State of Science, Technology and Innovation Skills for **Sustainability of India's Food and Land-use Systems**

The Food and Land Use Coalition

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Creating Innovative Solutions for a Sustainable Future

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TERI The Energy and Resources Institute
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ABOUT THE REPORT

This scoping study maps the existing information, data and literature on science, technology and innovation (STI) capability, and human resource status and skills requirements in India's large, complex, and diverse agricultural and allied sectors from the perspectives of sustainable food and land use. This is the first time such a comprehensive review has been undertaken. The study covers a broad conceptual range of capabilities and skills components of India's food and land-use systems and maps the relevant actors and government institutions along the various stages of the value chain. It develops a framework to guide the exploration of capabilities and skills in a detailed systematic manner, in order to develop appropriate offers for sustainable food systems. It is hoped that this study will provide a richly informed starting point for further investigations to understand and contribute to research, education, practice, and policy in multiple aspects of capabilities and skills in various areas of government, and the academic and extension systems. Being a multi-sectoral report, it identifies highly disparate but critically important actors/institutions and empirical material. The report does not focus on offering a comparative analysis alone, rather it provides an initial diagnosis, mapping and highlighting gaps in knowledge, given the paucity of reliable data in various institutions. This first comprehensive systematic evaluation of the human resources and skills available for India's food and land-use systems is particularly useful for clarifying the vast boundaries of the sector, identifying research and practice gaps, and exploring the connections. It leads to recommendations for the next steps for policy and research.

ABOUT TERI

The Energy and Resources Institute (TERI) is an independent, non-profit organization, with capabilities in research, policy, consultancy and implementation. TERI has multi-disciplinary expertise in the areas of energy, environment, climate change, resources, and sustainability.

With the vision of creating innovative solutions for a sustainable future, TERI's mission is to usher in transitions to a cleaner and more sustainable future through the conservation and efficient use of the Earth's resources and develop innovative ways of minimizing waste and reusing resources.

TERI's work across sectors is focused on:

- Promoting efficient use of resources across sectors
- Increasing access and uptake of sustainable practices
- Reducing the adverse impact on environment and climate

TERI works with a diverse range of stakeholders across governments, both at the national and state levels, international agencies, and civil society organizations to help deliver research-based transformative solutions. Headquartered in New Delhi, TERI has regional centres and campuses in Bengaluru, Gurugram, Guwahati, Mumbai, Nainital, and Panaji.

ABOUT FOLU INDIA

The Food and Land Use Coalition (FOLU) India platform is a joint initiative between the Council on Energy, Environment and Water (CEEW), the Indian Institute of Management, Ahmedabad (IIM-A), The Energy and Resources Institute (TERI), Revitalising Rainfed Agriculture Network (RRAN) and World Resources Institute India (WRI India). The FOLU India platform works towards developing long-term pathways for sustainable food and land-use systems to help inform policy decisions in the country and beyond.

The FOLU is a self-governed community of more than 60 organizations and individuals committed to the urgent need to transform food and land use for people, nature and climate. The FOLU community supports science-based solutions and helps build a shared understanding to unlock collective, ambitious action towards delivery of globally agreed sustainable development, climate and biodiversity goals. FOLU builds on the work of the Food, Agriculture, Biodiversity, Land Use and Energy (FABLE) Consortium teams which operate in more than 20 countries.

EXECUTIVE SUMMARY

As India strives to find ways of achieving food and nutrition security, ensuring the sustainability of its food and land-use systems, along with the efficient use of natural resources across its diverse agro-ecological regions, is imperative. Achieving this will mean building the capabilities and skills for advancing innovation, diversification, commercialization, sustainability and increased efficiency across the value chain.

Capabilities underpinning sustainable food and land-use systems are influenced by techno-managerial skills as well as linkages between various actors across the food value chain. These linkages call for an interdisciplinary approach and integrated strategies across sectors, as well as an adaptive and responsive governance structure. Anecdotal evidence suggests the capabilities and skills development priorities are inefficiently aligned with sectoral needs, which may impact the profitability, productivity, and sustainability of the food sector. The lack of requisite capabilities and skills for long-term productivity and sustainable management of food and land-use systems is likely to become more severe in the near future unless appropriate strategies are developed and implemented.

In this context, we need an assessment of the capabilities and skills requirements in agriculture and allied sectors in order to understand, plan for and address the emerging challenges and opportunities in the sector. This must be an integral part of agricultural and rural development efforts at national and sub-national levels.

State of Science, Technology and Innovation Skills for Sustainability of India's Food and Land-use Systems provides such an assessment, in an attempt to maximize the sector's positive contributions to providing healthy diets and livelihoods, to minimize its negative consequences for natural resources, and to build resilience to the challenges posed by climate change.

What does this study involve?

This scoping study aims to assess the capabilities and skills in India's agriculture and related sectors in order to underpin its long-term competitiveness and sustainability. To inform policy or actions aimed at addressing agricultural skill shortages and mismatches in the sector, the key issues and skills were investigated through:

- An assessment of the trends in education, research and extension, and in the capacity of the relevant institutions to meet the science, technology and innovation needs of the sector.
- An identification of skill gaps, and suggestions for addressing the gaps through a comprehensive scanning of existing programmes, resources, reports and studies on human resource needs in the food sector.

The report seeks to provide an overview of the literature, data and evidence in order to highlight the varying levels of capabilities and skills requirements across agriculture and allied sectors from the perspective of sustainable food and land-use systems. It aims to increase understanding of the desired capabilities and skills base for innovation and the policies that might enhance their development, and to point to areas for further analysis. To do so the study proposes a framework for capabilities and skills for innovation and sustainability in food systems and along the food value chain. The report concludes with a detailed roadmap for capabilities and skill enhancement for sustainable food and land-use systems.

Key findings

Workforce in S&T

There is a lack of recent studies in the last decade which uniformly quantify the institutional and human capacities (supply and demand of human resources) across agriculture and allied activities. There is also a lack of data on human resources in the private agri-sector, such as institution data on students and faculty, and data on human resources dealing with agricultural inputs, financial institutions, agri-business, social enterprises, etc. Based on the available data, this study finds that:

- The total number of educated and trained personnel in the agriculture sector is far too low as compared to the size of the sector. The unemployment rate is also quite high among this group owing to a mismatch between demand and qualifications.
- The number of full-time researchers was 11,363 in 2018, making India's one of the largest agricultural research and development (R&D) systems in the world. However, there has been stagnation in the number of full-time

equivalent (FTE) researchers per 100,000 farmers, which has been hovering at close to 4 FTEs per 100,000 farmers since 2005, implying too few researchers to cater to the demands of farmers.

- The number of scientists in the Indian Council of Agricultural Research (ICAR) has increased marginally (from around 4,189 scientists in the 1980s to 5093 in 2019-20), but is lower than the sanctioned strength of around 7000.
- There is a gap between the sanctioned and actual posts across various categories of employees in ICAR and its institutes. The shortage of scientific, technical, admin and support staff has risen by 109%, 33%, 37% and 31%, respectively in 2019-20 as compared to 2015-16. Further, vacancy rates of 69% (agriculture biotechnology division), 24% (horticulture division), 3% (crop sciences division) and 1% (veterinary sciences division) were found.
- The effective number of scientists engaged in actual research is a small percentage of the total number of scientists in the agricultural ICAR research system. Many of them spend more time on teaching and administrative tasks. Combined with inadequate funding, this poses a big challenge.
- A decline in scientific strength in the state agricultural universities (SAUs) is due to the failure to replace retiring faculty, combined with government restrictions on recruitment. There is an absence of information on scientists engaged in research in private companies in the areas of seed, fertilizer, food processing, etc.
- Indian higher agricultural education is being held back by inadequate training opportunities; devotion of too much time to administration at the expense of teaching, mentorship and research by senior scientific staff; and inappropriate recruitment policies in SAUs which cater for more localized selection.
- The quality of PhDs has reportedly dropped due to a lack of rigour in research. This is a serious threat. If the quality of our PhDs is not of international standard, we will miss out on benefits from frontier technologies and cutting-edge research. A fall in the quality of PhDs also reflects on the quality of students in the lower streams. The problem of 'in-breeding' in agricultural universities is a serious concern, calling for policy change.
- There is a lack of institutes for monitoring personnel requirements and management, and a lack of personnel to cater to the evolving needs of agriculture, horticulture, animal husbandry and fisheries.
- An inadequacy of human resources in the Krishi Vigyan Kendras (KVKs) has been observed across the workforce at the state, district, and block levels.

A number of posts are vacant and there are anomalies in postings. Under the Extension Reforms Scheme, in 2019-20, there was a human resource shortage of 33%.

- Overall, we find there is a lack of human resources in areas related to direct engagement with farmers for increasing productivity, quality, marketing, and value addition.

Investment and research focus

- R&D spending has not kept pace with the growth in India's agriculture gross domestic product (AgGDP) over time, leading to a decline in the agricultural research intensity (ARI) ratio in recent years. The ARI remained unchanged during 2000-17, ranging in 0.27-0.31% of AgGDP.
- A key concern in agricultural R&D is the lack of funding support. This is due to budget deficits and bureaucratic hurdles for infrastructural development for SAUs and ICAR zonal research stations in remote locations. Three-quarters of financial support provided by the state government is spent on salaries and allowances of regular employees, with only 10% of the total budgetary provision available for infrastructure, and the remaining 15% for meeting the operating costs.
- A disproportionate share of research activities involves food crops in irrigated areas. However, the composition of gross value added (GVA) and of the food plate of the average Indian has changed over the years to emphasize dairy, poultry, fruit and vegetables. Accordingly, the focus needs to shift to these and to rainfed agriculture.
- The overemphasis in research on the productivity of food crops remains a major concern. Agricultural universities specialized in crops continue to overlook the farming systems approach involving a diversity of activities, focusing too heavily on mono-crop systems. There is a need for a convergence of disciplines and regions to improve efficiency and quality.

Actors and linkages

- There is an interaction between extension and farmers; however, the interactions between research and extension and between research and farmers are lacking. The once-close links between science and public policy are also weakening, as are the links between scientist and farmer.
- Weak linkages between the state and markets, and between the public and private sector, have resulted in academic stagnation and also hampered research and extension that address real-world problems while responding to the economic and social context.

- There are more than 280,000 agri-input dealers who could become 'change agents' if they were given the requisite technical skills. Skilling them requires an innovative combination of regulations and incentives.
- Co-operatives have a vast network of training institutions, many of which have become out-dated in terms of content and capabilities. These can be further upgraded to meet the challenges of institution building involving farmer-producer organizations.
- While there are skilled professionals who are trained to manage their own stocks in warehouses, there is no training at the farm or small-trader level for reducing food loss, a national priority.

Emerging challenges and opportunities

Our findings lead to a number of recommendations. These are summarized below, and a detailed roadmap follows, listing actions required in the short, medium and long term:

- Urgently address the lack of a holistic approach to ecosystem-based land-use planning.
- Strengthen the links between land-use related ministries and the skilling approaches in India. There is no, or only minimal, involvement of the water ministry (Ministry of Jal Shakti), Ministry of Rural Development and Ministry of Environment, Forest and Climate Change
- Each sector should identify not only production skills, but also the post-harvest, processing, storage, transport, financial and marketing skills required and tailored to regional endowments. The absence of adequate participation in a 'skilling convergence' process by the important departments is a major policy gap, leading to wasteful expenditure.
- Focus on building skills along the entire value chain, rather than the prevailing bias towards upstream production systems. The skills' focus should be on better value capture by farmers e.g., food loss prevention, better pre-processing, etc. Skills are also needed for seeking opportunities such as carbon finance from climate change mitigation activities in agriculture and land use, food safety and labelling, and agri-residue and food-waste management.
- Inclusion of crop diversification skilling programmes in the National Skill Development Corporation (NSDC). These skills are urgently needed as crop diversification will help in removing the root causes of the agri-residue burning which is causing air pollution and groundwater depletion in Punjab, Haryana, and Uttar Pradesh.
- Strengthen the human resources and institutions at the local level which serve the farming community in terms of providing expert/technical counselling services. Capacity building should lead to better engagement with emerging advances in areas such as micro-

irrigation, bio-fertilizers, integrated farming systems, integrated nutrient and pest management, agro-ecotourism, clean energy applications, soil health analysis, waste and wastewater analysis, knowledge of weather forecasting and management, environmental and climate impact methods and analysis, market information, etc. These could have significant spillovers in terms of employment generation, improved efficiency, profitability, and sustainability.

- Identify the capabilities and skills required to support the development and deployment of new technologies, and the policy frameworks and market mechanisms required to facilitate new technology development, diffusion and adoption.

Roadmap for capabilities and skill enhancement for sustainable food and land-use systems

#	Theme	Actions		
		Short term	**Medium term**	**Long term**
1.	Policy, planning, and coordination 	• Use criteria such as changes in productivity and output, farm profitability, resource efficiency, inclusivity, suitability for the local environment (agro-ecosystem), climate-smartness, and existing capabilities and skill-sets, for prioritizing research, engaging with new technologies and determining budget allocations. • Determine the skill-building, research and extension agenda by agro-ecosystem specific needs rather than expert perceptions and a top-down 'generic' approach.	• Develop a suitable institutional framework based on structured analysis and documented process for fostering local skills ecosystems for capacity building, research prioritization, extension activities, and engaging with new and future technologies. • Adopt a more flexible funding mechanism for facilitating specific skill-sets needed in each agro-ecosystem, industry, etc. rather than the current approach of qualifications-based certification.	• Establish the operational feasibility of this framework for research and capacity-building initiatives to be attuned to local needs and for developing the required skills and capabilities. • Develop an efficient monitoring mechanism for the effective realization of the overall goal of developing a local ecosystem for capability development for sustainable food and land-use systems.

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#	Theme	Actions		
		Short term	**Medium term**	**Long term**
		• Review programmes for the development of agri-horti-animal husbandry, dairying, fishery, poultry, and forestry to ensure they are framed considering the entire food value chain and identify specific areas for capacity building. • Strengthen coherence between existing rural development and agriculture skilling schemes for food processing and logistics, market integration and trading. • Bridge the gaps in the Agricultural Skill Council of India and National Council for Green Jobs by involving the Ministry of Jal Shakti, Ministry of Environment Forest and Climate Change and Ministry of Rural Development.	• Increase cross-sectoral interactions and linkages between various skill councils towards a more integrated approach to skilling in the food sector. • Establish a viable mechanism for operationalizing development and skill-building programmes for each agro-climatic region by combining existing arrangements. • Skill Councils' capacity-building initiatives should be based on natural resource planning linked to the institutional, social and financial context at the agro-ecosystem or national level.	• Promote public-private partnerships and provide fiscal incentives to promote private investment in agricultural extension. • Put in place a dedicated civil service based on Indian agricultural and natural resource management services which promotes integrated food and land-use systems including through sustainable and regenerative farming practices/ models suitable for the country's agro-ecologies. • Increase investment in research, education and skill development along the value-chain for food and nutrition security, emphasizing especially areas such as natural resource management, low-growth areas, rainfed faming systems, smallholders and agricultural marketing.

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#	Theme	Actions		
		Short term	**Medium term**	**Long term**
		• Establish consortia on R&D in new technologies. • Strengthen the National Indicator Framework on Sustainable Development Goals (SDGs) to include clear indicators on science, technology and innovation and skilling.	• Create mechanisms for effective public-private partnerships for new technology development and innovation, including through centres of excellence in agricultural universities and research institutes. • Monitor, report, and evaluate rigorously the indicators under the National Indicator Framework on SDGs at national and state levels.	• Monitor, report, and evaluate rigorously the indicators under the National Indicator Framework on SDGs at national, state, as well as sub-state levels and agro-ecological regions.
2.	Capacity 	• Urgently introduce into skilling packs the skills required to meet the key priorities under the National Mission on Sustainable Agriculture and the National Action Plan on Climate Change (diversification of cropping systems; promotion of carbon sequestration in agricultural practices and building resilience in soil; sustainable soil management practices; popularization of aerobic rice cultivation methods; water saving technologies; and climate responsive research programmes).	• Find innovative processes to strengthen the current and future agricultural research system; create business models for linking universities-farmer-industry (seek successful models from India and abroad).	• Change criteria for development of education and research infrastructure to focus on agro-ecoregion rather than discipline, as sustainability of food and land-use systems requires multidisciplinary and holistic approaches.

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#	Theme	Actions		
		Short term	**Medium term**	**Long term**
		• Include in the National Skill Development Corporation (NSDC) packages skilling in carbon finance from climate change mitigation activities. • Include crop diversification skilling programmes in the NSDC. These skills are urgently needed to remove the root causes of the agri-residue burning which is causing air pollution and groundwater depletion in Punjab, Haryana, and Uttar Pradesh. • Build skills related to soil health in extension systems, which should emphasize advocating and promoting balanced use of fertilizer and soil health management.	• Strengthen specialized training in interdisciplinary fields pertaining to sustainability of food and land-use systems. • Restructure and streamline the course curriculum in higher education, research and innovation, and training packages to make them more interdisciplinary and attuned to sustainability of food and land-use systems. • Include agriculture crop insurance alongside packages for small enterprise finance and microfinance in the training packages offered under banking, financial services and insurance. • Introduce urgently a holistic approach to ecosystem-based land-use planning in the NSDC skill development packs. Strengthen skills in agriculture crop insurance and build a robust monitoring and information system.	• Enhance capacity and skills for managing infrastructure for the agri-retailing sector through public and private investment. Put in place renewable energy applications in warehousing and storage infrastructure. • Put greater emphasis on skills in food safety and labelling, including sustainability labelling. Currently skill modules only recognize quality issues and food safety in poultry.

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#	Theme	Actions		
		Short term	**Medium term**	**Long term**
			• Create consortia on quality seed production, sustainable and regenerative farming practices, storage, processing and marketing.	
3.	Demand-side measures 	• Strengthen and streamline the Agriculture Skill Council of India's SMART portal for facilitating single window access to information on capacities, skill-sets requirement and the popular job categories across the food chain at the agro-climatic zone level to address the demand-supply gap. Ensure active participation of relevant actors including food businesses and industries and launch a massive awareness campaign on the importance of the portal. • Provide a regular and reliable measure of the skills and employment gap in the food sector.	• Create research-extension-farmer-market linkages at the district level – shift focus from mere production to market demands and to producing more from less. • Integrate all farmer producer organizations with existing platforms such as the e-NAMs. • Develop an annual survey of workforce and skills requirements for the food sector in conjunction with industry. • Generate demand for skilled and quality human resources in the sector through incentives such as conditional loans and subsidies related to the food sector.	• Move towards integrated and adaptive approaches to demand and supply that consider agro-ecological conditions. • Enhance the utility of skills gap survey data by expanding the classification and reporting system with a greater level of detail on sustainable food and land-use systems by developing a standard for data collection and reporting and ensuring its effective adoption by key organizations. • Include farmers' knowledge in research and extension programmes through participatory approaches.

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#	Theme	Actions		
		Short term	Medium term	Long term
			• Promote micro-food enterprises and build capacity of micro-financing managers through suitable incentive mechanisms.	• Establish mechanisms for generating demand for quality personnel and infrastructure development at the local level by strengthening institutions of local governance (including Panchayats) and effective involvement of NGOs.
4.	Information systems 	• Monitor and implement the Agri Infrastructure Fund for farm-gate infrastructure for farmers. • Build an online database of all agri-input dealers along with their skillsets. Upscale the Diploma in Agricultural Extension Services for Input Dealers (DAESI) programme. Expand the coverage of registered agri-warehousing with appropriation monitoring and information systems.	• Put in place real-time management and information systems for agri-logistics. • Create an online facility for global information on recent production and marketing trends, emerging challenges and opportunities along the value chain.	• Evolve and adapt information systems to meet agro-ecological needs. • Adopt holistic extension approaches including rural infrastructure, such as roads, cold storage, food- processing units, warehousing facilities, and organized marketing.

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ABBREVIATIONS AND ACRONYMS

AgGDP	Agriculture Gross Domestic Product
AI	Artificial Intelligence
AICRP	All India Coordinated Research Project
AICTE	All India Council for Technical Education
AIEEA	All India Entrance Examination for Admission
ARI	Agricultural Research Intensity
ARYA	Attracting and Retaining Youth in Agriculture
ASCI	Agricultural Skill Council of India
ASRB	Agricultural Scientists and Recruitment Board
ASTI	Agricultural Science and Technology Indicators
ATMA	Agricultural Technology Management Agency
BFSI	Banking, Financial Services and Insurance
BGREI	Bringing Green Revolution to Eastern India
BIRD	Bankers Institute of Rural Development
BSSCI	Banking, Financial Services and Insurance Sector Skill Council of India
CP	Computer Programmer
CADWM	Command Area Development and Water Management
CAGR	Compounded Annual Growth Rate
CU	Central Universities
DAESI	Diploma in Agricultural Extension Services for Input Dealers

DARE	Department of Agricultural Research and Education
DAY	Deendayal Antyodaya Yojana
DFI	Doubling Farmers' Income
DRDO	Defence Research and Development Organisation
DU	Deemed Universities
FICCI	Federation of Indian Chambers of Commerce and Industry
FP	Food Processing
FPOs	Farmer Producer Organizations
GKY	Grameen Kaushalya Yojana
GoI	Government of India
GVA	Gross Value Added
HR	Human Resources
HRD	Human Resource Development
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
IFS	Integrated Farming System
IT	Information Technology
KACP	Kenya Agriculture Carbon Project
KVK	Krishi Vigyan Kendra
MGNREGS	Mahatma Gandhi National Rural Employment Guarantee Scheme
MoAFW	Ministry of Agriculture and Farmers' Welfare
MoF	Ministry of Finance
MoFPI	Ministry of Food Processing and Industry
MoRD	Ministry of Rural Development
MSDE	Ministry of Skill Development and Entrepreneurship
MT	Million Tonnes

NAARM	National Academy of Agricultural Research Management
NABARD	National Bank for Agriculture and Rural Development
NAIP	National Agricultural Innovation Project
NAPCC	National Action Plan on Climate Change
NARES	National Agricultural Research and Education System
NCCD	National Centre for Cold-chain Development
NCCT	National Council for Cooperative Training
NCUI	National Cooperative Union of India
NDDB	National Dairy Development Board
NERFMTTI	North Eastern Region Farm Machinery Training and Testing Institute
NFDB	National Fisheries Development Board
NFSM	National Food Security Mission
NGO	Non-government Organization
NHM	National Horticulture Mission
NILERD	National Institute of Labour Economics Research and Development
NOS	National Occupational Standards
NRM	Natural Resource Management
NSDA	National Skill Development Agency
NSDC	National Skill Development Corporation
NVEQF	National Vocational Education Qualification Framework
PD	Project Director
PG	Postgraduate
PhD	Doctor of Philosophy
PMKVY	Pradhan Mantri Kaushal Vikas Yojana
PPP	Public-Private Partnerships
QP	Qualification Packs

R&D	Research and Development
RAFTAAR	Remunerative Approaches for Agriculture and Allied Sector Rejuvenation
READY	Rural Entrepreneurship Awareness Development Yojana
RGM	Rashtriya Gokul Mission
RKVY	Rashtriya Krishi Vikas Yojana
RMP	Research Management Position
RPL	Recognition of Prior Learning
SAMPADA	Scheme for Agro-Marine Processing and Development of Agro-Processing Clusters
SAU	State Agricultural Universities
SCJG	Skill Council for Green Jobs
SDG	Sustainable Development Goals
SDP	Skill Development Programme
SEWP	State Extension Work Plan
SHC	Soil Health Card
SSC	Sector Skill Councils
SSDM	State Skill Development Missions
STT	Short-term Training
ToT	Training of Trainers
UG	Undergraduate
USAID	United States Agency for International Development
WUA	Water Users' Association
ZBNF	Zero-budget Natural Farming

1. INTRODUCTION

1.1 Sustainable food and land use in India– understanding the context

India is home to about 17% of the world's population but has only 2.4% of the world's land area. In the past 40 years, Indian agriculture has made tremendous progress, spurred by the Green Revolution which led to widespread adoption of high-yielding varieties of food grains, such as wheat and rice, irrigation facilities, fertilizers and pesticides. The Green Revolution emerged as a technological solution to meet the challenge of feeding India's population in the 1960s. However, the intensive use of land and related resources has raised concerns about land degradation and the unsustainable and inequitable use of water, particularly groundwater, for irrigation (Bhalla 2007; Pingali 2012). In recent decades the agricultural scenario has been facing several challenges, including declining farm profitability, depletion of natural resources, resurgence of new pests and diseases, global warming and climate change, all of which pose potential threats to sustainable agricultural production. Unsustainable land and water resources management practices in agriculture have grave implications for long-term food security in India, further aggravated by the prevalence of poverty, and uncertainties associated with changing climate. Yet with the population increasing, there is further pressure on this sector to meet the growing food demand.

Meeting the objectives of food and nutrition security, conservation of the natural resource base, sustainable and resilient rural livelihoods, and climate change mitigation and adaptation demands significant capabilities and high-quality human resources. It also requires a holistic and integrated approach to sustainable food and land-use systems which will involve a major reorientation of R&D practices and institutions. Thus, there is a need for a multidisciplinary and holistic approach based on the status and requirements of each agro-ecological region to improve efficiency and quality. This has profound implications for developing countries like India, which are locked into a path of knowledge generation, development and commercialization within an institutional set-up which may be increasingly less relevant for the emerging challenges and skills requirements. The need for institutional change in building science, technology and innovation (STI) capability and related skill sets has never been greater.

Rainfed farming is a major part of India's agriculture, with 52% of the total cropped area lacking assured irrigation. Rainfed agriculture supports an estimated 40% of the population and accounts for a large share of the cropped area under rice (42%), pulses (77%), oilseeds (66%) and coarse cereals (85%). Hosting about 78% of the nation's cattle, 64% of its sheep and 75% of its goats, rainfed areas are vital for India's meat market. However, crop production in rainfed areas is low; to realize the potential of these areas there is a need for more R&D and greater public investment (NITI Aayog 2018).

Although India is now food sufficient in terms of quantity, with agricultural production at 285.12 million tonnes (MT) of food grains in 2018-19 (MoAFW 2020a), 39% of India's population is under-nourished according to 2011-12 data from the 68th round of the National Sample Survey (NSS) (cited in Rawal, et al. 2019). India is ranked 102 out of 117 countries on the 2020 Global Hunger Index (von Grebmer, et al. 2020). Not surprisingly, concerns about poverty and malnutrition are widespread, prompting calls for a second Green Revolution. Furthermore, consumption patterns are evolving towards high-value commodities including milk, meat, fish and eggs, and fruit and vegetables, particularly in urban areas. Consumption of cereals has been declining despite increasing output.[1] Population growth, increases in per capita income and shifts in dietary preferences are leading to faster output growth in higher value-added sectors, resulting in diversification away from food crops to non-food crops. The share in value of output of fruit and vegetables was almost equal to that of cereals in 2015-16

[1] Expenditure elasticity of cereals has been estimated as negative in the rural (-0.13) as well as in urban sector (-0.04)(NITI Aayog 2018).

