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भाकृअनुप – राष्ट्रीय कृषि आर्थिकी एवं नीति अनुसंधान संस्थान
ICAR - National Institute of Agricultural Economics and Policy Research
(Indian Council of Agricultural Research)

Annual Report 2019

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Indian Council of Agricultural Research
New Delhi 110 012

ICAR-NIAP Annual Report 2019

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Preface

The ICAR-National Institute of Agricultural Economics and Policy Research (NIAP) has accelerated its research efforts to contribute to the agricultural development goals, and foster partnerships with various government departments and research organizations. The year under report witnessed an enhanced level of engagement of scientists with the activities of research, capacity building, and policy communication. In particular, there has been a focus on the measurement of sustainability of agriculture, doubling farmers' income, market reforms, and price forecasting. ICAR-NIAP has also stepped up its collaboration with sister institutes of ICAR, state agricultural universities and other academic institutions. The outreach of the capacity building programs and publications have also shown significant improvement. This was clearly evident from the citations of the publications and participation in various activities of the Institute.

The significant research contributions of the Institute pertain to the area of agricultural transformation, climate-resilient and sustainable agriculture, technology foresight, extension advisory services, commodity value chains and modelling, resource use planning, and micro-irrigation. The Institute was also actively engaged in policy dialogue with the Department of Agriculture, Cooperation and Farmers' Welfare for doubling farm income, and price forecasting. Fertilizer policy, commodity price stabilization, the policies for sustainable agriculture, and export policy are some of the areas where the Institute has provided proactive inputs for decision making. The capacity development for agricultural policy research in the national agricultural research system is another important mandate of ICAR-NIAP. The Institute organized courses for collaborating partners and other social scientists. A reference book on the quantitative methods was also published. The Institute also organized one training program for the probationary officers of the Indian Economic Services. The Institute maintained linkages with the Ministry of Finance, NITI Aayog, CG Centres, NABARD and other organizations of repute.

On behalf of the Institute, I sincerely thank Dr Trilochan Mohapatra, Secretary, DARE and Director General, ICAR, Shri Sanjay K. Singh, Additional Secretary, DARE and Secretary, ICAR, and Shri B. Pradhan, Additional Secretary, DARE and Financial Advisor, ICAR for their guidance and continuous support. Thanks are also due to Dr R.C. Agarwal, Deputy Director General (Ag Education) and Dr G. Venkateshwarlu, Assistant Director General (EQA&R) for their support in undertaking various activities of the Institute. Members of the Institute Management Committee and Research Advisory Committee provided invaluable guidance. I sincerely thank all my colleagues for their cooperation, particularly Dr S. K. Srivastava for coordination of the Annual Report, and Dr Prem Chand, Dr Kingsly I., Dr Balaji S. J. and Ms Sonia Chauhan for their help in the compilation of the material.

(Suresh Pal)
Director
ICAR-National Institute of
Agricultural Economics & Policy Research

April 30, 2020

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List of Acronyms

3SLS	Three Stage Least Square
AAEA	Agriculture & Applied Economics Association
AAU	Assam Agricultural University
ADG	Assistant Director General
AERA	Agricultural Economics Research Association
AERC	Agro-Economic Research Centres
AKMU	Agricultural Knowledge Management Unit
AOSF	Artisanal Off Shore Fishing
APRACA	Asia-Pacific Rural and Agricultural Credit Association
ARS	Agricultural Research Service
AUUP	Amity Institute of Organic Agriculture
BCM	Billion Cubic Metre
BHU	Banaras Hindu University
BPD	Business Promotion Development
CA	Conservation Agriculture
CA	Consumers Affairs
CAS	Current Awareness Service
CASI	Composite Agricultural Sustainability Index
CAU	Central Agricultural University
CEM	Coarsened Exact Matching
CEO	Chief Executive Officer
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Centre
CIRG	Central Institute for Research on Goats
CMFRI	Central Marine Fisheries Research Institute
CPRI	Central Potato Research Institute
CRISPR	Clusters of Regularly Interspaced Short Palindromic Repeats
CRP-GLDC	CGIAR Research Program-Grain Legumes and Dryland Cereals
CSIR	Council of Scientific and Industrial Research
CT	Conventional Technique
CTRI	Central Tobacco Research Institute
DAC&FW	Department of Agriculture, Cooperation and Farmers Welfare
DAHD	Department of Animal Husbandry and Dairying
DAO	District Agriculture Office
DARE	Department of Agricultural Research and Education
DDG	Deputy Director General
DDS	Document Delivery Service
DG	Director General
DPS	Dev Prakash Shastri
DSR	Direct Seeded Rice
EAS	Extension and Advisory Services
EPW	Economic and Political Weekly
ERNET	Education and Research Network
ERP	Enterprise Resource Planning
EU	European Union
FBO	Forever Living Product
FCI	Food Corporation of India
FDI	Foreign Direct Investment
FICCI	Federation of Indian Chambers of Commerce and Industry
GBPUA&T	Govind Ballabh Pant University of Agriculture and Technology
GCA	Gross Cropped Area
GDP	Gross Domestic Product

GFCF	Gross Fixed Capital Formation
GHG	Green House Gas
GOI	Government of India
GPF	Gross Provident Fund
HAU	Haryana Agricultural University
HVCs	High Value Crops
IAAE	International Association of Agricultural Economists
IARI	Indian Agricultural Research Institute
IASRI	Indian Agricultural Statistics Research Institute
ICAR	Indian Council of Agricultural Research
ICAS	International Conference on Agricultural Statistics
ICFA	International Conference on Fisheries and Aquaculture
IFPRI	International Food Policy Research Institute
IGI	Irrigation Governance Index
IGIDR	Indira Gandhi Institute of Development Research
IGP	Indo-Gangetic Plains
IHD	Institute for Human Development
IIFSR	Indian Institute of Farming Systems Research
IIHR	Indian Institute of Horticultural Research
IIM	Indian Institute of Management
IIMR	Indian Institute of Millets Research
ILL	Inter Library Loan
ILRI	International Livestock Research Institute
IMC	Institute Management Committee
IMC	Inter-Ministerial Committee
IMR	Inverse Mills Ratio
IRC	Institute Research Council
IRRI	International Rice Research Institute
ISMA	Indian Sugar Mills Association (ISMA)
ISO	International Organization for Standardization
IT	Information Technology
IVRI	Indian Veterinary Research Institute
JSC	Joint Staff Council
KAB	Krishi Anusandhan Bhavan
KVK	Krishi Vigyan Kendra
LBVZ	Lower Brahmaputra Valley Zone
LMO	Living Modified Organisms
LOOP	Law of One Price
MIS	Management Information System
MIS	Micro-Irrigation System
MIT	Micro-Irrigation Technologies
MK	Mann-Kendall
MNC	Multinational Corporation
MNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MPUAT	Maharana Pratap University of Agriculture and Technology
MSME	Micro, Small and Medium Enterprises
NAAS	National Academy of Agricultural Sciences
NAFED	National Agricultural Cooperative Marketing Federation of India
NAHEP	National Agricultural Higher Education Project
NARS	National Agricultural Research System
NASC	National Agricultural Science Centre
NBPGR	National Bureau of Plant Genetic Resources
NDRI	National Dairy Research Institute
NEH	North Eastern Hills
NGO	Non-Profit Organization
NIAP	National Institute of Agricultural Economics and Policy Research
NIASM	National Institute of Abiotic Stress

	Management
NISTADS	National Institute of Science, Technology and Development Studies
NITI	National Institution for Transforming India
NRM	Natural Resource Management
NRRI	National Rice Research Institute
NSSO	National Sample Survey Organization
OBC	Other Backward Class
OECD	Organisation for Economic Co-operation and Development
PAU	Punjab Agricultural University
PG	Post Graduate
PIM	Participatory Irrigation Management
PME	Priority Monitoring and Evaluation
PPFC	Public-Private-Farmer Cooperation
PPFP	Public-Private-Farmer Partnership
PPV&FRA	Protection of Plant Varieties and Farmers Right Act
QRT	Quinquennial Review Team
QWL	Quality of Work Life
R&D	Research and Development
RAC	Research Advisory Committee
RCP	Regional Crop Planning
RNFE	Rural Non-Farm Employment
RTI	Right to Information
SAARC	South Asian Association of Regional Cooperation
SAM	Social Accounting Matrix
SAU	State Agricultural University
SC	Scheduled Caste
SD	System Dynamics
SDG	Sustainable Development Goal
SFAC	Small Farmers' Agribusiness Consortium
SKAUST	Sher-E-Kashmir University of Agricultural Sciences & Technology, Kashmir
SKNAU	Sri Karan Narendra Agricultural University
SOPA	Soybean Processors Association
SQL	Structured Query Language
SRF	Senior Research Fellow
ST	Scheduled Tribe
TAAS	Trust for Advancement of Agricultural Sciences
TE	Triennium Ending
TERI	The Energy and Resources Institute
THST	Turbo Happy Seeder Technique
TNAU	Tamil Nadu Agricultural University
USA	United States of America
WIPO	World Intellectual Property Organization
YAE	Young Agricultural Economist
ZTM	Zonal Technology Management
ZTT	Zero Tillage Technology

कार्यकारी सारांश

भाकृअनुप – राष्ट्रीय कृषि आर्थिकी एवम् नीति अनुसंधान संस्थान, कृषि विज्ञान नीति के क्षेत्र में, भारतीय कृषि अनुसंधान परिषद् के लिए विचार मंच (थिंक टैंक) के रूप में कार्य करता है। संस्थान स्वंय तथा सहयोगी संस्थाओं के सहयोग से संचालित परियोजनाओं के माध्यम से कृषि विकास के समकालीन/समसामायिक मुद्दों पर नीतिगत शोध कार्य करता है तथा कृषि अर्थशास्त्र एवं नीति अनुसंधान के सुदृढ़ीकरण और प्रशिक्षण कार्यक्रमों द्वारा क्षमता निर्माण के लिए लगातार प्रयासरत है। संस्थान कृषि विकास में उभर रही चुनौतियों एवं प्राथमिकताओं तथा इनके समाधान के लिए रणनीतियों के बारे में परिषद् को अवगत कराता है। संस्थान में अनुसंधान कार्य प्रमुख रूप से तीन व्यापक क्षेत्रों, जैसे कि कृषि वृद्धि एवं विकास, प्रौद्योगिकी एवं टिकाऊ कृषि, और विपणन एवं व्यापार के अन्तर्गत किये जाते हैं। वर्ष 2019 की अवधि में संस्थान द्वारा प्राप्त अनुसंधान उपलब्धियों एवं संचालित अन्य गतिविधियों की एक संक्षिप्त झलक निम्नवत है:–

अनुसंधान उपलब्धियाँ

कृषि वृद्धि एवं विकास

कृषि में वृद्धि एवं विकास विषय के अन्तर्गत किये गये अध्ययनों में प्रमुख रूप से कृषि एवं ग्रामीण अर्थव्यवस्था में संरचनात्मक बदलाव, क्षेत्रीय विकास, कृषि में निवेश, विविधीकरण, कृषि यंत्रीकरण, किसानों की आय दोगुना करने, नियमन/सुशासन (governance) तथा पोषण संबंधी विषय शामिल थे। कृषि में उत्पादकता के रूझान से स्पष्ट संकेत मिलता है कि कृषि क्षेत्र से श्रमिकों के विस्थापन के बावजूद इसका उत्पादन प्रभावित नहीं हुआ है। वर्ष 2006–2016 की अवधि के दौरान, हिमाचल प्रदेश को छोड़कर, अन्य प्रमुख राज्यों में अलग–अलग दर से श्रमिकों ने कृषि से विस्थापन किये। लेकिन श्रम विस्थापन से कृषि उत्पादन प्रभावित नहीं हुआ। वास्तव में, कृषि उत्पादन बढ़ने के साथ, भूमि एवं श्रम उत्पादकताओं में अभिसरण की प्रवृत्ति मिली। ग्रामीण क्षेत्रों में श्रमिकों की उद्योगों तथा सेवाओं में बढ़ती सघनता इस बदलाव को और गति देगें। कृषि पूँजी एवं अनुसंधान में निवेश, उत्पादन में बाजार–माँग के अनुरूप बदलाव और उपभोक्ताओं की पसंद के अनुरूप जैसे उपायों को अपनाकर कृषि से श्रमिकों के विस्थापन को गति प्रदान की जा सकती है।

वर्षावधि 2011–12 और 2017–18 के दौरान अधिकांश राज्यों के ग्रामीण क्षेत्रों में गैर–कृषि रोजगार में उल्लेखनीय वृद्धि हुई है। ग्रामीण गैर–कृषि रोजगार में सर्वाधिक बदलाव बिहार (58%), उसके बाद छत्तीसगढ़ (48%) और हरियाणा (40%) में मिला। इस तरह के बदलाव कृषक परिवारों को अपनी आय के स्रोतों में विविधता लाने में मदद् कर रहे हैं। कई राज्यों में गैर–कृषि उद्यमों में पुरूष एवं महिला श्रमिकों की भागीदारी में एक बड़ा अंतर मौजूद है हालांकि, समय के साथ अंतर कम हो रहा है। नीति आयोग द्वारा चिन्हित 117 आकांक्षी जिलों में सीमांत एवं छोटी जोत वाले किसानों, विशेष रूप से पुरूष प्रधान परिवार गैर–कृषि माध्यमों से अपनी आय में विविधता ला रहे हैं। दूसरी तरफ, मध्यम एवं बड़ी जोत वाले किसान कृषि में ही रहकर पर्याप्त विपणन योग्य अतिरेक एवं आय पैदा कर रहे हैं। कृषि से अलग विविधीकरण में राशन कार्ड एवं मनरेगा जाब कार्ड रखने वालों के बीच नकारात्मक संबंध मिला।

कृषि एवं गैर–कृषि कार्यों में उत्पादकता सुधरने से कृषक परिवारों की आय में वृद्धि हुई है, इससे हाषिये के परिवारों की ओर आय का पुनर्वितरण हुआ है। मध्यम एवं बड़े कृषि परिवारों की अपेक्षा सीमांत एवं छोटे किसानों के लिए गिनी सूचकांकों की कम दर से आय वितरण में समानता की उच्च दर का पता चलता है। आय में बढ़ोत्तरी तथा इसके वितरण में कम असमानता पोषण सेवन के लिए अच्छा संकेत है। कैलोरी, प्रोटीन और वसा की अनुमानित आय लोच (income elasticity) सकारात्मक थी, जोकि आय और पोषण के बीच सीधा संबंध दर्शाती है। आय में वृद्धि का पोषण पर पड़ने वाला प्रभाव शहरी परिवारों की तुलना में ग्रामीण परिवारों में सर्वाधिक होगा। यद्यपि, समय के साथ–साथ आय और पोषण के बीच संबंध कम होता जा रहा है।

सामाजिक लेखांकन मेट्रिक्स के अनुमानों पर आधारित एक अध्ययन से संकेत मिलता है कि कृषि पूँजी प्रधान होती जा रही है। कृषि व्यापार, विशेष रूप से निर्यातोन्मुखी नीति अपनाने से घरेलू माँग को बढ़ावा मिलता है। विभिन्न खाद्य समूहों में, प्रसंस्कृत खाद्य पदार्थो को गैर–प्रसंस्कृत खाद्य पदार्थो के ऊपर तरजीह देकर, अर्थव्यवस्था में गैर–कृषि वस्तुओं की माँग बढ़ानें में सहायता मिलती हैं।

टिकाऊ कृषि विकास के लिए लाभकारी परिसम्पत्तियों में निवेश पहली आवश्यकता है। शुद्ध कृषित क्षेत्रफल में औसत वार्षिक निवेश प्रति हेक्टेयर कम है और प्रमुख रूप से कृषक परिवारों द्वारा किया जाता है। भविष्य में कृषि विकास और इस पर मंदी के प्रतिकूल प्रभावों को संतुलित/समायोजित करने के लिए कृषि में निजी निवेश (किसानों सहित) को बढ़ावा देना आवश्यक है। सार्वजनिक क्षेत्र के निवेश में बढ़ती प्रवृत्ति और सरकार द्वारा किसानों की आमदनी में सुधार उपायों पर बल देने से किसानों को स्वयं भी अपना निवेश बढ़ानें के लिए प्रोत्साहन मिलेगा।

विभिन्न हस्तक्षेपों के बीच, अधिक मूल्यवाली फसलों यथा सब्जियों, फलों, मसालों और वृक्षारोपण की तरफ कृषि विविधीकरण, किसानों को आजीविका हासिल करने, कृषि विकास में तेजी लाने और ग्रामीण गरीबी को कम करने के एक महत्वपूर्ण साधन के रूप में माना जाता है। एक बहुस्तरीय मॉडल का प्रयोग करने पर एक अध्ययन में मिला है कि यद्यपि व्यक्तिगत भिन्नताओं के कारण कृषि विविधीकरण में काफी अन्तर मिला, जबकि राज्यों एवं गावों के संदर्भ में इसका प्रभाव इसके भौगोलिक स्वरूप को प्रस्तुत करने में साफतौर से महत्वपूर्ण हैं। हालांकि, इसके प्रासंगिक प्रभाव फसलों एवं कृषि प्रक्षेत्र श्रेणियों में भिन्न होते हैं।

प्रौद्योगिकी एवं टिकाऊ कृषि

प्रौद्योगिकी एवं टिकाऊ कृषि क्षेत्र के अन्तर्गत सामयिक विषयों जैसेकि जलवायु परिवर्तन एवं अनुकूलन नीति, कृषि संवहनीयता आकलन, इष्टतम फसल पद्धति एवं संसाधन उपयोग योजना, कृषि अपशिष्ट प्रबंधन, भूजल प्रबंधन और कुशल जल उपयोग प्रौद्योगिकियों के प्रभाव, प्रौद्योगिकी दूरदर्षिता, कृषि पेटेंट और कृषि परामर्शी सेवाएं, आदि बीस अध्ययन किये गये।

जलवायु के दीर्घकालिक प्रतिरूप विश्लेषण से कृषि जलवायु क्षेंत्रों में अधिकतम एवं न्यूनतम तापमान के वार्षिक औसत में उल्लेखनीय वृद्धि हुई है। हिमालयी क्षेत्रों एवं गंगाा के मैदानी भागों में वार्षिक औसत वर्षा में गिरावट आयी है, जबकि तटीय क्षेत्र, पठार तथा पहाड़ियों और पश्चिमी शुष्क क्षेत्रों में वार्षिक औसत वर्षा में वृद्धि हुई है। जलवायु परिवर्तन का फसलों पर पड़ने वाले उपज प्रभाव का आकलन क्षेत्रीय जलवायु परिवर्तन मॉडल 4.5 और 8.5 परिदृश्यों के तहत किया गया है सभी जलवायु क्षेत्रों (RCP) में उपरोक्त दोनों परिदृश्यों में गेहूँ तथा चावल की उत्पादकता पर नकारात्मक प्रभाव पड़ेगा। जबकि गेहूँ की उपज पर गुजरात के मैदानी तथा पहाड़ी क्षेत्रों में प्रभाव नकारात्मक नहीं होगा। साथ ही में पश्चिमी समुद्र तट के मैदानी एवं घाट क्षेत्रों में गेहूँ एवं चावल की उपज पर प्रभाव सकारात्मक रहेगा। फसलों की पैदावार पर जलवायु परिवर्तन का दीर्घकालिक प्रभाव आरसीपी 8.5 की अपेक्षा आरसीपी 4.5 में अधिक गंभीर होगा। सीमांत जोत वाले किसान जलवायु परिवर्तन के प्रति ज्यादा संवेदनशील होते हैं तथा उनके ऊपर इसका असर भी ज्यादा होता है क्योंकि उनके पास कृषि एवं आजीविका में विविधीकरण की क्षमता कम होती है। अतएव व्यापक फसल एवं क्षेत्र विशेष अनुकूलन उपायों को महत्व दिया जाना चाहिए क्योंकि जलवायु परिवर्तन तथा इसकी संबंधित भेद्यता कृषि जलवायु क्षेत्रों के अनुसार भिन्न होती है।

यद्यपि सतत् कृषि विकास के मुद्दों पर व्यापक रूप से चर्चा की गयी है, लेकिन कृषि में स्थिरता की अवधारणा के संचालन पर सीमित अनुभवजन्य अध्ययन उपलब्ध हैं। इसलिए कृषि स्थिरता मूल्यांकन के लिए एक रूपरेखा विकसित की गयी। समग्र सूचकांक का उपयोग करते हुए पंजाब एवं हरियाणा राज्यों के जिलेवार कृषि स्थिरता का अध्ययन दर्शाता है कि दोनों राज्यों में कृषि मध्यम/औसत रूप से टिकाऊ है। राज्यों की पूर्ण स्थिरता का औसत सूचकांक इसके सापेक्ष स्थिरता सूचकांक की तुलना में अधिक था।

विशेष रूप से भूमि एवं पानी जैसे प्राकृतिक संसाधनों की बढ़ती कमी, बहुमुखी लक्ष्यों के इष्टतमीकरण की आवश्यकता पर बल देते हैं। इस संदर्भ में गणितीय प्रोग्रामिंग मॉडल का उपयोग करके शुष्क, अर्द्धशुष्क, उष्णकटिबंधीय और बाढ़ संभावित क्षेत्रों के लिए इष्टतम फसल योजनाएं विकसित की गयी हैं। अध्ययन में बुंदेलखण्ड क्षेत्र में प्राकृतिक संसाधनों को बनाये रखने के लिए अनाजों के अन्तर्गत क्षेत्रफल को दलहनों एवं तिलहनों के अन्तर्गत परिवर्तित करने का सुझाव दिया गया। बुंदेलखण्ड क्षेत्र में सतत् कृषि विकास के लिए सुझाये गये इष्टतम योजनाओं में अधिक संख्या में स्थानीय मवेशियों एवं भेड़–बकरियों को समाहित करने पर बल दिया गया है। राजस्थान के शुष्क क्षेत्र हेतु इष्टतम योजना में ज्वार, तिल, मूँग, ग्वार, ईसबगोल, चना और सरसों फसलों के तहत क्षेत्रफल बढ़ाने का सुझाव दिया गया है। असम राज्य की निचली ब्रहमपुत्र घाटी क्षेत्र में बाढ़ की समस्या के नियंत्रण के रूप में शरद ऋतु के धान उत्पादन हेतु संस्तुत उर्वरकों की मात्रा एवं प्रजातियों (*Luit, Disang*) तथा शीतकाल में धान की बाढ़रोधी किस्मों जैसेकि रंजीत सब–1 और बहादुर सब–1 और साथ ही में बकरी की उन्नत नस्ल (बीटल) को अपनाने का सुझाव दिया गया है। संसाधन संरक्षण प्रौद्योगिकियों के एक अध्ययन में पता चला है कि पारंपरिक एवं शून्य जुताई तकनीकों की तुलना में टर्बो हैप्पी सीडर तकनीक के प्रयोग से प्रति इकाई कम लागत एवं अधिक उत्पादन मिलता है। चावल की सीधी बुवाई विधि पानी, श्रम और कम उत्पादन लागत वाली तकनीक के रूप में उभरी है। यद्यपि, मशीनों की कमी और खरपतवारों की अधिकता इसके अपनाने में प्रमुख बाधाएं हैं।

भारत में खाद्य उत्पादन प्रणाली को टिकाऊ बनाये रखने में भूजल संसाधनों के सतत प्रबंधन की महती भूमिका है। देश में भूजल उपयोग की दोहरी चुनौतियाँ है– विशेष रूप में उत्तर–पश्चिमी क्षेत्रों में इसका अतिदोहन और देश के पूर्वी–क्षेत्रों में इसका कम उपयोग, गंगा के मैदानी भागों में विभिन्न फसल पद्धतियों, वर्षाजल वितरण में असमानता, सामाजिक–आर्थिक भिन्नता, नीतिओं एवं संबंधित आधारभूत कारक, आदि भूजल में व्याप्त स्थानिक भिन्नता को दर्शातें है। भूजल कारक की दीर्घावधि प्रवृत्ति का विश्लेषण दर्शाता है कि पूर्वी गंगा के मैदानी भागों में जहाँ भूजल का कम विकास हुआ है और वर्षा अधिक होती है, वहा भी बड़ी संख्या में कुओं के भूजल स्तर में धीमी गति से कमी आयी है। इसे एक चेतावनी संकेतक के रूप में लिया जाना चाहिए जोकि पूर्वी क्षेत्र में भी भूजल संसाधनों के स्थायी प्रबंधन की आवश्यकता पर बल देता है।

जल के टिकाऊ प्रबंधन में जल उपयोग दक्षता में सुधार और इसके नियमन प्रमुख मुद्दे है। कुशल जल तकनीकों के एक अध्ययन में पता चला कि फव्वारा सिंचाई के उपयोग से उपज एवं आय में बढ़ोत्तरी होती है। अध्ययन दर्शाता है कि देश में सूक्ष्म सिंचाई के तहत करीब 65 से 80 मिलियन हेक्टेयर क्षेत्रफल लाया जा सकता है। राज्यों के बीच, उत्तर प्रदेश में सूक्षम सिंचाई के अन्तर्गत सबसे अधिक क्षेत्रफल (25%) लाने की संभावना है उसके बाद राजस्थान (12%) तथा मध्यप्रदेश (11%) का स्थान आता है। सूक्ष्म सिंचाई तकनीक के अंगीकरण में प्रमुख रूप से भूजल उपलब्धता एवं श्रम उपलब्धता, शुद्ध कृषि क्षेत्रफल और पंपसेट द्वारा दी जा रही सेवा, कृषि विद्युतीकरण और सरकारी सहायता, आदि कारक प्रभाव डालते हैं। सतही सिंचाई के संदर्भ में, पानी छोड़ने की दोषपूर्ण समय सारणी, पानी की नालियों का अतिक्रमण, नालियों के रखरखाव में देरी और अपर्याप्त जल आपूर्ति पूर्वी यमुना नहर कमान क्षेत्र में प्रमुख बाधाएं हैं।

आधुनिक दौर में वैश्विक विकास एवं अन्तर्राष्ट्रीय समझौतों के तहत बौद्धिक संपदा अधिकारों की सुरक्षा अनिवार्य है। कृषि क्षेत्र में संश्लेषित जीवविज्ञान और कृत्रिम बुद्धिमत्ता में प्राप्त पेटेंट और वैज्ञानिक प्रकाशनों के रूझान का विश्लेषण दर्शाता है कि पेटेंट कानून 2005 में संशोधन से भारत में कृषि प्रौघोगिकियों के पेटेंट पर सकारात्मक प्रभाव पड़ा है। कृत्रिम बुद्धिमत्ता क्षेत्र की तुलना में संश्लेषित जीवविज्ञान में पेटेंट उद्धरणों की संख्या अधिक है क्योंकि पूर्व अनुसंधानों से उत्पादों एवं इसके पेटेंट प्राप्त करना आसान हुआ है। बीटी कपास उद्योग में प्रतिस्पर्धा विरोधी नीतियों पर सरकारी नियमन नीतियों के प्रभाव का विश्लेषण दर्शाता है कि व्यापारिक मॉडल और नियमन नीतियों के आपसी तालमेल से बीटी कपास उद्योग में प्रतिस्पर्धा पैदा होती है।

विभिन्न ज्ञान स्रोतों, परामर्शी विधियों, विभिन्न प्रसार कार्यकर्ताओं द्वारा समय आंवटन की प्रासंगिकता पर एक अध्ययन से पता चला है कि सरकारी संस्थान, अन्य प्रसार कार्यकर्ताओं के लिए ज्ञान के महत्वपूर्ण स्रोत हैं। अतएव भारतीय कृषि में हो रहे बदलाव और उभरती चुनौतियों के सन्दर्भ में, सरकारी संस्थानों तथा वैज्ञानिक साहित्य संदर्भों को समान रूप में आगे आना चाहिए। सूचना संचार तकनीकों के विकास एवं प्रसार कार्यकर्ताओं द्वारा इनके माध्यम से परामर्शी सेवाओं को प्रदान करने में इंटरनेट ज्ञान का एक प्रमुख स्रोत बन गया है।

विपणन एवं व्यापार

विपणन एवं व्यापार विषय के अन्तर्गत किये गये अनुसंधान प्रमुख से विभिन्न खाद्य वस्तुओं की मूल्य श्रृंखला का विश्लेषण, मूल्य अस्थिरता और प्रेषण, बाजार एकीकरण, वस्तुओं की दृष्टिकोण मॉडलिंग और भावी बाजारों आदि पर केन्द्रित हैं।

उत्तर प्रदेश में भैंस मूल्य श्रृंखला के मात्रात्मक मानचित्रण से पता चला कि किसानों एवं जीवित पशु बाजारों के बीच 72 प्रतिशत प्रवाह समूहक द्वारा, बाजार एवं बूचड़ खानों के बीच प्रवाह का 94 प्रतिशत व्यापारियों द्वारा किया जाता है और कुल मांस उत्पादन का 71 प्रतिशत आयात किया जाता है। मूल्य श्रृंखला निर्धारण के साथ–साथ, आठ अधिक जोखिम वाले क्षेत्रों की पहचान की गयी जोकि इस प्रकार हैं:– व्यापारियों द्वारा गाड़ियों का अतिसंग्रहण, पशुधन बाजारों में मृत्यु–पूर्व अनियमित परीक्षा, स्वास्थ्य प्रमाण के बिना लंबी दूरी तक पशुओं को ले जाना, पशुओं की गतिविधियों, अलगाव एवं परिक्षण हेतु विधियों (पूर्व एवं बाद की) की कमी, यात्रा के बाद हरबार वाहनों की सफाई/कीटाणु शोधन की व्यवस्था न होना, बूचड़खानों में रोगजनकों की जाँच के लिए उपायों की कमी, खुदरा दुकानों पर स्वास्थ्यकर कार्यप्रणाली की कमी, और मांस काटने हेतु दूषित काष्ठ स्लैब का उपयोग।

तमिलनाडु में बकरी मूल्य श्रृंखला के सन्दर्भ में सगंहक, किसानों और जीवित पशु बाजारों के बीच मुख्य कड़ी हैं। जोकि कुल प्रवाह का 77 प्रतिशत जुटाते हैं। कुल मांस का 90 प्रतिशत से अधिक उपभोक्ताओं द्वारा सीधे खरीदा जाता है। उपभोक्ताओं से प्राप्त कुल आय में किसानों की हिस्सेदारी, विभिन्न विक्रय माध्यमों में 80 से 95 प्रतिशत पायी गयी है। हाल ही में, डेयरी क्षेत्र में कई नये डेयरी स्टार्टअप सामने आये हैं जोकि उपभोक्ताओं को सीधे दूध की आपूर्ति करते हैं। कुछ स्टार्टअप देशी गायों (साहीवाल, गिर, कांकरेज) के दूध की आपूर्ति पर ध्यान दे रहे हैं और विशेष मूल्य लेकर इसे गंगानगर (राजस्थान) में रूपये 60 प्रति लीटर और राष्ट्रीय राजधानी क्षेत्र (दिल्ली, फरीदाबाद और नोएडा) में रूपये 110 प्रतिलीटर की दर से बेच रहे हैं। ये स्टार्टअप शहरी निवासियों को गुणवत्ता वाले कच्चे दूध की आपूर्ति पर ध्यान केंद्रित करते हैं। मूल्य श्रृंख्ला में खाद्य सुरक्षा उपायों को अपनाना दूध की कीमतों के साथ सकारात्मक सहयोग को दर्शाता है।

तमिलनाडु में गहरे समुद्र में मछली पकड़ने की मूल्य श्रृंखला विश्लेषण से पता चला है कि मछुआरों द्वारा समुद्र तट से काफी दूरी पर श्रमसाध्य एवं जोखिमभरी गतिविधियों में शामिल होने के बावजूद इनकी कमाई औसत है।

काश्मीर प्रभाग में चेरी का मूल्य श्रृंखला विश्लेषण दर्शाता है कि इसका विपणन कम संगठित है। चेरी की मूल्य श्रृंख्ला में प्रमुख बाधा कटाई–उपरान्त प्रंबधन है जिसमें अल्पकालिक गुणवत्ता, मूल्यवर्धन की कमी और कम संख्या में शीतगार/शीत संग्रहण की उपलब्धता हैं। उत्पादन पटल पर किसान आमतौर पर कम संग्रहण अवधि, पौध संरक्षण रसायनों की अधिक कीमत, अधिक बीमारियाँ, कम उत्पादन मूल्य, व्यस्ततम समय में गुणवत्तापूर्ण रोपण सामाग्री एवं श्रमिकों की कमी। इसके अतिरिक्त, कम गुणवत्ता की प्रसार

सेवाएं, आवागमन सुविधाओं की कमी और जलवायु परिवर्तन आदि कारक उत्पादन में बाधक हैं।

उत्तर–पूर्व पहाड़ी क्षेत्रों में अदरक, हल्दी एवं मिर्च की मूल्य श्रृंखला का अध्ययन दर्शाता है कि इनका जैविक विधि से उत्पादन अधिक मूल्य प्राप्ति कराता है। गैर–जैविक उत्पादों की तुलना में जैविक उत्पादों के सन्दर्भ में उपभोक्ताओं से प्राप्त आय में किसानों की हिस्सेदारी अधिक थी।

जीरे के बाजार एकीकृत पाये गये। लम्बे समय से जीरा की कीमत स्थिर है और इसमें अल्पावधि में कोई भी अस्थिरता बाहरी झटके के कारण आती है। ग्रेंजर काजेलिटी परीक्षण में बाजारों में द्विदिशात्मक मूल्य संचरण की पुष्टि हुई। जीरा की कीमतें मुख्य रूप से प्रमुख बाजारों द्वारा तय की जाती हैं अतएव इन बाजारों में मूल्य निर्धारण में आने वाली समस्याओं को लक्षित करके दूर किया जाना चाहिए। परिधीय बाजारों में हस्तक्षेप को दूसरे चरण में लागू करना चाहिए जिसमें वित्तीय एवं बुनियादी ढ़ाचे के अलावा, इंटरनेट और परिवहन सुविधाएं शामिल हैं।

चुनिंदा बाजारों के बीच प्याज की कीमत में अस्थिरता एवं इसके spillover प्रभाव विश्लेषण से पता चला है कि बाजार में पिछली अस्थिरता के झटकों का अन्य बाजारों में पिछले मूल्य अस्थिरता झटकों की तुलना में स्वयं के बाजार मूल्य अस्थिरता का अधिक प्रभाव पड़ा। कपास के वायदा कारोबार पर किये गये एक अध्ययन में प्रमुख रूप से इलेक्ट्रानिक इक्सचेंजों पर व्यापार के लिए आवश्यक कौशल की कमी के कारण वायदा कारोबार में भागीदारी का स्तर निम्न मिला। वस्तुओं के वायदा कारोबार मूल्य संकेत प्रदान करने, उत्पादन कारकों की लागत कम करने, समय पर वितरण, प्रतिपक्ष जोखिम कम करने, और श्रेणीकरण सुविधा में सुधार करने में सहायक होते हैं।

एक अध्ययन में प्रमुख अनाज फसलों के दृष्टिकोण मॉडलीकरण हेतु गतिशील एवं स्थानिक संतुलन ढ़ाचे के तहत वर्ष 2030 तक अनुमान लगाया गया। अध्ययन दर्शाता है कि वर्ष 2030 तक चावल, गेहूँ एवं मक्का के तहत क्षेत्रफल क्रमशः 42.34, 33.17 तथा 10.32 मिलियन हेक्टेयर के आसपास होगा और इन फसलों की औसत उपज क्रमशः 3.35, 3.5 और 3.2 टन प्रति हेक्टेयर होगी।

अन्य उपलब्धियाँ एवं गतिविधियाँ

अनुसंधान के अतिरिक्त, संस्थान ने किसानों की आय दोगुना करने और अर्न्तमंत्रालयी समिति, आवश्यक वस्तुओं की कीमत निगरानी करने के लिए अर्न्तमंत्रालयी समितियों को महत्वपूर्ण नीति संबंधी तकनीकी जानकारी मुहैया करायी, इसके साथ ही विभिन्न नीति मंचो पर जैसेकि नई निर्यात नीति के निर्धारण और नीति आयोग के तत्वाधान में अनुसंधान एवं विकास प्रयोगशालाओं की रैकिंग ढांचा तैयार करने में 'भारतीय कृषि अनुसंधान परिषद् का प्रतिनिधित्व किया। संस्थान ने रसायन और उर्वरक मंत्रालय को भारतीय उर्वरक कम्पनियों द्वारा कच्चे माल की प्राप्ति के लिए नीति निर्धारण एवं विचार–विमर्श में सुविधा प्रदान की। निआप ने कृषि एवं इसके संबद्ध क्षेत्रों पर एक वर्किंग पेपर का मसौदा तैयार किया जोकि नीति आयोग के दृष्टिपत्र 2035 के लिए आधारभूत सूचना प्रदान करेगा। यह संस्थान कृषि सहकारिता एवं किसान कल्याण विभाग का एक ज्ञानपरक साझीदार है और इसके द्वारा देश में बाजार सूचना एवं मूल्य पूर्वानुमान प्रणाली के विकास हेतु संस्थागत प्रयास किया जा रहा है। संस्थान द्वारा परिषद् की परिणाम समीक्षा समिति को सहयोग एवं सुविधा प्रदान की गयी। संस्थान ने वर्ष 2019 में समसामयिक मुद्दों पर 10 कार्यशालाओं और प्रशिक्षण कार्यक्रमों के आयोजन के साथ–साथ; शैक्षणिक एवं स्नातकोत्तर छात्रों को मार्गदर्शन प्रदान करके क्षमता निर्माण में योगदान दिया। वर्ष 2019 के दौरान संस्थान की अन्य महत्वपूर्ण गतिविधियों जैसेकि वार्षिक दिवस (2 मई), हिन्दी पखवाड़ा, स्वच्छ भारत मिशन, अर्न्तराष्ट्रीय योग दिवस और मेरा गाँव मेरा गौरव का आयोजन किया। संस्थान द्वारा नकद रहित लेन–देन और सरकार के ई–खरीद पोर्टल के माध्यम से वस्तुओं एवं सेवाओं की खरीद आदि सुधारों को भी लागू किया जा रहा है।

Executive Summary

The ICAR-National Institute of Agricultural Economics and Policy Research (NIAP) acts as a think tank of the Indian Council of Agricultural Research (ICAR) in agriculture and science policy. The ICAR-NIAP undertakes policy studies on contemporary agricultural development issues through in-house and collaborative research, and makes persistent efforts in strengthening agricultural economics and policy research through capacity building training programmes. The Institute also sensitizes policy planners and ICAR about the emerging challenges and priorities for agricultural development and strategies to address them. The research is mainly conducted under the three major themes, viz. Agricultural Growth and Development, Technology and Sustainable Agriculture, and Markets and Trade. A brief account of research achievements and other activities undertaken by the Institute during the year 2019-20 is given below.

Research Achievements

Agricultural Growth and Development

Under the theme Agricultural Growth and Development, focus was on structural transformation of agriculture and rural economy, regional development, investment in agriculture, diversification, farm mechanization, doubling farmers' income, governance, and nutrition related issues.

Productivity trends in agriculture clearly indicate that the shift of labour from agriculture has not affected the output. During the period 2006 to 2016, agricultural workers have withdrawn from farming at varying rate in all the major states except Himachal Pradesh. But, labour-shift did not affect agricultural output. In fact, agricultural output increased along with the convergence in both land and labour productivities. Expanding labour intensive industrial and services clusters in rural areas would augment this transition. On output side, investing in on-farm assets and research, realigning production to market demand and consumer taste are measures to speed-up the transformation.

Rural areas in most of the states have witnessed notable increase in non-farm employment between 2011-12 and 2017-18. Change in the share of rural non-farm employment was as high as 58 per cent in Bihar, 48 per cent in Chhattisgarh and 40 per cent in Haryana. Such transitions are helping farm households to diversify their sources of income. A large gap exists in male and female labour participation in non-farm enterprises in several states. However, the gap is reducing over time. In 117 aspirational districts identified by NITI Aayog, farmers with marginal and small holdings, especially male-headed households, diversifed their income through non-farm participation. On the other hand, households with medium and large farm holdings concentrated on agriculture as they could generate considerable marketable surplus and income. Possessing ration card and MGNREGA job card were negatively related with diversifying away from cultivation.

Improvements in Productivity of agriculture and non-farm participation have raised earnings of the farm households. This has resulted in redistribution of income towards the marginalized households. Relatively low values of Gini indices for the marginal and small farm households revealed higher degree of equality in income distribution as compared to medium and large farm households. Increased income and reduced inequality have definite implications for nutritional intake. Estimated

income elasticities of calories, protein and fat were positive, indicating direct association between income and nutrition. The nutritional impact of increase in income would be higher among rural households than that of urban households. However, the association between income and nutrition is diminishing over time.

