken by 20 states in India with monitoring and capacity-building protocols for detailed documentation. Various government departments dealing with MDMS in 20 major states are being mapped and steps taken to develop rapport with the corresponding officials. The activities are likely to be completed by December 2021.

CROSS-CUTTING THEME

CLIMATE CHANGE

The Climate Change group carried out substantial and important policy work and provided policy assistance to the Ministry of Environment, Forest and Climate Change (MoEFCC) in the year 2020–21. It also made significant progress in its ongoing work on the project 'Equity and CBDR&RC in the Context of 2°C Warming – Implications for India' funded by MoEFCC-GEF-UNDP. Another significant achievement for the Climate Change focus area was that the proposal prepared by it for M S Swaminathan Research Foundation (MSSRF) has qualified for the Google AI for Social Good Workshop based on the highly competitive review of the application.

Policy Engagement

Some of the most significant research on policy issues are listed below:

- Between June and July 2020, we reviewed the vision document entitled 'Carbon Neutral Development of Ladakh' as a member of the Expert Group coordinated with the MoEFCC. It brought out the conceptual and practical differences between carbon neutrality goal as promoted by developed countries versus India's focus on carbon-neutral development in ecologically fragile regions.
- We presented our work on 'Climate Change and Agriculture – Impact and Adaptation' in a meeting under the chairmanship of the secretary of MoEFCC on 'Third National Communication Studies on Climate Change Impacts on Agriculture, Urban and Water Sectors' held virtually on 3 July 2020.
- We provided policy and research support to the MoEFCC in preparation of India's Third Biennial Update Report (BUR) to the United Nations Framework Convention on Climate Change (UNFCCC). In a first, M S Swaminathan Research Foundation (MSSRF) has been included as one of the participating institutions in the BUR and provided inputs for the final presentation of India's Third BUR. Specific contributions include international contextualization on the basis of equity and CBDR (Common, but Differentiated, Responsibilities); framing the national circumstances; jointly preparing the executive summary; rewriting extensively sections on (i) climate finance and India, (ii) India's national circumstances with emphasis on equity, human development and smallholders in Indian agriculture, (iii) dramatic slowdown of green technology development in developed countries and its implications, (iv) global contextualization of India's mitigation efforts based on carbon budgets and equity and (v) ensuring clarity and accuracy in key reporting table on mitigation action. We did three rounds of editing of the scientific and policy-related text of the report.
- The team provided critical comments to the MoEFCC on the Intergovernmental Panel on Climate Change (IPCC) second order

draft of Working Group II and Working Group III Sixth Assessment Report. Additionally, for the Working Group III report, we coordinated the review of the draft. The critical comments on both the drafts provided by MSSRF were included in the government of India's review submitted to the IPCC.

- We submitted a policy note on proposed carbon border adjustment in the European Union's Climate Policy.

Google AI for Social Good

The Climate Change group submitted a proposal titled 'Aridification and Adaptation: Paddy Cultivation in the Cauvery Delta' for the prestigious Google AI for Social Good Workshop, and MSSRF received an invitation to participate in the workshop. Understanding the impact of aridification on crop production systems for sustainably improving crop productivity, ensuring food security, enhancing farmer incomes and building farmer resilience to climate change are crucial to studying the impact of global warming on agricultural production. In this proposal, the aim is to develop new tools to determine the impact of aridification and its drivers on paddy crop production and the corresponding coping and adaptation strategies adopted in the Cauvery delta. After the workshop, MSSRF collaborated with professors from IIT-Delhi to submit a proposal titled 'High Resolution Satellite Imagery for Modelling the Impact of Aridification on Crop Production: Paddy Cultivation in the Cauvery Delta' to Google for a competitive evaluation for research support.

Equity and CBDR&RC in the Context of 2°C Warming – Implications for India

The project 'Equity and CBDR&RC in the Context of 2°C Warming – Implications for India' is part of the GEF-Gol-UNDP project titled 'Preparation of India's Third National Communication and Other New Information to the UNFCCC'. It has four broad objectives and subareas of work, namely:

- Annex-I watch – Study of the BURs and National Communications of developed countries for critical review of where they are in terms of meeting their commitments.
- Detailed assessments of the shared social-economic pathways (SSPs), now a critical element in IPCC work (in #SR1.5 as well as upcoming AR6), from a global collective action perspective, including equity.
- Exploring the development-adaptation linkage in an alternate perspective by mapping yield gaps (Yg) in crop production across all major food crops at the district level, the relative climate sensitivity of such production and its relationship to the quantum of the gap.
- Critical review and assessment of the implications and potential of the existing IPCC reports in light of India's needs and challenges in global climate action. While the project is framed in the context of the Third National Communication, all its components provide significant co-benefits in developing inputs into India's position at the negotiations.