(15%), while the shares of livestock (28.8%), fisheries (5.16%) and forestry (7.9%) have also increased significantly (Dev 2018). It is projected that household demand for milk and milk products will continue to increase, from 119 MT in 2011-12 to 300 MT in 2032-33, and meat demand will increase from 11 to 36 MT (NITI Aayog 2018). However, nutritional diversification is still not adequate as food grains account for more than three-quarters of total calorie and protein intake.

India faces the dual challenge of achieving nutrition security, while addressing declining land productivity, land degradation and the loss of ecological services. Seventy percent of rural households in India depend on land – with agriculture being the largest source of livelihoods in the country (FAO 2020). However, the average landholding size fell from 2.82 hectares (ha) in 1970-71 to 1.08 ha in 2015-16. There are also significant land inequalities. Small and marginal land holders are increasingly vulnerable. They have 86% of the operational land holdings, but only around 48% of the farmed area (Agriculture Census Division 2014). Risks from climate change are significant for 275 million people in India, predominantly the poor and tribal population, who depend on forests for their sustenance and livelihoods (FRI 2017). Forests and trees support households' nutritional well-being, improve soil fertility, meet energy demands, and provide medicine, amongst others (FAO 1991). Any plan for developing sustainable land-use and food systems needs to factor in the nutritional security of the share of the population who depends on forests and small and marginal land holdings for their sustenance.

Given India's wide range of soil, water and climatic conditions, and socio-economic development levels, any science, technology and innovation (STI) to address these issues will need to be region-specific, and have an interdisciplinary focus. The capabilities and skills for innovation and sustainability hold special significance for addressing the challenges in the sector and steering development in a desirable direction.

This report seeks to provide an overview of the literature, data and the evidence in order to highlight the varying levels of capabilities and skills requirements across agriculture and allied sectors from the perspective of India's sustainable food and land-use systems. It aims to increase understanding of the desired capabilities and skills' base for innovation and the policies that might enhance their development, and to point to areas for further analysis. To do so the study proposes a framework for capabilities and skills for innovation and sustainability in food systems and along the food value chain. It then reviews the situation in India in terms of the gaps that need to be bridged and the skills being provided. The report concludes with a detailed roadmap for capabilities and skill enhancement for sustainable food and land-use systems.

1.2 A reskilling framework for sustainable food and land-use systems

Skills shortages, skills mismatches, and the large share of unskilled and semiskilled workers across the food value chain are important impediments in India. Given the socio-political, cultural, economic and environmental context of food systems, capabilities and skills are vital to make such systems more efficient, sustainable, resilient, equitable and supportive of healthy diets that can tackle the problems of hunger and the triple burden of malnutrition: undernutrition, micronutrient deficiencies, and obesity.

Figure 1.1 presents a basic framework for building capabilities for food systems that can achieve the Sustainable Development Goals. It covers the existing activities and services in agriculture and allied sectors (crops, horticulture, livestock, poultry and fisheries, forestry and land-use, sericulture, apiculture, etc.) along the different stages of the value chain (pre-production, production, collection, processing, retailing). Building capabilities in the chain involves many dimensions: investments in research and scientific capability, investments in non-scientific skills, creation of an enabling environment for the generation and application of knowledge, strengthening the policy process, and bringing about institutional change.

Building capability for agricultural research relevant to social and environmental needs is important. This requires strong interdisciplinary knowledge based on a trained scientific workforce able to create, adopt and apply knowledge. This will mean reorienting science and technology activities in universities, research institutes, funding agencies and industry, and a conducive institutional setting that facilitates interactive learning. For this research to contribute to agricultural productivity and income, enhance nutritional security and promote sustainability, the development of effective research-extension-farmer-market linkages is crucial. An adaptive and responsive governance structure that can create the conditions required for planning, financing skills development, scaling up investment in green technologies, quality assurance, certification, strengthening physical and intellectual resources at the local level and adopting a dynamic, integrated policy response for sustainable food and land use is important for guiding the process capability development.

By applying this framework, it becomes clear that to respond to sustainable development needs and emerging challenges and opportunities in the food sector, a range of strategies and approaches for developing capabilities and skills across the chain are necessary.

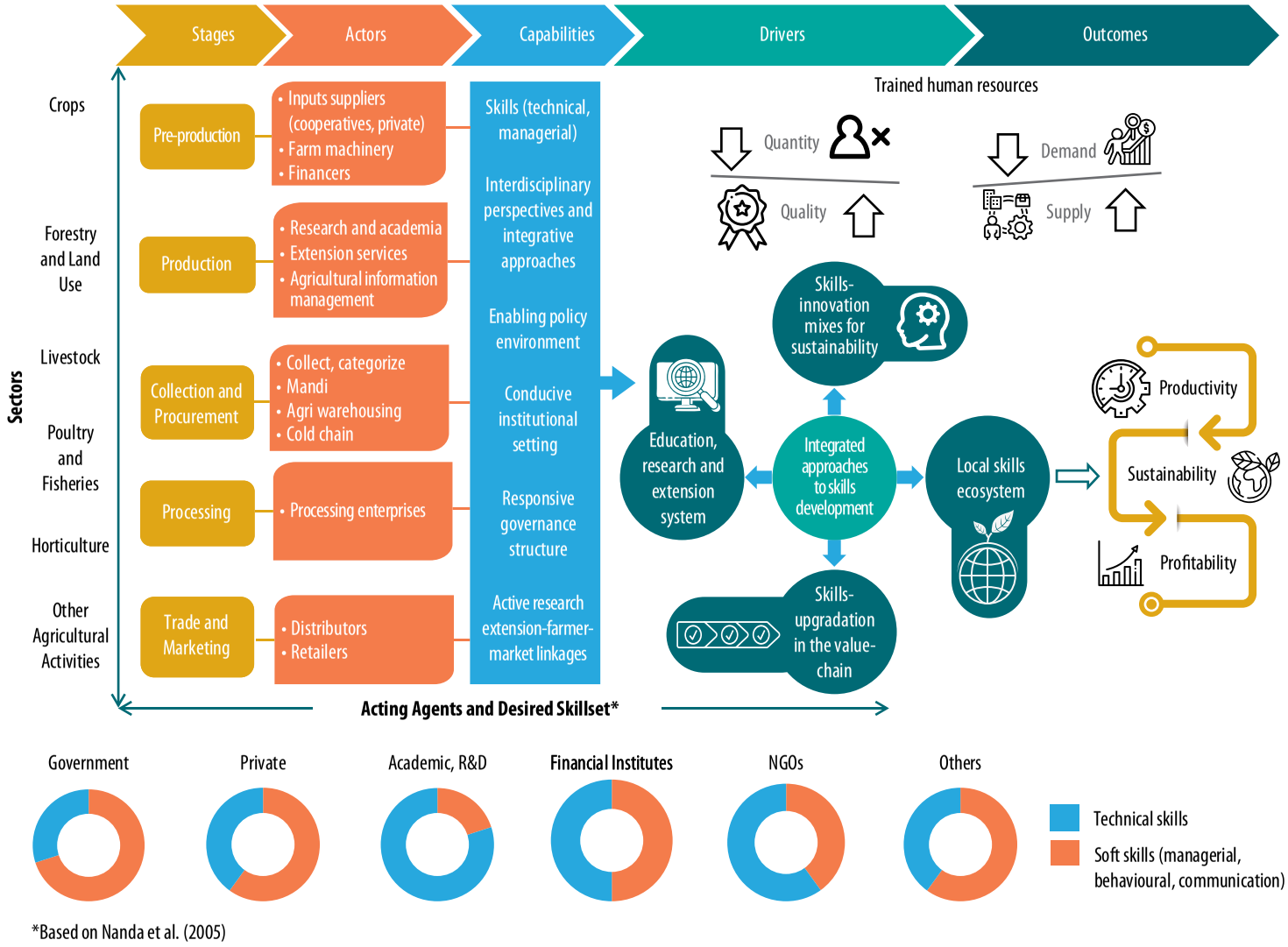

Figure 1.1: Basic framework for building capabilities for food systems

Source: *Compiled by study team*

For instance, the commonly used linear approach of research-extension-farm for generating knowledge and practice (training, skills) may not be successful for the adoption of sustainable agricultural practices, where relevant stakeholders need to build appropriate relationships and interact as and when required. The framework enables us to look at capabilities in a detailed systematic manner to develop appropriate offers for sustainable food systems.

1.3 Capabilities and skills for innovation and sustainability in food systems

Capabilities reflect the capacity of the system – including individuals (embodying skills, training, and experience) and organizations, together with the institutions and policies that affect their behaviour and performance – to address the challenges and harness the opportunities to act towards a "common purpose" (profitable, productive and sustainable food systems) (Figure 1.2). Capabilities (including knowledge and skills) can vary

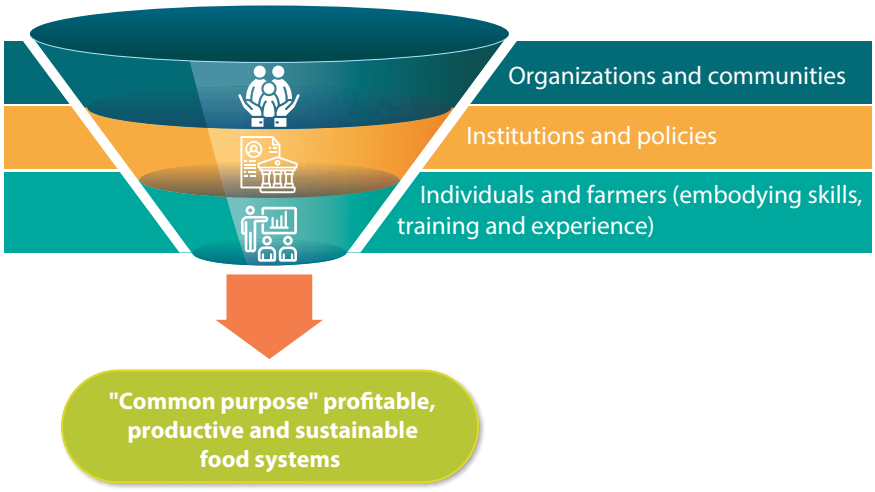

Figure 1.2: Capabilities for innovation and sustainability in food systems

between sub-sectors and at various levels of aggregation – micro, sectoral, and macro. Factors influencing capabilities include the availability of adequate human resources (both quantity and quality) with the required experience, skills and aptitude; the presence of relevant organizations for education, training and re-training and for research and development; transfer of technology; a favourable policy environment; and factor (of production) endowments, attitudes and customs.

The skillset, representing skills and knowledge in respect of both technical skills and soft skills (managerial, behavioural and communication), varies according to the actors involved (Figure 1.3). Looking at the actors and the institutional context in which knowledge generation, utilization and commercialization takes place, the agriculture sector includes research and extension, technology users, private companies, non-government organizations, farmers and supportive structures such as inputs and markets.

The research and knowledge base in the agriculture sector includes organizations such as the public sector research system (national research organizations, institutes of higher learning, and international research centres) and private R&D centres. Private firms – multinational and national agribusiness firms; small and medium enterprises engaged in agro-industrial processing, marketing, and distribution; industry associations; and individual entrepreneurs are also increasingly emerging as important actors. Civil society organizations are important actors and include producer and farmer associations, non-government organizations, consumer groups, etc. Finally, farmers, agricultural labourers, farm households, and rural communities that are engaged both in the utilization and production and diffusion of knowledge, are critical agents.

1.4 Study scope and limitations

The aim of this report is to assess the capabilities and skills in the agriculture and allied sector in order to improve its long-term competitiveness and sustainability. The report also aims to inform policy and actions for addressing agricultural skill shortages and mismatches in the sector. The key issues and skills are investigated through an assessment of trends in education, research and extension, and of the capacity of the various institutions to meet the STI needs of the sector. The report also identifies skill gaps and proposes solutions through a comprehensive scan of existing programmes, resources, reports and studies on human resource needs in the food sector.

Much of the data and information were gathered from the websites of respective institutions in the agricultural research and education system as well as from the grey literature. Information was also solicited

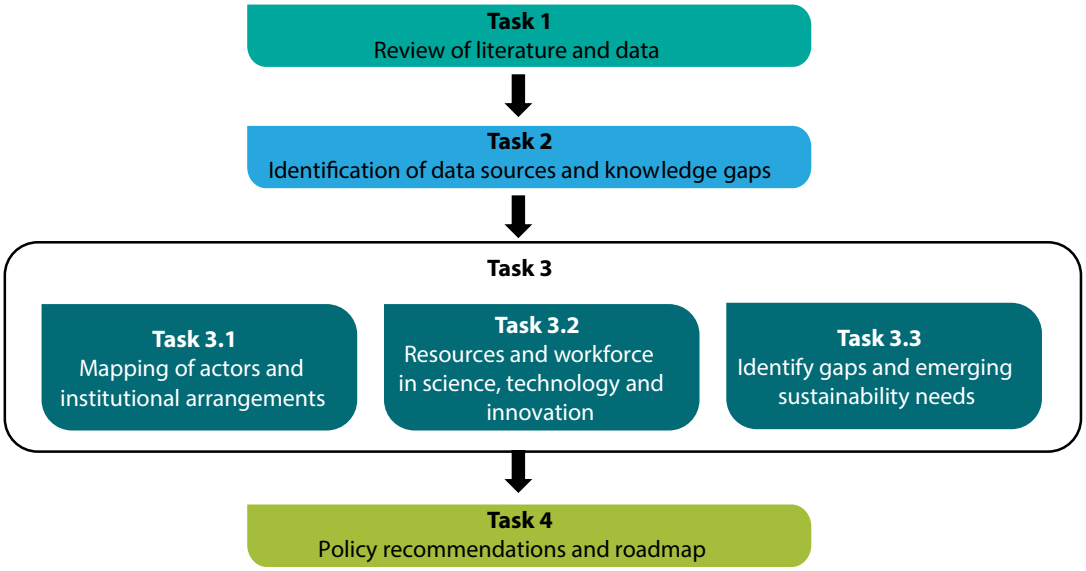

Figure 1.3: Research process for the study

from relevant government agencies by email and through online right-to-information applications.

This information was combined with an assessment of national policy developments to identify the gaps in capabilities and skilling for achieving a sustainable food and land-use trajectory. Figure 1.3 shows the research process involved.

The scoping covers a broad landscape of almost all available literature in the public domain. The data collected are extensive and bring available information under a single source. Admittedly, as data are generated and collated by various departments with the objective of monitoring and reporting on their specific programmes, the data are not comparable. They have to be further disaggregated and re-aggregated to make meaningful policy recommendations. As a first step, however, the information collected can serve as the foundation on which to build an interoperable set of data which can become a reliable source for policy making.

One of the big gaps is data on the private sector, which has made big strides in various aspects related to agriculture, food and allied sectors. These data are not easily available; the studies quoted here only give a partial picture. Planning for skills and capabilities in the agriculture and food sector needs at least an approximate

measure of the quantity and quality of human resources in the private sector. Based on current trends, the private sector is likely to dominate the technology, processing and marketing space. Therefore their investments in technology, skilled human resources and research will hold the key to progress and prosperity in the food sector. The range of skills in the private sector (not confined to the organized private sector) is large: ranging from genetics experts to tractor mechanics, from IT experts to the people who spray insecticides, and from data scientists to vaccinators. Therefore, as a logical next step, a comprehensive study of human resources and approaches towards skills in food and land use related areas is important.

Another area which requires consideration in a future attempt at mapping human resources is the skill sets available across the disciplines which are used in agriculture and related activities. These relate to skills in the financial sector, information technology, water conservation and management, weather-based services, insurance, food processing, warehousing and cold chains, marketing and retailing. These skills are not restricted to agriculture and food sectors, but impact them significantly. One has to accept the fact that various skills will be developed across the board and will be used wherever opportunities arise. There may be a general mapping of these skills available somewhere in the system. Instead of trying to figure out exact numbers for agriculture and related sectors, it is enough to have a reasonable idea of the developments which can impact the sector. It is important to recognize the fact that agriculture and land-related skills alone are not adequate in planning for the future.

While this study can help induce some meso-level changes in policy and programmes, it is suggested that for mapping the human resource status and requirements in the context of new challenges, further studies with much greater granularity are required to create better programmes and projects.


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2. SKILL GAPS AND SUSTAINABLE FOOD AND LAND USE

One of the major and important targets of the Indian Government is to double farmers' incomes. For this to be achieved, closing the skill gaps in the food and land-use sector is essential – increasing farmers' incomes is noted as an important outcome (MoAFW 2017a). This section explores some of these gaps in detail, focusing mainly on agro-ecological approaches, resource conservation and land use; climate resilience; value-chain approaches; and the use of new technology and other food-processing dimensions of food systems.

Figure 2.1 depicts the various qualification packs (QPs)[2] relating to the agriculture sector. It shows that only seven qualification packs are on to forestry and land use. Moreover, there is no QP on water conservation, except for micro-irrigation (Annex 1). If we want to achieve sustainable food and land-use systems, these aspects– and others explored here – will need to be up-scaled.

[2] The National Occupational Standards (NOS) specify the standard of performance an individual must achieve when carrying out a function in the workplace, together with the knowledge and understanding they need to meet a standard consistently. Each NOS defines one key function in a job role. The NOS are laid down by employers (through their Sector Skill Councils). A QP is a set of NOS aligned to a job role. A QP is available for every job role in each industry sector including agriculture.

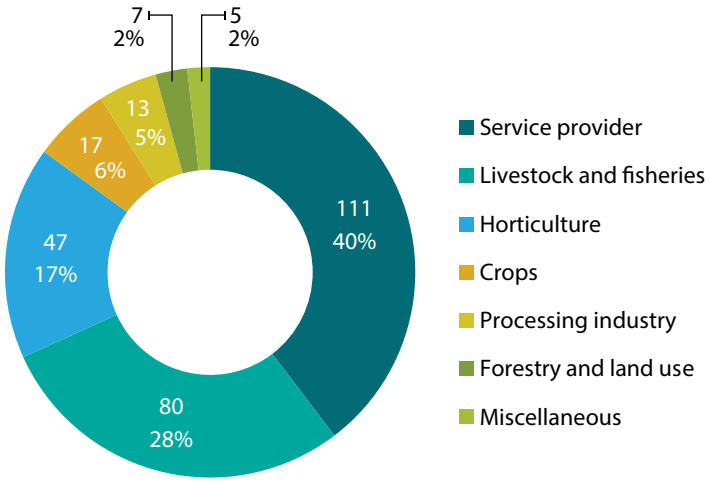

Figure 2.1: QPs according to agriculture framework sectors (numbers and percentage of total)

Source: *Compiled by study team based on Annex 1, drawing on information on the NSDC website.*

Apart from skills, STI has played a significant role in increasing India's agricultural productivity over the years. An extensive agricultural research system with a widespread extension network and supportive government policies has enabled the agriculture sector to respond to the increasing demand for agricultural produce. However, the challenges facing the farming sector today (outlined above) call for a new focus on research, technology generation and diffusion, accompanied by the development of the relevant capabilities and skill sets. Given the limits to water and land resources, STI can help by finding ways to increase productivity with fewer resources; develop quality inputs; adapt agricultural mechanization for smallholding, rainfed, and mountainous agricultural systems; minimize consumption of arable land and water resources; improve animal husbandry's outputs; increase crop productivity; reduce pollution and greenhouse gas emissions; address challenges posed by climate change; and reduce the risk of unpredictable natural disasters, etc.

STI can also improve information, such as on production variables (e.g., plantings, yields, areas of production, pest and disease management) and a wide range of related variables across the value chain, including areas of food demand; water availability, use, and rights; nutrition and food access; and infrastructure. Spatial

technologies can be used for local land-use planning and monitoring, including drone technology for agricultural land management and service delivery; water management in water-stressed areas; sources, scales, and quality of land resources and land-use data for efficient planning; and agroforestry systems management. Meanwhile new technologies like biotechnology, nanotechnology, and digital and AI (artificial intelligence) technologies hold immense significance for promoting the sustainable development of the food sector.

2.1 Agro-ecological approaches, resource conservation and land use

According to the report *Doubling Farmers' Income – Volume IV: Post-production Interventions: Agricultural Marketing,* market signals in the form of monetization of crops should not force a departure from the limits imposed by local agro-ecological and climatic conditions (MoAFW, 2017c). This implies that certain crops become inevitable under certain conditions of ecology, even when available markets may not favour them. Such commodities include hardy crops like millets, organically grown produce, indigenous animal breeds, and certain other traditional crops that are original to specific geographies, and over which farmers have rights. These commodities should be encouraged, by analysing and authenticating their inherent nutritional values and unique characteristics; creating awareness through aggressive marketing promotion; and linking them to organized retail including portal-based retail.

The current thinking on skills lacks a holistic approach to ecosystem-based land-use planning. The approach continues to be sub-sector specific and focuses only on inputs and outputs, without considering overall land-use planning. To rectify this, the first step would be to harmonize land resources databases at the national and sub-national levels and adopt a decentralized watershed-based approach to address the key issues of land degradation, land reclamation, land evaluation, and land-use planning.

There is also a need for skilling/re-skilling measures to help farms diversify and transition towards agro-ecological farming so that farmers are not locked into the cycle of industrial agriculture, where use of agrochemicals is predominant. This needs to be accompanied by skilling in the strong enforcement of quality control for pesticides as well as lab testing; these are not part of the skilling modules currently (MoAFW, 2017d). Validation of Zero-budget natural farming (ZBNF) is being carried out through ICAR-Indian Institute of Farming Systems Research, Modipuram, Uttar Pradesh. The Institute has initiated a study on "Evaluation

of zero-budget farming practices in basmati/ coarse rice-wheat system" from rabi 2017 at four locations, namely Modipuram (Uttar Pradesh), Pantnagar (Uttarakhand), Ludhiana (Punjab), and Kurukshetra (Haryana) under All India Network Programme on Organic Farming and All India Coordinated Research Project on Integrated Farming Systems. However, there is no qualification pack on ZBNF and integrated farming systems which can be taken up in the future as these practices are still under trial.

In terms of conservation agriculture, location-specific technologies are being promoted such as rainwater harvesting and recycling; the joint use of rain, surface and groundwater resources; smart and precision technologies for irrigation and farming practices; optimum irrigation scheduling; resource conservation technologies and efficient rainwater harvesting structures so that the harvested water can be used for supplemental/ lifesaving irrigation under water-scarce situations (MoAFW, 2019a). Apart from this, modern agronomic practices like raised bed sowing, alternate furrow irrigation, mulching, alternate wetting and drying method, laser land levelling, and adoption of varieties which require less water are being promoted through various programmes. Direct Seeded Rice (DSR) and the System of Rice Intensification (SRI) are being promoted for reducing the water requirements in rice. The scheme Per Drop More Crop (PDMC) of Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) focuses on enhancing water-use efficiency at farm level. However, the skills required for these components are missing from the Agriculture Skill Council of India (ASCI; see Section 3.1.2).

The efficient use and conservation of water should be a priority for water resources departments across states. According to a study by NITI Aayog, there is an urgent necessity for the Water Resources and Irrigation Departments to assess the training requirements across different levels of personnel deployed in the departments (NITI Aayog, 2015). For instance, the study states that the staff in the irrigation department at management level, as well as field staff and Command Area Development and Water Management (CADWM) functionaries, would need training in improving the deliveries from the main system, on-farm water management (OFWM), enforcement of Warabandi,[3] planning and designing of on-farm development (OFD) works, participatory irrigation management (PIM), etc. Farmers would also need training in maintenance of field channels and field drains and in the use of improved water management and agricultural practices (NITI Aayog, 2015). However, the Ministry of

[3] Warabandi is a rotational method for equitable distribution of the available water in an irrigation system by turns fixed according to a predetermined schedule.

Jal Shakti, responsible for water-related issues, is not part of the national skill development framework for food and land use co-ordinated by the Ministry of Skill Development and Entrepreneurship (MSDE; see Section 3.1).

The greatest potential for short-term adaptation is seen to be in demand management and more efficient and integrated management of surface and groundwater supplies through encouraging water-saving techniques such as water recycling, reducing losses in canal systems, adoption of drip or micro-irrigation, rainwater harvesting, groundwater recharge. These offer climate change adaptation options (MoAFW, 2017a). Moreover, watershed management for rainfed agriculture offers the scope to practise integrated water resource management at a local level with participation of communities and is integral to climate change adaptation. For the future, skilling also needs to be targeted at institutions such as Water Users' Associations (WUAs) for water rate collection and release of water on a volumetric basis, which is purchased by the WUAs (MoAFW, 2017b).

Parampragat Krishi Vikas Yojana, a scheme of the Indian Government, aims at the promotion of organic farming. If properly implemented, organic farming can take care of soil health and sustainability. It is evident from Figure 2.1 and Annex 1 that there is also a glaring gap in skills for promoting the products of and techniques for indigenous and organic agriculture. As a party to the United Nations Convention to Combat Desertification (UNCCD), India has voluntarily committed to raise its ambition for restoring its degraded land from 21 million to 26 million hectares by 2030 (UNCCD, 2019). The universal Soil Health Card Scheme (SHC), launched in 2014 in India, is a progressive step towards building a strong foundation for science-based soil nutrient management. Skilling related to soil health needs to be a focus of agriculture extension systems, which should advocate and promote a balanced use of fertilizer and soil health management. As is given in Annex 1, skill QPs for soil health are limited to testing and do not include remediation of degraded soil. Current skilling programmes also lack a focus on skills for crop diversification, despite the fact that diversifying cropping patterns from water-guzzling crops like lowland rice and sugar cane to pulses, oilseeds, maize, agroforestry is being promoted under the National Crop Diversification Programme (MoAFW, 2019a). The analysis of QPs reveals many gaps related to sustainable land and water use.

Additional skill areas can be developed in the fisheries and animal husbandry sector (MoAFW, 2017i). Marine fishers could be trained in collecting and recycling plastic and in making the best use of the collected plastic for supplementing their income.

For inland fisheries, recreational fisheries need to be promoted by professional and experienced angling associations in cooperation with state departments of fisheries. For animal husbandry and poultry, there is a need for skill modules for vaccination, enhanced feed, fodder production and pasture development. An efficient and integrated land-use management system which includes better utilization of wastelands and common property resources through proven silvi-pastoral/agri-silvi-pastoral systems needs to be encouraged. Krishi Vigyan Kendras (KVKs) can act as training centres for para vets.

2.2 Climate resilience

Climate change has been recognized as a future challenge to Indian agriculture (MoEFCC, 2020). According to the National Action Plan on Climate Change, the key priorities under the National Mission on Sustainable Agriculture are diversification of cropping systems; promotion of carbon sequestration in agricultural practices and building resilience in soil; sustainable soil management practices; popularization of aerobic rice cultivation methods; water conservation and use efficiency, soil moisture management; and climate responsive research programmes.

Against this backdrop, skilling and capacity building for climate-resilient agriculture is the key. The website of the Skill Council for Green Jobs (see Section 3.1.1) lists three categories of green jobs: environment, forest and climate change; and sustainable development. Yet, QPs only cover renewable energy (wind, solar and cookstoves) and waste management (Annex 1). There are no QPs related to land use, forestry or carbon sinks, and there is only one pack on climate change. There are no packs on climate-resilient farming.

