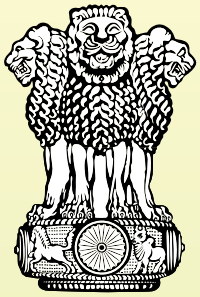

Report on Policies and Action Plan for a Secure and Sustainable Agriculture

30 August, 2019

Submitted to

The Principal Scientific Adviser to the Government of India

Vigyan Bhavan Annexe, Maulana Azad Road, New Delhi-110001

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Contents

Foreword

The recent success of India's space mission is an outstanding example of how convergence of science and technology with appropriate policy and budgetary support has transformed life on earth for the better. A classic example of the past was the Green Revolution in agriculture in India. The naming of the current geological era as 'Anthropocene' reflects the consequences of human driven actions dominating the present and future of our planet.

India's agriculture sector accounts for around 15.9 per cent of the country's $2.7 trillion economy and 49 per cent of total employment (2018-19). A recent global economic outlook estimated India's gross domestic product (GDP) growth at 6.6 per cent for the 2019-20 fiscal. Slowdown over the previous year has been attributed to steadily cooling activity in the manufacturing sector and, to a lesser extent, agriculture, indicating that the Indian economy may be slipping into a recession. Nonetheless, even today most of the Indians are directly (farming) or indirectly (doing business with agricultural goods) dependent on agriculture.

Agricultural productivity in India is below its potential. Some of the constraints include limited use of modern farming methods, volatility of weather, weak agricultural support services and lack of market-oriented production. The frequent occurrences of natural disasters like flood, drought, storms, hails, cyclones have led to severe hardship and farm distress. Feeding a growing population and ensuring food and nutritional security in future thus becomes a daunting challenge, especially in the era of climate change.

The agriculture sector is a leading area that needs a re-look and re-invention. It is time that India marches towards a '*millennium agricultural transformation'*, advancing from traditional agricultural systems (labor-intensive) to contemporary agribusiness system (capital- and technology-intensive).The Government of India has recently set an ambitious target to double the income of farmers by 2022-23, which corresponds to targeted annual agricultural growth of more than 14 per cent per year.

For this to happen, suitable policy actions with scientific interventions become imperative for Indian agriculture. This calls for implementation of cross-sector policies and programs at national and regional levels. While many on-going programs and schemes provide commendable support to agriculture sector, there is need to adopt a new approach to achieve the time-bound targets of doubling farmers' income and meeting the Sustainable Development Goals of ending hunger, poverty and malnutrition, in a sustainable manner. With this view, to provide suggestions on "Agricultural Policies and Action-Plans for a Secure and Sustainable Agriculture" an expert Committee Chaired by Dr R.S. Paroda, a renowned agricultural expert was formed by my Office on Feb. 12, 2019.

I am very pleased to see the report, which provides a deep insight into the agriculture situation of India and scientific, institutional and policy reforms with time-bound action plans, to meet the objectives stated above. It is expected that implementation of the recommendations would result in bringing real-time transformation in India's agricultural portfolio.

30 August, 2019

(K. VijayRaghavan)
Principal Scientific Adviser

Submission Certificate

The Office of the Principal Scientific Adviser (PSA) to the Government of India (GoI) constituted a Committee for "Agricultural Policies and Action-Plans for a Secure and Sustainable Agriculture" vide office memorandum dated Feb. 12, 2019, and subsequently revised on April 5, 2019. The objectives were to (i) review the existing policies related to agricultural development and identify gaps for required re-orientation; (ii) suggest strategies relating to role of agriculture in achieving sustainable development goals (SDGs); (iii) develop an action plan/road map for a secure and sustainable agriculture for improved livelihood of small holder farmers; (iv) suggest measures/mechanisms for effective implementation of policies and action plans; (v) consider any other suggestions that are relevant or offered by PSA.

Accordingly, the Committee deliberated on the issues concerning policies, schemes and programs related to Indian agriculture, including R&D. Current challenges and opportunities were discussed. Stakeholders including farmers, researchers, extension workers, private sector and subject matter specialists were contacted through interface/virtual meetings as well as through correspondence. Suggestions received from various quarters were thoroughly discussed during the five meetings of the Committee. Based on the various inputs received, the Committee has made specific recommendations and action plan. Accordingly, we the members of the Committee are pleased to present this report to the PSA to the GoI with an expectation that these will be implemented speedily by all concerned.

(J.C. Katyal)
Member

(A.K. Srivastava)
Member

(Ram Kaundinya)
Member

(Suresh Pal)
Member

(S.R. Rao)
Member

(W.S. Lakra)
Member

(Anil Prakash Joshi)
Member

(Nadesa Panicker Anil Kumar)
Member

(Shannon B. Olsson)
Member

(Gitanjali Yadav)
Member

(A. Arunachalam)
Member

(Anuradha Agrawal)
Member

(Ketaki Bapat)
Member Secretary

(R.S. Paroda)
Chairman

Preface

Targeting achievement of the United Nations' Sustainable Development Goals (SDGs) by 2030 calls for re-orientation of research, innovation, development and policy related programs of most of the nations. For an agrarian-based country like India, revisiting agricultural policy and approaches becomes an important domain to address the SDG targets. Although the Government of India (GoI) has periodically addressed issues relating to farming and farmers by implementing suitable policy measures, new emerging challenges do require mid-course corrections. This is especially important in the context of climate change, existing inequities in food and nutritional security, unsustainable use of natural resources (water, land, agrobiodiversity) and slow economic growth resulting in rising unemployment. More importantly, time is ripe. for the transformation of Indian agriculture to be more sustainable and profitable to farmers and other stakeholders, through the use of new science and technology, and enabling policy environment for accelerated agricultural growth.

This report is an outcome of in-depth deliberations, well considered views and opinions of members of the committee constituted by the Principal Scientific Adviser (PSA) to the GoI, to review and suggest "*Agricultural Policies and Action-Plans for a Secure and Sustainable Agriculture*", vide office memorandum dated Feb. 12, 2019 (Annexure I). Members were drawn from academia, research, private sector and non-government organizations, with expertise in varied fields of agricultural research, education, extension, development and policies (Annexure II).

Each member of the committee was assigned specific topic(s) to analyse and provide inputs, based on their expertise (Annexure III). The committee also networked with over 150 eminent experts from across the country and abroad to seek insights for this report (Annexure IV). During the six months, several peer review meetings and deliberations, individual consultations, and correspondence through emails were held, and very useful suggestions were obtained (Annexures V to IX). The persons contacted comprised experts from research, teaching, government and non-government organizations, farmers' groups, professional associations, industry, consultants and policy makers, including some international experts of Indian origin residing abroad. Existing government policies, programs, schemes and provisions related to Indian agriculture were thoroughly reviewed, along with the latest developments in agricultural research and technology. Also, assistance of a few senior consultants was obtained for collating, reviewing and editing this report.

The report is structured into different sections such as : (i) Role of Agriculture in Achieving Sustainable Development Goals; (ii) Accelerating Agricultural Growth for Secure and Sustainable Agriculture, covering sectoral (Natural Resource Management, Crops, Horticulture, Livestock, Fishery) and cross cutting (Agro-ecology based Planning, Role of Youth and Women, Private Sector Participation, Institutional Mechanisms and Reforms, Knowledge Dissemination and Capacity Development) issues (iii) Recommendations and Proposed reforms, (iv) Action Plan for Policy Reforms and Scalable Innovations.

I, on behalf of the committee members, would like to thank Dr K. VijayRaghavan, Principal Scientific Adviser to the GoI, for entrusting this important responsibility to prepare and submit the report. The help and support extended by the senior consultants, Dr Bhag Mal, Dr Rajesh Kumar Mittal, Dr Mruthyunjaya and Dr Umesh Srivastava besides Ms Simmi Dogra, Office Secretary, TAAS is duly acknowledged. The committee also places on record its gratitude for the *pro-bono* inputs of more than 150 agricultural

experts from India and those residing abroad, who shared their expert views/comments/suggestions. Personally, I thank each member of the committee, including the Member Secretary, Dr Ketaki Bapat, for their sincere efforts and cooperation in finalizing this report in a time-bound manner. I also place on record my grateful thanks to Dr Suresh Pal, Dr Anuradha Agrawal, Dr M.L. Jat and Dr Y.S. Saharawat for their support in reviewing and revising the technical write-ups for inclusion in this report.

It has been the endeavour of this committee to address specific gaps in existing policies and programs, current status of available technologies which deserve scaling and suggest key recommendations for ensuring both secure and sustainable agriculture that may improve the livelihood of smallholder farmers and help the nation in achieving SDG. It is expected that speedy implementation of suggested recommendations will help in accelerating faster growth of Indian agriculture.

30 August, 2019

(R.S. Paroda)
Chairman, Committee for
"Agricultural Policies and Action Plan for a Secure and Sustainable Agriculture"

Abbreviations and Acronyms

A-IDEA	Association for Innovation Development of Entrepreneurship in Agriculture
ABI	Agri-Business Innovation
ABS	Access and Benefit Sharing
ACBSC	Agro-Clinic-Business Support Centre
AECI	Agricultural Education Council of India
AER	Agro-ecological Region
AESR	Agro-ecological Sub-Region
AEZ	Agro-ecological Zone
AH&F	Animal Husbandry and Fisheries
AHIDF	Animal Husbandry Infrastructure Development Fund
AHPND	Acute Hepatopancreatic Necrosis Disease
AI	Artificial Intelligence
AI	Artificial Insemination
AMIF	Agri-Market Infrastructure Fund
APAARI	Asia-Pacific Association of Agricultural Research Institutions
APEDA	Agricultural and Processed Food Export Development Authority
APMC	Agriculture Produce Market Committee
APLMC	Agricultural Produce & Livestock Market Committee
AR4D	Agricultural Research for Development
AR4R	Agricultural Research for Result
ARI4D	Agricultural Research and Innovation for Development
ARI4SD	Agricultural Research and Innovation for Sustainable Development
ART	Assisted Reproductive Techniques
ASCI	Agriculture Skill Council of India
ASMM	Area-Specific Mineral Mixtures
ASPIRE	A Scheme for Promotion of Innovation, Rural Industries and Enterprise
ASRB	Agricultural Scientist Recruitment Board
ATARI	Agricultural Technology Application Research Institute
ATICs	Agricultural Technology Information Centres
ATMA	Agriculture Technology Management Agency
AU	Agricultural Universities
BARC	Bhabha Atomic Research Center
B.Ed.	Bachelor of Education
BAH&FS	Basic Annual Husbandry & Fisheries Statistics
BBF	Broad Bed and Furrow
BBFP	Broad Bed and Furrow Planter
BDA	Biological Diversity Act
BGREI	Bringing Green Revolution in Eastern India
BIRAC	Biotechnology Industry Research Assistance Council

BMC	Bulk Milk Coolers
BMGF	Bill and Melinda Gates Foundation
BRAI	Biotechnology Regulatory Authority of India
BROMARK	Broiler Producers Marketing Association
CA	Conservation Agriculture
CA-CoP	Conservation Agri-Community of Practitioners
CAGR	Compound Annual Growth Rate
CAP	Covered and Plinth
Cas9	CRISPR Associated Protein 9
CAU	Central Agricultural University
CBO	Community-Based Organizations
CCA	Certified Crop Advisory
CF	Customized Fertilizers
CFCs	Chlorofluorocarbons
CGHS	Central Government Health Scheme
CGIAR	Consultative Group for International Agricultural Research
CGTF	Credit Guarantee Trust Fund
CHAMAN	Coordinated Horticulture Assessment and Management using Geoinformatics
CHC	Custom Hire Centres
CIDR	Controlled Internal Drug Release
CIMMYT	International Maize and Wheat Improvement Center
CIRG	Central Institute for Research on Goats
CIWA	Central Institute for Women in Agriculture
CMSAP	Community Managed Sustainable Agricultural Program
CoP	Conference of Parties
CoE	Centers of Excellence
CPAIS	Central Pesticide Analysis Information System
CPRs	Common Property Resources
CRISPR	Clustered Regularly Interspaced Short Palindromic Repeats
CRPs	CGIAR Research Programs
CSO	Central Statistics Office
CSR	Corporate Social Responsibility
CSWRI	Central Sheep and Wool Research Institute
CWC	Central Warehousing Corporation
DAC&FW	Department of Agriculture Cooperation & Farmer's Welfare
DARE	Department of Agricultural Research and Education
DBT	Direct Benefit Transfer
DBT	Department of Biotechnology
DFI	Development Finance Institution
DFMD	Directorate on Foot & Mouth Disease
DIDF	Dairy Processing and Infrastructure Development Fund
DLC	District Level Committee
DoAHD&F	Department of Animal Husbandry, Dairying & Fisheries
DoLR	Department of Land Resources
DoRD	Department of Rural Development

DST	Department of Science and Technology
e-NAM	Electronic-National Agricultural Market
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuaria
E-NWR	Electronic Negotiable Warehouse Receipt
EAC	Expert Appraisal Committee
EHP	Enterocytozoonhepatopenaei
ELISA	Enzyme -linked Immuno Sorbent Assay
EU	European Union
EUS	Epizootic Ulcerative Syndrome
FAO	Food and Agriculture Organization
FCI	Food Corporation of India
FCO	Fertilizer Control Order
FCR	Feed Conversion Ratio
FDI	Foreign Direct Investment
FHP	Farm Harvest Prices
FIG	Farmer Interest Groups
FIRST	Farm, Innovations, Resource, Science & Technology
FLS	Farmer Learning School
FMD	Foot and Mouth Disease
FoB	Free on Board
FPC	Farmer Producer Company
FPO	Farmer Producer Organization
FSN	Farming System for Nutrition
FTA	Free Trade Agreement
FUE	Fertilizer Use Efficiency
FNUE	Fertilizer-N Use Efficiency
FSH	Follicle Stimulating Hormone
FYM	Farm Yard Manure
GAP	Good Agronomic Practices
GAP	Gender in Agricultural Partnership
GCARD	Global Conference on Agricultural Research for Development
GCF	Green Climate Fund
GCWA	Global Conference on Women in Agriculture
GDC	German Development Corporation
GDP	Gross Domestic Product
GE	Genetic Engineering
GEAC	Genetic Engineering Appraisal Committee
GFAR	Global Forum on Agricultural Research
GHI	Global Hunger Index
GHG	Green House Gas
GIAHS	Globally Important Agricultural Heritage Sites
GIFT	Genetically Improved Farmed Tilopia
GIS	Geographic Information System
GM	Genetically Modified
GMO	Genetically Modified Organism

GoI	Government of India
GPS	Global Positioning System
GR	Green Revolution
GSA	Gross Sown Area
GST	Goods & Services Tax
GVA	Gross Value Added
GW	Ground Water
GWD	Ground Water Development
GWh	Gigawatt hours
ha	hectare
HCFCs	Hydrochlorofluorocarbons
HMNEH	Horticulture Mission for North East and other Himalayan States
HPA	High Productivity Area
HPCM	High Power Committee on Management
HRD	Human Resource Development
HVC	High Value Crops
HYV	High Yielding Varieties
IARI	Indian Agricultural Research Institute
IBSC	Institutional Biosafety Committee
ICAR	Indian Council of Agricultural Research
ICARDA	International Center for Agriculture Research in the Dry Areas
ICDS	Integrated Child Development Scheme
ICDSS	Integrated Child Development Service Scheme
ICFMD	International Centre for Foot & Mouth Disease
ICMR	Indian Council for Medical Research
ICT	Information and Communication Technology
IFDC	International Fertilizer Development Center
IFPRI	International Food Policy Research Institute
IGP	Indo-Gangetic Plains
IIM	Indian Institute of Management
IIT	Indian Institute of Technology
ILS	Institute of Life Sciences
IMOD	Inclusive Market Oriented Developed
IMTA	Integrated Multi-Trophic Aquaculture
INDC	Intended Nationally Determined Contributions
INM	Integrated Nutrient Management
INSIMP	Initiative for Nutritional Security through Intensive Millet Produce
IOFS	Integrated Organic Farming System
IOR	Indian Ocean Region
IORA	Indian Ocean Rim Association
IOT	Internet of Things
IP	Intellectual Property
IPM	Integrated Pest Management
IPR	Intellectual Property Rights
ISRO	Indian Space Research Organization

ISS	Interest Subvention Scheme
ISTA	International Seed Testing Association
IT	Information Technology
ITC	Indian Tobacco Company
ITI	Industrial Training Institute
ITK	Indigenous Traditional Knowledge
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
IUU	Illegal, Unreported and Unregulated
IVLP	Institution-Village Linkage Program
IVRI	Indian Veterinary Research Institute
IWMI	International Water Management Institution
JLGs	Joint Liability Groups
KCC	Kisan Credit Card
KSI	Knowledge Skill Innovation
KVKs	*Krishi Vigyan Kendras*
LCC	Leaf Color Chart
LDN	Land Degradation Neutrality
LDN	Low Dose Nettrexone
LFM	Linkage Farmers to Market
LH	Luteinizing Hormone
LPA	Low Productivity Area
MAB	Marker Assisted Breeding
MAHYCO	Maharashtra Hybrid Seed Company
MAITRI	Multipurpose Artificial Insemination Technique for Rural India
MARDI	Malaysian Agriculture Research and Development Institute
MAYA	Motivating and Attracting Youth in Agriculture
MDGs	Millennium Development Goals
MDMS	Mid Day Meal Scheme
Meity	Ministry of Electronics and Information Technology
MGNERGA	Mahatma Gandhi National Rural Employment Guarantee Act
MI	Micro-Irrigation
MIDH	Mission for Integrated Development of Horticulture
MAKAAM	*Mahila Kisan Adhikar Manch*
MoA&FW	Ministry of Agricultural & Farmers' Welfare
MoAHD&F	Ministry of Animal Husbandry, Dairying & Fisheries
MoC	Ministry of Communications
MoC&I	Ministry of Commerce and Industry
MoCAF&PD	Ministry of Consumer Affairs, Food and Public Distribution
MoEF&CC	Ministry of Environment, Forests & Climate Change
MOADI	Modern Organic Agriculture Development Initiative
MOET	Multiple Ovulation And Embryo Transfer
MoF	Ministry of Finance
MoFC	Ministry of Fertilizers and Chemicals
MoFPI	Ministry of Food Processing Industries
MoI&B	Ministry of Information and Broadcasting

MoJ	Ministry of Jal Shakti
MoM	Ministry of Mines
MoRD	Ministry of Rural Development
MoS&T	Ministry of Science and Technology
MoSD&E	Ministry of Skill Development and Entrepreneurship
MoUD	Ministry of Urban Development
MSME	Marginal, Small and Medium Enterprise
MSP	Minimum Support Price
MSSRF	MS Swaminathan Research Foundation
NAARM	National Academy of Agricultural Research Management
NABARD	National Bank for Agriculture and Rural Development
NABI	National Agri-Food Biotechnology Institute
NAD&FWC	National Agricultural Development and Farmers' Welfare Council
NAFWP	National Agriculture and Farmers Welfare Policy
NAIF	National Agricultural Innovation Fund
NAMM	National Agriculture Mechanization Mission
NAPCC	National Action Plan on Climate Change
NARP	National Agricultural Research Project
NARS	National Agricultural Research System
NASA	National Aeronautics & Space Administration
NATP	National Agricultural Technology Project
NBA	National Biodiversity Authority
NBPGR	National Bureau of Plant Genetic Resources
NBS	Nutrient Based Subsidy
NBSS&LUP	National Bureau of Soil Survey and Land Use Planning
NBTs	New Breeding Techniques
NCDFI	National Cooperative Dairy Federation of India Ltd.
NCF	National Commission on Farmers
NCIWRD	National Commission on Integrated Water Resources Development
NCOF	National Centre of Organic Farming
NDC	Nationally Determined Contributions
NDDB	National Dairy Development Board
NDRI	National Dairy Research Institute
NE	North East
NEC	North-Eastern Council
NEH	North Eastern Hill
NFDB	National Fisheries Development Board
NFSM	National Food Security Mission
NFWC	National Farmers' Welfare Commission
NGO	Non-Governmental Organization
NHB	National Horticulture Board
NHM	National Horticulture Mission
NIC	National Informatics Centre
NICA	Natural Initiative on Conservation Agriculture
NICRA	National Initiative on Climate Resilient Agriculture

NIOF	National Institute of Organic Farming
NIPGR	National Institute of Plant Genome Research
NITI Aayog	National Institution for Transforming India
NLM	National Livestock Mission
NMAED	National Mission on Agricultural Extension and Skill Development
NMAET	National Mission on Agricultural Extension Technology
NMCA	National Mission on Conservation Agriculture
NMFD	National Mission on Fishery Development
NMOOP	National Mission on Oilseeds and Oil Palm
NMSA	National Mission on Sustainable Agriculture
NMYA	National Mission on Youth in Agriculture
NOFRI	National Organic Farming Research Institute
NPBBDD	National Program for Bovine Breeding and Dairy Development
NPK	Nitrogen, Phosphorous and Potassium
NR	Natural Resources
NRAA	National Rainfed Area Authority
NRCE	National Research Centre on Equines
NRHM	National Rural Health Mission
NRLM	Natural Rural Livelihoods Mission
NRM	Natural Resource Management
NRs	Natural Resources
NSA	Net Sown Area
NSC	National Seed Corporation
NSSO	National Sample Survey Office
NUE	Nutrient Use Efficiency
NW	North West
OA	Organic Agriculture
OP	Open Pollinated
OPV	Open Pollinated Varieties
PETP	Potential Evapotranspiration
PACS	Primary Agricultural Cooperative Societies
PARC	Pakistan Agricultural Research Council
PC	Protected Cultivation
PDS	Public Distribution System
PES	Payment for Environmental Services
PGD	Post Graduate Diploma
PHCR	Poverty Head Count Ratio
PHO	Post Harvest Opertions
PKVY	*Paramparagat Krishi Vikas Yojana*
PM KISAN	*Pradhan Mantri Kisan Samman Nidhi*
PMAASA	*Pradhan Mantri Annadata Aay Sanrakshan Abhiyan*
PMEGP	Prime Minister's Employment Generation Program
PMFBY	*Pradhan Mantri Fasal Bima Yojana*
PMKISAN	*Pradhan Mantri Kisan Sammellan Nidhi*
PMKVY	*Pradhan Mantri Kaushal Vikas Yojana*

PMKSY	*Pradhan Mantri Krishi Sinchai Yojana*
PMMSY	*Pradhan Mantri Matsya Sampada Yojana*
POS	Point of Sale
PPE	Personal Protective Equipment
PPP	Public-Private Partnership
PPPP	Public-Private-Producer Partnership
PPR	Peste Des Petits Ruminants
PPS	Pneumococcal polysaccharide vaccine
PPV&FR Act	Protection of Plant Varieties & Farmers' Rights Act
PRA	Pest Risk Analysis
PRI	Panchayati Raj Institutions
PSA	Principal Scientific Adviser
PUH	Peri-urban and Urban Horticulture
QPM	Quality Protein Maize
R&D	Research and Development
RAS	Recirculating Aquaculture System
RAWE	Rural Awareness Work Experience
RB Gene	Retinoplastoma Gene
RBI	Reserve Bank of India
RCEP	Regional Comprehensive Economic Partnership
RCGM	Review Committee on Genetic Manipulation
RDAC	Recombinant DNA Advisory Committee
READY	Student Rural Entrepreneurship Awareness Development Yojana
REDP	Rural Entrepreneurship Development Program
RFID	Radio Frequency Identification
RGCB	Rajiv Gandhi Centre for Biotechnology
RGM	*Rashtriya Gokul* Mission
RKVY	*Rashtriya Krishi Vikas Yojana*
ROR	Record of Rights
SAD	Sustainable Agricultural Development
SAMPADA	Scheme for Agro-Marine Processing and Development of Agro-Processing Clusters
SAPZ	Special Animal Product Zones
SAUs	State Agricultural Universities
SBCC	State Biotechnology Coordination Committee
SDGs	Sustainable Development Goals
SDP	Skill Development Program
SEPLS	Socio-Ecological Production Landscapes and Seascapes
SERP	Society for Elimination of Rural Poverty
SEWA	Self Employed Women's Association
SFAC	Small Farmers' Agribusiness Consortium
SFDA	Small Farmer Development Agency
SFWC	States Welfare Council
SH	Soil Health
SHC	Soil Health Card
SHGs	Self Help Groups

SHU	State Horticultural University
SJSRY	*Swarna Jayanti Shahri Rozgar Yojana*
SLM	Sustainable Land Management
SMAE	Sub-Mission on Agricultural Extension
SMEs	Small and Medium Enterprises
SMPP	Sub-Mission on Plant Protection and Plant Quarantine
SMSP	Sub-Mission on Seed/ Planting Material
SOC	Soil Organic Carbon
SPF	Specific Pathogen Free
SPI	Social Progress Index
SPV	Special Purpose Vehicle
SRR	Seed Replacement Rate
SSC	States Seed Corporation
STI	Science, Technology and Innovations
SWC	*State Warehousing Corporation*
SWFC	State Farmers' Welfare Commission
TAAS	Trust for Advancement of Agricultural Sciences
TERM	The Energy and Resources Institute
TFL	Truthful Label Seed
TFP	Total Factor Productivity
TILLING	Targeting Induced Local Lesions in Genomes
TMNE	Technology Mission for North-East Region
UAE	United Arab Emirates
UHT	Ultra High Temperature Processing
UK	United Kingdom
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNESCO	United National Educational Scientific and Cultural Organization
UNFCCC	United Nations Framework on Climate Change
UPNRM	Umbrella Program on Natural Resources Management
USA	United States of America
USDA	United State Department of Agriculture
VBSE	Village Based Seed Enterprise
VCI	Veterinary Council of India
VCRMC	Village Climate Risk Management Committee
VLW	Village Level Workers
VPO	Village Producer Organizations
WADI	Watershed Development and Tribal Development
WTO	World Trade Organization
WFGs	Woman Farmers' Groups
WSF	Water Soluble Fertilizers
WSSV	White Spot Syndrome Virus
WUA	Water Use Association
WUE	Water Use Efficiency
YPARD	Young Professionals for Agricultural Development

Executive Summary

Despite having achieved household food security, thanks to Green, White and Blue revolutions, the problem of poverty, hunger and malnutrition still persists and the real income of farmer has declined. To reverse this trend, there is an urgency for an introspection of existing technology, development and policy related initiatives and to evolve a new strategy with defined Road Map, to accelerate agricultural growth rate which seemed to have stuck around 3 per cent. Also, accelerating agricultural growth is warranted for achieving Sustainable Development Goals (SDGs) by 2030. This obviously calls for some bold policy decisions and their effective implementation.