A study based on estimates from Social Accounting Matrices (SAM) indicated that agriculture is becoming more capital intensive. Agricultural trade, notably export-led strategy, boosted domestic demand. Among different food groups, export promotion of processed foods generated more demand for non-farm goods in the economy compared to the unprocessed foods.

Investment in productive assets is a pre-requisite for sustainable agricultural development. The average annual investment per hectare of net sown area is low and primarily contributed by farm households. It is necessary to boost private investment (including by farmers) in agriculture to offset adverse effects of deceleration in investment on future agricultural growth and development. The increasing trend in public sector investment and government's focus on improving farmers' income are expected to incentivize farmers to raise their investment in agriculture.

Amongst several interventions, diversification of agriculture in favour of high value crops, such as vegetables, fruits, spices, condiments and plantations, is contemplated as an important means of securing farmers' livelihoods, accelerating agricultural growth and reducing rural poverty. A study Employing a multilevel model, demonstrated that although between-individual differences explain considerable variation in agricultural diversification, the contextual effects of states and villages are unequivocally important in shaping its geographical pattern. The contextual effects, however, differ across crops and farm classes.

Technology and Sustainable Agriculture

Twenty studies were conducted under the theme Technology and Sustainable Agriculture on the topical issues such as impact of climate change and adaptation strategies, agricultural sustainability assessment, optimum cropping pattern and resource use planning, farm waste management, groundwater management, efficient water use technologies, technology foresight, agricultural patents, and extension advisory services.

The analysis of long-term climate pattern revealed a significant rise in annual mean maximum and minimum temperature across agro-climatic zones (ACZs). Annual rainfall has declined in Himalayan Regions and Gangetic Plains, whereas it has increased in Coastal Region, Plateau & Hills, and Western Dry Region. The impact of climate change on crop yield was projected under RCP 4.5 and RCP 8.5 scenarios. The yield of rice and wheat will be affected negatively under both scenarios in all the zones except Gujarat Plains and Hills in case of wheat and West Coast Plan and Ghat in both the crops. The long-term impact of climate change on crop yields would be more severe under RCP 8.5 than RCP 4.5 scenario. Farmers with marginal land holdings are more vulnerable to climate shock owing to their lesser capacity to make suitable agriculture and livelihood diversifications. As relative impacts of climate change and associated vulnerability vary across ACZs, comprehensive crop and region-specific adaptation measures should be emphasized.

Although issues of sustainable agricultural development have been widely discussed, limited empirical work is available on operationalization of the concept of sustainability in agriculture. Therefore, a framework for agricultural sustainability assessment was developed. Agricultural sustainability across districts of Punjab and Haryana using composite index showed that the agriculture is

moderately sustainable in both the states. The state average scores of absolute sustainability were significantly higher than the relative sustainability scores.

Reducing availability of resources, particularly land and water necessitates optimization of multifaceted goals. In this context, optimum enterprise plans were developed for arid, semi-arid tropics and flood prone regions using mathematical programming model. The study suggested diverting the area from cereals towards pulses and oilseeds for sustaining natural resources in Bundelkhand region. Optimum plans with more number of local cattle and small ruminants were suggested for sustainable agriculture in the region. In arid region of Rajasthan, optimum plan suggested for increasing area under sorghum, sesame, green gram, guar, isabgol, gram and mustard. Cultivation of autumn rice with recommended doses of fertilizer and variety (Luit, Disang), growing flood prone winter rice varieties Ranjit Sub 1 and Bahadur Sub 1 and improved goat variety (*Beetle*) emerged as major interventions for managing the flood in Lower Brahmaputra Valley Zone of Assam. An assessment of resources conservation technologies revealed higher output energy per unit of input energy consumed in Turbo Happy Seeder technique as compared to the conventional and zero tillage techniques. Direct seeded rice emerged as water saving, labour saving and low cost of production technology. However, non-availability of machines and higher weed infestation are the major impediments in its adoption.

Sustainable management of groundwater resources is a pre-requisite for sustaining food production system in India. Groundwater resources in the country suffers from dual challenges of over-exploitation, primarily in the north-western region and its under-use in the eastern region of the country. The Indo-Gangetic Plains (IGP) exhibits wide spatial variation in groundwater level owing to variation in rainfall pattern, cropping pattern, and several socio-economic, policy and infrastructural related factors. The analysis of long-run trend in groundwater level showed that in the eastern IGP where level of groundwater development is low and rainfall is high, large number of wells are witnessing depletion in groundwater level, though at a slow rate. This shall be taken as an early warning signal, which warrants emphasis on sustainable management of groundwater resources even in the eastern region.

Improving water use efficiency and governance are emerging issues in the sustainable management of water. The studies on water efficient technologies revealed that use of sprinkler irrigation contributes towards improving crop yield and income gains. About 65 to 80 million hectare area can be brought under micro-irrigation in the country. Among the states, Uttar Pradesh has the largest potential area (25%) followed by Rajasthan (12%) and Madhya Pradesh (11%). Adoption of micro-irrigation technology depends on groundwater availability, labour availability, pumpset intensity, electricity use in agriculture, and subsidy. In case of surface irrigation, faulty scheduling of water release, encroachment of water channels, delay in de-siltation of channels, and inadequate water supply are the major impediments in the eastern Yamuna canal command area.

The protection of intellectual property rights is indispensable under the new regime, global development and international agreements. The study on trends in patents and scientific publications in synthetic biology and artificial intelligence in agriculture revealed that amendment of Patent Law 2005 had a positive impact on patenting of agricultural technologies in India. The number of patent citations is higher in synthetic biology compared artificial intelligence, as the research from the earlier leads to products which are easy to patent. The analysis of the effect of regulatory policies of

the government on anti-competitiveness in the Bt cotton industry showed that interaction of business model and regulatory policies results in anti-competitiveness in the Bt cotton industry.

A study on relevance of different knowledge sources, advisory methods, time allocation by different extension advisory staff showed that public institutions are important source of knowledge to other extension advisory service providers. Therefore, literature and recommendations of these institutions needs to be abreast with emerging problems and changing realities in Indian agriculture. With development of ICT, internet has become a major source of knowledge for extension advisory services providers.

Markets and Trade

Under the theme Markets and Trade focus was on value chain analysis of different food commodities, price volatility and transmissions, market integration, outlook modelling, and future markets.

The quantitative mapping of buffalo value chain in Uttar Pradesh showed that 72 per cent of flow between farmers and live animal markets is done by aggregators, 94 per cent between market and abattoir by traders, and 71 per cent of total meat is shipped to importing countries. Along the value chain, 8 risk hotspots were identified, *viz*. overstocking of vehicles by traders, irregular ante-mortem examination in livestock markets, animals transported for long distances without health certificates, no measure for pre- and post-movement isolation and testing, non-cleaning/ disinfection of vehicles after each trip, no measure for check for pathogens in slaughter houses, lack of hygienic practices at retail outlets, and use of contaminated meat cutting wooden slabs.

In goat value chain in Tamil Nadu, aggregators were found as the main link between farmers and live animal market, transacting 77 per cent of the total flow. More than 90 per cent of meat is purchased by consumers. Farmers' share in consumer's rupee varies from 80 to 95 per cent across different marketing channels.

Of late, many new dairy startups have emerged in the dairy sector which sell milk directly to the consumers. Few startsups focus on supplying milk of indigenous cow (Sahiwal, Gir, Kankrej) at a premium price which ranges from ₹ 60 in Ganganagar (Rajasthan) to ₹ 110 per litre in the National Capital Region (Delhi, Faridabad and Noida). These startups focus on quality raw milk supply to urban dwellers with ensured hygienic conditions. Adoption of food safety measures in the value chain bears positive association with the milk prices.

The value chain analysis of deep sea fishing in Tamil Nadu revealed that despite engaging in strenuous and risky activity at far away distances from the shore, the earnings of the fishermen are quite modest.

Value chain analysis of cherry in Kashmir division revealed that its marketing is less organized. Major constraints in the cherry value chain are related to post-harvest management, *viz*. poor keeping quality, low value addition, and less number of cold storages. On the production side, farmers usually struggle with lower shelf life, costly plant protection chemicals, high incidence of diseases, low output price, lack of quality planting material and labour availability during the peak season besides low-quality extension services, poor communication facilities and climate change.

Value chain analyses of ginger, turmeric and chilli in the North-Eastern hills region revealed that organic production fetches premium prices. The producers' share in the consumer rupee for the organically produced spices was fairly higher than non-organic products.

Markets of cumin were found to be integrated. The long-run prices of cumin are stable and any deviation is mainly due to external shocks that occur in the short-run. The Granger Causality test confirmed the existence of bidirectional price transmission across markets. Prices are primarily determined in the central markets and these markets should be targeted for removing inefficiencies arising in price formation. The interventions in peripheral markets need to be taken at second stage, which includes better integration with internet, logistics and transport infrastructure besides financial and other infrastructures.

The analysis of onion price volatility spill-over effects among selected markets indicated that past volatility shocks in market have a greater effect on their own market price volatility than past volatility shocks arising from other markets. The study on futures trade in cotton revealed low level of participation in futures trading primarily owing to lack of skills needed for trading on electronic exchanges. Commodity futures market is found to help in providing price signals, hedging input costs, timely delivery, reducing counterparty risk and in improving gradation facility.

The Outlook Model for major cereals under a dynamic and spatial partial equilibrium modelling framework forecasted that area under rice, wheat and maize will be around 42.34, 33.17, 10.32 million hectare, respectively in the year 2030. The yield of these crops will be around 3.35, 3.5, and 3.2 tonnes per hectare, respectively.

Other Achievements and Activities

Apart from research, ICAR-NIAP provided significant policy and technical inputs to Inter-Ministerial Committee of Doubling Farmers' Income, Inter-Ministerial Committee on Monitoring Prices of Essential Commodities, and represented ICAR at various policy forums, viz. formulation of New Export Policy and developing framework of ranking of R&D labs in NITI Aayog. ICAR-NIAP facilitated Ministry of Chemicals and Fertilizers in deliberation on framing policy for overseas acquisition of raw material by the Indian fertilizer companies. The Institute prepared draft working paper on agriculture and allied sectors which will form basis of Vision 2035 of NITI Aayog. The Institute is a knowledge partner of Department of Agriculture Cooperation and Farmers Welfare (DAC&FW) and undertaking a major programme to institutionalize the capacity for development of market information and price forecasting system in the country. ICAR-NIAP also facilitated outcome review of the Council and undertaking review of Agri-Economic Research Centres. The Institute contributed to capacity building by organising about 10 workshops and trainings on the topical issues, and through teaching and student guidance during 2019. Organization of ICAR-NIAP Annual Day on 2nd May, celebration of Hindi *Pakhwara*, *Swachh Bharat Mission*, International Yoga Day, Vigilance Awareness Week, etc. were some other important activities of the Institute during 2019-20. The Institute is also implementing the reforms like cashless transactions, and procurement of goods and services through e-procurement portals of the Government.

CHAPTER 1

ICAR-NIAP: An Overview

ICAR-NIAP

Vision

Leveraging innovations for attaining efficient, inclusive and eco-friendly agricultural growth through agricultural economics and policy research

Mission

Strengthen agricultural economics research for providing economically viable, socially-acceptable and environmentally-feasible policy options for science-led agricultural growth

Mandate

- Agricultural economics and policy research on markets, trade and institutions
- Growth and development models for sustainable agriculture
- Technology policy, evaluation and impact assessment

The National Institute (formerly Centre) of Agricultural Economics and Policy Research (NIAP), Pusa New Delhi was established in 1991 by the Indian Council of Agricultural Research (ICAR). The Institute is committed to provide a leadership role in strengthening agricultural economics and policy research within the National Agricultural Research System (NARS). It acts as a think tank of ICAR in the area of agricultural economics and policy research, and provides credible research-based inputs to the Council to actively participate in policy debates and decisions. Besides ICAR, the Institute also provides regular technical and policy inputs to NITI Aayog, various ministries at the Centre and States and to other stakeholders for policy decisions related to food and agriculture.

Over the last three decades, ICAR-NIAP has been contributing significantly to the growth of the discipline of agricultural economics. The Institute has guided the Council in prioritization of its research agenda so as to improve efficiency and equity in agricultural research, and made significant contributions towards understanding of the contemporary issues and the challenges of agriculture. Specifically, the Institute has made notable contributions in the areas like assessment of agricultural R&D, research prioritization, investment and subsidies, technological change, agricultural sustainability, diversification, domestic market reforms, international trade, institutional innovations, market intelligence, livestock economics, commodity outlook, prices and demand forecasts. ICAR-NIAP acknowledges importance of partnership in forging strong alliances to tackle common research problems and in shaping the trajectory of agricultural growth through policy-oriented research and communications.

To accomplish its vision and mandate, ICAR-NIAP undertakes and promotes agricultural policy research, training and policy interfacing programs focusing on:

1. Policy studies on contemporary agricultural development issues through in-house, collaborative and consultancy research
    - R&D policy and technology management
    - Natural resource and environmental economics
    - Agricultural development, markets and trade
2. Strengthening agricultural economics and policy research
    - Capacity development by facilitation, networking and dissemination of information
    - Training programs and collaborative research
    - Enhancing ICAR participation in policy decisions through policy dialogues and institutional linkages

Institute Activities

Research activities

The research activities of ICAR-NIAP are broadly covered under the following three major themes: (i) Agricultural Growth and Development; (ii) Technology and Sustainable Agriculture, and (iii) Markets and Trade.

Broadly, ICAR-NIAP research portfolio under the theme *Agricultural Growth and Development* comprises structural transformation of agriculture and disparities in development, agricultural diversification and drivers of growth, farm and non-farm linkages for enhancing farmers' income, property rights, gender and agriculture-nutrition-health linkages. *Technology and Sustainable Agriculture* theme includes policy studies on climate change, natural resources management and environment, risk in agriculture, valuation of environmental services, agro-climatic zonal planning, resource use efficiency, impact of agricultural technology, and performance evaluation of agricultural extension system. Under *Markets and Trade theme*, emphasis is on policy studies on market reforms, infrastructure

development, mapping value chains, market intelligence, marketing efficiency, commodity outlook, price forecasts, price transmission, food quality and food safety, innovations in input markets, credits and farm services, agricultural trade pattern and international agreements. The Institute is actively engaged in collaborative and multi-disciplinary research in a network mode by involving agricultural economists, social scientists, and biological scientists.

Capacity building

ICAR-NIAP plays a key role in strengthening capacity and human resources development in the field of agricultural economics and policy research. The network projects are used to develop formal linkages among the institutions within and outside NARS and to exchange modern concepts and advanced analytical skills among the researchers on contemporary issues in agricultural economics and policy research. The Institute regularly organizes capacity building workshops and trainings to keep pace with the new developments in the discipline. Association with the Post Graduate School of the Indian Agriculture Research Institute (IARI) for teaching and guiding M.Sc and Ph.D students is an important capacity building activity of the Institute.

Policy interface activities and communications

ICAR-NIAP contributes to policy formulation through participation of its faculty in policy dialogues, debates and several committees of Central and State Governments. The Institute has a history of publishing regularly Policy Papers, Discussion Papers, Policy Brief etc., on contemporary policy issues, which serves as a medium for constructive critique, and sensitization of peoples' representatives and policy makers.

Organization and Management

As per the guidelines of ICAR, Director of ICAR-NIAP is advised and assisted by the several committees and cells to manage research and other programmes.

Research Advisory Committee (RAC) comprising eminent professionals from outside the ICAR system, ICAR official and farmers' representatives, guides the institute in planning research thrusts and strategies. Initiatives in human resource

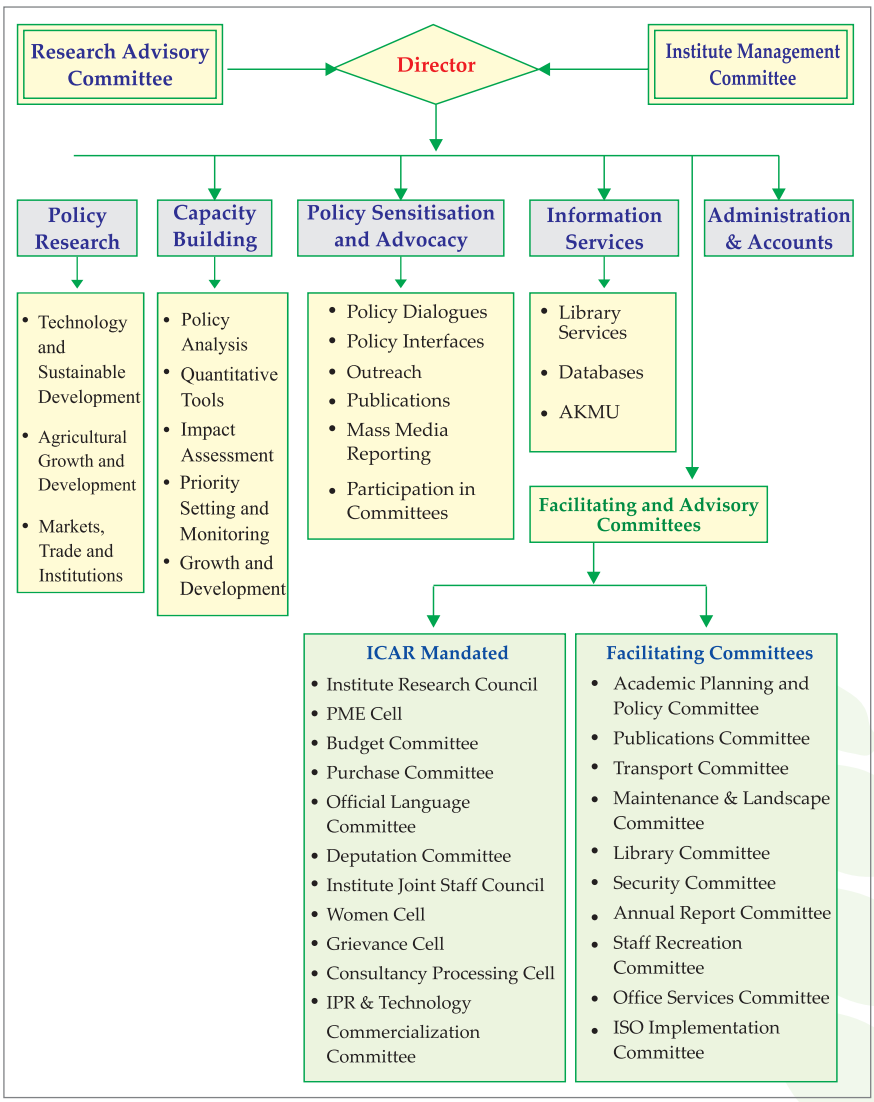


Figure 1.1. Organogram of ICAR-NIAP

development, approaches towards improving policy dialogues and evaluation are some other areas in which the Institute receives guidance from RAC. Professor Abhijit Sen, former Member, Planning Commission is the Chairman of the present RAC which was constituted by the Council for the three years from June 21, 2017.

The functioning of the Institute is supervised by the Institute Management Committee (IMC). Besides RAC and IMC, a number of internal committees and cells, including those mandated by ICAR, are operating for an efficient and decentralized management of the Institute. The Joint Staff Council (JSC) promotes healthy interaction and congenial work environment at the Institute. Director conducts regular meetings with staff, mostly every month, to discuss scientific and management issues to elicit suggestions for the cordial functioning of the Institute. The organogram of the Institute is given in Figure 1.1.

Information, Data and Facilitating Services

Agricultural knowledge management unit (AKMU)

AKMU manages research information and products, and provides other research related information through electronic and web mode. The goal of AKMU is to strengthen information management using modern technologies. The unit is also helping in implementation of IT reforms and management system.

Agricultural Knowledge Management Unit at ICAR-NIAP

Snapshot of MIS and FMS in ICAR

AKMU is well equipped with computers, servers, higher end internet security firewall (Fort iGATE 301e), centralised antivirus server and analytical software like SPSS, STATA, LIMDEP, GIS, GAMS, Stella, E-Views and SAS. For data management and in-house software development, SQL server and Visual Studio facilities are also available. NKN leased line of 100 mbps has been upgraded to 1000 MBPS to enhance quality and timeliness of network connectivity. All staff members of the Institute have been provided with latest computers and software, LAN, email account, internet facilities and other required computational facilities. ICAR email system is being fully used by ICAR-NIAP staff. AKMU maintains video conferencing facility at the Institute. The management information system (MIS) modules developed by the Council like FMS, PERMISNET, PIMS, HYPM, etc are fully functional and maintained by AKMU.

Management information system (MIS)

A centralized enterprise resource planning (ERP) system solution developed for entire ICAR is fully functional at ICAR-NIAP. The system includes solutions for financial management, project management, material management, human resource management and payroll. Various

functionalities provided by these modules are as follows:

Financial management: Solutions for General ledger, Account Payable, Account Receivable, Cash Management, Fixed Assets Management, Budget Management and grants.

Project management: Scope for Project Information, Costing, Project Documents, and Contract Management and Collaboration of Project documents.

Material management: Solutions for Purchase and Inventory Management.

Human resource: Employee information, HR policies, Leave Management, Performance and Appraisal System.

Payroll system: Salary, GPF, Pension Payment, Retirement Benefit Calculation and Income Tax Calculation Solutions for all the ICAR employees.

Library

ICAR-NIAP has a specialized collection of print, electronic and digital resources. Presently, library subscribes Economic and Political Weekly (EPW) digital archives and database like EPW Research Foundation (India time series data base), Indiastat and Districts of India. Electronic databases are available through LAN to the library users. Library is conducting innovative information literacy programme of J-Gate, Consortium for e-Resources in Agriculture for ICAR-NIAP staff. The library has 7,457 publications including books, journals, bulletins, CD ROMs, database publications, reports, SAARC publications and other reference materials, etc. The library has subscription of 15 international journals and 18 national journals. Institute's library has reserved a separate section for books of official language (Hindi).

Library of ICAR- NIAP

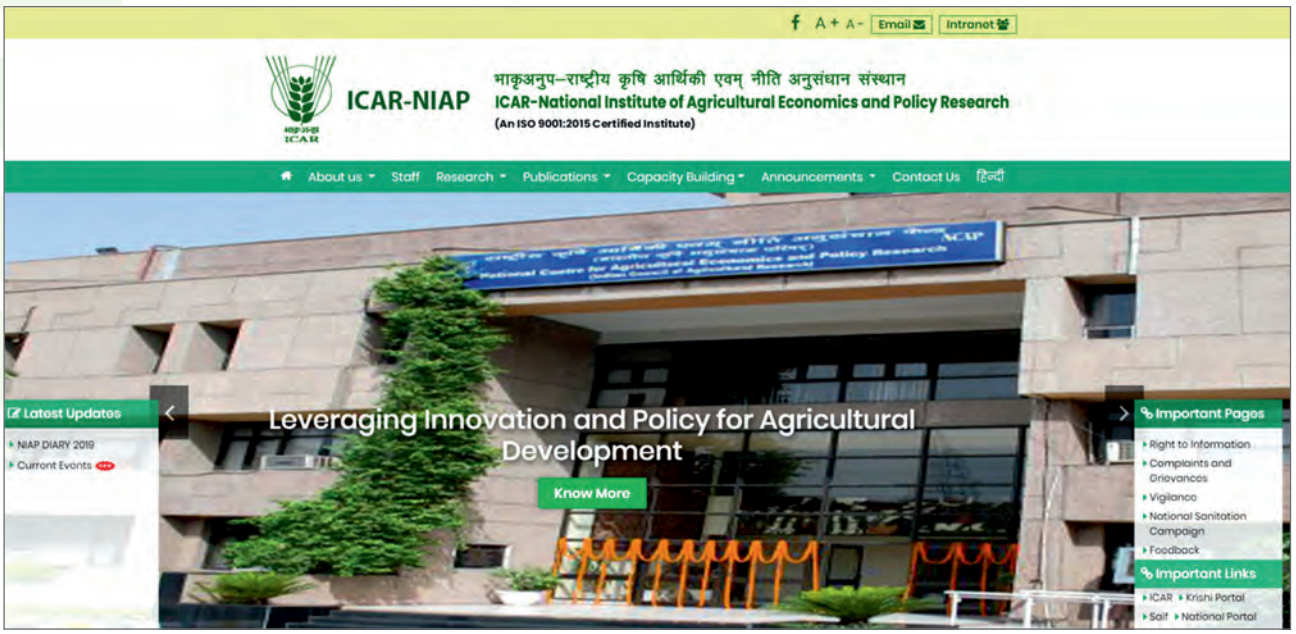
During 2019, the library procured 3 reference books, 6 official language books, 2 CD ROM and 3 database publications. The Library also acquired 45 gift publications. Library is playing an active role in timely dissemination of scientific and technical information for research via Document Delivery Service (DDS), Current Awareness Service (CAS), Newspaper Clipping Service, Resource Sharing Activities in other sister institute's libraries like IARI, IASRI. Inter Library Loan (ILL) facility on reciprocal basis from the CGIAR Centres like IFPRI, IWMI, CIMMYT, IRRI, ILRI is available at the Institute.

Exhibition-cum-record room

Research and other accomplishments of the Institute are displayed and documented in Exhibition-cum-record room. ICAR-NIAP publications, annual reports, and publications of scientists, recognitions and awards received by the Institute and the scientists are displayed here. In photo gallery memories of all important events organized by the Institute has been displayed.

ICAR-NIAP website

The Institute website (www.niap.icar.gov.in) in English and Hindi, show cases all the latest information per training to activities of its staff, infrastructure, research projects, publications, employment, tenders, RTI information and linkages. The website is hosted by Education and Research Network (ERNET), New Delhi, and is updated on a regular basis. All publications, *viz*. Policy Papers, Policy Briefs, Working Papers, PME Notes, Workshop Proceedings, etc. of ICAR-NIAP are available on the website. The website is visited nearly by 100 visitors every day.



Home page of NIAP website (www.niap.icar.gov.in)

Human Resources

The staff position at ICAR-NIAP during the year 2019 is given in table 1.1.

Table 1.1. Staff position at ICAR-NIAP during the year 2019

Name of the Post	Sanctioned strength	In position	Vacant
R.M.P	1	1	0
Scientific Staff	25	24	1
Technical Assistant	5	5	0
Administrative and supporting staff	14	10	4
Total	45	40	5

ISO 9001:2015 Certification

ICAR-NIAP operates a quality management system which complies with the requirements of ISO 9001:2015. ISO 9001:2015 certifies the Institute's ability to provide research and policy inputs on economic aspects of agriculture to the stakeholders and capacity development on agricultural economics and policy research.

CHAPTER 2

ICAR-NIAP: An Overview

Significant Research Achievements

Capacity Building

Policy Interactions

Research Output

Awards and Recognitions

Participation in Scientific Activities

Management Committee Meetings

Other Institute Activities

Personnel and Budget

Network projects	: 3
Externally funded projects	: 7
Institute funded projects	: 11
Consultancy/Contract projects	: 3
Agricultural Growth and Development	: 13 studies
Technology and Sustainable Agriculture	: 20 studies
Markets and Trade	: 10 studies

Theme – I
AGRICULTURAL GROWTH AND DEVELOPMENT

EXCERPTS

- Structural change has contributed around 30 per cent of national productivity growth during 2006-2016. This labour-shifting process has not affected agricultural output, in post-reforms period (1991-2005) and the subsequent decade (2006-2016). Among states, Madhya Pradesh, Rajasthan and Tamil Nadu have generated higher agricultural output along with significant reduction in agricultural workforce.
- Rising farm wages and higher institutional credit to agriculture promote mechanization. Still, presence of a less-than-unitary elasticity of substitution between labour and machines (between 0.5 and 0.8) in most of the crops restrains augmenting agricultural labour productivity growth.
- Processed foods sector has emerged as a predominant source of export-led growth strategy. Based on Social Accounting Matrix framework, promoting exports of processed foods would bring more demand for non-farm goods (76%) than that of farm goods (24%).
- Sugar production is highly elastic to the recovery rate (1.5), and elasticity of cane-crushed with respect to the area change is as high as 5.6. Thus, technology and area could potentially alter sugar supply. On consumption side, factors such as population and jaggery price have less-elastic effects with elasticities of 0.8 and 0.9, respectively.
- An improvement in irrigation governance reduces the gap between irrigation potential created and used. Raising area under non-food crops appears to be the other potential strategy to improve performance in public irrigation system.
- The average annual investment pre hectere of net sown area is low and primarily contributed by farm households. It is necessary to boost private investment (including farmers) in agriculture to fasten agricultural growth and development. It is also desirable to diversify investment portfolio towards livestock, fisheries & other sub-sectors.
- The calories and nutrient income elasticities are high in rural regions. During 2011-12, calories, protein and fat consumption elasticities with respect to income were 0.48, 0.53 and 0.83, respectively, in rural areas and 0.45, 0.47 and 0.68 in urban areas.
- Non-farm employment has risen rapidly in recent years, especially in rural regions. During 2011-12 and 2017-18, change in share of rural non-farm employment was as high as 58 per cent in Bihar, 48 per cent in Chhattisgarh and 40 per cent in Haryana. Further, the gap between male and female in non-farm participation is reducing across the states.
- In the aspirational districts, possessing smaller land for cultivation promotes engagement in non-farm activities. The size of holding has a significant positive relationship with the probability of entering into non-farm enterprises. Possession of ration card and MNREGA job card reduces the probability.
- Income distribution is more unequal among farmers having more than 4 hectares of land (2012-13). The Gini index stands at 0.6 for this class, and 0.5 for marginal and small holders.

Structural Transformation, Regional Disparity and Institutional Reforms in Agriculture

Suresh Pal., Balaji SJ and Subash SP

Drivers of agrarian change

Indian agriculture is undergoing significant structural changes in terms of output and employment. The evidences reveal that during pre-reform period (1981-90) increase in agricultural productivity accompanied rise in workforce leading to a stagnant labour productivity trend. The post-reform period (1991-2005) witnessed labour-shift from agriculture which augmented further during the subsequent decade 2006-2016 and led to a drastic improvement in agricultural productivity. In the absence of labour shift, productivity growth in agriculture would have been lesser. Labour-shift during the recent decade (2006-2016) did not affect agricultural output. In fact, output growth grew more rapidly and exhibited positive association with labour shift in a cluster of states in the recent decade (Figure 2.1). The decomposition analysis indicated 'within-sector' productivity growth is the major source of national growth, but clearly indicates rising contribution of 'structural change'. In the recent decade, structural change contributed 30 per cent of national growth. Contribution of agriculture to the 'within-sector' growth doubled from 12 per cent in the early decade of post-reforms to 24 per cent in later period; but its contribution to overall structural change is negative, by more than 35 per cent.

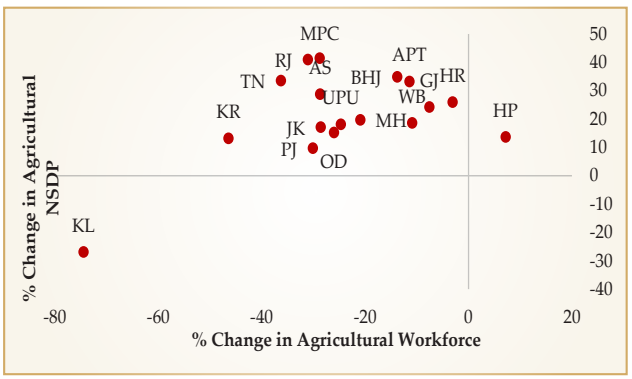


Figure 2.1. Response of agricultural NSDP to labour-shift (2005-06 *vs* 2015-16)

During the past three decades, output share of allied sector has increased substantially in Jammu & Kashmir, Tamil Nadu and Andhra Pradesh, while the states West Bengal, Himachal Pradesh, Madhya Pradesh, Assam, Karnataka and Maharashtra have lagged behind. Alongside, Punjab, Haryana and Kerala have also succeeded in reducing the labor share engaged in agriculture. Consequently, land and labour productivity moved towards convergence at the speed of 2 per cent and 1 per cent, respectively. Investing in technology that raises land productivity, and investing in human capital that enhances the skill levels of laborers in agricultural operation would further enhance the speed.

Table 2.1. Estimated elasticity of substitution between labour and machine

Crop	Elasticity	
	2000-01	2013-14
Rice	0.735	0.845
Wheat	0.608	0.620
Jowar	0.774	0.716
Bajra	0.811	0.572
Maize	0.539	0.761
Cotton	0.949	0.829
Sugarcane	0.497	0.593

Still, there exists constraints in augmenting the speed of transformation. More importantly, the possibility of replacing agricultural laborers with machines seems to be a challenging task. The substitution elasticities estimated using Non-Linear Seemingly Unrelated Regression method showed that the elasticities are less than one in almost all major crops (Table 2.1). Policy reforms in factor market, notably in land and labor would help address to some extent. During the year 2012-13 at least 18 per cent of marginal farmers and 7 per cent of small farmers leased-in land for raising crops. Given their large numbers, enacting tenancy laws that incentivize tenants as well as protect land owners can expedite transformation. Similarly, expanding labour intensive industrial and

service clusters in rural regions that protect minimum wages would augment the transition. On output side, investing in on-farm assets and research, adjusting production that respond to market demand and consumer taste are measures to speed-up transformation.

Export promotion policy options and its impact on Indian economy: A Social Accounting Matrix (SAM) approach[1]

Using Social Accounting Matrix (SAM) framework, the study analysed changes in aggregate demand in farm and non-farm sectors, changes in labour demand across gender and literacy, and changes in income inequality among households between 2007-08 and 2012-13. Farm sector share in total demand declined from 12.0 to 9.5 per cent during 2007-08 to 2012-13. While the contribution of labour and capital were more or less equal (50%) in 2007-08, the economy turned capital intensive (66%) in 2012-13. The share of rural labour demand in total labour demand declined from 58 to 53 per cent during the same period. The demand for illiterate male was highest both in rural and urban regions, while least demand was found for female graduates. The urban household income share in total household income slightly declined from 50 to 47 per cent. Inequality in income distribution reduced among both rural and urban households.

Further, using SAM multiplier model, various export promotion policy options (processed foods –*vs*- foodgrains –*vs*- fresh fruits and vegetables) were simulated to assess their impact on Indian economy. The results indicated that export promotion of unprocessed food items would bring equal growth in output demand for both farm and non-farm sectors, whereas promoting exports of processed foods would bring to more demand for non-farm items (76%) than farm sector (24%) based on SAM 2007-08. As per SAM 2012-13, the impact was same like in 2007-08 for processed foods, whereas the former was likely to bring slightly less share of farm sectors (about 10%) when compared to 2007-08. It is important to note that in 2007-08, foodgrain based policy option was most powerful for accelerating growth of output demand, while in 2012-13, processed foods-based policy option was most influential. It implies that processed foods sector has emerged as a predominant sector in export-led growth option.

As far as factor intensities are concerned, labor and capital contribution was more or less equal in 2007-08 under different scenarios. But in 2012-13, the capital-intensive (about 80:20) growth was observed not only in processed foods sector but also in other categories. The demand for low skilled labours was more than high skilled labourers in both the periods under different policy scenarios. The impact of export promotion on income distribution indicated that along with income growth, inequality had also increased across the rural and urban households both in 2007-08 and 2012-13 under all scenarios, except among rural households in 2007-08. It can be concluded that as per 2012-13 structure, promotion of processed foods exports could be the better policy choice for achieving higher economic growth.

Modelling Indian sugar sector[2]

Changes in sugar production in India affect both domestic and global sugar market and related industries. A simultaneous equation model was developed to understand the interrelationships between sugar supply and demand system in India using time series information over 44 years from 1970–71 to 2013–14. Data on the variables were collected from various issues of Indian Sugar Mills Association (ISMA), Cooperative Sugar, and Indian Sugar journals. Price and other economic variables were deflated by consumer price index (base year: 1986–87) to convert them into real terms. Production, consumption, price

[1] In collaboration with ICAR Indian Agricultural Research Institute, New Delhi

[2] In collaboration with Madras Institute of Development Studies, Chennai

and trade equations were set separately where production itself was represented by three additional interlinked equations.

Order and rank conditions of all the equations in the model were found over-identified. Following that, three stage least square (3SLS) regression model was used to estimate the elasticities of supply and demand equations of sugar. Simultaneous equation models should satisfy the conditions of relevancy, exogeneity, etc., to ensure the reliability of model. Estimates showed high correlation between instrument variables and endogenous regressors satisfied the relevancy test. Insignificant coefficients of Durbin's chi square value and Wu-Hausman's F-statistics indicated that there were no endogenous variables in the right-hand side of all equations. With respect to weak instrument tests, significant F-statistics of all the seven equations indicated that instruments included in the present study were very strong. Results of all the tests emphasized that the model given in the present study is appropriate for simultaneous equation analysis.

Results showed that sugar production with respect to cane crushed is elastic (1.03), implying that the use of crushed cane for sugar production is increasing rather than being diverted towards the production of other derivatives of sugarcane, such as jaggery and molasses. Recovery rate showed a positive and highly elastic relationship with sugar production (1.52), indicating that higher recovery rate would result in higher sugar production. Imposing of levy quota by the government on sugar production appeared to be negative but inelastic (-0.03). Elasticity of amount of cane crushed was highly elastic with respect to sugarcane area change (5.62). One-year lagged area under sugarcane, FRP, yield, rainfall, and value of competing crops affected the adoption of area under sugarcane. In the yield equation, both rainfall and time trend (proxy for technologies) variables appeared to have positive and significant impact on the yield (0.63 and 0.16, respectively). Specifically, change in yield was less responsive to technological change, indicating that there is a sluggishness in technological development to improve the yield of sugarcane.

On the consumption side, sugar price showed expected negative effect with sugar demand (-0.27). Population appears to have positive and moderately elastic effect on sugar consumption (0.83), suggesting that demand for sugar and sugar based products would keep pace with increased population. In the sugar price equation, the elasticity of sugar price to jaggery price changes is positive and moderately responsive (0.90 per cent), indicating that changes in unorganised sector of jaggery unit would affect level of sugar price considerably. The responsiveness of sugar price with respect to changes in export was significant, indicating that a higher price for sugar in the international market may increase the profitability of sugar mills and subsequently reduce domestic sugar price. Interestingly, no variable was statistically significant in export equation, indicating that international trade with respect to sugar production in India was irrelevant as more than 90 per cent of total sugar production in India is consumed by the domestic population. These results suggested that technological development and appropriate sugar policy measures are the primary choice to resolve the sugar complexities in future.

Governance and the performance of the public irrigation system[3]

The performance of the public irrigation system can be captured through the gap between irrigation potential created and irrigation potential utilized and/or utilization of irrigation potential created. To quantify the effect of irrigation governance on the performance of public irrigation, a panel regression model was employed. The performance indicator was measured as the gap between irrigation potential created and irrigation potential utilized. A set of explanatory variables included the irrigation governance index (IGI), rainfall and proportion

[3] In collaboration with Jawaharlal Nehru University, New Delhi

of area under non-food crops. The proportion of the non-food grain area to the total sown area is taken to capture the extent of crop diversification. The IGI was constructed using 14 indicators, such as receipts from public irrigation, electricity charges in agriculture, revenue and capital expenditure on public irrigation, irrigation potential created under the Accelerated Irrigation Benefit Programme (AIBP), net area irrigated by public canals and tanks, stage of groundwater development, etc.

Table 2.2. Results based on fixed effects model

Explanatory variable	Coefficient	Standard error
log (IGI)	-0.999***	0.215
log (rainfall)	0.004	0.175
% non-foodgrain area to total area	-0.450***	0.207
Constant	8.126***	1.390
R-squared:	0.084	F(3, 277)
Prob>F:	8.42	(0.00)
Hausman test statistic:	$Chi^2(3) = 6.44$	$Prob>Chi^2$ 0.092

Note: ***Significant at 1% level

The fixed effects model was chosen over the random effects model based on the Hausman test statistic. The coefficient of the governance index was negative and statistically significant, implying that an improvement in irrigation governance leads to a reduction in the gap between the irrigation potential created and utilized (Table 2.2). The effect of rainfall turned out to be positive but statistically insignificant. However, the effect of the proportion of the area under non-foodgrains on reducing the gap between the irrigation potential created and utilized is highly significant. Perhaps higher returns from non-food crops enable farmers to pay water charges regularly and maintain the canal properly. Overall, the results indicated that reforms that enable good governance in the irrigation sector will go a long way in improving the utilization of irrigation potential, efficiency of water use and the allocation of resources.