Under the National Innovation in Climate Resilient Agriculture (NICRA) project, the Ministry of Agriculture and Farmers' Welfare (MoAFW) has conducted climate change impact analysis, including the impact of the changing monsoon pattern. The findings indicate that the impact of climate change on production of certain crops like rice, wheat, maize, groundnut, chickpea and potato will vary. A 1-2˚C increase in mean air temperature is expected to decrease rice yield by about 0.75 tonnes per hectare (t/ha) in inland zones and 0.06 t/ha in coastal regions; while a 0.5˚C increase in winter temperatures is projected to reduce wheat yields by 0.45 t/ha (MoAFW, 2017a). The climate change impact assessment was carried out using crop simulation models. Simulation studies using an integrated modelling framework project that rainfed rice yields in India could fall by about 2.5% in both 2050 and 2080 scenarios. On the other hand, irrigated rice yields are projected to fall by 7% in 2050 and by 10% in 2080 scenarios. Studies conducted under the National Network Project on Climate

Change (2004-13) to assess the impact of medium-term (2010-39) changes in climate on Indian agriculture indicated an average reduction in productivity of 4-6% in rice, 6% in wheat, 18% in maize, 2.5% in sorghum, 2% in mustard and 2.5% in potato (though with significant regional variability). The study also demonstrated that appropriate adaptation measures could greatly mitigate the impact of climate change (MoAFW, 2017a).

Attempts are being made under NICRA to develop climate-resilient wheat, flood-tolerant rice, drought-tolerant pulses, and waterlogging and high temperature-tolerant tomatoes. This needs to be supported by appropriate farm management by farmers. The vulnerability assessment of Indian agriculture to climate change is undertaken by the Indian Council of Agricultural Research (ICAR) to guide policy making on agricultural development in the country. ICAR along with state agriculture universities and KVKs has prepared District Agriculture Contingency Plans (DACP-) for 650 districts, recommending location specific climate-resilient crops and varieties and management practices for use by the state departments of agriculture and farmers. These need to be reviewed in consultation with local farmers and the required skills need to be built at the sub-state and local levels.

The India Meteorological Department (IMD), in collaboration with ICAR and the Central Research Institute for Dryland Agriculture (CRIDA), issues weekly National Agromet Advisory Service (AAS) bulletins for planners at central and state levels, farmers and other organizations for preparedness to cope with weather conditions for better crop management throughout the season, particularly during prolonged dry spells or poor rainfall.

There is a notable absence in skills for availing of facilities for carbon finance from climate change mitigation activities. Box 2.1 gives the example of the Kenya Agriculture Carbon Project (KACP), which is building the skills of farmers' groups to tap into carbon finance while adapting their farming to reduce carbon emissions. Skilling in the future should also be targeted at equipping institutions and workforce in India for projects related to carbon finance.

Box 2.1: The Kenya Agriculture Carbon Project

The KACP is supported by the World Bank's Bio-Carbon Fund and in partnership with a Swedish NGO - Vi Agroforestry (ViA). The project beneficiaries are farmers who own an average of half hectare of land with a family size of five or more. The Sustainable Agricultural Land Management (SALM) developed by the BioCarbon Fund, consists of practices such as use of residues for mulching and composting, manure application, fertilizer use, water harvesting, terracing and tree planting to restore soil fertility and enhance soil carbon sequestration. Verified Carbon Standards (VCSs) approved the project in December 2011, spelling out how carbon sequestration is measured in soils. The project targets 3000 farmer groups, composed of about 60,000 farmers, covering 45,000 hectares of land and the purchase of a part of the carbon credits (150,000) estimated at USD600,000, to be generated from 2009 to 2016. The first ever batch of carbon credits generated by improved agricultural practices, issued in October 2013, amounted to a reduction of 24,788 metric tonnes of carbon dioxide, equivalent to taking 5164 cars off the road for one year and accrual of USD65,000 to the Kenyan farmers till date. Three years into the programme and with the experience of 1505 farmer groups, the integration of carbon finance with SALM has been amply illustrated. Early analysis of maize and beans showed that productivity increased by as much as 15%-20%, as also their resilience to climate change through enhanced soil fertility. There is a well-structured process for revenue flow from the World Bank (BioCarbon Fund) to the communities. The farmers have the options of investing in farmer enterprises and other developmental investments, micro-financial saving instruments, rural infrastructure or other uses for collective common good of the farmers.

Source: *Based on MoAFW (2017a)*

2.3 Value chain approach to sustainability

The skilling approach in India for food and land use has a huge mandate if it is to graduate from 'Green Revolution' to 'Income Revolution' (MoAFW, 2017k). A key problem in the Indian food supply chain is the presence of numerous stakeholders who are working in isolation, as well as the weak infrastructure connecting them. According to the report *Doubling Farmers' Income – Volume III: Post-production Agri-logistics: maximising gains for farmers,* integrated logistics networks are essential for agricultural markets and include agri-

logistics, safe handling, cross-geographical interconnectivity, and modernization of infrastructure (MoAFW, 2017f). Logistics interventions are required in terms of both storable and transportable lots. The recommendation is to consolidate farmers at the village level. Yet there are no skill QPs for logistics. In transport, there is only training for tractors. In addition to post-harvest logistics, even on the farm there is no training offered for agri-residue management, such as operation and maintenance of implements like balers, rotavators, mulchers or happy-seeders.

As seen in Figure 2.2, most of the QPs are focused on production. Only 10 packs (4% of the identified QPs) focus on trade and retailing and 23 packs (8% of the identified QPs) focus on collection and procurement. Boosting skills and creating demand in these categories in light of the recent agricultural reforms is extremely crucial.

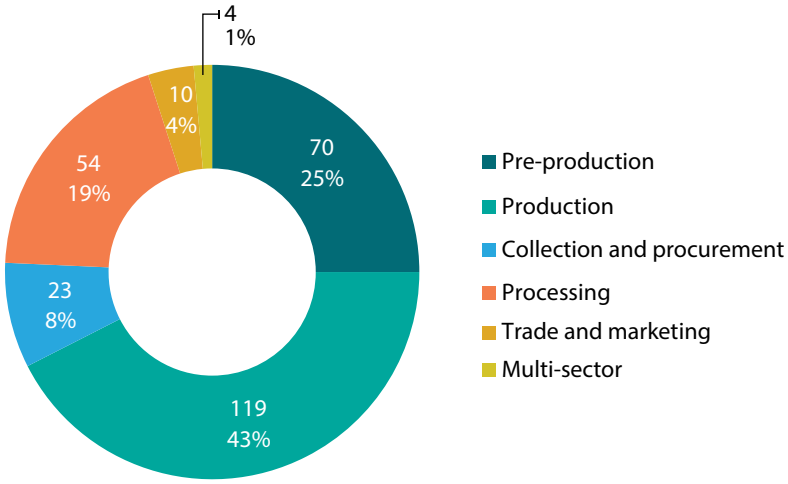

Figure 2.2: QPs according to agriculture value chain stages (number and percentage)

Source: *Compiled by study team based on Annex 1*

Currently, almost three-quarters of the organized warehousing sector is controlled by government public sector undertakings (PSUs), such as the Food Corporation of India (FCI), Central Warehousing Corporation (CWC) and State Warehousing Corporations (SWCs). The current capacity of the organized warehouses (controlled by PSUs, cooperatives and the private sector) is 126.97 million tonnes (MT), of which the

private sector has only 18.97 MT.[4] According to the Warehousing Development and Regulatory Authority, there are currently 1780 registered warehouses in India.[5]

As recommended by the Task Force on Cold-chain set up by Ministry of Agriculture and Farmers' Welfare, a National centre for Cold-chain Development (NCCD) was established in 2011 to promote and develop integrated cold chain in India for perishable agricultural and horticultural produce, including perishable from allied sectors. The NCCD is also responsible for undertaking applied R&D and human resource development programmes for meeting the requirements for skilled HR in the country's cold-chain sector.

Training in entrepreneur development for pack house and ripening chambers has been conducted across the country (NCCD, 2017). These trainings are designed to develop expertise across some of these sectors, including refrigeration (engineering), horticulture (perishables), logistics (warehousing and transport) and farming/processing (producers), especially aimed at those tasked with cold-chain development.

Agri-technology start-ups have helped to create and leverage disruptive technologies across the agricultural value chain in the form of a product, a service or an application. A 2018 PWC-FICCI study (PWC, 2018) found that the growth of agri start-ups has been concentrated around five focus areas (Figure 2.3).

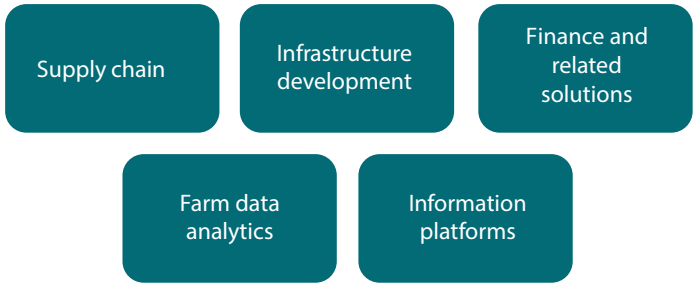

Figure 2.3: Five focus areas driving agri-technology start-ups

Source: *Authors' design*

[4] Indian Council of Food and Agriculture, https://www.icfa.org.in/assets/doc/reports/ALW.pdf

[5] Warehousing Development and Regulatory Authority, https://wdra.gov.in/documents/32110/38835931/RegisteredWarehouseList.pdf/32f79ca5-a287-6713-1199-c44466699225

The supply chain start-ups largely encompass those employed in e-distribution, e-marketplace and several linking platforms. The infrastructure developer sub-component largely includes offering drip-like technology solutions, systems or components, hydroponics, etc. In case of finance-related solutions, the work is focussed around payments, revenue sharing and innovative lending, while farm data analytics involve farm mapping, field operations and remote-sensing interventions. Information platform start-ups are connected to the information dissemination business.

According to one study, 366 agri-based start-ups were established between 2013 and 2017, with more than 50% of the start-ups being set up during 2015 and 2016. The study states that more than 90% of all funding is focused on seed stage and early stage start-ups (PWC, 2018). Most of these start-ups bring a different set of values to the process, mostly based on technology or markets. Agri start-ups need to urgently address the issue of skill and knowledge gaps amongst farmers while developing and commercializing their business models. With more than a quarter of farmers having access to smartphones, it is essential that mobile training programmes to educate farmers are developed so as to train farmers when adopting new technology.

Rashtriya Krishi Vikas Yojana (RKVY) has introduced an innovation and agri-entrepreneurship development programme to promote the growth of agri-technology start-ups by providing financial support and nurturing the incubation ecosystem. During the first phase (2020-21), 112 start-ups have been selected by different knowledge partners and agribusiness incubators in the area of agro processing, food technology and value addition (PIB, 2020).

For a value chain-based approach to future skilling and for addressing challenges to rural development, 'secondary agriculture'[6] activities as defined by the Committee for Doubling Farmers' Income should be recognized as a priority sunrise sector for rural industrialization. For this, there needs to be further convergence with enterprise promotion, incubation, and credit linkage dimensions of schemes under various ministries (MoAFW, 2017j; 2017k). For promoting secondary and tertiary sectors, there should also be greater emphasis on skills in food safety and labelling, including sustainability labelling. Currently skilling modules only recognize quality issues, and food safety is only covered in poultry. Skilling for agricultural extension reforms is essential for a value-system approach,

[6] Secondary agriculture is defined as a productive activity at enterprise level that:

(i) utilizes as raw material the primary product and by-products of agriculture and other biological resources available locally in its rural agrarian neighbourhood; and/or

(ii) deploys locally available skills or a high level of rural human resources, to operate/manage/ maintain the production of goods and services; and

(iii) can be categorized appropriately under the Micro, Small or Medium Enterprises Development (MSMED) Act 2006.

along with participation from the private sector, for which the active involvement of state governments will be key to reaching all farmers in all corners of the country. Awareness will be vital for moving towards sustainable food and land-use systems. Thus awareness-related skilling modules are essential, as are information, education, and communication-related activities – all currently missing.

Food processing is equally important for value chain-based skilling as the Indian food-processing industry accounts for 32% of the country's total food market and is ranked fifth in terms of production, consumption, export and expected growth. It contributes 8.8% of gross value added in manufacturing, 13% of India's exports and almost 6% of industrial investment.[7] While India has a strong agricultural production base, a significant amount of food produce is wasted due to inadequate infrastructure such as packaging facilities, storage, transportation, cold chain, and low levels of processing. The Ministry of Food Processing Industry estimates that post-harvest losses account for USD1.5 billion (INR920 billion) annually.[8]

The NSDC has engaged IMaCS (ICRA Management Consulting Services Limited) to estimate human resource and skill requirements in the food-processing sector by 2022 across various categories of qualifications. In terms of demand for skilled human resources for food processing in the organized sector, it can be observed that the highest labour demand is for personnel (with education below 10th/12th standard/ grade) who have undergone short-term training courses. These account for about 85% of the total labour demand for skilled workers (Lok Sabha Secretariat, 2020). The study also looked at human resource gaps across the whole food-processing sector. It found that supply fell short of demand across the organized sector due to skill gaps and poor education levels in the labour force. For instance, while there is a required demand for about 100,000 trained people annually, the actual supply is 10,000 people (Lok Sabha Secretariat, 2020). These gaps predominantly include inadequate knowledge of operations regarding waste management, lack of production skills (factory level), and lack of communication skills and insights to discover new demands (procurement and sales level) (Kushwaha, et al., 2015). The HR requirement will increase to over 0.53 million by 2022 if the unorganized/informal sector is also taken into account (Table 2.1) (Lok Sabha Secretariat, 2020).

[7] FICSI (2020), Food Processing Industry, http://www.ficsi.in/food-processing.php

[8] FICSI (2020), Food Processing Industry, http://www.ficsi.in/food-processing.php

Table 2.1: Total human resources demand (number of people) across food-processing sector by 2022

Sector	Demand in organized sector	Total demand including unorganized sector
Fruit and vegetable processing	2,000	12,000
Food grain milling	8,000	12,000
Dairy products	12,000	68,000
Meat and poultry processing	19,000	104,000
Fish processing	0	1,000
Bread and bakery	46,000	258,000
Alcoholic beverages	8,000	42,000
Aerated water/ soft drinks	0	2,000
Total	**95,000**	**530,000**

Source: *Lok Sabha Secretariat (2020)*

The study states that the demand for skilled human resources is continuously increasing, with greater demand in the unorganized sector than the organized sector (NSDC, 2010). Studies have also acknowledged that there is a huge opportunity to develop S&T capability and R&D in the food-processing industry, as well as a need to train the unskilled labour force in the sector (Rais, et al., 2013; Anand, 2005).

Another study observed that more than half of the employees in the food-processing industry in 2010 were employed in the actual production process and had education levels lower than 10th standard, while a large portion of the workforce in the unorganized sector comprises helpers who have had limited access to education (Varshney and Ghosh, 2013). This emphasizes the fact that skill development issues are prominent in this sector. According to 2017-18 annual report of the Ministry of Food Processing Industries (MoFPI), the food-processing sector employs 12.8% of the workforce in the organized sector (factories registered under Factories Act, 1948), and 13.7% of the workforce in the unorganized sector (4.79 million workers) (MoFPI, 2017a). Under the Skill India Mission, the Food Industry Capacity and Skill Initiative (FICSI) – promoted by the Federation of Indian Chambers of Commerce and Industry

(FICCI) with financial support by the National Skill Development Corporation (NSDC) – is the key agency for imparting skills in the food-processing sector. Recently, in the third tranche under the Atma Nirbhar Bharat Abhiyan (Self-reliant India), the Finance Minister announced measures to strengthen infrastructure logistics and capacity building for agriculture, fisheries and food processing. INR 1 trillion has been allocated for an Agri Infrastructure Fund for farm-gate infrastructure for farmers.[9]

The MoFPI launched the Pradhan Mantri Kisan Yojana (PMKSY) SAMPADA (Scheme for Agro-Marine Processing and Development of Agro-Processing Clusters) for the period 2016-20 with an outlay of INR 60 billion. Its focus was on creating modern infrastructure with efficient supply chain management to give a boost to the food-processing sector in the country and reduce waste of agriculture produce, increase processing levels and increase the export of processed foods. It has implemented several schemes, such as for mega food parks, integrated cold chain and value addition infrastructure, and human resources.

PMKSY also has a scheme for HR and skill development with a focus on R&D in the food-processing sector. It has allocated INR 500 million for 62 projects; the allocation for skill development in the various food-processing sectors is to the tune of INR 300 million (MoFPI, 2017a). The development of course curriculum for skill development and training modules based on the QPs validated by the NSDC will be implemented by the National Institute of Food Technology, Entrepreneurship and Management (NIFTEM), Indian Institute of Food Processing Technology (IIFPT) and other eligible institutions. A total of 32 projects has been sanctioned under the 'Unit' scheme of PMKSY, spread across almost 17 states and leveraging an investment worth INR 4.06 billion. The projects envisage the creation of direct and indirect employment for approximately 15,000 people, along with emphasis on employment opportunities in rural areas (PIB, 2020).

[9] Ministry of Finance (2020), https://pib.gov.in/PressReleasePage.aspx?PRID=1624153

2.4 Use of new technologies for sustainable food systems

Frontier cutting-edge technologies like biotechnology, nanotechnology, digital and AI (artificial intelligence) emerging under the 'Industry 4.0' revolution hold significant promise for the sustainability of food systems. Nanotechnology possesses very unique properties which can be applied for addressing challenges along the value chain, including crop production, use of agro-chemicals, precision farming techniques, intelligent feed, enhancement of food texture and quality, and bioavailability/nutrient values, packaging

and labelling, etc. (Prasad, et al., 2017). For instance, engineered nanoparticles rich in iron and sulphur developed by scientists in India can boost seed and root metabolism, leading to higher production and opportunities to cut down on fertilizer requirements. Commercially produced nano-fertilizers are available on the market that can play an important role in productivity through control of nutrients.

Similarly, AI was valued at USD432 million globally in 2016, and expected to be valued at USD2.6 billion by 2025 with a compounded annual growth rate of 22.5%. It has been suggested to have a significant global impact at all stages of the food value chain (Markets and Markets, cited in NITI Aayog, 2018). An Accenture study, cited in NITI Aayog (2018b), highlighted that digital farming and connected farm services can significantly enhance farmer income, to the tune of USD9 billion, impacting 70 million Indian farmers in 2020. Accordingly, the National Strategy on AI has recognized agriculture as one of the priority sector areas for implementation of AI-driven solutions (NITI Aayog, 2018b).

Table 2.2 lists some of the critical issues related to food systems in India along with some new technology-based solutions with potential to address these issues. Use of GPS data, satellite imagery and drone-borne sensors for detecting field-level variations, agricultural digital platforms and farming apps facilitating information, financial and commodity transaction processes along food value chains, harnessing the strengths of biotechnology, bioengineering and nanotechnology, especially in the upstream segment of the value chain (entailing input supply and production), biomaterials (on-farm waste processing), green sources of energy, etc. are some of the main technology innovations currently being developed and adopted globally and in India. While application of these new and future technologies can enable farm optimization and sustainability of food systems, by focusing on rainfed area systems – a key source of livelihood for poor farmers – new technologies can also potentially help reduce regional imbalances. To harness these knowledge and innovation trends, equipping different actors in the value chain with new knowledge and skills through relevant education, training and investment is vital, along with ensuring accessibility and affordability for poorer farmers.

Table 2.2: Issues in food systems and new technology options

Value-chain stage	Challenges	New technologies
Pre-production	Low agricultural input efficiency; lack of quality seeds, soil toxicity	Nanomaterials for agricultural bioremediation (Dixit, et al., 2015), ICT applications in machinery rental markets, mobile payments/savings (Baumüller, 2018), land registration and management (McLaren & Stanley, 2017)
Production	Unsustainable farm management practices; weather and climate change impacting productivity, information asymmetry	Carbon nanotube-based input delivery systems (Raliya, et al., 2013; Hajirostamlo, et al., 2015), nanopesticides (Bhattacharyya, et al., 2016), Quantum dots for bioimaging and verifying physiological processes (Hu, et al., 2010; Das, et al., 2015), high-tech agricultural system with use of engineered smart nanotool (Sekhon, 2014; Liu and Lal, 2015), ICT application in smart farming, precision farming, weather data, pest disease monitoring, farm advice (Cole & Fernando, 2012), peer extension (Wolfert, et al., 2017), monitoring the location, health status, feed history and immunization status of animals (using RFID, radio-frequency identification technology) (Bagazonzya, et al., 2017).
Collection and procurement	Price asymmetry	Harvest quality monitor, ICT application in loss verification (Kramer, et al., 2017)
Processing	Infrastructure and technology fatigue, wastage and price volatility	Micro- and nanoencapsulation for protection and increase in bioavailability of food components or nutraceuticals, for food fortification (Ozdemir and Kemerli, 2016). Nanomaterials for food packaging and labelling (Bumbudsanpharoke and Ko, 2015; Berekaa, 2015).
Trade and marketing	Produce quality assessment, price discovery mechanism	Nanobiosensors for food analysis (Viswanathan and Radecki, 2008; Sertova, 2015; Fraceto, et al., 2016). ICT-based data collection (e.g. using smartphones), market and price information (Baumüller, 2015), nutrition advice, e-marketing and governance (Wolfert, et al., 2017)

Uninterrupted advances in R&D are necessary for research, and also for growth in the farming sector. There are a vast number of institutions in agriculture and its allied sectors which are undertaking R&D of high-yielding crop varieties, innovations in technology and measures to propel production and human resource development in India. However, the National Commission on Farmers (NCF) has

indicated that there is a lack of backward and forward linkages between the agricultural laboratories and the farmers as far as communication of technology is concerned (NCF, 2007). Technology has not penetrated consistently throughout India. The 11th Five-year Plan Approach Paper had recognized the significance of dynamic technological progress for long run growth in agriculture output (GoI, 2006). The 12th Five-year Plan mentions the setting up of an Agriculture Technology Forecast Centre (ATFC) and attempts to reduce the gap between the research system and the extension machinery with the establishment of Agriculture Technology Management Agencies (ATMAs) across the country, with support at state, district and block levels (GoI, 2013).

A strategy for engaging with a new technology and harnessing its application potential for sustainable food and land-use systems should include structured analysis and a documented process consisting of (see Figure 2.4):

- identification of the new technology based on its co-benefit potential in social and environmental domains;

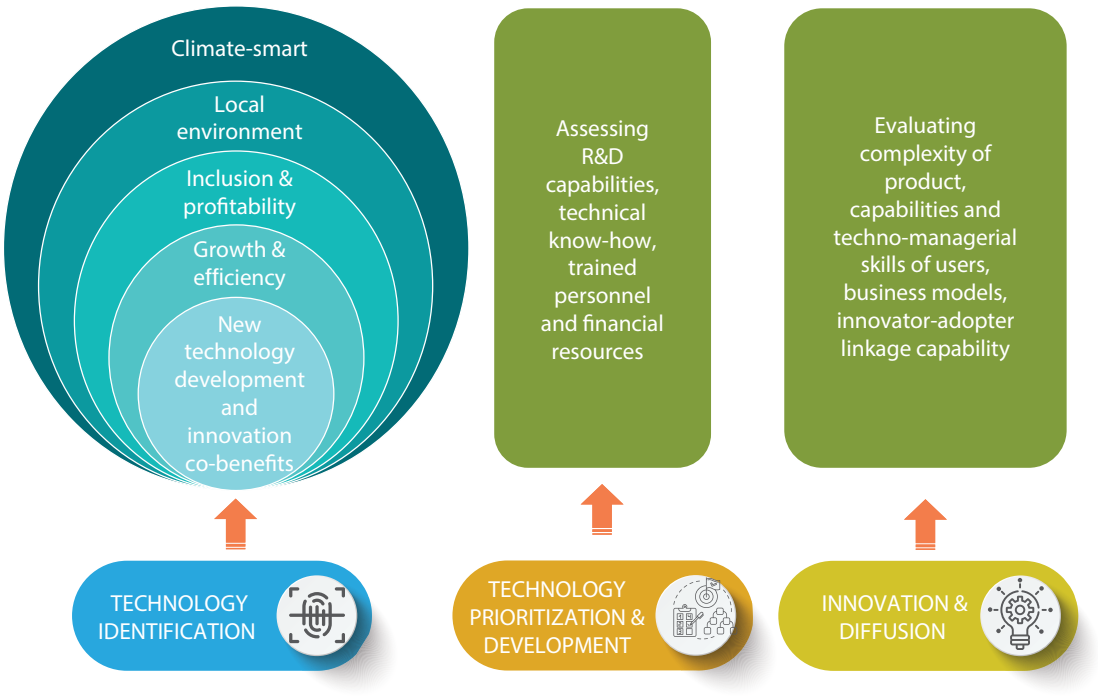

Figure 2.4: Five co-benefits and capabilities framework for engaging with new technologies in agriculture and allied sectors

Source: *Compiled by the authors*

- prioritization and development of the new technology based on the evaluation of R&D capabilities, technical know-how, trained personnel and financial resources; and,
- innovation and diffusion of new technology/product based on an assessment of capabilities and techno-managerial skills of users – producers, agricultural input agencies, processors, commission agents, transporters, etc. and business models for the efficient integration and upscaling of new technology at the relevant value-chain stage, the technological intensity of the product/practices to be adopted, and innovator-adopter linkage capability (skills needed to encode-decode knowledge and complex information between adopters and innovators).

A qualitative assessment of the co-benefit potential of new technology in order to improve the sustainability of food and land-use systems would include factoring in changes in productivity and output, farm profitability, resource efficiency, inclusivity, suitability for the local environment (agro-ecosystem), and relative climate smartness.

For harnessing emerging technologies, different capabilities are supported and mobilized by a variety of actors, networks, and institutions, including private firms, research organizations like universities and public and private research centres, financial institutions, and regulatory authorities. The institutional environment may facilitate interaction among various actors and the emerging policy options would have to be explored for application of new technologies in the production processes, with special focus on institutional environment. The promise of socio-economic–environmental benefits that could be derived from the new technologies should be prioritized based on existing capabilities and skill sets. Identification of existing capabilities and skills and the new ones required to support the development and deployment of new technologies, and the policy frameworks and market mechanisms required to facilitate new technology development, diffusion and adoption would be an important dimension of engaging effectively with new technology. This would also help identify relevant partners for collaboration and improve the efficiency of existing initiatives and efforts on developing necessary skills and organizational capabilities of domestic actors in innovation and technology.

The next chapter looks at India's institutional environment for skills and capability building, and the human resources challenges faced in trying to move towards more sustainable food and land-use systems.