Recognizing the above concerns, the Principal Scientific Adviser to the Government of India constituted a committee to review agricultural policies and suggest strategies as well as action plan to achieve faster a secure and sustainable agriculture so as to ensure improved livelihood of smallholder farmers. Besides its five meetings, the committee networked with more than 150 eminent scientists, agricultural experts and key stakeholders from across the country and those of Indian origin residing abroad, organized a few peer review meetings and had individual/virtual consultations. In the process, key existing government policies, programs and schemes related to agriculture were critically reviewed, along with some very promising innovations, which on scaling out, can make greater impact. Accordingly, this report is structured to highlight: (i) role of agriculture in achieving sustainable development goals; (ii) accelerating agricultural growth for secure and sustainable agriculture; iii) recommendations and proposed reforms, and iv) action plan for scalable innovations.

India is currently at the centre stage globally with regard to achieving SDGs, failing which possibly the UN targets would not be met in view of existing concentration of both poverty and hunger, being the maximum compared to elsewhere. Hence, there is an urgency to adopt some bold policies and to scale out new technologies and innovations to ensure increased production linked to input use efficiency, post-production, value chain, effective partnership with stakeholders, especially the private sector, and the linkages with both national and global markets. Fortunately, the Government's commitment to meet SDGs and the Paris Agreement for climate change do present unique opportunity for the entire agricultural sector to get aligned for a better tomorrow. Thus, there is an urgency that policy makers accord high priority to agriculture, which still sustains almost half of the Indian population, to ensure faster agricultural growth to achieve food, nutritional and environmental security for all. This obviously would demand doubling of funds for agricultural research and innovation for development (ARI4D), which still gives the highest returns (more than 10 times) compared to rest of other growth sectors. Also, the enhanced capital investment in non-Green Revolution areas such as eastern and north-eastern regions, especially to improve social progress index (SPI), becomes highly justified to ensure an Evergreen Revolution that is sustainable. Besides SDGs, India's commitment for doubling farmers' income is a major policy initiative, which demands specific focus now on increased production with low input cost, sustainable agricultural diversification and efficient post-production management, including value addition, and better options for linking farmers to market. Obviously, these would demand a paradigm shift in current national agricultural policies to become pro-farmer and to ensure higher agricultural growth for an over all prosperity.

This committee is of the firm view that farmers are currently the most stressed community whose income is not enough to meet their daily needs. Farmers need good land, healthy soils, adequate and good quality water, timely supply of key inputs, technologies that can ensure higher and efficient production, good and timely extension services, easy availability of credit at low interest rate, access to national

and global markets and finally the respect and dignity which they deserve in the society. Accordingly, this report centers around a new strategy and policy reforms aiming at accelerating agricultural growth, achieving SDGs, and doubling farmers' income while perusing a 'Farmer FIRST' approach.

This report also centers around transforming Indian agriculture and the food system towards a more productive, secure (resilient) and sustainable source of economic growth, improved livelihood for those engaged in the sector and a true catalyst for creation of jobs downstream in the production and post-production scenario. To achieve this noble transformation, a bold vision, accompanied by equally bolder policies and resolute actions are suggested, because the needed boldness is required to get to achieve a new plank, which we seemed to have slipped since India became food secure. Since then, agriculture has prodded along sluggishly being a reflection of complacency despite pockets of brilliance and available technological innovations needing policy support for scaling. Bringing new innovations to scale and to accelerate agricultural growth above 4 per cent, as envisioned in National Agricultural Policy (2000), would require increased investments with priorities and commitments as a pre-requisite for implementing suggested reforms and new programs in this report. The proposed recommendations are not just a continuation of the business as usual approach of providing technical solutions and essentially tinkering at the margin but are key for taking India to newer heights through over all accelerated growth and sustainable development in agriculture.

The new strategy suggested in the report to address farmers' diverse needs includes: doubling farmers' income through increased production, diversification in farming systems that are eco-regionally most sustainable, input cost reduction by scaling technical innovations (be scientist or farmer-led), availability of credit at low interest rate, value addition and better income through direct linkages to markets. The strategy centres around: harnessing scientific, technical and institutional innovations, besides needed policy reforms and both national and global partnerships.

The report highlights new opportunities for harnessing science for new gains through the use of: precision agriculture, biotechnology, sensor technology, bioinformatics, climate-smart agriculture, robotics, drones, big data management, artificial intelligence, etc. The committee firmly believes that there exists considerable scope for scaling out promising technologies for extending the gains such as: growing different crops in newer/non-traditional areas, exploitation of hybrid technology, use of biotechnology, especially GM crops, conservation agriculture, scientific land use and ecoregional planning, farm mechanization for precision farming, reversing soil degradation, improving soil health, especially through the restoration of soil organic carbon, doubling water use efficiency, improved nutrient use, generation of bioenergy and biofuel production, ICT for knowledge empowerment, etc.

The report covers major recommendations relating to key production sectors of agriculture, namely, natural resource management, crops, horticulture, livestock, fisheries and some cross-cutting areas such as: agro-ecological based land use planning, role of youth and women, private sector participation, institutional mechanisms and reforms, knowledge dissemination and capacity building along with action plan for policy reforms and some creative innovations that have great potential for outscaling to accelerate agricultural growth with desired impact on farmers' income.

Institutional reforms are important to sustain the gains in agriculture through scaling scientific innovations. Some key institutional reforms recommended include: review of existing agricultural policies and forming a new one on agriculture and farmers' welfare to meet the emerging challenges; needed reorientation of on-going missions/national programs, including urgency for initiating some new missions; clearance of some key pending Acts/Bills by the Parliament; strengthening of ICAR/SAUs/KVKs/PRIs with urgency for doubling current public funding; establishment of a new National Agricultural Development and Farmers' Welfare Council (NAD&FWC) under the chairmanship of Prime Minister, extremely essential for decision making and to ensure effective coordination and convergence so critical, since agriculture is a State subject; establishing Farmers' Welfare Commissions both at the Centre and State level, as an institutional mechanism for providing a neutral platform; an

Independent Strategic Planning, Monitoring, and Evaluation Unit to review and assess the impact of all central agriculture related schemes; grassroot knowledge empowerment through both public and paid extension systems; expanding the mandate of KVKs as 'Knowledge-Skill-Innovation Centres' and to facilitate the establishment of Agri-Clinics; support for creating more Farmer Producer Organizations; building trusted partnership with the private sector, and finally the empowerment and motivation of women and youth to remain in agriculture and be the important game changers.

The report also highlights an urgent need for policy reforms to increase capital investment in agriculture (both public and private), especially in the eastern, North-eastern, dryland and coastal regions that are capable of more sustainable Green Revolutions in future, increase in credit access to the farmers and young entrepreneurs at low interest rate (4%) and creation of more financial institutions such as Kisan Banks, increasing investments in rural (roads, electricity) and marketing infrastructure, including pledged warehouses, production and availability of quality seeds and planting materials, availability of safe and effective chemicals, farm machinery on custom hire basis, food processing facilities, etc. which are so critical for increasing social progress index (SPI), being a major determinant, for achieving the SDGs. Also, there is a need to rationalize input subsidies and transfer them henceforth to farmers through direct benefit transfer (DBT) mechanism such as: converting subsidies on fertilizers as incentives for use as per need assessed through soil health cards, power and irrigation subsidy through adoption of conservation agriculture as well as micro-irrigation practices, more land cover under trees (e.g. har med par ped) through adoption of agroforestry policy etc. Accordingly, it is recommended to convert subsidies as incentives for both farming efficiency and environmental services @ Rs 10,000 per acre per annum up to a maximum of 10 acres (4 ha) per farming family. Strengthening of price stabilization fund is also suggested with enhanced allocations and the creation of a credit risk management fund is suggested on the model of plantation crops. Insurance of horticultural crops, livestock and fishery needs to be given equal importance under *Pradhan Mantri Fasal Bima Yojana* (PMFBY), linked to operational efficiency for its implementation through accurate weather forecasting, mapping of losses using satellite imagery, and the timely settlement of claims, etc.

For increased income of farmers, and for attracting youth in agriculture, emphasis is clearly needed now on secondary and specialty agriculture, supported well by value chain for efficient post-harvest handling, rural based primary processing and marketing. All these are badly in need of policy support and technical backstopping. In this context, the minimum support price (MSP) be fixed at 1.5 times of cost C2 and the procurement in future be extended to all commodities, with decentralized procurements to be made by the States. Also, there is need to enhance markets intensity in rural areas and ensure market linkages through e-NAM requiring uniform adoption of Agriculture Produce and Livestock Marketing (APLM) Act and Contract Farming Act by various States. Further, the *mandi* tax has also to be rationalized around 5-7 per cent, whereas some even charge more than twice the amount. The Essential Commodities Act (ECA) and Agricultural Produce Marketing Committee (APMC) Act also need to be reviewed in regard to their relevance especially when intention through e-NAM is to create a unified national market to benefit both the producers and consumers. The concerns of seed industry with regard to implementation and harmonization of Biological Diversity Act and Protection of Plant Varieties and Farmers Rights Act (PPV&FRA), unresolved issues relating to access and benefit sharing (ABS) for use of genetic resources, besides intellectual property (IP) protection on innovation such as genetic modification (GM), genome editing, etc., pricing policy on seeds and long awaited revision of Seed Act need to be addressed on priority. The fertilizer and pesticides industries also have serious concerns relating to regulations and their effective implementation requiring immediate Government intervention to create an enabling environment to ensure accelerated growth of agriculture. It is proposed that corporate social responsibility (CSR) be now linked to efficient technology dissemination through active involvement of youth (including women) as technology/extension agents, input and/or service providers and for the establishment of Agri-Clinics involving young enterpreneurs. Considering enormous potential for agricultural

exports, it is suggested to revisit our export-import (EXIM) policy and make it long-term foresight oriented to harness the benefits of globalization. For this, Agricultural and Processed Food Products Export Development Authority (APEDA) needs to be strengthened to take-up additional functions of international demand assessment, establishing linkages with potential importing countries and to maintain international food safety and quarantine standards. It should also create a national system of certification of organic foods for both domestic and international markets.

Further, it has been observed that the Seed Bill, Pesticide Management Bill, Biotechnology Regulatory Authority of India (BRAI) Bill, and other important Bills/Acts relating to agriculture and rural development are pending for enactment by the Parliament for long and hence all these be got expedited without further delay. A National Policy on Biotechnology, embracing GM and genome editing, National Livestock Breeding Policy (including the enactment of a new Act to protect all indigenous livestock breeds), and the National Land Utilization Policy, which is both owner and tenant friendly, as proposed in the Model Land Leasing Act, should be considered for quick decision and implementation by all the States concerned. In this context, the fragmentation of land holdings below one ha in irrigated and 2 ha in the rainfed areas, being uneconomical, be legally not permitted. Also, the digitization of agricultural land ownership records be now made a priority requirement by all States.

Finally, it is committee's resolve that the growth of agriculture sector can be accelerated to help achieve SDGs much faster provided the recommendations given in the report are implemented through both a missionary zeal and as a package by the Government.

1. Role of Agriculture in Achieving Sustainable Development Goals

1.1 Introduction

Alleviation of absolute poverty, and ending hunger and malnutrition are the two most important sustainable development goals (SDGs) that must be achieved by all nations by 2030. In addition, there are country-specific development challenges for agriculture. Addressing these challenges and goals would require multidimensional interventions for availability and access (both economic and physical) to diversified and balanced food. India has made remarkable progress in food grain production for achieving food and nutrition security. India not only became self-sufficient but also emerged as a major exporting country. The past achievements of quantum jump in the production and productivity were attributed to the introduction and breeding of high yielding dwarf varieties of wheat and rice and their improved cultivation practices, which adequately demonstrate the vast potential of science-led revolutions Green, White, Blue, etc. The main factors for these successes had been: (i) political will to reform, (ii) good institutions and human resource, (iii) availability of critical inputs (seeds, water, fertilizer, etc.), (iv) partnership between extension workers and hardworking farmers and (v) partnership at the global level.

India could successfully feed the rising population, despite its population getting quadrupled. The current population of 1.36 billion is projected to rise to nearly 1.51 billion in 2030 and 1.65 billion by 2050. Soon India would emerge as the most populous country in the world. Feeding this huge population will pose serious challenge in view of our dwindling and degrading natural resources (soil, water, agrobiodiversity), fast changing dietary patterns and the adverse impact of climate change. The foremost limitation would be the availability of good land and water for agriculture, when net cultivated area has remained static around 140 million ha over the last five decades. Moreover, prime agricultural land is gradually decreasing due to urbanization and industrialization. The forest and tree cover, which as per National Forest Policy (1988), and New National Forest Policy (2018) should be around one third, is not even one fourth at present. The process of soil degradation continues unabated. As a result, the performance of agricultural sector is gradually declining. The real agricultural and allied gross value added (GVA) grew by 2.9 per cent during 2011-12 to 2017-18, whereas as per National Agricultural Policy (2000), it should have been around 4.0 per cent, to attain an overall economic growth of 8.0 per cent.

Today, agriculture in India accounts for 15.4 per cent of our gross domestic product (GDP) and provides employment to around 49 per cent of the population. Poor agricultural performance invariably leads to inflation, economic distress and negative impact on consumption, all of which can hold back the national economy. Further, the volatility of agricultural growth continues to be substantially higher than countries like China. Hence, India needs to raise its growth trajectory while transitioning to a more inclusive, stable and resilient growth of agriculture and agri-food system. To arrive at appropriate, implementable and politically feasible solutions, the contemporary debates on agriculture need to have a paradigm shift. From the traditional agriculture system aiming at mainly the physical productivity targets to now a diversified, secondary, specialty and resilient agriculture, well supported by smart policies, strengthened and relevant institutions, capable human resource and an overall enabling environment for both public and private sector investment and performance. Only then resilient and sustainable agriculture sector would be able to end poverty, ensure household nutritional security and improve the livelihood of millions of smallholder farmers in India.

The Government of India (GoI) has accorded high priority to agriculture and has come out with several policy and safety net related measures to enhance farmers' income. The following enabling policies are in place: (i) institutional policies such as facilitation of farmers collectives like Farmer Producer Organizations

(FPOs) with proper legal framework, credit to the farmers and formation of processing clusters, market reforms, micro-irrigation, machine rental services, etc.; (ii) research policies aiming at promotion of agro-ecological based planning, research for agro-processing and value chain promotions, new funding models for encouraging research by state government; (iii) price policies fixing higher minimum support price (MSP), inclusion of efficiency, compensation for risk and ecosystem service; and (iv) policies for more investment in agriculture rather than subsidies, and promoting private investments. Further, several existing GoI missions (Box 1) and central sector schemes and other programs (Annexure X) are operating to address major areas in agriculture. Sustainable agricultural practices are being pursued to balance both soil and environmental health and economic profitability in order to promote social and economic equity. These missions need to be invigorated and some to be re-organized. Notwithstanding these impressive initiatives and un-parallel progress, India still faces formidable challenges to meet the SDGs by 2030.

Box 1. GoI Missions in Agriculture and Allied Sectors

National Food Security Mission (NFSM) with Mini Mission (Rice), Mini Mission (Wheat), Mini Mission (Pulses), Mini Mission (Nutri-cereals), and Mini Mission (Oilseeds & Oil palm); National Mission on Oilseeds and Oil Pam (NMOOP), launched in XII Plan, has become part of NFSM as NFSM (Oilseeds & Oil palm); National Mission on Sustainable Agriculture (NMSA) with *Paramparagat Krishi Vikas Yojana* (PKVY), Soil Health Card (SHC) & Soil Health Management (SHM) Schemes, Rainfed Area Development (RAD), and *Pradhan Mantri Krishi Sinchayee Yojana* (PMKSY); National Mission on Agricultural Extension & Technology (NMAET) with Sub-Mission on Agriculture Extension (SMAE), Sub-Mission on Seed and Planting Material (SMSP), Sub-Mission on Agricultural Mechanization (SMAM) and Sub-Mission on Plant Protection and Plant Quarantine (SMPP); Sub-Mission on Skill Development, Technology Transfer and Transfer Extension (SMSDTT&E), Green Revolution - *Krishonnati Yojana*, and Integrated Scheme on Agriculture Census, Economics and Statistics (ISACE&S); *Rashtriya Gokul Mission* (RGM); National Livestock Mission (NLM) Sub-Mission on Livestock Development, Sub-Mission on Pig Development in the North-Eastern Region, Sub-Mission on Feed and Fodder Development (SMFFD), Mission for Integrated Development of Horticulture (MIDH) with National Horticulture Mission (NHM), National Horticulture Board (NHB), Coconut Development Board (CDB), Central Institute of Horticulture (CIH), National Agroforestry & Bamboo Mission (NABM); National Rural Livelihood Mission (NRLM), Integrated Scheme for Agricultural Marketing (ISAM), Agricultural Marketing Infrastructure (AMI), National Agriculture Market (e-NAM), National e-Governance Plan in Agriculture (NeGP-A), *Pradhan Mantri Fasal Bima Yojana* (PMFBY), *Pradhan Mantri Kaushal Vikas Yojana* (PMKVY), Pradhan Mantri Employment Generation Program (PMEGP), *Swarna Jayanti Shahri Rozgar Yojana* (SJSRY), and North Eastern Council (NEC)

1.2 Current Challenges

Agriculture is currently faced with second generation challenges of the Green Revolution and other emerging challenges such as: slowing down of total factor productivity growth, rising cost of cultivation, depleting natural resources (land, water, agrobiodiversity), increasing cost and inefficient use of inputs, higher incidence of diseases and pests, rising concern of nutrition, quality and safety of food, change in consumer preferences towards healthy foods, adverse impact of climate change, rapid division and fragmentation of land besides diversion of agricultural land to non-agricultural purposes particularly nearer to cities and suburbs, widening production disparities between agro-ecological regions, inadequate mechanization, labour shortage, significant wastage of agricultural produce due to inadequate post-harvest processing and storage facilities, and linking farmers to markets, lack of interest in agriculture among youth, and migration of agricultural labour to non-farm jobs.

Other challenges relate to meeting the SDGs requiring a major shift in focus from food security to nutritional security and from agricultural production to sustainable agri-food systems. Also, there will be a need to diversify our agri-food systems, while also ensuring food supplies at affordable price, and to protect the poor and most vulnerable from the risk of volatility, both social and environmental, while maintaining biodiversity, natural resources and ecosystem services. All these challenges have to be addressed through improved and innovative approaches.

Efforts or a transition toward sustainability should also ensure to preserve the environmental life support systems. In the past, political and policy disregard of environmental considerations in development projects has been a momentous mistake. Anthropogenic impacts on the environment are occurring at unprecedented scales. Issues like water and air pollution, ozone depletion and climate change, droughts or floods, disease epidemics and loss of biodiversity have reached a critical stage, potentially eroding the conditions upon which socioeconomic stability is possible. The consequences of environmental breakdown will fall hardest on the poorest that are most vulnerable to its effects. It is estimated that the poorest half of the global population are responsible for around 10 per cent of yearly global greenhouse gas emissions, with half of the total emissions attributed to the richest 10 per cent of people.

1.3 Agriculture and Sustainable Development Goals

The UN 2030 Development Agenda for Sustainable Development includes 17 SDGs and 269 targets. Out of 17, almost 10 SDGs are related to agriculture and farmers' welfare. These include: 1) No poverty, 2) Zero hunger 3) Good health and well-being for people 4) Quality education, 5) Gender equality 12) Responsible consumption and production, 13) Climate action, 14) Life below water , 15) Life on land, and 17) Partnerships for sustainable development. Hence, well-coordinated efforts need to be made to achieve these goals. Both, SDG 1 and 2 relating to elimination of poverty, ending hunger, achieving food security and improved nutrition are obviously the most important needing urgent attention.

While India has achieved considerable progress in reducing poverty and hunger, yet millions of people still go to bed hungry. Similarly, malnutrition is another aspect of hunger leading to many types of diseases, especially among the children thus affecting our economy adversely. South Asia has the largest concentration of poor and food insecure population (nearly 486 million in 2017) of which 71 per cent reside in India. India houses 24 per cent of world's malnourished. It has shown improvement in reducing child stunting but with 46.6 million stunted children, the country is home to over 30.9 per cent of all stunted children under 5 - the highest in the world. Like other countries, India also met most of the millennium development goals (MDGs) well before 2015, but the pace had been much slower as compared to China and other countries in South-East Asia. Also, the progress for some of the development goals had been rather inconsistent. While India can achieve the poverty reduction target, it may fall short of reducing hunger mainly on account of economic access to food and not because of shortage of food.

India since adoption of SDGs in September 2015, has directed its development pathway, through improvement in its social progress index (SPI), by improving infrastructure, employment, economic growth, food, water and energy availability, disaster management and poverty alleviation. India has also aimed to restore its natural resources and adopt transparent and robust governance along the democratic lines. However, emerging climate change impacts, increasing inequalities, and lagging human development indices as well as SPI are well recognized by both the people and the GoI. In fact, India would need to move faster to improve current SPI, which stands at 56.26 per cent at 100th position out of 146 countries. According to Paris Agreement, the temperature rise must be limited to 1.5^{o}C by 2030, carbon neutrality be achieved by 2050 and global emissions be limited to 45 per cent by 2030 (McKenna Phil, 2008). The SDGs provide an opportunity to renew and integrate efforts to meet the national and global aspirations in a defined time frame. The pressing need for India, therefore, is to effectively execute the new agenda through much needed partnership among key national and global stakeholders.

In India, the National Institution for Transforming India (NITI Aayog) is responsible for developing, monitoring and execution of implementation plan for achieving SDGs. In the process, the GoI should build stakeholder capacities to gather measurable data as indicators of change. Achieving SDGs in India, is indeed a difficult task, yet not unachievable. The GoI needs to clearly identify priorities, ordain development policies that are locally relevant and people-centric, and build strong partnerships. It also needs to have a focused plan for better coordination, monitoring and evaluation impact through successful interventions. The SDGs are, thus, a vision for India to ensure prosperity and economic growth. It is quite evident that India is in the centre stage globally, demanding concerted efforts to achieve SDGs, failing which the UN targets would possibly not be met considering the levels of both poverty and hunger that exist in India.

The targets to achieve SDG 2 "End hunger, achieve food security and improved nutrition and promote sustainable agriculture" include: (i) end hunger and ensure access by all people to safe, nutritious and sufficient food all the year round; (ii) end all forms of malnutrition in children under five years of age, adolescent girls, pregnant and nursing women and older persons; (iii) double the agricultural productivity and incomes of small-scale food producers; (iv) ensure sustainable food production systems and implement resilient agricultural practices and (v) maintain the genetic diversity of seeds, cultivated plants, farmed and domesticated animals, and their related wild species.

In fact, SDGs 1 and 2 resonate strongly with the Indian development agenda since elimination of poverty and hunger continues to be our major goals. Fortunately, our database for poverty indicators is robust and India has adopted some of the elements of a social protection network, like National Food Security Act (2013) which aims to provide subsidized foodgrains to approximately two thirds of India's population. It converts into legal entitlements for existing food security programs of the GoI, namely, the Mid-Day Meal Scheme (MDMS), Integrated Child Development Services Scheme (ICDSS) and the Public Distribution System (PDS).