Diversification in Indian Agriculture towards High Value Crops

PS Birthal, J Hazrana and DS Negi

Amongst several interventions, diversification of agriculture in favour of high value crops, such as vegetables, fruits, spices, condiments and plantations, is contemplated as an important means of securing farmers' livelihoods, accelerating agricultural growth and reducing rural poverty. In India, compared to the widely-grown staple food crops, these crops, often termed as high value crops (HVCs), are at least three times more remunerative and labour-intensive. There is also a strong inverse relationship between farm size and productivity in case of HVCs. Thus, the smallholder farmers, who have a larger endowment of labour in relation to land, have comparative advantage over larger farmers in cultivation of high value crops.

Employing a multilevel model, this study partitioned the variation in area share of high value crops at the household, village, district and state levels, and identified the level that has the largest contextual effects, over and above the compositional effects, on the process of agricultural diversification (Table 2.3). An understanding of the contextual effects of different geographical or administrative levels is essential for the correct targeting of efforts and investments for higher, sustainable and inclusive growth of agriculture. Findings showed that besides the household resource endowments the contextual factors play a significant role in shaping the geographical pattern of diversification into HVCs. By partitioning the variation in area share of high value crops across multiple levels, this study demonstrated that although between-individual

Table 2.3. Variance estimates and VPC (%) at different levels

	Unconditional		Conditional	
	Variance	VPC (%)	Variance	VPC (%)
HVCs				
Household	1.6138 (0.0130)	41.04	1.4557 (0.0135)	47.21
Village	0.7282 (0.0214)	18.52	0.6250 (0.0212)	20.27
District	0.3450 (0.0293)	8.77	0.2653 (0.0267)	8.61
State	1.2450 (0.4094)	31.66	0.7371 (0.2666)	23.91
Fruits and plantations				
Household	0.7571 (0.0061)	51.32	0.7487 (0.0069)	51.81
Village	0.3896 (0.0111)	26.41	0.3638 (0.0120)	11.55
District	0.1499 (0.0134)	10.16	0.1669 (0.0162)	25.17
State	0.1787 (0.0495)	12.12	0.1657 (0.0620)	11.47
Vegetables				
Household	0.9130 (0.0074)	60.45	0.6364 (0.0059)	69.61
Village	0.3094 (0.0097)	20.48	0.1981 (0.0073)	21.66
District	0.0886 (0.0092)	5.86	0.0392 (0.0054)	4.29
State	0.1994 (0.0524)	13.2	0.0406 (0.0156)	4.44

Figures in parentheses are standard errors

differences explain considerable variation in agricultural diversification, the contextual effects of states and villages are unequivocally important in shaping its geographical pattern. The contextual effects, however, differ across crops and farm classes. The contextual effects of higher geographical levels, especially of states, are stronger for fruits and are positively related to farm size. For vegetables, these are much smaller, and are invariable to scale.

From policy perspective, state actions and their implementation at lower administrative levels (i.e., districts) explain considerable variation in diversification. The findings of larger contextual effects of states for longer-gestation, capital-intensive crops, like fruits and plantations, and for large farmers suggested a re-orientation of state policies related to the provision of technology, credit, market and support services in favor of smallholder farmers. The local context, i.e., village or community, too merits attention for effective implementation and coordination of programs with higher administrative levels.

Regional Dynamics of Growth in India: Do Spatial Spill-Overs and Structural Transformation Matter?

J Hazrana, P S Birthal, D S Negi, G Mani and G Pandey

Using a panel of district-level data for 2001-2015 this study has demonstrated 'how spatial

dimensions influence regional dynamics of economic growth in India'. Three important conclusions emerge from this study: (i) contrary to the evidence of divergence in income growth across states as reported in several studies, it found an evidence of absolute convergence in per capita income across districts even without considering spatial effects. But, there are significant spatial effects on economic growth, leading to significant acceleration in its speed of convergence; (ii) driven by technological change, agriculture generates positive spill-overs on economic growth, but these have remained constant over time; (iii) services sector does not influence much the speed of convergence in economic growth.

These findings have some important policy implications for reducing regional disparities in economic development. Firstly, policies and strategies should target improving spatial inter connectedness by investing more in infrastructure, markets and communication networks; and it should be accompanied by dismantling of regulatory barriers allowing inter-regional trade and free flow of capital and labour, and diffusion of technologies or knowledge. Secondly, agriculture has potential to accelerate economic growth of poor regions through its spill-over effects. In these regions, agriculture is subsistence-oriented and faces several technological, informational, financial, infrastructural and market constraints, that need to be addressed to accelerate agricultural growth. Thirdly services sector has remained concentrated in few pockets in and around metropolitan cities, perhaps owing to better logistics and availability of skilled manpower, depriving rural areas of benefits of its rapid growth. This implies a need to identify skill requirements of different activities in the sector, and accordingly to invest in human capital and infrastructure to attract private investment for broadening the base of services sector beyond urban centers. Finally, although human capital and financial outreach are not found to impact much the speed of convergence, their importance as facilitators of economic growth should not be undermined.

Fostering Investment for Sustainable Agricultural Development

S.K. Srivastava and Suresh Pal

Agricultural production system is considered as sustainable when it is productive, economically viable, resilient, equitable and does not deteriorate natural resources. During the past six decades, agricultural productivity improved significantly leading to 2.4 times increase in per capita food production. India is expected to have a comfortable situation in terms of food security. The agriculture has also become more resilient and stable in the current decade as compared to previous decades. However, agriculture is relatively less remunerative as compared to non-farm sectors primarily due to dominance of crop sub-sector. Diversification towards livestock, fisheries, and commercial crops offers a great scope to raise returns from agriculture. Although Indian agriculture is gradually diversifying, its pace is slow due to several impediments. The evidences revealed relatively higher growth in cost of cultivation than the gross return from crop cultivation. This necessitates accelerating productivity improvement and farm mechanization to absorb the rising production cost and ensure economic viability of crop cultivation. Land, which is the primary asset of the farmer, is inequitably distributed across widely dispersed holdings and average land size is shrinking over time. Dominance of smallholdings with shrinking land holding size puts tremendous pressure on land resources to feed the rising population. It is therefore necessary to improve soil fertility to fulfil the increasing food demand. The use of water resources in agriculture is unsustainable

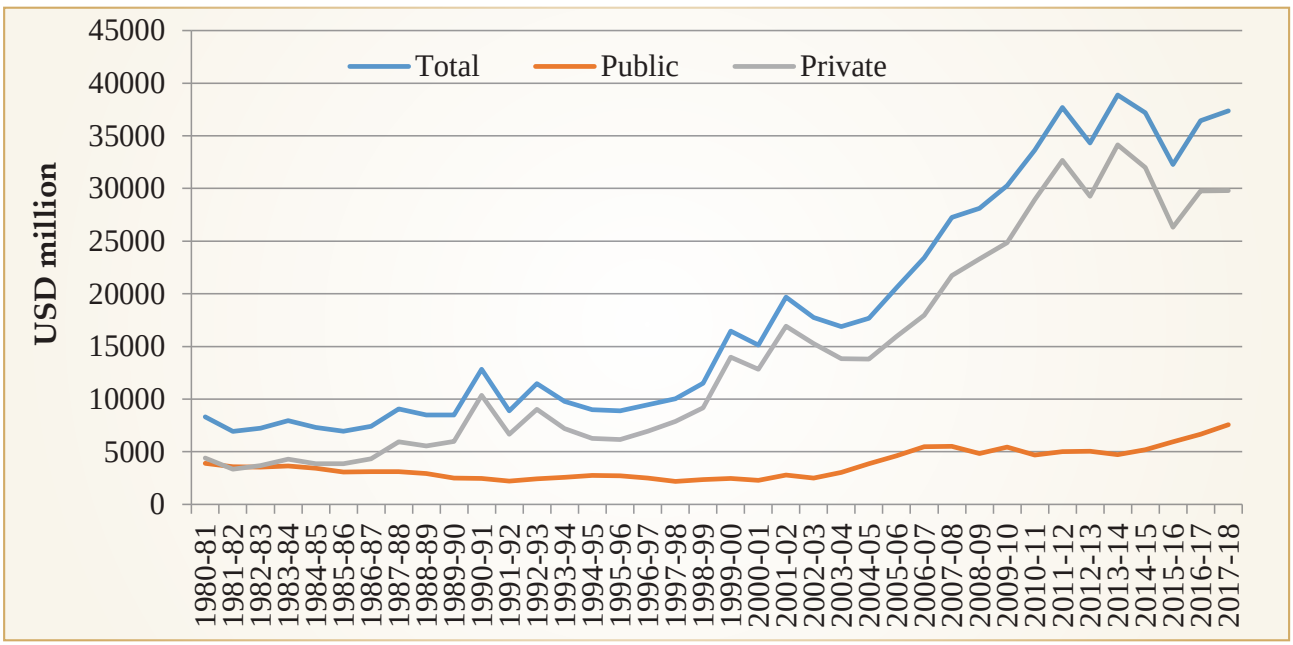


Figure 2.2. Trend in gross fixed capital formation in agriculture and allied sectors (at 2011-12 prices) in India

in many parts of the country and evidences suggested a strong need to adopt an optimum mix of both demand and supply side measures to manage water resources use in agriculture. Securing cooperation among public, private and farmers is essential for sustainable agricultural development in India.

Investment in productive assets is a pre-requisite for sustainable agricultural development. The long-run trends in GFCF-Ag (at 2011-12 prices) in India by public and private sectors during 1980-81 to 2017-18 are depicted in Figure 2.2. During the past four decades, GFCF-Ag at 2011-12 prices increased 4.5 times from USD 8301 million in 1980-81 to USD 37,357 million in 2017-18 at average annual growth rate of 5.39 per cent (Table 2.4).

However, the growth in GFCF-Ag was not uniform throughout the period. The analysis of decadal pattern in growth in GFCF-Ag revealed that during 1980s and 1990s, public investment in agriculture at constant prices declined and entire growth in GFCF was contributed by private investment (primarily farmer households). In the subsequent decade (2000-01 to 2010-11), government infused huge expenditure towards capital formation in agriculture at annual growth rate of 9.30 per cent. Private investment during this period also increased at 7.58 per cent per annum. Owing to a significant rise in public and private investments, GCFC-Ag registered 7.87 per cent growth. However, high growth in private investment could not sustain and the recent period 2010-11 to 2017-18 witnessed negative growth in private investment in agriculture. As private investment accounts for about 80 per cent of the GFCF-Ag, total investment has witnessed stagnation despite 6.61 per cent growth in public investment in the recent years. These evidences suggested that growth trajectory of GFCF-Ag follows the path of private investment, and it is necessary to boost private investment in agriculture to offset adverse effects of deceleration in investment on future agricultural growth and development. The increasing trend in public sector investment and government's focus towards improving farmers' income are expected to incentivize farmers to raise their investment.

Table 2.4. Growth rates in GFCF in agriculture and allied sectors

Period	Gross Fixed Capital Formation (GFCF)			Gross Value added
	Total	Public	Private	
1980-90	3.45	-4.19	8.12	3.13
1990-00	3.14	-0.45	4.05	3.18
2000-10	7.87	9.30	7.58	2.71
2010-17	0.40	6.61	-0.77	3.09
1980-2017	5.39	2.04	6.77	2.99

During 2017-18, value of GFCF-Ag at current prices was USD 49,797 million which is 13.2 per cent of GVA-Ag and 8.4 per cent of the total GCA in the economy. The average annual investment per hectare of net sown area turns out to be low at USD 355 at current prices. It is necessary to raise investment in productive assets in agriculture. The evidences revealed that investment in agriculture is primarily absorbed in crop sub-sector and it is desirable to diversify investment portfolio towards other sub-sectors such as livestock, fisheries, etc.

Farm Mechanization on Small and Marginal Farms

Nalini Ranjan Kumar

Farm mechanization in India is still in its early stage with tractor as a predominant machine. Tractor density in India, estimated as number of tractors operating per 1,000 hectares of net sown area has increased from around 6 in 1990-91 to 45 in 2017-18 (Figure 2.3). This indicates an increasing use of tractor operated agricultural machines and equipment among the Indian farmers. Assuming 10 years of working life for agricultural tractors, tractor sale in India during last 10 years was added to estimate the availability of tractors. Among the states, Haryana has the highest tractor density of 76 tractors per thousand hectares of net sown area followed by 58 in Punjab and 51 in Bihar. The lowest tractor density (2.3) was in Kerala.

The study examined drivers of farm mechanization by regressing tractor density with independent variables namely, wage rate of male labour in agriculture (₹/day), per capita electricity consumption (Kw-hr), road density (km/sq km of land area), GDP of agriculture and allied activity at constant price (₹crore), cropping intensity (%), institutional credit to agriculture (₹crore) and index of terms of trade between agricultural and non-agricultural sectors. Data on these variables were collected for the period 1990-91 to 2016-17 and Cobb-Douglas specification was used in the model. The estimated coefficients are presented in Table 2.5.

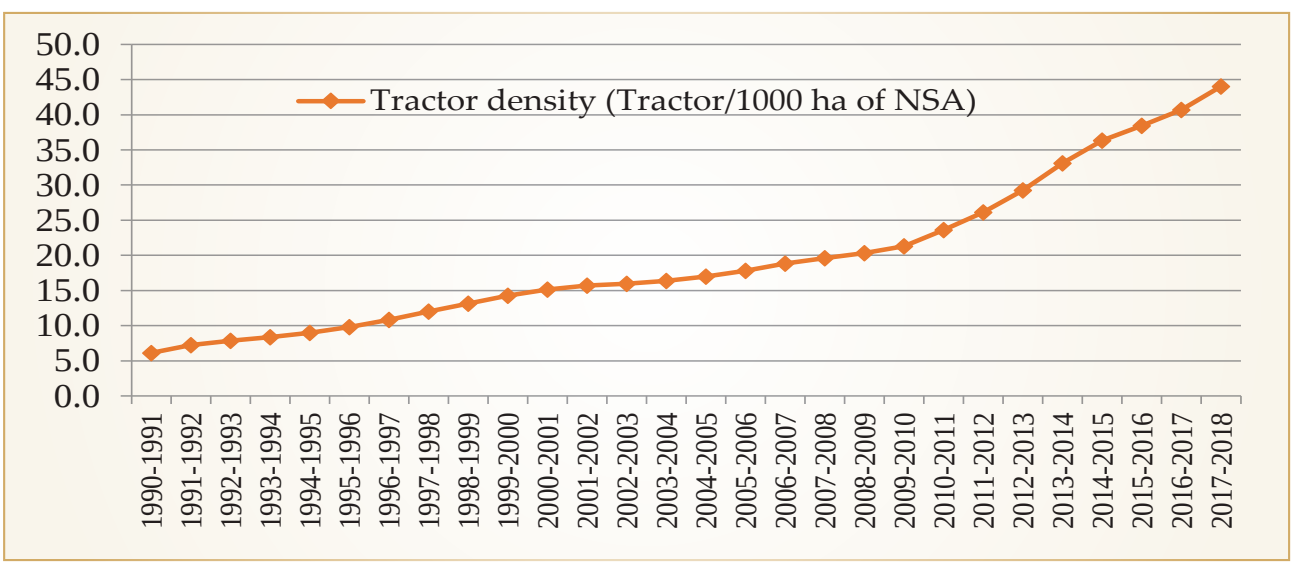


Figure 2.3. Trend in tractor density in India

Table 2.5. Estimated coefficients of log linear regression model

Variable	Coefficient	Standard error
Dependent variable: Tractor density (number/1,000 hectare)		
Explanatory variables:		
Intercept	-16.84***	5.22
Real wage rate of male agricultural labourer	0.72**	0.35
Per capita electricity consumption	-0.25	0.17
Road density	0.13	0.41
Institutional credit to agriculture	0.14***	0.05
Agriculture and allied sector GDP	1.15*	0.58
R^2	0.98	

Note: ***, ** and * indicate significance at 1 per cent, 5 per cent and 10 per cent levels respectively.

The estimated coefficients of real wage rate of male agricultural labourer and institutional credit were significant and positive indicating their direct association with farm mechanization. One per cent increase in real wages and institutional credit are expected to improve farm mechanization by 0.72 per cent and 0.14 per cent, respectively. Agricultural GDP also have a positive influence at 10 per cent level of significance. Thus, increased flow of institutional credit to the agricultural sector, increase in agricultural GDP and increase in real wage rate would accelerate the pace of farm mechanization in the country. Hence, there is need to increase inflow of institutional credit to agriculture. The influence of agricultural credit on farm mechanization may be taken as proxy of indirect effect of the government scheme "Sub-mission on agricultural mechanization", because subsidy for the purchase of farm machinery under the mission is linked with institutional credit.

Impact of Income on Nutrient Intake

Jaya Jumrani

Trends and patterns in food consumption and demand for nutrients were estimated for both rural and urban India. Between 1993-94 and 2011-12, calorie intake from most food groups had noted an increase (Figure 2.4). The increase in calorie intake from miscellaneous food products and beverages category was as high as 200 per cent in rural areas and 54 per cent in urban areas. This implies that there has been a significant

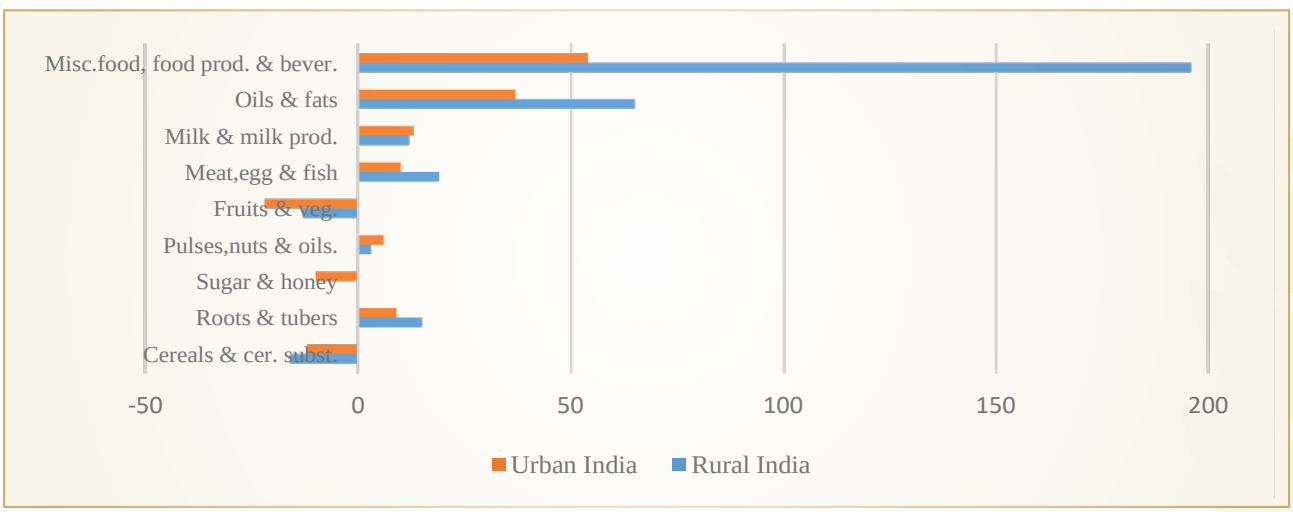


Figure 2.4. Percentage changes in caloric intakes across food groups between 1993-94 and 2011-12

increase in food consumption outside home in rural areas. Oils and fats, roots and tubers, and animal products had also showed an increase over the years and the rise was more among rural areas. Dairy products also noted a jump but it was marginally higher in urban areas. On the other hand, the share of calories sourced from cereals and cereal substitutes, and fruits and vegetables decreased during the period under consideration. This drop has been starker for rural areas in cereals, while fruits and vegetables consumption reduced more in urban India. A similar pattern was observed across all major states in rural India. The miscellaneous foods and beverages, oils and fats and roots and tubers noted an increase in their consumption across all states. Rural Madhya Pradesh had witnessed a 445 per cent increase in calories derived from miscellaneous foods and beverages, while rural Karnataka had observed a 122 per cent increase in its oils and fats consumption.

The estimates of calorie (nutrient)-income elasticities for rural and urban areas are presented in Table 2.6. The estimated elasticities were higher for rural households compared to urban counterparts for all the three macronutrients. This implies that nutritional impact of an increase in income would be higher among rural households. Further, the magnitude of elasticities have declined over time indicating diminishing role of income in enhancing nutrient intakes. The estimates were derived after controlling for potential confounders such as religion, social group, education, share of non-food expenditure, age and sex of the household head, educational status of the household head and cluster fixed effects. An increase in the share of non-food expenditure led to a decline in the nutrients intake in both rural and urban areas. Also, the presence of a female-headed household relative to a male-headed household led to a higher consumption of macronutrients across both the sectors. Better

Table 2.6. Elasticity estimates of calorie, protein and fat in 1993-94 and 2011-12

Particulars	1993-94			2011-12		
	Log of calories per capita per day (Kcal/d)	Log of protein per capita per day (gms/d)	Log of fat per capita per day (gms/d)	Log of calories per capita per day (Kcal/d)	Log of protein per capita per day (gms/d)	Log of fat per capita per day (gms/d)
Rural						
Log of real MPCE	0.622*** (0.003)	0.645*** (0.003)	1.077*** (0.004)	0.484*** (0.003)	0.534*** (0.003)	0.828*** (0.004)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.853	0.859	0.909	0.772	0.816	0.889
Observations	67145	67145	67145	57798	57862	57467
Urban						
Log of real MPCE	0.570*** (0.003)	0.561*** (0.004)	0.903*** (0.005)	0.455*** (0.003)	0.470*** (0.004)	0.680*** (0.005)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.833	0.782	0.884	0.784	0.772	0.846
Observations	44747	44777	44876	40616	40609	40499

Note: Control variables include religion, social group, share of non-food expenditure, age of household head, age and sex of household head, age squared, education of household head, dependency ratio and cluster fixed effects

Figures within parentheses are standard errors, *** p<0.01, ** p<0.05, * p<0.1

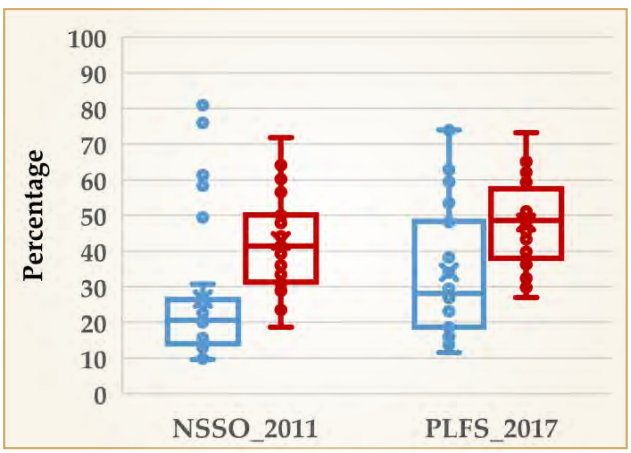
educated households had declined their caloric intakes but rather had higher fat consumption plausibly because of higher outside home-food consumption, and this was starker in urban areas.

Rural Non-Farm Sector: Trends, Structural Changes, Farm Sector Growth and Poverty Linkages

Subash S.P., Md. Ejaz Anwer, Balaji, S.J. and Prem Chand

Patterns and gender dimensions in rural non-farm sector

The recent trends and structure of rural non-farm employment in different states of India were compared using National Sample Survey Office (2011-12), Labour Bureau (2015-16) and Periodic Labour Force (2017-18) surveys. In Kerala, Manipur, Tamil Nadu, Punjab, Haryana, Assam, Meghalaya, Bihar, Mizoram, Nagaland, Arunachal Pradesh, Chhattisgarh and Telangana, there had been an increase in the share of rural non-farm employment. The share has almost doubled between 2011-12 and 2017-18 in north-eastern states. Among other states, the percentage change in the share of rural non-farm employment was higher in Bihar (58%), Chhattisgarh (47.7%) and Haryana (40.4%).



Note: Blue dot, female; red dot, male. Each dot is RNFE estimate of different states.

Figure 2.5. The share of male and female rural non-farm employment across states

In terms of gender-wise share in RNFE, comparing NSSO, EUS and PLFS survey estimates showed that there are narrowing gaps between male and female participation in workforce across states (Figure 2.5). The gap was reducing due to reduction in the share of female participation rates in few states and increase in male participation rates in other states. The gap was significantly higher among states like Haryana, Jammu and Kashmir, Jharkhand, Uttarakhand, Himachal Pradesh, Gujarat and Maharashtra. The proportion of rural non-farm employment was higher amongst male workforce and it ranged between 60 and 74 per cent in these states. In Chhattisgarh, Madhya Pradesh, Mizoram, Maharashtra, Karnataka, Gujarat, Andhra Pradesh, Meghalaya and Uttar Pradesh, the share of female workforce in rural non-farm employment were below the national average (45 %).

Table 2.7. Estimated rural non-farm employment

(Per cent, All India)

Particulars	Usual principal activity	Usual secondary activity
NSSO-EUS (2011-12)#	37.18	37.76
PLFS (2017-18)#	41.33	34.79
Before matching difference (PATT)* [2-1]	4.15	-2.97
After matching difference (SATT)**	2.32	-4.05

Note: #Estimated from unit level data employing sampling weights. * PATT-Population average treatment effect on the treated, ** SATT- Sample average treatment effect on the treated.

The study also explored comparability of RNFE estimates from NSSO-EUS (2011-12) and NSSO-PLFS (2017-18) surveys. Firstly, the surveys were compared based on methodological parameters such as type of data collected, sampling frame, sampling methodology and sample size. Secondly, Coarsened Exact Matching (CEM) technique was used in unit level data to create a comparable dataset. Individual and household characteristics such as sex, age, marital status,

education, household type, household religion and social category were used as covariates for matching. The comparison of methodological parameters showed that RNFE estimates could be compared over the period (Table 2.7). Based on the CEM results, out of the total sample, 2.15% and 2.39% of individuals were not matched in NSSO-EUS and PLFS data respectively. Comparison of the estimated values showed that the estimates though differ by extent, they are in similar in direction before and after matching.

Doubling Farmers' Income by 2022: Preparation of Strategic Framework and Estimation of Income

Raka Saxena, Suresh Pal, Naveen P Singh, Balaji SJ, Ranjit Kumar Paul, Md. Arshad Khan, Rohit Kumar, Vinita Kanwal, Kuldeep Sharma and Suman Verma

The Government brought farmers' income into the core of its deliberations and incorporated it as the fulcrum of its strategy. The major sources of growth operating within the traditional agriculture sector include (i) improvement in crop productivity, (ii) improvement in livestock productivity, (iii) resource use efficiency or saving in cost of production, (iv) increase in cropping intensity, and (v) diversification towards high value crops. Further, the following two sources of growth operate outside the traditional agriculture sector but contribute to farmers' income, (vi) improvement in real prices received by farmers, and (vii) shift from farm to non-farm occupations.

The Doubling Farmers Income (DFI) committee recommendations emphasized a lot on promoting marketing, logistics and supply chain along with price support. The DAC&FW through DFI Committee targeted to boost the agriculture segment by concentrating on an income-centered approach rather than customary approach of achieving farmers' welfare purely through augmenting the agricultural production. ICAR-NIAP, being the knowledge partner of DFI Committee providing technical facilitation in designing the framework for proposed "Ease of Doing Agriculture Index". ICAR-NIAP undertook various research studies pertaining to income estimation, income inequality, price volatility along with market and trade reforms in the country. Timely inputs were also provided to the DAC&FW on mid-term income estimation.

Income inequality and its drivers in agricultural household income in India

This study examined the overall distribution of income and inequality across the land size classes. Across all the farm size classes, income from crop is more evenly distributed and Gini index value for non-farm business income is the highest. Inequality in livestock income decreased with increase in landholding size, while inequality in the distribution of income earned from wages and salaries is positively related with farm size. It is noteworthy here that distribution of income is relatively more unequal among the farmers with more than 4 hectare land (Table 2.8).

A unit increase in the share of income from crop and livestock sources, with other factors remaining same, will decline the total income inequality among marginal farmers by around 0.076 and 0.004 units, respectively. The other two sources of income, *viz*, wages and salaries, and non-farm business have inequality-increasing effect within the given farm size class. Results indicated that increasing the income shares of crop and livestock will equalize the distribution of income and will bridge the income disparity among marginal, small and medium farmers. Strikingly, the same is not true for the farm households with more than 4 hectare holding size. The on-going development efforts in the country are congruent with this finding and thus, the DFI Committee has already targeted to enhance the share of crops and livestock in the total income of agricultural households from the 60 per cent to 70 per cent. While the small farm in India is superior in terms of production performance, it is weak in terms of generating adequate income and sustaining livelihood; nearly three-fourths of small farmers in India

Table 2.8. Decomposition of rural household's income by sources across farm size classes

Farm size classes	Income source	Proportion of total income (S_k)	Gini Index (G_k)	Correlation of Gini(R_k)	Percentage contribution to total inequality $(\frac{Rk\ Gk\ Sk}{G} * 100)$	Gini income elasticity $(\frac{Rk\ Gk}{G})$	Marginal effect
Marginal (<1 ha)	Crop	0.238	0.674	0.531	16.19	0.681	-0.076
	Livestock	0.205	0.786	0.656	20.10	0.982	-0.004
	Wage and salaries	0.453	0.731	0.791	49.80	1.10	0.045
	Non-farm	0.104	0.951	0.736	13.84	1.33	0.034
	Total income		0.526				
Small (1-2 ha)	Crop	0.500	0.521	0.744	39.23	0.785	-0.108
	Livestock	0.150	0.778	0.623	14.82	0.98	-0.003
	Wage ans salaries	0.260	0.841	0.737	33.00	1.254	0.066
	Non-farm	0.080	0.96	0.777	12.99	1.51	0.041
	Total income		0.494				
Semi-Medium (2-4 ha)	Crop	0.621	0.534	0.841	56.11	0.903	-0.060
	Livestock	0.133	0.757	0.612	12.40	0.932	-0.009
	Wage and salaries	0.167	0.869	0.656	19.16	1.146	0.025
	Non-farm	0.078	0.971	0.806	12.28	1.574	0.045
	Total income		0.497				
Medium and Large (>4 ha)	Crop	0.760	0.607	0.937	77.47	1.02	0.015
	Livestock	0.104	0.716	0.595	7.94	0.76	-0.025
	Wage and salaries	0.073	0.905	0.481	5.69	0.78	-0.016
	Non-farm	0.063	0.975	0.813	8.95	1.42	0.026
	Total income		0.558				

fall under poverty if they do not get income from non-farm sources.

Likelihood of shifting to non-farm business in "Aspirational Districts" of India

This study, based on 117 aspirational districts designated by the government of India, examined the prospects of shifting out from traditional cultivation practices to others sources of income based on situational assessment survey of National Sample Survey Office for 2012-13. Homogenous zones (broader typologies) were delineated within aspirational districts based on key agriculture related dimensions related to irrigation intensity, cropping intensity, rural literacy, credit availability and rainfall distribution using K means clustering technique. Various attributes govern the household choice for shifting away from traditional cultivation to various allied and other non-farm occupations. Multi-logistic regression model was used to study the probability of farm households getting income primarily from non-farm sources. The multi choice model was found to be suitable for this objective.

Table 2.9 provides the determinants of probabilities that a farmer will choose non-farm business enterprises over traditional cultivation the selected typologies. Shifting away from traditional cultivation practices to non-farm business enterprises was significant and positively related to the *pucca* home structure that household possess and was negatively influenced by the land possessed by the households. This directs that households with large farm size are less likely to diversify the livelihood strategies and depend largely on crop production. On the

Table 2.9. Probability of shifting from cultivation to non-farm business

Variable	Typology 1		Typology 2	
	Coefficient	Marginal Effects	Coefficient	Marginal Effects
Type of dwelling structure	0.5218* (0.211)	0.023	1.1846* (0.581)	0.001
Land owned	-0.6661* (0.153)	-0.021	-3.2117* (0.688)	-0.001
Land owned square	0.0314* (0.010)	0.001	0.1999 (0.149)	8.26E-05
MGNREGA job card	-0.1611 (0.205)	-0.009	-1.4349* (0.563)	-0.001
Ration card	-0.1382 (0.262)	-0.007	-1.0171*** (0.620)	-0.001
Sex	1.2078*** (0.730)	0.042	15.5017 (1833)	0.001
Age	0.0052 (0.053)	0.001	0.2286 (0.186)	9.93E-05
Age square	-0.0003 (0.001)	-1.48E-05	-0.0022 (0.002)	-9.43E-07
Education of household head	0.0077 (0.209)	0.002	0.8094 (0.621)	3.77E-04
Training in agriculture	-0.5699 (0.603)	-0.017	-14.6139 (2699)	-0.001
Household size	0.0357 (0.037)	0.001	0.2205 (0.145)	9.20E-05
Religion	-0.6666* (0.207)	-0.036	16.1162 (4844)	0.001
Schedule category	0.2852 (0.292)	0.012	-0.7311 (0.989)	-4.31E-04
OBC	0.3699 (0.244)	0.018	0.9819 (0.904)	-2.49E-04
Constant	-2.7696 (1.436)		-38.5693 (5179)	
LR chi^2	580.28		477.37	
Pseudo R^2	0.14		0.34	
Number of observations	**2,215**		**944**	

Note: *, ** and *** indicate the significance level at 1, 5 and 10 per cent level, respectively. Figures in parentheses indicate the standard errors.

other hand, lower farm size would encourage the farm households to diversify their income sources. The reason is palpable as the small land holding does not enable the farmers to produce sufficient marketable surplus and may shift them towards the non-farm activities to supplement the farm incomes from crops. In typology 1, male headed households were likely to shift from traditional cultivation to non-farm business activities for earning as evident from the significant and positive coefficient of this variable. Additionally, Hindus in comparison to other religious groups were more reluctant in adoption of non-farm business activities. In typology 2, possessing ration card and MGNREGA job card were negatively related with diversifying from cultivation, hence, a household getting subsidised ration as well as assured labour employment was less likely to undertake non-farm business enterprises.

Trajectory of livestock performance in India

An exhaustive review was undertaken to understand the growth trajectory along with key dimensions related to livestock marketing, trade, animal health services, feeding pattern along with the impact of climate. Growing importance of livestock towards enhancing food and nutritional security, increasing agricultural growth, reducing rural poverty and mitigating farm households' vulnerability to shocks in along with providing employment and empowerment opportunities to females is widely acknowledged and acclaimed in numerous studies.

The evidences suggested a clear shift towards fruits and vegetables, livestock products and fisheries (Figure 2.6). The trends in livestock output are given in Table 2.10. Increase in relative prices of cereals vis-à-vis other food commodities, diversification towards high-value food and changes in taste and preferences are responsible factors for a rapid rise in the demand for livestock products in India. Liquid milk consumption in India has considerably increased over last two decades from 1993-94 to 2009-10, the per capita consumption of liquid milk increased by 18.9 per cent in rural areas and 65.1 per cent in urban areas. Consumption of egg, fish and chicken in both rural as well as urban India showed significant increase. The studies have reported that majority of the small farmers in dairy value chains in India still resort to borrowings from the informal sources, viz. moneylenders, traders and input dealers, who often charge high rates of interest.

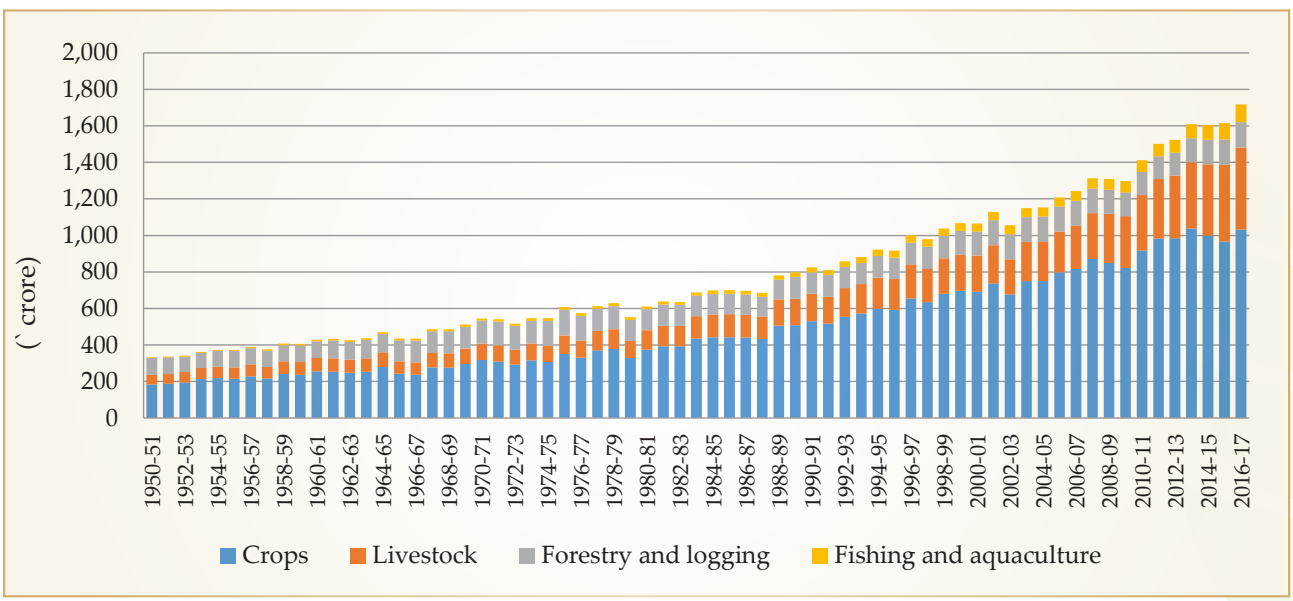


Figure 2.6. Sub-sector wise trend in gross value added of 2011-12 prices (₹ crore)

Table 2.10. Trends in livestock output

Particulars	Production			Growth rates (%)	
	2001-02	2010-11	2016-17	2001/02-2010/11	2010/11-2016-17
Milk (million tonnes)					
Cattle	34.51	54.90	77.41	4.75	5.03
Buffalo	45.40	62.35	80.38	3.22	3.70
Goat	3.50	4.59	5.62	2.75	2.93
Meat (thousand tonnes)					
Cattle	341	211	329	-4.68	6.57
Buffalo	414	805	1611	6.88	10.42
Goat	401	846	943	7.75	1.56
Sheep	192	369	486	6.75	4.00
Pig	140	402	388	11.15	-0.52
Poultry	364	2193	3264	19.67	5.84

Source: National Account Statistics, Livestock Census and DAHD Annual Report (Various issues)

A modernization perspective is required for the sector for technological innovations and help to overcome the challenges associated with shifting production, consumption and changing climate. The future growth in livestock sector needs to be focused on productivity and efficiency. Newer science tools will enhance animal productivity and make the sector a more profitable occupation. The country needs to focus on the niche items for exports and niche destinations along with addressing the safety issues. Gradual stress induced by global warming and climate change is also influencing fertility and productivity of livestock, the potentiality of science and livestock research should be harnessed by validating and transferring the technologies for enhancing animal productivity, improved value addition and improving competitiveness.

Efficient and effective extension services, sufficient feed and fodder, effective animal health services, incentives for shift from subsistence livestock to livestock entrepreneurship along with efficient chains for livestock marketing and trade are required. The other interventions required are more intense private or public private partnerships, effective use of different subsystems by adopting a farming research systems approach to suite low external-input production systems and more adaptive research. Efficient policy support and infrastructure through effective collaborations between different agencies involved in livestock development are required. Adequate policy support for all livestock species with regional livestock development priorities, and building capacities of livestock extension functionaries to handle the emerging challenges will provide ample impetus for the development of the Indian livestock sector.

Theme – II
TECHNOLOGY AND SUSTAINABLE AGRICULTURE

EXCERPTS

- The long-term impact of climate change on crop yields would be more severe under RCP 8.5 than that in RCP 4.5 scenario.
- Farmers with marginal landholdings are more vulnerable to climate shock owing to their lesser capacity to make suitable agriculture and livelihood diversifications.
- Agriculture is moderately sustainable in food bowl of the country. District-specific strategies are required to improve the eroded sustainability in the region.
- The cropping pattern in Bundelkhand region needs to be diverted from cereals towards pulses and oilseeds along with increasing number of local cattle and small ruminants for sustainable agriculture in the region. Inadequate infrastructural support for agriculture is one of the most limiting factors in the region.
- The Turbo Happy Seeder technique produced higher output energy per unit of input energy consumed as compared to conventional and zero tillage technique.
- Direct Seeded Rice is water saving, labour saving and less costly technology, however, non-availability of machines and higher weed infestation are the major impediments in its adoption.
- Amendment of patent law 2005 had a positive impact on patenting of agricultural technologies in India. The interaction of business model and regulatory policies results in anti-competitiveness in the Bt cotton industry.
- The Indo Gangetic Plains (IGP) exhibits wide spatial variation in groundwater level. Even in eastern IGP where level of groundwater development is low and rainfall is high, large number of wells are witnessing depletion in groundwater level, though at a the slow rate.
- Use of sprinkler irrigation contributes towards improving crop yield translating into income gains.
- Groundwater availability, labour availability, pumpset intensity, electricity use in agriculture, and subsidy are more critical for predicting the extent of adoption of micro irrigation in the arid region.
- Faulty scheduling of water release, encroachment of water channels, delay in de-siltation of channels, and inadequate water supply are the major impediments in surface irrigation in eastern Yamuna canal command area.
- Public institutions are important source of knowledge to other extension advisory service providers, therefore, literature and recommendations of these institutions need to be abreast with emerging problems and changing realities in Indian agriculture.