A consolidated interim project report was submitted to the MoEFCC documenting the progress made in each of these subareas through four separate reports. A brief description of the analysis carried out in each report and the key policy relevant findings are listed below.

Annex-I watch

We analysed mitigation actions by Annex-I countries to assess the possibility of achieving global net zero emissions by 2050 in a manner consistent with the principles of equity and CBDR&RC. It was done through a review of the BURs of the Annex-I countries and an assessment of where countries stand with respect to their historical responsibility, the ambition and adequacy of their mitigation commitment, and their progress towards meeting the targets agreed to in the Paris Agreement. Quantification was done for the fair share of carbon budget from 1850 and 1990 to global net zero (for 1.5°C and 2°C), cumulative emission commitments implied by Kyoto Protocol target, Cancun Pledges and the Nationally Determined Contributions (NDCs), and the actual emission of these countries from 1990 to 2017. Furthermore, a methodology was developed to assign capability and responsibility scores to Annex-I countries in their climate mitigation actions.

Key policy relevant findings

- Due to the highly inadequate climate action by Annex-I countries between 1990 and 2017, it will not be possible to achieve global net zero emissions by 2050 in

any manner consistent with equity and CBDR&RC.

- Most of the emission reduction from Annex-I countries can be attributed to the economies in transition (EITs) because of the long-drawn-out economic contraction in these countries.
- The 28 non-EIT Annex-I countries have collectively emitted 388 GtCO₂ eq between 1990 and 2017, excluding land use and land-use change and forestry (LULUCF) emissions. These countries, which account for only 13.5 per cent of the global population but 58 per cent of the world's GDP, account for 37 per cent of the cumulative emissions between 1990 and 2017.
- When the UNFCCC was ratified, the countries in this group were responsible for 57 per cent of the total global CO₂ emissions. (The Annex-I countries as a whole were responsible for 72 per cent of the historical emissions before 1990.)
- According to the Fourth Assessment Report (AR4) of the IPCC, the Annex-I countries as a whole were required to reduce their annual emissions by 25–40 per cent at least by 2020 with respect to the base year emissions of 1990. However, by 2017, the non-EIT Annex-I countries had reduced their emissions by only 2.2 per cent with respect to emissions in 1990.
- It can be concluded that the NDCs of the Annex-I countries are extremely inadequate to meet either of the temperature targets in any manner consistent with equity and CBDR&RC.

- Historical responsibility based on the fair share of the carbon budget – 1850 onwards:
 - Of the 43 Annex-I countries, 40 have already exceeded their fair share of the remaining carbon budget from 1850 onwards for a global carbon budget consistent with a 50 per cent probability of keeping the global temperature rise below 1.5°C.
 - Of these countries, 30 have also exhausted their fair share of the carbon budget remaining from 1850 onwards for a global carbon budget consistent with a 50 per cent probability of keeping the global temperature rise below 2°C.
- Historical responsibility based on the fair share of the carbon budget – 1990 onwards:
 - Of the 43 Annex-I countries, 22 have already exceeded their fair share of the remaining carbon budget from 1990 onwards for a global carbon budget consistent with a 50 per cent probability of keeping the global temperature rise below 1.5°C.
 - Of these countries, 20 have also exhausted their fair share of the carbon budget remaining from 1990 onwards for a global carbon budget consistent with a 50 per cent probability of keeping the global temperature rise below 2°C.

Annex - I watch – patenting and technology development

For the interim report, an analysis of the trend in patenting activities in key environment-

related sectors and key renewable energy-generation/enabling technologies (climate change mitigation technologies or CCMTs) in major Annex-I countries was undertaken. Trends in public R&D funding for energy technologies in the major developed countries were also scrutinized.

Key policy relevant findings

- There is a clear slowdown in patenting activity in the major sectors of environment-related technologies such as energy, transportation and buildings post 2011–12. Percentage share of environment-related technologies in terms of total patents has reduced from 11.4 per cent in 2011 to 7.2 per cent in 2016.
- Technological development is concentrated in sectors such as energy and transportation, followed by buildings, waste management and production processes.
- Solar energy, particularly solar photovoltaic technologies, forms a major part of the patent applications for the selected group of countries. It is followed by the contribution of wind, hydro energy and biofuel.
- Patenting activity in the key sectors related to CCMTs is concentrated in developed countries such as the United States, the European Union (28 countries) and Japan along with major contributions from China and South Korea.
- Inventive activity in developing countries such as India is relatively low across sectors and renewable/enabling technologies.