India is justly proud of its success at the food production front. However, this has not taken care of existing hunger because of access to quality food largely depends on income status and prevalence of prices. If India succeeds in its goal of poverty reduction, it will also contribute largely towards elimination of hunger (measured in terms of low dietary energy intake). Over the last two decades, we have come to understand now that India faces a serious problem of malnutrition besides rising levels of obesity. Many of our children (3 out of 5 below 5 years of age) are stunted and weigh less than children in other impoverished countries in the world. This could partly be due to illiteracy of women, the young age marriages, and their poor nutritional status. The GoI has, thus, to evolve a robust policy to address the problem of malnutrition especially the protein and micronutrient deficiency and achieve household nutrition security. The problem of obesity also needs to be addressed on priority since the percentage of Indian adults living with obesity is continuously increasing.

1.4 The New Strategy

In order to achieve SDGs, there is an urgent need to adopt a new strategy evolved around scaling of technologies and innovations, through an enabling policy environment and better governance. The new strategy should promote new agriculture on the principles of efficiency, inclusiveness and ecology, innovative institutions, public-private partnership (PPP) and higher public investment. The SDGs do present a unique opportunity for the entire agricultural sector to get aligned for a better tomorrow. At the same time, it is imperative that policy makers accord high priority and increase the allocation for agricultural research and innovation for development (ARI4D) and all rural institutions that are associated with empowerment of farmers. However, the success on these fronts of achieving SDGs would require a mission-mode approach to implement and effectively monitor the progress of SDGs. This would require enhanced capital investment in non-green revolution areas so as to improve SPI. Besides macro priorities of SDGs, enhancing farmers' income is a major policy objective, which shall need focus on not only on production but on post-harvest management, value addition and diversification for rural livelihood options. The new strategy must blend these farm household priorities with national and global development agenda. Some of the important changes needed in the strategy are summarised below:

1.4.1 Harnessing Science, Technology and Innovations

There is a need for prioritization of research portfolio in tune with the fast-changing global, regional and national needs. The 'top-down' approach adopted in the past will have to be changed to make it a 'bottom-up' approach. A shift from project to program mode and also from commodity/crop to farming system's mode is urgently warranted. In this context, focus on system diversification, exploitation of hybrid vigour and biotechnology, information communication technology (ICT), geographic information system (GIS) and good agronomic practices (GAP) would help in doubling farmers' income and attain resilience in agriculture with efficient input (water, fertilizers, pesticides) use. For resilience in agriculture, ecofriendly and climate resilient technologies and efficient farming systems in different ecoregions should be adopted with focus on improving soil health through organic matter recycling, conservation agriculture, need based use of nutrients based on soil test, improved water use efficiency using micro-irrigation techniques, etc. Increasing income, especially of the 86.2 per cent farmers who are small and marginal having holdings less than 2 ha would require technologies and innovations by which they can economize on cost of inputs and earn more income by higher productivity, product quality and also by linking them to value chains and markets. Thus, scaling of innovations like hybrid technology, integrated nutrient management (INM), integrated pest management (IPM), adoption of genetically modified (GM) food crops, protected cultivation, etc. becomes high priority. Agricultural diversification towards high-value crops can potentially increase farmer's income. Also, shifting orientation from cereal dominance to high value crops like horticulture and livestock could prove to be immensely useful. For all these to happen, enabling policies, strong PPP and innovative extension systems to transfer right knowledge especially around Natural Resource Management (NRM), secondary and specialty agriculture would be needed. For resilience in agriculture, ecofriendly and climate resilient technologies and efficient farming systems in different ecoregions needs to be adopted with focus on improving soil health through organic matter recycling, conservation agriculture, use of nutrients based on soil test, improved water use efficiency using micro-irrigation techniques etc.

1.4.2 Pre- and Post-Production Management

There is a need for developing new agri-food systems for post-production management through processing, value addition and by ensuring no wastage of food during storage, transportation and consumption. The reforms should begin with market linkages through e-NAM, revision of Agricultural Produce Marketing Committee (APMC) and provision of pledged storage. Development of secondary and speciality agriculture, value chain development and backward linkages are necessary. These developments should lay emphasis on rural youth as entrepreneurs and service providers. Also, an effective coordination and convergence mechanism is required at all levels.

1.4.3 Policy Reforms

The food and agricultural policy needs to become more holistic and strengthen possible links between productivity, environment and human health. The agri-food systems approach should also strengthen production and consumption linkages, and form the basis for developing a policy framework for future sustainability of farming systems.

The agriculture policy should be such that it promotes the use of vast untapped growth potential, increased resource use efficiency, water resource management, soil protection against urban and industrial encroachment, promote value chain, mechanisation of pre and post-harvest operations, product efficient post-harvest management, linking farmers to markets, promote agri-business, strengthen rural infrastructure, improve transport and storage, enhance rural employment, and provide better amenities and living conditions to attract youth in agriculture and discourage their migration to urban areas. There is also an urgent need to attract private sector in development of wholesale markets, warehouses and cold storages, input delivery, agro-processing, micro-irrigation and agricultural extension. Policy orientation is also required to promote diversification of agriculture, use of emerging technologies such as precision agriculture, biotechnology and nanotechnology, remote sensing, big data and artificial intelligence, vertical farming, organic farming and space agriculture. Thus, concerted efforts are urgently needed to take effective

measures to attain and sustain an annual growth of 4.0 per cent, efficient use of resources while conserving available land, water and agrobiodiversity, attaining fast growth across the regions and catering to the needs of domestic and global markets. The policy and investment priorities in agriculture need to readjust to these new imperatives, increase farmers' income, and cater to the changing consumer preferences and overcome the challenge of malnutrition.

Agricultural growth shall be sustainable when it meets socioeconomic concerns and improves economic welfare of farmers and other agricultural workers. This will have direct impact on alleviation of absolute poverty and promotion of overall economic growth. The aim of the policy for a secure and sustainable agriculture, therefore, should be to change attitudes and promote action plans which could result in assessing agricultural progress in terms of improvement in the income of farm families, enhance their capacity to invest in agriculture, and improve family welfare. An aggressive approach on policy advocacy and reforms is urgently warranted for faster scaling of innovations. Thus, sustainable agricultural development is the key to achieve SDGs by 2030. This report suggests some of the short- and medium-term policy and institutional changes, and action plan to harness the potential of science and upscale important impact-oriented innovations for a secure and sustainable agriculture.

2. Accelerating Agricultural Growth for Secure and Sustainable Agriculture

The present day agriculture has progressed substantially well and becoming more and more efficient over time. Despite these appreciable achievements, inadequacy of farm income to meet household needs, market inefficiencies for perishables, rising fiscal burden of subsidies, challenges associated with climate risk and depleting natural resources need immediate attention. From food-security angle, India in a way is food secure, but not from the point of zero hunger and nutritional security. In the 2018 Global Hunger Index (GHI), India was ranked 103rd out of 119 qualifying countries (with a score of 31.1), classifying the country to be suffering from a 'serious level of hunger'. According to one estimate, proportion of undernourished people in India is disproportionately high (190 million or 14.5% of the total population). Sixty per cent of the Indian population depends on agriculture for livelihood while contribution to the national GDP is only 14-15 per cent, leading to unsustainable development.

In the foreseeable future, agri-food systems will be under an unprecedented confluence of pressures. The challenges will centre on access to food, nutrition, and the sustainability of agro-ecological systems. The increasing population accompanied by rising income, changing dietary patterns and increased demand for a more varied, high quality diet requiring additional resources for production will exert pressure on the food systems. Parallel demographic changes, such as the migration of youth into urban areas will affect agricultural productivity through labour and wage effects. The availability and productivity of water, energy, and land shall vary enormously between regions and production systems, and competition for efficient and judicious use of these resources will further get intensified. Farmers, especially small and marginal farmers, agricultural labourers, fishers and pastoralists are projected to face acute livelihood challenges due to lack of rural infrastructure to support farm and non-farm activities. Therefore, addressing their needs and aspirations is a matter of national priority in order to achieve successfully the SDGs by 2030. Further, India's climate change challenges are aggravated by serious degradation of its natural resources, including rapidly depleting availability of water, soil degradation, deforestation, land degradation and threats to agro-biodiversity.

This section provides an overview of the status, challenges and opportunities relevant to agriculture sector *per se*, as well as sub-sectors like natural resources, crops, horticulture, livestock, fisheries, etc. It also reviews the contribution and role of the varied stakeholders like farmers, youth, women and private sector towards agriculture development. The importance of technological and institutional innovations, and the need for reorientation of some policies to promote both secure and sustainable agriculture, providing livelihood security to millions of smallholder farmers are enumerated. Importantly, it delves on issues like attracting investment (both public and private), reorienting diversified and responsive agricultural research and innovation for development (ARI4D), enabling environment for all stakeholders, better Centre-State coordination mechanisms, improved and efficient market and value chain linkages, urgent land reforms, assuring availability of quality inputs, broadening partnership, and efficient systems for risk management. to make agriculture more productive, profitable, climate-smart, and ecofriendly.

2.1 Role and Needs of Farmers

The farm sector today predominantly comprises small and marginal farmers (around 86%), and their contribution towards national economy is still quite significant. Farmers invariably face major problems in accessing the right knowledge and basic agricultural inputs/resources at affordable cost. Many farmers are in stress and becoming labourers or shifting to other means of livelihood. Also, farming is considered to be a low key activity and is not being sought as a profession/career by the younger generations.

Indian farmers require long-term sustainable solutions instead of short term rhetorical promises and reactive concessions. The farmers are not connected to aggregators, food processors and retail chains to help shape the nature of their produce. As a result, produce remains the same annually, largely dependent on farmers and is often driven by the government's MSP program. The farmer is barely empowered as a supplier. He continues to be small and marginal, inadequately resourced, ill-informed on marketing, ill-equipped to manage risk, burdened with credit and debts and is dependent on traders to reach the buyers. The farmer is not only technology starved but untrained also to adopt it fast. Further, there is a staggering lack of infrastructure across the entire agricultural value chains.

Therefore, future ARI4D agenda and the national agricultural policy must keep in centre smallholder farmers. There is now a need to widely adopt the Farmer FIRST (farm, innovations, resources, science and technology) approach in order to improve their livelihood and to make agriculture a respectable profession.

2.1.1 Challenges

The marginal and small farmers invariably depend on farm inputs either from their own resources or from the available government schemes. The major constraints and difficulties faced by them are as follows:

- Availability of good cultivable land, due to soil erosion and over-exploitation, land becoming uneconomical and conversion of good land around cities for non-agricultural purposes.
- Water scarcity due to the repeated droughts and depleting water resources; access to sufficient water for irrigation
- Scarcity of input resources like improved quality seed, low-cost fertilisers, effective and safe insecticides and pesticides etc.
- Less options for scaling of innovations and technologies, e.g. rural based low-cost value addition and post-harvest processing, that otherwise can create employment opportunities for the youth and women
- Lack of easy credit availability at low interest rates
- Inadequate linkages to the markets, easy transportation and availability of warehouses around *mandis*/markets for storage of produce, especially to avoid distress sale
- Lack of infrastructure to ensure technology transfer, gaps to identify farmer's priority in the changing climate scenario
- Lack of measures to protect the farm from wild animals

Also, there is a need for motivation of farmers to produce organic or customised manure locally to increase productivity and improve their soil fertility. In reality, majority of smallholder farmers are unable to sell their produce at MSP. Due to small quantity, they invariably are not able to go to *mandis* to sell their produce.

2.1.2 Opportunities and Strategies

In view of above, present policies need a paradigm shift to have a pro-farmer (Farmer FIRST) focus with income and prosperity being the central theme of agricultural planning in future. The planning for a secure and sustainable agriculture should involve: (i) designing the agricultural policy to focus on the best returns to farmers, (ii) agricultural diversification towards high-value crops, (iii) shifting orientation

from cereal dominance to high value crops like horticulture and livestock, (iv) farmer friendly long term export policy, (v) greater investment and participation of private sector in research and development, (vi) adoption of new models for collection, dissemination and usage of data, effective use of ICT for knowledge dissemination; and (vii) linking subsidies with efficient farming practices around use of water, seeds, fertilisers, pesticides, and farm mechanisation. For all these to happen, enabling policies, strong public-private partnership and innovative extension systems (including private extension involving youth) would be urgently needed. Farmers and farming must be served under a single window system for which reorganisation of the institutional mechanisms at the district/block level would be needed. In this context, strengthening of *Krishi Vigyan Kendras* (KVKs), Cooperative Banks, Agri-Clinics, Farmer Producer Organizations (FPOs), Self-Help Groups (SHGs), Custom Hire Centres (CHC), etc. should receive top priority now. Even successful models for credit to farmers at low interest rate like Grameen Bank in Bangladesh or to establish Kisan Banks in rural areas would be a desirable step to make a difference. Therefore, reorientation of Indian agriculture through an 'out of box' approach is warranted.

2.1.3 Doubling Farmers' Income

(i) Sources of income growth

The strategy for doubling farmers' income focusses on the interventions by the Centre and State agencies at disaggregate level to achieve higher share of farm income in the farmers' cumulative income. The time frame for achieving the target of doubling farmers' income, in real terms, is from 2016-17 to 2022-23, with 2015-16 as the base year. The average annual income of the farmer at the national level in the base year is taken as Rs 96,703, which is an extrapolation of the 2012-13 NSSO estimates. The targeted farmers' income in 2022-23 shall be Rs 1,92,694 (at 2015-16 prices). For the prescribed time frame, a target of farm income growth rate of 10.4 per cent a year is required, as against current level of 5 per cent. Hence, it is indeed a task not all that easy to be accomplished unless concerted and missionary efforts are made with enabling policy support for reforms and reorganisation suggested by this committee in the report. The target is also to change the ratio of farm to non-farm income from the existing 60:40 (in 2015-16) to 70:30 (by 2022-23). This is likely to ensure greater viability of farming.

The major sources of growth operating within the agriculture sector include: (i) improvement in crop and livestock productivity (ii) resource use efficiency for reduction in the cost of production (iii) increase in cropping intensity by raising second crop on fallow lands and (iv) diversification towards high value crops. Further, the following two sources of growth operate outside the traditional agriculture sector but contribute to farmers' incomes; first is improvement in agricultural terms of trade and second is a shift from farm to non-farm occupations. It is estimated that the scope and contribution of these factors at the all-India level shall be about 75 per cent growth in farmers' farm-income (crops, horticulture and livestock) in next seven years, assuming that all the factors underlying the growth in farmers' income rise at the same rate as experienced during the decade ending 2014. The strategy for doubling farmers' income should focus on the following:

Diversification: Agricultural diversification towards more sustainable cropping/farming systems and towards high-value crops can potentially increase farmers' income. The non-traditional areas may include shifting orientation from cereal dominance to high value commodities like horticulture and livestock sector. Even, as pulses are becoming a high value commodity, shift in their favour can meet the nutritional as well as income security. In this context, exploiting eco-regional advantages could be a better strategy. Focusing Jammu & Kashmir, Himachal Pradesh and Uttarakhand for fruits production, targeting marginal and smallholder vegetable growers and directing large farmers for capital intensive fruits and flowers sector could be augmented. This diversification must take place with adequate price and infrastructure support, technological interventions and training of farmers to grow better and remunerative crops. Increase in cropping intensity at the same rate as observed in the recent past has the potential to raise farmers' income by 3.4 per cent in 7 years and 4.9 per cent in ten years; this can turn out to be much higher as the possibilities for taking second crop gets brightened.

Cost reduction: The cost of cultivation is very high for some of the crops and there exists scope for its

reduction. The cost of labor is quite high in most of the crops and wages are rising faster in view of scarcity of labour. Therefore, farm mechanization has tremendous scope for reducing the cost of production. Some of the machines are expensive and, therefore, institutional credit support is critical. Many progressive farmers and rural youth would be willing to buy these machines and use for custom hiring. In fact, already there are successful examples of CHC in different states, which are owned by rural institutions, NGOs and farmers SHGs. Such centres need to be multiplied with adequate funding support. Role of KVKs in popularizing these machines through revised mandate to facilitate Agri-Clinics involving youth entrepreneurs thus get institutionalized technological options like precision farming, conservation agriculture, micro-irrigation and integrated nutrient as well as pest management shall reduce the cost of production, thereby increasing the farm income.

Value addition: High emphasis be now given to post-harvest management, linking to markets, logistics and supply chains along with price support. Operation Greens, which focuses on bringing the price stability in tomato, onion and potato, has been initiated on the lines of operation flood with a focus on agri-logistics, processing and professional management. FPOs of less than Rs 100 crore turn over are exempted from income tax for first five years - to encourage professionalism in postharvest value addition. Organic farming by Village Producer Organizations (VPOs) and FPOs is being encouraged in large clusters. Cluster based cultivation and development to achieve economy of scale in the horticultural supply chain though FPOs/ VPOs. e-NAM, a mission for a common online market platform to facilitate pan-India trade in agriculture commodities, providing better price discovery through transparent auction process based on quality of produce along with timely online payment is being made functional. Now 16 states and 585 APMC markets have been integrated with e-NAM platform. Besides, a number of other schemes and programs have been started for enhancing the income of farmers through better marketing opportunities.

Non-farm income: With rising income and productivity, demand for rural non-farm services and industry products are rising fast. Important among these are: rural construction, maintenance of farm and other machines, localized marketing and petty trade etc. Given farm and non-farm linkages, the growth in the latter is expected to accelerate. Therefore, investment in human capital (education and health), especially among youth including women and access to financial services are important for enhancing income through rural non-farm sector. The support announced in the recent budget under A Scheme for Promotion of Innovation, Rural Industries and Enterprise (ASPIRE) shall help develop livelihood and technology incubators to promote rural entreprenuers. Finally, the strategy for doubling farm income is based on a uniform approach, which may not result into desired outcomes. It is, therefore, suggested that an ecoregionally differentiated strategy focusing on relevant components of doubling farm income should be adopted. This strategy be backed with adequate resources for both capital investment and technology generation. The participation of the states is extremely important in this regard as most of the programs will have to be implemented by the states in partnership and with support of the Centre.

2.2 Overview and Growth of Agriculture Sector

The growth of gross value added (GVA) in agriculture improved from a negative 0.2 per cent in 2014-15 to 6.3 per cent in 2016-17 but decelerated to 2.9 per cent in 2018-19. While the crops, livestock and forestry sectors showed fluctuating growth rates over the period from 2014-15 to 2017-18, the fisheries sector has shown a rapid growth from 4.9 per cent in 2012-13 to 11.9 per cent in 2017-18 (Fig.2.2.1).

With an increasing contribution from allied sector each year, the performance of agricultural sector has turned modest in the recent past. The real agricultural and allied GVA grew by 2.9 per cent between 2011-12 and 2017-18 (Table 2.2.1). Crop sector growth was less than one per cent, and has turned less stable over years. While pulses, fruits and vegetables production recorded notable growth, rest of the crops have slowed down. Rather, livestock and fisheries sectors have registered sustained rise in growth. Observing annual growth

Table 2.2.1 Output Growth in Agriculture (2011-12 to 2017-18)

Sector	CAGR (%)
Crops	0.8
Livestock	7.3
Forestry & Logging	2.3
Fishing & Aquaculture	8.5
Agriculture & Allied	2.9

(Source: CSO; Base: 2011-12=100)

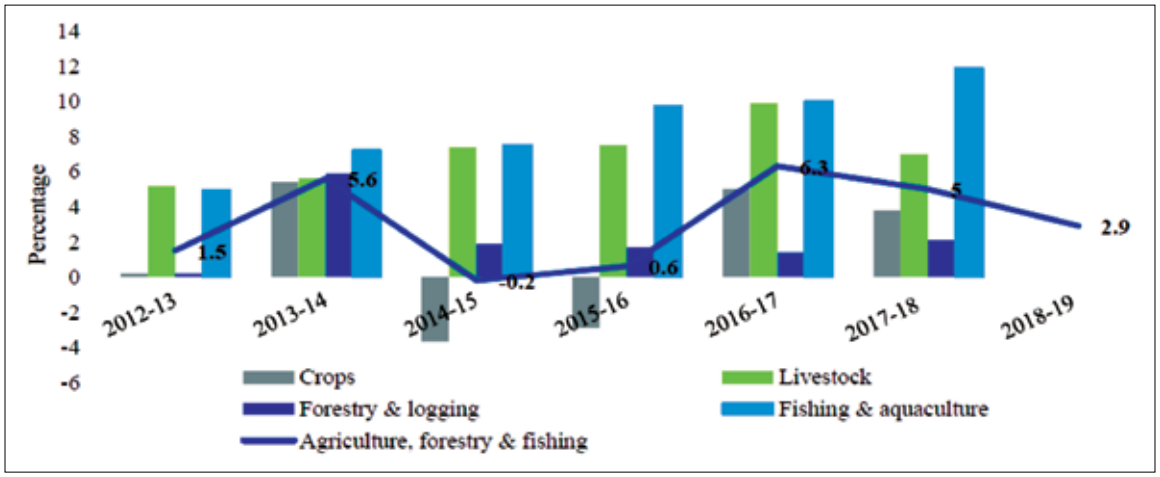

Fig. 2.2.1 Growth rate of GVA in agriculture and allied sectors (2011-12 prices)

(Source: Economic Survey of India, 2019)

trends, from a 5.2 per cent over the previous year in 2012-13, the livestock sector growth has risen to 7 per cent during 2017-18. The fisheries sector has surpassed the livestock sector, growing from 4.9 per cent to 11.9 per cent during these years. Thus, an increasing tendency of diversification and their role in sustaining agricultural growth is clearly visible.

The sources of growth had rather varied across the states. While some states grew more rapidly by raising more crops, others grew with livestock and a few with fisheries. Madhya Pradesh (6.6 %), Andhra Pradesh (5.0%), Chhattisgarh (4.9%) and West Bengal (4.1%) were a few States with notable crop sector growth during the year 2011-12 to 2017-18. During these 7 years, livestock sector growth was the highest in Madhya Pradesh (18.0%) and Tamil Nadu (14.9%), and was more than 8 per cent in the States of Rajasthan (9.7%), Andhra Pradesh (9.5%), Himachal Pradesh (8.5%), Jammu & Kashmir (8.5%) and Bihar (8.4%). In Andhra Pradesh and Odisha, fisheries sector grew by more than 10 per cent a year. Hence, sustaining future growth would largely depend on specific potential sectors of agriculture in different states. Planning at further disaggregated scale would, therefore, require redefining agro-climatic zones and major changes that have occurred in the existing cropping/farming patterns.

As regards the agrarian structure, as per Agricultural Census of 2015-16, the number of operational holdings has increased by 5.3 per cent, from 13.8 crore in 2010-11 to 14.6 crore in 2015-16. The share of marginal holdings (less than 1 ha) in total operational holdings also increased from 62.9 per cent in 2000-01 to 68.5 per cent in 2015-16, while the share of small holdings (1-2 ha) decreased from 18.9 per cent to 17.7 per cent during the same period. Large holdings (above 4 ha) also decreased from 6.5 per cent to 4.3 per cent. The area operated by the marginal and small holdings has increased from 38.9 per cent in 2000-01 to 47.4 per cent in 2015-16, while that of the large holdings decreased from 37.2 per cent to 29 per cent during the same period (Fig. 2.2.2).