3. ACTORS AND INSTITUTIONAL ISSUES

The institutional set-up for guiding skills and capabilities for food and land use is crucial. This chapter provides an overview of the relevant actors in India and highlights some of the challenges still to be resolved. It starts by exploring the government framework for skills and capabilities, then moves onto the agricultural research sector, followed by an analysis of the education framework for agriculture and relevant sectors. Finally, it assesses the situation in the extension system.

3.1 The national skill development framework for food and land use

The Government of India, under the Ministry of Skill Development and Entrepreneurship (MSDE), has been implementing various sector and group-specific schemes to bridge the gap between the demand and supply of skilled workers. Figure 3.1 depicts the institutional framework for skill development for food and land use under MSDE.

Overall, about 20 ministries/departments run more than 70 schemes for skill development in the country. However, they mostly operate in their own silos. There are also gaps in the framework. Looking at the institutional framework in Figure 3.1, one of the glaring gaps is the absence of Ministry of Environment, Forest and Climate Change (MoEFCC), except for forestry and non-timber forest produce. Another key absence is that of the Ministry of Jal Shakti for water-related issues – both surface and groundwater – which are also key to land use.

The sector is hindered by poor quality training infrastructure and outputs, inadequate focus on workforce aspirations, absence of certification and common standards and a lack of focus on the unorganized/informal sector (Jamal, Mandal, & Saini, 2015). Most importantly, the design of training projects and the selection processes need to be reviewed.

The sections which follow outline some of the key ministries involved in the skill development framework. Annex 2 also provides an overview of agriculture and related central government schemes and programmes for skill development.

3.1.1 The Ministry of Skill Development and Entrepreneurship

The MSDE implements the flagship scheme Pradhan Mantri Kaushal Vikas Yojana (PMKVY). The scheme aims to impart short-term skill training to youth. It also aims to seek recognition of prior learning of informally trained labour through qualifications aligned with the National Skilled Qualification Framework (NSQF) through the involvement of private training partners. PMKVY has a four-year target (2016-20) of training 10 million people across the country. PMKVY 2016-20 has two components: (i) the Centrally Sponsored Centrally Managed (CSCM) component, implemented by the National Skill Development Corporation (NSDC); and (ii) the Centrally Sponsored State Managed (CSSM) component, popularly known as the State Engagement Component, and implemented by the State Skill Development Missions (SSDMs) of the states and union territories.

The training involves three variants: (i) short-term training (STT) for providing skills to school or college drop-outs and unemployed youth; (ii) recognition of prior learning (RPL), provided to recognize existing skills and prior learning experiences; and (iii) special projects to address skill requirements of vulnerable groups and allow flexibility in conducting STT. According to the PMKVY dashboard on its official website, as of August 2020 there were close to 3.4 million enrolments in STT for all sectors, with 2.8 million certified candidates and 1.6 million students placed in agriculture-related employment.[10] For RPL, there were 3.3 million enrolments, of which 2.7 million were certified. In the case of Special Projects, 0.15 million candidates have enrolled, of which 53,000 have secured placements.

The NSDC is a public-private partnership organization which has facilitated the creation of Sector Skill Councils (SSCs). These are industry-led bodies whose role is to meet the skill requirements of various sectors. According to the NSDC, there are 38 sector-specific skill councils (discussed further in Section 3.1.2).

The National Skill Development Agency (NSDA) is an autonomous body under MSDE. It hosts the National Skill Qualifications Framework (NSQF) and allied quality assurance mechanisms for synergizing skill initiatives in India. It is the nodal agency for the State Skill Development Missions, helping to enhance their capacities. The NSDA is dynamically engaged with various state governments to develop their skill development action plans, assist in developing their skill development policies and set up suitable administrative mechanisms. It also helps to synchronize the approach to skill development across various central ministries/departments, state governments, the NSDC and the private sector.

The National Skill Development Fund (NSDF) was launched in 2009 for building skill development capacity and developing strong linkages with the market to fulfil the objectives of the NSDC. The NSDC acts as a conduit for skill development by providing financial support to enterprises, companies and organizations that provide skill training.

[10] PMKVY Dashboard, [Online: web] Accessed on 18 November 2020, URL: http://pmkvyofficial.org/Dashboard.aspx.

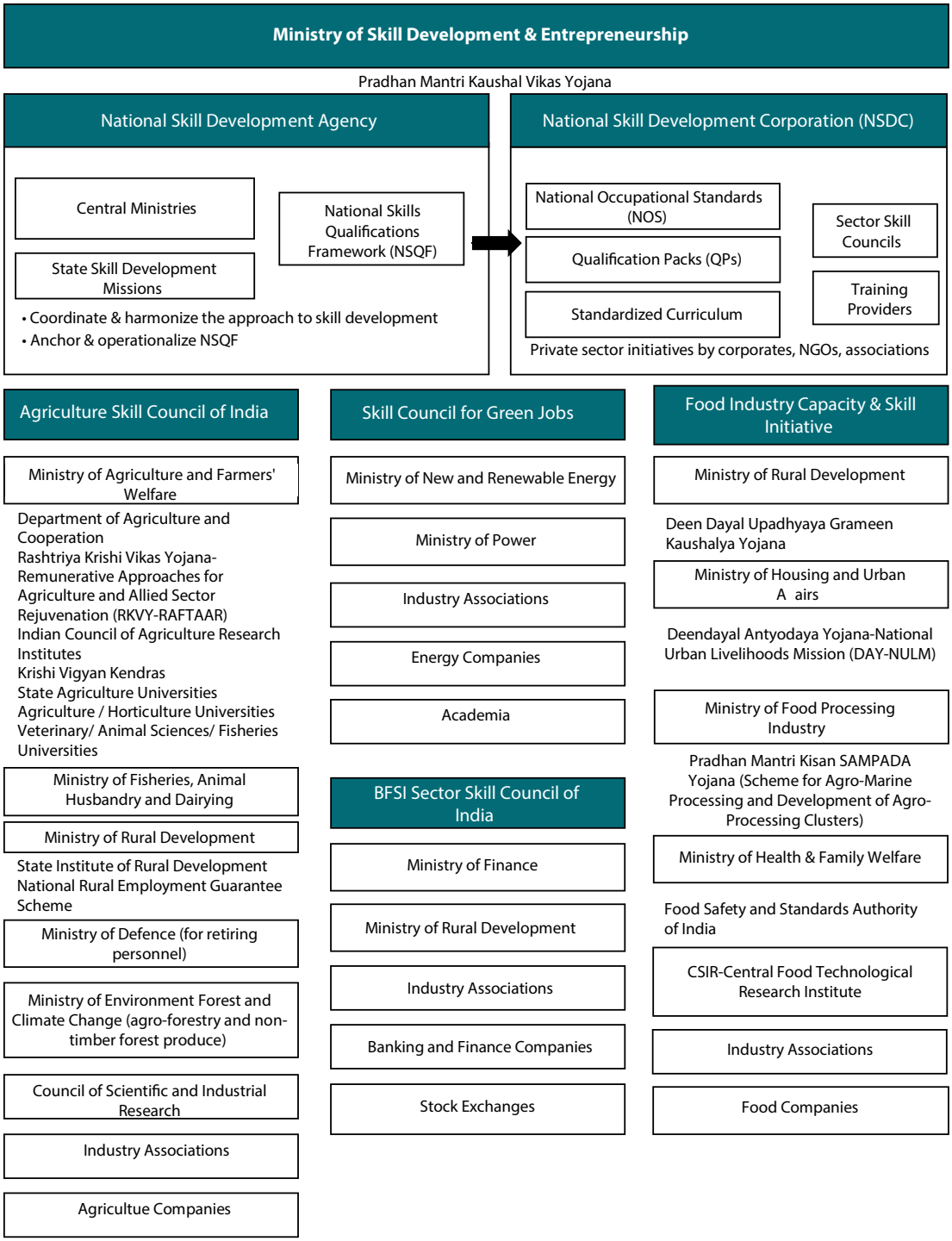

Figure 3.1: National skill development framework for food and land use

New kinds of jobs are emerging across different sub-segments, such as precision farming, cold storage, dairying, farm mechanization, poultry, horticulture, post-harvest supply chains, etc. As there is a need to develop the capacity of the youth and entrepreneurs in these new roles, an MoU was signed between MSDE and the Ministry of Agriculture and Farmers' Welfare (MoAFW) to improve the livelihoods and employability of youth by enriching them with relevant skills via training in various vocations in agriculture (MSDE, 2018). MSDE identifies the job roles and partners with the Ministry of Agriculture to support the 690 Krishi Vigyan Kendras (KVKs; see Section 3.1.6) in providing the training and ensuring that market-relevant skills are imparted. Both ministries plan to use existing infrastructure for undertaking skill development, such as MANAGE, KVKs, Central Farm Machinery Training Institutes, etc.

The Indian Council of Agricultural Research (ICAR; see Section3.2.1) will help in setting up and strengthening skill councils to undertake the training programmes sponsored by MSDE. This alliance will address the challenges of emerging job roles, for example, in using new technologies such as sensors and drones for monitoring purposes and robotics in harvesting, milking and aquaculture. Other areas include e-auction for agri-markets, farm advisory services like GIS, contract farming, land pooling, and commodity exchanges.

3.1.2 Sector Skill Councils

Four councils are relevant for food and land use: the Agriculture Skill Council of India (ASCI), Food Industry Capacity and Skill Initiative (FICSI), Skill Council for Green Jobs (SCGJ), and BFSI (Banking, Financial Services and Insurance) Sector Skill Council of India (BSSCI) (Figure 3.1). These SSCs are responsible for determining skills, competency standards and qualifications and for developing qualification packs (QPs) aligned with National Occupational Standards (NOS).

The ASCI seeks to contribute to skill development in agriculture and to address challenges such as stagnant growth in the sector, moving human resources to other sectors, climate change and transformations in international agriculture markets that challenge the competitiveness of Indian agriculture. The vision of ASCI is to create a sustainable industry-aligned ecosystem for robust skill and entrepreneurship development in agriculture and allied sectors. It undertakes skilling and capacity building of farmers, wage workers, self-employed and extension workers engaged in organized and unorganized segments of agriculture and allied sectors. Training programmes are undertaken at KVKs across the country. As of 2020, ASCI has enrolled over one million trainees, has 936 training partners, and 685 industry partners. These include Jain

Irrigation under the Irrigation Association of India, the National Seeds Association of India (NSAI), agri-procurement companies such as Cargill India, and agri-logistics such as Blue Star for cold storage warehousing (ASCI 2020).

The FICSI aims to ensure that the food-processing industry can grow with skilled human resources, and increase productivity and profitability. Accordingly, FICSI works towards generating a critical mass of industry-employable skilled people to fill the skill gap in the food-processing industry.

The Skill Council for Green Jobs is jointly promoted by the Ministry of New and Renewable Energy and the Confederation of Indian Industry. It is managed by an industry-led governing council to meet the skill requirements for green businesses. SCGJ aims to act as a bridge between the government, industry, and various key stakeholders for developing strategy and implementing programmes for skills development that are aligned with industry needs and international best practices.

The Banking, Financial Services and Insurance Sector Skill Council works with the involvement of the Ministry of Finance and Ministry of Rural Development, which are part of the governing body. BSSCI accredits service providers who partner in training. The skill council works towards social development and financial inclusion through training in credit, insurance and other financial services.

3.1.3 Ministry of Agriculture and Farmers' Welfare

The MoAFW consists of two departments: the Department of Agriculture, Co-operation and Farmers' Welfare and the Department of Agriculture Research and Education.

There are a number of programmes undertaken by the Department of Agriculture, of which the most important for addressing skill gaps are covered under Rashtriya Krishi Vikas Yojana (RKVY), Bringing Green Revolution to Eastern India (BGREI), the National Food Security Mission (NFSM) and the National Horticulture Mission (NHM). According to the newly revamped RKVY guidelines, the objectives of RKVY-Remunerative Approaches for Agriculture and Allied sector Rejuvenation (RAFTAAR) are to empower youth through skill development, innovation and agri-entrepreneurship based agri-business models in the agriculture field. Activities include providing financial support to public/private incubation centres, and involving KVKs in skill training of farmers or farmer producer organizations (FPOs) in innovative ideas for establishing agri-businesses which will be useful to small and medium agri-entrepreneurs. BGREI is a sub-scheme of RKVY, launched in 2010-11, to address the constraints limiting the productivity of rice-based cropping systems in Eastern India. Farmers were given technical backstopping from research institutes during this programme to boost

their skills and economic empowerment. Human resource development through training and demonstration is an integral component of both the NHM and NFSM. Capacity building and training programmes for farmers are conducted at district and state levels on emerging issues. The NHM helps to support skill development and create employment generation opportunities for rural youth in horticulture and post-harvest management, particularly in the cold-chain sector.

The National Institute of Agricultural Extension Management (MANAGE), under the aegis of the MoAFW, introduced the Skill Training for Rural Youth (STRY) in 2015-16 with the objective of providing skills in agri-based vocational areas. This was in compliance with the 2015 National Policy on Skill Development and Entrepreneurship to aid in boosting human resources with the skills to perform farm and non-farm operations. About 50 skilling areas spanning agriculture, horticulture, animal husbandry, dairy and fisheries have been identified for STRY (Table 3.1). The expertise and infrastructure of KVKs, Extension Education Institutes (EEIs), and Farm Machinery, Testing and Training Institutes (FMTTIs) will be used to further the skills of rural youth and develop occupational standards and QPs in consultation with the ASCI. Ten states covering 78 districts, reaching 4680 beneficiaries, have been envisaged under the STRY programme.[11]

[11] https://www.manage.gov.in/stry&fcac/target-stry.asp

Table 3.1: Indicative skilling areas in agriculture and allied sectors

Agriculture	Horticulture	Animal husbandry, dairying and fisheries
1. Agricultural apprenticeship training under mechanization and technology 2. Soil conservation 3. Training on oilseed, maize and oil-palm development 4. Soil testing 5. Organic farming 6. Seed production 7. Repair and maintenance of tractors 8. Repair and maintenance of farm equipment 9. Setting up of custom hiring agro service centres 10. Installation and maintenance of food-processing machinery 11. Selection, operation and maintenance of plant protection machinery 12. Storage and maintenance of food grains and other agricultural produce 13. Grading of agricultural produce for marketing and storage 14. Management of rural godowns 15. Integrated pest management in crops 16. Rodent pest management in urban areas 17. Detection and identification of stored grains pests 18. Production of bio-control agents 19. Production of bio-pesticides 20. Vermi-composting 21. Production of bio-fertilizers	1. Mushroom production techniques 2. Bee-keeping 3. High-value floriculture 4. Protected cultivation of high-value vegetables 5. Installation and maintenance of micro-irrigation system 6. Post-harvest processing and packaging of fruits and vegetables 7. Harvesting, cleaning and grading of fruits and vegetables 8. Organic production of fruits & vegetables 9. Transportation and marketing of fruits and vegetables 10. Nursery management 14. Orchard management and maintenance 15. Production of quality planting material through tissue-culture 16. Production and processing of medicinal and aromatic plants 17. Planting, execution and maintenance of landscapes 19. Production and marketing of planting material 20. Cold chain management 21. IPM in vegetables 22. IPM in fruit crops	1. Post-harvest activities on fish handling and processing of fishes 2. Clean milk production (CMP) 3. Integrated dairy development 4. Integrated development of small ruminants and rabbits 5. Feed and fodder management 6. Rearing of improved breed and rearing of cattle and management. 7. Pig rearing and management 8. Poultry rearing and management 9. Fish rearing and management 10. Goat rearing and management 11. Ornamental fish farming 12. Duck farming

Source: *Authors' compilation based on https://www.manage.gov.in/stry&fcac/target-stry.asp*

3.1.4 Ministry of Fisheries, Animal Husbandry and Dairying

The Department of Animal Husbandry, Dairying and Fisheries (DADF) is responsible for matters relating to livestock and fisheries production, preservation, protection and improvement of stocks, and dairy development. Over the years, the Department has formulated various training modules for farmers, unemployed youths, and NGOs in various disciplines within these sectors. Training in activities such as pond culture, reservoir fisheries, wetlands and brackish water aquaculture are being conducted by different ICAR and fisheries institutions and KVKs in the different states and union territories.

The Ministry of Animal Husbandry, Dairying and Fisheries launched Rashtriya Gokul Mission (RGM) in December 2014 for the development and conservation of indigenous breeds through selective breeding and genetic upgradation of the nondescript bovine population. ICAR, through the All India Coordinated Research Project (AICRP) on Utilization of Animal Energy, is engaged in research and development on the use of animal energy for enhanced system efficiencies, with a special focus on hilly, tribal and low-mechanization regions of the country. Under this scheme, improved animal drawn implements/tools for tillage and sowing, tools for intercultural operations, straw collectors, farmyard manure spreaders and animal-drawn dung collectors have been developed and are being popularized among farmers through training and front-line demonstrations by eight cooperating centres of the AICRP.

3.1.4.1 National Dairy Development Board (NDDB)

The NDDB was created to promote, finance and support producer-owned and controlled organizations. Over the years, the Board has undertaken training programmes on cooperative services, productivity enhancement, quality assurance, National Dairy Plan (NDP) trainings and other trainings for dairy personnel. The initiatives have been centred on building organizational capability through investment in the development of human resources. Needs-based functional as well as managerial/behavioural training has been facilitated for NDDB employees via in-house customized programmes as well as through sponsorship to training programmes in premier institutions in India and abroad. During 2018-19, 14,118 people were trained under various categories (including 2700 women) across a total of 584 programmes at NDDB Anand and its regional training centres (NDDB, 2019).

3.1.4.2 National Fisheries Development Board (NFDB)

The National Fisheries Development Board (NFDB), Department of Fisheries, Government of India emphasizes the importance of HRD for skilling and

extension. Training modules have been worked out keeping in view the specific needs of different target groups, and with a focus on job creation and performance requirements. According to its latest Annual Report (2019-20), NFDB successfully trained about 15,000 farmers, aqua-preneurs and state officials and funded 330 training programmes including skill development programmes, training of trainers (ToT) workshops, seminars, etc. independently or in collaboration with other institutes and states (NFDB, 2020). The NFDB has also conducted international events, training and exposure visits (NFDB, 2020).

3.1.4.3 National Institute of Fisheries Post-Harvest Technology and Training (NIFPHATT)

Diversified trainings in the various fields of fisheries post-harvest technology, refrigeration technology, quality control and value-added product development are conducted by NIFPHATT under DADF to augment the development of human resources in the fisheries and allied sectors.

The training programmes have been moulded in such a way that they provide intensive hands-on experience to students who are pursuing specialized education in fisheries science, biotechnology, food science, food microbiology and food engineering, as well as to professionals working in the fisheries sector. A total of 1374 students have received training during 2018-19 (MoAFW, 2019b). Some of the HR programmes conducted by NIFPHATT include on the job training in fisheries post-harvest technology for under and postgraduate students from various schools, colleges and universities; training in microbiological analysis; in-plant training; skill upgrades for fishermen and women in high-end product development; short-term training on value-added product development; training in on-board and onshore handling of sashimi tuna in association with CIFNET; and vocational higher secondary education (VHSE) apprenticeship training.

3.1.5 Ministry of Rural Development

The Ministry of Rural Development, through its National Rural Livelihoods Mission (NRLM), runs a placement-linked skill development programme involving public-private partnerships (Deen Dayal Upadhyaya Grameen Kaushalya Yojana (DDU-GKY). This programme, along with integrated farming initiatives for rural development across the country, is significant for greater success in boosting the skills and employment potential of rural youth.

The Department of Rural Development at the Ministry of Rural Development is implementing Mahila Kisan Sashaktikaran Pariyojana (MKSP) to empower women in agriculture. The MKSP is a sub-component of Deendayal Antyodaya Yojana-National Rural Livelihood Mission (DAY-NRLM) launched in 2010-11 to build the capacity of

women in the domain of agro-ecologically sustainable practices. To date, nearly 8 million women farmers have become engaged in agro-ecological practices across 29 states and 121,159 villages.[12] The states of Andhra Pradesh (1.4 million), Maharashtra (1.3 million), Telangana (1 million) and Madhya Pradesh (1 million) have the majority of mahilakisans (women farmers), with each state engaging more than 1 million mahilakisans in agro-ecological practices.

The Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) under the Ministry of Rural Development (MoRD) aims to improve livelihood security in rural areas through the provision of at least 100 days of wage employment in a financial year to every household whose adult family members volunteer to undertake unskilled manual work. In 2019, the MGNREGS was linked with skill development and capacity building scheme by converging it with various programmes including the National Rural Livelihoods Mission. MoRD incentivizes casual labourers undergoing skill development training for specialized work with a daily allowance, in addition to equipping them with better employment opportunities. The MoRD has joined up with KVKs to train the workers under MGNREGS for organic manure preparation and basic storage of crop produce (Sharma, 2019).

[12] Source: http://mksp.gov.in/ViewProjectsStatus.nic?value=2

The activities undertaken under MGNREGS are directly linked to agriculture and allied activities, such as public works involving natural resources management (water conservation and water harvesting structures to augment and improve groundwater such as underground dykes; micro and minor irrigation works, and maintenance of irrigation canals); community assets or individual assets (land development and providing suitable infrastructure for irrigation, including wells, farm ponds and other water harvesting structures; infrastructure for promotion of livestock and fisheries); common infrastructure including for NRLM compliant self-help groups (creating durable infrastructure required for bio-fertilizers; post-harvest facilities) and rural infrastructure (construction of food grain storage structures) (MoRD, 2020).

According to the Management Information System (MIS), 164 works are related to agriculture and allied activities based on the list of permissible works under Schedule I of Mahatma Gandhi National Rural Employment Guarantee Act. There are immense possibilities for convergence both at state and district levels with departments and schemes like agriculture, horticulture, fisheries, sericulture, animal husbandry, etc. The District Agricultural Plans, introduced under RKVY during the 11th Plan, were supposed to draw up integrated and participatory action plans at the district level, taking into account agro-climatic

conditions, natural resource issues and technology, and integrating livestock, fisheries and poultry more fully. Such a bottom-up approach to planning and skill development needs to be reinvigorated and better convergence is essential with other rural development programmes including skill development.

The synergy between Deendayal Antyodaya Yojana NRLM (DAY-NRLM) and MGNREGS programmes could be tapped by facilitating the farmers identified under MKSP and other sustainable agriculture-based interventions taken up under DAY-NRLM for skilling for creating durable and sustainable assets under MGNREGS.

3.1.6 Ministry of Food Processing Industries

The Ministry of Food Processing Industries (MoFPI) extends financial assistance as grant-in-aid to various institutions, universities, public-funded organizations and recognized R&D laboratories in both the public and private sectors, to promote and undertake demand-driven R&D work in product and process development, design and development of equipment, improved storage, shelf-life, packaging, etc. It aims to provide a sector-specific skilled workforce from floor-level workers, operators, packaging and assembly line workers through to quality control supervisors, etc. in the various segments of the food-processing industries. It also aims to contribute to achieving the projected skilled HR requirement of 17.8 million people by 2022, as envisaged by the National Skill Development Corporation (NSDC). MoFPI is working in close collaboration with other related agencies to augment skilled human resources in the food- processing sector, including the Food Industry Capacity and Skill Initiative (FICSI), and the Sector Skill Council (SSC) in food processing. It is working on the validation of qualification packs (QPs) for identified job roles and developing a course curriculum for the food-processing sector through the National Institute of Food Technology Entrepreneurship and Management (NIFTEM).

The Ministry also launched the Pradhan Mantri Kisan SAMPADA Yojana (Scheme for Agro-Marine Processing and Development of Agro-Processing Clusters) for the period 2016-20 with an allocation of INR 60 billion. Its goals are to enhance the processing and production capacities of HR and institutions. Additional details regarding the scheme are discussed in Section 2.2.

3.2 Agricultural research

3.2.1 The role of ICAR

ICAR is an autonomous organization but falls under the remit of the Department of DARE. It is mandated, since its inception in 1929, to build proficient and skilled human

resources for the agriculture research system in India. It is the apex body for coordinating, guiding and managing research and education in agriculture and allied activities and has pioneered national-level programmes related to agricultural research, higher education and frontline extension by means of a network of research institutes, KVK and agricultural universities. ICAR's Agricultural Education Division coordinates education planning, human resource development and quality reforms of the National Agricultural Research and Education System (NARES; see Box 3.1).

The ICAR-AU system of India includes 75 agricultural universities, including 64 state agricultural universities (SAUs), imparting education in agriculture, veterinary, horticultural and fisheries; 4 ICAR-Deemed Universities, i.e, Indian Agricultural Research Institute (IARI), Indian Veterinary Research Institute (IVRI), National Dairy Research Institute (NDRI) and Central Institute for Fisheries Education (CIFE); 3 central agricultural universities; and 4 central universities (CUs) with faculties of agriculture. Every year more than 15,000 graduates, 11,000 postgraduates and 2500 PhDs are admitted into the NARES across various disciplines in agriculture and allied sciences.[13]

[13] https://icar.nta.nic.in/WebInfo/Public/Home.aspx updated on 31st Aug, 2020

Box 3.1. ICAR's role in improving quality in education

ICAR conducts the All India Entrance Examinations for Admission (AIEEA) to undergraduate, postgraduate and PhD courses in agriculture universities. It also awards scholarships and fellowships in agriculture and allied sciences. In order to tackle the challenges of human resources development in agriculture, ICAR has established a nationwide arrangement with the universities under the ICAR-SAU system to set aside 15% and 25% of their seats for bachelor and master's degree programmes filled through the AIEEA. These are conducted annually by the Education Division of ICAR along with the All India Competitive Examination (AICE) for the award of Senior Research Fellowships for pursuing doctoral degree programmes in agriculture and allied sciences. The vital purpose of these examinations is to encourage mobility and talent among researchers and students in research establishments, infuse merit coupled with national integration and to support uniform examination standards across the universities, thereby helping to upgrade the quality of higher agricultural education in the country.

Furthermore, a ranking of agricultural universities was initiated by ICAR in 2017 in line with the National Initiative on Ranking of Indian Institutions in order to force the universities to improve quality standards, enhance their visibility globally and take part in international rankings. This will also assist students to make informed choices for university placement and facilitate self-assessment among institutes. Parameters such as teaching resources and outcome, faculty profile, students' performance, research productivity, research impact and excellence, extension activities, outreach programmes, revenue generation and peer recognition of the faculty, students and staff of the university, etc. are taken into account while evaluating the agricultural universities. In this regard, an external peer review on outcomes needs to be undertaken.

Adjusting the number of scientists by share of research expenditure relative to extension and education (for ICAR) and percentage of time spent on research (for SAUs), the number of full-time scientists in the late 1990s was 2999 in ICAR and 8132 in SAUs, giving a total of 11,131 full-time researchers in the country and making it one of the largest agricultural R&D systems in the world at that time (Singh, et al., 2013).

However, today the work of the ICAR system is being hindered by staff shortages. Figure 3.2 indicates the gap between the sanctioned and actual posts across different categories of employees in ICAR and its institutes. In 2015-16, there were shortfalls of 696, 1603, 1087 and 2932 scientific, technical, admin and support staff respectively. In 2019-20 these deficits had grown to 1452, 2128, 1492 and 3853.