- China performs very strongly in patenting outputs at levels comparable with the developed countries, and in some technologies/sectors it even leads the table in inventive activity.
- The analysis of temporal trends in inventive activity depicts a decline in major renewable energy technologies such as wind, solar thermal, solar PV and biofuels in the post-2011 phase, except in China which has registered growth in almost all sectors and technologies.
- The decline in patenting outputs and public spending on R&D is presaged by the Copenhagen Accord of 2009, which effectively signalled the demise of legally binding commitments by Annex-I countries. A clear and significant slowdown in patenting from the developed world in innovation in green technology has been witnessed since then.
- The role of developments in the global climate regime, especially successive conference of parties (COPs), needs to be examined.
- Calls for carbon neutrality that are not based on holding developed countries accountable for taking the lead in low carbon innovation and technology transfer are counterproductive to principles of equity and CBDR&RC. This indicates an urgent need for developing countries, including India, to find a way to foreground this issue in the negotiations based on the principles of technology transfer laid down in the UNFCCC.

Critical Review of the SSP Framework, Methodologies and Projections

In the interim report it was noted that there were several serious issues with the SSPs, especially those that are considered to provide equitable pathways to 1.5°C and 2°C targets. Among the notable issues with such SSPs that were highlighted in the interim report are: absence of differentiation, grandfathering of past emissions, underplaying the limitations due to the global carbon budget through negative emissions, inequitable assignment of even negative emissions, sanctioning inequitable access to the global carbon budget, reviving the ‘contract and converge’ scenarios of mitigation that are not equitable, problematic linking of global and local climate action and inequitable outcomes for developing countries in basic development indicators even at the end of the century. Further, specific issues with the SSPs from the viewpoint of the modelling methodologies was highlighted. The report also analyzed the SSP1 ‘storyline’ and discussed in depth the inequitable outcomes embedded in the scenarios for limiting warming to 1.5°C and 2°C. Further, it examined the assumptions made and the conclusions drawn in SSP scenarios for India and assessed whether the scenarios adequately account for India’s developmental needs.

Key policy relevant findings

- In the three recent special reports in the AR6 cycle, a very significant part of the discussions of the social and economic impact of climate change, cost of mitigation,

issues of climate adaptation and so on are viewed through the lens of the SSPs. Other approaches and perspectives have been increasingly marginalized and pushed aside.

- A key conclusion of this interim report is that SSPs must be firmly criticized and rejected at the policy level, especially in international negotiations. In the IPCC, effort should be made to ensure that the scope of the findings from SSPs are kept limited and that the SSP findings do not appear as the key element in the Summary for Policymakers for all the reports that will be part of the AR6.
- Among the notable drawbacks of the SSPs from a developing country perspective are:
 - Absence of differentiation: The basis of the analysis of the SSPs does not take account of differentiation between developed and developing countries.
 - Grandfathering of past emissions: The responsibilities of individual countries for past (pre-1990) emissions and current (1990–2020) emissions play no role of any kind in the considerations.
 - Undermining carbon budget through negative emissions: All SSP scenarios try to get past the fact that carbon budgets for the 1.5°C global warming target are very limited by assigning arbitrary amounts of ‘negative emissions’ based on speculative future technological changes that artificially inflate the carbon budget.
 - Inequitable assignment of even negative emissions: Negative emissions are inequitably assigned between developed and developing countries, with developed countries getting a disproportionately higher assignment to obfuscate their overuse of the global carbon budget beyond their fair share.
 - Sanctioning inequitable access to the global carbon budget: The SSP scenarios all sanction inequitable access to the global carbon budget for the Annex-I parties into the future, while severely limiting the carbon space for developing nations.
 - Reviving the ‘contract and converge’ scenarios of ‘equity’: The SSP scenarios systematically try to revive the so-called contract and converge view of equity that has been roundly rejected by most major developing countries as not representative of equity.
 - Problematic linking of global and local climate action: The SSP framework tries to combine mitigation and adaptation by creating feedback systems that can connect mitigation outcomes to adaptation requirements and find interventions that have both mitigation and adaptation co-benefits at the local level. However, it ignores the fact that adaptation efforts will depend on global (and not just local) mitigation action. A consequence of such an approach is to draw the developing countries immediately into mitigation without

adequate assessment of its costs and benefits, even while their adaptation burden will rise due to inaction by developed countries.