As per earlier estimates, the real farm income got doubled, which took almost 20 years (between 1993-94 and 2015-16). As per the present target of the Government to double the farmers' income in 7 years between 2015-2022 and considering the past trend of growth, economists are of the view that we would require a minimum of 10.4 per cent annual growth rate in the income and larger part of this growth should come from production growth which currently is 2.9 per cent. Therefore, considering this to be a major challenge, a well-planned strategy for accelerating growth through diversified farming and increasing income through value chain, besides linking farmers to market would be the only option for achieving this target by 2022. The time frame for achieving the target of doubling farmers' income, in real terms, is from 2016-17 to 2022-23, with 2015-16 as the base year. In addition, there are other development related challenges, originating from SDGs, important ones being zero hunger, no poverty, life on land, and gender equality. All these can be achieved faster when there is sustainable growth of agriculture. This will be possible only through attracting more investment, scaling innovations through application of science and technology, facilitating regulations and policy framework, placing national priority on agriculture and

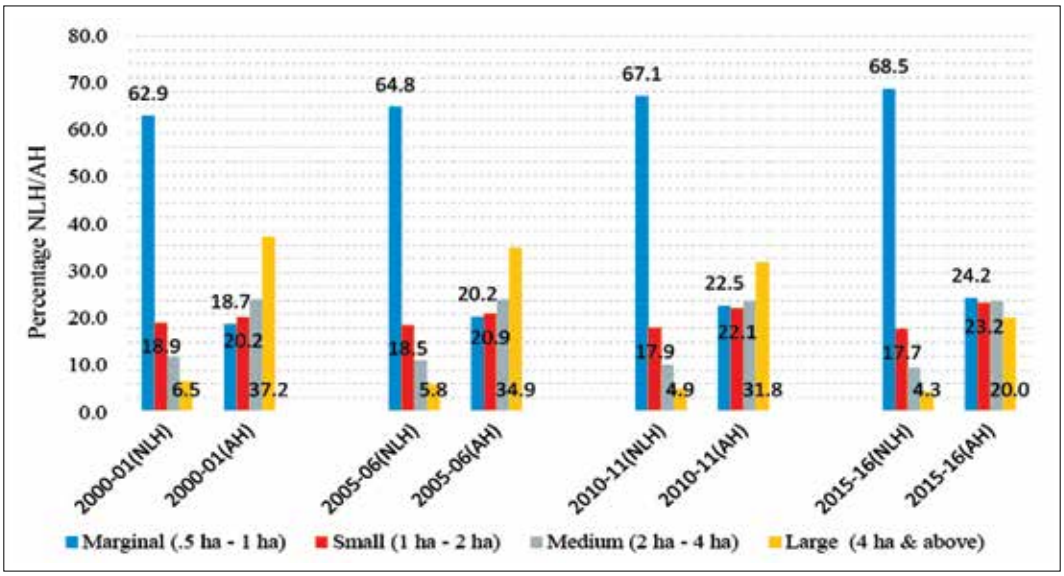

Fig. 2.2.2 Operational land holdings (number and area in ha)

(Source: Economic Survey of India, 2019)

supporting institutions/services linked to agriculture. Also, there should be efforts for voluntary aggregation or pooling of land, enhancing water and fertilisers use efficiency, creating an alternative mechanism for farmers to get better price for their produce, associated with provisions of direct sale of their produce and creation of pledged warehouse facilities for storage to avoid distress sale, developing enabling policies for rural based primary processing and value addition and for the export of agricultural commodities. Moreover, implementation of all developmental activities around agriculture would require an effective mechanism of coordination and convergence between Center and the States. With the acceleration of growth and improved profitability, youth (including women) would get motivated and attracted to farming and shall practice not only the improved and sustainable practices but would go for secondary and specialty agriculture, opening avenues for higher income. This coupled with improved SPI through better rural infrastructure, health, education, communication, and marketing facilities would attract progressive youth to continue building rural India and perceive agriculture a respectable profession.

2.2.1 Investments and Subsidies in Agriculture

(i) Capital investment in agriculture

The most important component of agricultural policy in India so far had been the public funding for creating infrastructure and support services. Public investment was the major source of growth in agriculture during the Green Revolution period. The contribution of public investment in 1985 was 33 per cent, which declined consistently to reach 17 per cent currently, with pace of decline being faster since 1990s. In absolute terms, the real agricultural investment during the year 2016-17 stands at Rs 2.6 lakh crores, amounting to around 2.2 per cent of GDP (Fig 2.2.3). Further, 83 per cent of investment has come from private sector, predominantly by farmers, and public investment mainly for surface irrigation, electricity and R&D. Farm household investment is 8 per cent of farm income and of this, 18 per cent is on livestock, 33 per cent for farm machinery and 42 per cent for other productive assets. The remaining 6.8 per cent is for non-farm business. This indicates that though farm household investment is rising but still it is low and will not be adequate to fill in the gap. Hence, accelerating further the pace of public investment, especially in the region left out of the Green Revolution, in particular eastern and north-eastern region, is most justified.

On the contrary, there had been considerable variation among states. Long-run public investment growth (1981-82 to 2015-16) had been more than 6 per cent in Andhra Pradesh (7.7%), Karnataka (6.7%), Gujarat (6.5%) and Tamil Nadu (6.2%), including the investments in irrigation. Interestingly, during 2001-02 to 2015-16, the lagging states have also raised their spending considerably for agriculture and irrigation. Among these, the states of Assam (15.9%), West Bengal (15.6%), Odisha (9.7%), Madhya Pradesh and Bihar

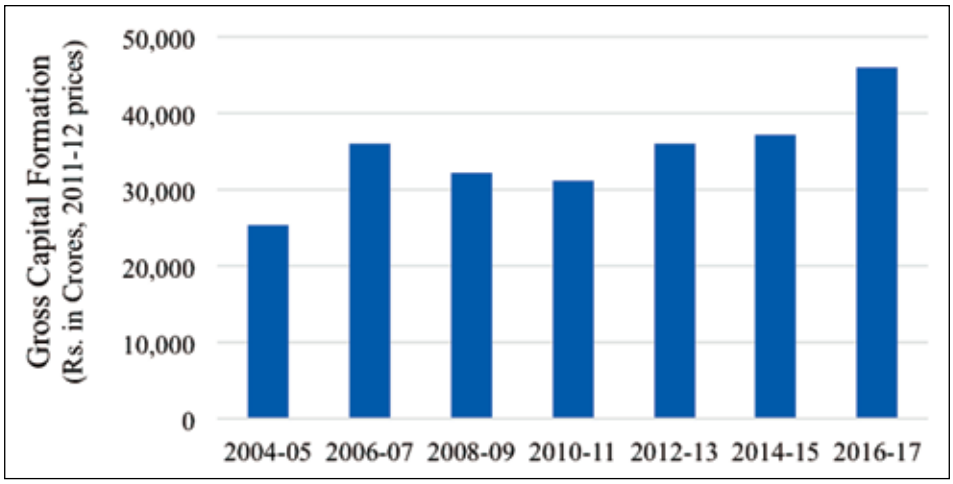

Fig. 2.2.3 Capital formation in agriculture in public sector (All-India, 2004-05 to 2016-17)
(Source: CSO, 2017-18)

(8.9% each) are the notable examples. At the same time, the growth in investment by the farmers had been relatively higher in Karnataka (15.3%), Bihar (14.8%), Himachal Pradesh (10.8%), Andhra Pradesh (10.3%) and Maharashtra (10.2%) between 2002-03 and 2012-13, whereas it remained less than 2 per cent in the states like Uttar Pradesh, Odisha, Tamil Nadu and Haryana. Thus, while the states like Madhya Pradesh, Andhra Pradesh and Karnataka witnessed substantial growth in both public and private investments, other states have projected mixed performances.

The key issues at the investment front are two-fold. First, the agriculture sector is under-invested, especially by the Government. Empirical observations clearly indicate that public investments have substantial role in accelerating agricultural growth. When public investment grew just by one percent during 1991-2005, agricultural GDP grew by almost 2.7 per cent. When investment increased in subsequent period (2006-2017) to 3 per cent, GDP growth raised to 3.3 per cent. Hence, it is clear that the scale of public investment has to be enhanced, especially when the ambitious policy of doubling farmers' income is in operation. Second, the private sector investment has to be accelerated in agriculture sector. The private sector investments could come for R&D, input supply such as seeds, chemicals, machinery, food processing, agricultural value chain export etc. Studies indicate that given the right incentives and regulatory framework, the private sector could contribute significantly towards higher agricultural growth. Fortunately, the current policy of the Government to attract private investment, even up to 100 per cent FDI, is a welcome initiative. This needs to be accelerated fast in agriculture sector as well. Hence, there is an urgent need to simplify the regulations and provide incentives to the private agriculture sector as well.

It is estimated that an annual growth of private (farmers) investment by 11 per cent and public investment by 15 per cent could help in doubling farmers' income by 2022. Hence, though private investment is rising over the public investment, but concern currently is to enhance public investment or else it will affect the growth adversely. Therefore, capital intensification by the Government especially in the lagging states, an increase in credit access to the farmers from formal financial institutions, especially in eastern and North-eastern regions, and increasing investments in market infrastructure, R&D, seeds, chemicals, machinery and food processing sectors could accelerate both productivity and income. Moreover, the agricultural capital has to be complemented with higher capital investment for rural development like roads, electricity, markets etc. This is important for increasing SPI being a critical indicator for achieving SDGs.

(ii) Investment in agricultural R&D

Agriculture R&D in India is largely under public domain and receives funding from the Government (Table 2.2.2). Both Central and State governments have made intense efforts and have followed a policy of committed support to build agricultural R&D infrastructure in the country. This has helped increased availability of resources and the amount reached to Rs 13,786 crore in TE 2017-18. But in terms of research intensity (0.37%), when compared with other countries, like China (0.62%), Brazil (1.8%) and high income

countries (average 3.1%), it is significantly low in India (Fig. 2.2.4). Both Centre and the States have contributed almost equally to R&D funding, though agriculture is a state subject in India. Obviously, the state funding is not adequate and the line departments as well as State Agricultural Universities (SAUs) are mostly dependent on the Indian Council of Agricultural Research (ICAR) and Ministry of Agriculture and Farmers Welfare (MoA&FW). This needs to be corrected by doubling the resource allocation to agriculture sector, including ARI4D, by both Centre and State Governments. Unfortunately, the well-justified demand for doubling resource allocation for ARI4D is pending for more than two decades as research intensity is hovering around 0.4 per cent and hence should be met on priority if we have to achieve faster growth in agriculture so critical for achieving SDGs successfully by 2030.

Table 2.2.2 Expenditure intensity in R&D in India

	Expenditure intensity in India (%)	
	Research	Extension
1983	0.25	0.10
1993	0.31	0.15
2003	0.39	0.14
2014	0.40	0.18
2018	0.39	

(Source: NIAP, 2017-18)

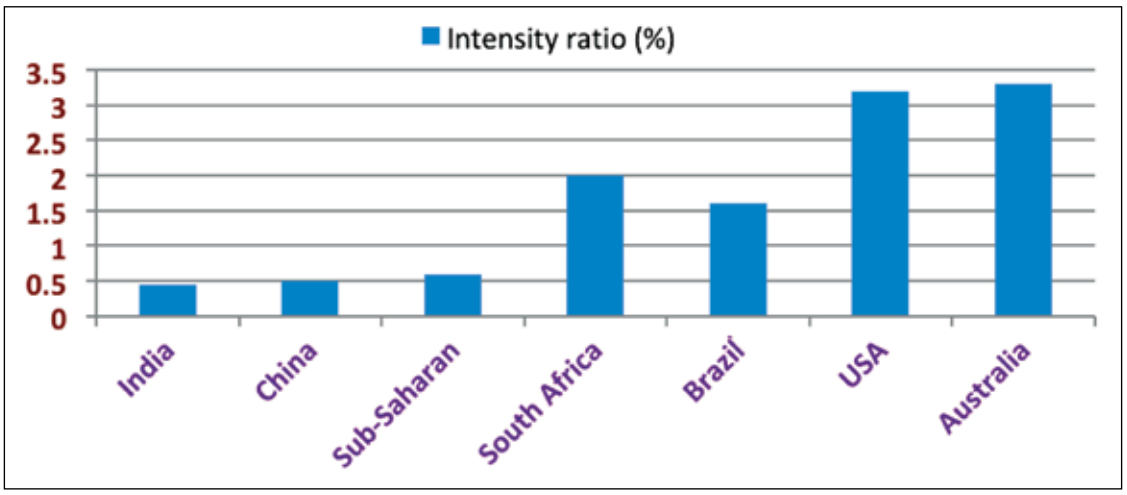

Fig. 2.2.4 International agricultural research expenditure intensity ratios (%), 2010s

(Source: NIAP, 2011-12)

(iii) Agricultural subsidies

The Central and State Governments used 'input subsidies' in the past as a key instrument for faster adoption of modern agricultural technologies, promote on-farm investment and to compensate rising production costs. Today, the provision of subsidies has come under criticism on several counts, such as poor targeting, lack of effectiveness when compared with other public interventions, negative externalities to environment and natural resources and fiscal burden on public exchequer. On targeting, the evidence shows that agricultural subsidies are often universal and bequeathed on per unit basis; hence these in general benefit large farmers and irrigated regions. On efficiency scale, studies have shown that returns on investment in roads, agricultural research, irrigation and education have yielded higher returns compared to spending on subsidies (Table 2.2.3). Further, it has been observed that higher expenditure on subsidies crowds out public investment in agriculture and

Table 2.2.3 Returns in agricultural GDP (RPS per RPS spending)

	1960s-1970s	1980s	1990s
Roads	19.99	8.89	7.66
Education	14.66	7.58	5.46
Irrigation investment	8.00	4.71	4.37
Irrigation subsidies	5.22	2.25	2.47
Fertilizer subsidies	1.79	1.94	0.85
Power subsidies	12.06	2.25	1.19
Credit subsidies	18.77	3.00	4.26
Agricultural R&D	8.65	7.93	9.50

(Source: IFPRI, 1999)

yields comparatively less returns. The studies also report significant regional disparities with regard to intensity of subsidies, i.e. irrigated rice-wheat dominated regions have benefited more than the rainfed regions.

The pervasiveness of subsidies, largely on political grounds, has also led to an increase in fiscal burden. In 2017-18, the Government (Centre and States) provided input subsidies (excluding loan waivers) worth Rs 2.4 lakh crore that equals to about 1.5 per cent of the GDP (Table 2.2.3). While the public agricultural investment hovers around Rs 60,000 crore (2015-16), subsidies, when included with loan waivers, stand more than six times what the Government spends for investment purposes, hence raising concerns over long-term viability on such an approach. The average subsidy spent by the Center on fertilizer, credit, crop insurance and price support are Rs 9,035/ha. The contribution of states on loan waivers and crop insurance comes to Rs 10,464/ha. This means that Rs 19,499/ha is given as subsidy by the Centre and States together.

Table 2.2.3 Estimates of Central and State Government subsidies (2017-18)

Subsidy Category	Amount (Rs crores, current prices)
Central Government	
Fertilizer	70,000
Credit	20,000
Crop Insurance	6,500
Price Support	30,000
Sub-Total	1,26,500
State Government	
Power	91,000
Irrigation	17,500
Crop Insurance	6,500
Loan Waivers	1,40,000
Sub-Total	2,55,000
Total (Centre & States)	**3,81,500**

(Source: B. Ramaswami, Personal communication)

Leaving asides distribution considerations, agricultural subsidies result in several hidden costs. Subsidies on irrigation and electricity have promoted water-intensive crops like rice, wheat, sugarcane, etc. but compromising the long-term food security due to decline in natural resources, such as soil health water (including decline in water table), etc. Electricity subsidy has a significant negative impact on groundwater. Similarly, free water has led to excessive mis-use like flood irrigation, etc. The other hidden cost of input subsidies arises from a change in the relative prices of plant nutrients. For example, the heavily subsidized price of urea has promoted over-use of nitrogen relative to other nutrients (phosphorus and potassium in particular), the consequences of which are negative impact on crop yields besides the environmental pollution, greenhouse gas emission, and contamination of soil and groundwater.

As the need for financial incentives to farmers such as subsidies cannot be ruled out in view of rising capital intensity of agriculture and low farm income, it is suggested to rationalize and target subsidies. The fertilizer subsidy could be transferred to the farmers through DBT rather than to the industries upon purchase of various fertilizers based on analysis through 18.5 crore already registered soil health cards. This would invariably help in reducing indiscriminate use of fertilizers throughout India. Also, fertilizer subsidy should be ecoregionally differentiated based on soil survey maps of each districts already available. Alternatively, subsidy on fertilizers, power and irrigation could be given directly to farmers on a *pro rata* subsidy of Rs 15,000/ha to all farmers up to 4 ha land holding. This should exclude credit and insurance which are in a way direct subsidy to farmers who borrow loans. This rate of subsidy should be indexed to the cost of inputs for revision in subsequent years. This change shall target resource poor farmers. Also, farmers should be incentivized for sustainable agricultural practices like carbon sequestration, afforestation, conservation agriculture, introduction of legumes, control of soil loss etc. An incentive for ecosystem services to the order to Rs 10,000/ha should be paid. This rate of subsidy is arrived assuming that improved practices shall sequester carbon up to one ton per ha, and the value of this carbon shall be Rs 3,500 using an international price of US$ 50/tonne (higher that the rate used for temperate agriculture). Adding the value of reduction of soil loss through soil conservation and other carbon reduction effects of farm practices (16.3 t/ha @ $5/t) and nitrogen fixation by legumes (30kg/ha @ Rs18.9/kg), Rs 10,000/ha is justified. This transfer, however, should be linked with conservation and afforestation practices, which can be tracked by the state land revenue department and application of space science. Here it may be noted that these two rates of subsidy are based on economic and

ecological grounds and income transfer under the *Pradhan Mantri Kisan Samman Nidhi* (PM KISAN) is excluded from this. Similarly, subsidy given for micro-irrigation and solar energy should continue as per the existing guidelines.

2.2.2 Credit and Risk Management

(i) Credit

In order to cater the credit needs of farmers, several measures have already been taken by the Government. Notable among them are the Interest Subvention Scheme (ISS) and Kisan Credit Card (KCC) Scheme (Fig. 2.2.5). In the budget 2018-19, the Union Government extended the KCC scheme to Animal Husbandry and Fisheries (AH&F) to help farmers meet their working capital requirements. Existing information indicates that there are presently 6.9 crore active KCC's (17.3 crore total) in India (2019). To bring small, marginal, tenant farmers, oral lessees, etc. into the fold of institutional credit, Joint Liability Groups (JLGs) have been promoted. The total loans and advances through all financial institutions were Rs 11.6 lakh crores, of which Rs 6 lakh crore is through KCC. Under the PM-KISAN program, farmers will now be provided direct income support at the rate of Rs 6,000 per year.

Despite these developments, issues such as regional disparity in credit delivery and extent of coverage continues to persist. Limited access of small and marginal farmers to institutional credit is still a matter of concern. Among various means of credit, only 31 per cent of agricultural households owning less than 0.40 ha land and 37 per cent of households with 0.41 and 1.0 ha have access through commercial banks. The advantage of increasing credit disbursement over the years did not reach large number of small and marginal farmers. There is a continued dependence of small and marginal farmers on informal sources of credit such as private moneylenders. Around 25 per cent of households still receive credit from money lenders, and hence require a mechanism to link them with institutional credit (Fig. 2.2.6).

Long term credit plays an important role in enhancing agricultural productivity by financing capital formation. The bank should meet the target of priority sector lending and this should include only direct credit to farmers. Also, share of small and marginal farmers should be raised in priority sector lending and KCC must be issued to all the farmers. However, deepening long-term agricultural credit for capital formation has been a major issue. In this regard, 'multiple pledging' of the assets like, land has to be allowed as long as the total credit doesn't exceed the mortgage value of the land. For KCC, credit limit at a lower rate of interest of 4 per cent should be enhanced to Rs 5 lakh from 3 lakhs.

Primary Agricultural Cooperative Societies (PACS) are more close to farmers and these meet various needs of farmers, including credit. It is necessary that these PACS should be revived by providing more capital and professional management. PACS should be provided added opportunity to provide credit to farmers beyond their limit and this credit can be transferred to commercial bank. PACS can benefit from

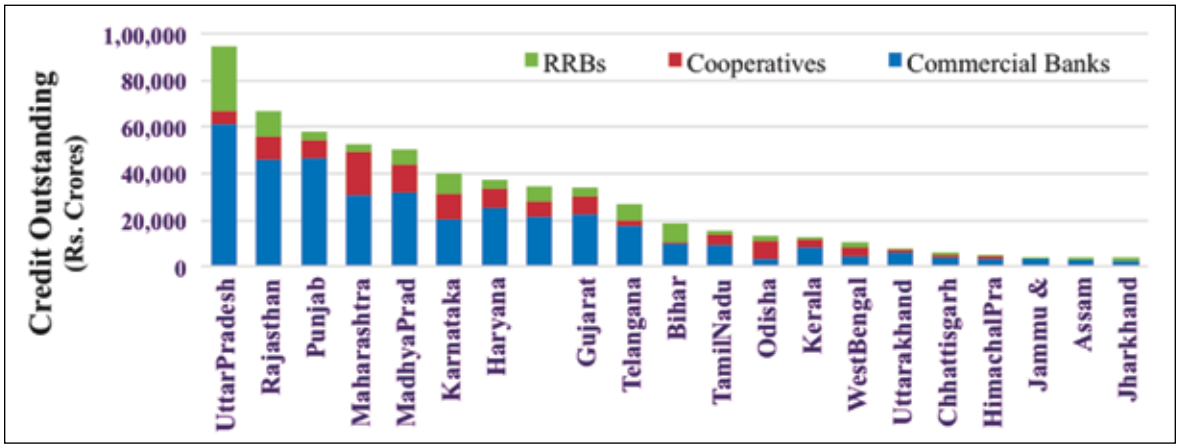

Fig. 2.2.5 Credit outstanding under KCC (as on March 31, 2017)

(Source: DoAC&FW, 2017-18)

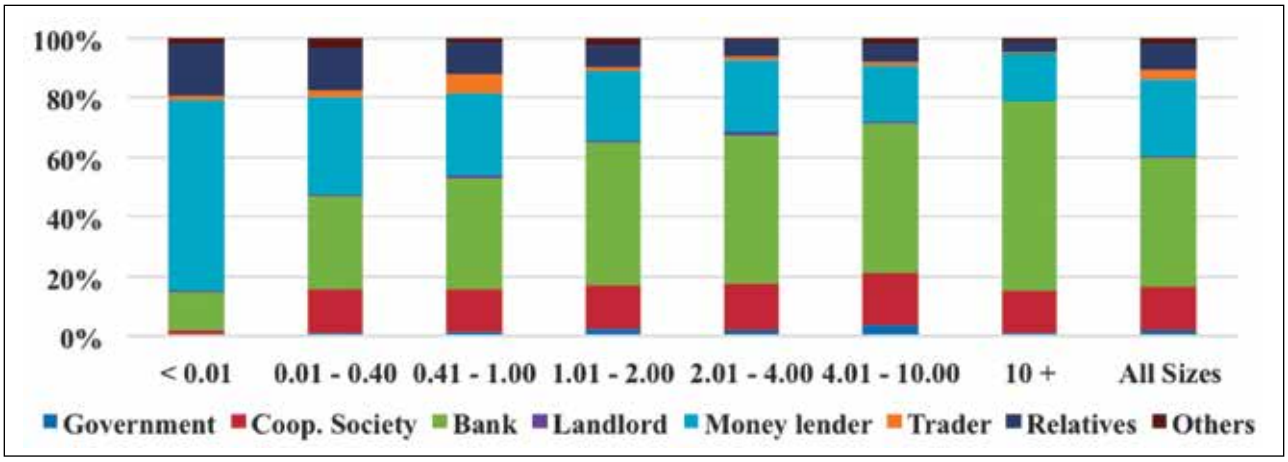

Fig. 2.2.7 Sources of agricultural credit across land classes (All-India, 2012-13)
(Source: NSSO (70/33): Key Indicators of Situation of Agricultural Households in India)

incentives to provide credit and commercial banks can meet priority sector lending target without investing much resources to expand their rural network.

(ii) Risk management

Agricultural production is exposed to a variety of risks. These include weather risks, natural catastrophes, and pests and diseases. Production risks are exacerbated by price risks, credit risks, and technological risks. The common risk management tools at operation include calamity relief, crop insurance, and interventions like Minimum Support Prices (MSP), price stabilization fund, futures market and contract farming. The support prices announced by the Government against price risk are long-felt inadequate to cope-up with the rise in the production costs. For non-MSP crops, Price Stabilization Fund are not adequate to cover needed market operations and therefore allocations should be enhanced. Crop insurance is a major risk management scheme and this has been modified time and again. The *Pradhan Mantri Fasal Bima Yojana* (PMFBY) scheme is under implementation and the progress as in 2017-18 shows that 34.3 million ha in *kharif* and 17.7 million ha in *rabi* has been covered. In total, 52.1 million farmers have benefitted from the scheme with admissible claims of Rs 20,839 crores; which is against the premium paid by farmers Rs 4,485 crore and Rs 21,116 crore by the Governments. The states with larger coverage include Maharashtra, Rajasthan, MP and UP. Overall claim to premium ratio was 0.72, indicating the scheme is financially viable.

Strengthening of market intervention and price stabilization schemes (now in operation) is also suggested by providing more resources and creation of a price risk management fund on the model of plantation crops. At present, crop insurance is the main mechanism to manage risk in agriculture. The present PMFBY scheme has addressed some of the constraints in the previous schemes; still, there exist operational constraints whose efficiency has to be assured. Farmers should have the option of choosing crops for insurance and mandatory linking with credit should be avoided. Latest technologies such as weather forecasting and dissemination, and early mapping and loss assessment through remote sensing have to be adopted on a wider scale. Large scale use of remote sensing technology for timely settlement of agricultural insurance claims, introduction of new distributional channels and nationally consistent database with timely distribution of information would be highly helpful to compensate farmers against crop loss.