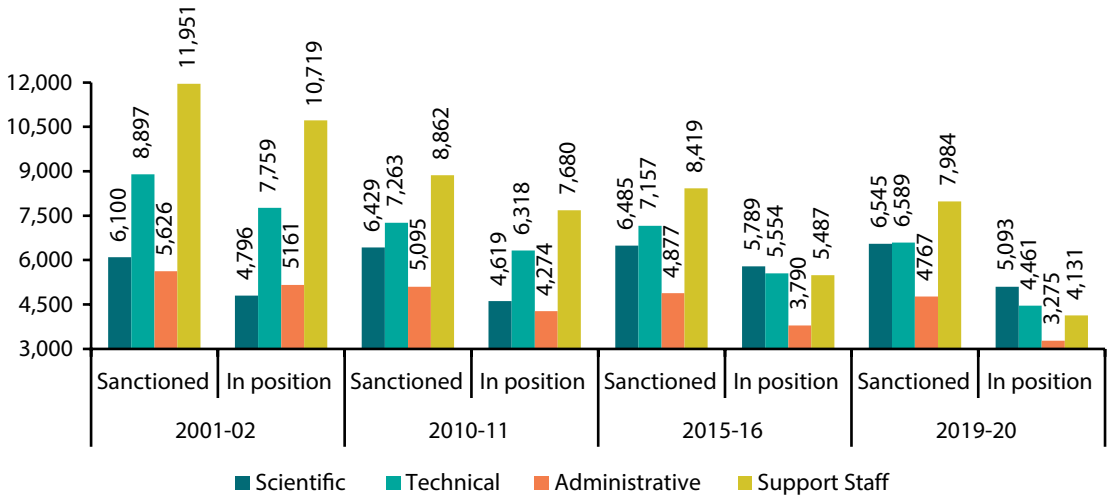

Figure 3.2: Staff shortfalls (scientific and non-scientific) in ICAR research institutes

Source: *DARE-ICAR Annual Reports (2001-02, 2010-11, 2015-16 and 2019-20)*

Figure 3.3 shows that over the last 20 years ICAR has had a serious shortage of scientists. The last three years have witnessed more than 1000 vacant posts for scientists.

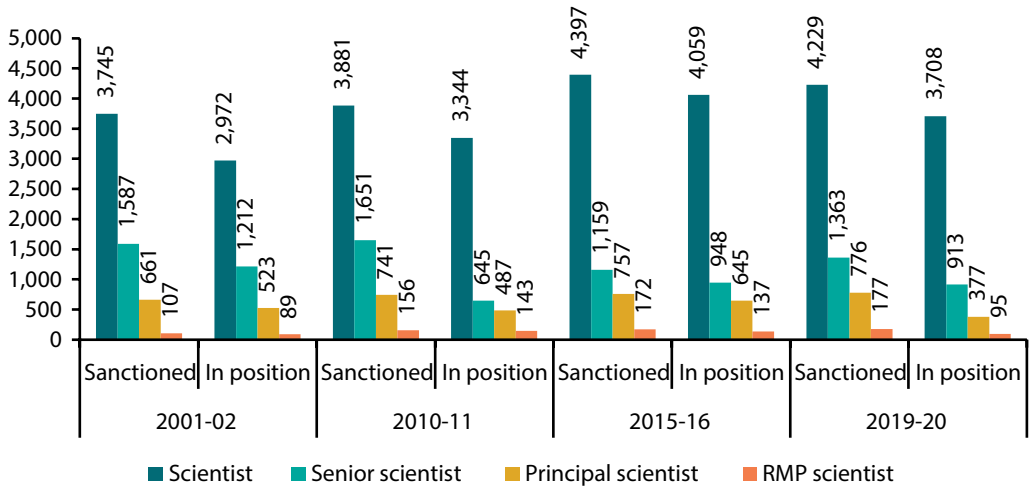

Figure 3.3: Shortfalls of scientists in ICAR research institutes

RMP=Research Management Position

Source: *DARE-ICAR Annual Reports (2001-02, 2010-11, 2015-16 and 2019-20)*

As of 16th September 2020, according to the ICAR website,[14] there were staff vacancy rates of 69%, 24%, 3% and 1%, respectively across the agriculture biotechnology, horticulture, crop sciences and veterinary sciences divisions of its 45 research institutions.[15] While this is indicative and cannot be taken as conclusive data on the sanctioned staff or staff in position, the Standing Committee on Agriculture 2019-20 in its Tenth Report also raised concerns about the large number of vacant posts across scientific and technical categories in ICAR and its institutes (Lok Sabha Secretariat, 2020). It stated that such a high rate of vacant positions, many of which are for scientists and technical staff, would adversely impact the research activities in ICAR, while the lack of support and administrative staff will impede the proper functioning of ICAR system.

The DARE acknowledges that reforms and restructuring activities in the Agricultural Scientists and Recruitment Board (ASRB) have halted recruitment in ICAR. These reforms are being undertaken for better efficiency, increased transparency, accountability and independent functioning. As a result there has been no recruitment in the last three years. Forty-eight recommendations for revamping the board were noted in an ICAR order dated 17th July, 2017 (ICAR, 2018d). One of the measures is for both ICAR and ASRB, through a coordination committee, to develop an in-built mechanism for efficient human resources planning and recruitment so that all expected vacant posts are filled well in time. It was suggested that ICAR must ensure that the requisitions for the vacant posts, along with well-defined qualifications, are sent to ASRB at least six months in advance. The proposed qualifications for each research management position (RMP) should also be discussed and proposed by the ICAR-ASRB Coordination Committee (ICAR, 2018d).

There has been an increase in the number of research institutes, which have more than doubled over the years. Also, an increase in disciplinary diversification has been observed over time both within ICAR institutes and the SAUs. Within ICAR institutes there was an increase from 51 disciplines in the late 1970s to 135 in 2001-02. The numbers of scientific and research institutes have increased to encourage research focused on region, commodity, and issue/theme. However, this has also resulted in the overlap and duplication of research work and competition for financial resources, and has posed considerable coordination challenges among units. The establishment of a vast network of research institutions across the country has resulted in significant knowledge and technology

[14] https://icar.org.in/ICAR-Institutes

[15] There are 64 ICAR institutions under the Research Institutes category. The ICAR website has data available for 45 institutions as on September 2020. Among the 45 institutions there were data gaps in either sanctioned staff or staff in position in 21 institutions.

generation. But it has been observed that most of the technologies being generated remain on paper (Jishnu, et al., 2013). There is a definite need for sharper focus and a well-directed peer review. On aspects related to quality of research, a ranking of agricultural universities was initiated by ICAR in 2017 in line with the National Initiative on Ranking of Indian institutions to improve quality standards and participate in international research rankings (Box 3.1). These rankings, however, do not consider aspects related to impact on farmers and are more focused on research quality in terms of publications.

3.2.2 The role of the private sector

R&D funding for Indian agriculture in universities and research institutions comes mainly from the government (central government and state governments), followed by private companies and cooperatives, and foreign donors. Public research, which is policy driven, is aimed at larger social benefits by focusing on problem-oriented research. On the other hand, private sector research in agriculture, which is market-driven, has a strong presence in agrochemicals, machinery and agro-processing, and is expanding rapidly in hybrid seeds and horticulture. The private sector has been investing at an increasing rate in emerging technologies like ICT, biotechnology and nanotechnology.

The private sector has certain advantages, including focused product development, a rapid time-frame for the delivery of research products, high productivity of scientists, optimal use of research infrastructure, and competitiveness of rivals (Ramasamy & Selvaraj, 2007). This helps it to be more cost effective than the public sector.

Until recently in India the culture of public organizations working in collaboration with their private counterparts was almost non-existent. Public institutes mostly worked in an isolated manner and the private sector was mainly interested in gaining the technology (public research institutes are important repositories of germplasm) available in the public institutions. From the experiences of agricultural biotechnology, public-private relationships were found to be mostly one way. The private sector either used to access germplasm/ technology from the public sector, or it used the infrastructure of the agricultural research system for conducting field trials and tests. However, for agriculture to perform efficiently and keep pace with changing demands will require greater cooperation between the public and private agencies. At present there are no established mechanisms for effective public-private partnerships. In the light of the financial resource crunch in public research institutions it would be essential to encourage private funding in research on new and future technologies.

3.3 Education in agriculture

The human resources developed by agricultural educational institutions have played a significant role in the overall transformation of agriculture in India (Tamboli & Nene, 2013). Agricultural education in India is centrally streamlined by ICAR and imparted through the 75 agricultural universities and a few other institutions in the private sector. There are about 35,000 faculty members spread across these universities, actively engaged on a full-time basis in teaching, research and extension in the fields of agricultural and allied sciences.

The Indian higher agricultural education sector is currently facing many critical challenges in spite of efforts by ICAR and the agricultural universities. Some of the challenges include scarce and poor quality human resources, meagre funding, deteriorating quality of education, weaknesses in teaching-learning processes, and a lack of systematic faculty development alternatives (Krishnan, 2020).

State government funding has provided expansion opportunities for SAUs; however, staff recruitment has not kept pace with the growing student numbers, and numerous faculty and other positions remain vacant. Long-term recruitment restrictions have ultimately increased staff workloads and reduced the time available for research.

Moreover, the phenomenon known as "academic inbreeding" is pervasive, with approximately half of all agricultural faculty members earning their undergraduate and postgraduate degrees from a single university and about 80% of faculty recruits graduated from their employing university.

Weak linkages with the private sector have promoted academic stagnation at a time when competitiveness demands increased networking, not less. About half of India's agricultural employment opportunities are in the private sector, yet curricula predominantly target the needs of the public sector. Few incentives are in place to incentivize innovation or productivity in either teaching or research.

3.3.1 The state agricultural universities

The SAUs have a major stake in the growth and development of agricultural research and education under the NARES. All key states have at least one SAU, and most of the SAUs are multi-campus universities. ICAR has direct participation in the management of the SAUs and it supports them through regular grants. New SAUs have been established in some states by elevating an old campus to the university level. A large number of institutions are established in the northern and southern parts of the country. Meanwhile, western and north-eastern states have been given low priority.

Agricultural students in 2019-20 predominantly hail from Karnataka (23,352), Uttar Pradesh (18,111), Maharashtra (16,896), Andhra Pradesh (10,476) and Gujarat (9443). A major proportion of faculty members hail from Maharashtra (1648), Karnataka (1444), Gujarat (1316), Haryana (1261), Uttarakhand (1,137), Andhra Pradesh (1051) and Tamil Nadu (1031) (ICAR, 2020).

Data on the intake of students across the 64 SAUs summarized in Table 3.2 indicate that in 2019-20, the agriculture sector had the largest share of the intake across undergraduate, postgraduate PhD levels, at more than half (53%, 50% and 51%, respectively). This was followed by enrolments for veterinary and animal sciences (15%) and horticulture (13%) at undergraduate level. At postgraduate level, the intake for veterinary and animal sciences followed behind agriculture at 18%, with horticulture in third place (11%). Similarly at PhD level, the intake for veterinary and animal sciences came in second at 19%, followed by horticulture at 11%. For disciplines like home science, biotechnology, etc. it is important to point out that there are large number of students in these subjects in other colleges/ universities for which data are not available.

Table 3.2: Student intake in SAUs by degree level (2019/2020)

Total number of students	Diploma	Undergraduate	postgraduate	PhD
Agriculture	–	18,467	6,677	2,452
Veterinary & animal sciences	150	4,544	2,430	942
Horticulture	150	5,249	1,521	510
Fishery	–	1,263	310	145
Forestry	–	838	306	139
Home science	–	708	223	85
Sericulture	–	204	14	7
Biotechnology	–	145	37	6
Others	3,450	3,647	1,931	550
Total	**3,750**	**35,065**	**13,449**	**4,836**

Note: *"Others" include College of Basic Sciences and Humanities, College of Technology, College of Agribusiness Management, Post Graduate Institute, Renewable Energy and Environmental Engineering, technology, PHT and Food Processing, Dairy Technology, Community Science, Home sciences, etc*

Source: *Agricultural Education Portal, ICAR*

capacity over time, which is a worrisome trend (ICAR, 2017a). Some of the issues could be due to austerity measures adopted by state governments, lack of funding, or state recruitment policies, with few SAUs having retained a significant proportion of human resources owing to a low rate of attrition. This gives rise to ageing

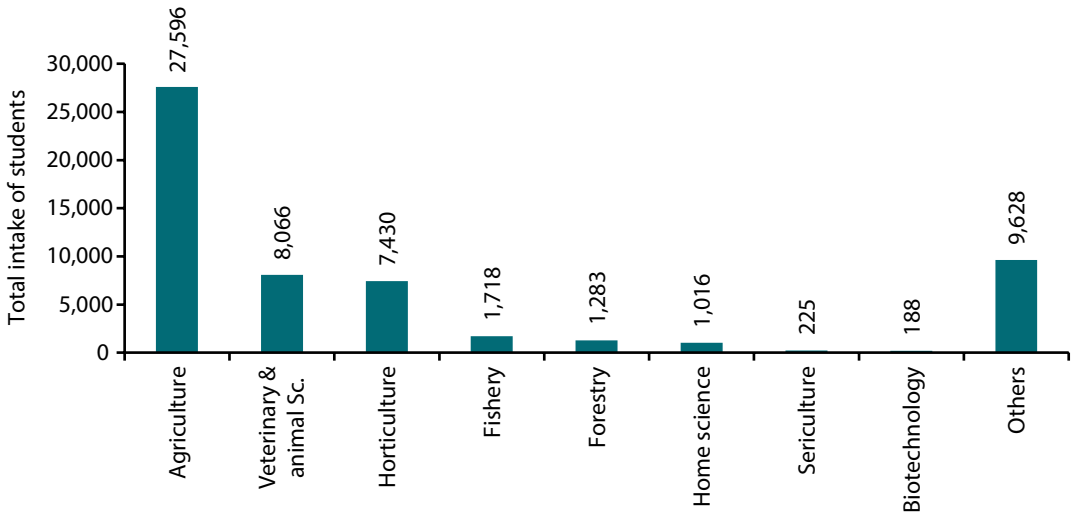

Figure 3.4: Total intake of students in ICAR/SAU system (2019/20)

Note: *'Others' include College of Basic Sciences & Humanities, College of Technology, College of Agribusiness Management, Post Graduate Institute, Renewable Energy and Environmental Engineering, technology, PHT & Food Processing, Dairy Technology, Community Science, Home sciences etc.*

Source: *ICAR website*

Analysing total student intake according to different disciplines for the academic year 2019/2020 reveals 52% of the total intake is in the agriculture sector (crop focused), followed by veterinary and animal sciences (15%) and horticulture (14%). Fisheries and forestry courses had smaller intake levels at 3% and 2%, followed by the rest (Figure 3.4).

The average number of scientists per SAU has fallen, today standing at 287 (2019/2020) compared to 426 in 2001, indicating a severe reduction in research of scientists in SAUs which is another major concern. Further, the number of SAUs has also risen recently.

The total number of faculty employed in SAUs fell from 17,678 in 1992 (Rao & Muralidha, 1994) to 13,633 in 2001 (Jha and Kumar, 2006), and then moderately increased to 14,701 in 2009 due to the establishment of new SAUs. According to the agricultural education portal on the ICAR website, the total number of faculty (professor, associate professor and

assistant professor) in 2019/2020 is 18,374. Thus, during the last decade (2010-20), there has been 25% increase in faculty staff.

3.3.2 Quality issues in agricultural universities

A study undertaken between 2012-14 to assess the teaching aptitude and personality characteristics of about 500 faculty members of different agricultural universities in India indicated that almost one-third (29%) of the faculty have 'average' to 'low' levels of teaching aptitude (Ramesh & Reddy, 2015). The faculty members scored very low on dimensions related to 'teaching potential' and 'interest towards students'. This necessitates institutionalization of need-based capacity- building programmes for the teaching fraternity.

A 2018 study of 550 entry-level agricultural scientists recruited by ICAR, who possess similar qualifications as any entry-level agricultural faculty, at the beginning of their Foundation Course at ICAR-NAARM, concluded that 25% of scientists have an 'unfavourable' attitude towards research, while 45% have a 'moderately Favourable' attitude towards research. Less than one-third of the entry-level scientists (30%) were found to have an 'above average' attitude towards research and research-related activities (Ramesh, 2018). The study helps to gauge the overall pool of postgraduates in agricultural sciences, due to similar qualifications of the entry-level scientists in ICAR and those of the entry-level faculty members of agricultural universities. It brings into focus the difficulties in identifying agricultural graduates with a reasonable aptitude for research from among the potential aspirants, and the need for a comprehensive foundation course for the freshly recruited faculty members.

In order to assess the training needs of agricultural universities' faculty, a recent study was conducted with 292 faculty members of Indian agricultural universities. It aimed at finding out relevance and knowledge levels of selected teaching competencies as perceived by educational administrators, faculty and students (Ramesh, et al., 2019). The relevance and knowledge levels of selected teaching competencies were tested through a teaching competency questionnaire. It found that the vital areas in which faculty members of Indian agricultural universities need to improve their skills and attitudes include knowledge and application of teaching strategies and skills, motivating students through different teaching methods, developing more positive attitudes towards students, and awareness of the importance of life-long learning and updating of subject-matter knowledge.

The study observed that faculty require periodic in-service training programmes to become effective and competent teachers in the current educational environment. The authors of the study developed

a framework for assessing teaching competencies, classified into five teaching domains: (i) professional skills (ii) knowledge and communication skills (iii) curriculum knowledge (iv) assessment and evaluation and (v) attitude and values.

To support more relevant and higher quality education, ICAR initiated the National Agricultural Higher Education Project (NAHEP) in 2017 with assistance from the World Bank, at a total cost of USD165 million over a five-year period. It addresses quality by supporting interested agriculture universities to propose and implement technically sound and verifiable investments that increase faculty performance, attract better students, improve student learning outcomes and raise their prospects for future employability, particularly in the private sector. Relevance is addressed by:

- aligning academic curricula and course contents with skill sets being demanded in agriculture and allied sectors;
- increasing the certificate-level vocational courses to address gaps of trained technical personnel, particularly in market-led extension.

Quality and relevance are supported via investments in ICAR that improve its ability to set and enforce standards across ICAR-agriculture universities and reinforce international cooperation to the advantage of agricultural education.

Some of the achievements under NAHEP in the context of training and capacity building are indicated in Box 3.2.

Box: 3.2 Training and capacity building achievements under NAHEP

- Students from 19 participating agriculture universities and faculty members were sent for overseas training. As on 31st March 2019, 59 students have received international training.
- Demonstrations by adjunct professors for undergraduate students have been organized on topics like organic farming and automatic production and processing of mushrooms.
- Ten MoUs have been signed during 2018-19 with overseas universities for both student and faculty training and exposure visits.
- Trainings for students have been undertaken in thematic areas of new ICT initiatives in agriculture, online education, social media for agricultural development, artificial intelligence (AI), Internet of Things (IOT), cloud computing, RS and GIS applications and virtual learning.

Source: *ICAR (2019a)*

3.3.3 From education to jobs: vocational education and entrepreneurial skills

The Directorate General of Training (DGT) under the Ministry of Skill Development and Entrepreneurship (MSDE) is the lead organization for developing and coordinating at the national-level programmes relating to vocational training, including women's vocational training. The Craftsmen Training Scheme (CTS) implemented by DGT was launched to enhance skills, and extend vocational and technical training to potential human resources. The DGT lists the areas for which one-year training is conducted under the fourth National Skills Qualifications Framework (NSQF) level.[16] They include floriculture, landscaping, horticulture, soil testing and crop technician work.[17]

The National Vocational Education Qualification Framework (NVEQF) is a descriptive framework declared by the Ministry of Human Resource Development which offers qualifications. The All India Council for Technical Education (AICTE) is the statutory authority for approving vocational programmes and has identified five specializations for the agriculture sector: farm machinery and power engineering, greenhouse technology, renewable energy, processing and food engineering, and soil and water conservation (AICTE, 2012). Under NVEQF, the courses proposed for specialization for the agricultural sector are agriculture mechanization, agriculture operation and maintenance, and involve up to seven levels.

The *Report on Policies and Action Plan for a Secure and Sustainable Agriculture* submitted to the Principal Scientific Advisor mentions that investment in human capital (education and health), especially among youth and women, is vital for boosting income in the rural non-farm sector (Office of the Principal Scientific Adviser, 2019).

In order to make agriculture more attractive to rural educated youth, the Attracting and Retaining Youth in Agriculture (ARYA) scheme was initiated in 2015 (Box 3.3). Further, to reorient agricultural graduates for self-employability and entrepreneurship development an initiative "Student READY (Rural Entrepreneurship Awareness Development Yojana)" was launched by the ICAR in partnership with over 55 agricultural universities in the academic session 2016-17. The one-year programme is designed for students in the various agricultural universities across the country as an essential requirement for the award of an undergraduate degree. It includes

[16] The National Skills Qualifications Framework (NSQF), anchored in the National Skill Development Agency (NSDA), is a competency-based framework that organizes all qualifications according to a series of levels of knowledge, skills and aptitude. These levels, graded from one to ten, are defined in terms of learning outcomes which the learner must possess regardless of whether they are obtained through formal, non-formal or informal learning.

[17] https://dgt.gov.in/cts_details

five components which are interactive in nature and created for building skills in project development, execution, decision making and resolving conflicts. It has a range of outcomes (Figure 3.5). Students are provided with a stipend of INR 3000 for a maximum of six months and have access to financial support in the form of a profit share from experiential learning programmes (ICAR, 2019c).

Box 3.3. Skills and jobs for young rural people: the ARYA scheme

The ICAR, via its Agricultural Extension Division, has been implementing the "Attracting and Retaining Youth in Agriculture (ARYA)" project since 2015-16 to capitalize on the country's burgeoning youth population, half of whom reside in rural regions (ICAR 2019a). Skill development of rural youths will encourage them to pursue farming as a profession, and generate additional employment opportunities to absorb under-employed and unemployed rural youth in secondary agriculture and service-related activities in rural areas.

ARYA has trained 4280 youths to set up micro-entrepreneurial units through KVKs across 25 districts in 25 states (ICAR, 2019a). Currently, ARYA is being implemented in 100 districts with a target of training 10,000 rural youth over a period of three years in various aspects (Kumar, 2020). The enterprises taken up as a result of the scheme during 2016-18 are listed in Table 3.3. However, quite often although units are established, they close down after some time due to inadequate market knowledge or technical and financial difficulties. These issues need to be addressed and prioritized in the planning and development process.

Table 3.3: Achievements of the ARYA scheme, 2016-18

Major enterprises	No. of youths trained (A)	No. of youths establishing their own entrepreneurial units (B)	Ratio trained: established (A:B)
Mushroom production	847	291	34%
Poultry	792	280	35%
Lac cultivation*	230	100	43%
Pig farming	387	91	31%
Bee keeping	406	82	20%
Fishery	80	80	100%
Goat farming	221	69	31%
Broiler duck farming	55	46	83%
Value addition	40	40	100%
Nursery management	72	13	18%

Note: **Lac is the resinous secretion of a number of species of lac insects. Thousands of lac insects colonize the branches of the host trees and secrete the resinous pigment. The Shellac is the processed product and greatly used in confectionary, food products, pharmaceuticals, cosmetics, paints and varnishes, etc.*

Source: *ICAR (2019a)*

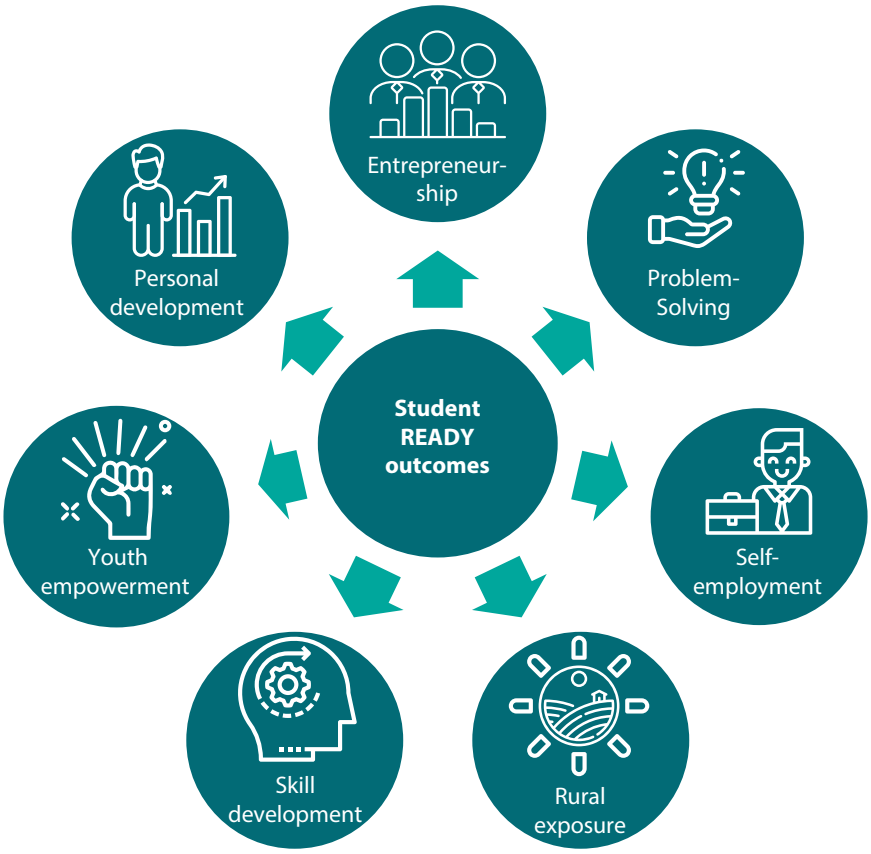

Figure 3.5: Major outcomes of the student READY programme
Source: *Based on ICAR (2019c)*

A total of 452 experiential learning (EL) modules have been provided so far to various agricultural universities across different disciplines, namely, agriculture, agricultural engineering, community science, dairy technology, fisheries, food technology, forestry horticulture and veterinary sciences (Figure 3.6). In addition, various states have also sponsored several EL units.

Many students have opted for further studies to enhance their skills. For example, more than 2500 biotechnology students, 1250 agricultural engineering students and more than 500 veterinary sciences

students have opted for higher education (Figure 3.7). Other students were keen on starting their own enterprise, especially students of biotechnology, horticulture and veterinary sciences. In 2017-18, more than 3000 students were placed in private jobs or opted for entrepreneurship; similarly more than 3000 students secured government employment opportunities.