- A key finding of this analysis is that an independent effort to create a new scenario framework that takes adequate note of both development and equity considerations is essential. Such an option is difficult to extract from the high complexity by now embedded in all the models. Even if some of these could be implemented, several others would be missing. There is clearly no option to developing an independent global scenario exercise that meets India's policy needs. Such a scenario development exercise must go beyond simple carbon budget frameworks and answer the challenge posed by the SSP framework.

Development Deficits and Climate Change Adaptation:

Yield Gaps in Agriculture For the interim report, the distribution of Ygs and the primary factors contributing to the Ygs of major crops (rice, wheat, maize, sorghum, soybean and pearl millet) across different climatic zones in the country were analyzed. The findings show that there is a significant variation in yield across districts of the country. Second, this variability in yield exists even in districts with similar agro-climatic conditions. Third, the findings on the analysis of the district-level Yg variations show it has significant association with determinants of agricultural productivity such as soil water holding capacity, extent of irrigation, nitrogen use, high-yielding variety and proportion of area under small

and marginal farmers, though the extent of dependence varies with the crop considered.

Key policy relevant findings

- The impact of climate change tends to be confused with the impact of current climate variability in the context of the low productivity of Indian agriculture in the present. Such low productivity very frequently arises, across many crops and regions, not because of climate change, but because of the socioeconomic conditions that have come in the way of increasing productivity.
- Yield gap is a critical indicator of the development deficit in the context of crop production in agriculture.
- India's place as one of top five producers of rice, wheat, maize, sorghum and soybean is secured due to a larger area under cultivation rather than high yield when compared with the other countries.
- India's annual growth rate of yield continues to be moderate or low compared with other major producing countries.
- Crop-wise concentration of Yg across areas under cultivation in different climatic zones indicates that except for wheat and soybean, all other crops have Yg greater than 50 per cent for more than 50 per cent of the area under cultivation.. It is highest for sorghum where 88 per cent of the total area under cultivation has a Yg of more than 50 per cent, followed by maize (83 per cent area under cultivation), pearl millet (67.7 per cent area under cultivation) and

rice (50 per cent area under cultivation), all of which have a Yg more than 50 per cent.

- For sorghum, the semi-arid region accounts for 67.5 per cent area under cultivation and the Yg for sorghum for this climatic region is between 76 and 100 per cent. Furthermore, 37.3 per cent of area under cultivation for maize is in the semi-arid region, and maize in this region displays a Yg between 76 and 100 per cent. Similarly, for pearl millet, arid region accounts for the largest percentage of area under cultivation (32 per cent) with corresponding Yg between 76 and 100 per cent. Dry, sub-humid region accounts for the largest area under cultivation for rice (28.2 per cent area) with Yg between 51 and 75 per cent.
- Currently, a larger proportion of the area under cultivation (for all the crops mentioned above, except sorghum) that concurrently falls under drier climatic condition and that has higher Ygs is also disproportionately located in the low-income states of Bihar, Uttar Pradesh, Rajasthan, Madhya Pradesh, Chhattisgarh, Odisha and Jharkhand.
- The analysis shows that India has high Ygs for various crops spread over a large area under cultivation. Therefore, there exists substantial scope for improving crop production, with the help of improved agricultural and land management practices even under current climatic conditions.
- The extent of Ygs of major crops suggests that there exists substantial potential to increase productivity. The prospect of increased production can be determined by the extent of Ygs that needs to be bridged and the extent of area with the specified Yg.
- Prima facie, closing Ygs is one of the most significant adaptation actions to be undertaken.
- Location-specific adaptation can substantially improve yield in most areas even now, thereby not only making up for the gap in productivity but also offsetting the negative impacts of climate change.



MSSRF
@mssrf

Helping one another - how pigeon pea supports finger millet in drought conditions. More in this joint #research paper here: bit.ly/2WVuVqQ #millets #drylands #bioirrigation #science

MSSRF and BGCi launch 'Edible Schools' to connect children to food crops and farm fields

KERALA

MSSRF and BGCi launch 'Edible Schools' to connect children to food crops and farm fields

E.M. Manoj

KALPETTA, JULY 10, 2021 13:06 IST
UPDATED: JULY 10, 2021 13:06 IST

SHARE ARTICLE

The students were also trained in the collection and multiplication of seeds of native wild trees.