The cost of insuring horticultural crops is felt to be high and demands are made to lower the premium. Possibility of such proposal needs to be considered. The coverage of insurance in the livestock and fisheries sector is rather limited. The Central Government has implemented a Group Accident Insurance Scheme to provide compensation for fishermen who meet with accidental death or disability. However, there is a need for comprehensive coverage of various risks components of fisheries and aquaculture including craft and gear, household assets, etc. Negotiations need to be initiated to address these concerns. In

livestock sector, insurance scheme is spread in 300 selected districts covering all states. It aims to provide protection mechanism to the farmers and cattle rearers against any eventual loss of their animals. The scheme has to be promoted to the entire districts and it would further augment the risk bearing capacity. Horticulture, livestock and fisheries are the growth engines in present day agriculture. Addressing price risks through feasible policies would further strengthen productivity in these sectors, hence could lead to higher agricultural growth.

2.2.3 Agricultural Marketing, Price and Trade

The existing state of agricultural marketing system in India is the outcome of several policy reforms, institutional development and infrastructure improvement over the years. The present status of agricultural marketing can be understood by analysing extent of marketed surplus, market infrastructure, price volatility, value chains, institutional changes and policy reforms taking place in the country.

(i) Market infrastructure

The total number of regulated markets in the country has increased from just 286 in 1950 to 7,115 in 2014. Apart from regulated markets, there are 28,723 rural periodical markets, about 20 per cent of which function under the ambit of regulation. However, average area covered by each of these regulated market is about 454 sq km, against the recommended radius of about 5 km (approx. 80 sq km) by the National Commission on Agriculture. Thus, there is a need to establish additional agricultural markets to provide farmers easy access to market.

There exists wide gap in marketing infrastructure for agricultural commodities in the country. Lack of inadequate scientific storage facilities cause heavy losses to farmers in terms of huge wastage of quantity and quality of crops in general and of fruits and vegetables in particular. Seasonal fluctuations in prices are aggravated in the absence of these facilities. In 2017-18, the total storage capacity available with CWC, SWC, and FCI was about 85.7 million tons, and another 15 million tons is with cooperative sector and 57.7 million tons with the private sector. It is estimated that about 25 million tons of grains are stored in the form of CAP (covered and plinth). The private storage/warehouses are mostly for crops like potato and fruits. Keeping in view size of agricultural production in the country, the available storage facilities/ capacities are rather inadequate. The Central Government has recently approved creation of a corpus of Rs 2,000 crore for Agri-Market Infrastructure Fund (AMIF) with NABARD for development and upgradation of agricultural marketing infrastructure in Gramin Agricultural Markets and Regulated Wholesale Markets.

(ii) Price volatility

The volatility in agricultural prices has catastrophic effect on all the stakeholders involved in the production, marketing and consumption of the food commodities. Small farmers, with low propensity to save and poor access to efficient saving instruments, cannot cope with the revenue variability resulting from fluctuations in output prices. It not only renders an element of risk and uncertainty in farm decisions but also dampens farmers' enthusiasm to invest in agriculture and thereby future production. For Government, unforeseen variations in prices can complicate budgetary planning and jeopardize attainment of the financial targets. Therefore, stabilization and forecast of agricultural prices has become a paramount importance especially in the agriculture sector where production decisions for most farm products are made much in advance of the time the product is marketed. Further, agricultural prices are influenced by variety of socioeconomic, policy and inefficiency factors prevailing in the region. This necessitates regional/state level analysis to understand the causes and impact of agricultural prices. Eastern India needs special attention in terms of improving price realized by farmers, which also includes the infrastructure development. Proper understanding of agricultural price mechanism and their forecast would help farmers to plan and decide about the production portfolio and their marketing for improved farm profit, consumers to plan their budget, traders to know the market trend and Government to augment economic development in the nation. The sufficient information about the prices would strengthen the otherwise weak linkage between production and marketing in the country.

(iii) Value chain development

The initial steps required for improving value chain are concentrating on post-harvest handling, ambient controlled field storage, and primary processing including sorting, grading, cleaning, and preparing for transportation. All these activities should be promoted at cluster level. Also, infrastructure status at collection centers and *mandis* need to be significantly improved. Further, the incidence of food borne diseases is increasing and international food trade is disrupted by frequent disputes over food safety and quality requirements. There is a need to resolve safety and quality issues at every stage, i.e. pre-production, production and post-production. It is imperative to sensitize and train farmers about food safety standards and their compliance during production and storage. Moreover, marginal, small and medium enterprises (MSMEs) should also be trained about food safety standards, so as to ensure that safe food enters the marketing chain. Also to ensure safety of perishable farm produce from spoilage during transit to the processing units, cold chain is very important, including storage capacity and reefer trucks.

To gain access to remunerative or niche markets, to reduce marketing and transaction costs and to check monopsonistic or oligopsonistic tendencies of the buyers, the producer-driven value chain may take form of a cooperative society or a producer association or a SHG. In order to engage small-scale producers, the development organizations, including NGOs and government agencies facilitate their organization into collectives, and extend benefits provided by the Government like tax exemptions and provisions of venture capital. From the perspective of financing, value chain can be assumed as a substitute for physical collateral and also a means to overcome lending risks. The activities can be financed using resources from within the chain and also from outside the chain.

Promoting value chains and agro-processing hold the key to improving price realized by farmers, value addition and employment generation. These will also link production with demand and make available products for consumption over a longer period of time. It is, therefore, suggested that agro-processing should be exempted from all taxes (GST and corporate) for at least initial period of five years and for entire project life in disadvantageous regions and products. This shall attract private investment in agro-processing. FPOs should also be encouraged to undertake primary processing, but this would need provision of venture capital and management skills, which the government should support. Finally, promotion of food safety and quality standards shall improve acceptability of Indian products globally. This needs adoption of good practices along with value chains.

Modernizing value chain of nutri-cereals/nutri-crops is the need of hour. Incentivizing diversification and subsidizing the production of nutri-cereals/nutri-crops would be the initial steps in this direction. The nutri-cereals, thus, produced can be linked with Mid-Day Meal Scheme/Integrated Child Development Scheme to ensure proper disposal of produce with higher prices from farmers' side, and to ascertain nutritional supplementation to the child from the other side. Promoting business investment, encouraging innovation and entrepreneurship in value chain would turn the process of modernization to the higher

Table 2.2.5 Output and growth in food processing industries (All-India, 2011-12 to 2017-18)

Year	GVA (Rs lakh crores)			Growth (%)		
	Total economy	Agriculture & allied	Food Processing Industries	Total economy	Agriculture & allied	Food processing industries
2011-12	81.07	15.02	1.47			
2012-13	85.46	15.24	1.30	5.42	1.49	-11.72
2013-14	90.64	16.09	1.30	6.05	5.57	0.39
2014-15	97.12	16.06	1.34	7.15	-0.22	2.66
2015-16	104.92	16.16	1.61	8.03	0.65	20.55
2016-17	113.19	17.17	1.78	7.88	6.27	10.76
2017-18	121.04	18.03	1.92	6.94	4.98	7.68

(Values are at 2011-12 prices, Source: MoFPI, 2017-18)

level. The provisions under the Scheme for Agro-Marine Processing and Development (SAMPADA) of Agro-Processing Clusters have to be made use to the fullest extent to promote cold chain and value addition infrastructure, expanding food processing and preservation capacities and promote infrastructure of agro-processing clusters. The individual farmers and FPOs have to be encouraged to be the key players in such clusters, and interest-free credit, for about 3-5 years, has to be extended to these clusters and individuals involved in agripreneurship.

(iv) Food safety and quality

Safe food is an important element of food security and food borne illness often go unnoticed, despite their unfortunate effects, both in terms of human suffering and economic cost. With the rising liberalization of agro-industrial markets and thus the worldwide integration of food supply chains, the assurance of food quality and safety has become a major concern. Hence, legal requirements for quality assurance systems and food control along with the entire food chain, from seed and agricultural production, through food processing and the distribution system, up to consumers table are increasing considerably. As a consequence, farmers and companies, legislative and control bodies, accreditation, certification and advice giving organizations need to develop and implement respective institutional capacities, guideline and knowledge transfer systems aimed at assuring food quality and safety. All the major stakeholders in the food supply chain should recognize that primary responsibility lies with those who produce, process and trade food and that public control should be based on scientific risk assessment. A safe and good quality product should be the result of adequate control at all stages of the supply chains rather that corrective action late in the process. The sensitivity of the consumers in the importing countries about safe food and the growing concern in our own country makes the issue complex and to be addressed on priority.

(v) Market regulations

The marketing of agricultural and food products has undergone a series of regulations. Notable among them are Agricultural Produce (Grading and Marketing) Act (1937), Essential Commodities Act (1955), Warehousing Corporation Act (1962), Food Corporation of India Act (1964), Agricultural and Processed Food Products Export Authority Act (1985), Model APMC Act (2003), Food Safety and Standards Act (2006), Warehousing (Development and Regulation) Act (2007) and the model Agricultural Produce and Livestock Marketing (Promotion & Facilitation) Act (2017). Some of them are intended to provide remunerative price to farmers but most of them aim to protect consumers. There is a need to revisit these Acts in the present context by forming a high power committee.

The Model APMC Act (2003) and Rules (2007) intends to induce private investment in agricultural marketing. The main provisions are (i) new markets can be established by private entities or cooperatives, (ii) promotion of direct marketing, direct purchases by traders or processors from farmers (iii) promotion of contract farming and (iv) provisions for single point levy of market fee across the state. The model Agricultural Produce and Livestock Marketing Act (2017) seeks to replace the earlier APMC Act (2003). The purpose is to create a single agriculture market with a single license wherein crops as well as livestocks produce could be traded. Recently, the Centre has come out with draft Model Contract Farming Act, 2018. The National Agriculture Market (e-NAM) is a pan-India electronic trading portal which networks the existing APMC *mandis* to create a unified national market for agricultural commodities. The e-NAM portal provides a single window service for all APMC related information and services. This includes commodity arrivals and prices, buy & sell trade offers, provision to respond to trade offers, among other services. Even private market yards, warehouses and cold storages are allowed to act as regulated markets. Besides, it allows unified single fees for farmers and traders across the markets within the states.

The Warehousing Corporation Act (1962) defines the specific functions and the order of operations of central and state warehousing corporations. The Warehousing (Development and Regulation) Act (2007) addresses the issue of encouraging private investment in warehousing, regulation of warehouses and legalizing the use of warehouse receipts as negotiable and exchangeable instrument. The Act makes the warehouseman liable for loss of or injury to, goods caused by his failure and also provides for compensation to the depositor of the goods. It also provides for punishment if the warehouseman knowingly issues a

negotiable warehouse receipt without taking the actual physical delivery of the goods or without reasonably satisfying himself that the number, weight or grade of the goods corresponds to the number, weight or grade specified in the warehouse receipt. Given that provisions are made for improving various aspects in marketing agricultural commodities and laws are defined, it is the cooperation of various states that would turn the attempts successful. Despite several provisions, the intended benefits have not been observed satisfactorily.

The adoption of model Agricultural Produce and Livestock Marketing (Promotion & Facilitation) Act, 2017 (APLM) and Contract Farming Act by various states should be expedited. Also, there is a need for rationalizing *mandi* taxes as these range from 3.15-11.5 per cent and very high in some states like Punjab (14.5%) and Andhra Pradesh (13.13%). The adoption of contract farming act would benefit farmers with access to better inputs, scientific practices and credit facilities that may be provided by the firm. Keeping contract farming out of Agricultural Produce Market Committee (APMC) will incentivize companies to buy directly from farmers as it will free them up from the hassles of APMC regulation and also help save them around 5-10 per cent market fees paid to the APMCs. Once the process is streamlined, it has the potential to link Indian farmers to global supply chains, especially the horticulture sector. Similarly, while provisions exist for pledging warehouse receipts, use of such instruments among farmers is observed to be extremely limited. This pledging system has to be made more approachable and popular as this would potentially bring down the distress-sale of farm produce by farmers. The pros and cons of removing agricultural products from the Essential Commodities Act should be explored as in some sense it is thought that decontrolling the prices of agricultural commodities in the market could lead to higher agricultural prices and harm the consumers. Unless the benefits of higher prices don't percolate to the famers, it would not turn as an appealing move.

For ensuring MSP to farmers, procurement has to be ascertained to the listed commodities and the act of procurement by the Center has to be shared by the states under decentralized procurement for greater effectiveness. Also, higher funds should be allocated to public agencies for procurement. The participation of states would raise the responsibility and efficiency of states in handling the produce at one hand and improve accountability of both procuring and purchasing states on the other hand. The possibility of including pulses and edible oil in PDS has to be considered. For selected commodities like *ragi*, *bajra*, etc., region-specific procurement activities have to be encouraged. The possibility of adopting the deficiency price payment mechanism across states under PM ASHA has to be seriously thought of and a fool-proof model of price delivery has to be designed that neither compromise with product quality, nor allow for exploitation by the market functionaries.

India has developed export competitiveness in selected products like frozen shrimp and prawns, meat, basmati rice, raw cotton, spices, tea, oil cake, tobacco, cashew, fruits and refined sugar. In 2018, India accrued a US$14.6 billion trade surplus of agricultural, fishery, and forestry goods, making it the world's 14th largest agricultural, fishery, and forestry product exporter. Export till 1980s was US$ 2.6 billion, and increased to US$ 6.2 billion by 2000 and in 2018 reached to US$ 39.4 billion. Rapidly increasing trend occurred in fish, meat, spices and rice. Hence, long-term strategy and enabling environment for promoting agriculture export could make India emerge as an important global player in the next decade. Exports of commodities with surplus production can improve farm prices and therefore there should not be any restriction of exports, except products of short supply. Compact value chains, compliance to quality standards and infrastructure development like cold chains shall contribute to export promotion. The GoI has identified the export clusters and infrastructure should be built around these clusters. The Agricultural and Processed Food Export Development Authority (APEDA) is an agency to promote agricultural exports, and this should also take the functions on international demand assessment, developments in competitive countries, and proactive support to maintain food safety standards. It should also strengthen system for certification of organic foods for both domestic and international markets. It would be helpful if an agricultural attaché is placed in the embassies of important countries.

2.3 Natural Resource Management Sector

Sustaining quality of natural resources (NRs) (soil, water, biodiversity and micro-climate) is the main stay of agricultural production and for decent survival of humanity and their animal support system. Since biophysical contours of NRs vary at scale across regions, so does their productive capacity (productivity). Our natural resources are severely stressed due to much higher demographic, economic and socio-political pressures compared to rest of the world. More than nature, human's management (of soil fertility, moisture availability, aeration, biotic life and micro-climate) influences native productive capacity of NRs. India can hardly afford further deterioration of the NRs, since its growing population requires ~3 million tons additional food grains every year. Further, changing land uses, urbanization and increasing pollution could affect major food security production systems directly and indirectly through their impacts on climate change variables. For example, about 51 per cent of the Indo-Gangetic plains (IGP), the green revolution corridors may become unsuitable for wheat crop, a major food security crop for India, due to increased heat-stress by 2050. UN's Panel of Scientists noted, "There are increasingly negative effects on GDP from impacts on land-based values and ecosystem service as temperature increases" (Nitin Sethi, 2019). Similarly, water table in western IGP has been depleted at 0.3-1.0 m/year due to over-pumping for rice, will also have serious impacts on regional agro-ecosystem and food production. Soil degradation (runoff, erosion, depletion of soil organic matter, salinization, multi-nutrient deficiency and imbalance, compaction and surface sealing, floods and droughts), diversion of land to non-agricultural uses (urbanization) and mining, low use efficiency of water (30-50%) and nitrogen (20-30%) are the serious challenges for agricultural sustainability, future food, nutrition and environmental security and farmers' income so as to meet agriculture's contribution towards SDGs directly to 2, 6, 13 and 15 and indirectly to several others.

In order to ensure physical, social and economic access to sufficient and safe food, it is necessary to produce it efficiently and competitively to: (i) maintain necessary growth in productivity, (ii) increase in farm income, (ii) make safe food available at affordable prices and (iii) contain natural resources degradation and greenhouse gas emissions (GHG). By 2030, if ongoing surge in number of mouths (~17 million/year) to be fed continues, ~40 million tons more food grains will be required to be produced. It is going to be a challenge, since 96.4 million ha land area of India, suffering from degradation/desertification (ISRO, 2016), has lost its native productive capacity at least by 15 per cent. Aquifer drying has become more rampant in the recent times. NASA data on global state of aquifers show that North-West India is among the most stressed regions in the world (Frankel, 2015). Though expert interventions can reverse the loss, but 9 out of 10 small and marginal farmers have insufficient means to bear the regeneration-cost. Paralleling the loss in quality of NRs is the fall in growth rates of production, which fell from 2.5 per cent per annum during the first 25 years of Green Revolution to less than 1.2 per cent per annum, thereafter. India can hardly afford this kind of damage to food grain production, happening, primarily due to loss in health and quality of NRs. A recent report of UN convened scientific panel warns that cereal prices could rise by up to 29 per cent in 2050 due to land degradation/desertification and climate change (Nitin Sethi, 2019). The task of containing price rise is far more daunting, when farming on 2 out of 3 ha is threatened by drought every year and the effect is becoming more erratic in incidence and more virulent in its influence on productivity.

Reaching the goal of land degradation neutrality by 2030 (SDG goal # 15), substantially improving WUE across all sectors (SDG goal # 6) and limiting climate change to less than 2^0C rise over the 21st century (SDG goal # 13) for alleviating poverty (SDG # 1), achieving zero hunger (SDG# 2), promoting good health and wellbeing (SDG # 3), achieving gender equality (SDG#5) through responsible consumption and production (SDG #12), necessitates a robust plan, strategy and action for sustainable management of natural resources. This section summarizes (i) the current state of the natural resources-causes and effects and (ii) the key recommendations on technical, institutional, social and policy aspects and methods and (iii) strategies of their scaling-up to control, combat and mitigate the degradation of land, water, climate, and input use adversaries of sustainable growth of agriculture in all its aspects.

2.3.1 Current Status of Natural Resources

(i) Land and land use changes

Land use pattern: In India, of the ~328 million ha geographical area, ~43 per cent is devoted to agriculture (net sown area, NSA), which has remained constant over the last four decades. Compared to that, since

independence, country lost ~30 million ha of ecologically productive land (area covered by miscellaneous tree and groves, culturable waste lands) and diverted 19 million ha land to 'other uses' for housing and development infrastructure. Also, nation has 25 million ha of 'fallow land', which is potentially available for cultivation. Since 1970-71, area under forests has grown from 64 million ha to 70 million ha. Of this, whopping 40 per cent falls in the category of 'open forest' (tree cover density <40%). Under the aegis of National Action Plan on Climate Change, Green India Mission aims at afforestation of 6 million ha of open forest lands and expanding forest area from the current 23 per cent to 33 per cent by 2030 (GoI, 2017. Agricultural Statistics at Glance). NSA (~140 m ha) has remained constant since 1970-71, while the gross cropped area (GSA) has expanded from 166 million ha to 198 million ha. Although area devoted to food grain crops has remained unchanged (~124 m ha), but that covered by rice and wheat grew from 56 to 75 million ha. This rise was at the expense of fall in area under coarse cereals. Forced by economic and environmental reasons, further conversion of food grain area are less likely to occur.

Land degradation: Quantitatively, if inherent economic productive capacity of a land declines by >10 per cent, it is said to be a degraded land. Land degradation is called desertification, if it originates in arid, semi-arid and sub-humid regions (ratio of precipitation to potential evapotranspiration or P/ETP < 0.65). In this report, land/soil degradation in any ecoregion and desertification in above-specified agro-ecologies are not distinguished from each other. Worldwide, 2 billion people and 42 per cent of the very poor live on degraded lands. Share of India in global degraded soil area is about 10 per cent and of population is 17 per cent.

Extent of land degradation: A recent ISRO Report cum Atlas (2016; data period 2011-13) has estimated that 29.3 per cent (96.4 mha) of India's geographical area suffers from degradation of one or the other kind. The ISRO findings point out that Rajasthan, Gujarat, Maharashtra, Jammu & Kashmir and Karnataka have the highest area of lands undergoing degradation/desertification (18.4% out of India's 29.3% or equal to 2 out of 3 ha); all the other states harbour < 2 per cent of the total degraded land area (29.3%) each. Compared to the extent of land degradation in 2003-05, country experienced a 0.57 per cent cent rise in 2011-13; increase was greater in North-Eastern (NE) and some other states. Despite insignificant increase i.e., 1.87 million ha, surging trend is significant from India's standpoint, who is committed to reach LDN by 2030. LDN mandates, the country must maintain or even improve the amount of healthy and productive land resources over time and in line with the committed sustainable development priorities (UNCCD). The task is challenging, since every minute country loses 23 ha of dryland to desertification (MoEF&CC). Water erosion (40%), followed by vegetation ruin (30%), wind erosion (16%) and salinity/alkalinity (4%) are chief sources of land degradation. Soil acidity constrains optimum performance of agriculture on 25 million ha area having pH below 5.5 which is though not included in the ISRO statistics but is a large proportion of degraded land. Fall in soil health (SH)/quality - led by soil infertility, depletion of soil organic matter physical degradation (crusting, compaction) and chemical extremes (soil acidity, salinity, heavy metal pollution) are among other causes of land degradation. In India process of land degradation are primarily anthropogenic.

Cost of land degradation: An estimation of land degradation costs shows that the global economic impact could go as high as US$ 490 billion (Nkonya *et al*., 2016). TERI (2015) quoted losses from land degradation and land use shifts at 2.54 per cent of India's GDP or equal to US$ ~45 billion; of this ~US$ 10 billion equivalent was attributed to agriculture. According to another report, India annually loses 5340 million tons of top soil valued at ~US$ 30 billion of which 540 million worth of plant nutrients are lost annually. Productivity and economic losses due to salinity are colossal; global economic losses stand at staggering US $27.3 billion/year (Qadir *et al*. 2014); India's share stands at approximately 1 per cent of the global loss. Cost of action to reverse land degradation is far less than cost of no action.

(ii) Soil health and nutrient use efficiency

Soil health: The integration of physical, biological and chemical state of soil determines its health and productivity potential. Maintaining soil fertility, which is a key element of soil health, is essential to sustain food security. Fertility is described as ability of a soil to supply all 17 essential plant nutrients in amounts and proportions necessary for optimum plant growth and development. World-wide only 3 per cent of the soils are fertile and India is no exception to that. Royal Commission on Agriculture (1928) observed that 'Indian soils have been depleted to the extent that no further depletion is possible'. The situation on depleted fertility state has not changed much since then. Confirmed by analysis of thousands of soil samples, extent of deficiency (% soil samples) is: N 99; P

80; K 50; S 41; Zn 43; B 33; Fe 15. Soil salinity (and alkalinity) influences crop productivity on ~ 7 millionha. Soil salinity happens due to introduction of canal irrigation without drainage in arid and semiarid areas (alkalinity is largely an outcome of soil forming processes). Soil acidity occurs in soils having pH < 5.5, which hinders optimum growth and development of crop plants. It is of common occurrence in humid and sub-humid parts of country (eastern and north-eastern parts). Acid soils occupy an area of 25 million ha.

Fertilizers and organic manure are the chief means of soil fertility. Because of limited availability, organic manures are found grossly inadequate to recoup estimated 38 million tons NPK, for maintaining fertility of soils; hence it is necessary to apply the balance through fertilizers. At present, the amount of N and P removed is nearly neutralized, but there exists a K deficit of about 7 million tons. In addition to the soil fertility depletion, the state of soil physical conditions and biological parameters has been deteriorating due to inefficient farming practices and inappropriate soil management systems and are aggravated by the depletion of soil organic carbon (SOC). Considering the serious concerns of soil health and its role for a sustainability of future food and nutritional security, the GoI initiated a 'National Soil Health Mission' and a status report based on over 19 million soil health cards reveals serious soil health related concerns including deficiency of as much as nine nutrients which need immediate attention. It is envisaged and recommended that the national soil health report shuld be published every five years, beginning with the baseline report in 2020.