Strategic Research Component of National Innovations on Climate Resilient Agriculture

Naveen P Singh, Bhawna Anand and Surendra Singh

Impact of climate change on Indian agriculture: An agro-climatic zone level estimation

A considerable uncertainty exists over the likely impact of climate change on crop yields for homologous regions. Attempts to when made develop estimates of link between crop yield and climate variables and to project the likely yield changes under RCPs 4.5 and 8.5 climate change scenarios for three time periods (2030s, 2050s and 2080s) across Agro-Climatic Zones (ACZ) of India. While examining change in climate parameters during the period 1966-2011, a significant rise was observed in both the annual mean maximum and minimum temperature across ACZs. Rainfall recorded an annual decline in Himalayan Regions and Gangetic Plains while increased in Coastal Regions, Plateau & Hills and Western Dry Region. The future projection on crop yields were more pronounced for RCP 8.5 than 4.5.

Projected impact of climate change on kharif crop yields

Under RCP 4.5: Rice yield will decline by 5.49 and 6.79 per cent in Eastern Himalayan Region by 2050s and 2080s (Table 2.11). In near-term it is likely to reduce by 2.94 and 3.56 per cent in Western and Eastern Himalayan Region. By 2080s maize yield is likely to increase by around 7 to 8 per cent in Western Himalayan Region and Lower Gangetic Plains. Yield loss in groundnut is expected to be around 5 per cent by 2050s in Gujarat Plains & Hills. In the mid and long term periods, sorghum yield is likely to increase by around 8 and 11 per cent in Western Plateau & Hills and decrease by the same magnitude in Central Plateau & Hills respectively. Sugarcane yield is projected to decline by 11 and 13 per cent in Middle Gangetic Plains and East Coast Plains & Hills by 2030s. Pearl millet yield is likely to increase by 15.58 per cent by mid-term period in Trans-Gangetic Plains.

Under RCP 8.5: By the end of the century, maize yield is projected to increase by 12 per cent in Western Himalayan Region and Lower Gangetic Plains. Under mid-term period the yield will lower by 3.33 and 2.51 per cent in Central Plateau & Hills and Western Dry Region. In Western and Eastern Himalayan Region, rice yield is likely to reduce by 5.52 and 6.72 per cent by 2050s, respectively. The yield loss in case of Pearl millet by 2080s is expected to be around 7 and 3 per cent in Gujarat Plains & Hills Western Dry Region. By 2050s, finger millet yield will increase by 2.64 per cent in West Coast Plains & Ghats. By the end of the century, sorghum yield is projected to decline up to 19 per cent in Central Plateau & Hills, while, for the similar period it will increase by about 18 per cent in Western Plateau & Hills. In Middle Gangetic Plains and East Coast Plains & Hills, sugarcane yield is expected to decline by 21.17 and 24.79 per cent under mid-term period, respectively. The productivity of groundnut is projected to decline by 9.11 and 6.62 per cent in Gujarat Plains & Hills and Southern Plateau & Hills by 2080s, respectively.

Projected impact of climate change on rabi crop yields

Under RCP 4.5: Climate projections for *rabi* crops indicated that wheat yield will reduce by 5.84 and 7.17 per cent by 2050s and 2080s in Western Dry Region (Table 2.12). For the similar periods it will reduce by 3.98 and 4.93 per cent in Eastern Himalayan Region and 2.57 and 3.11 per cent in Trans-Gangetic Plains. In Gujarat Plains & Hills, wheat is likely to increase by 3.20 per cent by 2050s. Rapeseed and mustard are projected to increase up to 9.10, 7.10 and 6.75, per cent by 2080s in East Coast Plains & Hills, Central Plateau & Hills and Western Dry Region respectively. By 2050s barley will reduce by 1.25 in Western Himalayan Region and 0.4 per cent in Trans-Gangetic Plains.

Table 2.11. Regionally aggregated climate change impacts and projections for *kharif* crop yields under RCPs 4.5 and 8.5

Per cent

Agro-climatic Zone	Crops	Marginal Effects	RCP 4.5			RCP 8.5		
			2030s	2050s	2080s	2030s	2050s	2080s
			Δ MinT= 1.36	Δ MinT= 2.14	Δ MinT= 2.63	Δ MinT= 1.50	Δ MinT= 2.6	Δ MinT= 4.43
			Δ MaxT= 1.26	Δ MaxT= 1.81	Δ MaxT= 2.29	Δ MaxT= 1.36	Δ MaxT= 2.3	Δ MaxT= 3.94
			Δ R= (+/-) 5%	Δ R= (+/-) 10	Δ R= (+/-) 12%	Δ R= (+/-) 5%	Δ R= (+/-) 10	Δ R= (+/-) 12%
Western Himalayan Region	Rice	-2.34	-2.94	-4.41	-5.49	-4.02	-5.52	-9.59
	Maize	3.29	4.17	5.97	7.57	4.49	7.59	12.95
Eastern Himalayan Region	Rice	-2.62	-3.56	-5.49	-6.79	-3.89	-6.72	-11.39
	Maize	1.33	1.83	2.97	3.61	2.04	3.56	6.10
Lower Gangetic Plains	Rice	-1.17	-1.60	-2.34	-2.96	-1.71	-2.92	-4.87
	Maize	2.83	3.99	6.29	7.74	4.37	7.60	12.78
Middle Gangetic Plains	Rice	-0.17	-0.26	-0.41	-0.51	-0.28	-0.49	-0.80
	Maize	0.19	0.45	0.79	0.96	0.48	0.87	1.30
	Sugarcane	-8.02	-11.15	-17.43	-21.50	-12.21	-21.17	-35.70
Upper Gangetic Plains	Rice	-0.07	-0.16	-0.27	-0.33	-0.17	-0.30	-0.45
	Sugarcane	-0.13	-0.77	-1.57	-1.85	-0.82	-1.60	-2.18
	Maize	-0.03	0.12	0.27	0.32	0.12	0.25	0.27
	Sorghum	-0.68	-0.88	-1.36	-1.67	-0.97	-1.67	-2.91
Trans-Gangetic Plains	Rice	-0.37	-0.40	-0.54	-0.69	-0.44	-0.72	-1.30
	Cotton	-0.59	-0.86	-1.50	-1.78	-0.98	-1.74	-2.99
	Pearl millet	2.09	8.43	15.58	18.90	8.63	16.49	22.03
	Maize	-0.65	-0.90	-1.53	-1.83	-1.03	-1.81	-3.14
Eastern Plateau & Hills	Rice	-0.67	-1.08	-1.71	-2.12	-1.16	-2.03	-3.27
	Maize	0.28	0.30	0.30	0.43	0.29	0.46	0.78
Central Plateau & Hills	Sorghum	-4.54	-5.71	-8.76	-10.80	-6.35	-10.87	-19.08
	Maize	-1.33	-1.75	-2.72	-3.35	-1.93	-3.33	-5.73
	Groundnut	0.55	0.95	1.59	1.94	1.03	1.84	2.95
Western Plateau & Hills	Sorghum	4.68	6.15	8.56	11.01	6.47	10.93	18.13
	Cotton	-1.74	-2.24	-3.36	-4.19	-2.45	-4.19	-7.18
	Sugarcane	-3.66	-4.39	-6.17	-7.84	-4.75	-7.97	-13.87
Southern Plateau & Hills	Rice	-0.72	-1.06	-1.65	-2.05	-1.14	-1.99	-3.27
	Groundnut	-1.56	-1.96	-3.06	-3.75	-2.19	-3.77	-6.62
East Coast Plains & Hills	Rice	-0.37	-0.57	-0.93	-1.13	-0.62	-1.09	-1.79
	Groundnut	-0.49	-0.52	-0.74	-0.93	-0.58	-0.97	-1.79
	Sugarcane	-9.91	-12.94	-20.26	-24.87	-14.37	-24.79	-42.87
West Coast Plains & Ghats	Rice	0.01	0.07	0.14	0.16	0.07	0.14	0.21
	Groundnut	-1.51	-1.82	-2.75	-3.39	-2.02	-3.44	-6.10
	Finger millet	1.10	1.38	2.14	2.63	1.54	2.64	4.63
Gujarat Plains & Hills	Pearl Millet	-1.23	-2.00	-4.17	-4.70	-2.45	-4.54	-7.95
	Cotton	0.02	-0.30	-1.06	-1.08	-0.44	-0.95	-1.58
	Groundnut	-1.26	-2.31	-4.97	-5.58	-2.82	-5.31	-9.11
Western Dry Region	Pearl millet	-0.84	-0.82	-1.17	-1.45	-0.95	-1.56	-3.01
	Maize	-1.03	-1.32	-2.03	-2.50	-1.46	-2.51	-4.37

Note: Direction of rainfall for the future projections was premised on trend analysis for the period, 2001-2011.

Table 2.12. Regionally aggregated climate change impacts and projections for *rabi* crop yields under RCPs 4.5 and 8.5

per cent

Agro-climatic Zone	Crops	Marginal Effects	RCP 4.5			RCP 8.5		
			2030s	2050s	2080s	2030s	2050s	2080s
Western Himalayan Region	Wheat	-0.47	-0.66	-1.05	-1.29	-0.73	-1.27	-2.14
	Barley	-0.76	-0.91	-1.25	-1.60	-0.98	-1.63	-2.81
Eastern Himalayan Region	Wheat	-2.03	-2.61	-3.98	-4.93	-2.87	-4.93	-8.49
	Rapeseed and mustard	-1.08	-1.44	-2.16	-2.70	-1.56	-2.68	-4.53
Lower Gangetic Plains	Wheat	-0.96	-1.04	-1.45	-1.83	-1.14	-1.90	-3.43
	Rapeseed and mustard	-1.21	-1.67	-2.46	-3.10	-1.79	-3.06	-5.12
Middle Gangetic Plains	Wheat	-0.28	-0.37	-0.56	-0.69	-0.40	-0.69	-1.18
	Rapeseed and mustard	1.04	1.26	1.90	2.36	1.39	2.38	4.15
	Barley	0.04	0.05	0.10	0.12	0.06	0.12	0.22
Upper Gangetic Plains	Wheat	-0.09	-0.11	-0.17	-0.21	-0.12	-0.21	-0.37
	Barley	0.01	0.03	0.06	0.08	0.03	0.06	0.08
	Rapeseed and mustard	0.20	0.29	0.46	0.57	0.32	0.56	0.91
Trans-Gangetic Plains	Wheat	-1.02	-1.53	-2.57	-3.11	-1.70	-3.01	-5.02
	Barley	-0.26	-0.30	-0.40	-0.52	-0.32	-0.54	-0.95
	Rapeseed and mustard	1.59	2.32	3.89	4.70	2.59	4.58	7.71
Eastern Plateau & Hills	Wheat	-0.26	-0.30	-0.48	-0.58	-0.34	-0.59	-1.07
	Linseed	-0.87	-1.23	-2.00	-2.43	-1.36	-2.39	-4.04
Central Plateau & Hills	Wheat	-0.94	-1.31	-2.07	-2.54	-1.44	-2.50	-4.22
	Rapeseed and mustard	2.73	3.69	5.76	7.10	4.06	7.03	11.97
Western Plateau & Hills	Wheat	-0.88	-1.12	-1.62	-2.05	-1.21	-2.05	-3.49
	Rapeseed and mustard	-1.86	-2.05	-2.45	-3.29	-2.13	-3.44	-6.01
Southern Plateau & Hills	Wheat	-1.27	-1.73	-2.62	-3.27	-1.88	-3.23	-5.44
	Linseed	-1.35	-1.72	-2.51	-3.16	-1.86	-3.16	-4.88
East Coast Plains & Hills	Wheat	-1.46	-2.01	-3.19	-3.92	-2.22	-3.86	-6.56
	Rapeseed and mustard	3.45	4.71	7.41	9.10	5.19	8.99	15.31
West Coast Plains & Ghats	Wheat	0.33	0.48	0.77	0.95	0.54	0.92	1.54
	Rapeseed and mustard	2.45	3.37	6.34	6.53	3.71	7.47	10.91
Gujarat Plains & Hills	Wheat	0.44	1.29	3.20	3.49	1.62	3.20	5.29
	Rapeseed and mustard	0.31	0.86	2.13	2.32	1.09	2.14	3.56
Western Dry Region	Wheat	-2.73	-3.71	-5.84	-7.17	-4.09	-7.03	-12.05
	Rapeseed and mustard	2.57	3.50	5.50	6.75	3.86	6.69	11.42

Source: Authors estimation based on ICRISAT-VDSA and India Meteorological Department (IMD) Databases

Note: Direction of rainfall for the future projections was premised on trend analysis for the period, 2001-2011.

Under RCP 8.5: By 2080s, wheat yield is projected to decline by 12.05, 8.49 and 6.56 per cent in Western Dry Region, Eastern Himalayan Region and East Coast Plains & Hills, respectively. In Trans-Gangetic Plains wheat yield will be lower by 3.01 per cent under the mid-term period. Barley was not found much impacted to climate change, as yield loss were projected to be 0.54 and 1.63 per cent by 2050s, in Trans-Gangetic Plains and Western Himalayan Region. For the long-term period, the rapeseed and mustard yield is expected to increase by around 11-12 per cent in Central Plateau & Hills, West Coast Plains & Ghats and Western Dry Region. In Eastern Plateau & Hills and Southern Plateau & Hills, Linseed yield is expected to decline by 2.39 and 3.16 per cent by 2050s.

The relative impacts of climate change and the associated vulnerability vary between ACZs, hence comprehensive crop and region-specific adaptation measures should be emphasized to help enhancing resilience of agricultural system in short to medium term.

Socio-economic factors affecting climate vulnerability and technology adoption

Climate change and extreme weather fluctuations are the most threatening challenges to the farming communities especially in semi-arid tropics. Socio-economic factors affecting vulnerability and adoption of innovations using micro-level survey data of 100 systematically selected farmers in the Jodhpur district of Rajasthan who investigated. In assessing the determinants of climate vulnerability, the coefficients for income, irrigation, obtaining seeds from institutional sources and adoption of wide row spacing were negative and statistically significant. Farmers with marginal landholdings were more vulnerable to climate shock owing to their lesser capacity to make suitable agriculture and livelihood diversifications. The grass-roots enquiry revealed that farmers were adopting several mechanisms to mitigate the harmful effects of climate variations (Figure 2.7). About 33 per cent of the farmers were making appropriate changes in their cropping pattern; 25 per cent were adopting groundwater recharge techniques and soil conservation methods; 81 per cent were reducing the number of irrigation sessions. Further, more than 50 per cent were adopting micro-irrigation technology, conserving water through conventional methods and construction of watershed structures. On the contrary, a substantial proportion of the respondents were digging new bore wells and further deepening the existing ones to extract groundwater. Migration (seasonal or permanent) was emerging as a significant strategy against increasing climate uncertainty and dwindling farm profitability.

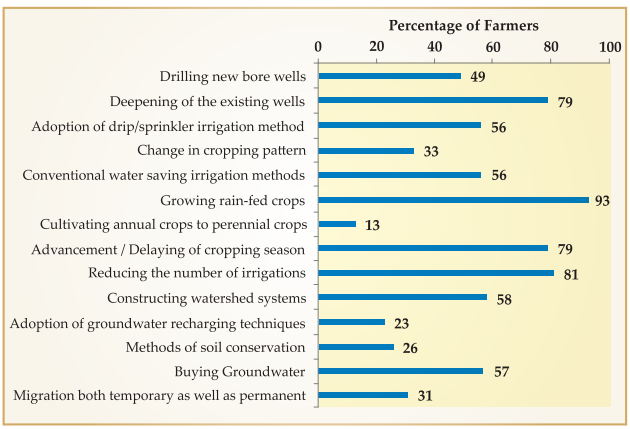


Figure 2.7. Adaptation strategies adopted by surveyed farmers

The estimates of the factors influencing farmer's decisions to adopt wide row spacing technique for pearl millet crop are given in Table 2.13. The probability of adopting technology was lower for illiterate farmers, as compared to educated farmers, who are better equipped to understand the social costs and benefits of the prescribed technologies and also the influence of changing weather and market conditions. Better access to irrigation facilities positively influenced farmer's technology adoption decision. Farmers with information on changing climatic conditions were 3.41 times and those skilled with training programs were 4.24 times more likely to choose innovation. Further, provision of institutional seeds significantly influence farmers' decision towards adoption of wide row spacing technology against climatic changes.

Table 2.13. Determinants of wide row spacing technology in pearl millet cropping system

Explanatory Variables	Coefficient	Odds ratio
Education (Illiterates= 1, otherwise= 0)	-0.0457*	1.25
Land size (Marginal= 1, otherwise= 0)	-0.0954*	0.21
Social group (Scheduled caste and scheduled tribe= 1, otherwise= 0)	-0.5470*	0.28
Infrastructure (Warehouse= 1, otherwise= 0)	0.0421*	3.21
Irrigation (continuous)	0.8095*	2.23
Seeds (Institutional source= 1, otherwise= 0)	0.4516*	4.21
Awareness of climate change (Yes= 1, otherwise= 0)	0.0457*	3.41
Agricultural training (Yes= 1, otherwise= 0)	0.4721*	4.24
Agriculture insurance (Yes= 1, otherwise= 0)	0.2415*	3.25
Improved and hybrid seed varieties (Yes= 1, otherwise= 0)	0.4571*	2.32
Constant	0.2764*	0.25

Note: * Significant at 1% level

The diversified crop sequence involving pearl millet-wheat-cluster bean-barley-onion, farmers' adoption of suitable adaptation strategies and climate resilient technologies will improve with better awareness, education and farm governance with regard to climate change. Moreover, technologies suitable to the local contextual needs must be developed and disseminated for reducing climate-induced vulnerability.

Impact of Climatic Hazards on Agricultural Growth in India

PS Birthal, J Hazrana, DS Negi

Using a panel of state-level data for 1970-2018 this study assessed the impacts of climatic hazards viz., droughts, floods, heat-waves and cold-waves on agricultural growth in India, and evaluated the effectiveness of some important adaptation measures such as irrigation, changes in input-use and diversification into low-risk crops and livestock in managing their adverse growth effects. The findings reveal and that climatic hazards negatively impact agricultural growth, but the impact of different climatic hazards was different. Droughts and heat-waves have a larger negative impact on agricultural growth compared to other climatic hazards. The negative effects were more pronounced in the low-income and pre-dominantly agrarian states. Nonetheless, the negative growth effects tend to dissipate over time. The findings further demonstrated that it is possible to reduce the negative growth effects of climatic hazards through the adaptation measures, such as irrigation, diversification of agriculture towards low-risk crops and livestocks and manipulations in fertilizer-use. Irrigation and crop diversification were more effective against droughts and heat-waves, but their effectiveness declines considerably when these occur more frequently. Livestock and fertilizer-use although provided comparatively less adaptation benefits, these were more effective in rising frequency of climatic hazards.

A Multilevel Analysis of Drought Risk in Indian Agriculture

PS Birthal, J Hazrana and DS Negi

Drought is an important downside risk in Indian agriculture; and the spatial differences in its intensity and probability of occurrence are considerable. Enhancing the resilience of smallholder farming systems is a big challenge as it requires significant and sustained technical, financial, institutional and policy support, and actions at different geographical or administrative levels. To develop strategies to manage the risk of drought, and to coordinate and implement these strategies, it is essential to

understand the variation in drought risk across geographical or administrative levels.

Using a multilevel modeling approach, the study decomposes the variation in drought risk across states, regions, districts, villages and households, and finds it disproportionately distributed (Figure 2.8). About half the variation is attributed to between-individual (i.e., household) differences and the rest to between-population differences, mainly to states and villages. These findings suggested the potential for a critical role of states (policies) and local institutions (communities) in enhancing resilience of agriculture to droughts through the correct targeting of policies and support for the most appropriate geographic level. At lower levels, the focus should be on creating resilience at the village or community level in terms of building local institutions that serve as a link between the lower level (household) and higher levels for various purposes.

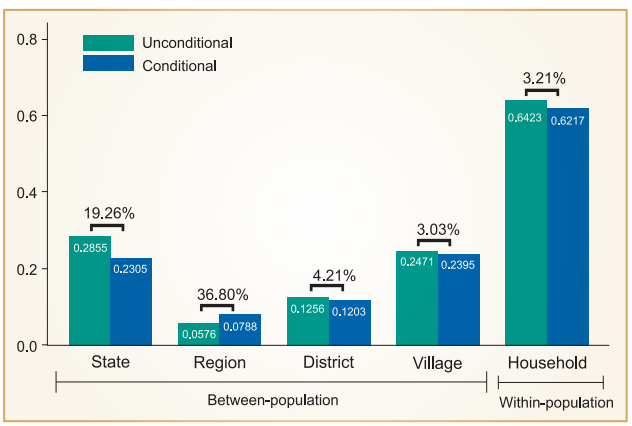


Figure 2.8. Per cent of the total variation in drought risk attributed to different geographical levels

Developing Composite Agricultural Sustainability Index

Suresh Pal, Chhabilendra Roul, SK Chadhari, Prem Chand, Kalu Naik, M S Raman, Gaurav Karad and Bhoopendra Raghav

Issues of sustainable agricultural development have been widely discussed, but only limited empirical work is available on operationalisation of the concept of sustainability in agriculture. A framework for assessing the sustainability of agriculture using composite indicators were developed. The methodology includes calculating 79 sustainability indicators covering six components of the concept (soil, water, agro-biodiversity, environment, economic and social) finalised after intensive literature search and series of stakeholders consultations. These indicators were subsequently aggregated into four different types of indices, namely, Soil Health Index, Agricultural-Water Sustainability Index, Ecological Security Index and Socio-Economic Sustainability Index. Two different methods viz. min-max and benchmark were used to normalize the indicators. The purpose of min-max normalization was to assess the relative sustainability, while that of benchmark normalization was to measure the absolute sustainability status. Finally, all the four indices were aggregated into Composite Agricultural Sustainability Index (CASI) by assigning weights to all the indicators and component indices. Three different weighting methods-equal weights, weights based on experts' opinion and statistical weights calculated using Principal Component Analysis, were used.

The index was applied to assess the sustainability of agriculture across districts of Punjab and Haryana. The findings indicated that the agriculture is moderately sustainable in both the states with the index values of around 0.5 on the scale of 0 to 1, where zero indicates least sustainability. The state average scores of absolute sustainability were significantly higher than the relative sustainability scores. The CASI could be an effective policy tool and an element to support governance in agriculture. For example, western districts of Haryana, particularly Bhiwani, Sirsa, Mahendragarh, Rewari and Jind were less sustainable as compared to eastern districts largely because of weak socio-economic and water dimensions of sustainability and therefore, the policy focus should be on improving the weak-linked aspects in these districts. Contrary to this, eastern districts of Ambala and Panchkula though performed better in terms of overall sustainability need attention in improving agro-

biodiversity aspect. Such information could help to improve current agricultural policies, with the aim of improving the sustainability of the sector in the region.

Resource Use Planning for Sustainable Agriculture

Prem Chand, Rajni Jain, Suresh Pal, Priyanka Agarwal, Sulakshana Rao

Multi-objective optimization for sustainable agriculture in Bundelkhand

Considering current resource constraints, particularly water in Bundelkhand region, the study obtained a sustainable cropping pattern and crop-livestock mix. The input-output coefficients were estimated using unit-level data of cost of cultivation scheme for the TE 2014, while the level of resource availability was estimated using secondary data. Goal programming model was developed to maximize net returns and minimize water use with set of physical, economic and environmental constraints. Five different scenarios were built by simulating various resource saving technologies and policy interventions. The conceptual model is presented in Figure 2.9.

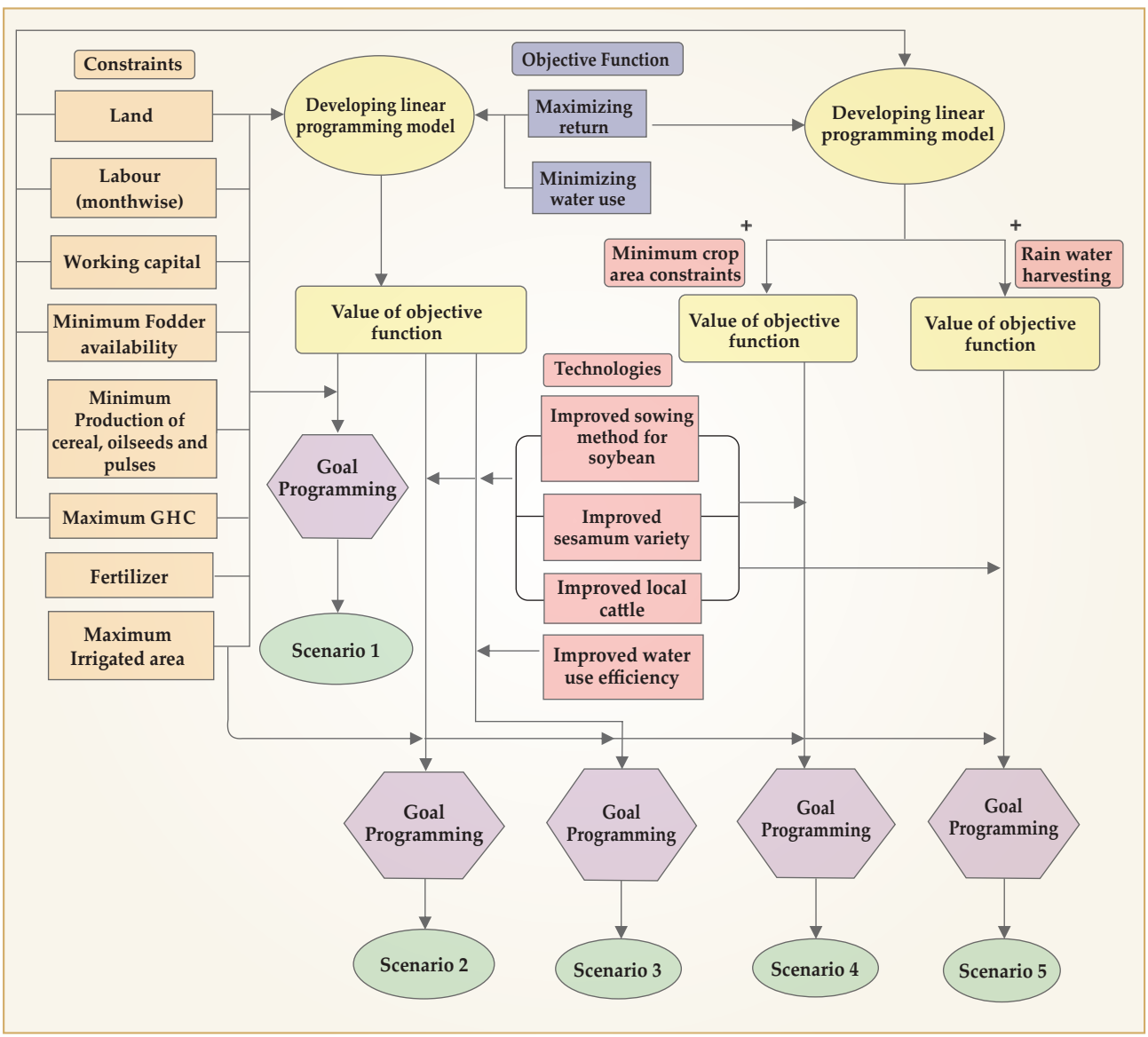


Figure 2.9. Diagrammatic representation of conceptual framework for developing goal programming model

The evidences suggested that currently the resources in the Bundelkhand region are used sub-optimally. In the scenario of optimum use of existing resources, returns increased by 42 per cent to 61 per cent and water use was reduced by 6.37 to 16 per cent. Farm credit was one of the most limiting constraints in the region. The optimum plan (scenario-1) suggested for utilizing *kharif* fallow in the region and allocated more area under pigeon pea, sorghum, soybean and vegetables, while reducing the area under water guzzling crops such as paddy and sugarcane (Figure 2.10). The employment increased by 47 per cent under this scenario. Scenario 2 simulated the effect of improved technologies like methods of sowing (raised bed in soybean), crop variety (sesame) and improved breed of local cattle. This scenario requires an additional investment of ₹ 8 billion and suggested diverting the area from conventional practices to resource saving technologies under these crops. This scenario also ensured self-sufficiency of pulses and oilseeds in the region as the area under these crops increased by 31 per cent and 28 per cent, respectively. However, the cereal production is reduced by 16 per cent than the existing level.

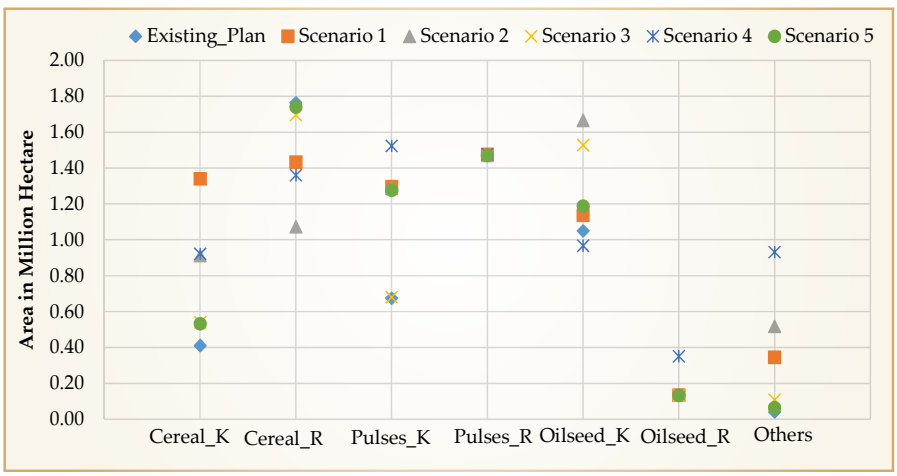


Figure 2.10. Area under crop categories in different scenarios

The sensitivity analysis of sprinkler and drip irrigation in pea, tomatoes, chillies, maize and wheat under the Scenario 3 saved the irrigation water by 26 per cent and increased the production of oilseeds by 58 per cent without affecting existing pulse and cereal production. The subsequent two scenarios were developed with single objective of maximizing net returns subjected to set of constrains. In Scenario 4, upper bound of available water was set whereas in Scenario 5 the water availability was increased by 6.7 per cent as potential rainwater harvest. A comparison of net returns obtained revealed that with an initial investment of ₹ 88 per m^3 of water harvested, the net returns could be enhanced by 16 per cent. All of the five scenarios are suggested to divert area from the conventional rice-wheat cropping system towards pulses and oilseeds. Increasing the number of local cattle and small ruminants, particularly goats was also suggested in all plans.

Agricultural infrastructural adequacy across districts of Bundelkhand

Adequacy of agricultural infrastructure like markets, roads, irrigation, extension services, credit facilities, storage etc, the facilitates lowering the farming costs and increase in farm income. The study measured adequacy status of rural infrastructure and categorised it into highly suitable, moderately suitable, marginally suitable or not suitable category for Bundelkhand. Five parameters namely road density, market concentration, extension system score, and credit institutions availability score in Bundelkhand region were used to estimate the corresponding infrastructural suitability. The four categories of infrastructural suitability and the corresponding range for irrigation score, road score, extension score and credit score are given in Table 2.14..

Considering each of the five dimensions as an essential requirement for boosting agriculture,

Table 2.14. Criteria developed for assigning suitability classes to irrigation, road, extension and credit scores

Category	Irrigation score (I)	Road score (S)	Extension score (E)	Credit score (L)	Infrastructural class
>mean plus standard deviation	8.2	5.48	8.30	5.73	S1
Mean to mean plus standard deviation	8.2 - 4.9	4.53-5.48	8.30 - 6.51	5.73 - 4.00	S2
Mean minus standard deviation to mean	4.9 - 1.7	3.58-4.53	6.51 - 4.72	4.00 - 2.28	S3
< Mean minus standard deviation	1.7	3.58	4.72	2.28	N

the study revealed that there is not a single district, which is adequate enough in all five dimensions even at the level of moderately suitable category (Figure 2.11). Analysis revealed that infrastructure is relatively better in northern and western parts of Bundelkhand as compared to southern districts. The topography is one of the major reason of difference in infrastructure facilities. The mean slope of the entire region is towards north and northeast making these districts suitable for irrigation. The region has poor literacy rate therefore, face to face interaction and demonstrations would be much effective rather than distance learning techniques requiring more number of extension institutions, specially strengthening of grass root extension system. The ICT based extension system need to be customised as per the requirement of the region such as dissemination of scientific methods and improved technologies using audios and videos. District Jaulan, Damoh and Hamirpur require improvement in road and extension; Banda and Lalitpur in markets and extension; and Panna in irrigation and extension. Almost 25 per cent districts of Bundelkhand are under marginal or not suitable category in three aspects of socio-economic infrastructure. Among these, Chattarpur and Mahoba require improvement in irrigation status, credit access as well as extension system, while Chirakoot needs significant improvement in irrigation, market and credit access. Tikamgarh and Sagar are under moderate category of irrigation availability but inadequate in all other four parameters. Besides agroforestry, models including pastoral components should be promoted in the region. Thus, there is ample scope for agricultural productivity enhancement in Bundelkhand by improving various dimensions of agricultural infrastructure.

Economic analysis of establishment techniques of wheat in Haryana[4]

Conservation agriculture (CA) practices one recognized as the immediate as well as long-term solution to achieve goals of sustaining crop productivity, improving natural resource base and economic growth of the Indian farmers. Estimated Resource use efficiency was estimated and constraints faced in adoption of various CA practices in wheat sowing in Karnal and Kaithal district of Haryana during 2017-18 were identified. Input energy was calculated by considering energy from all sources i.e. human labour, seed, chemical fertilizers, pesticides, tractor, diesel, machinery, tubewell irrigation etc., whereas, output energy was calculated by taking into account energy from grain and straw. The Cobb-Douglas production function analysis revealed that the seed and plant protection chemicals are being underutilized and there is a scope for

[4] In collaboration with Chaudhary Charan Singh Haryana Agricultural University, Hisar

increasing the productivity of wheat by adding more inputs. However, the fertilizer cost can be reduced without affecting productivity. The energy utilization pattern indicated that Turbo Happy Seeder Technique (THST) is energy efficient over Zero Tillage Technology (ZTT) and Conventional Technique (CT) as it escapes the pre sowing energy requirement. The THST produced higher output energy as compared to CT and ZTT (Table 2.15).

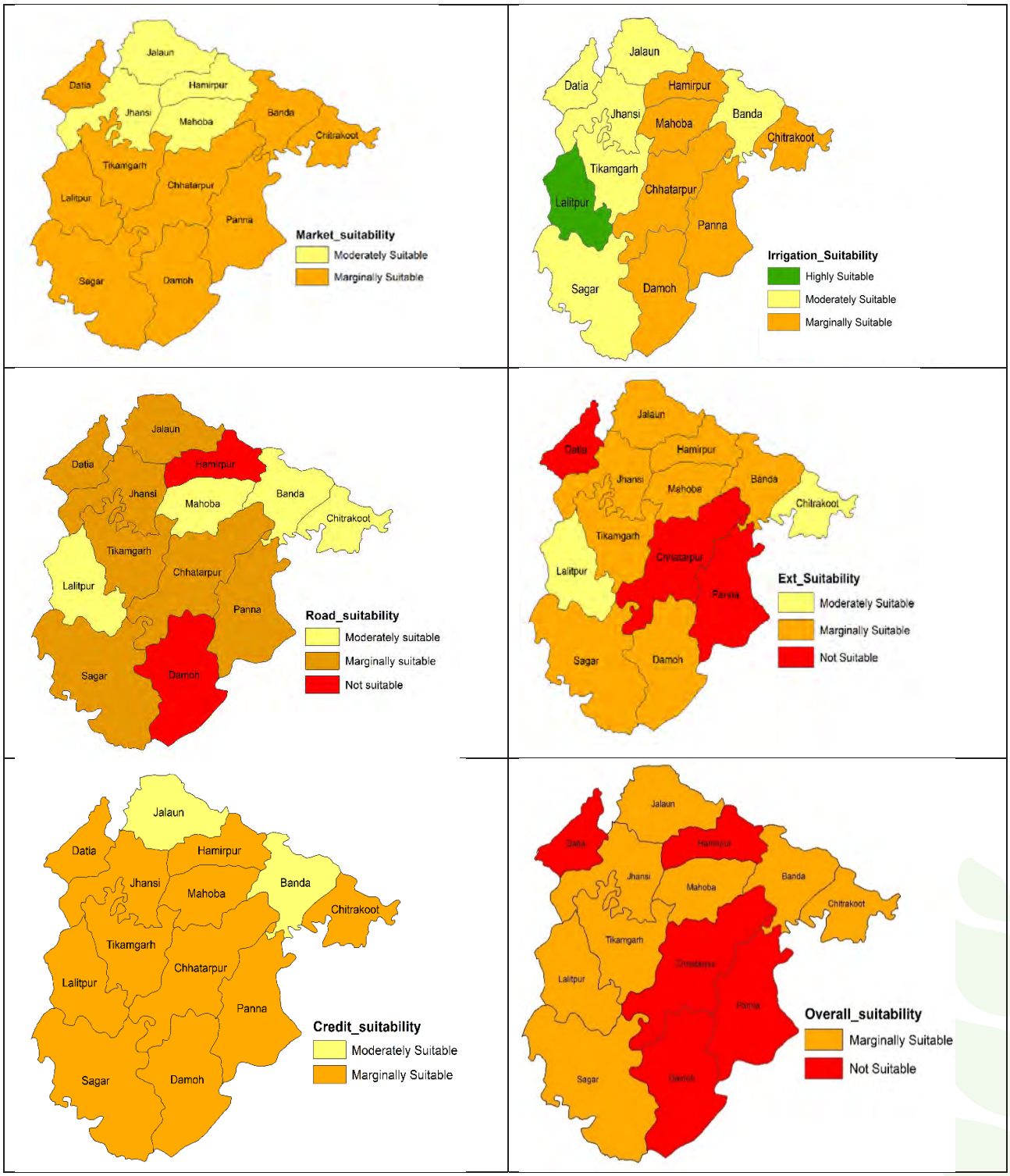


Figure 2.11. District level agricultural infrastructural suitability in Bundelkhand

Table 2.15. Output energy pattern of wheat cultivation in Haryana in 2017-18

MJha^{-1}

Particulars	CT Energy (MJ ha^{-1})	ZTT Energy (MJ ha^{-1})	THST Energy (MJ ha^{-1})
Karnal			
Output energy	80,791	79,439	82,790
Input energy	21,702	18,607	14,259
Input-output ratio	3.72	4.27	5.81
Kaithal			
Output energy	80,056	78,351	81,512
Input energy	21,627	19,284	13,800
Input-output ratio	3.70	4.06	5.87
Overall			
Output energy	80,424	81,834	82,144
Input energy	21,680.29	19,087	14,010
Input-output ratio	3.71	4.29	5.86

Note. CT=Conventional Technique, ZTT=Zero Tillage Technique, THST=Turbo Happy Seeder Technique.

Input use pattern and economics of paddy varieties in Punjab agriculture[5]

The paddy-wheat monoculture in Punjab has resulted in various agro-ecological problems. The short window of time between paddy harvesting and wheat cultivation is considered as major cause of crop reside burning in the state. As per experts Punjab needs not only to decrease the area under paddy cultivation but also to decrease the area under long duration variety PUSA 44, which is highly environment-unfriendly. Using the primary data collected from 60 farmers of Ludhiana and Barnala district of Punjab, this study compares the input use and economics of two short duration paddy varieties namely PR121 and PR126 with most preferred varieties of paddy namely PUSA 44. The analysis revealed that expenses on fertilizers, plant protection measures, human labour use, and diesel for irrigation were considerably lower in short duration varieties as compared to PUSA 44 (Table 2.16). Though returns over variable costs in short-duration varieties were lower by 5-7 per cent than that of PUSA 44, the water requirement was lower up to 20 per cent. The benefits of short duration paddy varieties in terms of judicious groundwater usage and lower input requirement can help in saving labour/ energy. One of the urgent measures needed for agricultural sustainability of the state is increasing area under short duration varieties at this critical juncture. The farmers should be incentivised to cultivate these varieties.