MSSRF

"Locust attacks: What India's farming community needs to know"



Prof M S Swaminathan Archives

Padma Shri 1967
Padma Bhushan 1972
Padma Vibhushan 1989

Communication and Outreach

The Communication and Outreach consists of Communication, Library and Information Technology (IT) units which disseminates the details of the various activities being carried out by MSSRF to different stakeholders. Some of the major achievements during the year are as follows:

- Establishment of the M S Swaminathan Archive
- Mina Swaminathan Media Fellowship

MSSRF Archive

We engaged a specialist to archive the documents and collections of Prof Swaminathan. Documents and correspondences of M S Swaminathan and MS Swaminathan Research Foundation (MSSRF) were separately listed and categorized into containers and subcontainers. A total of 814 containers have been created, and these contain over 19000 documents, books, handwritten letters, notes made during seminars/conferences and letters received from various persons. The archive can be accessed at: <https://www.mssrf.org/content/mssrf-archives>. The archive website contains the following:

- Accession records
- Descriptive summary of the archives
- Guidance notes on how to access the archives

Though most of the collections or documents that have been archived were in good

condition, some of them needed preservation because the documents were damaged either by insects or by fungus. An archive conservation specialist visited the archive and undertook the task of its conservation. We are yet to categorize the photo and video/audio archives, which will be taken up soon.

To ensure that the archive is properly conserved and maintained, and accessible to researcher, we propose to donate the material to the archive at the National Centre for Biological Sciences (NCBS) in Bangalore, located on the campus of the University of Agricultural Sciences.

Mina Swaminathan Media Fellowship

The award was instituted by Prof M S Swaminathan in recognition of Ms Mina Swaminathan's work, including development of undergraduate curriculum on gender, agriculture, rural livelihood and development for agricultural universities and contributions to early childhood development which formed the base for ICDS (Integrated Child Development Services), taking the multiple needs of women into account.

Three young journalists, two of them women, are the first Mina Swaminathan Media Fellows, 2020. These journalists, who work in Odia, Malayalam and Tamil media, were mentored on the theme 'Gendered Impacts of COVID-19'. They are Ms Nandhini V, a journalist with *The Hindu Tamil*; Ms Jomol Jose, who writes for The Better India, Malayalam; and Mr Shreekanta Sahoo, working with *Sambad*, Odia.

In Tamil, the fellow narrated the constraints of farm labourers and landless farmers faced during the lockdown and their coping mechanisms. The narration included the loss of employment and income impacting household food security; accessing credit; household food needs; managing loans; caring children and elders; along with their domestic work. The fishing women faced different problems as a result of travel restrictions in selling their fish that impacted their income, other income generating opportunities including health and hygiene issues. Other issues such as access to economic opportunities, psychological issues in managing the household credit flow for food and health expenses of family members.

While in the case of Kerala, the stories focussed on, the pandemic induced restrictions affecting women labourers in the plantation sector particularly, in Idukki, Wayanad, Thrissur, Pathanamthitta, Kollam, Palakkad, Thiruvananthapuram and Malappuram districts with more area under plantation and employing more women workers. The proportion of Differently abled (especially autistic persons) children are high in this region. Declaration of lockdown resulted in shutdown of schools due to which women labourers faced problems in managing such special children. Furthermore, some of the estates were also closed during the lockdown. As a result, many of the labourers lost their employment and income and difficulty in ensuring the household food needs. It also covered the issues of child care and safety, men and women's employment and household food security.

The stories covered in Odisha were diverse in nature. A tale of a resource poor Kandha tribal family affected due to restricted travel and lockdowns. Yet they managed with their minimal resources in their farms to food requirements. Another story covered the malnutrition among women and children, highlighted the importance of nutrition garden in addressing the household gaps in nutrition and the importance of linking Mahatma Gandhi National Rural Employment Guarantee Scheme and promoting backyard nutrition garden among tribal households. Another positive story of uncovering the Odisha Millet Mission empowering women during the lockdowns through the value addition of millet seeds by the women farmers ensuring their economic opportunities and empowering them.

Visit of Chairman, NABARD

On 17 September 2020, Dr G R Chintala, Chairman of NABARD, visited MSSRF, addressed the scientists and staff and said, 'An active interface between research, credit facilities and the farmer is required to take agriculture and rural development forward. Core research is being done by labs but it has to be customized to the farmers' requirement, in terms of what is called action research.' Mr Selvaraj, Chief General Manager of the Tamil Nadu regional office, accompanied the chairman. Prof Swaminathan said, 'NABARD is the most powerful financial instrument in our country to help small farmers and their growth is essential for sustained intensification and diversification of agriculture.' Dr Madhura

Swaminathan, Chairperson of MSSRF, reiterated that while high science was being done by the Foundation, it was very much in partnership with communities to reach the research to them.