Fertilizer use, efficiency and policy: Since 1950-51 and up to 2016-17, fertilizer use has grown from 0.07 million tons to 26 million tons (from ~0.5 to ~131 kg/ha). Current N, P and K use is, respectively divided into 84.4, 35.6 and 12.7 kg/ha. Current use ratio of 6.6:2.8:1, does neither correspond to perceived ideal consumption ratio of 4:2:1 nor to crop uptake pattern i.e., 1.0:0.3:1.3. It indicates that NPK use tilts towards N and P, more typically towards N. This imbalance is not new. It has continued over the years, which indicates that NPK additions fell short of crop removals, typically in respect of K (by 7 million tons). The result is rising deficiency of K in soils and falling response ratio of NPK use. In 1970s, each kg of NPK produced 11 kg grain, whereas it now yields ~4 kg. This imbalance, specifically, has hit hardest the N use efficiency (NUE). Despite improvement in crop varieties and agronomic management practices, NUE has hovered around 30 per cent. Besides weakening of technology transfer promoting balanced NPK use, the main factor contributing to the dismal state of NUE has been and continues to be the policy on subsidy extended to NPK fertilizers. Like on several previous occasions, ongoing nutrient based subsidy (NBS) scheme tilts far more towards N. Resultantly, P and K fertilizers are, respectively 3 and 4 times more expensive than urea-N. Being cheap, farmers are tempted to use more N than their crops really need, making farming expensive and less profitable. Also, unknowingly they degrade health of their soil, pollute groundwater and fuel rise in global warming. Worried, perhaps, by these developments, Honourable Prime Minister in November 2017, gave a call to reduce N fertilizer use to one half of the existing level by 2022. In order to meet that challenge, the way forward is increasing NUE by inducting precise agronomic methods of placement, fertigation, diversification with N-efficient crops, new products and corrections in NBS.

A recent study made by Chinese scientists has projected, that if India's surplus N [difference between (inorganic + organic N additions) - N removals] in 2010 has to nearly half in 2050, it would be necessary to raise fertilizer-N use efficiency (FNUE) from 30 per cent to 60 per cent. With these projections in forefront, it seems less likely to cut the urea-N consumption to less than one half by 2022, the target year set by the Prime Minister. Affecting that big reduction, would mean further fall in productivity growth, typically wheat and rice, which fill the food security basket of India.

(iii) Water resources

Currently, only 47 per cent of the available 400 million ha meters [4000 billion cubic meters (Bm^3)] water is utilized and remainder is lost. India's utilizable fresh water resources equal 1123 Bm^3; 690 Bm^3 surface water and 433 Bm^3 groundwater (GW) (Central Water Commission, 2015). Share of agriculture in water resource is 82 per cent, households 9 per cent, industry 2 per cent and remaining 7 per cent is for all other purposes. Decoding this distribution further reveals that of the total water use, the share of ground water in agriculture, urban households and rural inhabitants is 89 , 50 and 85 per cent, respectively.

A network of canals (estimated length 12,000 km), distributaries and minors deliver surface water for irrigation. Since 1951 and up to 2014-15, canal irrigated area increased 2 folds (8.3 mha vs 17 mha). The corresponding utilization fell dramatically; from 40 per cent to 26 per cent; all because of faulty handling of delivery

from open canal system to farmers' fields; ~40 per cent gets lost before it reaches its intended destination - the farmers' fields. Unlined canals, seepage, breaches, poor maintenance, evaporation plunder the water in transit.

Unsecured transmission of surface water by poorly maintained unlined canal system is possible to improve by up to 50 per cent through transporting it to fields using fully lined canal system. Currently, ~50 per cent length of canals is unlined. NCIWRD (2014) has proclaimed that surface water transmission through lined canals would neutralize the loss of the created potential happening due to transmission losses. But, still 15-20 per cent will vanish due to evaporation.

Per annum, India has an asset of 447 Bm^3 of replenishable groundwater. Of this, 411 Bm^3 is available for use. Country annually withdraws 253 B m^3 for irrigation and other uses. It means, GW development (GWD = ratio of GW draft to net deposit; 253/411) is 62 per cent. As a whole, India, thus, stands in the so called 'safe' category of GWD; a region is classified 'safe', if the GWD is <70 per cent or contrarily unsafe/exploited, if this limit is exceeded. On this basis of the 6,607 assessment units (2011 data), 1,071 were categorized as 'Over-exploited' - GWD >100 per cent, found in North-western India: Punjab GWD 172 per cent and Haryana GWD 133 per cent; 217 as 'Critical - GWD >90 per cent but<100 per cent: found in western India: Rajasthan: Jhalawar GWD 99 per cent and Bundi GWD 95 per cent; 697 as 'Semi-critical' - GWD >70 per cent but <90 per cent; found in southern part of peninsular India: Tamil Nadu GWD 77 per cent; and 4530 as 'Safe' - GWD <70 per cent; concentrated in North-East and Eastern India: Assam GWD 16 per cent, Bihar GWD 45 per cent. It means, 30 per cent of the GW observation well sites in 2011 fell in the unsafe category. Compared to 1990, proportion of unsafe wells has grown nearly 4 times (8% in 1990 vs 30% in 2011). Apart from causing fall in water table, over-development promotes surfacing of salinity and rise of contaminants and pollutants like nitrate, fluoride and arsenic beyond the safe limits for human use.

Despite the fact that availability of surface water is 1.5 times greater than the GW, the latter in 2012-13 served 62 per cent irrigated area as against only 24 per cent by the former. With time, this unprecedented development on GW dependence became the leading cause of aquifer drying in North-West Indian states of Punjab and Haryana (fall in GW table = 60 to 70%). According to a NASA satellite imagery, North-West India is among the most water stressed regions in the world (Frankel, 2015). Like Punjab and Haryana, eastern state of Bihar has also high density of tube-wells, but because of uncertain power availability, there the GW remains unutilized. Policies to assure power supply at dirt-cheap rates, added momentum to depletion of GW in Punjab and Haryana. In total, compared to 92 per cent GW safe districts in 1995, 30 years later in 2015 the corresponding figure was 68 per cent. On the state of GW, UNESCO stated (2012) that India is the largest extractor of groundwater in the world. In fact, over-exploitation of GW is contributing to "the worst water crisis in its history" (NITI Aayog, 2018). Besides over-subsidized power, absence of regulation on abstracting GW, limits focus on diversification from high- water-requiring sugarcane and rice and continuing with water-wasting methods of management (flooding) are the chief factors contributing to rising overdevelopment and expanding number of overexploited districts in the country.

Apart from surface and GW, there are ancient systems of irrigation. *Phahadas* in Bihar, *Bandharas* in Maharashtra and tanks in central and southern states contribute to about 15 per cent of the irrigated area in the country. *Phahadas* involves use of seasonal overflow from local rivers and collected naturally in the fields for irrigation, whereas, *Bandharas* include directing the rivers' overflow for irrigation by a system of bunds. Tank irrigation is based on stashing rainfall run-off for drinking and irrigation. Over the years, extent of tank irrigation has been hit due to collapse of community institutions and obstruction created by infrastructure projects for runoff reaching the destination. In 1950-51, share of tank irrigation was 17 per cent (3.6 m ha), which fell to 2.5 per cent (1.7 m ha) in 2014-15. Since tanks mainly serve rainfed areas of semiarid tropics, their revival is a must to effectively deal with phenomenon of recurring droughts. Also, water holding capacity of drylands, typically dominant category of red soils (Alfisols), is poor (~10%), making growing crops easy target of brief drought events. Low SOC (<0.3) provokes this vulnerability, since there exists a close relationship between water holding capacity and level of SOC.

Water Use Efficiency (WUE): Current use efficiency of canal water is ~30 per cent. Compared to that WUE of GW irrigation is higher, ~55 per cent. In either case, huge scope exists to improve WUE by 20 to 30 per cent, if replaced with micro-irrigation (MI) techniques. Not only low WUE but the consistent low productivity of irrigation water is a matter of grave concern. Currently, it is <Rs 3/m^3/ha of water whereas the possibility exists to elevate it 4 to 5 times.

(iv) Climate/environment

Climate refers to the observed weather patterns of a region, range of extremes in distribution of temperature and precipitation, and frequency of these events over time in a region. As observed over several decades, indications are climate change is real and it is man-made. Rise in earth's average temperatures by 1.5^{0}F (0.8^{0}C) over the past century confirms it. Deforestation, land use change destroying ecologically balancing havens, over-dependence on fossil fuels, intensive tillage and soil erosion destroying SOC pool, inefficient use of fertilizers, water, mismanagement of refrigerants (CFCs and HCFCs), entry of pollutants and chemicals are anthropogenic activities provoking climate change. If this business-as-usual approach continues and climate change mitigating strategies remain ignored, it is projected that global temperatures will rise another 2-11.5 °F over the next 100 years (U.S. National Climate Assessment). As a result, demand for water will rise, loss will increase and more importantly incidence of heavy rainstorms, frequency, intensity and duration of drought, a greater number of warmer days and nights, lasting warm spells/heat waves will multiply. On a long-term basis, it is predicted that climate change is estimated to cause 31-43 per cent decline in existing crop yields even under the slowest temperature rise scenario (Schenker and Roberts, 2008). Because of differential thermo-sensitivity, negative influence of global warming on wheat yields is going to be far more critical than maize and rice. Climate change being a complex phenomenon, the solutions have to be multi-dimensional and holistic. It means while harvesting the technological benefits for sustaining food security is necessary, equally important it would be to contain the negative consequences of doing that by advanced climate change planning and management.

2.3.2 Recommendations

Indian National Policy on Agriculture envisages minimization of regional disparities and a 4 per cent/ annum growth in agricultural productivity. Against this target of growth in agriculture sector in India does not follow a consistent pattern. It adopts a kind of random pattern as evidenced by the recent information. Over the last seven years, GVA (%) ranged between -0.2 (2014-15) and 6.3 (2016-17), with a mean value of 3.1 (Economic Survey, 2019). More disturbing is the crop sector on which hinges the food grain security of the country. The GVA spanned from -3.7 to 5.4, with average value of just 1.3. It is the crop sector, which occupies maximum NSA (93%), appropriates water (~90%) and consumes energy (~90%). Then there are regions, which occupy more area but are unable to produce sufficient food for the population they support. Example: 54 per cent rainfed area produces 27 per cent foodgrains for 42 per cent population. NE Hill States, occupy country's ~ 8 per cent area, inhabit 4 per cent population and produces only 1.5 percent foodgrain. In order to sustainably secure 4 per cent GVA product/annum and to achieve SDG targets, the key action plan would focus to achieve:

(i) Land Degradation Neutrality (LDN) (SDG 17) by institution of a land utilization policy, enhancing local governance mechanisms, CA spread at 2 million ha/ year, coverage with agroforestry at 2 million ha/ year and maximization of alternative sources of energy, increase NUE by 30 per cent, diversification of rice area with water efficient crops by 10 per cent, liming of entire 25 million ha area over a period of 4 years, diverting 5 million ha fallow lands/year for agriculture or ecologically productive purposes.

(ii) Water security (SDG 6) by enforcing sustainable water management to assure availability by achieving rainfall runoff harvesting for small scale irrigation of at least 30 million ha, canal water delivery through closed pipes, improve WUE by 20 per cent; MI spread at 2 million ha/year,

(iii) Containing climate change (SDG 13) by raising SOC by 0.1 per cent/annum supported by CA, agroforestry, NUE and WUE, as outlined above. Target of 0.1 per cent (1 per thousand) is far below the limit of 0.4 per cent (4 per thousand) set by the COP 21. In reality, special efforts would have to be made to achieve this level, since India's contribution to the global SOC pool ranges between 20–25 Gt for the top 1 m and with estimated annual C emissions of ~566 million tons (CDIAC database), the neutralizing C sequestration rate for India would be ~23 to 28 per thousand as opposed to the global requirement of 4 per thousand. It necessitates to make special and concerted efforts by laying emphasis on restoration of soil health, zero diversion of ecologically productive lands and regeneration of open forests, no-till farming, cover crops, efficient nutrient management, manuring, rotational grazing, rainwater-runoff harvesting, precision irrigation practices, agroforestry practices, and growing energy crops on land capability class +IV lands.

(iv) Food security and poverty minimization (SDG 2) by applying area differentiated technologies/ interventions as outlined above. Area specific focus will centre on exploiting the productivity potential of low productivity – high potential regions; reversing falling/negative productivity growth rates of high productivity regions; raising productivity of low productivity rainfed regions.

(i) Land degradation neutrality

Apart from the provisions contained in the existing Draft Land Utilization Policy 2013, it is recommended to develop and introduce a "Sound Land Utilization Policy", keeping in tune with the commitments on saving NR quality supporting land degradation neutrality (LDN). To be effective, land utilization policy development must bring States and stakeholders on board, similar to the process and partnerships followed, while evolving GST regulations. Specific recommendations needing emphasis are as follows:

- Strengthen and rigorously implement land-zoning system, protecting agricultural lands from being converted to non-agricultural purposes, especially to accommodate expanding urbanization and needs of development infrastructure.
- Preparing soil resources map of India on 1:10,000 scale overlain on diverse land use contours, defining ecoregion boundaries but by enhancing local governance mechanisms to facilitate adoption of sustainable land management practices (land use as per local biophysical attributes). The soil health report needs to be prepared every five years.
- Farmer-centric, production system-based land use planning, utilizing rainfed area priority index (integration of natural resources index and livelihood index) to cover rainfed regions by 2030.
- Reversing land degradation to meet the goal of reaching LDN by 2030: involve community-based organizations (CBOs), adopting ridge to valley approach covering a total watershed area; utilize the services of a change agent to facilitate community participation and entry of development agencies, providing financial protection; for erosion control, support cost of building mechanical/vegetative measures and for re-vegetation of denuded lands public agency provides region-specific seed and planting material and in either case community extends labour for land treatment, establishing barriers, seeding/planting and maintenance.
- Land reforms: ensure completion of digitization of land records, issuance of computerized record of rights (RORs) linked to cadastral maps including no fragmentation below 1 ha.
- Minimizing area under fallow lands (25 million ha) by extending a special support package. incentivizing CBOs, who collectively use their land for ecologically productive purposes, harvest and conserve rainwater for irrigation and follow NR quality-building and income enhancing diversified farming systems.
- Create enabling conditions for private investment in sustainable land management innovations like setting up of custom hiring centres for machinery and farm equipment.
- Create a specific provision for paying to those who contribute to building environmental services (example: soil organic carbon sequestration) through good soil management practices (zero tillage, efficient use of fertilizers, and water management in rice cultivation is estimated to reduce half of Indian agriculture's carbon footprint).
- For controlling salinity to spread, irrigated saline areas, public agencies should strengthen lining of canals to prevent seepage and support rainwater conservation, encouraging groundwater recharge; leaching of salts by surface pounding of water is a common practice. In rainfed saline areas, where leaching by impounding is nearly ruled out, special land configurations that encourage surface washing of salts by rainfall runoff need to be supported (raised earth mounds draining into juxtaposed trenches), involvement of change agent necessary for community shared action.
- To neutralize acidity, lime application (~3 tons lime/ha) is the most common and effective technique. One-time treatment, costing Rs 4,800/ha (@ Rs 1,600/ton on FOB, having freight collect at destination basis) will last for 4 years. The total investment would be Rs 1,200 crore for ameliorating entire 25 million ha acid soil area. Hence, it is recommended that Central Government supports liming of 25 million ha acid soils, by distributing reclamation of 25 per cent area/year and respective State Governments and farmers share transport charges 50 per cent each.

(ii) Soil organic carbon (SOC)

Whether it is erosion, loss of ecologically productive area or rise of salinity, it is the resultant fall of SOC that drives land degradation and loss of soil health. It happens, all because of resort to non-sustainable/ non-holistic land management practices. Examples: cereal-cereal rotations without intervening intercrop or diversification; extensive tillage, leaving land without any protective cover (soil, organic or synthetic mulch), exclusive reliance on fertilizers with disuse of organic, focus of technology transfer system on raising

productivity and ignoring its consequences on health of land and environment. Fall in SOC is the major cause of stagnation in productivity growth rates, rise in multiple nutrient deficiencies, decline in response ratio to fertilizers, degradation of soil physical attributes and biodiversity, increase in drought, rise in cost of cultivation and fall in farm profitability. Thus, keeping in forefront India's commitments on achieving LDN reaching the targets of 4 per thousand initiative' and limiting the rise in temperatures and corresponding role of SOC in maintaining soil health and climate regulation, it has become more critical than ever before to raise the current level of 0.3 to 0.6 per cent to a level of 0.8 to 1 per cent by 2030. Following action plan on building SOC is suggested to reach the projected target during the next 10 years:

- Give greater emphasis on *in situ* generation of organic manures like FYM by composting/vermicomposting; give pecuniary support for installation of one vermicompost pit/landholder plus vermiculture
- Guide and support those who grow green manure crops on unused land parcels; provide free seed/ planting material
- Incentivize farmers who do not burn but return the maximum crop residue back to soil
- Encourage mixed cropping/agroforestry, particularly in rainfed areas and in areas dotted with land capability class IV and worse for giving stimulus to raise permanent vegetative cover; it is recommended to support with assured supply of planting material of perennial and quality seed of annual crop free of cost
- Integrate crop with livestock farming, specifically for small-farm and rainfed agriculture; the essential focus has to be on infusion of inputs and technologies that strengthen farmers' run integrated farming systems with the object of reducing cost, improving income and assuring sustainable source of livelihood
- promote conservation agriculture based on no-till, residue retention as mulch, no in-field burning, use of complex rotations including forages and adopting strategies of integrated nutrient management.

(iii) Promote conservation agriculture as a sustainable mission

Conservation agriculture (CA) adopted over 180 million ha across the world has emerged as an alternative to an inefficient tillage-based conventional agriculture. CA addresses several major challenges confronting agriculture in India including climate change, water scarcity, soil health deterioration, low farm profitability, environmental pollution and its adverse impacts on ecosystem and human health. As such, CA contributes to at least 8 SDGs and should be valued by policy makers accordingly. In most part of India especially in rainfed and drylands, the agronomic yield of food staples and oilseeds can still be increased significantly through bridging management yield gaps by a widespread adoption of CA based sustainable intensification (SI) practices, yet conserving and protecting natural resources and reducing climatic risks. Through concerted efforts and strategic arrangements (listed below), India has a potential for scaling CA to at least 15 million ha of irrigated and 20 million ha of rainfed and drylands specially for cropping systems with wheat, maize, dryland cereals, legumes, cotton, oilseeds (soybean, safflower, mustard etc.) and 5 million ha of rice-fallow. Salient recommendations are as follows:

- Benefit of CA like improvement in soil health and containment of climate change is not visible immediately as is the case with response of HYVs and fertilizers. In order to influence famers' mindset, scientists need to work closely with them through the medium of adaptive trials lasting for at least for 5 years. These pilots need to be in large numbers for spreading the message across large areas.
- There is a need to better aggregate and map knowledge of CA across ecoregions in order to define recommendation domains that consider soil, climate, cropping systems and socioeconomic conditions of different regions of the country.
- Soil suitability guide for CA must be developed on the basis of the soil map, ecoregions and farming systems.
- Commercial availability of scale appropriate machinery is one of the critical factors for success and large-scale adoption of CA. Hence, CA mechanization priorities need to be defined and strengthened in the regions having week manufacturing capacity and distribution channels. Special emphasis should be made on establishing CA mechanization hubs in rainfed ecologies and Eastern India.
- Scalable and sustainable business models should be developed for promoting adoption of CA on large scale through motivating and attracting youth in agriculture and empowering women for creating effective custom hiring centers as well as manufacturing hubs. Enhanced capacity development of all stakeholders involving farmers service providers-scientists-to policy makers should be an integral part of such models.

- There is a need to establish a National Institute on Conservation Agriculture (NICA) to serve as a platform for permanent demonstration-cum-training and knowledge sharing and capacity development sites at strategic locations of major agroecologies covering diverse soil and climatic conditions with deficit, limited and adequate water availability situations. NICA should also be mandated to serve as a platform for converging different schemes/investments related to elements of CA and connecting CA-Community of Practitioners (CA-CoP) with a mechanism for regular interactions, knowledge sharing and capacity development
- The CA should be the part of course curriculum of undergraduate and post-graduate courses in all the State Agricultural Universities. The Education Division of ICAR may take appropriate action to initiate such courses. In all the universities as well as ICAR research institutions and KVK farms, there should be large-scale demonstrations of CA based systems for training of young researchers. The practical crop production program at undergraduate level by the students should be mandated for CA-based production system.

(iv) Organic agriculture

Organic agriculture (OA) represents a production process, which mimics nature's way of supporting plant growth and development. It is embodiment of a farming system, fostered by ecological processes, biodiversity and native nutrient and water cycles. Since time immemorial, OA occupies a place of pride in India. Farming in nature's way is its origin. God's Way of Farming, Zero-Budget Farming and *Prampragat Kheti* are its other names. OA is in fact raising crops with natural resources without the use of man-made inputs. Currently, India engages the largest number of organic producers in the world (World of Organic Agriculture Report, 2018); ~31 per cent of the total (835,000 vs 2.7 million). With 1.5 million ha area under OA, however, out of 10 countries, India stands at number 9. Keeping in forefront the food-security compulsions, OA is not recommended to replace input-intensive, energy-dense modern farming methods, necessary for self-sufficiency in food. Following are the important recommendations:

- Spread OA, suiting locally adapted systems driven primarily by socioeconomic and biophysical conditions. Example: Tribal belts of WE and NE Hill States (all kinds of produce), parts of Rajasthan (spices, medicinal produce), Kerala (spices, condiments, plantation crops), Tamil Nadu and Karnataka (pulses, coffee).
- SAUs/Research Institutes and development agencies are proposed to act as facilitators for mapping regional strengths, infusion and adoption of improved varieties, standard agronomic practices, generation of bioresources, and mechanical methods, as opposed to using synthetic materials.
- Organic farming should be promoted in the niche areas and crops. "Certified organic farming" with combination of tradition, innovation and scientific organic packages should be promoted in the de-facto organic areas (hills) and rainfed/ dryland regions for safe food security and climate resilience, besides increased income of farm households. Accelerated adoption of ***"towards organic"*** (integrated crop management) approach for intensive agricultural areas (food hubs) will positively contribute to the cause of soil, human, livestock and ecosystem health, the basic objective of organic agriculture. To strengthen this, there is a need for a new program as Modern Organic Agriculture Development Initiative (MOADI) for farming in India.
- Low volume high value crops, Integrated Organic Farming System (IOFS) and low-input use areas should be given impetus for promotion of organic farming especially for export economy.
- Potential zones need to be identified on the line of "Special economic zone" and be named "Special organic farming system zone". For example, potential exists for creation of "Organic Spice" zone in Kerala, "Organic Coconut zone" in Nicobar district of Andaman and Nicobar Islands, "Organic basmati rice zone" in Uttarakhand, Haryana and Punjab, Hi-value vegetables in selected states, tuber and special root crops in NEH region and seed spice zone in Rajasthan and Gujarat. These zones can also be made as agro-eco tourism centres for attracting the eco tourists. Tax holidays for private players who are investing in the zone should be given. The zone should be planned such a way that all the input required for organic farming are produced within the zone by setting up the organic manure, biofertilizer, biopesticide production units etc. Integrated organic farming system models should be developed in all the niche areas, which should serve as research-cum-demonstration units. Cluster of villages can also be encouraged for organic farming depending upon the niche.
- The guidelines of national standard for organic production should be reviewed and 'regional referral organic agriculture quality laboratories' should be established for analysing the quality standards of the organic produce and help farmers for fetching better price and easy marketing

- MSP for organic growers should be announced every year, which should be at least 20-25 per cent higher than the chemically grown crops as organic agriculture takes care of many aspects such as soil health, human health and environment and in the long run, helps in future generations. While deciding, MSP on the organic produce, the 'Payment for Soil C sequestration and ecosystem services' should also be taken in to account.
- Linking "Clean India" to organic farming for a "Green India": India's per capita waste generation stands at 450 ± 75 g/day and it grows at the rate of 4 per cent /year in conservative locations and @ 5 per cent/year in fast growing areas. Biodegradable wastes can be separated and subjected to composting by soil microorganisms which can be used for enhancing the fertility of soil which in turn will make India greener. The composts thus produced from bio-degradable wastes could be source of nutrients for organic growers. Through this multiple goals such as clean and hygienic city, reduction of greenhouse gases, 8 to 9 times saving of urban land, prevention of soil degradation from compost usage and employment potentials to unskilled workers can be achieved.
- The main problem of organic growers is the lack of continuous and reliable supply of inputs (bio agents, certified manures, etc.) and marketing of produce. Hence, steady and reliable input and output chain should be made as a part of mission. For strengthening the 'assured quality organic input supply' rural youth led businesses/entrepreneurships should be established through linking them with various Government schemes.
- Education of youth is the strong foundation for propagation of any technique or knowledge. Presently, no Indian University is offering degree exclusively on organic farming/*paramparagat krishi*. Hence, the proposed national institute on organic farming should start graduate and post graduate courses.