Economics and constraints in direct seeded rice in Punjab[6]

Direct seeded rice (DSR) helps in saving water, reduce labour requirement, and mitigate greenhouse gas (GHS) emissions. However, the rate of adoption of the DSR is very slow as compared to transplanted puddled rice (TPR). Comparative returns from directed seeded *vis-a-vis* transplanted rice and were worked out constraints associated in adoption of DSR technology, were identified based on data collected from 84 sample farmers (30 adopters and 54 non-adopters) of Ludhiana and Barnala

[5] In collaboration with Punjab Agricultural University, Ludhiana

[6] In collaboration with Punjab Agricultural University, Ludhiana

Table 2.16. Input use pattern and economics of paddy varieties in Punjab, 2018-19

Per hectare

Particulars	Pusa 44		PR 121		PR 126	
	Q	V	Q	V	Q	V
Seed (kg)	10.97	295	12.55	375	12.42	435
Fertilizer use (kg)						
Urea	380	2,287	305	1,835	300	1,795
Di-ammonium phosphate	35	770	25	570	30	685
Zinc Sulphate	12.5	762	6.57	442	10	555
Muriate of Potash	-	-	3.03	182	3.47	262
Plant protection measures (₹)	-	4,475	-	4,107	-	3902
Human labour (hr)	327	14,880	305	14,122	285	13,295
Number of irrigations and cost of diesel use, if any	35.9	2,400	30.6	1180	29.2	-
Combine harvesting + S.M.S (hr)	1.27	3,757	1.35	4185	1.3	4,160
Tractor use (hr)	12.77	9,450	12.97	9,243	11.95	8,870
Interest on variable cost*	-	879	-	815	-	765
Total variable cost	-	**39,956**	-	**37,056**	-	**34,724**
Yield (q/ha)	74.12	1,31,187	69.87	1,23,667	67.77	1,19,967
Gross returns	**-**	**131187**	**-**	**1,23,667**	**-**	**1,19,967**
Returns over variable cost	**-**	91,231	**-**	86,611	**-**	85,243

Note: Q is quantity and V is value in ₹ ; * Ratio of interest was applied @ 9 per cent/ annum for half of the crop season.

districts of Punjab. The results revealed that the labour use in DSR was substantially lower as compared to TPR. Similarly, the use of machine was also lower by 30 per cent. The irrigation water use in DSR was less than half of that of the TPR farms. The gross returns were lower in DSR but the returns over variable costs turned out to be higher because of lower total variable cost. Farmers also perceived DSR technology beneficial in terms of lower water usage, labour saving and lower cost of production. Non-availability of seed drill, higher weed infestation and lack of awareness among the farmers about DSR technology were the important constraints reported by the farmers. Study suggested for enhancing skills of farmers in effective management of weeds and creating awareness about DSR to increase the area under this technology in the state.

Enterprise planning for sustainable agriculture: A case study of arid semi-arid zones of Rajasthan[7]

Irrigation water is one of the most limiting factors in arid and semi-arid regions of Rajasthan. The state occupies 10 per cent of the total geographical area but has only 1 per cent of the total water resource in the country. Therefore, agri-enterprise should be planned to maximize income of farmers and sustain natural resources. The study develops zonal level optimum enterprise plans for two arid and semi-arid zones of Rajasthan using the unit level data for TE 2014-15 collected under cost of cultivation scheme. A linear programme model was developed to maximize the net returns with available land, water, fertilizers, working

[7] In collaboration with Maharana Pratap University of Agriculture and Technology, Udaipur

capital and human labour. The study revealed that the existing enterprise plan in these zones is sub-optimal and optimizing the existing resources can help in enhancing net returns by 31 per cent. The optimum plan suggested for increasing the area under sorghum, sesame, green gram, *guar*, isabgol, gram and mustard while reducing the area under wheat, pearl millet and moth bean. The plan suggested for rearing more number of cattle and goats as major supporting activity for farmers of arid region. Accordingly, the plan suggested for allocating additional area under fodder crops.

Developing optimum plan for lower Brahmaputra valley zone of Assam[8]

Optimum crop plan for lower Brahmaputra valley zone (LBVZ) of Assam has been developed using linear programming technique with the objective to maximize net returns subjected to set of constraints. Before developing the crop plan, a case study was done to find out the possible intervention to deal with the flood. Two optimum plans were developed wherein the first plan (P1) optimized the existing resources and second plan (P2) simulated the effect of flood management interventions. In the optimum plan with intervention (P2), three interventions were made: cultivation of autumn rice with recommended doses of fertilizer and variety (Luit, Disang), growing flood prone AAU recommended winter rice variety (Ranjit Sub 1 and Bahadur Sub 1) and improved goat breed (Beetle). The optimum plan (P1) recorded higher cropping intensity with higher net return than the existing plan (P0) (Table 2.17). Further, optimum plans with intervention (P2) also recorded increased cropping intensity and higher net return over the existing plan.

Table 2.17. Optimum crop and livestock plan for Lower Brahmaputra Valley Zone of Assam.

Crop	Existing plan		Optimum plan		Optimum plan with intervention	
	P0	% of GCA	P1	% of GCA	P2	% of GCA
Rice	832170	70.36	8,61,073	69.27	8,66,914	69.24
Other cereals	20078	1.7	20561	1.65	20078	1.61
Oilseeds	121515	10.27	1,31,518	10.58	1,30,151	10.4
Pulses	55739	4.72	57,810	4.64	56,970	4.55
Vegetables	66945	10.39	1,32,576	10.67	1,31,886	10.53
Spices	9569	0.81	11465	0.93	11465	0.91
Other crops	76700	6.49	85828	6.9	91705	7.33
GCA	**11,82,716**	**100**	**12,43,021**	**100**	**12,52,199**	**100**
NSA	**8,49,221**		**8,49,221**		**8,49,221**	
CI	**139.27**		**146.37**		**147.45**	
Local cattle	23,02,305		18,41,844		20,72,074	
Crossbred	1,24,874		1,74,824		1,87,312	
Buffalo	59,092		47,274		53183	
Goatery (IMP)	-				84280	
Goatery (Local)	12,54,173		10,03,338		9,35,914	
Cropping intensity (%)	139.27	-	146.37	(+)5.10*	147.45	(+)8.61*
Total profit (₹ in lakh)	5,71,990	-	6,21,230	(+)5.87*	6,45,755	(+)12.89*

Note: *Indicates per cent change over existing plan

[8] In collaboration with Assam Agriculture University, Jorhat

Under the optimum plan (P1), area under maize, jute, mustard, black gram, pea, chillies, sugarcane, cauliflower, brinjal, okra, onion and ginger increased, whereas area under autumn rice, winter rice, summer rice, wheat, sesamum, green gram, potato, cabbage, tomato, turmeric and other fodder decreased. The optimal plan with intervention (P2) increased the area under jute, mustard, sesamum, chillies, sugarcane, onion, ginger and other fodder, whereas area under autumn rice, winter rice (flood free), summer rice, wheat, maize, black gram, green gram, pea, lentil, potato, cabbage, brinjal and turmeric decreased. The number of local cattle, buffalo and local goat decreased in plan P2, whereas crossbred and improved goatery increased over P0. The net returns increased by 8.61 per cent and 12.89 per cent under P1 and P2, respectively over existing pattern. Similarly, cropping intensity was also increased by 5.10 per cent and 5.87 per cent in P1 and P2, respectively.

Technology Foresight in Agriculture

Subash S.P., Md. Ejaz Anwer, Arathy Ashok, Suresh Pal

The study was conducted to (i) Track plant varieties under Protection of Plant Varieties and Farmers Right Act (national), (ii) patent landscaping of emerging agricultural areas and technologies (global and national), (iii) scientometric analysis and mapping of research in agricultural sciences (global and national), and (iv) make foresight on emerging agricultural technologies (Synthetic biology) for sustainable food systems in India. The study explored the trends in patents in agriculture using World Intellectual Property Organization (WIPO) patentscope database for 45 major countries for the period 1990-2017. China has emerged as a key patenting country in the World. In India, amendment of patent law 2005 had a positive impact on patenting of agricultural technologies.

The trends in scientific publication of emerging technologies such as synthetic biology and artificial intelligence in agriculture were also explored. The study used lens.org an open access platform to search for articles, patents and citation of emerging technologies. The platform has more than 119 million patent records, 211 million scholarly works and 2 billion document linkages. The trends in articles, patents citation and scholarly citation showed that both the technologies had achieved its peak in the mid of this decade (Figure 2.12 and 2.13). The trend in patent citation precedes journal articles followed by scholarly citation. This is as a result of researchers applying for patents before journal publication as it is a necessary condition for getting a patent. The number of patent citations is higher in synthetic biology compared to artificial intelligence, as the research from the earlier leads to products which is easy to patent compared to algorithms or processes developed by the later. Both the technologies have applications across different sectors. These are the key emerging disruptive technologies of the fourth industrial revolution. Application of these technologies such as deep learning and algorithms to predict disease and pest outbreaks, genome editing for new improved varieties are already in market.

The new technologies and business systems are evolving in agricultural sector and it needs newer set of laws and research. For example, the regulations on data sharing, new breeding techniques (CRISPR-Cas 9), require the existing laws to evolve suiting the such rapidly advancing scientific improvements. Many of these questions are common across sectors but their applications specific to agricultural sector need to be analyzed. In case of research, unlike the previous industrial revolution, basic research of these emerging technologies in biology were developed in public research institutions (eg, the basic research and patents of CRISPR were developed in MIT and University and California), while algorithms and machine learning tools were developed majorly through crowdsourcing. Though the

AI based algorithms and machine learning tools are open source and available for public, it requires diverse data set to simulate for specific application. Such kind of Big data are available mostly with few technology giants. United States has made huge investment in AI research, while China had developed large volume of own data. In the US private sector is leading in the efforts on developing such technology, but most of the development work are outsourced to China. Indian companies are also leading in application of these technologies and over half of them are using AI. India needs to design and develop policy framework supporting democratization and distribution of data which can be utilized by these ventures to develop innovative solutions and business models. The policy should also take care of the issues with ownership, privacy, protection, security and transparency of these data.

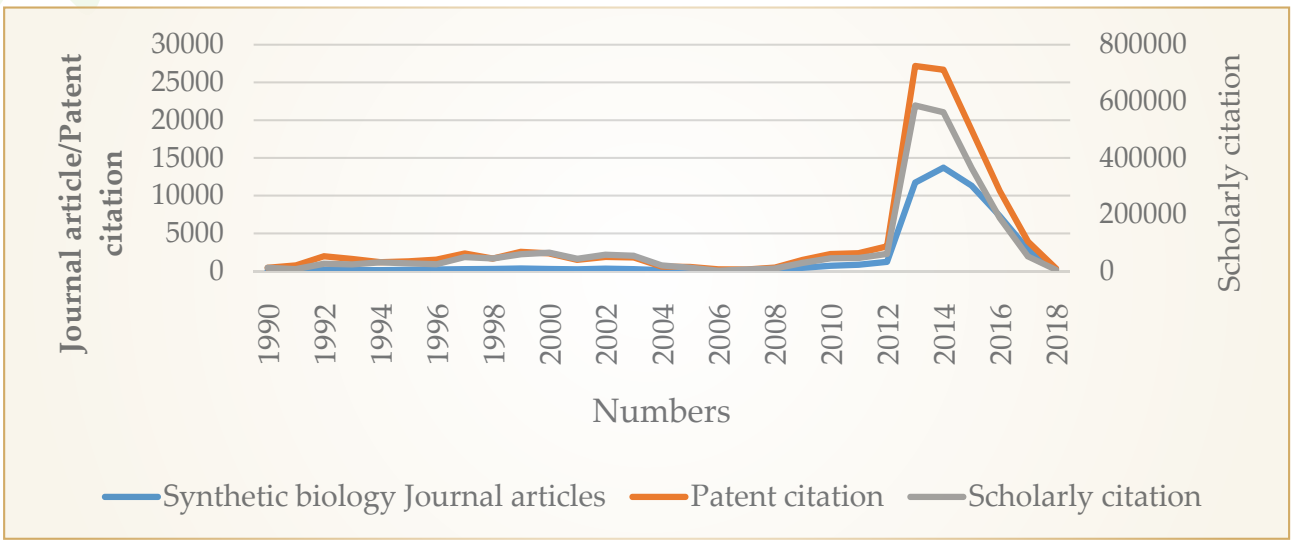


Figure 2.12. Trends in scientific publication, patents and citations on synthetic biology in agriculture

Source: Extracted from Lens open access data (2019). Citation based on N= 47,069 journal articles.

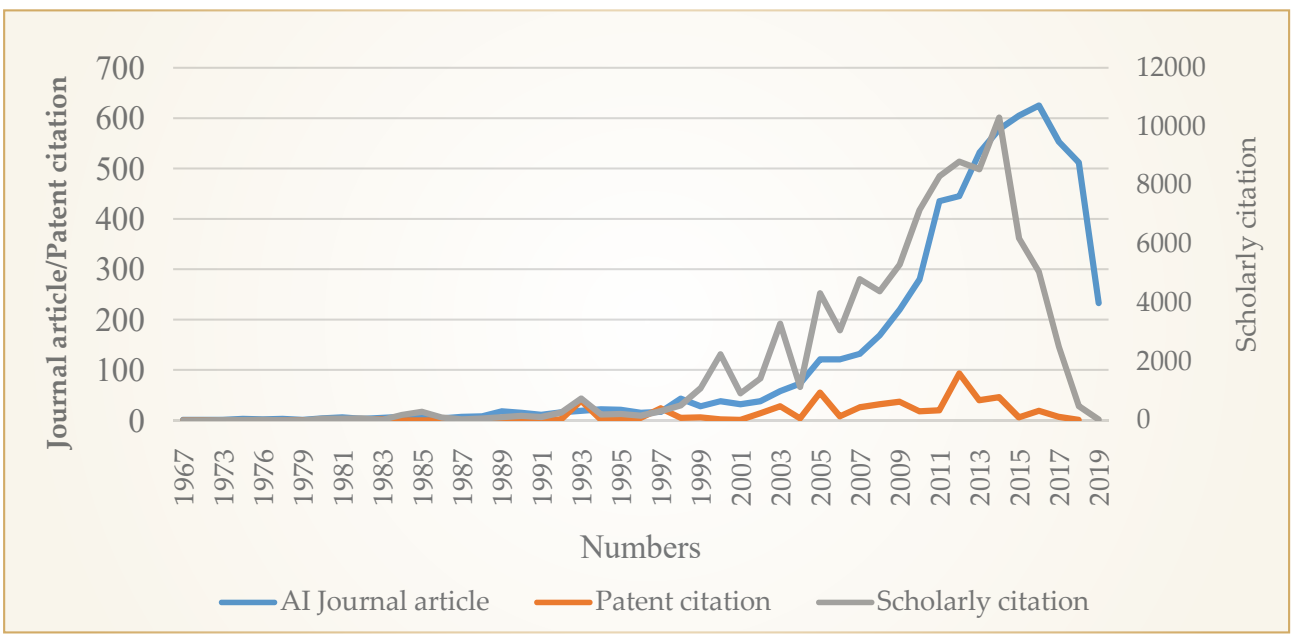


Figure 2.13. Trends in scientific publication, patents and citation on Artificial Intelligence in agriculture

Source: Extracted from Lens open access data platform (2019).

The study analysed the effect of regulatory policies of the government on anti-competitiveness in the Bt cotton industry. Timeline analysis used to understand the events helped in understanding the 'temporal scope' and 'inter-temporal dependences' of these events. The timeline of events in Bt cotton industry in India is shown in Figure 2.14. The timeline is divided into three phases, phase 1 (1990-2002), phase 2 (2002-07), phase 3 (2008-2019). Phase 1 is the initial regulation phase, where the regulatory authorities assessed the technology. In phase 2, the technology got widely adopted in the country with lesser regulatory intervention, and in phase 3, there was a series of litigation and emergence of strong re-regulations.

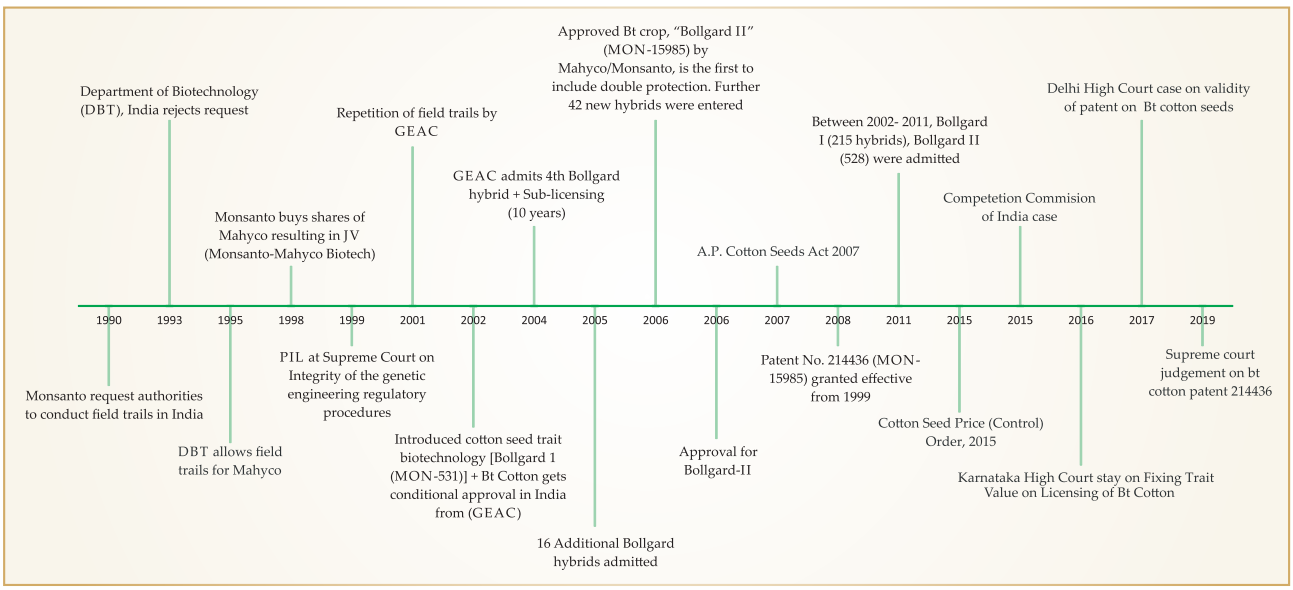


Figure 2.14. Timeline of events in Bt cotton industry in India

Based on the timeline analysis, the study showed that the new business model (sub-licensing) resulted in barriers to entry for a non-patented product. Later, when the newer version of the product emerged with patent, the business model discouraged other firms to pursue developing new varieties based on their patents. Government intervention through enforcing price cap also discouraged the firms from investing in R & D based on new patents. The study showed that an interaction of business model and regulatory policies resulted in anti-competitiveness in the industry.

Long-run Trend in Groundwater Level in the Indo-Gangetic Plains

S.K. Srivastava and Jaspal Singh

Sustainable management of groundwater resources is a pre-requisite for sustaining food production system in India. Groundwater resources in the country suffers from dual challenges of over-exploitation primarily in north-western region and its under-use in eastern region of the country. The study examined spatial variation in groundwater level in Indo-Gangetic Plains (IGP) and analyzed changes in its level during 2004 to 2014. IGP exhibited wide spatial variation in groundwater level in 2018 (Figure 2.15). Northern part of IGP has deeper groundwater level as compared to eastern parts due to variation in rainfall pattern, cropping pattern and several socio-economic, policy and infrastructural related factors. It is to be noted that up to 10 metre below ground level (m bgl) groundwater level is considered relatively safe where groundwater can be extracted using surface (centrifugal) pumps at less energy and cost. However, groundwater extraction from beyond 10 m bgl depth requires costlier and

energy-intensive technologies like submersible pumps. In such situations, many farmers who cannot afford to invest in deep tube wells and heavy pumps, loose access to groundwater resources adversely affecting crop production.

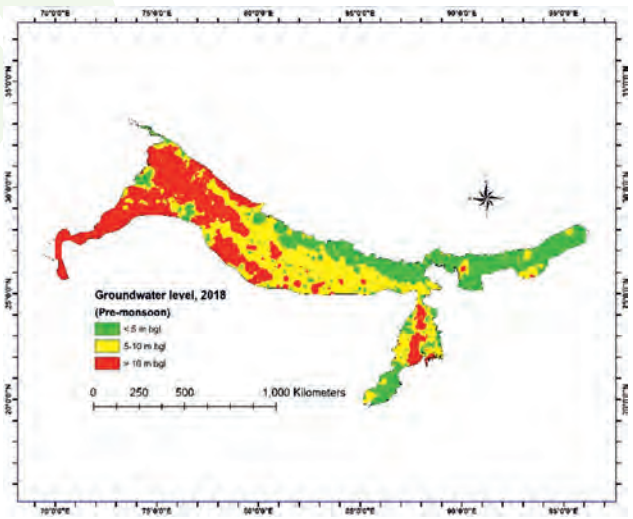


Figure 2.15. Spatial variation in groundwater level in Indo-Gangetic Plains of India in 2018

The trend in groundwater level (pre-monsoon) during 2004 to 2014 was examined at the selected observation wells of Central Groundwater Board by applying Mann-Kendall (MK) test. The results of the MK test revealed whether observation wells witnessed rising/declining/no significant trend in groundwater depth during the study period. The distribution of observation wells across these categories in the IGP states is presented in Table 2.18. The per cent of wells with significant trend (rise/decline) in groundwater level varied from 22 per cent in Bihar to 58 per cent Punjab. Among the wells with significant trend, wells with declining groundwater level far exceeded the wells with rising groundwater level. Interestingly, in eastern IGP where level of groundwater development is low and have high rainfall, large number of wells witnessed declining trend in groundwater level, though at a slow rate. This shall be taken as an early warning signal which warrants emphasis on sustainable management of groundwater resources even in the eastern region.

Direct Benefit Transfers for Micro-irrigation: Impact on Farm Performance

Prabhat Kishore and Pratap Singh Birthal

Efficiency gains from adoption of sprinklers irrigation technology

Assessment of efficiency gains from adoption of sprinkler irrigation has been done using data from a farm survey of over 400 sampled household in Bundelkhand region of Uttar Pradesh. The gains in crop yield, water productivity and technical efficiency by adopting sprinkler irrigation (over flood irrigation) has been estimated after correcting for omitted variable bias. The results revealed 21.9 per cent higher wheat yield under sprinkler system over

Table 2.18. Distribution of observation wells according to trend in groundwater depth during 2004 to 2014 (Man-Kendall test results)

State	No significant trend (per cent)	Significantly rising trend (per cent)	Significantly declining trend (per cent)	Total wells (numbers)
Punjab	42	14	44	159
Haryana	49	15	36	259
Uttar Pradesh	75	7	18	678
Bihar	78	5	17	184
West Bengal	69	5	26	520
Assam	58	6	36	203

traditional method of irrigation. This translates into significant income gains. Similarly, water productivity and technical efficiency estimated using Stochastic production function was higher for adopters of sprinkler irrigation. Differences in efficiency gains could be due to differences in input use or unobservable farm and farmer characteristics of adopters and non-adopters. There was no significant difference in use of critical inputs such as fertilizer, seed and machines between adopters and non-adopters. Interestingly, adopters of sprinklers used significantly lesser human labour, irrigation water and diesel to pump groundwater, and saved around 15 per cent of irrigation water, 8 per cent diesel, and 11 per cent labour.

Table 2.19. Results of outcome equations

Particulars	Yield	Technical efficiency	Water productivity
Ln seed (kg/acre)	-0.231*** (0.059)	-	-
Ln fertilizer (kg/acre)	0.006 (0.06)	-	-
Ln labour use (mandays/acre)	0.040** (0.019)	-	-
Ln machine use (hours/acre)	0.175*** (0.039)	-	-
Ln irrigation (hours/acre)	0.152*** (0.036)	-	-0.609*** (0.089)
Sprinkler irrigation=1, otherwise=0	0.207*** (0.024)	19.252*** (2.322)	0.238*** (0.059)
Ln farming experience (years)	0.008 (0.02)	0.573 (2.024)	-0.016 (0.05)
Ln family size (no)	-	-0.1 (0.379)	-
Ln schooling (years)	-	1.116** (0.545)	0.023* (0.014)
Caste (SC/ST, OBC=1, otherwise=0)	-	-	-0.204*** (0.069)
Ownership of tube-well (yes=1, otherwise=0)	-	9.301*** (3.102)	0.003 (0.079)
Ownership of electric pump (yes=1, otherwise=0)	-	2.623 (3.021)	0.282*** (0.077)
Ownership of diesel engine (yes=1, otherwise=0)	-	-2.057 (2.363)	-0.059 (0.06)
Access to extension support (yes=1, otherwise=0)	-	4.910** (2.024)	-
District dummy (Jhansi=1, otherwise=0)	0.053*** (0.021)	3.328* (2.008)	0.288*** (0.05)
Inverse Mills Ratio (IMR)	-0.034* (0.02)	1.489 (2.368)	-0.058 (0.061)
Constant	2.419*** (0.408)	52.351*** (8.692)	1.942*** (0.432)
Number of observations	403	403	403
Prob > F	0.000	0.000	0.000
R-squared	0.331	0.232	0.296

Note: Figures in parentheses are standard errors; *, ** and *** are significant at 10, 5 and 1per cent, respectively

The study identified key factors influencing adoption of sprinkler irrigation by fitting probit model. Landholding size, ownership of tube-well and electric pump, and households' association with any social organization significantly influencined adoption of sprinkler irrigation. The probability of adoption of sprinkler irrigation is higher for larger farmers, and for those who own their own tube-wells and electric engines for pumping groundwater for irrigation. Household's association with social organization increases chances of adoption of sprinkler irrigation due to their better awareness about benefits of sprinkler irrigation and flow of information on government schemes.

Estimates of effects of sprinkler irrigation on crop yield, technical efficiency and water productivity, after accounted for selection bias are given in Table 2.18. Inverse Mills Ratio is significant only in crop yield. The coefficient of dummy for sprinkler irrigation is positive and highly significant, suggesting that application of sprinkler irrigation contributes towards improving crop yield. As expected, technical efficiency is positively and significantly associated with sprinkler irrigation. Consequently, sprinkler irrigation leads to an improvement in water productivity i.e. more yield with less water. This is reflected through positive and significant value of coefficient of dummy of sprinkler.

Efficiency of Micro-Irrigation in economising water use in India: Learning from potential and under explored states

Subhash Chand, Prabhat Kishore, S.K. Srivastava, R. S. Pundir and Ravindra Singh Shekhawat

The share of area under micro irrigation in gross sown area and gross irrigated area across the states revealed that Andhra Pradesh leads in the coverage of micro-irrigation (Figure 2.16). The study examined the spread and adoption of micro-irrigation system (MIS) in three progressive states (high coverage under micro- irrigation) namely Maharashtra, Gujarat and Andhra Pradesh and in one potential (low micro-irrigation coverage) state of Punjab. Total 72 adopters of micro-irrigation and 180 non-adopters from each selected state were surveyed in the study. The analysis revealed family size, possession of soil health card, crop insurance, electricity prices and ownership of tubewell as important determinants of micro irrigation adoption. The availability of free electricity discouraged farmers from adopting micro-irrigation. The net returns were higher among adopters of MIS. The other positive impacts of micro-irrigation are-increased employment opportunity, reverse migration and potential attracting youth towards agriculture.

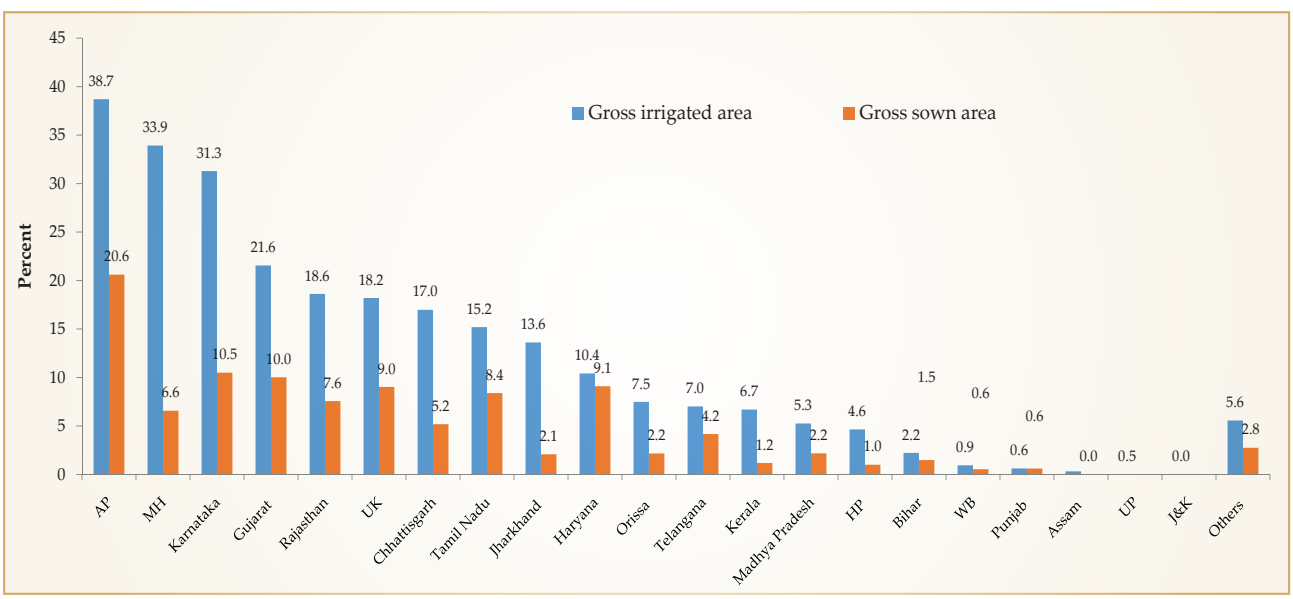


Figure 2.16. The share of micro irrigated area in gross irrigated and gross sown area across states

The study estimated potential area in major states which can be brought under micro-irrigation (Table 2.20). The potential area for micro irrigation was estimated under two scenarios. Firstly, by considering proportion of area irrigated by groundwater (tubewell +other well) and tank irrigation. Secondly, by adding 50 per cent of area irrigated by canal to scenario-1. The potential area under micro irrigation in the country in scenario-I and scenario-II was estimated as 65.33 m ha and 80 m ha, respectively. Among the states, Uttar Pradesh has the largest potential area (25%) followed by Rajasthan (12%) and Madhya Pradesh (11%).

Institutional Mechanisms in Irrigation Water Management and Water Markets in Northern India

Subhash Chand, Prabhat Kishore and Hubbalal

The study estimated rate of groundwater extraction, identified structure of existing water market and examined constraints faced in managing surface irrigation system in Eastern Yamuna Canal. Eastern Yamuna Canal originates from left bank of Yamuna river from Tajevala and fulfils irrigation water requirement in Hindon and Yamuna Doab of Saharanpur,

Table 2.20. Estimation of potential area across the states

million ha

States	Scenario 1*			Scenario 2 #		
	Sprinkler	Drip	Total	Sprinkler	Drip	Total
Andhra Pradesh	1.08	1.15	2.23	1.39	1.49	2.88
Assam	0.06	0.04	0.10	0.09	0.06	0.15
Bihar	2.55	0.89	3.44	3.16	1.10	4.26
Chhattisgarh	0.34	0.26	0.60	0.65	0.50	1.15
Goa	0.02	0.01	0.03	0.02	0.01	0.03
Gujarat	2.66	2.13	4.79	2.96	2.38	5.34
Haryana	2.62	0.81	3.43	3.54	1.09	4.63
Himachal Pradesh	0.04	0.01	0.05	0.04	0.01	0.05
Jammu & Kashmir	0.02	0.01	0.03	0.16	0.07	0.24
Jharkhand	0.13	0.03	0.16	0.13	0.04	0.17
Karnataka	1.12	0.95	2.07	1.48	1.25	2.72
Kerala	0.15	0.09	0.24	0.18	0.11	0.29
Madhya Pradesh	6.11	0.87	6.98	6.85	0.97	7.83
Maharashtra	1.57	1.27	2.84	1.97	1.59	3.55
Odisha	0.15	0.13	0.28	0.45	0.40	0.85
Punjab	4.20	1.43	5.63	4.98	1.70	6.69
Rajasthan	6.56	1.10	7.67	7.69	1.29	8.99
Tamil Nadu	1.45	1.03	2.48	1.68	1.19	2.87
Telangana	1.11	1.08	2.18	1.19	1.16	2.35
Uttar Pradesh	12.50	4.03	16.53	13.92	4.49	18.41
Uttarakhand	0.23	0.14	0.37	0.28	0.16	0.44
West Bengal	2.02	1.20	3.21	3.87	2.30	6.17
Total	46.68	18.65	65.33	56.69	23.35	80.04

Note: Calculated based on index 1* and index 2#

Muzaffarnagar, Shamli, Baghpat and Ghaziabad districts. Groundwater is the major source of irrigation accounting for 84 per cent of total irrigated in the study area. Between 1993-94 and 2013-14, the number of shallow well (depth < 35 meters) increased in Baghpat and Saharnapur, whereas in Ghaziabad it significantly decreased. The dug wells in these districts are almost nil due to deeper groundwater table. There has been a significant increase in deep tubewell (depth more than 70 m) in Baghpat, and Saharanpur since 1993. Analysis showed that deep tubewell in Ghaziabad has declined although water table has gone much deeper and stages of groundwater exploitation stand at 128 per cent. The Minor Irrigation Census reports no minor surface flow and surface lift schemes.

Structure of groundwater markets: The primary survey in Saharanpur, Baghpat and Ghaziabad districts revealed four types of participants in existing groundwater market *viz.* self-users, self-user and seller, self-user and buyer, and buyers. Distribution of sample participants across farm-size classes along with family size and average size of land holding is presented in Table 2.21. More than three-fourths of the small farmers do not have own water extraction devices and buy water from medium and large farmers. The prices charged by water seller depends on the energy used to energize pump sets. The water rates for electric operated pumps are almost stagnant since 2015, whereas for the diesel operated pump sets it has increased sharply in the recent years in the study area. Apart from source of energy, prices were also found to vary based on social structure and personal acquaintance with the water sellers.

Constraints in surface irrigation management: The institutional, administrative and policy related constraints in management surface irrigation in the study area were identified. Majority of warabandi farmers faced difficulty in scheduling of water release and conflict resolutions, particularly at critical stage of crops due to difficulty in contacting the staff of irrigation department (Table 2.22). More than 62 per cent of the farmers reported that prior intimation on release of water scheduling is not given. Encroachment of water channels, delay in de-siltation of channels, inadequate water supply are other major constraints faced by the farmers. Therefore, monitoring of the governance issues such as distribution, accessibility and maintenance of surface irrigation system by addressing above issues is essential.

Table 2.21. Distribution of sample households across water market regimes

Water market regime	Household category				Family size	Landholding size (ha)
	Small	Medium	Large	Total		
Self user	17 (12.88)	11 (25.58)	6 (17.65)	34 (16.27)	6.7	1.3
Self user + seller	9 (6.82)	18 (41.86)	16 (47.06)	43 (20.57)	6.2	3.01
Self user + Buyer	5 (3.79)	14 (32.56)	12 (35.29)	31 (14.83)	6.5	2.10
Buyer	101 (76.52)	-	-	101 (48.33)	5.8	0.48
Total	132	43	34	209	6.13	1.37

Note: Figures within parentheses are per cent of total

Table 2.22. Constraints faced by sample households in irrigation management

Constraints	Type of response					
	Agreed		Not agreed		No reply	
	No.	%	No.	%	No.	%
Administrative and departments level						
Deficit Irrigation dept. staff	79	37.87	68	32.56	62	29.57
Non availability of Jiladars	127	60.8	53	25.58	28	13.62
Difficulty in contacting the higher authority for water	126	60.13	50	23.92	33	15.95
Inadequate water supply	129	61.79	72	34.45	8	129
Lack of training programmes	18	8.64	115	54.82	76	18
Complication for water related matters resolution.	58	27.91	138	66.11	12	58
Lack of credit facilities	12	5.74	26	12.62	171	12
Delay in desilting of canal works	159	76.08	45	21.59	5	159
Policy related						
Lack of certain time schedule for water release	131	62.79	65	31.10	13	6.11
No action/control on upper reach fellow farmers	154	73.75	31	14.83	24	11.42
Less water for tail enders	130	62.05	50	23.92	29	14.03
No control on encroachment/ stealing water	149	71.43	58	27.75	2	0.82
No restriction on installation of number of tube wells	62	29.57	95	45.51	52	24.92

Determinants of Groundwater Depletion in India

Prabhat Kishore, Dharam Raj Singh, and Prem Chand

Farmers have identified groundwater irrigation as much reliable and timely source of irrigation over canal irrigation. With an annual groundwater draft of 249 BCM, irrigation alone consumes nearly 90 per cent of it irrigating 62 per cent of irrigated area of the country. Groundwater development has been more intense in north western region of the country and transcended its groundwater availability. Analysis of groundwater table in 499 districts across Indian states for TE2002 and TE2016 revealed that depletion of water table occurred in 67 per cent of the districts. The depletion of water table was more intense (> 4 m) in 10 per cent districts (50 districts); more than 50 per cent of these falls in Punjab and Haryana.

The study fitted both fixed and random effects models and chose fixed effect model based on Hausman test. The heteroscedasticity bias was also corrected in the final model. The estimated corrected fixed-effects model showed negative association between rainfall and depletion of groundwater (Table 2.23). Rainfall reduces the requirement of irrigation water as well as recharges aquifers and improves water table. The result indicated that increase in share of groundwater irrigated area leads to depletion of water table. Similarly, increase in the share of

rice and sugarcane in gross sown area is directly related with depletion of water table as these crops considered being water guzzling crop. The increase in the area under fruits and vegetables was also directly related with groundwater depletion. Random effect estimate suggested that increase in wheat area is related with improvement in water table, which is contrary to our hypothesis.

Country is grappling with worst water crisis across states, which will have repercussion of agricultural production system. In this context, there is a need to generate region specific crop plan based on available water resources and backed by government intervention in the form of assured income to farmers. The promotion of efficient method of irrigation like micro irrigation will be indispensable to diminish irrigation water demand. Sustainability of agricultural production system will largely depend on planning for efficient water use and its enforcement at farm level in coming years.

Performance and Determinants of Micro-Irrigation in Rajasthan

Sant Kumar, Kingsly I.T, Pramod Kumar, Prabhat Kishore and M. Awais

Progress in micro-irrigation in Rajasthan

The study examined physical and financial progress in adoption of micro-irrigation technologies in Rajasthan during the period 2005-06 to 2018-19. The area under micro-irrigation increased four times from 37.6 thousand ha in 2006 to 185 thousand ha in 2019. In the year 2015, sprinkler irrigation covered 90 per cent area under micro-irrigation which reduced to 87 per cent by the year 2019. This is due to the increasing emphasis on drip irrigation in the state (Figure 2.16). The expenditure on micro-irrigation substantially increased after the launch of NMMI in 2008-09. The spending increased by 323.9 per cent and coverage grew by 49.5 per cent during 2009 to 2012. Data showed slump in growth of both coverage and spending on micro irrigation during 2013 to 2019.