Seminar Series

A seminar series was initiated on 20 August 2020, for the purpose of knowledge sharing about all the programme areas. A total of 30 seminars were organized wherein 27 speakers highlighted the work done by the various programmes of MSSRF. Three external speakers were invited for the seminar. Dr Julian Gonsalves, from the International Institute of Rural Reconstruction, spoke on understanding of a wider role for agrobiodiversity in climate change adaptation; food and nutrition security; and climate smart villages as platforms for local adaptation. Prof Tauhidur Rahman, from the University of Arizona, spoke on women's anti-poverty programme in India and presented evidence of its causal effects on gender norms and women's executive function. Dr Abhishek Banerji, a consultant, spoke on the preservation of records and alternatively forming repositories.

Newsletters

Our fortnightly newsletter gives us an opportunity to increase awareness among stakeholders, members and friends about our work. In the past year, we published a total of 16 newsletters which were shared with 2083 subscribers.

Social Media

Social media emerged as an important tool for communication. The Foundation has a strong presence on social media platforms such as Twitter, Facebook, LinkedIn, Flickr and Instagram to disseminate information regarding its activities and send out messages to its stakeholders. We have received encouraging responses to our regular posts, that is, messages, photos and videos. The following are the links to our social media pages:

<https://www.facebook.com/mssrf.org>

<https://twitter.com/mssrf>

<https://www.linkedin.com/company/ms-swaminathan-research-foundation>

https://www.instagram.com/mssrf_official/

MSSRF's COVID-19 Response

In the wake of COVID-19 pandemic and the lockdown induced by it, the M S Swaminathan Research Foundation started engaging with their stakeholders to provide relief in its own capacity – from providing basic necessities to the underprivileged and its partners such as farmers and fishing community supplying protective gear like masks and assisting awareness campaigns on social distance and mask. Some of the measures taken by our different divisions are as below:

Coastal Systems Research Programme Area

The Coastal Systems Research Centre supported 1500 vulnerable fisher families towards livelihood, health, and nutrition during the COVID-19 pandemic to overcome livelihood challenges. Fish for All Research and Training Centre has initiated a COVID-19 response program to help the poor- vulnerable fishing communities cope with the pandemic situation and lead a normal life.

As part of the program, the Centre has identified 20 fishing villages in Ramanathapuram, Pudukottai, and Mayiladuthurai districts of Tamil Nadu coast. It provided two COVID-19 responses packages i.e. Health and Livelihood package. The Center has benefitted 15000 families through health and livelihood support programs and provided them a supporting hand to combat the challenges of the pandemic.

Under the Health package, the team at the Centre provided biofortified food rich in

minerals and vitamins to 5000 households focusing on women, elderly fishers, and children. In addition, the team distributed around 55000 double-layered masks and 1000 litres of hand sanitizers to 10300 households.

Under the Livelihood package, the team provided 50 litres of ice boxes to 500 women fish vendors and small craft fishers for the hygienic transportation of fishes from the landing Centre to the market places to avoid contamination of fish.

A total of 15 Videos, audio conferences, and phone-in programs were conducted through Village Knowledge and Resource Centres on different topics to create awareness about the regulations for fishing in the COVID-19 situation.

Biodiversity Programme Area

A modified pedal-operated hand sanitizer dispenser (low cost and readily manufactured using PVC pipes) was developed and distributed (12 numbers) for institution/ public use. The Centre conducted series of awareness campaigns on 'COVID-19 pandemic, produced and distributed hand sanitizer, hand wash, face masks, and face shields for the benefit of frontline workers of COVID-19 and the general public. The Centre also supported two women groups consisting of 21 members to make the double-layered, reusable cotton mask (with 240 thread count) and distributed 10000 such masks.

Ecotechnology Programme Area

The Ecotechnology's district teams engaged in COVID-19 assistance package for the 28

producer collectives and enterprise groups in six districts: Theni, Madurai, Dindigul, Karur, Trichy, and Namakkal in Tamil Nadu.

During the lockdown, some online meeting platforms such as Zoom and Goto were used to build the capacity of the field level intermediaries and the farmers to ensure their adequate access to agriculture extension services. There were 63 online programs organized in which around 2700 farmers (22 per cent women) participated. In addition, the WhatsApp advisories served usefully to farmers with android phones. The team on the ground created two WhatsApp groups in which 364 farmers were members. Our team

communicated with them daily. In the last year, farmers made 1209 queries to get advisories. The platform effectively served as a farmer to farmer learning platform.

Besides, farmers also responded to the online plant clinics. Our team had conducted 120 online plant clinic meetings, and it proved helpful to the farmers to get solutions for their crop's problem from their homes. Later, farmers gave feedback that timely diagnosis and advisories supported them in reducing 55-65 per cent input cost and enhancing 12-15 per cent increased productivity with a net gain in income ranges from 12.5-16 per cent.