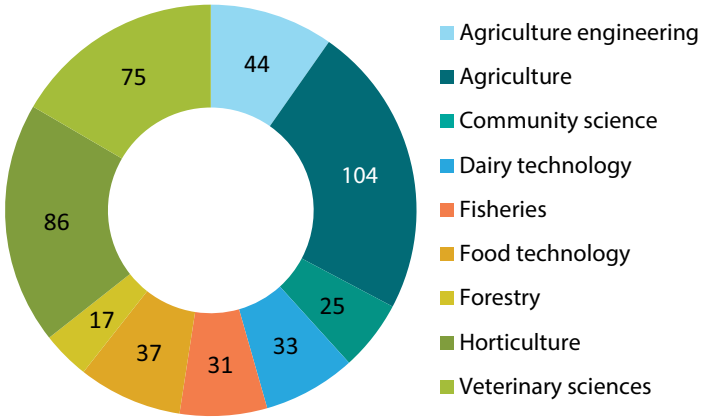

Figure 3.6: Number of experiential learning units by discipline under the student READY programme

Source: *ICAR (2019c)*

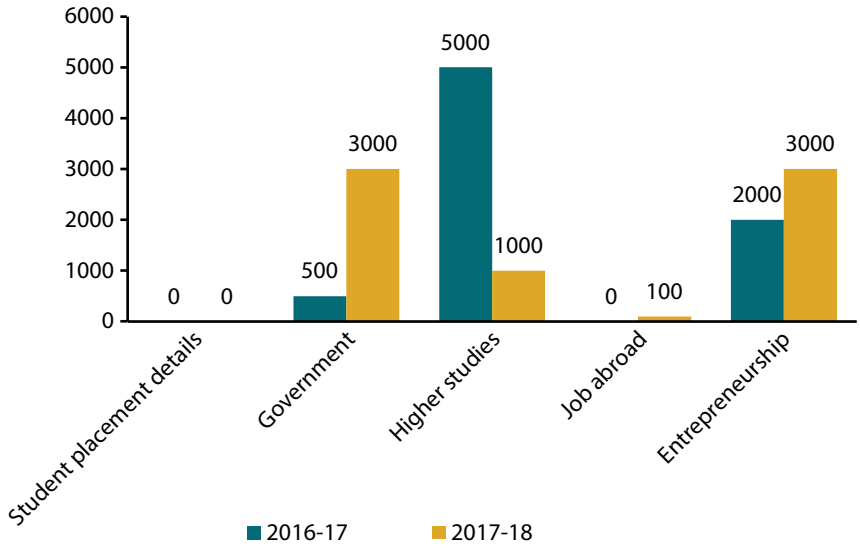

Figure 3.7: Student placements through the READY programme, 2016-18

Source: *ICAR (2019c)*

3.4 Extending science and technology to farmers

Diffusion of innovations in agriculture and technology is important for food and nutritional security. Farmers must have access to technologies for crop, livestock, forestry and fisheries production that improve productivity and sustainability. To enable this, overcoming many gaps – especially local-level capacity and linkages with local-level institutions – is essential.

building a foundation for the farming community. These have now grown to 721 KVKs as of September 2020[18] (Figure 3.8).

The KVK networks and the 11 Agricultural Technology Application Research Institutes (ATARIs)[19] undertake major activities, such as technology assessment, demonstration and capacity development. Under the District Agriculture Plans, KVKs are envisaged to provide the necessary technical input and development initiatives required in the district.

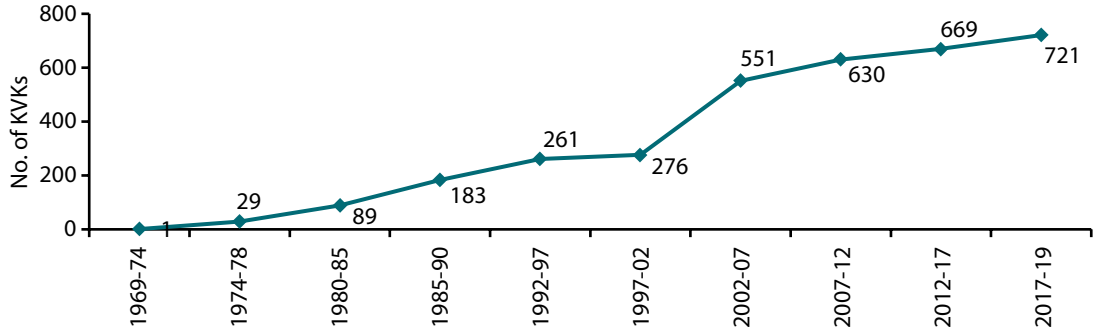

Figure 3.8: Growth of KVKs, 1969-2019
Source: *ICAR website*[20]

3.4.1 KVKs lack human resources

The krishi vigyan kendras (KVKs) were established to facilitate farmer-centric growth in agriculture and allied sectors through the application of appropriate technologies in specific agro-ecosystems. ICAR established the first KVK at the grassroot level during the 4th Five-year Plan Plan in 1974, with the intention of

The extension reform scheme 2019-2020 is a component of the Centrally Sponsored Scheme "Sub-Mission on

[18] https://fvms.icar.gov.in/Circulars/List%20of%20DARE%20Approved%20projects%20for%20fvms.pdf

[19] The ATARIs coordinate and monitor with headquarters at Ludhiana, Jodhpur, Kanpur, Patna, Kolkata, Guwahati, Barapani, Pune, Jabalpur, Hyderabad and Bengaluru.

[20] https://icar.org.in/content/agricultural_extension_division

Agriculture Extension" (SMAE) under the National Mission on Agricultural Extension and Technology (NMAET). It promotes decentralized farmer-driven and farmer-accountable extension systems through an institutional arrangement for technology dissemination in the form of an Agricultural Technology Management Agency (ATMA) at district level. However, there is a shortage of human resources for implementing this scheme. Figure 3.9 reveals that the human resources shortfall is 33%, with 14,353 filled posts out of 21,379 approved posts. Figures 3.10, 3.11 and 3.12 break down the workforce status (approved and reportedly filled) under the extension reform scheme 2019-2020 into state, district, block and post. It can be observed that there is a shortage of staff across all post categories at state level, with an overall unmet demand of 44%. More than 50% of posts are unfilled for Gender Coordinator (GC) and State Coordinator, followed by Deputy Director at 48%. Similarly, across all post categories at district level there is an overall unmet demand of 35%, and more than 50% of Deputy Project Director posts are unfilled. At the block level there is an overall workforce shortage of 32%, while 36% of Assistant Technology Manager posts are unfilled.

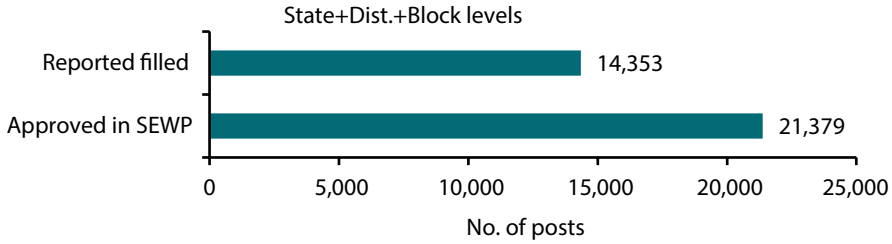

Figure 3.9: Human resources shortages in the extension system
SEWP: State Extension Work Plan
Source: *Extension Reform Monitoring System, Department of Agriculture, and Farmers' Welfare*

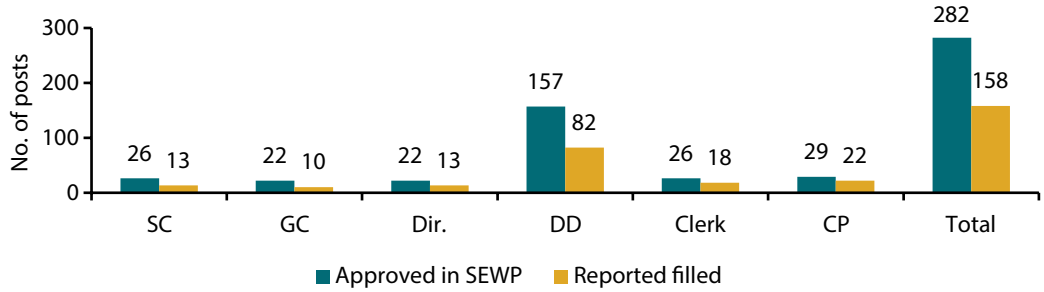

Figure 3.10: Human resources shortages at the state extension level
CP=Computer Programmer, DD=Deputy Director, Dir.=Director, GC=Gender Coordinator, SC=State Coordinator, SEWP=State Extension Work Plan
Source: *Extension Reform Monitoring System, Department of Agriculture, and Farmers' Welfare*

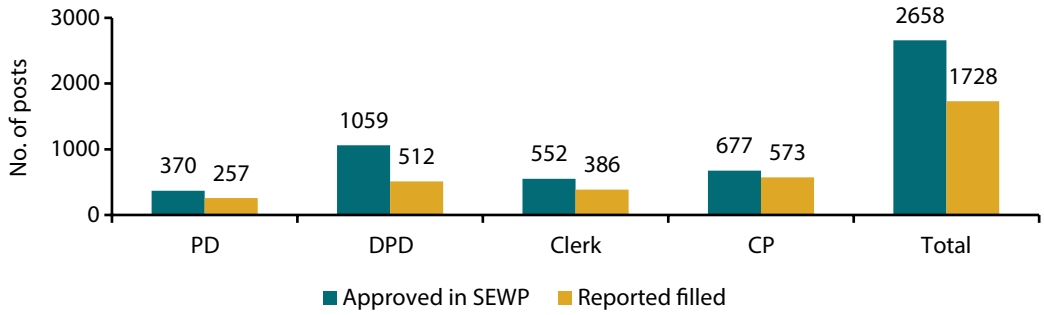

Figure 3.11: Human resources shortages at the district extension level
CP=Computer Programmer, DPD=Deputy Project Director, PD=Project Director, SEWP=State Extension Work Plan
Source: *Extension Reform Monitoring System, Department of Agriculture, and Farmers' Welfare*

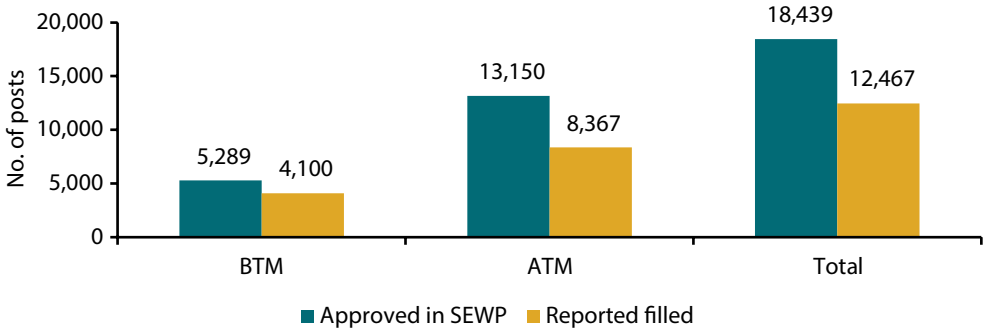

Figure 3.12: Human resources shortages at the block extension level
BTM=Block Technology Manager, ATM=Asst. Technology Manager, SEWP=State Extension Work Plan
Source: *Extension Reform Monitoring System, Department of Agriculture, and Farmers' Welfare*

The approved and reportedly filled posts at block, district and state levels across 31 states and UTs are provided in Figure 3.13. The graph illustrates the glaring number of vacancies across all states, barring Himachal Pradesh and smaller states like Arunachal Pradesh and Tripura. J&K and Bihar have the highest vacancy rates at 85% and 78%, respectively.

A 2015 study by the National Institute of Labour Economics Research and Development on human resources in KVKs looked at 48 KVKs and 1870 farmers across five states in the north, east, north-east, west, south and central regions (Rajasthan, Arunachal Pradesh, Maharashtra, Tamil Nadu and Madhya Pradesh) (NILERD, 2015). The major findings of the study were that KVKs are short of staff and lack the required infrastructure. It indicated that there is a high percentage of vacancies in KVKs housed in SAUs, with more

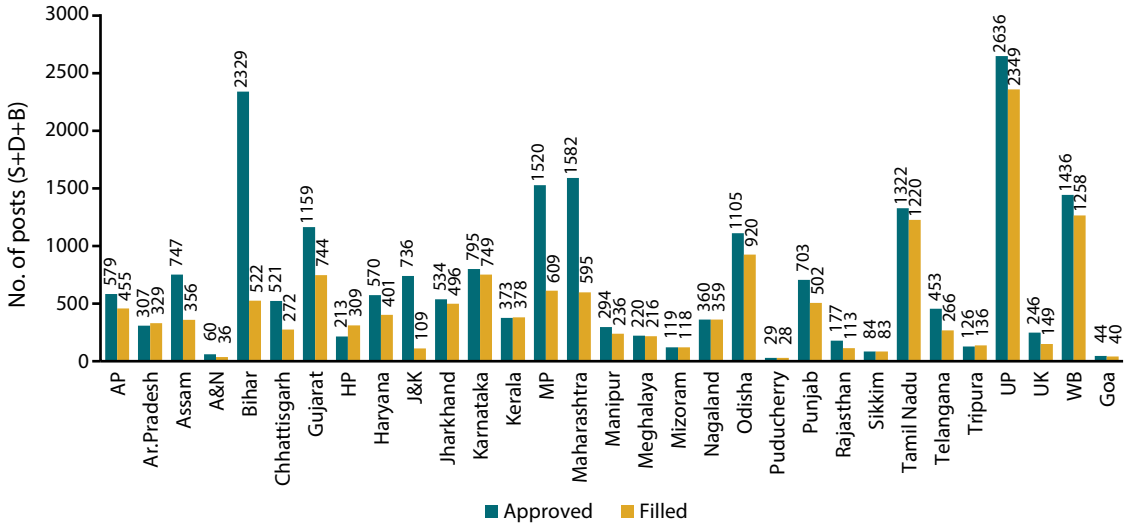

Figure 3.13: Human resources shortages in the extension system across 31 states and UTs

A&N = Andaman and Nicobar Islands, AP = Andhra Pradesh, J&K = Jammu and Kashmir, MP = Madhya Pradesh, UK = Uttarakhand, UP = Uttar Pradesh, WB = West Bengal

Source: *Extension Reform Monitoring System, Department of Agriculture, and Farmers' Welfare*

vacancies in Rajasthan and Maharashtra for technical support staff, scientists and other contractual staff categories. The percentage of vacancies ranged between 60 and 100%. In Rajasthan almost half the vacancies were for technical support staff and one-third were for scientists. There has been a reduction in budgetary allocations over the years which is minimizing the coverage of KVK activities. There have also been delays in sanctioning budgets, leading to a financial crunch and affecting the activities of KVKs housed in SAUs. The study also mentions problems relating to anomalies in postings. For instance, a number of KVKs have infrastructure such as laboratories and equipment for soil testing, but lack technical assistants.

To conclude, we find that the linkages are weakening between science and public policy, which was once very close, and between the scientist and farmer. In the past the former would go to the farmer's field to demonstrate a technology. Although this gap was sought to be addressed by the KVKs, their role lacks focus in terms of research or extension or both. Scientists at the KVKs prefer to be in research institutes than in KVKs. The roles of extension in KVKs at grassroots level are changing. These changes can be segregated into four areas (Table 3.4): (i) increasing the visibility of KVKs; (ii) training and capacity building; (iii) research and extension activities; and (iv) capitalizing on ICTs as a viable option.

Table 3.4: Areas of focus for future extension at grassroots level

Increasing KVKs' visibility	**Research & extension activities**
◆ A storehouse of knowledge through instructional farms ◆ Training centre for specialized solutions for sustainable agriculture ◆ Active demonstration units at KVK to serve as good models for training farmers ◆ Intensive fieldwork in selected Taluka of new KVK ◆ Serving as knowledge dissemination centres for all line departments of district	◆ Sensitizing farmers about new technologies ◆ Conducting benchmark surveys for problem identification through agro-ecosystem analysis ◆ Prioritizing research and extension targets ◆ Conducting on-farm trials on selected technologies ◆ Impact assessment of technologies ◆ Quality seed production of important crops, seedlings ◆ Livestock development and demonstration centres
Changing roles of extension in krishi vigyan kendras	
Training and capacity building	**Capitalize on ICT as a viable option**
◆ Training of farmers in resource conservation technologies ◆ Organizing farmers into groups – farmer clubs, clusters, and FPOs ◆ Forming farmers groups for common property resource management ◆ Training of Para Extension Trainers ◆ Training women in post-harvest and value addition processing technologies for microenterprise development ◆ Training of extension functionaries for updating their knowledge ◆ Training of youths in entrepreneurial motivation and enterprise development	◆ Establishing a web interface with social media and networking platform ◆ Developing crop-specific mobile apps (diagnostic purposes) ◆ Maintaining a knowledge repository (database management) in coordination with ATARI ◆ Developing video modules for different farming practices ◆ Maintaining the KVK website with new technologies and success stories ◆ Developing online ferti-meter for the proper combination of fertilizer use based on soil health cards ◆ Linking of market and crop insurance information on the website with agmarknet/eNAM[21]

FPOs=farmer producer organizations
Source: *Kumar, et al. (2020)*

[21] National Agriculture Market (eNAM) is a pan-India electronic trading portal which networks the existing Agricultural Produce Market Committee (APMC) mandis to create a unified national market for agricultural commodities.

3.4.2 The potential role of agri-input dealers

In India, there are more than 282,000 agri-input dealers; they are one of the major sources of information on farming accessed by farmers (Department of Agriculture and Cooperation, 2014). However, most of these input dealers do not have any formal education in agriculture, nor have they received training on selection and use of agro-inputs. In 2014, the National Institute of Agriculture Extension Management (MANAGE) designed a one-year diploma course titled 'Diploma in Agricultural Extension Services for Input Dealers (DAESI)', which imparts relevant and location-specific agricultural education to equip these input dealers with sufficient knowledge to transform them into para-extension professionals so as to enable them to address the day-to-day problems being faced by farmers at field level. The course fee is subsidized by the Department of Agriculture a Cooperation (DAC), GoI, at the rate of INR 10,000 per input dealer. However, where agribusiness companies are involved, the company will contribute INR 10,000 and the balance of INR 10,000 will be contributed equally by DAC and the input dealer at INR 5000 each. The states of Jharkhand and Odisha are contributing INR 15,000 per input dealer from RKVY funds, thus reducing the course fee share of input dealer to INR 5000 only. It is suggested to continue this model in these states, and other states may also adopt this model.

4. FINANCING THE CAPABILITIES AND SKILLS FOR SUSTAINABLE FOOD AND LAND USE

Sufficient and timely availability of funding to support agricultural research and development activities is a key dimension of capability for science technology and innovation (STI). Funding is required across the innovation chain, starting from knowledge generation, through to use and commercialization. R&D expenditure on agricultural activities acquires special importance in India given the country's need to feed over a billion people, coupled with the pressure on arable land in light of expanding urbanization. Greater expenditure on agricultural R&D would also be important for agriculture to contribute to the SDGs, given that the sector is key for achieving half of the 17 SDGs and 169 targets set for 2030.

4.1 Financing agricultural research and extension in India

Agricultural research, education and extension investments in India, which are largely publicly supported, account for barely 0.7% of agricultural GDP (0.54% for research and education, 0.16% for extension and training; based on expenses in 2013-14) (Gulati, et al., 2018). Central Government expenditure on ICAR agricultural R&D fell from 12.49% of the R&D expenditure by Central Government in 2000-11 to 11.37% in 2014-15 (Figure 4.1). During 2017-18, ICAR accounted for the third-highest share (11.1%), with the Defence Research and Development Organisation (DRDO) accounting for the maximum share of 31.6%, followed by the Department of Space at 19% (DST, 2020).

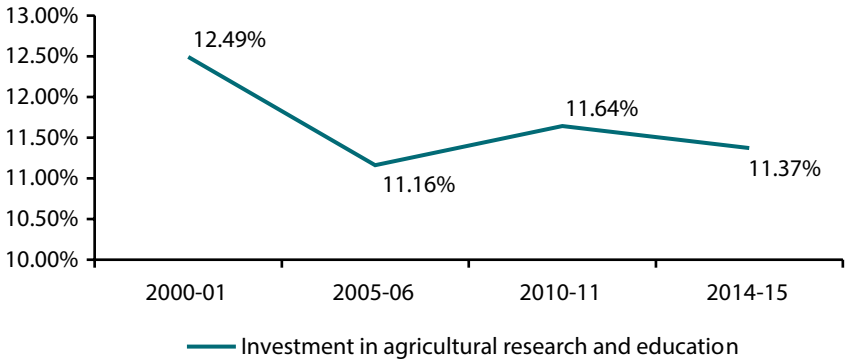

Figure 4.1: Share of R&D expenditure on agriculture in total R&D expenditure
Source: *IASRI (2019)*

In absolute terms, however, investment in agricultural research and education has been growing (Figure 4.2). It almost doubled from INR 11,617.4 million in 2000-01 to INR 17,172.7 million in 2005-06, and it increased by 85% between 2005-06 and 2010-11, highlighting the continuing emphasis on agriculture as a priority sector. R&D expenditure in 2014-15 grew by one-fourth of the investments made in 2010-11.

The financial outlay of the Department of Agricultural Research and Education for 2016/17-2020/21 is shown in Figure 4.3. There has been a gradual rise in the allocations to R&D in agriculture, in line with the recommendations of the 2017 Committee on Doubling Farmers' Income (MoAFW, 2017h). In 2020-21, agricultural research and education was allocated a budget of INR 83,625 million, an increase of 6.6% over the revised estimate of 2019-20. The allocation is primarily for salaries, pensions and administrative expenses, as well as support for various schemes under ICAR. The increased allocation for agriculture extension in the 2020-21 budget, which is reflected in the rise in overall

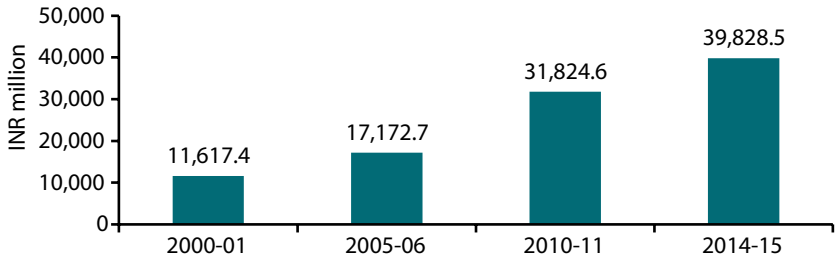

Figure 4.2: Share of R&D expenditure on agriculture in total R&D expenditure
Source: *IASRI (2019)*

financial outlay by DARE, has also been augmented in comparison to the last three fiscal years, keeping in mind the additional expenditure on increasing the number of KVKs, creating the required infrastructure for setting up new KVKs and strengthening the infrastructure in the old KVKs. The amount set aside for agriculture extension in the 2020-21 budget is INR 2425 million (Lok Sabha Secretariat, 2020).

Looking at the sectoral distribution of expenditure on research, education and extension between 2002-03 and 2013-14, there is a huge bias towards crop husbandry (70% of total research and education expenditure; 92% of total extension expenditure) as compared to animal husbandry and dairy (10% of total research and education expenditure; 0.9% of total extension expenditure) (Gulati, 2018). Close to 10% of ICAR's budget is spent on demonstrating new technology and farmers' skill development, in partnership with private and civil society organizations (ICAR, 2017).

The Standing Committee 2016-17 on Agriculture observed in its 36th report[22] the significance of major commodities imported between 2011 and 2016 (vegetable oils, pulses, cashew, spices, sugar) and the need to increase their production. It recommended that the central government allocate additional funds to ICAR for this purpose. The expenditure allocated to the ICAR accounts on average for 63% of the Department of Agricultural Research and Education allocation in the four years between 2017-18 and 2020-21.

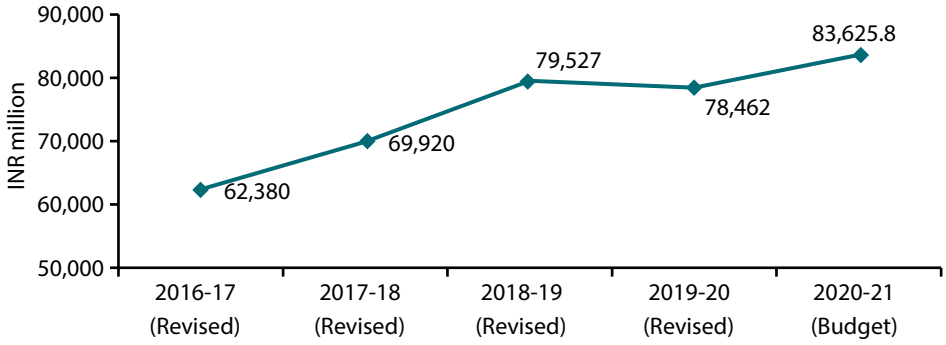

Figure 4.3: Financial outlay of Department of Agricultural Research and Education, 2016-21
Source: *ICAR (2016a), ICAR (2017b), ICAR (2018a), ICAR (2019b), MoF (2019)*

[22] Report no. 36, Standing Committee on Agriculture: 'Demand for Grants (2017-18), Department of Agricultural Research and Education', Lok Sabha, March 2017, http://164.100.47.193/lsscommittee/Agriculture/16_Agriculture_36.pdf.

The average expenditure on agricultural education in total expenditure has been 10% in the last five years (Figure 4.3). The provision for agricultural education in the budget allocation by DARE helps to provide financial support to all the agricultural universities in the country, including the SAUs, Deemed Universities (DUs) and Central Universities (CUs) with agriculture faculties.

In the case of crop sciences and animal sciences, the budgeted expenditures for 2020-21 were to the tune of INR 9645 million and INR 4,860 million respectively, which was a 12.3% and 7.4%, respective increase from the revised revenue expenditure incurred in 2019-20 (Figure 4.4). Agriculture education witnessed a surge of 7.6%, from INR 6,876 million in 2019-20 to INR 7,400 million in the 2020-21 budget. It was observed that between the 2017-18 revised budget and the 2020-21 budget, the share of expenditure on central sector research schemes/projects in total R&D expenditure remained almost steady (Table 4.1).