Table 2.23. Estimate of corrected fixed effect model

Particulars	Coefficient	Robust Std. Err.
Dependent variable: Ln (pre-monsoon water table)		
Explanatory variables		
Ln (rainfall)	-0.073*	0.042
Share of groundwater irrigation	0.003**	0.001
Share of rice area	0.045***	0.009
Share of wheat area	-0.004	0.004
Share of sugarcane area	0.021	0.022
Share of fruits and vegetables area	0.035***	0.008
Share of cotton area	0.007	0.007
Irrigation intensity	0.00	0.000
Constant	1.656***	0.417
sigma_u	1.026	
sigma_e	0.245	
rho	0.946	

Note: ***, ** & *- 1 per cent, 5 per cent and 10 per cent level of significance

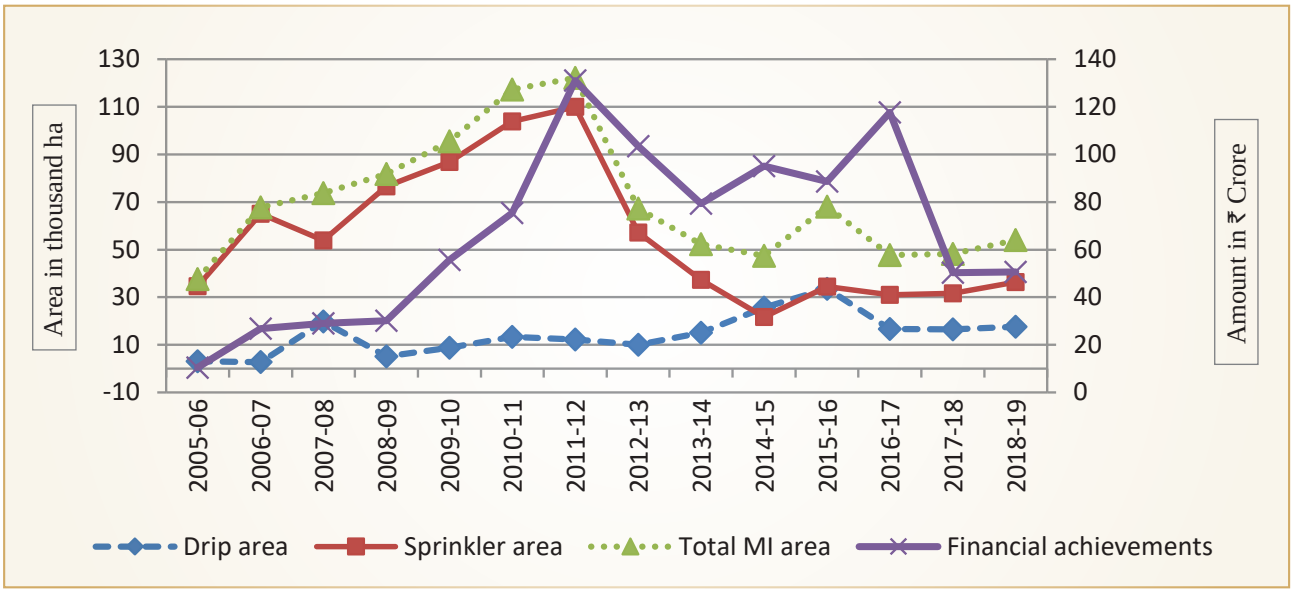


Figure 2.17. Progress in coverage and expenditure on micro-irrigation in Rajasthan, 2006-2019

Determinants of micro irrigation in India

The study analysed key determinants of the adoption of micro irrigation technologies (MITs) using fixed effects regression model. The regression estimates for adoption of MITs are presented in Table 2.24. The explanatory variables taken in the model contributed 35.3 per cent of variations in the extent of adoption of MITs in study states. The estimated value of F (18.4915) was significant. Further, the t-value of regression coefficients of variables, viz. groundwater availability, labour availability, pumpset intensity, electricity use in agriculture, and subsidy were significant and had expected signs. The regression coefficients for canal irrigated area and fruits and vegetables area were non-significant.

Table 2.24. Determinants of adoption of micro irrigation

Explanatory variables	Coefficient	t-value	p-value
Groundwater availability (tubewell area ha)	0.605***	3.704	0.000
Labour availability	1.124***	3.65	0.000
Ground water depth (m)	-1.078***	-3.054	0.002
Subsidy (after 2005 = 1, otherwise = 0)	0.244 **	1.908	0.057
Electricity use in agriculture (kwh per ha)	0.279**	1.792	0.074
Pumpset intensity	-0.902***	-4.745	0.000
Canal area (ha)	-0.153	-1.262	0.208
Fruit and vegetable area (predicted) ha	0.016	0.152	0.880
Number of observation	294		
F (8, 272)	18.4915		
Prob > F	0.0000		
R-square	0.35228		

***, ** significant at 1 per cent and 10 per cent level, respectively

As expected, the groundwater availability is positively and significantly associated with the adoption of micro-irrigation. It could be inferred that assured irrigation water prompts farmers to adopt capital intensive technology to increase its efficiency by irrigating more area with available water and raise benefits by reducing cost of other inputs. It is widely recognised that adoption of micro irrigation is more effective in increasing area under irrigation and making judicious use of precious water resources. Declining groundwater level was found to be other important factor determining adoption of micro irrigation. The electricity use in agriculture positively and significantly affected the adoption of micro irrigation. Assured availability of electricity encourages farmers to go for micro irrigation and mechanization of other farm operations. Government subsidy has been found instrumental in increasing adoption of improved technology. Adoption of micro irrigation across states increased with government subsidy for installation of micro irrigation systems. because this reduced the cost of installation and incentivized farmers to go for installing capital intensive irrigation infrastructure.

Labour intensity was positively and significantly related with the adoption of micro irrigation in states. Adoption of MI creates employment in both primary and secondary sectors, hence more labour is required for its adoption. The regression coefficients for canal irrigated area and fruits and vegetables area had expected but non-significant sign. Though the Government is promoting MI for fruit and vegetable crops, but the extent and progress under horticultural crops need more time to become important factors. Bleak possibility of increasing area under canal could be the reason for less possibility of influencing the adoption of micro-irrigation.

Role of Micro Irrigation in Reducing Crop Productivity Risk in Rajasthan

The reduction in yield risk is studied by estimating coefficient of variation for the period I (1997-98 to 2006-7) and period II (2007-08 to 2016-17). The period II indicated gradual spread of micro irrigation technology (especially sprinkler system) in Rajasthan after its launch in the country in 2005-06. The crops considered for analysis include bajra, moth, and soybean in *kharif* and wheat, gram and rapeseed/mustard in *rabi*. During *kharif*, yield risk in bajra declined by over 45 per cent at state level, varying from 3 per cent in southern plains to 63 per cent in eastern plains (Table 2.25). In moth, variability in yield reduced by 43 per cent and the decline varied from 35 per cent in western plains to 71 per cent in southern plains. In soybean, almost similar trend was noticed with inter-regional variations.

Table 2.25. Reduction in yield risk (coefficient of variation) in various *kharif* crops in Rajasthan

Agro-climatic zones	Bajra			Moth			Soybean		
	P-I	P-II	% Change	P-I	P-II	% Change	P-I	P-II	% Change
Western plains	0.83	0.55	33.97	0.61	0.40	34.66	-	-	
Transition plains	0.47	0.36	23.78	0.66	0.43	35.34	0.25	0.15	39.60
Eastern plains	0.40	0.15	63.09	0.41	0.22	46.41	0.29	0.13	55.55
Southern plains	0.54	0.52	3.33	0.35	0.10	70.99	0.28	0.18	38.17
Humid plains	0.80	0.42	47.12	-	-	-	0.31	0.22	29.54
Rajasthan State	0.41	0.22	45.21	0.51	0.29	43.52	0.29	0.17	40.55

Note= P-I refers (1997-98 to 2006-07); P-II refers (2007-08 to 2016-17)

Among the crops grown during *rabi* highest decline in variability of yield was noticed in rapeseed and mustard (over 61 per cent at state level), which varied from 27 per cent in western plains to 50 per cent in eastern plains (Table 2.26). In gram, yield variability reduced by 10 per cent in transition plains to 34 per cent in western plains and average of 43 per cent at state level. Yield variability in wheat crop declined by 23 per cent at state level, varying 12 per cent in western plains to 30 per cent in humid plains. The results revealed that critical irrigation in low water requiring crops like bajra, moth, soybean, and gram helped in large extent reduction of yield risk over wheat which is usually grown under assured irrigation conditions.

Performance and Impact Assessment of Agricultural Extension and Advisory Systems

Vinayak Nikam and Arathy Ashok

A system level analysis of extension and advisory services (EAS) in Maharashtra

Study on relevance of different knowledge sources, advisory methods, time allocation by different extension advisory staff revealed that public institutions remained important source of knowledge for almost all the EAS providers (Figure 2.18). Other EAS providers except cooperatives and FPCs were gaining knowledge from all other EAS providers. This

Table 2.26. Reduction in yield risk (coefficient of variation) in various *rabi* crops in Rajasthan

Agro-climatic zones	Wheat			Gram			Rapeseed & Mustard		
	P-I	P-II	% Change	P-I	P-II	% Change	P-I	P-II	% Change
Western plains	0.18	0.16	12.18	0.834	0.51	38.49	0.43	0.31	26.70
Transition plains	0.25	0.19	26.19	0.639	0.58	9.70	0.45	0.26	42.47
Eastern plains	0.20	0.17	15.00	0.655	0.44	32.98	0.39	0.20	49.87
Southern plains	0.36	0.27	24.51	0.516	0.39	24.81	0.50	0.32	36.85
Humid plains	0.26	0.19	29.92	0.506	0.35	30.83	0.47	0.27	43.46
Rajasthan State	0.25	0.19	22.71	0.479	0.27	42.80	0.31	0.12	61.44

Note= P-I (1997-98 to 2006-07); P-II (2007-08 to 2016-17)

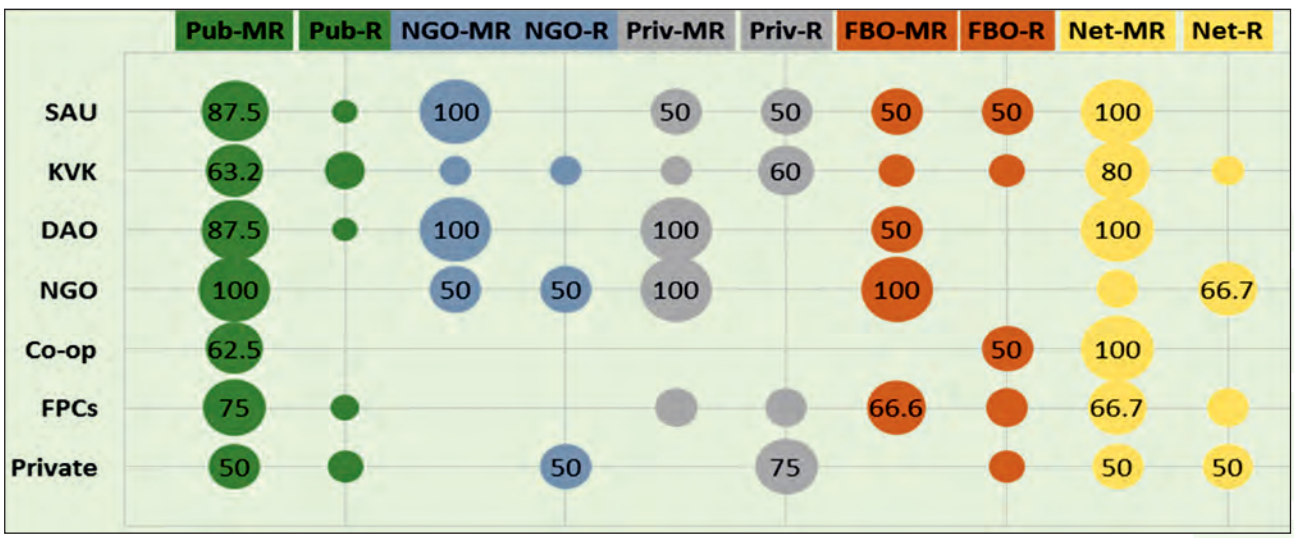


Figure 2.18. Relevance of different knowledge sources (horizontal axis) to various EAS providers

(Figures are in percentage; MR-more relevant, R-relevant, Pub-public, Priv-private EAs providers, DAO-district Agriculture Office)

indicated mutual learning process among all EAS providers, as they were learning from each other's experience. Almost all the EAS relied on internet as source of knowledge, as it is easily available and accessible to them.

Major advisory methods: In terms of individual, group and mass contact, SAUs and KVKs were using all the methods in a balanced way. Department of agriculture reported more use of individual contact method, while NGOs, cooperatives, private and FBOs were using more of group contact methods to provide advisories to farmers.

Time spent by EAS staff from various organisations: Among all the EAS providers, advisory work forms the major chunk of time spent by organizations except DAOs. In DAO most of the staff time would go for R&D activities and administration and management. As compared to private, NGOs, Cooperatives and FBOs staff, staff involved in EAS in public organizations was more burdened with R&D, administration and management activities. This burden is huge in DAO, which is considered as major extension system in India, leaving staff very less time for extension and advisory related work.

The study concluded that public institutions are important source of knowledge to other EAS providers therefore literature and recommendations of these institutions needs to be abreast with emerging problems and changing realities in Indian agriculture. Public EAS relied more on individual contact methods (50% in DAO), which can be replaced with group contact methods (Krishi mela, exhibitions, farmers' day etc.) so that with same resources and time more number of farmers can be contacted. This can be supported by more use of ICT and mass media. In case of public EAS providers, very less time spent by staff on advisory work (15% in case of DAO) and engaged in other types of activities. As this is a major extension system in country, for effective extension service delivery field staff need to provide offload other responsibilities so that they dedicated services to the farmers.

Theme – III
AGRICULTURAL MARKETS AND TRADE

EXCERPTS

- In the buffalo value chain in Uttar Pradesh, 72 per cent of the flow between farmers and live animal markets is done by aggregators, 94 per cent of flow between market and abattoir is done by traders, and 71 per cent of total meat is shipped to importing countries. Along the buffalo value chain, 8 risk hotspots need special attention to maintain food safety.
- In the goat value chain in Tamil Nadu, aggregators are main link between farmers and live animal market, transacting 77 per cent of the total flow. More than 90 per cent of the meat is purchased by consumers. Farmers' share in consumer's rupee varies from 80.18 to 95.30 per cent across different marketing channels.
- Dairy industry is dominated by informal sector and 48.15 per cent of dairy startups adopt direct selling of milk from producer to consumer. The value addition along the chain and profits were realised higher in the value chain of integrated production and processing system. Adoption of food safety measures in the value chain bears positive association with milk prices.
- An analysis of value chain of deep sea fishing in Tamil Nadu revealed that despite engaging in strenuous and risky activity at far away distances from the shore, the earnings of the fishermen were quite modest.
- An analysis of value chain of cherry in Kashmir division revealed that its marketing is less organized. In cherry value chain the major limitation are due to post-harvest constraints, viz. poor keeping quality, low level of value addition, and less number of cold storages.
- An analysis of value chain of ginger, turmeric, and chilli in the north-eastern region revealed that organic cultivation fetches premium prices than non-organic.
- Markets of cumin are integrated. The long-run prices of cumin are stable and any deviation is mainly due to external shocks that occur in the short-run.
- The Outlook Model for major cereals was updated for 2030.
- The analysis of onion price volatility spill-over effects among selected markets indicated that past volatility shocks in individual markets have a greater effect on their own market price volatility than past volatility shocks arising from other markets.
- Commodity futures market helps in providing price signals, hedging input costs, timely delivery, reducing risk and in improving gradation facility.

Policy Imperatives for Promoting Value Chains of Agricultural Commodities in India

Shiv Kumar, Abimanyu Jhajhria, Kingsly I. T., D. Bardhan, A. K. Dixit, Shinoj P., S. A. Wani, and Ram Singh

Buffalo meat (carabeef) value chain in Uttar Pradesh

The performance of buffalo value chain in terms of transaction costs and distribution of benefits realised by various chain actors was assessed. Risk analysis was carried out to identify the disease risk hotspots in the value chain. The quantitative mapping showed that aggregators constituted the main link between farmers and live animal markets and accounted for 72 per cent of the total flow of buffaloes to livestock markets. Sub-traders/traders ship the bulk of the flow (94%) from markets to abattoirs. Of the total meat produced, 71 per cent is shipped directly to importing countries and the rest to local markets. From local markets, retailers take away 87 per cent and restaurants 13 per cent. Costs (per kg carcass weight) incurred by various chain actors in purchase and sale of live animals / meat cuts were INR 147 for aggregators, INR 154 for traders, INR 183 for retailers, and INR 177 for slaughter houses. Of the total value added, traders in the domestic value chains and export-oriented units captured a significant share.

The risk analysis across value chain revealed its 8 risk hotspots. These are overstocking of vehicles by traders, irregular ante-mortem examination in livestock markets, animals transported for long distances without health certificates, no measure for pre and post-movement isolation and testing, non-cleaning/ disinfection of vehicles after each trip, no measure for check for pathogens at slaughter houses, lack of hygienic practices at retail outlets, and use of contaminated meat cutting wooden slabs.

Analysis of consumer behaviour revealed that 64 per cent of consumers purchased buffalo meat regularly (4-6 times per week). Monthly average consumption per household was 5.61 kg. About 51 per cent of respondents reported that meat occupies the first rank in their food basket. Among different attributes of buffalo meat, 94 per cent of the respondents considered the specific retail outlet from where they source the meat to be the most important one, followed by tenderness (73%) and food safety (69%). In contrast, no respondent reported price the most important attribute. Family size was the only variable which was associated with the expenditure on buffalo meat. Only variable, viz. expenditure on buffalo meat exerted a significant and positive influence on consumer's willingness to pay for a premium on the existing price for buffalo meat, provided quality of the meat is guaranteed by a government certification process.

The findings of value chain identified structural deficiencies and vulnerabilities and provided the framework for intervention policies that can improve system efficiency. These may be helpful in streamlining the animal preservation acts in the country to promote scientific practices of meat animal production, rejuvenating the scheme on salvaging and rearing of male calves for meat production and implementation of integrated and inclusive contract farming system for meat buffalo production.

Goat meat value chain in Tamil Nadu

The study was carried out in four randomly selected districts of Tamil Nadu to assess the performance of value chains in terms of price spread and the distribution of benefits across various stakeholders, and identify the constraints faced by them. In the study area, there are about 600-700 number of aggregators, 16 livestock markets, 300-350 retailers and 200-250 restaurants. The survey was conducted with 160 goat farmers, 4 livestock markets, 33 aggregators, 37 retailers/ butchers, 13 restaurants and 40 consumers.

The analysis revealed that the major proportion (77%) of goats was sold by the farmers at the livestock markets through the aggregators, and about 16.5 per cent was sold by the farmers directly to the retailers. Among the total meat sold by the retailers, 93.5 per cent of the meat was procured by the consumers as raw meat. Only 6.5 per cent of the meat was accounted for the restaurants. No difference was observed between flow of volume and the flow of value across value chains. In all markets, the majority (50.55%) of the animals transacted belonged to 6-12 months age group, followed by >12 months age group (23.27%).

Net returns were negative for the goat rearers. However, exclusion of the imputed value of family labour costs from the total costs turns the net returns (family labour income) positive. Net margin per kg effective carcass weight received by the aggregator and retailers was INR 5.98 and INR 21.17, respectively. Farmers share in consumer's rupee was 92.89 per cent in Farmer – Aggregator – Retailer - Consumer chain, 95.30 per cent in Farmer – Retailer – Consumer chain (transaction through livestock market), 82.95 per cent in Farmer – Retailer – Consumer chain (direct procurement at farmers' door step), 86.58 per cent in value added goat meat (biriyani) value chain and 80.18 per cent in value added goat meat (curry) chain.

Dairy value chain: Dairy startups

The value chain of dairy entrepreneurs was mapped based on data from 48 startups covering Haryana, Punjab, Uttara Pradesh, Rajasthan, Andhra Pradesh, Delhi, Uttarakhand, Gujarat, Jharkhand. The average herd size of the farm was 96 animals with daily average milk production of 19,800 litres per farm and the value chain is given in Figure 2.19.

It is evident that informal sector dominates in the dairy industry and 48.15 per cent of dairy startups adopted direct selling of milk from producer to consumer. This could be due to realization of higher profits (average price ₹ 41.21/ litre). These startups were focusing on

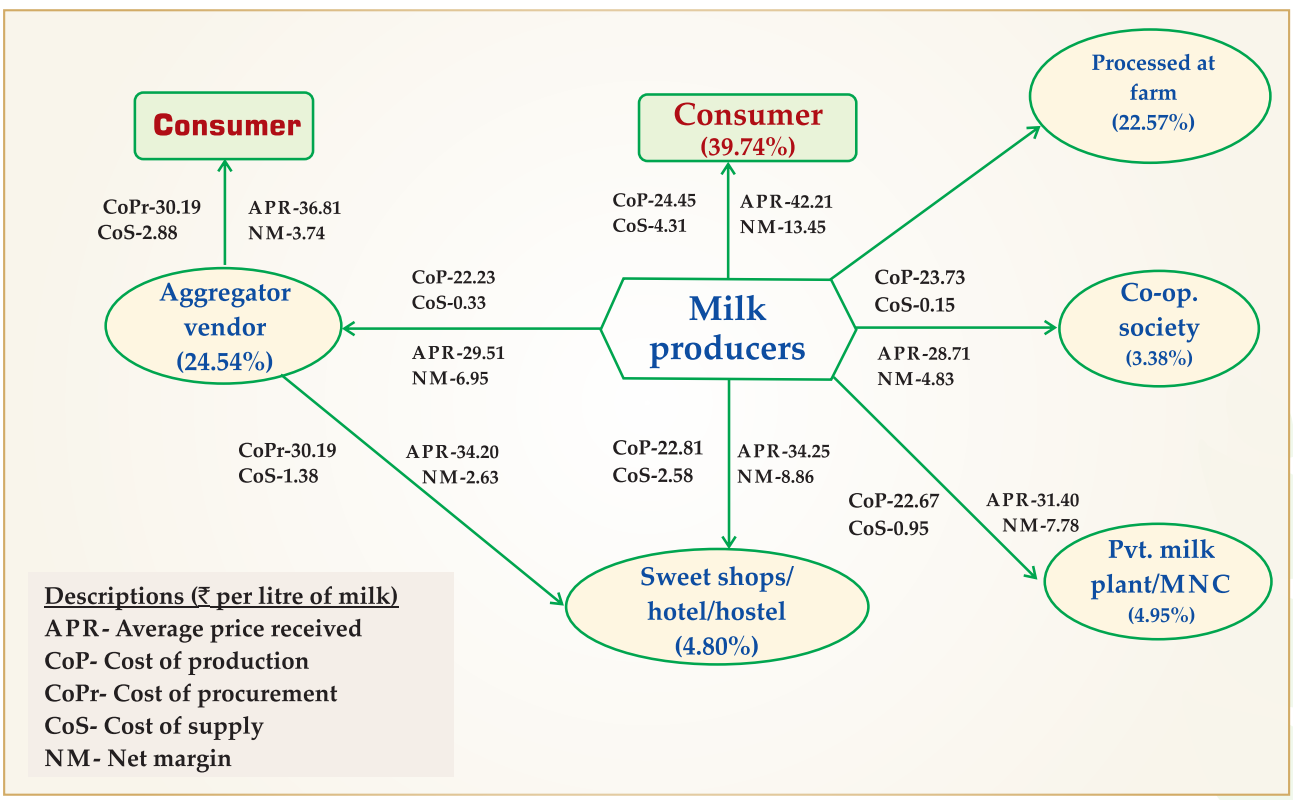


Figure 2.19. Value chain of dairy start-ups

quality milk supply mainly to urban dwellers in hygienic conditions like selling raw milk in clean glass bottles and few of them were selling milk of indigenous cow (Sahiwal, Gir, Kankrej) which fetched higher price ranging from ₹ 60 in Ganganagar (Rajasthan) to ₹ 110 per litre in National Capital Region (Delhi, Faridabad and Noida). The consumers also preferred raw fresh milk over pasteurised pouch milk. Other channels identified were selling milk to aggregator vendor and selling milk to a cooperative society. The volume of milk sold through the former channel was 24.55 per cent, whereas it was merely 3.38 per cent through later channel. The channels producer to sweetshops/hotels/hostels and producers to private milk plants/MNC disposed 22.58 per cent of the milk per day in production catchments. Majority of the farmers had adopted multiple channels to avoid marketing risk, to manage fluctuations in milk production and to efficiently manage fluctuating demand in the market for milk and milk products. The value addition along the chain and profits were realised higher in the value chain of integrated production and processing system. This system is able to generate the profit of ₹ 7.21/litre over and above the model profit of ₹ 2.5/ litre (Figure 2.20).

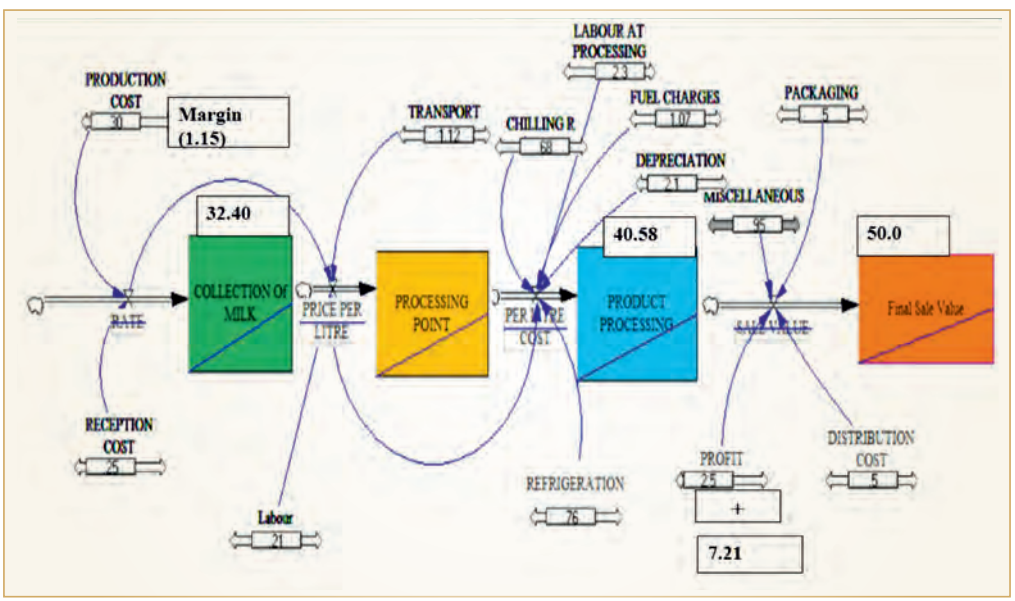


Figure 2.20. Mapping of value chain of integrated production and processing system

The study developed food safety adoption index by considering 68 scientific practices adopted by different stakeholders in the milk value chain. Importance of safety practices was measured on a four-point continuum as critical, major, minor and not necessary by assigning the score in a range of 8 (maximum) and 0 (minimum) with the help of experts. The total score for all the practices was 278 (out of this, 148 scores assigned to processing operations and disposal, 68 scores to milking and post milking practices, 62 scores to transport activities). The regression analysis between food safety index and its determinants revealed positive association between adoption of food safety measures in the value chain and milk prices.

Value chain analysis of the deep sea fishing industry

The study on value chain analysis of the deep sea fishing industry based at Thuttoor, Tamil Nadu was carried out to gain insight into the existing linkages, estimation of cost and returns and to bring out effective recommendations for future development. The analysis on earnings out of 515 deep sea fishing trips made by the 50 sample units during the year 2019 revealed that despite engaging in strenuous and risky activity at far away distances from the shore, the earnings of the Thuttoor fishermen are quite modest. Comparative estimates with other artisanal fishing methods along the south-west coast of India showed that average income realized by vessel crew per working day for AOSF (Artisanal Off Shore Fishing) was around

INR 568, whereas that for inboard ring seine vessels and purse seine vessels were INR 1,305 and INR 1,643 respectively.

Value chain analysis of cherry

Quantity of cherry dispatched from the fruits and vegetables markets of the Kashmir Division was 2165.57 metric tonnes with the total turnover of ₹ 21 crores in 2019. Marketing of cherry is not well organized. The commonly encountered channels identified in its marketing were (I) Producer–Pre-harvest Contractor-Commission Agent- Wholesaler-Retailer–Consumer, (II) Producer-Commission Agent-Wholesaler-Retailer– Consumer and (III) Producer - Retailer – Consumer. Majority of the farmers sell their surplus to contractors. Out of total average marketable surplus available per farm, 37 per cent was sold through these contractors, 19 per cent farmers sold their produce directly to retailers and 44 per cent through wholesalers. About 46 per cent of the farmers sold their produce through channel II with more than 43 per cent quantity disposed through this channel followed by channel I and channel III. Marketing efficiency was highest in channel III and price spread across all channels revealed that producers received a higher proportion of consumer's price in channel III. The intervention of controlled atmospheric stores added time value of ₹ 35 per kg for a storage period of 30-40 days.

In the cherry value chain, the major constraints at production level were lower shelf life, costly plant protection chemicals, high incidence of diseases, low price of output, lack of quality planting material and labour availability during the peak season besides low-quality extension services, poor communication facilities and climate change. The major constraints at the post-harvest level were poor keeping quality, low level of value addition, and less number of cold storages. To make cheery value chains more lucrative, need was felt to achieve large economies of scale to derive maximum utilities and logistics especially at post-harvest management level. The way forward is to minimize the fruit loss at all stages of value chain besides value addition and to ensure quality produce to consumers at a reasonable price.

Value chain analysis of organic spices

Value chains of ginger, turmeric, and chilli in the north-eastern region were analysed to work out comparative costs and returns, mapping of value chain actors and estimation of compliance cost, investment and margins along the value chains. The states having the highest areas under the selected spices were selected and compared with the state adopting organic production practices. Sikkim was purposively chosen as control state as it has largest area under organic production.

Ginger

In north-eastern region, ginger is grown in three farm situations - upland, terrace and *jhum/shifting* cultivation. The non-adopter states of Meghalaya, Mizoram, Arunachal Pradesh and adopter state, Sikkim were selected for the study with a total of 275 ginger growers from the non-adopter states and 84 from the organic adopter state. Major collection centres were identified in the selected states with a total of 91 stakeholders/actors involved in the value chain of ginger. The per hectare cost of cultivation of ginger was reported as ₹77,361 in Meghalaya, ₹82,243 in Mizoram, ₹80,030 in Arunachal Pradesh and ₹1,09,880 in Sikkim. The high total cost of cultivation in organic state was due to the relatively higher price of organic rhizomes (₹52,016/ha) than that in the non-adopter states (below ₹ 30000). The net returns, however was highest in the organic adopter state (₹94,687/ha). A huge return gap of 60.98 per cent, 77.83 per cent and 64.85 per cent were observed between Meghalaya, Mizoram, Arunachal Pradesh with Sikkim. These evidences implied that cultivation of organic ginger fetches premium prices. The producers' share in the consumer rupee for the organic adopted state was fairly higher than

the non-adopted states. The channels which included processing or value addition of the ginger produce, incurred a low producers' share in consumer rupee, while earning a higher net margin for the processors and retailers of the processed products.

Turmeric

For analysing value chain of turmeric, 279 growers from Meghalaya, Manipur and Mizoram states (non-adopter) and 78 turmeric growers from the organic state Sikkim were surveyed. A total of 15 major collection centres involving 48 stakeholders/actors were also surveyed. Total cost of cultivation in turmeric was found to be the highest in Sikkim (₹95,749/ ha). The adopter state, Sikkim obtained the highest yield (5.51/MT) and yield difference with Meghalaya and Manipur was 8.53 per cent and 4.53 per cent, respectively. A huge yield gap (38.66%), however, was observed between Mizoram and Sikkim. The marketing channels observed in all the selected states were simple and processors played a dominant role. The conversion of raw turmeric to dry flakes and powdered form was observed only in Mizoram and Meghalaya, while in Manipur and Sikkim, raw turmeric was converted to powdered form only. On an average the conversion ratio of raw turmeric to dry flake was estimated at 3.5:1 to 5:1 and the conversion ratio of dry turmeric to powder form was 1.10:1 to 1.25:1. A higher share in consumer rupee was obtained for the powdered form of turmeric in comparison to the dry flakes. The producers' share for powdered turmeric form was highest in the non-adopter state Mizoram, in the value chain having direct marketing linkage between the producer and consumer.

Chilli

Different varieties of chilli are commonly grown in NEH region. A total of 168 chilli growers from Mizoram and Nagaland and 75 from Sikkim were selected for the study. Ten major collection centres with a total of 46 stakeholders were identified. The total cost of cultivation was highest in the state of Sikkim ₹ 47,742/ ha with the major cost incurred in human labour in all the selected states. The net returns of the chilli growers were highest in Sikkim (₹ 5,27,055/ha) due to higher productivity and higher prices received by the farmers. Post-harvest activities of drying and powdering the chilli were observed only in Nagaland and Mizoram, while pickle chilli products were observed in Sikkim. On an average, the conversion ratio of raw chilli to dry form is 6.5-7:1. Producers' share was highest when the chilli was sold in the raw form and directly by the producer to the consumer. In the processed form of chilli, the pickled chilli in Sikkim obtained a higher producers' share than that of the dry form of chilli in the non-adopter states.

Price Transmission in Major Cumin Markets

Abimanyu Jhajhria, Shiv Kumar and Kingsly I T

The cumin is one of the dryland spices crops grown in western states of Gujarat and Rajasthan. These two states contribute 55.8 per cent and 43.9 per cent to total cumin production in the country. India stands first in the export of cumin in world market. Cumin being a risky crop in production settings witnesses high price fluctuations due to supply shocks along with international market disturbances. The cumin markets are linked with flow of information and goods from one market to another. The deficit region and surplus region of cumin production and consumption are equalized by scope of regional arbitrage. The regional arbitrage brings a law of one price (LOOP) for producers and consumers after adjusting transaction and transportation cost. The knowledge on performances of markets has great importance in understanding its dynamics.

The study analysed extent and pattern of horizontal cumin market integration, price transmission and causality. The Johansen's cointegration test was applied on the weekly

price data from four major cumin markets of India, viz. Unjha, Rajkot, Jodhpur, and Merta for the period 2012-2019 to examine integration across selected markets. The results showed that even though the selected cumin markets are isolated and spatially segmented, they are well-connected in terms of prices, and have long-run price association across them (Table 2.27). The coefficient of the error correction term was negative and significant for all market pairs which implied that the prices of cumin are stable in the long-run and any short-run deviations due to external shocks are well adjusted.

The Granger causality test confirmed the occurrence of price transmission across markets, implying that bidirectional causality between all market pairs except Rajkot to Merta and Jodhpur to Merta (Table 2.28). This implied that markets which are distant and of low volume transaction (small market) were slow in pace of price transmission to big markets. This reveals that horizontal market integration works according to the radial market theory. The major market becomes the central market due to its more concentration of market functionaries and high volume

Table 2.27. Long-run and short-run coefficients from error correction model

Market pair	long-run coefficient (β)	short -run coefficient (α_1)	Co-integration rank
Unjha-Rajkot	-1.00* (0.02)	-0.12* (0.03)	1
Unjha-Jodhpur	-1.12* (0.03)	-0.06* (0.02)	1
Unjha-Merta	-0.97* (0.05)	-0.08* (0.02)	1
Rajkot-Jodhpur	-1.12* (0.03)	-0.14* (0.04)	1
Rajkot-Merta	-0.97* (0.04)	-0.14* (0.03)	1
Jodhpur-Merta	-0.85* (0.05)	-0.18* (0.03)	1

Figures within the parentheses are standard error, and * denotes significance at 5% level.

Table 2.28. Pair-wise Granger causality in major cumin markets

Market pair	Null hypothesis	F-statistics	Granger cause	Direction
Unjha-Rajkot	Unjha does not Granger cause Rajkot	12.67*	Yes	Bidirectional
	Rajkot does not Granger cause Unjha	21.05*	Yes	
Unjha-Jodhpur	Unjha does not Granger cause Jodhpur	31.49*	Yes	Bidirectional
	Jodhpur does not Granger cause Unjha	07.75*	Yes	
Unjha-Merta	Unjha does not Granger cause Merta	07.12*	Yes	Bidirectional
	Merta does not Granger cause Unjha	14.93*	Yes	
Rajkot-Jodhpur	Rajkot does not Granger cause Jodhpur	30.07*	Yes	Bidirectional
	Jodhpur does not Granger cause Rajkot	08.56*	Yes	
Rajkot-Merta	Rajkot does not Granger cause Merta	02.52	No	Unidirectional
	Merta does not Granger cause Rajkot	22.89*	Yes	
Jodhpur-Merta	Jodhpur does not Granger cause Merta	01.55	No	Unidirectional
	Merta does not Granger cause Jodhpur	21.41*	Yes	

Note: (a) The lags of the dependent variable used to obtain white-noise residuals were determined using the Schwarz Information Criterion (SIC); (b) * denotes rejection of the null hypothesis at 1% level of significance.

transaction. The small markets become the peripheral markets i.e. situated away from the central market. The central market forms and discovers the price due to its more intense interplay of market forces. The study suggested that central market or major markets, which form prices need to be intervened first to remove all sorts of inefficiency arising in price formation. The intervention in peripheral markets needs to be taken at second stage including better integration with internet, logistics and transport infrastructure besides financial and other infrastructures.

Commodity Outlook Models for Major Grains

Kingsly I T

With the increasing commercialization and diversification towards high value agricultural commodities, under expanding liberalization and global interfaces, and foreign direct investments in the Indian agriculture, there is an increasing realisation of the need for timely and reliable information on the likely demand, production, trade and prices of important agricultural commodities in the country. Globally, Commodity Outlook Models are widely used to generate advance information on medium- and long-term projections on the above-mentioned economic variables. These models generate outlook for future, and also capable of undertaking sensitivity analysis and simulations under alternative policy and technological scenarios.

Outlook model for major cereals was updated up to the year of 2030 under a dynamic as well as spatial partial equilibrium modelling framework. It incorporates a system of simultaneous equations for effectively depicting the linkages between various economic variables corresponding to the food balance sheet of major foodgrains in India. This model specifically focuses on three major staple foodgrains of India, viz., rice, wheat and maize, along with their interrelations with other complementary and substitute crops. Technically, the model utilises the time series information for undertaking projections, but simultaneously derives equilibrium values of the variables based on the linkages established through a set of equations that cut across commodity as well as spatial dimensions. The projections with base year 2016-17 on major variables for the three primary crops are presented in the Table 2.29.

Table 2.29. Projection for wheat, rice and maize with the base year 2016-17

Particulars	Wheat			Rice			Maize		
	2020	2025	2030	2020	2025	2030	2020	2025	2030
Area (lakh ha)	324	330	332	433	429	423	99	101	103
Yield (t/ha)	3.14	3.31	3.49	2.71	3.02	3.34	2.8	3.0	3.2
Production (lakh tonnes)	1015	1091	1157	1170	1296	1415	276	303	330
Consumption (lakh tonnes)	1006	1020	1043	1015	1088	1154	270	296	324
Food (lakh tonnes)	914	908	907	947	1001	1060	119	127	137
Feed & other uses (lakh tonnes)	92	112	135	69	87	94	151	169	187
Ending stock (lakh tonnes)	174	184	192	116	116	116	15	15	16
Net trade (lakh tonnes)	4	5	6	101	102	103	6	6	7

Volatility Spill-Overs across Major Onion Markets

Raka Saxena, Ranjit Kumar Paul and Rohit Kumar

This study examined onion price volatility spill-over effects among selected markets to examine the price volatility transmission for five major onion markets, viz. Lasalgaon, Pimpalgaon, Bengaluru, Delhi and Indore Own-volatility shocks for all five markets (a_{11}, a_{22}, a_{33}, a_{44} and a_{55}) are significant and varied from 0.286 (Indore) to 0.584 (Delhi), indicating the presence of ARCH effects (Table 2.30). This means that the past shocks arising from the Delhi market will have the strongest impact on its own market price volatility compared to the shocks stemming from the other four markets. Based on the magnitudes of the estimated cross-volatility coefficients, a_{ij} ($i \neq j$), innovations (price shocks) in all of the five markets influence the volatility of other markets, but the own-volatility shocks, a_{ij} ($i=j$), are generally larger than the cross-volatility shocks. This suggested that past volatility shocks in individual markets have a greater effect on their own market price volatility than past volatility shocks arising from other markets. It appeared that the lagged market-specific shocks (ARCH effects) do contribute to the market volatility of any given market in a recursive way. The degree of cross-volatility shocks was pair-wise the weakest between Bengaluru and Indore (0.091) and the strongest between the Pimpalgaon and Lasalgaon (0.276).

Table 2.30. Parameter estimation for the diagonal vech (1, 1) equation

Parameters	Markets	(i_1) Lasalgaon	(i_2) Bengaluru	(i_3) Pimpalgaon	(i_4) Delhi	(i_5) Indore
C	**(j_1) Lasalgaon**	4304				
	(j_2) Bengaluru	2781	2565			
	(j_3) Pimpalgaon	3720	2724	3574		
	(j_4) Delhi	2607	1790	2604	3361	
	(j_5) Indore	2205	1265	2142	1684	1854
A	**(j_1) Lasalgaon**	0.324				
	(j_2) Bengaluru	0.199	0.333			
	(j_3) Pimpalgaon	0.276	0.167	0.289		
	(j_4) Delhi	0.228	0.242	0.234	0.584	
	(j_5) Indore	0.194	0.091	0.189	0.187	0.286
B	**(j_1) Lasalgaon**	0.567				
	(j_2) Bengaluru	0.602	0.614			
	(j_3) Pimpalgaon	0.598	0.595	0.605		
	(j_4) Delhi	0.582	0.617	0.579	0.464	
	(j_5) Indore	0.678	0.755	0.679	0.68	0.702
α+β	**(j_1) Lasalgaon**	0.891				
	(j_2) Bengaluru	0.801	0.947			
	(j_3) Pimpalgaon	0.874	0.762	0.894		
	(j_4) Delhi	0.81	0.858	0.813	1.048	
	(j_5) Indore	0.872	0.847	0.869	0.867	0.988

All parameters significant at 5 per cent level.

