

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

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Introduction

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. Rather than offer a comparative analysis, the report offers an initial diagnosis, mapping what is known 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.

Food and Land Use Coalition

Food and Land Use Coalition (FOLU) is a self-governed community of more than 60 organisations and individuals committed to the urgent need to transform food and land use for people, nature and climate. 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 Energy and Resources Institute

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

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 badly 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.

This report 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 agricultural sector is far too low given 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 5,093 in 2019-20), but is lower than the sanctioned strength of around 7,000.
- 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, fertiliser, 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 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 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 (KVK) 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 2019-2020, 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 2000-2017, ranging between 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 emphasise 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 organisations.
- 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.
- Include 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 ground-water 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 spill-overs 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	<ul style="list-style-type: none"> 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 prioritising 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. 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 	<ul style="list-style-type: none"> Develop a suitable institutional framework based on structured analysis and documented process for fostering local skills ecosystems for capacity building, research prioritisation, 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. 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 	<ul style="list-style-type: none"> 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 realisation of the overall goal of developing a local ecosystem for capability 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

		<p>Climate Change and Ministry of Rural Development.</p> <ul style="list-style-type: none"> • 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. 	<p>institutional, social and financial context at the agro-ecosystem or national level.</p> <ul style="list-style-type: none"> • 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. 	<p>security, emphasizing especially areas such as natural resource management, low-growth areas, rainfed farming systems, smallholders and agricultural marketing.</p> <ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • 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). • 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 	<ul style="list-style-type: none"> • 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

		<p>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.</p> <ul style="list-style-type: none"> • Build skills related to soil health in extension systems, which should emphasize advocating and promoting balanced use of fertilizer and soil health management. 	<p>crop insurance alongside packages for small enterprise finance and microfinance in the training packages offered under banking, financial services and insurance.</p> <ul style="list-style-type: none"> • 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. 	<p>recognize quality issues and food safety in poultry.</p>
3.	Demand side measures	<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • 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

		reliable measure of the skills and employment gap in the food sector.	<p>human resources in the sector through incentives such as conditional loans and subsidies related to the food sector.</p> <ul style="list-style-type: none"> Promote micro-food enterprises and build capacity of micro-financing managers through suitable incentive mechanisms. 	<p>research and extension programmes through participatory approaches.</p> <ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> 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.