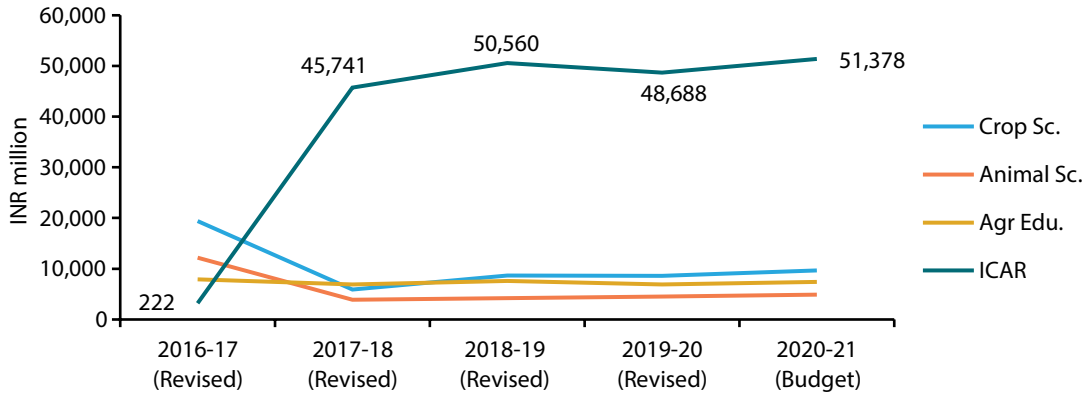

Figure 4.4: Financial outlay on central sector research schemes and projects
Crop Sc. = crop sciences; Animal Sc.= animal sciences; Agr Edu.=agricultural education
Source: *ICAR (2019b), MoF (2019)*

Table 4.1: Share of central sector research schemes and projects in total R&D expenditure

Central sector schemes/projects	2016-17 (Revised)	2017-18 (Revised)	2018-19 (Revised)	2019-20 (Revised)	2020-21 (Budget)
Crop Sc.	31%	8%	11%	11%	12%
Animal Sc.	20%	6%	5%	6%	6%
Agr Edu.	13%	10%	10%	9%	9%
ICAR	5%	65%	64%	62%	61%

Source: *IASRI (2019)*

Studies have indicated a lack of funding and allocation inefficiencies in public research in agriculture with no clear concept of budget (Pal, et al., 2003). A major concern in agricultural R&D is the lack of funding support due to budget deficits and bureaucratic hurdles for infrastructural development for SAUs and ICAR zonal research stations in remote locations. Three-fourths of financial support is spent on salary and allowances for regular employees provided by the state government, with only 10% of the total budgetary provision available for infrastructure and the remaining 15% for meeting the operating costs. This may be partly attributed to overstaffing in non-scientific posts.

Though the private sector has also started getting involved in recent years, a major proportion of private investment is for in-house research by input companies and is concentrated in the areas of plant breeding, pesticides, food processing, animal health and farm machinery (Pray & Nagarajan, 2012). These private R&D organizations can be broadly classified into multinational companies, mostly active in seeds; large national companies working in all fields of agricultural R&D (mostly inputs); and small national companies working at the state or regional level.

There has also been significant support from the World Bank and United States Agency for International Development (USAID) in terms of funding and capacity building for agricultural research and education in India (Table 4.2). From the early 1960s, the USAID supported the establishment of the SAUs and provided funding for agricultural research and training scientific human resources (Alex, 1997). Since 1980s, the World Bank through its National Agricultural Research Project (1978-96), National Agricultural Technology Project (1998-05) and National Agricultural Innovation Project (NAIP) (2006-14), has become a major sponsor of agricultural research at the state, zonal and national levels. The projects focused on institutional development such as research-extension linkages, as well as supporting research programmes and human resources development in the SAUs.

4.1.1 Agricultural R&D spending

Total agricultural R&D spending[23] in India has risen from USD 1786.3 million in 2000 to USD 4172 million (constant 2011 PPP dollars; Figure 4.5). The rate of increase was higher in the initial years of the observed period: between 2015 and 2017 there has been an average growth of 4% in agriculture R&D expenditure.

[23] Total agricultural R&D spending (excluding the private for-profit sector) includes salaries, operating and programme costs, as well as capital investments for all government, non-profit, and higher education agencies involved in agricultural research in the country. Expenditures have been adjusted for inflation and are expressed in 2011 prices.

Table 4.2: Trends in international support for agricultural research and education in India

(in million US dollars)

Period	USAID	World Bank	Total
1963-65	3.24	-	**3.24**
1966-77	2.84	-	**2.84**
1978-86	4.94	27.00	**31.94**
1986-96	4.12	72.10	**76.22**
1995-2001	-	59.50	**59.50**
1998-2005	-	196.80	**196.80**
2006-14	-	200.00	**200.00**

Source: *Alex (1997), ICAR (2017)*

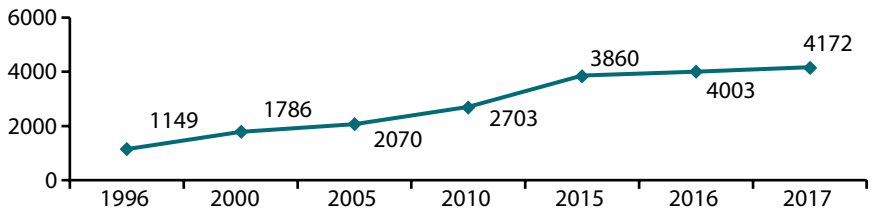

Figure 4.5: Agricultural R&D spending, 1996-2017 (USD million, constant 2011 PPP dollars)
Source: *Agricultural Science and Technology Indicators (2020)*

4.1.2 Agricultural research intensity

The measure of research intensity helps to indicate the commitment to agricultural R&D. It can be measured as the total agricultural R&D spending (excl. private for-profit sector) as a percentage of agricultural output (AgGDP) or the number of researchers per 100,000 farmers. The 12th Five-year Plan aimed at investing at least 1% of its AgGDP in agricultural research and education by the end of the plan period (IFPRI & NAARM, 2016). Figure 4.6 shows that long-term R&D spending has not kept pace with AgGDP growth over time, resulting in a decline in the agricultural research intensity (ARI) ratio in recent years. It can be observed that during 2000-17 the ARI remained unchanged, ranging in 0.27-0.31% of AgGDP.

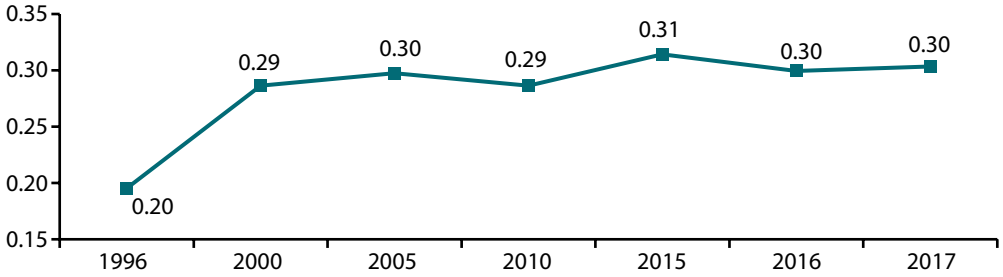

Figure 4.6: Agriculture research intensity: spending as a share of AgGDP (1996-2017)

Note: *Data for AgGDP were sourced from the World Bank's World Development Indicators; data on number of farmers were from FAOSTAT*[24]

Source: *Agricultural Science and Technology Indicators (2020)*

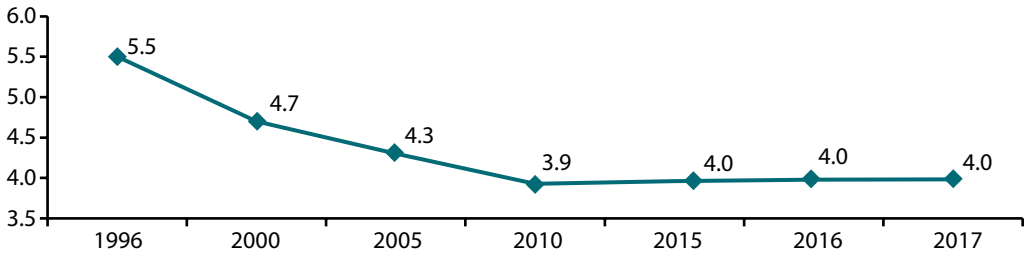

Figure 4.7: Number of researchers per 100,000 farmers (1996-2017)

Source: *Agricultural Science and Technology Indicators (2020)*

4.2 Financing rural entrepreneurship

The National Bank for Agriculture and Rural Development (NABARD) has been at the forefront of capacity-building programmes since 1990, with the introduction of Rural Entrepreneurship Development Programmes (REDPs) and Skill Development Programmes (SDPs). One of the bank's thrust areas includes the endorsement of an entrepreneurial culture among rural youth by helping to kick-start enterprises in rural off-farm sectors. The bank has been instrumental in lending support to skilling initiatives of the Ministry of Rural Development through the provision of grants to rural development and self-employment training institutes (RUDSETIs) and Rural Self Employment Training Institutes (RSETIs). NABARD manages four training establishments in Lucknow, Mangaluru and Bolpur to take care of

[24] FAOSTAT provides free access to food and agriculture data for over 245 countries and territories and covers all FAO regional groupings from 1961 to the most recent year available (http://www.fao.org/faostat/en/#data)

capacity-building programmes.
As of 31st March 2020, NABARD had supported 34,878 REDPS/SDPs, with grant assistance of INR 1.54 billion, imparting training to around 90.4 million unemployed rural youth (NABARD, 2020).

NABARD launched a new initiative in 2017 to place training related data on an online portal called NABSKILL which can help compile a database to allow for monitoring of programmes. The portal facilitates training institutions to seek financial support from the bank. This programme will permit appraisal of the ground-level impact of the training imparted to rural youth and fine-tune the policies. The Bankers Institute of Rural Development (BIRD) is an autonomous society promoted by NABARD to cater to the training requirements related to agriculture and rural banking. BIRD is also engaged in identifying and documenting issues critical to the expansion of inclusive rural credit and facilitating policy discussions on these issues of national importance (BIRD, 2020). Training programmes by BIRD include banking, finance, micro finance, financial inclusion, projects, development themes, IT applications in banking, human resource management, climate change, sustainable development, and natural resource management.

5. FINDINGS AND POLICY IMPLICATIONS

From a capability perspective, the existence of a vast array of agricultural science and technology organizations across various agro-ecological regions of the country, performing the tasks of research, education, extension, and a sizeable chunk of human resource development are the strengths of agricultural sector in India. However, within these strengths are embedded limitations – including a rigid government-controlled R&D system, sub-optimal research, the absence of a vibrant technology sector, and a shortage of high-quality human resources.

This scoping study on the STI capabilities and skill components of India's food and land-use systems brings out some important facts and observations which underline the need to take a closer look at the relevant policies, programmes and institutions. They are summarised below.

The policy focus is narrow and rigid

The policy focus in agriculture has been mostly on technological innovation for improving productivity levels in food crops. While this has met the immediate concerns of food security, the pattern of development has been uneven and the plight of the majority of producers has remained below par. A rigid set of habits and practices characterize most of the organizations involved in knowledge-intensive development activities (research, technical advice, training). These also set the 'industry standard' of how these knowledge-intensive activities are conducted (Sulaiman, et al., 2006). Thus, greater emphasis has to be put on bringing institutional change across research, education and extension organizations, as well as others involved in agricultural and rural development. In this endeavour, it is important to note that besides ensuring the active participation of the farming community in technology generation and promotion, there is also a need to examine the interaction patterns of various actors and their roles in innovation. This would promote meaningful interventions in terms of innovation and building S&T capability.

Government ministries and departments' skill programmes are too compartmentalized

While skill development has been emphasized in all departments, the skilling programmes do not seem to be designed as part of a larger picture. Each sector has its own requirements, and within each sector, each sub-sector also has its specific requirements. In the NSDC initiatives related to food and land use, there is no, or only minimal, involvement of the water ministry (Ministry of Jal Shakti), Ministry of Rural Development and Ministry of Environment, Forest and Climate Change. There is also inadequate participation in a 'skilling convergence' process by the important departments of Rural Development, Land Resources, Water Resources, etc. This is a major policy gap, leading to wasteful expenditure. Coherence is possible only when each sector identifies not only production skills but also the post-harvest, processing, storage, transport, financial and marketing skills required with respect to regional endowments.

Inadequate human resource quantity and quality are holding back sustainable productivity

Overall, the report finds that across the system there is a lack of human resources with the skills required to enhance the capability of farmers for increasing productivity, quality, marketing and value addition. However, overall assessment of scientific strength in the sector is difficult due to the absence of information on scientists engaged in research in the private companies, such as for seed, fertilizer, food processing, etc.

The report finds that the total number of educated and trained personnel in the agricultural sector is much too low given the size of the sector. At the same time, the unemployment rate is also quite high among these personnel owing to a mismatch between skills needed and training offered. The number of full-time researchers in 2018 was 11,363 (excluding the private for-profit sector due to lack of available data), making it one of the largest agricultural research and development (R&D) systems in the world. However, the number of full-time equivalent (FTE) researchers per 100,000 farmers has stagnated at close to 4 FTEs since 2005, which is too low to cater to farmers' needs.

At 5093 in 2019-20, the number of scientists in the Indian Council of Agricultural Research (ICAR) is significantly lower than the sanctioned strength of around 7000. Further, a decline in scientific strength in the SAUs is observed due to the non-replacement of retiring faculty and government restrictions on recruitment. There is a gap between the sanctioned and actual posts across various categories of employees in ICAR and its institutes. Latest data show vacancy rates of 69% (agriculture biotechnology division), 24% (horticulture division), 3% (crop sciences division) and 1% (veterinary sciences division).

Only a small share of scientists is engaged in actual research; most spend more time on teaching and administrative tasks than in research. Combined with inadequate funding, this poses a big challenge. Finally, the expenditure on non-scientific and non-technical staff in 'scientific' organizations remains a matter of concern.

Research is overly focused on food crops in irrigated areas

The role of research in reducing regional imbalances has not been satisfactory. Agriculture in the less-favoured regions (mostly rainfed) covers around 70% of the cropped area and nearly 40% of agricultural production. Yet the level of research investment in these regions is disproportionately low. There is also very little private sector research interest in such areas, characterized by resource-poor small and marginal farmers. Private sector companies are generally interested in the high-value commercial crops cultivated mostly under irrigated conditions. The research focus of the private sector has been mainly on chemicals (pesticides and fertilizers) and food processing, followed by seed and machinery, biotechnology and plant breeding, animal health and poultry (Pal & Jha, 2007).

The disproportionate share of research on food crops in irrigated areas is a hang-over from 'food shortage' days. Yet the past decade has seen the composition of gross value-added (GVA) change: milk has a higher GVA than the combined GVA of rice and wheat. The composition of the food plate of the average Indian has also

changed, with a shift to a greater share of protein, fruit and vegetables. This change is significant since India is currently battling undernutrition more than hunger. Emphasis on dairy, poultry, fruits and vegetables is necessary from a supply and a demand point of view. Accordingly, the focus needs to shift to these and to rainfed agriculture.

While the number of scientific and research institutes has been increasing to encourage research focused on region, commodity, and issue/theme, this has also resulted in the overlap and duplication of research work and competition for financial resources, and has posed considerable coordination challenges among units. And while the establishment of a vast network of research institutions across the country has resulted in significant knowledge and technology generation, most of the technologies generated remain on paper. R&D spending has not kept pace with AgGDP growth over time, resulting in a decline in the agricultural research intensity (ARI) ratio in recent years. Agricultural R&D institutes lack funding due to budget deficits and bureaucratic hurdles for infrastructural development for SAUs and ICAR zonal research stations in remote locations.

Education is being held back

Some of the concerns relating to the Indian higher agricultural education set-up include inadequate training opportunities, inadequate mentorship and devotion of too much time to administration at the expense of teaching and research by senior scientific staff, and inappropriate recruitment policies in state agricultural universities which cater for more localized selection.

The quality of PhDs has reportedly dropped due to a lack of rigour in research. This is a serious threat. If the quality of our PhDs is not of international standard, we will miss out on benefits from frontier technologies and cutting-edge research. A fall in high-quality PhDs reflects on the quality of students in the lower streams as well. The problem of 'in-breeding' in agricultural universities is a serious concern, calling for a policy change.

The qualification and skilling system does not reflect today's challenges

More qualification packs related to environmental management and climate change need to be developed by engaging a broader set of actors. For example, skilling programmes under the National Skill Development Corporation (NSDC) have no packs on crop diversification. This needs to be urgently addressed as this will also help in removing the root causes of agri-residue burning linked air pollution and ground-water depletion in Punjab, Haryana and Uttar Pradesh.

While there are skilled professionals who are trained to manage their own stocks

in warehouses, there is no training at the farm or small trader level on reducing food loss, another national priority. There appear to be widespread gaps in the availability of a workforce with requisite skills in the food sector. There are several dimensions to this. Firstly, there is a need for trained human resources with basic technical skills. Secondly, there is a need for capacity-building initiatives to continuously upgrade skills within the experienced workforce. Finally, there is a need to develop techno-managerial skills for expanding innovation through business management training.

The extension system needs to be refocused

Little has been achieved in terms of institutional innovation to adapt public sector agricultural research and extension in response to changing demand. Indian agricultural research and extension is marked by an unwillingness to reform its institutions (Lele & Goldsmith, 1989; Raina, 2003). The Krishi Vigyan Kendras (KVKs) lack the human resources (in terms of both numbers and skills) required to enhance farmers' capacity for increasing productivity, as well as quality, sustainability, marketing and value addition. An inadequacy of human resources is observed across all levels of the workforce in KVKs.

Analysis of research, extension and farm linkages reveals that although there is interaction between extension and farmers, the interactions between research and extension, and between research and farmers, are lacking. Thus, the whole system needs a re-look by outside experts and a new farmer-focussed design. Also, weak linkages with the private sector have promoted academic stagnation and hampered research and extension in addressing real-world problems and economic and social aspects. There are more than 280,000 agri-input dealers who could become valuable 'change agents' if they were given the requisite technical skills. Skilling them needs an innovative combination of regulation and incentives. Furthermore, co-operatives have a vast network of training institutions in India. Many of these have become outdated in terms of content and capabilities. Updating them help to meet the challenges of institution building for farmer-producer organisations.

Fisheries, particularly inland fisheries, are emerging as an important area for sustainable increases in farmers' incomes and for nutrition. This has vast scope for poorer states and has relevance for many other parts of the country as well. To tap this potential will require new skills, not only in the production process, but also in processing, storage and transportation. This can be taken up as a new area of skilling and for STI approaches.

6. A CAPABILITIES AND SKILLS ROADMAP FOR SUSTAINABLE FOOD AND LAND-USE SYSTEMS

Looking at the challenges and opportunities in the context of sustainable food and land-use systems raised in this report, skilling in India needs a holistic and ecosystem-based approach. This will require greater convergence between land-use related ministries and skills frameworks. This final chapter sets out a capabilities and skills roadmap for sustainable food and land-use systems. It first outlines the broad new directions in which India needs to head, followed by specific recommendations broken down into short, medium and long-term actions for enhancing capabilities and skills in the sector for policy makers and development practitioners.

6.1 Moving towards a systems approach

According to the Sustainable Development and Climate Change vision proposed by the Government of India (GoI, 2020), the aim of the government is to align its development priorities with SDG indicators. This 'nexus' approach employs the principles of integrating management and governance across sectors and scales. The approach recognizes the linkages among the various Sustainable Development Goals (SDGs) which have strong impacts on reinforcement of policies. This necessitates looking at systems instead of individual components or short-term outcomes; looking at the inter-related feedbacks from other sectors; and promoting cooperation among sectors while reducing competition for scarce resources. It also recognizes that various socio-ecological processes are interlinked.

Food and land use also need to be looked at as 'systems' following this nexus or interlinkages approach. Favouring a system approach over a compartmentalised approach can allow for diversification of income-generation activities at the farm level and secure higher total output without stress on the production ecology. A systems approach should be linked to changing market trends, should utilize information technology in the agricultural sector, and should enhance agro-processing, including industrial uses and food supply chains, which will generate new opportunities and make the agricultural system sustainable.

6.1.1 Base policy on agro-ecological regions

For an optimum utilisation of resources on a long-term basis and to anticipate and mitigate adverse implications or unintended consequences, it is suggested to develop a survey and undertake studies to map the various agro-climatic zones in the state using a sustainable food and land-use systems lens. This will help to understand the micro-level status of capabilities and skills requirements, as well as meso-level interventions with regard to institutions and arrangements that need to be carried out to raise the profitability and sustainability of the system.

Fostering locally available skills ecosystems means concentrating relevant actors in an area/agro-ecological region and enhancing their ability to forge effective partnerships for training, skills development, and knowledge flows and for fostering local innovation suited to local needs. The development of integrated farming systems (IFSs) such as zero-budget natural farming is in progress (MoAFW, 2020d). ICAR has developed 51 IFS models and 45 organic farming models for promotion in different agro-ecologies of the country; the majority of these are livestock based.

Policy making in agriculture has to be sensitive to the choices between different types of investments, especially infrastructure, human capital and agricultural research, and between different

types of agricultural regions, e.g., irrigated and high and low-potential rainfed areas. Formulation and implementation of effective STI policies needs capacity to address the various challenges being faced and to find appropriate solutions. Policy making can play an important role in providing incentives through macro-economic policy measures and enhancing the skills base in scientific research, design, and development; and in the management and generation of financial resources. Further, policy can play an important role in not only deciding the type of investments and prioritization of research, but also in attaching importance to the various ethical, legal and societal dimensions.

Moreover, given the three tier of governments in the Indian federal setup, creating more expansive learning environments and using skill-sets would involve developing frameworks for sustainable food and land use and ensuring effectiveness and buy-in at the local level; improving curriculum and pedagogy based on skill needs; ensuring effective linkages with the job market; providing local forecast and information support; quality and accreditation assessment; and supplementing the limited resources of the formal research, education and extension system.

6.1.2 Place greater research emphasis on integrated farming and rainfed conditions

Over emphasis on food crops for irrigated areas in research remains a major concern. The significance of agriculture practised under rainfed and marginal conditions and its socio-economic implications demand greater attention by the research and policy community. There is greater need to harness supplementary and complementary relationships among crop, animal husbandry, poultry, fisheries, and multipurpose trees systems through integrated farming systems, particularly in the case of small and marginal farmers (MoAFW, 2017e).

6.1.3 Build a holistic and integrated education, research and extension system

Strengthening the higher education, research and extension system; developing highly skilled personnel in the emerging knowledge domains and technological areas; enabling greater interaction between research, extension and farmers; expanding and reinvigorating vocational training programmes; enabling greater private sector involvement in skills and training; forging partnerships to tap relevant knowledge and skill bases; and improving the quality of personnel and infrastructure are all important for enhancing capabilities

and skill development. More often than not, the suggested solution is a substantial increase in research funding. While the argument for increasing funding stands, a comprehensive review of the research architecture in government is called for. Result orientation and performance enhancement should become the pillars of this architecture.

The vast infrastructure of universities and research institutes in agriculture in India needs to be spruced up to engage with the new technologies in the agriculture-food sector. Creation of new and future technology centres in these organizations, drawing expertise from a variety of areas, could provide a platform to the scientific community for better exploring the potential of technology. The successful use of new technologies like AI and nanotechnology along the value chain would require a greater degree of interaction and collaboration among disciplines and actors. In this regard, consortia on R&D in new technologies could be established. The scientific community would need to be made aware of and trained in new technologies and their applications in food systems. Extension can also play an important role in raising awareness among the farming community about this technology and its various applications.

6.1.4 Build public-private partnership in the food sector

The interdisciplinary characteristics of new technologies demand greater public-private partnership in the food sector. Private sector involvement can be ensured in setting up new technology centres in the agricultural universities and research institutes. The private sector's extensive experience and marketing networks, better access to new technologies and close linkages with foreign companies are some of the advantages which the public sector can draw on when collaborating with private sector companies. Private sector companies in turn can benefit from the extensive network of research facilities and experimental stations of the public sector. However, public-private partnerships in agriculture are not widespread, mostly because of the bureaucratic culture of public agencies which either excludes private sector collaboration or makes it tedious for the private sector to participate. The inability of research organizations to form local partnerships and linkages with enterprises, civil society and other stakeholders poses a considerable challenge for the uptake of new technologies and identification of priorities in the sector. It would be a good idea to allow SAUs and ICAR institutes to form joint ventures with private partners to commercialize viable technologies. Technologies of larger public interest could be kept exclusively in the public domain.

To realize this and improve the linkages would require institutional changes.

6.2 A roadmap for the path ahead

The specific recommendations stemming from this report are outlined below, broken down into short, medium and long-term actions for enhancing capabilities and skills in the sector, and categorized into (1) policy, planning and coordination; (2) capacity; (3) demand-side measures; and (4) information systems.

6.2.1 Policy, planning and co-ordination

Short-term

- Use criteria such as changes in productivity and output, farm profitability, resource efficiency, inclusivity, suitability for the local environment (agro-ecosystem), climate-smartness, and existing capabilities and skills-set for research prioritisation and engaging with new technologies and determining budget allocation.
- Determine the skill-building, research and extension agenda by agro-ecosystem specific needs rather than expert perceptions and a top-down 'generic' approach.
- Review programmes for the development of agri-horti-animal husbandry, dairying, fishery, poultry, and forestry to ensure they cover the entire spectrum of activities along the food value chain and identify specific areas for capacity building.
- Strengthen coherence between existing rural development and agriculture schemes for skilling in agriculture, food processing and logistics, market integration and trade
- Bridge the gaps in the Agricultural Skill Council of India and National Council for Green Jobs by involving the Ministry of Jal Shakti, Ministry of Environment Forest and Climate Change and Ministry of Rural Development.
- Establish consortia on R&D in new technologies.
- Strengthen the National Indicator Framework on SDGs to include clear indicators on science, technology, innovation and skilling.

Medium-term

- Develop a suitable institutional framework based on structured analysis and documented process for fostering local skills ecosystems for capacity building, research prioritization, extension activities, and engaging with new and future technologies.
- Adopt a more flexible funding mechanism focused on facilitating the specific skill-sets needed in a particular agro-ecosystem, industry, etc. rather than the current approach of qualifications-based certification.

- Increase cross-sectoral interactions and linkages between different skill councils towards more integrated approach to skilling in the food sector.
- Establish a viable mechanism for operationalizing development and skill-building programmes for each agro-climatic region by combining existing arrangements.
- Skill Councils' capacity-building initiatives should be based on natural resource planning linked to the institutional, social and financial context at the agro-ecosystem or national level.
- Create mechanisms for effective public-private partnership for new technology development and innovation including through centres of excellence in agricultural universities and research institutes. Create a specific space in the policy environment for private sector participation.
- Monitor, report and evaluate rigorously the indicators under the National Indicator Framework on SDGs at national and state levels.

Long-term

- Establish the operational feasibility for this framework for research and capacity-building initiatives to be attuned to local needs and towards developing the required skills and capabilities.
- Develop efficient monitoring mechanism for effective realisation of overall goal of developing local ecosystem for capabilities development for sustainable food and land-use systems.
- Promote public-private partnerships and provide fiscal incentives to promote private investment in agricultural extension.
- Put in place a dedicated civil service based on Indian agricultural and natural resource management services which promotes integrated food and land-use systems including through sustainable and regenerative farming practices/ models suitable for the country's agro-ecologies.
- Increase investment in research, education and skill development along the value-chain for food and nutrition security, emphasizing especially areas such as natural resource management, low-growth areas, rainfed faming systems, smallholders and agricultural marketing.
- Monitor, report and evaluate rigorously the indicators under the National Indicator Framework on SDGs at national, state, as well as sub-state levels and agro-ecological regions.

6.2.2 Capacity

Short-term

- Urgently introduce into skilling packs the skills required to meet the key priorities under the National Mission on Sustainable Agriculture and the

National Action Plan on Climate Change (diversification of cropping systems; promotion of carbon sequestration in agricultural practices and building resilience in soil; sustainable soil management practices; popularization of aerobic rice cultivation methods; water saving technologies; and climate responsive research programmes).