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Awards and Recognition

Jayaraman, T. 2021. Member, Technical Advisory Committee, Biennial Update Reports

to the United Nations Framework Convention on Climate Change.

Kartik Charan Lenka, 2021. Prakruti Bandhu Award for the year 2020-21. Department of Forest, Environment and Climate Change, Government of Odisha.

Velvizhi, S. 2021. Women Achiever Award. The Indian Federation of University Women's Association Chidambaram Chapter, Chidambaram.

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The M.S. Swaminathan Research Foundation (MSSRF) was registered in 1988 as a non-profit Trust. MSSRF is recognized by the Government of India, Department of Scientific and Industrial Research, New Delhi, and by the Director General of Income Tax Exemptions, for the purpose of exemption of contributions from Income Tax under Section 80G and sections 35(1)(ii) of Income Tax Act, 1961, read with Rule 6 of Income Tax Rules, 1962. The Ministry of Home Affairs, Government of India, has recognized the Foundation for receiving funds from sources abroad under the provisions of Foreign Contribution (Regulation) Act, 1976.

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Mr. B. Sivakumar, *Electrician*
 Mr. P. Muthukumar, *Electrician*
 Mr. E. Thiruvengadam, *Electrician*
 Mr. T. Krishnamoorthy, *Guest House Caretaker*
 Mr. P. Balaji, *Driver*

DISTINGUISHED CHAIR & FELLOW

Ms. Mina Swaminathan*
Distinguished Chair - Gender and Development
Professor P.C. Kesavan*
Distinguished Fellow

CONSULTANTS

Ms. Priyanka Mohan*
 Mr. P. Senthilkumar
 Mr. P. Sasikumar
 Mr. Dildarkhan Pathan
 Mr. M.K. Pavithran*
 Dr. J. D. Sophia*
 Mr. N. Mohanan*
 Mr. E. Charles Newton Thambidurai*

*left during the year

List of Donors 2020-21

Individual Donors - National

Mr. Samith Kumar Thakur

Individual Donors - International

Dr. Bruce Alberts

Sources of Project Support

Programme Area 100: Coastal Systems Research

National

Tata Power Co Ltd, Mumbai

Indian National Centre for Ocean Information Services (INCOIS), Hyderabad (Ministry of Earth Sciences, Govt. of India)

NTPC Tamil Nadu Energy Company Limited (NTECL), Chennai

National Bank for Agriculture and Rural Development (NABARD), Mumbai and Chennai

ICAR-National Bureau of Fish Genetic Resources, Lucknow

Charities Aid Foundation (CAF) India, New Delhi

Andhra Pradesh State Biodiversity Board, (APSBB)

Space Application Centre (SAC), ISRO, Ahmedabad

International

Mitsubishi Corporation, Japan

Qualcomm, USA

Bluesensus, Germany

ORACLE, USA

International Centre for Environmental Management, Vietnam

Adaptation Fund Board (USA)

Programme Area 200: Biodiversity

National

International

Rashtriya Krishi Vikas Yojana (RKVY), Govt of India, New Delhi

Directorate of Agriculture and Food Production, Govt. of Odisha, Bhubaneswar

Department of Science and Technology (DST), Govt. of India, New Delhi

The National Academy of Sciences (NASI), Prayagraj (Allahabad)

Indian Institute of Rice Research (IIRR), Hyderabad

Kerala Council for Science, Technology and Environment, Govt. of Kerala, Thiruvananthapuram

National Bank for Agriculture and Rural Development (NABARD), Chennai and Thiruvananthapuram

Kerala State Biodiversity Board, Thiruvananthapuram

HDFC PARIVARTAN, Mumbai

ICAR-National Agricultural Science Fund (NASF), New Delhi

Asia-Pacific Network for Global Change Research

Anaha Trust, Bengaluru

ICAR - Indian Institute of Millets Research, Hyderabad

Bioversity International, Italy

Botanic Garden Conservation International, UK

Internews Network, USA

Food and Agriculture Organization of the United Nations (FAO) under

The Global Forum on Agricultural Research and Innovation (GFAR)

National

International

Programme Area 300: Biotechnology

Department of Biotechnology, Govt. of India,
New Delhi

Department of Science and Technology, Govt.
of India, New Delhi

Biotechnology Industrial Research Assistance
Council (BIRAC), Govt. of India, New Delhi

Department of Agriculture, Govt. of Karnataka,
Bengaluru

Programme Area 400: Ecotechnology

VA Tech Wabag Ltd., Chennai

Indian Meteorological Department, Ministry
of Earth Sciences, Govt. of India, New Delhi