Evaluation of the Benefits of the Commodity Futures Market in the Cotton Ecosystem

Naveen P Singh, Raka Saxena & Mohd Arshad Khan

This study assessed the benefits of cotton futures trading based on the primary survey of cotton farmers, traders, exporters and ginners was conducted in two cotton producing and trading states, viz. Haryana and Tamil Nadu. Sirsa and Coimbatore were selected as the major locations from the cotton belt of selected states. Around one quarter (23.08) of the sample respondents were aware about the futures trading but only around 5 per cent of them have participated in the futures trading (Figure 2.21). Lack of skills needed for trading on electronic exchanges was reported as one of the important reasons for low participation. The introduction of futures in cotton helped various stakeholders in getting better prices and effective risk management technique to hedge their investments from the future price fluctuations. The study analysed the impact of cotton futures trading on the cotton ecosystem, including improvement on the stakeholders of various elements in the value chain. The study also examined the indirect impact of availability of futures prices to the farmers and traders ecosystem. Besides these, the study also examined the price linkages among the major domestic markets and futures prices, which will help in deciding the suitable strategies for the farmers and stakeholders participating in the futures trading of cotton. The overall socio-economic changes in infrastructure, employment, etc., in the value chain ecosystem of cotton as a result of the futures market will provide insights in further improvement in farmers' welfare in the selected eco-systems.

Lack of skills needed for trading on electronic exchanges, absence of trading terminals in villages and absence of basic infrastructure like continuous power supply and high speed broadband were reported to be the main reasons for less participation. Indeed, cotton growers have got a reference point to start negotiation with a buyer, received better prices for their produce and reduced volatility the gains from cotton crop. The improvement in the storage and grading infrastructure was also reported post futures market. Though considerable number of the growers has knowledge, but very few of them have used the warehouse receipt facility. It points towards the need for enhancing the understanding of cotton farmers regarding the use of warehouse receipt. Futures market helped them in terms of providing price signals, hedging input costs, timely delivery, reducing counterparty risk and in improving gradation facility. The introduction of futures in cotton helped ginners in getting better prices and effective risk management technique to hedge their investments from the future price fluctuations. The cotton ecosystem changed after the introduction of cotton futures. Farmers'

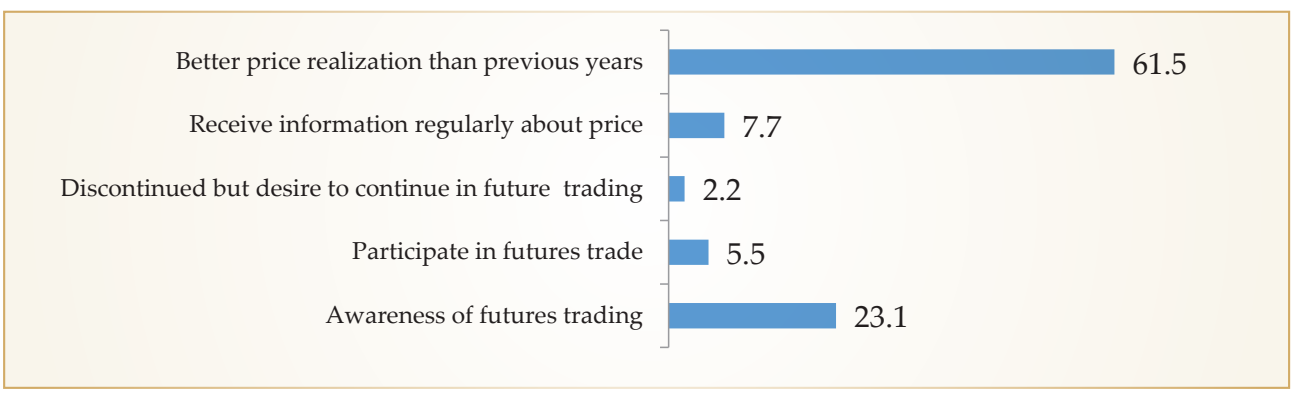


Figure 2.21. Status regarding awareness about futures trading among cotton growers (% of sample cotton growers)

associations and cooperatives can play an important role on behalf of their affiliates by serving as intermediaries between small farmers, warehouses and banks. Efforts should be made to enhance the understanding of cotton growers regarding the use of warehouse receipt. In view of the misperceptions and lack of awareness among stakeholders of cotton value chain, the commodity exchanges may take necessary steps to create more awareness among stakeholders.

List of Research Projects

Table 2.31. On-going research projects

Title of the project	Project area	Project period	Project team
Network Projects			
Structural transformation, regional disparity and institutional reforms in agriculture	Agricultural Growth and Development	October 2017-March 2020	Suresh Pal, Balaji S.J. Pavithra, S. Subash, S.P. Nalini Ranjan Kumar
Resource use planning for sustainable agriculture	Technology and Sustainable Agriculture	October 2017-March 2020	Prem Chand Rajni Jain Subhash Chand Prabhat Kishore
Policy imperatives for promoting value chain of agricultural commodities in India	Markets and Trade and	November 2017-March 2020	Shiv Kumar Abhimanyu Jhajharia T.K. Immanuelraj
Externally Funded Projects			
Doubling farmers' income in India by 2021-22: Estimating farm income and preparation of strategic framework	Agricultural Growth and Development	April 2017-March 2022	Suresh Pal Raka Saxena Naveen P Singh Usha Ahuja Balaji S. J. Ranjit Kumar Paul
Agricultural sustainability in India – A parametric study	Technology and Sustainable Agriculture	June 2018-March 2020	Suresh Pal Chhabilendra Roul S. K. Chaudhari Prem Chand
Strategic research component of national innovations on climate resilient agriculture	Technology and Sustainable Agriculture	April 2017-March 2020	Naveen P Singh Arathy Ashok Bhawna Anand Surendra Singh
Efficiency of micro-irrigation in economising water use in India: Learnings from potential and under explored states	Technology and Sustainable Agriculture	December 2017-May 2019	Subhash Chand Prabhat Kishore R. S. Pundir S. K. Srivastava R S Shekhavat
Investments in ICAR leadership in agricultural higher education (2019-2021)	Technology and Sustainable Agriculture	February 2019-March 2021	Rajni Jain
Agricultural innovations and technology management	Technology and Sustainable Agriculture	November 2017-March 2020	Sant Kumar

Title of the project	Project area	Project period	Project team
Management and Impact assessment of farmers FIRST Project	Technology & Sustainable Agriculture	February 2017-March, 2020	Shiv Kumar Rajni Jain Vinayak R. Nikam T. K. Immanuelraj Abimanyu Jhajhria
Institute Funded Projects			
Farm mechanization on small and marginal farms in India- Trends and drivers	Agricultural Growth and Development	April 2017-March 2020	Nalini Ranjan Kumar S.V. Bangaraju T.
Rural non-farm sector (RNFS) in India: Trends, structural changes, farm sector growth and poverty linkages	Agricultural Growth and Development	October 2017-March 2020	Subash S.P. Prem Chand Balaji, S. J.
Crop insurance in India: Progress, farmers' willingness to pay and role of information	Agricultural Growth and Development	October 2017-March 2020	Pavithra S Jaya Jumrani Arathy Ashok
Nutrient demand and the effect of women empowerment in improving nutritional outcomes in India	Agricultural Growth and Development	March 2018-March 2020	Jaya Jumrani Usha Rani Ahuja
Performance and impact assessment of agricultural extension and advisory systems	Technology and Sustainable Agriculture	April 2017-March 2020	Arathy Ashok Vinayak Nikam
Technology foresight in agriculture	Technology and Sustainable Agriculture	October 2017-March 2020	Subash, S.P. Arathy Ashok Suresh Pal
Direct benefit transfers for micro-irrigation: Impact on farm performance	Technology and Sustainable Agriculture	October 2017-March 2019	Prabhat Kishore P. S. Birthal
Institutional mechanisms in irrigation water management system and water markets in northern India	Technology and Sustainable Agriculture	October 2017-March 2020	Subhash Chand Prabhat Kishore Hubbalal
Assessing impact of soil and water conservation schemes and innovative agricultural technology	Technology and Sustainable Agriculture	November 2017-March 2020	Sant Kumar Pramod Kumar
Marketing reform and infrastructure	Markets and Trade	October 2017-March 2020	Raka Saxena Abhimanyu Jhajhria
Market integration and price transmission in agricultural commodities	Markets and Trade	April 2017-March 2020	T. K. Immanuelraj Abimanyu Jhajhria Shiv Kumar

Table 2.32. Consultancy and contract research projects

Name of the scientist	Institution to which consultancy provided	Area of consultancy/contract research
Pratap S Birthal	International Food Policy Research Institute, Washington DC	Transformation, and Sources of Growth in Southeast Asian Agriculture
Suresh Pal, M.S. Pavithra, Abhimanyu Jhajharia, Subash SP	Department of Fertilizer, Ministry of Chemicals and Fertilisers	Framing Policies for overseas acquisition of raw material by Indian Fertilizer Companies and role of Government in India
Shiv Kumar, Raka Saxena, Kingsly IT, Abhimanyu Jhajharia	Directorate of Marketing & Inspection, Faridabad	Research Studies on Post Harvest Profiles of 10 selected commodities

CHAPTER 3

Seminars/workshops organized	:	9
Trainings organized	:	2

Seminar/Workshop Organized

Sustainability of Indian agriculture: Methodology and indicators

National workshop on "Sustainability of Indian agriculture: Methodology and indicators" was organised at ICAR-NIAP during June 18-19, 2019. The workshop aimed to finalize soil, water, bio-diversity, environmental, climate change and socio-economic indicators of sustainability. Sh. Chhabilendra Roul, IAS, Secretary, Department of Fertilizers, Ministry of Chemicals & Fertilizers, GOI, New Delhi chaired the workshop. Dr S K Chaudhary, ADG, Soil Water Management, Dr Himanshu Pathak, Director, NRRI, Dr Kuldeep Singh, Director, ICAR-NBPGR and Dr P S Birthal, National Professor, ICAR, Dr Suresh Pal, Director, ICAR-NIAP and experts from various ICAR Institutes provided valuable suggestions regarding methodology and benchmarks of the sustainability indicators.

Another workshop on methodology on agricultural sustainability was organized at Amity Institute of Organic Agriculture (AUUP) on August 31, 2019.

National workshop on "Sustainability of Indian agriculture: Methodology and indicators" June 18-19, 2019 (at ICAR-NIAP) and August 31, 2019 (at AUUP)

Securing supply of fertilizers and feedstock for fertilizer industry in India

A brainstorming session on 'Securing supply of fertilizers and feedstock for fertilizer industry in India' was organized on August 29, 2019 at ICAR Lecture Hall, NASC Complex, New Delhi. The session was co-organized by ICAR-NIAP and Department of Fertilizer. Shri Chhabilendra Roul, Secretary, Department of Fertilizer, Ministry of Chemicals & Fertilizers, Government of India chaired the session. Stakeholders from fertilizer industry; Fertilizer Association of India (FAI), top management representatives from both public and private fertilizer companies, attended and provided inputs. Representatives from other ministries such as Ministry of Petroleum and Natural Gas, and Department of Agricultural Co-operation and Farmers Welfare, Ministry of Agriculture & Farmers Welfare also shared their experiences in the session.

Policy imperative for promoting value chains of agricultural commodities in India

Two-day annual review workshop of network project on "Policy imperative for promoting value chains of agricultural commodities in India" was organized on June 28-29, 2019 at ICAR-NIAP. The workshop was attended by project partners from SKUAST, Srinagar, CAU, Imphal, ICAR-IVRI, Bareilly, ICAR-NDRI, Karnal, ICAR-IIHR, Bengaluru, CMFRI, Kochi and project team from ICAR-NIAP. Dr Suresh Pal, Director, ICAR-NIAP inaugurated the workshop. Dr Abimanyu Jhajhria presented on the application of system

dynamics (SD) approach in value chain analysis and Dr D. Bardhan presented on the application of system dynamics approach in the goat value chain. The workshop emphasized the need to publish completed work and to move from qualitative analysis to quantitative analysis of value chains with the application of system dynamics approach.

Monetization of ICAR technologies

A meeting of core group of 'Agricultural economists' from selected ICAR institutes on "Monetization of ICAR Technologies" was held at ICAR-NIAP, New Delhi on August 3, 2019. The purpose of this meet was to identify the top ICAR technologies, data need and appropriate common methodology and time frame for assessing impact and prepare a detailed report. Scientists representing ICAR Divisions of crop, horticulture, fisheries, animal science, engineering and natural resource management participated in the meeting. During the meeting top ICAR technologies across divisions were identified along with agreed time frame and methodology to assign monetary value based on evidence of technology impact and made changes in life of people and society. The group agreed to explore existing sources for data about adoption needed for estimating impact. The meeting was presided by Dr Suresh Pal, Director, ICAR-NIAP.

Core group meeting of 'Agricultural economists' on "Monetization of ICAR technologies", August 3, 2019

Impact assessment of ICAR technologies

ICAR-NIAP organized a workshop on "Impact assessment of ICAR technologies" on November 28, 2019. The workshop was inaugurated by Dr Trilochan Mohapatra, Secretary, DARE, and DG, ICAR. ICAR-NIAP policy paper on Market intelligence in Agriculture was also launched on the occasion. Dr Uma Lele, President, International Association of Agricultural Economists (IAAE) attended inaugural session and briefed the participants about the 2021 IAAE meeting scheduled to be held in New Delhi. Impact of 25 technologies were discussed in the 3 technical sessions of the workshop.

Workshop on "Impact assessment of ICAR technologies", November 28, 2019

Climate change: Impact on agriculture and cost of adaptation

A seminar was organized on "Climate change: Impact on agriculture and cost of adaptation" on August 20, 2019 at ICAR-NIAP. Dr Suresh Pal, Director, ICAR-NIAP welcomed and introduced the speaker, Dr Channing Arndt, Director of Environment and Production Technology Division, IFPRI. Dr Shahidur Rashid, Director for South Asia, IFPRI graced the occasion. The lecture was followed by discussion with colleagues from ICAR-NIAP, IFPRI and other ICAR institutes of Pusa campus.

Lecture on "Climate change: Impact on agriculture and cost of adaptation", August 20, 2019

Lecture on "Agricultural research: Then and now"

Dr Marco Ferroni, SMB Chair, CGIAR delivered a lecture on "Agricultural research: Then and now" on July 9, 2019 at ICAR-NIAP. The lecture was chaired by Dr T. Mohapatra, Secretary, DARE and DG, ICAR. The lecture was graced by eminent personalities *viz*. Dr P Carberry, DG, ICRISAT, Dr Arabinda Kumar Padhee, Director, Country Relations and Business Affairs, New Delhi, ICRISAT and Dr Shichiri from FAO. The ICAR-NIAP staff, participants from sister institutes and delegates from CGIAR centers attended the lectures and were benefited from it.

Training on "Agricultural policy analysis and communication" under India Africa Forum Summit-III

ICAR-NIAP successfully organized 10 days training program for African Nationals on "Agricultural policy analysis and communication" under India Africa Forum Summit-III during August 16-25, 2019. Training program was inaugurated by Dr N S Rathore, DDG (Edu), ICAR. Dr Prem Chand, Dr S K Srivastava, Dr Vinayak Nikam and Dr Abimanyu Jhajhria coordinated training program. Training included specialized lectures on emerging issues on agricultural development and hands-on exercises on statistical techniques and measures to address the emerging issues. Field visits to Farmers Producers Company, Aterna, Sonepat and ICAR-CIRG, Mathura were also arranged. The valedictory function was chaired by Mr. Chhabilendra Roul, Secretary, Department of fertilizer, Ministry of Chemical and fertilizer, GOI.

International training programme on "Agricultural policy analysis and communication" for African nationals, August 16-25, 2019

Resource use planning for sustainable agriculture

Review meeting of network project on "Resource use planning for sustainable agriculture" was held at ICAR-NIAP, New Delhi on 29-30 May, 2019. Discussions on case studies by network partners from AAU, BHU, MPUAT, HAU, IARI, PAU and TNAU, on crop planning matrix and technology identification were held. Hands on exercise on refinement of optimum crop plan models was carried out by each partner under the supervision of Director and project team of ICAR-NIAP.

Review meeting of network project on "Resource use planning for sustainable agriculture", May 29-30, 2019

Summer school on "Quantitative methods for social sciences"

ICAR Summer School on "Quantitative methods for social sciences" was organized at ICAR-NIAP during September 21 to October 11, 2019. The training program was coordinated by Dr Vinayak Nikam and Dr Abimanyu Jhajhria. Dr Suresh Pal, Director, ICAR-NIAP inaugurated the training and Professor Abhijit Sen, Former Member, Planning Commission graced the Valedictory session of the training. A book on "Quantitative Methods for Social Sciences" was released in the Valedictory session.

ICAR Summer School on "Quantitative methods for social sciences", September 21- October 11, 2019.

Review meeting for the Agro-Economic Research Centres

The Department of Agriculture, Cooperation and Farmers Welfare decided entrusted ICAR-NIAP the responsibility to review the Agro-Economic Research Centres. The first meeting of the representative of DAC&FW, Agro-Economic Research Centres (AERC, Institute of Economic Growth, New Delhi; AERC, Institute for Social and Economic Change, Bengaluru; AERC, Indian Institute of Management, Lucknow; AERC, Delhi University) and experts was convened on December 7, 2019 at ICAR-NIAP. The meeting was chaired by Dr Ramesh Chand, Member, NITI Aayog.

Review meeting of the Agro-Economic Research Centres, December 7, 2019

Teaching and Research Guidance to Students

Table 3.1. Teaching activities at PG School, ICAR-Indian Agricultural Research Institute

Name of the scientist	Course Name	Credit hours	Role (Course Leader/ Associate)	Division
Rajni Jain	Artificial Intelligence	2+1	Leader	Computer Application
	Advance Data Mining	2+1	Associate	Computer Application
Nalini Ranjan Kumar	Macroeconomics-I	3+1	Associate	Agricultural Economics
	Macroeconomics-II	3+1	Associate	Agricultural Economics
Naveen P Singh	Marketing Management	3+1	Leader	Agricultural Economics
Shiv Kumar	Agricultural Marketing	2+1	Leader	Agricultural Economics
	Fundamentals of Business Management	3+1	Leader	Agricultural Economics
Shivendra Kumar Srivastava	Agricultural Price Analysis	2+1	Associate	Agricultural Economics
	Quantitative Analysis for marketing and Business Decision	2+1	Associate	Agricultural Economics
Kingsly Immanuelraj	Agricultural Price Analysis	2+1	Leader	Agricultural Economics
	Agricultural Production and Resource Economics II	2+1	Associate	Agricultural Economics
	Agricultural Production and Resource Economics III	2+1	Associate	Agricultural Economics
	Agricultural Production and Resource Economics IV	2+1	Associate	Agricultural Economics
Vinayak Nikam	Advance Management Techniques	12	Leader	Agricultural Extension
	Organisational Behaviour	12	Associate	Agricultural Extension

Table 3.2. Guidance to post-graduate students of ICAR-IARI and ICAR-IASRI, New Delhi

Scientist	Student	Role in Advisory Committee	Thesis topic
Suresh Pal	Mrs. Nithyashree, M.L., Ph.D	Chairman	Investment and development of food
	Mr. Biswajit Sen	Chairman	Farmers' choice for adoption of water conservation practices: Evidences from Maharashtra
Nalini Ranjan Kumar	Mr. Thrilok Belli BM, M.Sc., ICAR-IARI	Chairman	Impact of custom hiring services on farm mechanization in Indian agriculture
Rajni Jain	Mr. Sreekumar Biswas, Ph.D., ICAR-IASRI	Chairperson	Document categorization using text mining in agricultural domain
	Mrs. Kamalika Nath, Ph.D., ICAR-IASRI	Chairperson	Nature inspired algorithms for optimization of crop plan
	Ms. Shabana Begam, Ph.D., ICAR-IASRI	Chairperson	Development of particle swarm optimization based model for crop planning
	Ms Sapna Nigam, Ph.D., ICAR-IASRI	Chairperson	Development of Deep Learning Model for identification of major wheat diseases
Shiv Kumar	Chikkathimme Gowda Ph.D (Agricultural Economics), ICAR-IARI	Chairman	An economic analysis of value chain of cumin (*Cuminum cyminum L.*) in India
	Neelakantappa P., M.Sc (Agricultural Economics), ICAR-IARI	Chairman	Contractual arrangements for potato in Gujarat: An economic investigation
Naveen P Singh	Jobin Sebastian, Ph. D, (Agricultural Economics) ICAR- IARI	Chairman	Impact of climate change on rice based cropping system in east coast plains: An analysis in the coastal zones of Andhra Pradesh
	Philip Kuriachen, Ph. D, (Agricultural Economics), ICAR- IARI	Chairman	An economic analysis of impacts and adaptation strategies in Bundhelkand region of central India
	Niranjan Sivalingam, Ph. D, (Agricultural Economics), ICAR- IARI	Chairman	Climate change impact and resilience analysis

CHAPTER 4

Number of policy interface of national importance : 14

- **Strategies for doubling farmers' income:** The Government constituted an inter-ministerial committee to recommend strategies for doubling farmers' income (DFI) in April, 2016 under the Chairmanship of Dr. Ashok Dalwai, CEO, NRAA. The Director, ICAR-NIAP was the member of DFI Committee and presently member of Empowered Body for implementation of DFI strategies. The committee developed DFI strategies, which aimed towards income-centricity, shift to cost efficient agriculture, and adopting sustainable technologies and systems by ensuring a more equitable growth. The Committee's final report was accepted by the Government in September 2018. Implementation of the strategy has begun and being monitored continuously for effective outcomes. ICAR-NIAP, being the Knowledge Partner of DFI Committee provided technical facilitation in designing the framework for DFI strategies and implementation. The Institute provided technical facilitation in designing the framework for proposed "Ease of Doing Agriculture Index", which is being developed for bringing governance reforms across states. Mid-term income estimates, developed in the Institute, were discussed with Hon'ble Minister of Agriculture, NITI Aayog and senior officers at DAC&FW. These are being used by the Government in effective implementation of DFI strategies.
- **Policies for a secure and sustainable agriculture:** A committee was constituted by the Office of Principal Scientific Advisor (PSA) to make the recommendations and action plan for a secure and sustainable agriculture. The Committee was chaired by Dr R.S. Paroda, Chairman, TAAS. The committee made a number of deliberations, which were facilitated by ICAR-NIAP and the office of PSA. The committee made specific recommendations for different sectors, e.g. crops, natural resources, livestock, fisheries and horticulture. The committee recommended that there should be a coordination and monitoring mechanism at the level of NITI Ayog and Farmers' Commission should be established for better implementation of agricultural schemes. There are recommendations for establishment of the new missions (mechanization, livestock, oilseeds, conservation agriculture, and horticulture) to provide the desired impetus to the implementation. Farm subsidies should be reformed and these should be linked to improved and sustainable farm practices, and reforms in input and product markets should be undertaken. Investment in R&D should be enhanced to harness the potential of science, and agri-entrepreneurship should be encouraged in KVKs for attracting youth in agriculture. Some of the recommendations have been implemented by the Government.
- **Fertilizers trade policies:** ICAR-NIAP undertook a consultancy project on 'Framing Policy for Overseas Acquisition of Raw Material by the Indian Fertilizer Companies and Role of the Government' for the Department of Fertilizers, Ministry of Chemicals and Fertilizers, Government of India. The study was carried out involving different stakeholders like Ministry of External Affairs, Ministry of Petroleum and Natural Gas, Ministry of Agriculture and Farmers Welfare, Fertiliser Association of India (FAI), fertilizer companies such as RCFL, NFL, IFFCO, IPL, KRIBHCO, GSFC, SFC, Chambal Fertilizers and Indorama. The study looked into the overall fertilizer's availability scenario, India's import dependence both at present and in future likely scenario, the import mechanism and international market scenario of import of fertilizers, their raw materials, feedstock, natural gas and intermediaries. It also compared the policies/ policy framework of any other department

of GOI and other countries. The study came up with a policy framework for encouraging international co-operation and role of the Government for ensuring the availability of fertilizers to Indian farmers at a reasonable price. The study provided strategies for the Department of Fertiliser for securing supply of fertilizer and feedstock for fertilizer industry in India.

- NITI Aayog is preparing Vision 2035 for different sectors of the economy. ICAR-NIAP has prepared draft working paper for agriculture and allied sectors. The paper presented evaluation of transitions in agriculture and discussed emerging opportunities and challenges for a paradigm shift towards sustaining food and nutritional security and accelerating overall economic development in the country. The inputs provided in the paper would form basis for the Vision 2035 document of NITI Aayog.
- As a representative of DARE/ICAR, ICAR-NIAP regularly participated and provided inputs to Inter-Ministerial Committee (IMC) constituted by Department of Consumers Affairs, Ministry of Consumers Affairs, Food and Public Distribution to review prices of essential commodities and agricultural scenario in the country. The Committee comprised of representatives of Consumers Affairs and other departments of different ministries besides special invitees, viz. FCI, SFAC, Food and Supply Department of Delhi, NAFED, Mother Dairy etc. The Committee reviews the prices on weekly basis under the Chairmanship of the Secretary, Consumers Affairs/Senior Economic Advisor (CA) at Krishi Bhawan.
- ICAR-NIAP was given the responsibility of review of Agro-Economic Research Centres (AERC). Consultations with stakeholders to assess the output and outcomes were undertaken at ICAR-NIAP.
- ICAR-NIAP provided inputs to Ministry of Agriculture and Farmers Welfare on the revision of wholesale price index of agricultural commodities.
- Deliberations with various stakeholders for improving contents and modalities for the implementation of Situation Analysis of Farm Households, Indebtedness and Livestock Survey of NSSO.
- ICAR-NIAP provided technical inputs to NABARD for next phase of All India Rural Financial Inclusion Survey. Also, provided expert advice on the prioritization of research proposals.
- ICAR-NIAP provided inputs to Department of Commerce on formulation of New Export Policy and strategy to implement the policy.
- ICAR-NIAP contributed to Agriculture Centre of South Asian Association of Regional Cooperation (SAARC) through a country paper on "Fostering investment for sustainable agricultural development for SAARC member countries: Public-Private-Farmer Cooperation (PPFC)". The paper presented evaluation of investment pattern in Indian agriculture and discussed how the approach of PPFC can foster investment in agriculture to unleash economic potential of agriculture and address the emerging challenges for sustainable agricultural development.
- The NITI Aayog under took an exercise to develop a framework for rating and ranking of R&D labs. ICAR-NIAP represented ICAR and contributed to the development of framework and in particular inputs were provided on assessment of socio-economic impact. This framework is being implemented by the office of Principal Scientific Adviser to the Government of India and ICAR-NIAP is the part of the process.
- The DAC&FW is undertaking a major program to institutionalize the capacity

for development of market information and price forecasting system. ICAR NIAP is a knowledge-partner of DAC&FW and shall help develop the mechanism for price forecasting and development of AI platform.

- The outcome review of ICAR is under progress and ICAR-NIAP is facilitating this exercise. Information on significant research outputs and their outcomes were compiled by ICAR-NIAP and submitted to the Committee for finalization of the report.

CHAPTER 5

Edited book	: 1
Policy paper/policy brief	: 2
Peer reviewed research articles	: 41
Book chapters	: 18
Abstracts/conference proceedings	: 20
Popular articles	: 9
Newspaper articles	: 8

Edited Book

Nikam, V., Jhajhria, A. and Pal, Suresh. (2019). Quantitative Methods for Social Sciences. ICAR-National Institute of Agricultural Economics and Policy Research, New Delhi.

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CHAPTER 6

Membership of committees/
Working groups of national importance : 10

Suresh Pal

- Member, Committee for providing specific views on all issues related to DARE/ICAR to the Fifteenth Finance Commission constituted by Secretary DARE & DG, ICAR.
- Member, Inter-Ministerial Committee for recommending strategy for doubling farmers' income, DAC&FW.
- Member, Technical Committee on Market Intelligence (Supply Management, Price and Demand Forecasting) under the Chairmanship of CEO, National Rainfed Area Authority.
- Member, Committee for 'Agricultural Policies and Action Plans for a Secure and Sustainable Agriculture' constituted by Principal Scientific Adviser to the Government of India.
- Member, Core-Committee to Prepare Policy Document on Futuristic Crop Planning for 2030/2050 under the chairmanship of Deputy Director General (NRM).
- Member Secretary, Committee to undertake an Outcome Review of various Schemes of ICAR for XII Plan period.
- Member, Internal Committee to study and suggest implementation plan for the recommendations made by the High Powered Committee constituted by the Government to review the structure and function of ICAR.
- Representative of ICAR as Member of Task Force to prepare the framework with specific indicators to rank the scientific laboratories/ institutions.
- ICAR nominee for Committee constituted by Department of Science and Technology to review Policy Research Centres.
- Member, Research Advisory Committee for setting up Institute specific annual work-plan and targets for AERCs/ Units at Institute of Economic Growth.
- Member, Editorial Board of *The Indian Journal of Agricultural Sciences.*

Pratap Singh Birthal

- Chairman, NSSO Working Group on Situational Analysis of Farm Households, Indebtedness and Livestock holdings, Ministry of Statistics and Program Implementation, Government of India.
- Member- Sub-group on Agricultural Commodities for Revision of Wholesale Price Index, Ministry of Agriculture and Farmers Welfare, Government of India
- Member, External Research Committee, National Bank for Agriculture and Rural Development, Mumbai.
- Member, Research Advisory Committee, Indian Veterinary Research Institute, 2017-2020.
- Member- Quinquennial Review Team, Indian Institute of Rice Research, Hyderabad.
- Chairman of the session "Food Systems Transitions underpinning rural-urban and nutrition linkages" Organized by CRP-GLDC and ICRISAT in the 27th Annual Conference of Agricultural Economics Research Association on Changing Landscape of Rural India at Punjab Agricultural University, Ludhiana, Punjab, December 17-19, 2019.
- Convener of a Brainstorming Session on "Payment for Ecosystem Services in Agriculture" organized by NAAS at NASC complex New Delhi on October 31, 2019.
- Chief Editor, *Agricultural Economics Research Review*.
- Member Editorial Board, *SAARC Agriculture Journal*.

Nalini Ranjan Kumar

- Member, Editorial Board, Potato Journal, a Journal of Indian Potato Association, ICAR-CPRI, Shimla
- Member, Board of School of Agricultural Sciences & Rural Development, Nagaland University.

- Reviewer of *Potato Journal*, *Fishery Technology*, *Indian Journal of Agriculture Sciences* and *Journal of Indian Fisheries Association*.

Rajni Jain

- Member, Institute Management Committee, IASRI, 2019-20
- Member, Executive Committee, Indian Society of Agricultural Information Technology (INSAIT), 2019-20
- Evaluator, Mentor and Jury Member, ICAR Representative, Smart India Hackathon, 2019, organised by Ministry of Human Resource and Development at CSO-CSIR, Chandigarh, 8-12 July 2019

Subhash Chand

- Member of expert group CSIR-NISTADS, Delhi, on the ongoing study on "Socio-Economic Impact assessment of CSIR-Aroma Mission" on 20-11-2019.
- Member of committee for selection of RAs and SRFs for the projects undertaken at ICAR-NIAP, New Delhi.

Sant Kumar Pandey

- Member, Executive Committee, Indian Society of Agricultural Economics, Mumbai.

Naveen P Singh

- Member, Editorial Board, *Agriculture Economics Research Review*.
- Member, Editorial Board, *Weather and Climate Extremes*, Elsevier.
- Member, Indian Society of Agricultural Economics.
- Member, Editorial Board, *Journal of Atmospheric Science Research*.
- Members, FICCI Committee on Commodity Markets.
- Member, CAS meeting for ARS Scientists at ICAR-IIVR, Varanasi, UP
- Member, Quinquennial Review Team, ICAR-NIAP, New Delhi
- Member, Institute Management Committee, IIMR, PAU Campus, Ludhiana.
- Member, CAS meeting for ARS Scientists at ICAR-CTRI, Rajahmundry, Andhra Pradesh.
- Member, Institute Management Committee, ICAR-NIASM, Baramati, Pune.
- Member, Institute Management Committee, IIMR, PAU Campus, Ludhiana.
- Member, Selection Committee for PhD admissions, ICAR-IARI, New Delhi.
- Panellist in evaluation of Uma Lele Award and YAE award by AERA, New Delhi.
- Reviewer of • *Indian Journal of Traditional Knowledge, CSIR*; • *Science of Total Environment, Elsevier*; • *Environment, Development and Sustainability, Springer*; *International Journal of Water Resources Development*, Taylor & Francis • *Natural Hazards, Springer*; • *Climate Risk Management*; Elsevier and *Journal of Agrometerology*

Raka Saxena

- Theme Leader, Session on Doubling Farmers Income: Technologies, Business Models and Sustainable, in International Workshop on Strengthening International Agribusiness Trade: Stakeholder Dialogue and Partnerships towards SDGs, TERI School of Advanced Studies, New Delhi.
- Reviewer for *Journal of Agribusiness* in *Developing and Emerging Economies*, *Theoretical and Applied Climatology*, *Indian Journal of Dairy Science*, *Agricultural Research and Agricultural Economics Research Review*.

Shivendra Kumar Srivastava

- Panelist in the panel discussion on "Integrating value chain for agricultural water management" in India Water Week-2019, New Delhi on September 26, 2019.

- Keynote lecture on "Improving nutrition outcomes in India: Drivers and policy interventions" in International Workshop on Strengthening International Agribusiness Trade at TERI University, New Delhi on November 14, 2019.
- Recognized as a resource person by NITI Aayog to prepare a working paper and subsequently Vision 2035 on agriculture and allied sectors.
- Recognized as expert by SAARC Agriculture Centre to contribute a country paper on "Fostering investment for sustainable agricultural development for SAARC member countries: Public-Private-Farmer Partnership (PPFC)."
- Member, Publication Committee for 8th International Conference on Agricultural Statistics, Organized by Food and Agriculture Organization (FAO) and ICAR-Indian Agricultural Statistics Research Institute in New Delhi during November 18-21, 2019.
- Re-inducted as faculty member in the Discipline of Agricultural Economics, IARI, New Delhi.

Vinayak Nikam

- Recognition as research guide by Post Graduate School of Indian Agricultural Research Institute, New Delhi.

Subash SP

- Reviewer of *Journal of Agricultural Education and Extension*, *Journal of Agribusiness in Developing and Emerging Economies* and *Asian Development Perspectives.*
- Rapporteur, Impact Assessment of ICAR Technologies workshop.