- Include in the National Skill Development Corporation (NSDC) packages skilling in carbon finance from climate change mitigation activities.
- Include crop diversification skilling programmes in the NSDC. These skills are urgently needed to remove the root causes of the agri-residue burning which is causing air pollution and ground-water depletion in Punjab, Haryana and Uttar Pradesh.
- Build skills related to soil health in extension systems, which should emphasize advocating and promoting balanced fertilizer use and soil health management.

Medium-term

- Strengthen specialized training in interdisciplinary fields pertaining to sustainability of food and land-use systems.
- Restructure and streamline the course curriculum in higher education, research and innovation, and training packages to make them more interdisciplinary and attuned to sustainability of food and land-use systems.
- Include agriculture crop insurance alongside packages for small enterprise finance and microfinance in the training packages offered under banking, financial services and insurance.
- Introduce urgently a holistic approach to ecosystem-based land-use planning in the NSDC skill development packs. Strengthen skills in agriculture crop insurance and build a robust monitoring and information system.
- Create consortia on quality seed production, sustainable and regenerative farming practices, storage, processing and marketing.

Long-term

- Change criteria for development of education and research infrastructure to focus on agro-ecoregion rather than discipline, as sustainability of food and land-use systems requires multidisciplinary and holistic approaches.
- Enhance capacity and skills for managing infrastructure for the agri-retailing sector through public and private investment. Put in place renewable energy applications in warehousing and storage infrastructure.
- Put greater emphasis on skills in food safety and labelling, including sustainability labelling. Currently skill modules only recognize quality issues and food safety in poultry.

6.2.3 Demand-side measures

Short-term

- Strengthen and streamline the Agriculture Skill Council of India's SMART portal for facilitating single window access to information on capacities, skill-sets requirement and the popular job categories across the food chain at the agro-climatic zone level to address the demand-supply gap. Ensure active participation of relevant actors including food businesses and industries and launch a massive awareness campaign on the importance of the portal.
- Provide a regular and reliable measure of the skills and employment gap in the food sector.

Medium-term

- Create research-extension-farmer-market linkages at the district level – shift focus from mere production to market demands and to 'producing more from less'.
- Integrate all farmer producer organizations with existing platforms such as e-NAMs.
- Develop an annual survey on workforce and skills requirements for the food sector in conjunction with industry.
- Generate demand for skilled and quality human resources in the sector through incentives such as conditional loans and subsidies related to the food sector.
- Promote micro-food enterprises and build capacity of micro-financing managers through suitable incentive mechanisms.

Long-term

- Move towards integrated and adaptive approaches to demand and supply that consider agro-ecological conditions.
- Enhance the utility of skills gap survey data by expanding the classification and reporting system with a greater level of detail on sustainable food and land-use systems by developing a standard for data collection and reporting and ensuring its effective adoption by key organisations.
- Include farmers' knowledge in research and extension programmes through participatory approaches.
- Establish mechanisms for generating demand for quality personnel and infrastructure development at the local level through strengthening institutions of local governance (including Panchayats) and effective involvement of NGOs.

6.2.4 Information systems

Short-term

- Monitor and implement the Agri Infrastructure Fund for farm-gate infrastructure for farmers.
- Build an online database of all agri-input dealers along with their skill sets. Upscale the Diploma in Agricultural Extension Services for Input Dealers (DAESI) programme. Expand the coverage of registered agri-warehousing with appropriation monitoring and information systems.

Medium-term

- Put in place real-time management and information systems for agri-logistics.
- Create an online facility for global information on recent production and marketing trends, emerging challenges and opportunities along the value chain.

Long-term

- Evolve and adapt information systems to meet agro-ecological needs.
- Adopt holistic extension approaches including rural infrastructure, such as roads, cold-storage, food-processing units, warehousing facilities and organized marketing.

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ANNEX 1:

List of qualification packs relevant for food and land use

#	QP name	Stage	Framework sector
	Agriculture Skill Council of India		
1	Dairy Farmer/ Entrepreneur	Production	Livestock and fisheries
2	Dairy Farmer Entrepreneur	Production	Livestock and fisheries
3	Dairy Worker	Production	Livestock and fisheries
4	Dairy Farm Supervisor	Production	Livestock and fisheries
5	Milk Route Supervisor	Collection and procurement	Livestock and fisheries
6	Village Level Milk Collection Centre Incharge	Collection and procurement	Livestock and fisheries
7	Milk Tester	Processing	Livestock and fisheries
8	Bulk Milk Cooler (BMC) Operator	Processing	Livestock and fisheries
9	Chilling Plant Technician	Processing	Livestock and fisheries
10	Broiler Farm Supervisor	Production	Livestock and fisheries
11	Poultry Farm Manager	Production	Livestock and fisheries
12	Poultry Shed Designer	Production	Livestock and fisheries
13	Poultry Feed, Food Safety and Labeling Supervisor	Production	Livestock and fisheries
14	Small Poultry Farmer	Production	Livestock and fisheries

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#	QP name	Stage	Framework sector
15	Layer Farm Worker	Production	Livestock and fisheries
16	Hatchery Operator	Production	Livestock and fisheries
17	Chick Sexing and Grading Technician	Production	Livestock and fisheries
18	Goat Farmer	Production	Livestock and fisheries
19	Veterinary Field Assistant	Production	Livestock and fisheries
20	Veterinary Clinical Assistant	Production	Livestock and fisheries
21	Artificial Insemination Technician	Production	Livestock and fisheries
22	Animal Health Worker	Production	Livestock and fisheries
23	Animal Health Worker - Transnational Standards	Production	Livestock and fisheries
24	Aquaculture Worker	Production	Livestock and fisheries
25	Sericulturist	Production	Miscellaneous
26	Beekeeper	Production	Miscellaneous
27	Service Technician-Watershed	Pre-production	Service provider
28	Watershed Supervisor	Pre-production	Service provider
29	Soil and Water Testing Lab Assistant	Pre-production	Service provider
30	Soil and Water Testing Lab Analyst	Pre-production	Service provider
31	Paddy Farmer	Production	Crops
32	Wheat Cultivator	Production	Crops
33	Maize Cultivator	Production	Crops
34	Pulses Cultivator	Production	Crops
35	Soyabean Cultivator	Production	Crops
36	Cotton Cultivator	Production	Crops
37	Sugar Cane Cultivator	Production	Crops
38	Jute and Mesta Cultivator	Production	Crops
39	Banana Farmer	Production	Horticulture

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#	QP name	Stage	Framework sector
40	Mango Grower	Production	Horticulture
41	Citrus Fruit Grower	Production	Horticulture
42	Vineyard Worker	Production	Horticulture
43	Makhana Grower-cum-processor	Production	Miscellaneous
44	Temperate Fruit Grower(Options: Apple / Pear, Peach and Plum / Kiwi)	Production	Horticulture
45	Orchard Worker	Production	Horticulture
46	Bulb Crop Cultivator	Production	Horticulture
47	Solanaceous Crop Cultivator	Production	Horticulture
48	Tuber Crop Cultivator	Production	Horticulture
49	Coffee Plantation Worker	Production	Horticulture
50	Tea Plantation Worker	Production	Horticulture
51	Coconut Grower	Production	Horticulture
52	Friends of Coconut Tree	Production	Horticulture
53	Neera Technician	Collection and procurement	Horticulture
54	Chillies Cultivator	Production	Horticulture
55	Coriander Cultivator	Production	Horticulture
56	Spice Crop cultivator	Production	Horticulture
57	Floriculturist - Open Cultivation	Production	Horticulture
58	Floriculturist - Protected Cultivation	Production	Horticulture
59	Florist	Production	Horticulture
60	Florist - Transnational Standards	Production	Horticulture
61	Flower Handler Packaging and Palletizing	Collection and procurement	Horticulture
62	Gardener	Production	Horticulture

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#	QP name	Stage	Framework sector
63	Rooftop Gardener	Production	Horticulture
64	Assistant Interior Landscaper	Production	Horticulture
65	Assistant Gardener	Production	Horticulture
66	Assistant Groundskeeper	Production	Horticulture
67	Interior Landscaper	Production	Horticulture
68	Nursery Worker	Production	Horticulture
69	Hydroponics Technician	Production	Horticulture
70	Gardener-cum-nursery Raiser	Production	Horticulture
71	Heritage Gardener	Production	Horticulture
72	Horticulture Supervisor (Electives: Garden / Nursery / Turf)	Production	Horticulture
73	Medicinal Plants Grower	Production	Horticulture
74	Essential Oil Extractor	Processing	Horticulture
75	Greenhouse Fitter	Pre-production	Service provider
76	Micro Irrigation Technician	Pre-production	Service provider
77	Greenhouse Operator	Production	Service provider
78	Greenhouse Operator	Pre-production	Service provider
79	Tractor Operator	Pre-production	Service provider
80	Tractor Operator	Pre-production	Service provider
81	Harvesting Machine Operator	Production	Service provider
82	Agriculture Machinery Operator	Production	Service provider
83	Irrigation Service Technician	Production	Service provider
84	Operator-Reaper Thresher and Crop Residue Machinery	Production	Service provider
85	Service and Maintenance Technician-Farm Machinery	Production	Service provider

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#	QP name	Stage	Framework sector
86	Agriculture Machinery Demonstrator	Pre-production	Service provider
87	Tractor Mechanic	Pre-production	Service provider
88	Farm Workshop Foreman/Supervisor	Production	Service provider
89	Farm Workshop/Service Manager	Production	Service provider
90	Agriculture Machinery Repair and Maintenance Service Provider	Pre-production	Service provider
91	Custom Hiring Service Provider	Pre-production	Service provider
92	Organic Grower	Production	Horticulture
93	Pesticide and Fertilizer Applicator	Production	Service provider
94	Vermicompost Producer	Production	Miscellaneous
95	Farm Worker	Production	Service provider
96	Farm Manager	Production	Service provider
97	Farm Supervisor	Production	Service provider
98	Vineyard Grower	Production	Horticulture
99	Quality Seed Grower	Pre-production	Service provider
100	Seed-Processing Worker	Pre-production	Service provider
101	Seed Analysis Incharge	Pre-production	Service provider
102	Seed processing Plant Technician	Pre-production	Service provider
103	Seed Plant Production Supervisor	Pre-production	Service provider
104	Supply Chain Field Assistant	Collection and procurement	Service provider
105	Warehouse Worker	Collection and procurement	Service provider
106	Packhouse Worker	Collection and procurement	Service provider
107	Ripening Chamber Operator	Collection and procurement	Service provider

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#	QP name	Stage	Framework sector
108	Cold Storage Supervisor	Collection and procurement	Service provider
109	Cold Storage Manager	Collection and procurement	Service provider
110	Cold Store Keeper	Collection and procurement	Service provider
111	CA Store Technician/Operator	Collection and procurement	Service provider
112	Agri Warehouse Supervisor	Collection and procurement	Service provider
113	Agriculture Extension Service Provider	Collection and procurement	Service provider
114	Agriculture Extension Executive	Collection and procurement	Service provider
115	Agriculture Field Officer	Collection and procurement	Service provider
116	Bare Foot Technician	Production	Service provider
117	Community Service Provider	Production	Service provider
118	Mushroom Grower	Production	Miscellaneous
119	Agri Service Input Dealer	Pre-production	Service provider
120	Institution Development Manager	Pre-production	Service provider
121	Group Farming Practitioner	Production	Service provider
122	Agri-Clinic and Agri-Business Centre Manager	Production	Service provider
123	Agri Research Analyst	Pre-production	Service provider
124	Agri Commodity Quality Assayer	Collection and procurement	Service provider
125	Risk Analyst Manager-Agri Commodity	Trade and marketing	Service provider
126	Commodity Procurement Manager	Collection and procurement	Service provider

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#	QP name	Stage	Framework sector
127	Electronic Trading Supervisor-Agri Commodity	Trade and marketing	Service provider
128	Commodity Account Manager	Trade and marketing	Service provider
129	Produce Mapping Surveyor	Trade and marketing	Service provider
130	Agri Commodity fumigation Operator	Trade and marketing	Service provider
131	Plant Tissue Culture Technician	Production	Service provider
132	Soil Sampler/Collector	Pre-production	Service provider
133	Piggery Farmer	Production	Livestock and fisheries
134	Canine Breeder	Pre-production	Livestock and fisheries
135	Canine Trainer and Handler	Production	Livestock and fisheries
136	Companion Animal Groomer	Production	Livestock and fisheries
137	Zoo Animal Keeper	Production	Livestock and fisheries
138	Stray Animal Catcher	Production	Livestock and fisheries
139	Laboratory Animal Attendant	Production	Livestock and fisheries
140	Stud Farm Worker	Production	Livestock and fisheries
141	Assistant Equine Breeder	Pre-production	Livestock and fisheries
142	Horse Trainer	Production	Livestock and fisheries
143	Equine Farrier	Production	Livestock and fisheries
144	Equine Groom	Production	Livestock and fisheries
145	Hatchery Production Worker	Production	Livestock and fisheries
146	Shrimp Farmer	Production	Livestock and fisheries
147	Aquaculture Technician	Production	Livestock and fisheries
148	Freshwater Aquaculture Farmer	Production	Livestock and fisheries
149	Brackishwater Aquaculture Farmer	Production	Livestock and fisheries

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#	QP name	Stage	Framework sector
150	Crab Farmer	Production	Livestock and fisheries
151	Fish Seed Grower	Production	Livestock and fisheries
152	Mariculture Operator	Production	Livestock and fisheries
153	Ornamental Fish Technician	Production	Livestock and fisheries
154	Aquatic Animal Health Lab Assistant	Production	Livestock and fisheries
155	Hatchery Manager	Production	Livestock and fisheries
156	Pearl Culture Technician	Production	Livestock and fisheries
157	Cold water Aquaculture Farmer	Production	Livestock and fisheries
158	Seaweed Cultivator	Production	Livestock and fisheries
159	Cage Culture Fish Farmer	Production	Livestock and fisheries
160	Marine Capture Fisherman-cum-processor	Production	Livestock and fisheries
161	Fishing Boat Driver	Production	Livestock and fisheries
162	Inland Capture Fisherman-cum-primary Processor	Processing	Livestock and fisheries
163	Deep Sea Fisher	Production	Livestock and fisheries
164	Fishing Boat Deckhand	Pre-production	Livestock and fisheries
165	Fishing Boat Maintenance Worker	Pre-production	Livestock and fisheries
166	Fishing Boat Mechanic	Pre-production	Livestock and fisheries
167	Fish Retailer	Trade and marketing	Livestock and fisheries
168	Fishing Gear Technician	Pre-production	Livestock and fisheries
169	Fishing Equipment Technician	Pre-production	Livestock and fisheries
170	Fisheries Extension Associate	Production	Livestock and fisheries
171	Aquarium Technician	Pre-production	Livestock and fisheries
172	Feed Technician	Pre-production	Livestock and fisheries
173	Aquaculture Fabricator	Pre-production	Livestock and fisheries

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#	QP name	Stage	Framework sector
174	Bamboo Grower	Production	Forestry and land-use
175	Non-timber Forest Produce Collector	Collection and procurement	Forestry and land-use
176	Forest Nursery Raiser	Production	Forestry and land-use
177	Timber Grower	Production	Forestry and land-use
178	Lac Cultivator	Production	Forestry and land-use
179	Climate Change and Risk Mitigation Manager	Pre-production	Service provider
180	Watershed Community Mobilizer	Pre-production	Service provider
181	Watershed Consultant	Pre-production	Service provider
182	Watershed Manager	Pre-production	Service provider
183	Watershed Engineer	Pre-production	Service provider
184	Watershed Assistant	Pre-production	Service provider
185	Solar Pump Technician	Pre-production	Service provider
186	Broiler Farm Worker	Production	Livestock and fisheries
187	Broiler Poultry Farm Worker - Transnational Standards	Production	Livestock and fisheries
188	Hatchery Incharge - Poultry	Production	Livestock and fisheries
	BFSI Sector Skill Council of India		
189	Loan Approval Officer	Multi	Service provider
190	Loan Processing Officer	Multi	Service provider
191	Small and Medium Enterprise Officer	Multi	Service provider
192	Microfinance Executive	Multi	Service provider
	Food Industry Capacity and Skill Initiative		
193	Plant Baker	Processing	Processing industry
194	Craft Baker	Processing	Processing industry
195	Plant Biscuit Production Specialist	Processing	Processing industry

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#	QP name	Stage	Framework sector
196	Mixing Technician	Processing	Processing industry
197	Baking Technician/Operative	Processing	Processing industry
198	Dairy Products Processor	Processing	Livestock and fisheries
199	Dairy Processing Equipment Operator	Processing	Livestock and fisheries
200	Butter and Ghee Processing Operator	Processing	Livestock and fisheries
201	Ice Cream Processing Technician	Processing	Livestock and fisheries
202	Cottage Cheese Maker	Processing	Livestock and fisheries
203	Milk Powder Manufacturing Technician	Processing	Livestock and fisheries
204	Supervisor: Dairy Products Processing	Processing	Livestock and fisheries
205	Fish and Sea Food Processing Technician	Processing	Livestock and fisheries
206	Chief Miller	Processing	Crops
207	Milling Technician	Processing	Crops
208	Grain Mill Operator	Processing	Crops
209	Pulse Processing Technician	Processing	Crops
210	Extruder Operator-Food Processing	Processing	Crops
211	Corn Starch Manufacturing Technician	Processing	Crops
212	Multi Skill Technician (Food Processing)	Processing	Processing industry
213	Squash and Juice Processing Technician	Processing	Horticulture
214	Pickle Making Technician	Processing	Horticulture
215	Jam, Jelly and Ketchup Processing Technician	Processing	Horticulture
216	Fruit Ripening Technician	Processing	Horticulture
217	Fruits and Vegetables Drying/ Dehydration Technician	Processing	Horticulture
218	Fruit Pulp Processing Technician	Processing	Horticulture
219	Fruits and Vegetables Canning Technician	Processing	Horticulture

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#	QP name	Stage	Framework sector
220	Fruits and Vegetables Selection Incharge	Processing	Horticulture
221	Supervisor-Fruits and Vegetables Processing	Processing	Horticulture
222	Meat and Poultry Processor (Electives: Butchery/Poultry Dressing)	Processing	Livestock and fisheries
223	Offal Collector and Utilizer	Processing	Livestock and fisheries
224	Supervisor: Meat and Poultry Processing	Processing	Livestock and fisheries
225	Food Products Packaging Technician	Processing	Processing industry
226	Packing Machine Worker - Food Processing	Processing	Processing industry
227	Modified Atmosphere Storage Technician	Processing	Processing industry
228	Cold Storage Technician	Processing	Processing industry
229	Purchase Assistant - Food and Agricultural Commodities	Trade and marketing	Service provider
230	Assistant Lab Technician - Food and Agricultural Commodities	Processing	Service provider
231	Quality Assurance Manager	Trade and marketing	Service provider
232	Food Microbiologist	Processing	Service provider
233	Processed Food Entrepreneur	Trade and marketing	Service provider
234	Food Regulatory Affairs Manager	Trade and marketing	Service provider
235	Production Manager	Processing	Service provider
236	Plant Manager	Processing	Service provider
237	Industrial Production Worker - Food Processing	Processing	Processing industry
238	Soya Beverage-making Technician	Processing	Crops
239	Traditional Snack and Savoury Maker	Processing	Processing industry
240	Spice-processing Technician	Processing	Horticulture
241	Convenience Food Maker	Processing	Processing industry

Contd...

#	QP name	Stage	Framework sector
	Skill Council for Green Jobs		
242	Optimize resource utlilization at workplace	Processing	Service provider
243	Adopt sustainable practices at workplace	Processing	Service provider
244	Paper Bag Technician	Processing	Forestry and land-use
245	Paper Bag Entrepreneur	Processing	Forestry and land-use
246	Solar PV Installer (Suryamitra)	Pre-production	Service provider
247	Solar PV Installer - Electrical	Pre-production	Service provider
248	Solar PV Installer Civil	Pre-production	Service provider
249	Rooftop Solar PV Entreprenuer	Pre-production	Service provider
250	Solar Proposal Evaluation Specialist	Pre-production	Service provider
251	Rooftop Solar Grid Engineer	Pre-production	Service provider
252	Solar PV Business Development Executive	Pre-production	Service provider
253	Solar PV Site Surveyor	Pre-production	Service provider
254	Solar PV Structural Design Engineer	Pre-production	Service provider
255	Solar PV Designer	Pre-production	Service provider
256	Solar PV Project Helper	Pre-production	Service provider
257	Solar PV Engineer (Option: Solar water-pumping system)	Pre-production	Service provider
258	Solar Site Incharge	Pre-production	Service provider
259	Solar PV Project Manager (E&C)	Pre-production	Service provider
260	Solar PV Maintenance Technician - Electrical (Ground Mount)	Pre-production	Service provider
261	Solar PV Maintenance Technician- Civil (Ground Mount)	Pre-production	Service provider
262	Solar PV O&M Engineer	Pre-production	Service provider
263	Solar Off Grid Entrepreneur	Pre-production	Service provider

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#	QP name	Stage	Framework sector
264	Solar PV Manufacturing Technician	Pre-production	Service provider
265	Solar Lighting Technician (Options: home lighting system/street lights)	Pre-production	Service provider
266	Solar Domestic Water Heater Technician	Pre-production	Service provider
267	Solar Thermal Plant Installation and Maintenance Technician	Pre-production	Service provider
268	Solar Thermal Engineer Industrial Process Heat (Option: Consultant)	Pre-production	Service provider
269	Assistant Planning Engineer-Wind Power Plant	Pre-production	Service provider
270	Site Surveyor- Wind Power Plant	Pre-production	Service provider
271	Construction Technician (Mechanical)- Wind Power Plant	Pre-production	Service provider
272	Construction Technician (Civil)- Wind Power Plant	Pre-production	Service provider
273	Construction Technician (Electrical)- Wind Power Plant	Pre-production	Service provider
274	CMS Engineer - Wind Power Plant	Pre-production	Service provider
275	O&M Mechanical Technician-Wind Power Plant	Pre-production	Service provider
276	O&M Electrical and Instrumentation Technician –Wind Power Plant	Pre-production	Service provider
277	Agri-residue Aggregator	Collection and procurement	Crops
278	Biomass Depot Operator	Collection and procurement	Crops
279	Animal Waste Manure Aggregator (Option: Biogas Plant Operator/Compost Plant Operator)	Collection and procurement	Livestock and fisheries
280	Manager- Waste Management (Elective: Biomass Depot/Compost Yard/Dry Waste Centre)	Collection and procurement	Service provider

Source: *Compiled from Sector Skill Councils and NSDC website; https://nsdcindia.org/*

ANNEX 2:

Overview of agriculture and related central government schemes and programmes for skill development

Name of ministry/ department	Name of scheme	Duration of the training programme (hours/ days/months/years	Socio-economic group targeted
MoAFW (Department of Agriculture and Cooperation)	Extension Reform-Farm School	Once during each of the 6 critical stages in a cropping season	Farmers
	Agri clinic and Agri Business Centres Scheme	2 months	Graduates in agriculture and allied subjects from SAUs/Central Agricultural Universities/universities recognized by ICAR/UGC and the beneficiary farmers
	Diploma in Agricultural Extension Services for Input Dealers (DAESI)	48 days spread over 1 year	Input dealers and prospective dealers
	Postgraduate Diploma in Agricultural Extension Management (PGDAEM)	1 year	Graduates in Agriculture
	National Food Security Mission (NFSM)	Full crop season for single day in a week or fortnight 8-20 seasons	Farmers
	National Horticulture Mission (NHM)	3 months -1 year (Farmers - 2 to 5 days)	Entrepreneurs, gardeners, farmers, supervisors, field staff

Contd...

Name of ministry/ department	Name of scheme	Duration of the training programme (hours/ days/months/years	Socio-economic group targeted
	Horticulture Mission for North East and Himalayan States (HMNEH)	3 months-1 year (Farmers- 2 to 5 days)	Entrepreneurs, gardeners, farmers, supervisors, field staff
	National Centre for Organic Farming	4 weeks	Farmers
	Mechanization and Technology (M&T)	Not fixed (generally 4 weeks)	Farmers
MoAFW (Department of Animal Husbandry, Dairying and Fisheries)	Department of Poultry and Fodder	2 to 4 weeks	Farmers
	Department of Cooperatives and Dairy Development	4 to 5 days, (For maitris 3 months)	Farmers
	Department of Livestock Health	2 to 5 days	Vets and paravets
	Department of Fisheries		Fishermen and people engaged in the post productionactivities
MoAFW (Department of Agricultural Research and Education)	Training in agricultural extension (21 training centres)	1 day to 3 weeks	Personal engaged in agricultural institutions and support services, members of cooperatives, and farmers under KVK, 550/589districts are covered
	Under the university stream, various undergraduate, post graduate and PhD courses are offered (DARE)	UG courses – 4 years, PG courses- 2 years and PhD	Students with qualifications as usual under University stream of education

Contd...

Name of ministry/ department	Name of scheme	Duration of the training programme (hours/ days/months/years	Socio-economic group targeted
	Central Agricultural University, State Agriculture University and National Institutes of Indian Council of Agricultural Research having the status of Deemed University	Undergraduate, master's and PhD degree programme	Students with qualifications as usual
	ICAR also arranges need-based training programmes in any of state agricultural university or ICAR institute in new and emerging areas	1 week to 3 months (or longer duration, as fixed)	Faculty and scientist
Ministry of Food Processing Industries	Creation of infrastructure facilities for running degree/ diploma courses in food-processing technology under NMFP	N.A.	N.A
	Entrepreneurship Development Programme (EDP) under NMFP to be conducted by various government and private organizations, industries, or NGOs	6 weeks	SC/ST/minority community/ women- at least 35%
	Grants-in-aid for setting up of Food Processing Training Centres (FPTC) under NMFP	N.A.	SC/ST/minority community/ women-percentage not specified

Contd...

Name of ministry/ department	Name of scheme	Duration of the training programme (hours/ days/months/years	Socio-economic group targeted
	Training at recognized national/state level institutes, etc. sponsored by MoFPI/ other training programmes under NMFP	1-10 working days	N.A.
	Degree programmes and short-term courses offered by National Institute of Food Technology, Entrepreneurship and Management (NIFTEM), Kundli, Haryana and Indian Institute of Crop Processing Technology (IICPT), Tamil Nadu	1 day - 1 month (IICPT); 1-2 weeks (NIFTEM)	N.A.

State of Science, Technology and Innovation Skills for Sustainability of India's Food and Land-use Systems seeks to provide an overview of the literature, data and evidence on the topic in order to highlight the varying levels of science, technology and innovation (STI) capabilities and skills requirements across agriculture and allied sectors from the perspective of sustainable food and land-use systems. It aims to inform policies by increasing understanding of desired frameworks and approaches for innovation and skill development. To do so, the study proposes a framework for capabilities and skills for innovation and sustainability in food systems taking a value chain approach. The report concludes with a detailed roadmap for capabilities and skill enhancement for sustainable food and land-use systems.

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