GIZ, New Delhi

National Bank for Agriculture and Rural
Development (NABARD)

CABI, New Delhi

Tamil Nadu Rural Transformation Project

Department of Biotechnology, Govt. of India,
New Delhi –Blue Sky Research

Ministry of Consumer Affairs, Dept of Food and
Public Distribution, Govt. of India, New Delhi

Global Challenges Research Fund, University
of Cambridge, UK

Global Challenges Research Fund, University
of Reading, UK

Norwegian Institute of Bioeconomy Research,
Norway

Common Wealth of Learning, Canada

Programme Area 500: Agriculture Nutrition and Health

National

International

State Development Policy Council, Govt. of
Tamil Nadu, Chennai

Global Child Nutrition Foundation

Agricultural Technology Management Agency
(ATMA), Koraput

Others

Ministry of Environment, Forest and Climate
Change, Govt. of India, New Delhi

World Food Prize Foundation, USA

Nature Research, New York

Protection of Plant Varieties and Farmers'
Rights Authority, New Delhi

Karupa Institute of Development Initiatives

World Resources Institute India (Pvt.) Ltd,
New Delhi

State Bank of India foundation Mumbai

National Biodiversity Authority, Chennai

FINANCIAL STATEMENT 2020-21

M.S.SWAMINATHAN RESEARCH FOUNDATION

No.6, Third Cross Road, Taramani Institutional Area, Taramani, Chennai - 600 113

BALANCE SHEET AS AT 31st MARCH 2021

		FOUNDATION		Figs in Rs. Lakhs			
LIABILITIES	Sch. No.	2020-2021 Rs.	2019-2020 Rs.	ASSETS	Sch. No.	2020-2021 Rs.	2019-2020 Rs.
OWN FUNDS				OWN ASSETS			
CORPUS FUNDS	1	166.96	166.96	FIXED ASSETS	4	422.10	449.77
GENERAL FUND & OTHER FUNDS	2	3468.23	3407.33	INVESTMENTS	5	6729.05	6691.56
ENDOWMENT FUNDS	3	4902.82	4854.62	CURRENT ASSETS			
CURRENT LIABILITIES	10	515.03	424.13	CASH & BANK BALANCES	7	1415.23	1188.10
				ADVANCES	8	486.66	523.61
TOTAL [A]		9053.04	8853.04	TOTAL [A]		9053.04	8853.04

		PROJECTS					
LIABILITIES	Sch. No.	2020-2021 Rs.	2019-2020 Rs.	ASSETS	Sch. No.	2020-2021 Rs.	2019-2020 Rs.
PROJECT FUNDS & OBLIGATIONS	4	1461.79	1181.16	PROJECTS RECEIVABLES	9	124.18	104.43
CURRENT LIABILITIES	10	189.75	155.94	ADVANCES	8	484.73	269.03
				BANK BALANCES	7	1042.63	963.64
TOTAL [B]		1651.54	1337.10	TOTAL [B]		1651.54	1337.10
GRAND TOTAL [A]+[B]		10704.58	10190.14	GRAND TOTAL [A]+[B]		10704.58	10190.14

Provisional (Unaudited)

M.S.SWAMINATHAN RESEARCH FOUNDATION

No.6, Third Cross Road, Taramani Institutional Area, Taramani, Chennai - 600 113

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st MARCH 2021

EXPENDITURE	FOUNDATION				Figs in Rs. Lakhs		
	Sch. No.	2020-2021 Rs.	2019-2020 Rs.	INCOME	Sch. No.	2020-2021 Rs.	2019-2020 Rs.
SALARIES	15	506.22	448.74	INTEREST INCOME	11	586.36	605.94
ENDOWMENT EXPENSES	16	41.04	46.72	DONATION	12	181.86	275.12
MEETINGS & OTHER RELATED EXPENSES	17	6.25	17.49	RENTAL RECEIPTS		0.92	07.18
OTHER ADMINISTRATIVE EXPENSES	18	140.30	263.53	MISCELLANEOUS		61.26	42.46
DEPRECIATION ON FIXED ASSETS	5	27.49	32.68				
10% OF ENDOWMENT INTEREST INCOME TRANSFERRED TO ENDOWMENT FUNDS		48.20	51.05				
EXCESS OF INCOME OVER EXPENDITURE FOR THE YEAR TRANSFERRED TO THE GENERAL FUND		60.90	70.50				
TOTAL		830.40	930.70	TOTAL		830.40	930.70

Provisional (Unaudited)



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III Cross Road
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Taramani
Chennai 600 113, India