(v) Doubling water productivity

Water is the most crucial input for agricultural production. Water is one of the key inputs (the other two are HYVs and fertilizers) that anchored happening of Green Revolution and in making India food secure. India though abundant in water resources, but does not have good record in its efficient management. Leaky canal system, indiscriminate use and over-pumping have resulted in depletion of surface and ground water resources. Currently, water deficit created by misuse is responsible for "the worst water crisis in its history" (NITI Aayog, 2018). Situation is getting complexed by ongoing climate change, since with each degree C rise in temperature increases demand for 10 per cent more water, particularly in arid and semi-arid regions of the country. In India, the utilizable fresh water resources equal 1123 Bm^3; 690 Bm^3 surface water and 433 Bm^3 groundwater (GW); about 82 per cent is associated with agriculture. And almost 70 per cent of canal water and 55 per cent of groundwater is lost because of poor conveyance and flood irrigation. Therefore, policies, programs, technologies and strategies for implementing the concept of *'More Crop Per Drop'* in intensively irrigated (North-West), sub-optimal use in water congested (Eastern India) as well as rainfed agro-ecosystems (South, West and Central India), a three pronged strategy (i) precision water management practices (micro-irrigation, laser levelling, automation), (ii) cropping systems optimization and diversification and (iii) capturing and effectively utilizing rain /surface waters would be warranted. Therefore, for achieving the mission of *'More Crop Per Drop'*, the following action points are suggested:

- Government must invest in conveyance of canal water through RCC Hume-pipes by involving private partners,
- Incentivize efficient use of water through delimiting subsidy on water and energy in a phased manner and provide energy use-based incentives by metering electricity and using pre-paid cards and promoting precision water management technologies (micro-irrigation, laser land levelling, conservation agriculture) and water use efficient production systems
- There should be a policy mechanism in place to regulate ground water extraction considering water as a national property
- Create irrigation water infrastructure in water-congested ecologies of eastern India
- Link rural development schemes like MGNREGA and other related developmental programs for on-farm water harvesting structures and field bunding, etc. at village level with a community-based management of rain and surface water, making water as a village community property. Promote whole farm water use efficiency through developing farm and village level water budgeting-based incentives though village panchayats

- Design whole command area based efficient, profitable and sustainable cropping systems considering precision (micro-irrigation, laser land levelling, conservation agriculture) water management technologies
- Promote conservation agriculture, precision land levelling, micro-irrigation and field bunding through incentivizing water footprints
- Incentivise conjunctive use of brackish and good quality waters
- Develop women and youth-led mobile pump-set based micro-irrigation services for efficient use of small farm ponds in rainfed and water limited ecologies.
- Increase soil water storage capacity by building SOC (details in an earlier section) and reducing delivery and evaporation losses by replacing surface water delivery through open canals by conveyance through closed RCC Hume pipes.

(vi) Increasing nutrient use efficiency

Since 1950-51 and up to 2016-17, fertilizer (nitrogen, phosphorus and potassium or NPK) use has grown from 0.07 million tons to 26 million tons (from ~0.5 kg/ha to ~131 kg/ ha). Current N, P and K use is divided into 84.4, 35.6 and 12.7 kg/ha, respectively. Current use ratio of 6.6:2.8:1 does not correspond to crop uptake pattern i.e., 1.0:0.3:1.3. It indicates emphasis of NPK use, tilting towards N and P, more typically towards N. This imbalance is not new. It has continued over the years, which indicates that NPK additions fell short of crop removals, typically in respect of K (by 7 m tons). The result is rising deficiency of K in soils and falling response ratio of NPK use. In 1970s, each kg of NPK produced 11 kg grain, whereas it now yields ~4 kg. This imbalance, specifically, has hit hardest the nitrogen use efficiency (NUE). Despite improvement in crop varieties and agronomic management practices, NUE has hovered around 30 per cent. Dismally poor NUE results in a huge waste of resources and drain on foreign exchange (more than 60% of the total subsidy amount) and causes serious pollution of soil, air, and water with ammonia, nitrates, and nitrous oxide. The low efficiency is attributed to several factors, such as blanket application, disregarding soil test-based application rates, over and imbalanced use continued broadcast and on the soil's surface. Another factor contributing to the poor state of NUE is the faulty policy on subsidy extended to NPK fertilizers. Like on several previous occasions, current nutrient based subsidy (NBS) scheme tilts far more towards N. Resultantly, P and K fertilizers are, respectively 3 and 4 times more expensive than urea-N. More N use influences soil health decline and rise of global warming. Giving prominence to capacity building of farmers on soil test-based applications, integrated nutrient supply and management including both organic sources and biofertilizers and precision nutrient and water management methods applied in harmony with the resource conservation technologies, it is possible to reduce dependence on chemical fertilizers by one half within a time frame of 10 years. In order to reach this goal within the stipulated time frame disbanding an irrational policy like NBS and replacing it with a new-look instrument supporting balanced use of all deficient nutrients would be necessary.

Recently, Government of India, seems determined to promote more judicious use of fertilizers and to restore soils to serve their original purpose of efficiently delivering nutrients to plants to improve yields, and store carbon to reduce effects of climate change through nation-wide schemes as "Soil Health Card" (SHC), *neem*-coated urea, zincated urea, reducing urea bag size to 45 kg and organic farming. But doubling nutrient use efficiency and reducing subsidy burden would need science led technical innovations along with enabling policies with a short-, medium- and long-term strategy and goals. These innovations may enhance sustainable production, profitability, and environmental security along with achieving sustainable development goals (SDGs). The following actons need priority attention:

A. Precision nutrient management

- Blanket fertilizer recommendation to be substituted by cropping system-based recommendation using soil health card and yield potential in area-specific production zone
- Sub-surface placement of basal fertilizer be made mandatory by giving subsidy on seed-cum-fertilizer drills. Top dress fertilizer before irrigation and its application rate to be calibrated as per leaf colour chart readings
- Sufficient biological cover (residue, cover crops) over the soil surface to reduce losses (see conservation agriculture section for details);

- Promote fertigation system (MI plus fertilizer application) in a phased manner starting from high value and high water-requiring crops like sugarcane to cereal crops and ensure similar nutrient-based subsidy on liquid fertilizers too;
- Promote integrated (organic + inorganic) fertilizer/manures approach linked with SHC.

The above five approaches can be targeted as a short- to medium-term goal and be achieved through science-based technology recommendation, awareness creation and knowledge sharing with stakeholders/ farmers, village panchayat level technology demonstrations, and facilitating public-private sector with investments and policies. The agri-clinic concept (see youth and women section for details) can be an innovative tool to scale-out and scale-up the block specific recommendations in collaboration with village panchayat, KVKs, SAUs, ICAR, NGOs and private sector.

B. Efficient Fertilizer Sources

- Promote production and distribution of customized fertilizers based upon cropping system and SHC in particular eco-region for balanced nutrition and improving efficiency
- Promote CFs manufacturing (dry granulate by compressing) in the heart of key production systems by allowing private manufacturer to promote this activity as franchise/start-up. Easing of rules on approval and marketing of CFs and extending benefit of subsidy for all fertilizer sources being part of formulation.
- Develop a "Fertilizer Innovation Centre" in public-private partnership mode to initiate new research and business models for efficient fertilizer sources by modifying release mechanism (poly-coating, nano-material), slowing mineralization (polymer and formaldehydes), changing fertilizer spheres, inhibiters, host-and climate-smart fertilizers, biofertilizers and organic fertilizers to double the nutrient use efficiency

The first two approaches can be targeted as a short- to medium-term goal and third as medium- to long-term goal in a public-private-producer partnership (PPPP) mode. These approaches would need more of science led innovations, investments in science and policy support to be included in existing subsidy policy. This would need a trans-disciplinary approach including agriculturist, chemical engineers etc.

C. Reforms in NBS policy

- Existing NBS policy favour N fertilizers, fuelling thereby overuse of N. There is a need to rationalize NBS policy
- Focus on alternative subsidy mechanisms to minimize system leakage as direct benefit transfer (DBT), voucher system (IFDC) to directly benefit farmers with wider usage of ICT tools and *Aadhar* card.
- Promote SHC card based NBS policy with major emphasis on smallholder farmers
- Support biofertilizers, one vermi-compost pit/land holder and organic fertilizers through NBS
- Support manufacturing of compacted multi-nutrient products and CFs at local level with financial assistance to install compaction facility
- Streamline procedures accelerating approval of the new grades of CFs
- Promote glauconite-K mineral as multi-element slow release source

(vii) Climate change

For climate change mitigation strategy, the following specific recommendations are suggested:

- **Long-term:** The strategy focuses on plans that create lasting sink for CO_2 and minimize emissions into atmosphere. Turning soil into sink by green cover comes to fore. Greening soil cover includes: (i) restoring the lost forest cover (afforestation) and forestation of denuded and barren lands; (ii) disallowing shift of ecologically productive lands to other uses; (iii) introducing land use plans that maximize land cover period (agroforestry) and (iv) inducting CA for cultivation of crops, whose growth habits match with the land attributes and their produce is market relevant. Maximum results are expected by actuating execution of joint forest management for improving health of forests and social forestry. Backstopped by a committed change agent, these ventures have to grow as people's movement; genuine policy support would be essential.

- **Medium-term:** It requires effecting big changes, like increasing reliance on renewable energy sources by replacing fossil fuels. Nearly 75 per cent of the global rise in CO_2 is happening due to burning of fossil fuels like coal, natural gas, oil including patrol; India is no exception to that. Shift to alternative energy sources such as solar, wind energy, etc. would have great mitigating effect by limiting global warming. India has rightly set the target to raise solar energy from the current 22 giga watts (GW) to 100 GW by 2022.
- **Short-term:** The practices, technologies or services, which help improving adaptive capacity, enhancing food security and reducing environmental foot prints of food production are the building blocks of 'Climate Smart Agriculture'. CA is an embodiment of climate smart agriculture, as it has proven credentials in mitigating the consequences of global warming by sequestering SOC, lowering chances of soil temperatures to rise, and sustaining necessary productivity growth by making agriculture more efficient, competitive and a resilient enterprise. A system of innovation, involving partnership among farmers, agricultural scientists, development department officials and private individual/ firms is proposed to be established (details in an earlier section). Climate change mitigation value of CA would get further enhanced by moderating the ongoing rise in the consumption of animal-based foods. Awareness is to be created by educating people on threatening consequences of production and consumption of animal-based foods on climate change and depletion of NRs. It would also be necessary to substantially raise the ongoing dismally poor use efficiency of water (details in an earlier section) and fertilizers (details in a subsequent section). There is also need to rethink on subsidy schemes (fertilizers, power and water) and replace subsidy investments for payment for efficient use and consequent generation of environmental services.

The agriculture sector has a large carbon footprint, accounting for ~7 per cent of the greenhouse emissions globally and 18 per cent in India. Payment for ecosystem services (PES) is a tool being experimented/ implemented to compensate farmers who generate climate mitigation products like SOC build up and C sequestration by adopting climate smart sustainable land management practices like CA. An estimate on environmental services generated by 1 ha cropland equals ~ Rs 68,000 (Lalit Kumar *et al*. 2019). Of this, farmer recovers Rs 24,000 from marketing of produce and non-marketed services include climate mitigation (Rs 13,800), genetic diversity (Rs 12,894) and soil fertility (Rs 4,991). It is recommended to develop a system of paying for environmental services, since for marketable produce farmer earns only ~35 per cent of the full value of products and services emanating from the farm.

(viii) Region-specific strategies for sustainable management of natural resources

A. Green Revolution regions

- High productivity area (HPA) presents a museum of major and micronutrient deficiencies; practicable solutions espousing development and use of tailor-made customized-fertilizer solutions are necessary for management of soil fertility.
- Infusion of legume intercrop between cereal-cereal rotation would make region more sustainable, provide right duration legume seed free of cost.
- Introduction and adoption of CA would be game changing intervention for revitalizing agriculture of this region details in an earlier section.
- HPA is a model of wasteful use of water (exhibited by rapid fall in water tables, due to heavy input of subsidy for energy to draw water) and fertilizers (NBA inspired overuse of N) (revival plan in an earlier section).
- Focus diversification for replacing water-wasteful crops with water-saving crops; shift from rice to maize cultivation in Punjab and Haryana by making necessary arrangements for public procurement of maize as is done for rice; replace, specifically, flooding of sugarcane with MI.
- Introduce right duration varieties of main and inter-crops, optimizing sowing dates.

B. Low productivity - high potential regions

Largely includes, Eastern-Madhya Pradesh, Chhattisgarh, Central and Eastern Uttar Pradesh, Bihar, Jharkhand, Odisha, Assam, West Bengal. Share of low productivity areas (LPA) ranges from 57 per cent in coarse cereals and 92 per cent in oilseeds (yields less by 40 per cent than high productivity areas). Nearly

60 per cent LPA of rice is in Bihar, Odisha, Jharkhand, Chhattisgarh, West Bengal and Central and Eastern Uttar Pradesh and 68 per cent LPA of wheat is in central and Eastern Uttar Pradesh , Madhya Pradesh, Bihar and Rajasthan. This region inhabits large proportion of adivasi population and is faced with recurring floods and droughts. Recommendations are as follows:

- Focus on flood control, drainage management and improvement of irrigation; development, particularly of minor irrigation, with provision of solar pumps which hold the key.
- Abundance of acid soils, necessitates public support for liming (Rs 4800/ha and its effect lasts for years). Since acid soils suffer more from S, B and Mo deficiencies, strengthen strategy on integrated nutrient supply and management and enhance availability of custom-made fertilizers to assure balanced management of these nutrient deficiencies; use of glauconite-K mineral will reduce dose of lime and strengthen integrated nutrient supply and management (bringing glauconite in the schedule of minerals is necessary).
- Institutionalize tenancy reforms including forced consolidation of fragmented holdings at least in irrigated areas.
- Support rejuvenation/creation of wells to be powered by solar pumps, specifically for *adiwasi* farmers give total support for digging a well, solar powered pump and flexible pipe for water distribution (cost of package ~Rs 5 lakh) (Tata-IWMI Report, 2016).
- Provide cost-effective inputs, cash-less machinery hiring and impart knowledge and skill enhancing training to diversify crop portfolio by turning it into science driven enterprise. Establish organic agriculture (OA) hubs in the form of 'biovillages' for generating organic rice, spices, fruits, vegetable and facilitate securing collective packing, labelling and certification.

C. Rainfed regions

Currently, 54 per cent of net sown area is rain-dependent. Livestock-based systems contribute 70 per cent to 80 per cent to the total farm income; suffers from low productivity (~one third of irrigated agriculture). Rainfed regions share: 89 per cent of millet production, 88 per cent of pulses, 73 per cent of cotton, 69 per cent of oilseeds and 40 per cent of rice production. Continuation of low productivity lies in the recurring episodes of in-season drought; flaws in land treatments for maximizing in situ rainwater conservation, weak focus on rainwater-runoff harvesting and use, imperfections in land use planning for sustenance of soil health, maintenance of green cover and negating the impact of overexploitation of NRs, component-based treatment and management of land, water and animal resources of individual fields and not on water-shed or entire landscape basis. Also, there exists a serious policy bias, when it comes to public funding/support to rainfed farming and farmers.

Rainfed agriculture is socioeconomically complex, diverse and risk prone. Though true, future imperative is to shed this thesis by combining arable farming and use of natural resources – water, livestock, fodder and trees in a highly integrated fashion, as the rainfed farmers do. With this integration, it is possible to stabilize and improve low-income, small-scale rainfed farming. Rainwater harvesting will be the central point for bringing Green Revolution to dryland regions.

Keeping the above background and imperatives in forefront, following action points are suggested:

- Adopt integrated farming systems approach, utilizing watershed-based Rainfed Area Priority Index for suggesting location and situation specific interventions (details in a later section).
- Support creation of a class of change agents, who help transforming individual farmers into community-based organizations, identifying entry points, assuring success of translative interventions into transformative impact.
- Introduce simple land treatments maximizing rainwater soaking in the field on which it falls (*in situ* rainwater conservation); area-specific (soil type and seasonal rainfall-dependent) application is necessary (some examples: bunding, broad-bed and furrow method for black soils, cultivation against the slope followed by ridging once the crop is established for red soils).
- Increase availability of machinery suiting diverse land treatments, support rent-free access to use of specific machinery, example broad-bed and furrow (BBF) land treatment for black soils by making available BBF planter (BBFP) at farmer field. Model of custom-hiring system, needs to be adopted.

- Support people-led models of rainwater harvesting and conservation, place focus on revival of ancient water stashing structures (like *johads*, tanks etc.); *Kakatiya* Mission Telangana.
- Support creation of on-farm water ponds, only if farmer solicit it.
- Follow the old dictum, '*khet ka pani khet mein'*, while supporting groundwater recharge – a farmer-preferred option, by surface recharge; recommended to cover GW recharge as part of PMKSY.
- Enhance lasting sustainability of harvested rainwater for future by making farmers more responsible for self-regulatory rainwater budgeting, adoption of area-right land treatment, crop diversification and precision management of harvested water; support for capacity building knowledge and know-how, mentoring and financial hand-holding are necessary.
- Turn rainwater harvesting, use and management into people-led watershed-based a wide area movement like the '*pani roko abhiyan*' in Madhya Pradesh and international award-winning 'khet talawadi' movement in Gujarat. Self-regulation – decentralised collective management of created resources by water users' community and government funding are necessary.
- Strengthen mixed cropping and agroforestry systems for risk-distributing and income stabilizing crop management methods. Typically, introduction of trees as in agroforestry systems moderates undergrowth temperatures and are proven to produce 4-6 times higher pasture biomass (example *khejri* and pearl millet combination in Rajasthan). Promotion of horticultural trees, multi-purpose perennials and bushes is a ready and sustainable source income.
- Support for holistic rainfed agriculture development needs to imbibe a 10-year perspective after the re-energized traditional water bodies/ (tanks)/ancient systems development have created visible water resource; holistic development would involve farmers' feedback on their perspective and preparedness on rainfed farming development, followed by initial capacity building and its repeat for strengthening every aspect of development; components of overall improvement of integrated farming system would require infusion of improved breeds of livestock, protected agriculture, agroforestry systems serving needs of livestock, intensifying horizontal use of land, risk moderation and enhanced income,
- Minimize policy bias when it comes to public funding/support to rainfed farming and farmers. In pursuance, it is recommended to adopt a more balanced approach to give rainfed farmers the same research and development focus and production and marketing support that irrigated farmers have received over the last 5 decades.

D. North-eastern regions

Includes ecologically fragile mountainous (e.g., NE Hill States) and desert regions. These regions represent vary favourable land to man ratio, but are not self-sustaining as far food grain production is concerned. NE Hill States suffer from widespread land degradation in the form of soil acidity and erosion. Action plan for NE is suggested as follows:

- Support for liming is must; entire amelioration cost is recommended to be met by the Central Government.
- Establish on-farm water harvesting, combined with shade-net protected agriculture (preferably organic agriculture), drip irrigation and SPV based pumping system (specifically for NE). Begin as pilot project to be convened by local SAU, CAU and ICAR NE Hill Complex, but under farmer field conditions (cost of one pilot ~Rs 6 lakh).
- Support multiple natural resources use with peoples' participation, laying more emphasis on livestock, fish and plantation crop-based integrated production systems; indigenous knowledge needs to be kept as base before making suggestions on infusion of modern techniques.
- For affecting reduction in *jhooming* area, consultation with the local farming communities is necessary. Raising cash crops and horticulture using forest as alternative to *jhuming* in Nagaland has proved to be a promising model; recommended to be validated and replicated in other *jhuming* areas.

E. Desert regions

Desert regions are concentrated in Gujarat (Great Rann of Kachchha or salt desert, 4.5 mha), Rajasthan (sandy desert, ~15 mha), Himachal Prdesh (Lahaul and Spiti) and Jammu & Kashmir (Ladakh) (cold desert, area <1 mha). Action plan is as follows:

- Diversification emphasizing agro-pastoral and agroforestry systems are recommended to be strengthened in ecologically fragile regions.
- Strengthen indigenous animal-based systems.
- For development cold desert agriculture, introduction of protected agriculture comes to the fore; need is to develop and test naturally ventilated zero-energy polyhouses suiting cold deserts.

Increasing S&M farmers' income: Right technology is fundamental for sustainable growth in productivity leading to food security. It is not adequate to increase income of S&M farmers, in particular. More viable option instead would be to give preference to cultivation of sun-rise crops (flowers/exotic vegetables/medicinal plants) and rearing specialty animals (duck/quails farming, cuniculture, fishery). Creating awareness, strengthening adaptability and adoption of science-driven management of land, water, agro-inputs and crops would be essential. Following recommendations are made:

- Strengthen competence of intending farmers by real-life training in the art and science of all aspects of expert farming techniques; launch special training programs on production of high value low volume products and rearing of speciality animals under controlled and uncontrolled conditions under the auspices of Agriculture Skill Council of India.
- Encourage open field farming by following professional management methods, e.g., plant crops on raised beds through holes in an organic or plastic mulched ground, support fertigation to efficiently deliver water and fertilizers.
- Manage solar powered crop cultivation under controlled conditions to stabilize quality and yield by pacifying the adverse impact of fluctuating weather conditions.
- Make producer a component of value chain by pre-organized and established market links with private agri-business houses.
- Provide comprehensive backing (institutional, financial, legal) of public policy making bodies and development departments in that the core concerns of intending farmers on availing government schemes supporting local corporatization of tiny farms into producer companies, credit and necessary mutation of land use for setting up processing plant are addressed effectively.

(ix) Scaling NRM innovations

The NRM innovations are entirely different from that of seed/fertilizers/irrigation and hence need different approaches, capacity and tools for last mile delivery. No action plan can have any chance of success, unless the millions of small farmers in the country accept its objectives, share in its making, regard it as their own and are prepared to make contributions in implementing it. This will happen, if the professional advice and solution offered are aligned to their (farmers) needs and perceptions and the delivery of knowledge and enabling inputs to use it are real time and reach covers the most unreachable swiftly. Apparently, technology transfer apparatus has to become more proactive and involved so that farmers get advice and inputs from a single window. Since, NR related technologies do not show immediate visible response, to convince farmers the scientists have to work with them facilitating change of their mind set. It has to gain momentum because lack of literacy stands in the way of "absorbing technologies and adopting risk-mitigating measures." noted India's 2017-18 Economic Survey. Scientists, therefore, must move to farmer's fields from their labs and prove that their findings have practical application, in terms of reducing input costs and increasing output value. Involvement of private sector in firming up holistic NR management needs priority.

Public policy has a huge rule in supporting the action plan on NR management. Focus has to be to be urgently formulate a Land Use Policy, which enhances local governance mechanisms, supporting role of users in sustainable land management; ensuring completion of digitization of land records, issuance of computerized record of rights (RORs) linked to cadastral maps including no fragmentation below 1 ha; minimizing area under fallow lands (25 mha) by extending a special support package and creating enabling conditions for private investment in sustainable land management. A rethink is necessary on irrational policies like nearly free water and power and rationalizing NBS scheme on subsidy given to fertilizer nutrients.

2.4 Crop Sector

One of the greatest challenges being faced currently is to ensure a guaranteed supply of enough nutritious and healthy foods that are produced in an economically, culturally, socially and environmentally sustainable manner. In the past over five decades, with widespread adoption of Green Revolution technologies, India's food production increased 3.8 times to about 285.2 million tons (2018-19). At the same time, the country's population has increased by 2.55 times to 1.36 billion and is likely to reach 1.51 billion by 2030 and therefore, the challenge facing the country is to produce more and more from diminishing per capita arable land and irrigation water resources and increasing abiotic and biotic stresses. The current situation in India is that cereal production has to be doubled by 2050 in order to meet the needs of an expected population of 1.65 billion by 2050 (Swaminathan & Bhawani, 2013), in addition to meeting the needs of livestock and poultry. Since land is a shrinking resource for agriculture, the pathway for achieving these goals can only be higher productivity per unit of arable land and irrigation water. Factor productivity will have to be doubled, if the cost of production is to be reasonable and the prices of farm products are to be globally competitive. The average farm size is going down and nearly 80 per cent of farm families belong to the marginal and small-farmer categories (2 ha or less). Enhancing productivity, increasing small-farm income through crop-livestock-aquaculture integrated production systems and multiple livelihood opportunities through agro-processing and biomass utilization, are essential to meet food production targets and for reducing hunger, poverty, nutritional security and rural unemployment. About 55 per cent of the Indian population continues to depend on agriculture and allied activities for their livelihood. Hence, growth of crop sector is an essential prerequisite for overall economic growth of the country.

The main goal of Green Revolution had been to ensure India's national food security, more precisely its self-reliance in foodgrain production. Today, India has achieved self-reliance in foodgrain production. It has become the world's second largest producer of both wheat and rice and the largest exporter of rice. Despite the large increases in total production, per capita availability of all foodgrains has increased only modestly as the population has more than tripled since the mid-1960s. What has changed markedly is that wheat and rice have largely displaced more nutritious pulses and millets in consumption. India's increases in total food production have, unfortunately, not translated into proportionate decreases in malnutrition. While over the last two or three decades, higher rates of economic growth, declining poverty and availability of staples have led to reductions in the number of undernourished to around 15 per cent of the population, malnutrition remains high. As a result, India ranks 103rd out of 119 countries in the Global Hunger Index (IFPRI 2018) and is home to the largest number of malnourished people in the world, about one quarter (195.9 million) of the global total which places the country in a 'High and Serious Risk' category. By this measure 14.8 per cent of the population is undernourished in India. Even countries like Nepal, Bangladesh, and Sri Lanka are better in hunger score. Malnutrition in India today is concentrated among children under five. While the rates of child malnutrition have diminished over the last decade or two, child wasting and stunting are still widespread. According to the 2018 Global Nutrition Report, in 2015 about 21 per cent of all children under five were wasted and 38 per cent stunted.