CHAPTER 7

Table 7.1. Lectures delivered by ICAR-NIAP Scientists

Name of the scientist	Topic	Venue and Date
Suresh Pal	Agricultural policy in India	ICAR-IASRI, New Delhi May 21, 2019
	Priorities and strategies to boost farmers income	IISR, Lucknow June 14, 2019
	Agricultural price policy in India: Learnings and recommendations	ICAR-NIAP, New Delhi August 16, 2019
	Agriculture price policies	ICAR-NIAP, New Delhi September 23, 2019
	Smallholder aggregation model for efficient value chain and their financing	Hotel Taj Palace, New Delhi November, 12, 2019
Pratap Singh Birthal	Climate change and rural transformation in India	NASC Complex New Delhi, April 26, 2019.
	Sources of growth in Punjab agriculture	Punjab Agricultural University, Ludhiana, September 6, 2019
	Foundation day lecture on transition in India's agri-food policy	SKAUST-J, Jammu on September 19, 2019.
	Policies for livestock development	NASC Complex, New Delhi, November 1-2, 2019
	Aligning agricultural schemes with green box provision of WTO	Punjab Agricultural University, Ludhiana, Punjab, December 17-19, 2019
Nalini Ranjan Kumar	Farm mechanisation: Impacts and institutional mechanism	ICAR-NIAP, New Delhi August 23, 2019
	Farm mechanization in India	IARI, New Delhi October 7, 2019
	Contract farming in potato	CPRIC, Modipuram December 6, 2019
Rajni Jain	AHP approach for suitability analysis of cereal crops	Ashoka Hotel, New Delhi November 21, 2019
	Data mining using decision tree	Lady Irwin College, University of Delhi April 4, 2019
	Data mining using WEKA	Lady Irwin College, University of Delhi April 4, 2019
	A practical approach towards decision tree induction	ICAR-NIAP, New Delhi September 25, 2019

Name of the scientist	Topic	Venue and Date
	Text mining using R	ICAR-IASRI, New Delhi September 30, 2019
	Artificial intelligence, big data and machine learning: An overview	ICAR-NIAP, New Delhi October 1, 2019
Subash Chand	Watershed Programmes & Policies: Impact on Indian Agriculture	SKUAST, Jammu September 13, 2019
	Impact assessment of natural resources conservation programs	ICAR-NIAP, New Delhi October 10, 2019
	Watershed Programmes & Policies and Impact on Indian Agriculture	ICAR- NIAP, New Delhi August 23, 2019
	Vision of Mahatma Gandhi on socio economic upliftment of rural India	ICAR- NIAP, New Delhi October 03, 2019
Sant Kumar	Agricultural R&D policy and systems in India	ICAR-NIAP, New Delhi August 24, 2019
	Research priorities in Indian agriculture	ICAR-NIAP, New Delhi October 5, 2019
Naveen P Singh	Setting research priorities and policies for climate resilient agriculture	ICAR-NIAP, New Delhi August 22, 2019
	Role of policy research in the sustainable development of agricultural sector	ICAR-ATARI, Ludhiana, Punjab 27 August, 2019
	Analytical approaches on doubling farmers' Income	ICAR-IARI, New Delhi October 1-21, 2019
Raka Saxena	Potato price linkages among the northern hill and plain markets	ICAR-CPRI Regional Station, Modipuram, December 6, 2019
Prem Chand	Sustainable Agriculture Production India: A policy tool	ICAR-NIAP, New Delhi, August 19, 2019
Shivendra Kumar Srivastava	Analysis of changing structure of crop production cost and its effects on farmers income	ICAR-NIAP, New Delhi August 19, 2019
	Change in cost of production in India: Input prices, substitution and technological effects	ICAR-IARI, New Delhi, October 18, 2019

Name of the scientist	Topic	Venue and Date
Kingsly Immanuelraj T	Price transmission and Cereal Outlook Model	ICAR-NIAP, New Delhi August 21, 2019
	Market integration	ICAR-NIAP, New Delhi August 26, 2019
	Computing TFP using DEA and SFA	ICAR-NIAP, New Delhi September 10, 2019
Vinayak Nikam	Role of FPOs in nutrition security	ICAR-IARI, New Delhi August 28, 2019
	Farmers innovations: Case analysis	ICAR-NIAP, New Delhi January 4, 2019
	Effective policy communication	ICAR-NIAP, New Delhi August 24, 2019
Jaya Jumrani	Food and nutritional security in India	ICAR-NIAP, New Delhi August 24, 2019
Balaji S.J.	STATA: An introduction	ICAR-NIAP, New Delhi September 21, 2019
	Panel data and instrumental variables (IV) regressions in social science research	ICAR-NIAP, New Delhi September 21, 2019
Abimanyu Jhajhria	Horticulture development in India	ICAR-NIAP, New Delhi August 25, 2019
Prabhat Kishore	Impact assessment of Direct Benefit Transfer (DBT): Evidences from micro-irrigation schemes"	ICAR-NIAP, New Delhi August 24, 2019
	Synthetic control method for impact assessment	ICAR-NIAP, New Delhi October 1, 2019
Subash SP	NSSO data extraction using STATA software	ICAR-IARI, New Delhi October 15, 2019
	Regression discontinuity design	ICAR-NIAP, New Delhi September 30, 2019
	Social network analysis	ICAR-NIAP, New Delhi October 1, 2019
	Agricultural input markets in India: Recent policy reforms and way forward	ICAR-NIAP, New Delhi August 16, 2019
	Agricultural technology policies and strategies in India	IFPRI South Asia Office, New Delhi May 2-7, 2019

Table 7.2. Training/Seminar/Conference attended

Name of the scientist	Name of the event	Venue and duration
Suresh Pal	National Conference on Growth and Regional Development in India: Recent Experiences and Emerging Perspectives	India International Centre Lodhi Estate, New Delhi May 13, 2019,
	Workshop on Integrative Value Chain Analytics Supporting Food Systems Transformation	ICRISAT, Hyderabad May 27- 31, 2019
	Brain storming Workshop on Enhancing Science Culture in Agriculture Research Institutions	NASC Complex, New Delhi June 25, 2019,
	Executive Development Programme	ASCI, Hyderabad August 9-11, 2019
	Workshop on Efficient Participatory Irrigation Institutions to Support Productive and Sustainable Agriculture in South Asia	Ganga Sabhaghar, Adhiveshan Bhavan, Patna September 17, 2019
	National Dialogue on Land Use for Integrated Livestock Development	NASC Complex, New Delhi November 1-2, 2019
	6th World Congress on 'Rural and Agricultural Finance: Critical Input to Achieve Inclusive and Sustainable Development	Hotel Taj Palace, New Delhi November 12, 2019
	Session on Sustainability Assessment of Agriculture in International Conference on Agricultural Statistics (ICAS)	Hotel Ashok, New Delhi November 19, 2019
	Annual Seminar of Fertilizer Association of India on New Approach to Fertilizer Sector	Hotel Andaz, Delhi December 2-3, 2019.
	Roundtable Discussion on Policies for Enhancing Private Sector Investment in Agriculture to Make Indian Farmer Globally Competitive	NASC Complex , New Delhi December 4, 2019
	27th Annual Conference Agricultural Economics Research Association on Changing Landscape of Rural India	Punjab Agricultural University, Ludhiana, December 17-19 , 2019

Name of the scientist	Name of the event	Venue and duration
PS Birthal	Policy Forum on Social Transfers to Revitalize Rural India	NASC Complex, New Delhi April 26, 2019
	13th Indo-Japanese Dialogue on Indian Economic Development	Punjab Agricultural University, Ludhiana, September 6, 2019
	Brainstorming Session on Payment for Ecosystem Services in Agriculture	NASC complex, New Delhi October 31, 2019.
	National dialogue on Land Use for Integrated Livestock Development	NASC complex, New Delhi November 1-2, 2019
	27th Annual Conference Agricultural Economics Research Association on Changing Landscape of Rural India	Punjab Agricultural University, Ludhiana December 17-19 , 2019
	102nd Annual conference of Indian Economic Association	Pandit Ravi Shankar University, Raipur December 29, 2019
Rajni Jain	8th International Conference on Agricultural Statistics	Ashoka Hotel, New Delhi November 18-21, 2019
	Prof Gildhial Memorial Lecture	ICAR-IARI, New Delhi September 25, 2019
	User Conference 2019 on GIS: Creation Vision for a New India	Leela Ambience, Gurgaon August 28-29, 2019
Subhash Chand	Land Use Planning with Partners	ICAR-NIAP, New Delhi May 29-30, 2019
	Annual IRC Meeting	ICAR-NIAP, New Delhi June 10 -11,2019
	QRT Meeting	ICAR-NIAP, New Delhi July 18, 2019
	National Seminar on the Common: Past and Future Security	NASC complex, New Delhi October 4, 2019
	International Conference on Soil and Water Resource Management for Climate Smart Agriculture, Global Food and Livelihood	NASC complex, New Delhi November 5-9, 2019
	Review Meeting of Agro Economic Research Centers	ICAR-NIAP, New Delhi December 7, 2019
	27th Annual Conference Agricultural Economics Research Association on Changing Landscape of Rural India	Punjab Agricultural University, Ludhiana, Punjab December 17-19 , 2019
	Water Walk and Talk Programme	National Water Mission Government of India, New Delhi July 19, 2019

Name of the scientist	Name of the event	Venue and duration
S K Pandey	Policy Forum on Social Transfers to Revitalize Rural India and Launch of IFPRI Global Food Policy Report-2019	NASC Complex, New Delhi April 26, 2019
	Committee Meeting of Enhancing Brand Visibility of ICAR	Krishi Bhawan, New Delhi May 14 and Jun 12, 2019
	Review Meeting of Sustainability of Indian Agriculture	ICAR-NIAP, New Delhi June 18-19, 2019
	Brainstorming Session on Loan Waiving Versus Income Support Schemes: Challenges and Way Forward	NASC Complex, New Delhi June 24, 2019
	Release of India Social Development Report 2018: Rising Inequality in India	IIC, New Delhi June 24, 2019
	First Meeting of IV QRT of NIAP	ICAR-NIAP, New Delhi July 18, 2019
	Promoting Brand ICAR	Krishi Bhawan, New Delhi September 13, 2019
	Second Meeting of IV QRT of NIAP	ICAR-NIAP, New Delhi September 24, 2019
Naveen P Singh	26th General Board Meeting and foundation Day Programme of the academy	NASC Complex, New Delhi June 4-5, 2019
	Workshop on Mapping the Adoption of Improved Cultivars of Major Horticultural Crops and Assessing their Impact in India	NASC Complex, New Delhi June 12, 2019
	1st meeting of Quinquennial Review Team meeting of ICAR-NIAP	ICAR-NIAP, New Delhi July 4, 2019
	Integrated Farming System	NIASM, Baramati, Pune July 16-17, 2019
	Workshop on Securing Supply of Fertilizer and Feedstock for Fertilizer Industry in India	NASC Complex, New Delhi August 29, 2019
	Stakeholder Workshop of EPICC project	Habitat Centre, New Delhi September 17, 2019
	Agri-entrepreneurship Orientation Programme Trainees of CCS NIAM	ZTM & BPD, IARI, New Delhi October 11, 2019
	Brainstorming Session on Payment for Ecosystem Services in Agriculture	NASC, Complex, New Delhi October 31, 2019

Name of the scientist	Name of the event	Venue and duration
	Indo-Brazil Cross Border Incubation Program by Pusa Krishi Incubator, ICAR- IARI	NASC Complex, New Delhi December 09, 2019
	Meeting with NCAER Officials to bring closure to the project Impact Assessment of major technologies developed by NARS - Contribution of ICAR Institutes to Agricultural Policy	ICAR, New Delhi August 20, 2019
	Second Quinquennial Review Team meeting of ICAR-NIAP	ICAR-NIAP, New Delhi September 24, 2019
	Seminar on Acceleration of Investments in Climate Smart Agriculture	Hotel Le Meridien, New Delhi October 22, 2019
	Workshop of Impact of ICAR Technologies	NASC Complex, New Delhi November 28, 2019
	NICRA Annual Workshop	NASC Complex, New Delhi December 17-18, 2019
Raka Saxena	Growth and Regional Development In India: Recent Experiences and Emerging Perspectives	Institute for Human Development (IHD), Delhi May 13-15, 2019
	Strengthening International Agribusiness Trade: Stakeholder Dialogue and Partnerships towards SDGs	TERI School of Advanced Studies, New Delhi November 14-15 2019
	Roundtable on Indo-Australia Agribusiness Trade	TERI School of Advanced Studies, New Delhi November 15, 2019
Purushottam Sharma	Workshop on Integrative value chain analytics supporting food systems transformation	ICRISAT, Hyderabad May 27-31, 2019
Prem Chand	Workshop on Securing supply of fertilizer and feedstock for fertilizer industry in India	NASC Complex, New Delhi August 29, 2019
	Workshop on Agricultural sustainability indicators: Methods and weight determination	Amity University, Noida August 31, 2019
	Brainstorming session on Payment for ecosystem services in agriculture	NASC complex, New Delhi October 31, 2019
	Training on IFPRI IMPACT Model	ICAR-NIAP, New Delhi November 4-8, 2019

Name of the scientist	Name of the event	Venue and duration
	National dialogue on Land Use for Integrated Livestock Development	NASC complex, New Delhi November 1-2, 2019
	27th Annual Conference of Agricultural Economics Research Association on changing Landscape of Rural India	Punjab Agricultural University, Ludhiana December 17-19, 2019
Shivendra Kumar Srivastava	Workshop on Securing Supply of Fertilizer and Feedstock for Fertilizer Industry, NASC Complex	NASC Complex, New Delhi August 29, 2019
	Training on IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (IFPRI-IMPACT)	ICAR-NIAP, New Delhi November 4-8, 2019
	8th International Conference of Agricultural Statistics (ICAS 2019)	Ashoka Hotel, November 18-21, 2019
	27th Annual Conference of Agricultural Economics Research Association on Changing Landscape of Rural India	Punjab Agricultural University, Ludhiana December 17-19, 2019
Kingsly Immanuelraj T	International Training Workshop on Integrative value chain analytics supporting food systems transformation	ICRISAT, Hyderabad May 27-31, 2019
	Workshop of IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (IFPRI-IMPACT)	ICAR-NIAP, New Delhi November 4-8, 2019
Vinayak Nikam	Workshop on Impact Assessment of ICAR Technologies	ICAR-NIAP, New Delhi November 28, 2019
Jaya Jumrani	15th Annual Conference on Growth and Development	Indian Statistical Institute, New Delhi December 18-20, 2019
Balaji S.J.	Training on IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (IFPRI-IMPACT)	ICAR-NIAP, New Delhi November 4-8, 2019
	The Forced Exile of Rohingyas into Bangladesh: Economic and Nutritional Outcomes and Future Policy Options	International Food Policy Research Institute (IFPRI), Washington DC July 10, 2019

Name of the scientist	Name of the event	Venue and duration
	Addressing Water Variability and Scarcity: The Role of Agricultural Research	International Food Policy Research Institute (IFPRI), Washington DC July 17, 2019
	Discussion on the Key Findings of FAO's 2019 State of Food Security and Nutrition in the World Report	International Food Policy Research Institute (IFPRI), Washington DC, July 18, 2019
	Agricultural and Applied Economics (AAEA) Annual Meet 2019	Atlanta GA, USA July 21-23, 2019
	Workshop on Agricultural Transformation	Bali, Indonesia September 30- October 4, 2019
	Umable-Aera (India)-AAEA Mentorship programme	IFPRI, Washingtorn DC, July 2-30, 2019
Abimanyu Jhajhria	Workshop on Integrative value chain analytics supporting food systems transformation	ICRISAT, Hyderabad May 27-31, 2019
	Training on IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (IFPRI-IMPACT)	ICAR-NIAP, New Delhi November 4-8, 2019
	Food Systems Dialogue 2019	New Delhi November 11, 2019
	Eighth International Conference on Agricultural Statistics	Hotel Ashok, New Delhi November 18-21, 2019
Prabhat Kishore	International Conference on Soil and Water Resources Management for Climate Smart Agriculture, Global Food and Livelihood Security	NASC Complex, New Delhi November 5-9, 2019
	Workshop on Impact of ICAR Technologies	ICAR-NIAP, New Dellhi November 28, 2019
Prem Narayan	Rajbhasha Mahotsav	National Physical Laboratory New Delhi October 23-24, 2019
Khyali Ram	National Conference on Role of Agricultural Libraries in the Networked Digital Environment	Navsari Agricultural University, Navsari (Gujarat) September 25-27, 2019
	J-Gate@CeRA Regional Training Program 2019	NASC Complex, New Delhi October 23, 2019
Sonia Chauhan	Workshop of ICAR Research Data Repository for Knowledge Management	NASC Complex, New Delhi December 10-11, 2019

Participation in Other Scientific Events

Suresh Pal

- Meeting of the Working Group – Evaluation of Science Indicators of Centrally Funded R&D Organizations on May 14, 2019 at Lodhi Road, New Delhi
- 26th General Body Meeting and Foundation day program of NAAS on June 4-5, 2019 at NASC, New Delhi.
- Chaired the session on India-Africa Cooperation in Agriculture: Prospects and Challenges in RIS-IRRI Roundtable on India-Africa Partnership in Agriculture on June 7, 2019 at India Habitat Centre, New Delhi.
- 8th half yearly NARAKAS Hindi meeting June 26, 2019, NASC, New Delhi.
- Brainstorming session on Technological Innovations and Strategies for Farmers' Prosperity in Rajasthan at NASC complex on July 13, 2019.
- Foundation Day and Award Ceremony of ICAR on July 16, 2019 at NASC complex.
- Interaction with the ICAR committee on Crop Planning at ICAR- Indian Institute of Farming Systems Research (IIFSR), Modipuram, Meerut on July 21, 2019.
- Meeting to discuss India's joining of the OECD's Committee for Scientific and Technological Policy at India Habitat Centre, New Delhi on July 23, 2019.
- Presentation on Doubling Farmers Income-Action Taken thereof to Hon'ble Minister of Agriculture & Farmers Welfare at Krishi Bhawan on August 19, 2019.
- MoU signing ceremony between ICAR and Ministry of Micro Small and Medium Enterprises (MSME) at NASC Complex, New Delhi on August 21, 2019.
- Chaired a session on Agriculture-Industry Linkages in National Seminar on Inter-Sectoral Linkages, Productivity and Competitiveness of Agro and Food Processing Industries in India at JNU, New Delhi on September 20, 2019.
- Presentation on 'Agriculture Price Forecasting in India-Recent Developments and Way Forward' in 'India Agricultural Outlook Forum 2019' organized by the Department of Agriculture Cooperation and Farmers Welfare at NASC Complex on September 27, 2019.
- Two-day seminar on EU Food Standards, Farming Policy and Trade organised by the Directorate General for Agriculture and Rural Development of the European Commission on October 10, 2019 at Andaz Hotel, Aerocity, New Delhi
- राजभाषा महोत्सव at National Physics Laboratory, New Delhi on October 23, 2019.
- Meeting on liberalization and simplification of FDI policy in various sectors at Udyog Bhawan, New Delhi on 29 October, 2019.
- Brainstorming Session on 'Payment for Ecosystem Services in Agriculture' organized by NAAS Academy at NASC complex on October 31, 2019 .
- National Dialogue on 'Land Use for Integrated Livestock Development' organized by TAAS, ICAR and ILRI at NASC Complex on November 1-2, 2019.
- 2nd meeting of Working Group for Evaluation of Science Indicators of Centrally Funded R&D Organizations at Prithivi Bhawan, New Delhi on November 5, 2019.
- Meeting on Examination of Demands for Grants (2019-20) of the Ministry of Agriculture & Farmers Welfare (Department of Agricultural Research & Education) at Parliament House, New Delhi on November 6, 2019.
- Second edition of `Food Systems Dialogues' organized by Bharat Krishak Samaj on

November 11, 2019 at India International Centre, New Delhi.

- NARAKAS 2nd half yearly meeting of the year 2019-20 at NASC Complex on November 11, 2019.
- 6th World Congress on 'Rural and Agricultural Finance : Critical Input to Achieve Inclusive and Sustainable Development' organized by APRACA, Business Session (BS2) on `Smallholder Aggregation Model for Efficient Value Chain and their Financing' at Hotel Taj Palace, New Delhi on November 12, 2019.
- Chief Guest for the Valedictory function and delivered valedictory address in International Workshop on Strengthening International Agribusiness trade at TERI School of Advanced Studies, New Delhi on November 15, 2019.
- Panelist for Panel Discussion on Agrochemicals for Sustainable Farming in Country: Key Issues and Concerns in 1st National Agrochemical Congress at B.P. Pal Auditorium, IARI, on November 16, 2019.
- Inaugural Function of ICAS on November 18, 2019 at ICAR Convention Hall, NASC Complex, New Delhi, India.
- Chaired technical session on Sustainability Assessment of Agriculture; Sustainability Indicators; Bio-Physical Indicators, Socio-Economic Indicators, Ecosystem Valuation in 'International Conference on Agricultural Statistics (ICAS)' at The ASHOK, Chanakyapuri, New Delhi on 19 November 2019.
- Australia-India Agricultural Research Roundtable. The Roundtable hosted by the Australian Government Department of Education in conjunction with the University of Western Australia and Western Sydney University on 21 November at 'Kamal Mahal' ITC Maurya Hotel, New Delhi.
- Roundtable Discussion on 'Policies for Enhancing Private Sector Investments in Agriculture to Make Indian Farmer Globally Competitive' and lead discussant in Group II on 'Making Indian Farmers Globally Competitive' organized by TAAS at Hotel Taj Palace on December 4, 2019.
- Agro-Economic Research Centres and experts meeting on December 18, 2019 at PAU, Ludhiana

Nalini Ranjan Kumar

- Evaluated Ph.D thesis entitled 'Analysis of Cashew Value Chain in Tamil Nadu; Perspectives on Structure, Governance and Rural livelihood opportunities', TNAU, Coimbatore (TN).
- Evaluated Ph.D thesis entitled 'An Economic Study of Production, Processing and Marketing of Maize in District Etah (UP)' , CSAAU&T, Kanpur
- Evaluated Master of Business Administration Thesis entitled 'A study on Quality of Work life (QWL) of Employees in Textile Mill', TNAU Coimbatore
- Evaluated Master of Business Administration Thesis entitled 'Stakeholder Analysis of Key Techno-Commercial Enablers on Adoption of Solar water Pumps in Coimbatore District', TNAU Coimbatore

Rajni Jain

- Panel discussion on NIAP@2020, organized by ICAR-NIAP at CC Maji auditorium, NIAP on May 2, 2020.
- NAHEP review workshop organized by NAHEP, Education Division, ICAR, New Delhi, at NASC Complex, New Delhi during August 5-6, 2019.
- NAHEP Component II review workshop organized by IASRI, New Delhi at NASC Complex during September 17-18, 2019.
- Brainstorming Session on 'Payment for Ecosystem Services in Agriculture' organized

by National Agriculture Science Academy at NASC, DPS Marg, New Delhi on October 31, 2019.

- NAHEP review workshop organized by NAHEP, Education Division, ICAR, New Delhi, KAB-II, New Delhi on December 20, 2019.
- Workshop on Impact Assessment of ICAR Technologies at ICAR-NIAP on November 28, 2019.
- Brainstorming Session on Big Data Analytics in Agriculture organized by National Agriculture Science Academy at NASC, New Delhi on December 18, 2019.
- 4th Workshop of Officer In-Charge, Research Data Management/Nodal Officers of ICAR Research Data Repository for Knowledge Management initiative organized by IASRI, New Delhi at NASC, DPS Marg, New Delhi during December 10-11, 2019.

Naveen P Singh

- Evaluated Ph.D thesis entitled 'Economic Valuation of Indigenous Dairy Breeds-A Case of Sahiwal in India', NDRI Karnal.
- Evaluated Ph.D. thesis entitled, 'Sustainability of Dairy Farms in Karnataka, Tamil Nadu Agricultural University, Coimbatore.
- Evaluated Ph.D. thesis entitled 'Value Chain Analysis of Dairy Processing Units in Karnal District of Haryana' NDRI, Karnal.
- Reviewer of the manuscript entitled 'Multi-Peril Crop Insurance in India: A Review and Assessment', IIM, Ahmedabad.
- External examiner to conduct preliminary oral examination of Ph. D Scholar, Department of Agricultural Economics, C.S. Azad University of Agriculture & Technology, Kanpur.
- External examiner to conduct Ph. D viva-voice examination, SKN College of Agriculture, Jobner.
- Contributed for preparation of draft report of Outcome review of ICAR, 2019.
- Contributed for the report on 'Policies and Action Plan for a Secure and Sustainable Agriculture' headed by Dr R.S. Paroda.
- Inputs provided for various Parliamentary Questions especially on Policy for Becoming a Global Force in Science and Conversion of Agricultural Zone in to Industrial Zones.

Subhash Chand

- Evaluated Ph.D thesis on 'Economic Evaluation of Sericulture Production in Jammu Region', SKUAST, Jammu.
- Evaluated M.Sc. thesis on 'Economic Analysis of Production and Marketing of Mustard in Jammu District', SKUAST, Jammu.
- Evaluated Ph.D thesis on 'Political Will as Driver of Community Participation in Watershed Programme in India. Delhi University.
- Conducted viva-voce exam for M.Sc. Ag Economics student of SKUAST, Jammu on September 13, 2019.
- Conducted viva-voce exam for M.Sc. Ag Economics student of SKUAST, Jammu on September 27, 2019.

S K Pandey

- External examiner for Ph.D. Scholar for evaluation of thesis on 'A Study on Market Arrivals and Price Trend of Potato in the Selected Markets of Uttar Pradesh' and for conducing viva-voce of Ph.D scholar at Banaras Hindu University on September 30, 2019.

Raka Saxena

- Launch of reports on Inequality and Farmers' Suicides and Inequality and the Demand for Non-Farm Jobs from National Institute of Advanced Studies at International Centre on November 13, 2019.

Shivendra Kumar Srivastava

- Meeting to discuss about the Working Paper and Vision 2035 for agriculture and allied sectors at NITI Aayog on October 1, 2019 and October 14, 2019.

Vinayak Nikam

- Farmer FIRST workshop for capacity building of partners of the project at CSSRI, Karnal, Haryana from February 12-14, 2019.
- Farmer FIRST workshop for capacity building of partners of the project at NRRI, Cuttak from March, 1-2, 2019.

Participation in TV/Radio talk

Suresh Pal

- DD News, June 24, 2019
- DD Kisan July 5, 2019 (Union Budget)
- DD News July 9, 2019 (Union Budget)
- DD Kisan, October 9, 2019
- DD News, December 12, 2019

Visits Abroad

Name	Nature of the visit	Place and duration
Suresh Pal	Executive Development Programme on "Developing Effective Organizational Leadership for Senior Officer of ICAR"	Netherlands, Belgium, Germany, Switzerland October 12-21, 2019
Prem Chand	Formulation and study of spatial development, climate change, and the environment for agricultural transformation	Manila, Philippines November 18-22, 2019

CHAPTER 8

Quinquennial Review Team (QRT)

QRT is constituted for five-year review of progress of research and evaluation of constraints, potentials and strategies to achieve mission and goal of the Institute. Present QRT (4th) is constituted by the ICAR to review the progress for the period 2011-2017. The QRT is chaired by Professor S. Mahendra Dev, Director and Vice Chancellor, Indira Gandhi Institute of Development Research (IGIDR), Mumbai. The composition of QRT is given in Table 8.1.

Table 8.1. Fourth Quinquennial Review Team of ICAR-NIAP

Professor S. Mahendra Dev Director and Vice Chancellor Indira Gandhi Institute of Development Research, Mumbai	Chairman
Dr. Devendra Verma Former Director General Central Statistics Office Ministry of Statistics and Programme Implementation	Member
Dr. Vasant Gandhi Professor Indian Institute of Management, Ahmedabad	Member
Dr. R. S. Sindhu Registrar Punjab Agricultural University, Ludhiana	Member
Dr. J. P. Mishra Former Additional Director General Indian Council of Agricultural Research	Member
Dr. Naveen P Singh Principal Scientist ICAR-National Institute of Agricultural Economics and Policy Research	Member-Secretary

First meeting of fourth QRT was convened on July 18, 2019 at ICAR-NIAP. The meeting was chaired by Professor S. Mahendra Dev. The QRT team briefed about their expectations from ICAR-NIAP. Dr Suresh Pal, Director, ICAR-NIAP provided overview of ICAR-NIAP. This was followed by theme-wise presentations regarding achievements of ICAR-NIAP for the review period. Members and chair expressed satisfaction and provided useful comments and suggestions. Professor P.S. Birthal, National Professor, ICAR and all the scientists from NIAP attended the meeting.

Research Advisory Committee (RAC)

The present RAC is constituted by ICAR for the three years from June 21, 2017 with the composition as given in table 8.2.

Table 8.2. Research Advisory Committee of ICAR-NIAP till June 20, 2020

Professor Abhijit Sen Former Member Planning Commission, New Delhi	Chairman
Dr. A. K. Singh Former Director Giri Institute of Development Studies, Lucknow	Member
Professor Shashanka Bhide Director Madras Institute of Development Studies, Chennai	Member
Dr. P. N. Mathur Former ADG (Ext.) ICAR, New Delhi	Member
Dr. P. K. Joshi Director, South Asia IFPRI, New Delhi	Member
Professor Srijit Mishra Director Nabakrushna Choudhury Centre for Development Studies, Bhubaneshwar	Member
Mr. Sanjay Kumar S/o Lt. Sh. Mahender Singh Badarpur, New Delhi	Member
Mr. Jeet Ram Solanki Ex. MLA Pooth Kalan, Delhi	Member
Dr. Suresh Pal Director ICAR-NIAP, New Delhi	Member (Ex-officio)
Dr. G. Venkateshwarlu Assistant Director General (EQR) Agril. Education Division ICAR, New Delhi	Member (Ex-officio)
Dr. Usha Ahuja Principal Scientist ICAR-NIAP, New Delhi	Member-Secretary (up to August 31, 2019)

Institute Management Committee (IMC)

The present IMC was constituted on February 1, 2017 for the three years with the composition as given in Table 8.3.

Table 8.3. Institute Management Committee (IMC) of ICAR-NIAP till January 31, 2020

Dr. Suresh Pal Director ICAR-NIAP, New Delhi	Chairman
Director Directorate of Economics & Statistics, Delhi	Member
Director (Economics & Statistics) Department of Planning, Yojana Bhawan, Lucknow	Member
Dr. R.K. Grover Director (HRM) CCS, Haryana Agricultural University, Hisar	Member
Mr. Sanjay Kumar R/o 187, Badarpur, New Delhi	Member
Mr. Jeet Ram Solanki Ex. MLA R/o H.No. 209, Pooth Kalanm Delhi	Member
Dr. Anil Rai Professor and Head Centre for Agricultural Bioinformatics, IASRI, New Delhi	Member
Dr. M. Krishnan Head ICAR-NAARM, Hyderabad	Member
Dr. Harbir Singh Principal Scientist ICAR-IARI, New Delhi	Member
Dr. Amit Kar Head Division of Agricultural Economics, IARI, New Delhi	Member
Dr. G. Venkateshwarlu Assistant Director General (EQR) Agril. Education Division ICAR, New Delhi	Member
Director (Finance) ICAR, New Delhi	Member
Ms. Neha Agarwal Administrative Officer ICAR-NIAP, New Delhi	Member Secretary

Institute Research Council (IRC)

Annual meeting of IRC of ICAR-NIAP was held on June 10-11, 2019. The IRC meeting was chaired by Dr Suresh Pal, Director, ICAR-NIAP. Dr Vishwa Ballabh, Professor, XLRI and Dr B C Roy, Professor, Vishva Bharti University attended meeting as external experts. The experts appreciated the research being conducted at ICAR-NIAP and provided valuable suggestions for each project. The research gaps and scope for improvement in each project was identified in the IRC and stressed on more publications in quality journals from research projects.

CHAPTER 9

ICAR-NIAP Annual Day

ICAR-NIAP celebrated its 28th Annual Day on on May 2, 2019. On the occasion, Dr Rajiv Kumar, Vice Chairman, NITI Aayog made his gracious presence as the Chief Guest, and delivered the 12th Professor Dayanatha Jha Memorial Lecture organized in commemoration of Prof. Dayanatha Jha, former Director, ICAR-NIAP. The function was presided by Dr Trilochan Mohapatra, Secretary DARE and Director General, ICAR and chaired by Dr Mruthyunjaya, Former Director, ICAR-NIAP. In welcome address, Dr Suresh Pal, Director, ICAR-NIAP briefed contribution of the Institute in agricultural economics and policy research and duly acknowledged the contributions of previous directors in nurturing the Institute to reach its present heights. Dr Mruthyunjaya, congratulated the staff of ICAR-NIAP for maintaining its edge in policy research in National Agricultural Research System and in agricultural economics as a whole.

In his lecture on "Indian Agriculture: Retrospect and Prospects", Dr Rajiv Kumar presented status of Indian agriculture in comparison with the rest of the world and flagged major issues and future prospects. He emphasized on the application of Zero Budget Natural Farming (ZNBF) as a viable agricultural practice for restoring ecosystem balance, the need of revamping agricultural markets and price policies, adoption of Model Tenancy Law, promotion of agri-preneurship and value addition and promotion of NDDB model in agriculture. Dr T. Mohapatra, DG, ICAR made his remarks on the various issues in agricultural sector raised by the chief guest. He stressed upon the need for adequate investment in agricultural R&D. He also urged that the Institute may reach to a level of globally competitive position in agricultural economics and policy research.

12th Professor Dayanatha Jha Memorial Lecture by Dr Rajiv Kumar, Vice Chairman, NITI Aayog

Panel discussion on NIAP@2050

In the consecutive session, a panel discussion was organized on the topic 'NIAP @2050'. Panel constituted of Professor Abhijit Sen (Formerly Member, Planning Commission), Dr Mruthyunjaya (Former Director, ICAR-NIAP), Dr P K Joshi (Former Director, ICAR-NIAP), Dr Vijay Paul Sharma (Chairman, CACP) and Dr K.L. Prasad (Senior Economics and Statistical Advisor, DES, DAFW). Deliberations were made by different panellists regarding the future roles and linkages of ICAR-NIAP in the fields of agricultural economics research, capacity building and policy advocacy with a vision of making it as a Centre of Excellence with global reputation by 2050.

Social functions at Annual Day of ICAR-NIAP, May 2, 2019

Promotion of Official Language

For the implementation and extensive use of Rajbhasha among the staff of the Institute, a Committee on Rajbhasha Official Language was established by Central Rajbhasha Department. The Committee monitors the progress of various actions being taken and suggests measures for implementation of official language. It coordinates and helps in executing the Council orders and circulates Central Rajbhasha Department Annual program guidelines. Institute Rajbhasha Committee submitted the quarterly progress reports online as well as hard copy timely to Central Rajbhasha Department and ICAR headquarter and half yearly progress report to Nagar Rajbhasha Karyanvyan Samiti. The Institute's Rajbhasha Karyanvyan Samiti organized quarterly meeting of Rajbhasha and Hindi workshop regularly during 2019.

The Institute has bilingual facilities in all computers through Hindi fonts and Unicode for Hindi typing. In Institute's programme "मेरा गाँव मेरा गौरव" the information is disseminated in Hindi language to the farmers. For better awareness of Hindi typing in Unicode font, a Hindi Workshop was organized in September 2019. The Official Language Committee of ICAR-NIAP organized a series of events

to celebrate "Hindi Pakhawada" during September 13-30, 2019. The activities during the "Hindi Pakhawada" included debate on अंतरिक्ष विज्ञान एवं विकास, essay competition on "मनुष्य की कृत्रिम बुद्धिमत्ता", dictation of administrative words in Hindi, translation from English to Hindi and extempore activities. The quiz competition was also arranged for general awareness in Rajbhasha. Hindi Pakhwada ended with poem recitation competition. Dr Suresh Pal, Director, NIAP distributed the prize to winners in various events during Hindi Pakhwada.

150th Birthday Ceremony of Mahatma Gandhi Ji

ICAR-NIAP celebrated 150th Birth Anniversary of Gandhi Ji on October 2, 2019 by having activities like *Yoga*, *Shram Dan*, Tree plantation and *Swachhta Abhiyan*. Venetran journalist Shri Rahul Dev visited ICAR-NIAP on October 3, 2019 and expressed his views on the philosophy of Gandhi Ji and on Rajbhasha.

Mera Gaon, Mera Gaurav (MGMG)

Under this activity, three teams of scientists visited 15 villages in Rohtak, Palwal and Mewat districts of Haryana state. Scientists discussed with farmers about advantages of organic farming. Scientists also conducted a focus group discussion on the interim budget of Government of India, various agricultural practices and penetration of different government schemes in the village. Awareness on proper seed treatment, land preparation and other general aspects like health and sanitation, education of girl child and nutrition were also discussed. On 22 July, 2019, Kisan Gosthi on "Possibility of Growing Horticultural Crops" with villagers of MGMG adopted Villages Jor Khera and Khokiyaka villages of Palwal was organized.

Participation in ICAR Sports Meet

The Institute participated in ICAR Zonal Sports Meet (Central Zone) 2019 with 12 member contingents during November 07-11, 2019 which was organized by ICAR-NBSS&LUP, Nagpur. Dr Subash Chand borne the responsibility of Chief De-Mission of the team. The team secured one gold and one silver medal in individual events. Ms Sonia Chauhan brought laurels to the institute by securing first place in women carom and second place in women chess championship.

ICAR-NIAP staff with Shri Rahul Dev, Veteran Journalist

Celebration of Mahatma Gandhi Ji's 150th Birthday Ceremony at ICAR-NIAP.

Ms Sonia Chauhan receiving prize in ICAR Central Zone Sports Meet 2019 at ICAR--NBSS&LUP, Nagpur

International Yoga Day

5th International Yoga Day was celebrated on June 21, 2019 in the presence of Hon'ble Shri Kailash Choudhary, MoS, Ministry of Agriculture and Farmers Welfare with scientists, technical staff, students and administrative staff of all Delhi based ICAR institutes including ICAR-NIAP at ICAR-IARI. Dr Trilochan Mohapatra, Secretary DARE and DG, ICAR hosted the event.

Vigilance Awareness Week

ICAR-NIAP observed Vigilance Awareness Week during October 28 to November 2, 2019. Various activities like integrity pledge, poster making, essay competition and panel discussion on theme "Integrity-A way of Life" were organised during the week. ICAR-NIAP staff participated in the activities with enthusiasm.

ICAR-NIAP staff observed Vigilance Awareness Week during October 28 to November 2, 2019

Distinguished Visitors

Dr Rajiv Kumar
Vice-Chairman
NITI Aayog

Dr Ramesh Chand
Member
NITI Aayog

Dr Trilochan Mohapatra
Secretary, DARE and Director General
ICAR

Dr R.S. Paroda
Chairman, TAAS

Shri Chhabilendra Roul,
Secretary,
Department of Fertilizers, Ministry of Chemicals & Fertilizers

Dr A.K. Srivastava
Member
Agricultural Scientists Recruitment Board

Dr Ashok Dalwai
Chief Executive Officer
National Rainfed Area Authority

Professor Abhijit Sen
Former Member
Planning Commission

Dr N.S. Rathore
Vice Chancellor
Maharana Pratap University of Agriculture and Technology, Udaipur.

Dr S. Mahendra Dev
Director and Vice Chancellor
Indira Gandhi Institute of Development Research, Mumbai

Dr Joykrushna Jena
Deputy Director General, Fisheries, ICAR

Dr K Alagusundaram
Deputy Director General, Agricultural Engineering , ICAR

Dr A. K. Singh
Deputy Director General, Agricultural Extension, ICAR

Dr A. K. Singh
Deputy Director General, Horticulture Science, ICAR

Dr P.K. Joshi
Former Director-South Asia,
IFPRI, New Delhi

Dr C. Ramasamy
Former Vice Chancellor
TNAU

Dr Mruthyunjaya
Former Director,
ICAR-NAIP

Shri Satish Chandra
Director General
Fertiliser Association of India

Dr Devendra Verma
Former Director General
Central Statistical Office

Dr Manoj Panda
RBI Chair Professor, IEG

Dr Sukhpal Singh
Professor and Chairperson
Centre for Management in Agriculture (CMA)
Indian Institute of Management, Ahmedabad

Dr Vasant Gandhi
Professor
Indian Institute of Management, Ahmedabad

Dr Ajit Mishra
Director, IEG

Dr R.S. Sidhu
Registrar
Punjab Agricultural University, Ludhiana

Dr A.K. Padhee
Director, Country Relations,
ICRISAT

Shri Parth Sarthi Sen Sharma
Joint Secretary
Department of Fertilisers

Foreign Delegation/Visitors

Dr Uma Lele
President
International Association of Agricultural Economists (IAAE)

Dr Marco Ferroni,
SMB Chair, CGIAR

Dr Peter Carberry,
Director General
ICRISAT

Dr Derek Byerlee
Australian Agricultural Researcher, Economist and Policy Advisor

Dr Tomio Shichiri
FAO Representative, New Delhi

Dr Shahidur Rashid
Director-South Asia
IFPRI

Dr Channing Arndt
Director
Environment and Production Technology Division, IFPRI

Dr David R. Just
Susan Eckert Lynch Professor in Science and Business, Cornell University, USA

Ms Kimberley Marie
Agricultural Economist
Office of Global Analysis, USDA

CHAPTER 10

ICAR-NIAP: An Overview
Significant Research Achievements
Capacity Building
Policy Interactions
Research Output
Awards and Recognitions
Participation in Scientific Activities
Management Committee Meetings
Other Institute Activities

Personnel and Budget

Personnel

Scientific

Name	Designation
Dr Suresh Pal	Director
Dr P. S. Birthal	National Professor
Dr Nalini Ranjan Kumar	Principal Scientist
Dr Rajni Jain	Principal Scientist
Dr Subhash Chand	Principal Scientist
Dr S. K. Pandey	Principal Scientist
Dr Naveen P. Singh	Principal Scientist
Dr Shiv Kumar	Principal Scientist
Dr Raka Saxena	Principal Scientist
Dr Mahendra Singh	Principal Scientist
Dr Purshottam Sharma	Senior Scientist
Dr Prem Chand	Scientist (SS)
Dr S. K. Srivastava	Scientist (SS)
Ms Arathy Ashok	Scientist (SS)
Dr Vikas Kumar	Scientist (SS)
Dr Kingsly Imnanuelraj T	Scientist
Dr Vinayak Ramesh Nikam	Scientist
Ms Jaya Jumrani	Scientist
Ms Pavithra S	Scientist
Mr Balaji S.J.	Scientist
Mr S V Bangaraju	Scientist
Dr Abimanyu Jhajhria	Scientist
Mr Prabhat Kishore	Scientist
Mr Subash S. P.	Scientist
Mr Kiran Kumara T. M.	Scientist
Mrs Ankita Kandpal	Scientist

Technical

Name	Designation
Mr Prem Narayan	Chief Technical Officer
Mr Khyali Ram Chaudhary	Assistant Chief Technical Officer
Mr Mangal Singh Chauhan	Assistant Chief Technical Officer
Ms Sonia Chauhan	Assistant Chief Technical Officer
Mr Satender Singh	Technical Officer (Driver)

Administrative

Name	Designation
Mrs Neha Agarwal	Administrative Officer
Mr Mohammad Irfan	Assistant Finance and Account Officer
Mr Inderjeet Sachdeva	Assistant Administrative Officer
Ms Umeeta Ahuja	PS to Director
Mr Sandeep Mathur*	Assistant
Mr Yatin Kohli	Assistant
Mr Harish Vats	Assistant
Mr Deepak Tanwar	Jr. Steno
Mr Ajay Tanwar	UDC

* He is on lien from 30.06.2018

Skilled Supporting Staff

Name	Designation
Mr Mahesh Kumar	Skilled Supporting Staff
Mr Mahesh Pal	Skilled Supporting Staff

Promotions

Shri Inderjeet Sachdeva, Assitant to the next higher grade of Assistant Administrative Office w.e.f. 06.11.2019.

New Joining

- Mr Mohammad Irfan, joined as AF&AO on 19.08.2019.
- Mr Kiran Kumara T. M. joined as Scientist on 27.11.2019
- Dr Mahendra Singh, joined as Principal Scientist on 02.12.2019.
- Dr Purushottam Sharma, joined as Senior Scientist on 04.12.2019.
- Dr Vikas Kumar, joined as Scientist (SS) on 20.12.2019
- Ms Ankita Kandpal, joined as Scientist on 30.12.2019.

Study Leave

- Ms Arathy Ashok, Scientist on study leave w.e.f. 01.08.2019 to 31.07.2022 to ICAR-NDRI, Karnal and relieved on 31.07.2019 (A/N).

- Ms Pavithra S., Scientist on study leave w.e.f. 19.08.2019 to 18.08.2022 to ICAR-IARI, Pusa, New Delhi and relieved on 17.08.2019 (A/N) (Being Sunday on 18.08.2019).
- Mr Prabhat Kishore, Scientist on study leave w.e.f. 05.12.2019 to 04.06.2021 to ICAR-IARI, Pusa, New Delhi and relieved on 05.12.2019 (F/N).

Retirement

- Shri Vinod Kumar Rai, Ex-AF&AO, Superannuation on April 30, 2019 (A/N).
- Shri Sushil Kumar Yadav, Ex-AAO, Superannuation on May 31, 2019 (A/N).
- Dr (Ms) Usha Rani Ahuja, Ex- Principal Scientist, Superannuation on August 31, 2019 (A/N)

Budget

Table 10.1. ICAR-NIAP expenditure

₹ Lakh

Head	Grant Expenditure	
Grants for Creation of Capital Assets (Capital)	**April 2019 to December 2019**	**April 2019 to March 2020**
Equipment	5.49	15.54
Information technology	26.41	43.67
Library books and journals	5.37	5.39
Furniture & fixtures	2.83	5.40
Others	0.59	0.00
Total capital expenditure	**40.69**	**70.00**
Grant in Aid-salaries (Revenue)		**658.05**
Total establishment expenses	**542.36**	**658.05**
Grant in aid-general		
Research and operational expenses	232.05	250.62
Administrative expenses	118.33	157.20
Others	123.47	130.19
Total expenditure grant in aid-general	**473.85**	**538.00**
Grand total	**1,056.90**	**1266.06**

Revenue receipt : (₹ 2,03,522/- (April 2019 to December 2019)
(₹ 8,41,417/- (April 2019 to March 2020)

ICAR - National Institute of Agricultural Economics and Policy Research
(Indian Council of Agricultural Research)

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ICAR–NIAP