2.4.1 Current Status

The agriculture sector of India has occupied almost 47 per cent of geographical area. Over 55 per cent of rural household depends on agriculture. The area of cultivation of cereal crops is 15 per cent, pulses 12 per cent and fruits or vegetables are below 10 per cent. The agriculture accounts for about 17 per cent of the national GDP and nearly 50 per cent of the employment. The stunted structural change in Indian economy has also added to the asymmetries highlighting the importance of production plus approach. The dependency of population decline from 75 per cent to 58 per cent but at the same time the sectoral contribution has fallen from 61 per cent to around 17 per cent in the GDP of the country. Apart from several missions (see Box 1 under Section 1), central sector schemes and programs operating to tackle major areas in agriculture, sustainable agricultural practices are also in place to balance environmental health and economic profitability in order to promote social and economic equity. Therefore, stewardship of

both natural and human resources is very important. Sustainable agriculture involves the processes that would enable us to meet the current and long-term societal needs for food, fiber and other resources. This challenge is indeed formidable.

While in irrigated areas (about 65 mha), farmers have widely adopted Green Revolution technologies including use of high yielding variety (HYV) seeds, farm mechanization, chemical fertilizers and pesticides, as much as 55 per cent of India's total sown area (141 million ha) is still under traditional rainfed/arid agriculture, accounting for about 48 per cent under food crops and 68 per cent under non-food crops. Green Revolution technologies are now being seriously challenged as continued use of more chemicals have started resulting in widespread deterioration in soil health and water availability, besides contributing to major environmental hazards such as air and water pollution adversely affecting human health. For example, over the past five decades, in Punjab and Haryana, continuous use of Rice-Wheat cropping system, has contributed to serious ecological imbalances leading to decline in total factor productivity (TFP), soil degradation, low organic carbon, over-exploitation of groundwater; and widespread water logging and salinity in canal irrigated areas. Thus, the farming systems need to be suitably modified using conservation agriculture (CA) for sustainable intensification, climate smart agriculture, and environmentally friendly conservation practices.

Over the past few years, the overall annual growth in agriculture has been around 2-3 per cent. The growth in fruits and vegetables has been relatively higher. Approximately 27 per cent of the total value of agricultural output is from cereals group and 26 per cent from fruits and vegetables. Our requirement for foodgrains would be around 350 million tons by 2030. Between 1950 and 2007, production of foodgrains (comprising rice, wheat, coarse cereals, pulses, etc.) in the country increased at an average annual rate of 2.5 per cent compared to 2.1 per cent growth of the population. In 2001, foodgrain production was only 196.87 million tons. Subsequently, the trend changed and food production and productivity gradually increased (up to 265.04 million tons, in 2013–14, 275.68 million tons in 2016-17, and 284.63 million tons in 2017-18) owing to good monsoon rains and various policy initiatives by the government (Fig. 2.4.1) but due to drought in two consecutive years, output had dropped considerably (251.57 million tons) during 2015-16. The year

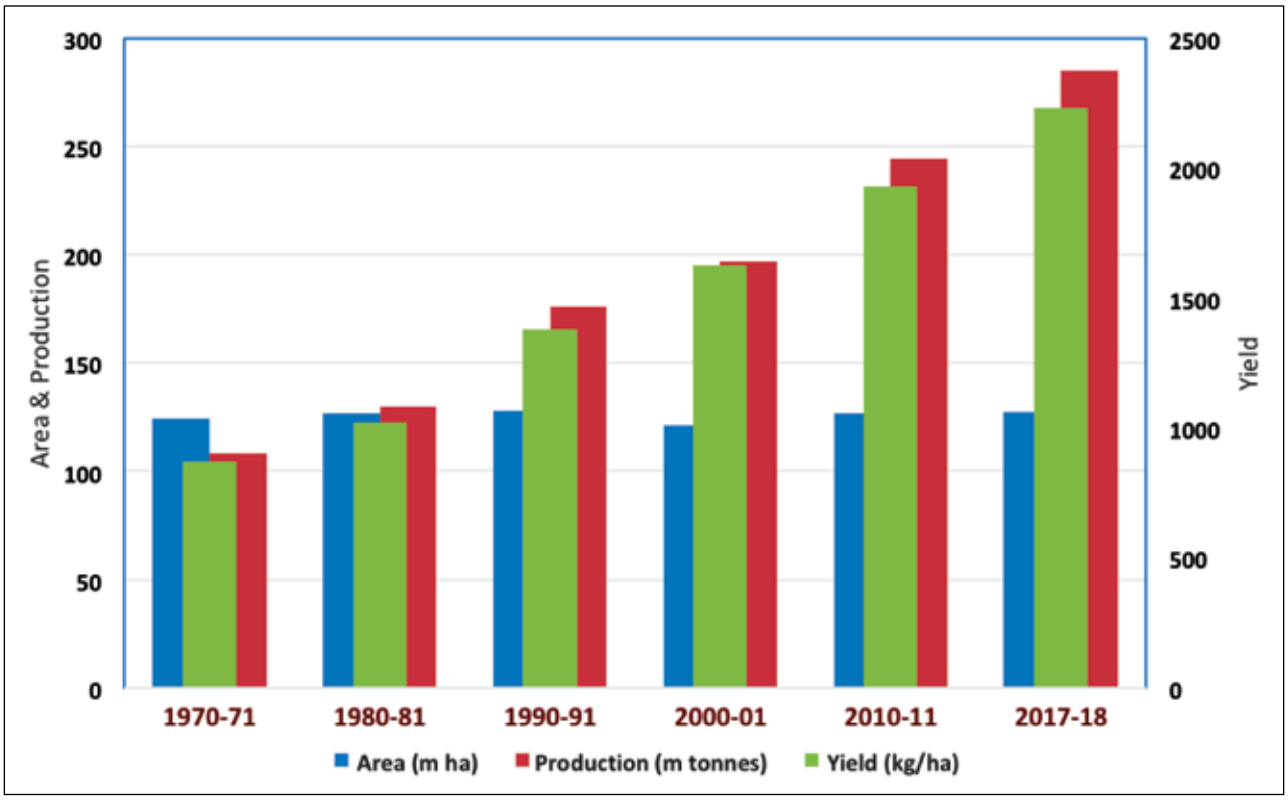

Fig. 2.4.1 Area, production and yield of total food grains in India

(Source: DAC&FW, 2017-18)

2018-19 witnessed an all-time record production of 285.2 million tons in spite of monsoon rainfall declining by 9 per cent below normal. This amply shows that there is tremendous opportunity of agriculture sector to expand. The area under foodgrain production has also marginally increased from 120.70 million ha (2012-13) to 128.02 million ha (2017-18) means only 5.06 per cent increase in total area under foodgrain production in India (MoA&FW, 2017-18). The average yield increased due to better crop productivity. The phenomenal increase has led to a surplus situation which has led to an increase in overall exports. However, there is a huge difference in foodgrain production and its availability to the masses. Approximately, 6.16 per cent growth has been marked in per capita foodgrain availability in India during the period 2000 to 2018. The highest availability per person per year was the maximum in 2002 (180.4 kg) and the minimum in 2001 (151.9 kg). In 2018, foodgrain availability slightly reduced to 176.8 kg per person per year. These indicators alarm us to enhance crop production and productivity targets a great deal.

India is one of the hotspots of plant domestication. Rice, barley, wheat, and pulses all have their domesticated beginnings in India/South Asia due to which the wild relatives of most of these crops still grow as weeds in natural environments, where they retain traits of natural resistance to biotic (diseases and pests) and abiotic (drought, flood, cold, salinity, alkalinity) stresses. In many cases, the offspring (F1 generation) of crosses between modern cultivated species and their wild relatives retain fertility, facilitating breeding programs. With the development of the modern high yielding varieties/hybrids used in post-Green Revolution agriculture, the use of landraces has been discouraged because of their relatively poor yields but these are still important locally and can be a good source of useful genes to be transferred to otherwise superior agronomic varieties of crops.

2.4.2 Challenges

Nearly 80 per cent of the land holdings in India are below 2 ha. Unlike in industrialized countries, where only 2 - 4 per cent of the population depends on farming for their work and income security, agriculture is the backbone of the livelihood security system for two thirds of India's population. Hence, improving small-farm production and productivity can make the greatest contribution to the elimination of hunger and poverty. Experience of countries that have succeeded in reducing hunger and malnutrition shows that growth originating in agriculture, in particular the smallholder sector, is at least twice as effective as growth from non-agriculture sectors in benefitting the poorest. As stated earlier, higher productivity requires higher investment in agriculture and agricultural research, a fact that needs to be paid attention by policy makers. The Green Revolution had been largely confined to irrigated farming areas and to rice and wheat. The per unit area productivity today is much lower in India compared to other countries. There are also wide gaps in yield among and within states. China has yield levels far more than that of major foodgrain crops in India. Agricultural production of foodgrains can be increased by adopting a twin-pronged strategy to deal with gaps in production and productivity. First, there exist significant yield gaps between genetic potential, yield attained at experimental station/frontline demonstration and actual/average yields at farmers' fields (vertical gaps). Second, significant yield gaps also exist between different regions/districts/states in different crops (horizontal gap). In the major cereal crops, the vertical gaps vary from 32 per cent to 83 per cent, i.e. 32-59 per cent in wheat, 48-76 per cent in rice and 65-83 per cent in maize. These gaps are largely due to management practices adopted, ranging between 14 per cent and 78 per cent, i.e., 14-48 per cent in wheat, 30-69 per cent in rice and 60-77 per cent in maize. The gap in potential and real yields (vertical gap) is quite significant. For example, in the case of wheat, the gaps between (i) yield (national average) under research conditions (4.20 t/ha), (ii) yield demonstrated on farmers' fields (3.32 t/ha) and (iii) actual average yields (2.79 t/ha) are: 26.5 per cent between research and demonstrated yields, and 19 per cent between demonstrated yields and actual yields. Much larger gaps exist in Bihar (58 per cent) and Madhya Pradesh. Other reasons for this gap need to be ascertained through specific studies and addressed through appropriate interventions. These yield gaps have to be bridged. The lands sown only once can be double- or even triple-cropped with appropriate investment and concerted efforts (Hooda Committee Report, 2010). There are wide variations in inter-state/ inter-district productivity (horizontal gap) also. It is a matter of concern that over the years, the use of germplasm for breeding new varieties of different crops has gone down. This trend is global and that

is why a global initiative on plant breeding has been initiated by the FAO through the support of the Bill and Melinda Gates Foundation (BMGF), which aims to reverse the trend. It is apparent that there is some complacency in recent efforts in plant breeding. It is important to understand that biotechnology can't replace plant breeding, it can only supplement.

With small and marginal holdings constituting about 80 per cent of the total holdings, one of the major challenges faced by the Indian economy lies in enhancing foodgrain production of this group of farmers, which could significantly improve the growth prospects of the country. Therefore, the goal of long-term food security can be attained only if agriculture is made sustainable through reforms in agricultural policies. In case of crops such as maize, gram and soybean, the growth in acreage was also substantial. Growth in acreage under, oilseeds and pulses came at the expense of coarse cereals, particularly sorghum and pearl millet.

(i) Cereals

Promotion of hybrid rice (which yields 20% more than conventional varieties) and adoption of farm mechanization, particularly the rice transplanters and direct-seeded rice, using multi-crop planters are the main interventions needed urgently. The challenge of raising the productivity of rice in Punjab and Haryana is to increase its productivity with less water. China was the first to release super hybrid rice with a target yield level of 15 t/ha. India has 42 million ha under rice, but hybrid rice area is approximately 3 million ha only. If we take 1970-71 as base, rice productivity increased by 120 per cent whereas wheat productivity increased by 150 per cent in the year 2017-18. Further, there is vast scope for increasing rice production in West Bengal, Assam, Odisha, Andhra Pradesh, Tamil Nadu, Karnataka and even Kerala during the *rabi* season. Although wheat production is likely to meet the target of 100 million tons by 2020, production of 115 million tons rice in 2018-19 against the target of 123 million tons by 2020 indicates a gap of 8 million tons. Wheat productivity, however, seems to be plateauing now and therefore, concerted efforts need to be made to address this issue on priority. Although pace of development of rice hybrids has slowed down considerably in public sector during the last 10 years, it needs to be given greater attention on priority. Currently, 15 hybrids are available and out of these six from public sector and three from private sector are very popular, but the area expansion has still not picked up. The reasons for slow adoption are: (i) the preferred grain type by consumers is medium slender like *Samba Mahsuri* but only a few hybrids have this trait and hence the farmers prefer to grow *Samba Mahsuri* or similar other self-pollinated varieties having such grain type; (ii) seeds of hybrid rice costs 5-6 times that of self-pollinated varieties. Therefore, Government needs to subsidize cost of hybrid rice seed by at least 50 per cent so that farmers get hybrid seed at double the price of self-pollinated rice varieties; (iii) special effort has to be made for developing grain type similar to variety-*Sambha Mahshuri*. Meanwhile, available hybrids in the market should be promoted in a big way irrespective of their release by public or private sector. The major issues with regard to slow adoption are policy related. Researchable issues relate to quality i.e. grain type as well as higher yield advantage which needs to be addressed on priority. Further, there is need to invest in research to develop super hybrids (like in China) which will show significantly higher yields in the Green Revolution areas. Investment of private industry to be incentivized in developing efficient hybrid seed production through modern technology so that seed production areas can be diversified (right now the bulk of the seed is produced only in Andhra Pradesh and Telangana) and the cost of production is brought down which in turn will help in reducing prices.

To enhance the average productivity of wheat and rice both district-wise planning with emphasis on increasing the productivity in eastern and southern states, timely sowing, balanced use of fertilizers, increased use of organic manures, crop residues and biofertilizers has to be ensured. The challenge is how to improve yield further for which hybrid technology needs to be exploited. In the 1980s and 1990s, the Indian wheat program recorded an annual genetic gain of 1 per cent p.a. This has stagnated since the release of wheat variety PB 343.The inter-state variation in productivity is more conspicuous, ranging from as low as 1.4 t/ha in Maharashtra to as high as 4.3 t/ha in Punjab. Similarly, inter-district variations range from 1.23 tons/ha in Bihar to 4 tons/ha in Punjab and inter-district variations are prominent within states also.

The large gap in yield of maize production in India and rest of the countries is quite striking. Maize yield in India has reached only 2.66 tons/ha, which is strikingly low as compared to that of the United States,

where the yield has reached up to 10.7 tons/ha. With less than half of acreage under maize cultivation as compared to the area under cultivation in India, Argentina and Ukraine are able to produce more than double the yield of Indian maize. Considerable effort is required in improving the yield and total production of maize in India. Maize production in India has grown at a CAGR of 5.5 per cent over the last ten years from 14 million tons 2004-05 to 26.0 million tons in 2017-18. During 2009-10, there was a decline in production primarily due to drought that affected production of *kharif* crops in the country. The area under maize cultivation in the period has increased at a CAGR of 2.5 per cent from 7.5 million ha in 2004-05 to 9.4 million ha in 2013-14, the remaining increase in production is due to increase in yield (India Maize Summit, 2014). India requires 45 million tons of maize by the year 2022. In order to achieve the goal, production must match with demand. It signifies that production needs to grow at 15 per cent CAGR to suffice the domestic demand, which in turn, could be possibly met through significant leap in existing yield level. Key production drivers include area expansion, technology adoption and hybridization. By growing maize, farmers save 90 per cent of water, and 70 per cent of power compared to paddy as it requires less water. Only 15 per cent of cultivated area of maize is under irrigation.

(ii) Coarse cereals

Coarse cereals (sorghum, pearl millet, finger millet etc.) are the important component of Indian food basket. These crops have tremendous potential to grow under rainfed/arid areas and on poor soils and their water requirement is much lower as compared to rice and wheat. However, the acreage under coarse cereals declined from 28.94 million ha in 2004-05 to 24.71 million ha in 2014-15, indicating a drop of about 15 per cent. A record production of coarse cereals was 44.19 million tons in 2016-17, whereas the previous high was 43.39 million tons in 2013-14. During 1950-51, area under pearl millet was only 9.02 million ha with production of 2.60 million tons at a productivity of 288 kg/ha. During seventies, it increased to 8.03 million tons in an area of 12.91 million ha with productivity level of 622 kg/ha. Thereafter, area reduced slowly but production and productivity increased to 9.80 million tons with 1,312 kg/ha productivity in an area of 7.47 million ha during 2016-17. This happened due to better hybrids and good agricultural practices (GAP). Sometimes, the productivity imbalance in pearl millet is due to no rain/erratic rains/shifting of pearl millet cultivation to marginal soils due to diversification of traditional area to high value crops across the country. Only about 8 per cent of pearl millet area is irrigated. Pearl millet has high scope of production in the areas/states like South-West Haryana, Rajasthan and Gujarat besides a number of states in the eastern and southern parts of India.

The situation of sorghum is almost the same as in pearl millet. Sorghum was grown in an area of 15.57 million ha with production of 5.50 million tons at a productivity of 353 kg/ha during 1950-51 and remained more or less same up to the eighties. From 1990 onwards both area and production continuously reduced owing to its replacement with high value crops and during 2017-18, it is at the minimum production level 4.7 million tons in an area of 4.9 million ha but with increased productivity around 880 kg/ha, due to introduction of HYVs. In 2016-17, the area under millets stood at 14.72 million ha down from 37 million ha in 1965-66, prior to the pre-Green Revolution era. This decline was largely due to change in dietary habits (induced by a cultural bias against millets during post-Green Revolution period), low-yield of millets, and conversion of irrigated area towards rice and wheat. Though farmers have been cultivating major millets such as *jowar, bajra* and *ragi*, production has been volatile largely due to concerns over low productivity and profitability. Production of millets stood at 16.14 million tons in 2016-17, of which, minor millets such as foxtail and kodo millets was 4.5 lakh tons. Recognizing the nutritional importance of these crops, GoI has given a boost to millet cultivation through the recent 'Initiative for Nutritional Security through Intensive Millet Production' under RKVY and current scheme on 'Nutri-Cereals'.

(iii) Pulses

India is the major producer and consumer of pulses. Unfortunately, productivity is less than 1 t/ha. A major effort is, therefore, required to adopt a comprehensive, well-planned mission-mode approach to enhance its production. The Government gives priority to increasing the production by allocating around 50 per cent of the budget under the NFSM to pulses. During 1950-51, area under pulses was only 19.09 million ha with overall production of 8.41 million tons at a productivity of 441 kg/ha. The trend was almost

stagnant up to 2007-08 and in 2010-11 the trend increased a great deal and production and productivity rose continuously from 18.24 million tons in 2010-11 to the highest ever production of 25.23 million tons during 2017-18 from over 29 million ha area at a productivity level of 841 kg/ha. This has happened due to increased production levels of soybean and chickpea in the states of Himachal Pradesh, Gujarat, Punjab, Madhya Pradesh, Chhattisgarh, Bihar and Jharkhand. The exponential growth rate in production of pulses during 2016-17 was more than 9 per cent. During 2017-18, significant growth was registered under total pulse production, both over the base year (2014-15) and during the period 2012-13 to 2016-17 at the level of 47 per cent and 34 per cent, respectively. Major increment was recorded in *kharif* production i.e. 62 per cent mainly due to lion's share contributed by urdbean (82%) followed by pigeonpea (52%) and mungbean (34%). *Rabi* pulses recorded a 39 per cent hike over the base year (2014-15) which was mainly contributed by chickpea (53%) and lentil (55%). The total pulse productivity increase during the same period has been about 15 per cent over the base year (2014-15), comprising *rabi* and *kharif* increment at about 19 per cent and 15 per cent, respectively.

(iv) Oilseeds

The major oilseeds grown in India are groundnut, sunflower, sesame, soybean, niger, safflower, castor, linseed, and rapeseed- mustard. The area under oilseeds was only 10.73 million ha in 1950-51 with overall production of 5.16 million tons at a productivity of 481 kg/ha. The trend changed drastically from 2010-11 and production reached up to 32.48 million tons. After that trend remained almost constant till date i e., 32.50 million tons in 2017-18. But GoI has now planned to achieve a production of 45.64 million tons by 2022-23, expecting an additional production of about 15.58 million tons over and above the 32.50 million tons production. For expanding cultivation of oilseeds, newer areas need to be explored, for example, groundnut, hitherto not grown in Gujarat, is at present the number one crop in the state. For soybean, the yield levels are higher in Rajasthan, Maharashtra and Andhra Pradesh as compared to Madhya Pradesh.

Seed is a critical and basic input for attaining higher crop yields and sustained growth in crop production. Unfortunately, good quality seeds are out of reach of the majority of farmers, especially small and marginal farmers mainly because of exorbitant prices of better seeds. Along with public sector, role of private partners (seed industry) is not only to produce adequate quantity of quality seeds but also to achieve varietal diversity to suit various agroclimatic zones of the country. There is a need to make available to the Indian farmer, adequate quantities of superior quality seed at the appropriate time and place and at an affordable price so as to meet the country's food and nutritional security goals. Public investment in agriculture is on a declining trend from 2000 onwards. The contribution of private sector in agricultural investment is quite low. Other challenges facing crop production and productivity include meeting nation's food security (food demand of 350 million tons by 2030), shift in consumer preferences towards healthy foods (5-6 % CAGR of fruits/ vegetables and pulses), increased stress due to climate change (54 % of India faces high or extremely high water stress), food wastage across the value chain (fruits and vegetables up to 37% and cereals up to 25%), lack of rural infrastructure to support farm and non-farm activities, stagnant yields in many important crops, and lack of interest in agriculture among youth.

2.4.3 Opportunities

There are enormous opportunities for improvement in production and productivity of crops and thus, improving the lives of the people dependent on agriculture and allied activities. Exploiting the potential of hybrid technology offers a tremendous opportunity and need to be harnessed under PPP mode. Further, there is an urgent need for enhanced use of high yielding varieties/hybrids, crop diversification in different agro-ecological regions as per their suitability, speedy access to novel crop protection and biotechnology products; access to balanced fertilizers, micro-nutrients and other new technology products that can radically change the production potential, plant nutrition and improve soil health; and use of digital and satellite technologies to improve precision. For increasing rice productivity, the expansion of area under *boro* rice (winter) by increasing cropping intensity, especially in the states of Assam, Bihar, Jharkhand, Odisha, and West Bengal, should be a priority. Efforts are needed to introduce hybrid rice in areas where rice productivity is still below 3 t/ha. The private sector can play a major role, as the public sector has not been able to deliver expected output in hybrid

seed production. In wheat, there is a need to target low-productivity states/districts to bridge yield gaps and enhance productivity to meet future food requirements (Hooda Committee Report, 2010).

Single-cross hybrid maize technology provided higher productivity (7–8 t/ha) in USA. The area under hybrid maize, particularly single-cross and quality protein maize (QPM) hybrids, is low, currently around 60 per cent. Its production can be doubled, provided the hybrid maize area is increased. Possibility of exploitation of Bt hybrid maize released in other countries with yield high potential (up to 12 t/ha) needs to be explored for which the Government must take urgent steps to lift the ban on the use of GM food crops. All North-Eastern states have good potential for maize production. Area expansion in maize by almost 1 million ha in Eastern Uttar Pradesh, Bihar, Jharkhand and West Bengal in the last decade is a positive indication**.** Amongst all cereals, maize is currently having the highest productivity, which is higher than 4 per cent. The national average in pearl millet is 1.011 tons/ha. If its productivity in Rajasthan, Maharashtra, Karnataka, Andhra Pradesh, Telangana and Jammu & Kashmir are brought to the level of the national average, an additional 2 million tons of pearl millet production can be achieved. There is a need to develop high-yielding sorghum hybrids both for *kharif* and *rabi*; and downy mildew-resistant, drought/heat tolerant and short-duration hybrids in pearl millet. Large-scale adoption of high-yielding early maturing varieties; strengthening of PPP for hybrid research and quality seed production need careful attention.

In order to increase the production of pulses in the eastern states, these have been included under the Bringing Green Revolution in Eastern India (BGREI) Scheme also from 2015-16 onwards. For further increase, short-duration varieties need to be promoted in new areas, namely, chickpea in the South, urdbean (black gram) in rice fallows in the coastal regions of Andhra Pradesh, Odisha and West Bengal, pigeonpea in the North-West (Haryana, Gujarat, Maharashtra and Rajasthan), and mungbean (greengram) in the North (Western Uttar Pradesh, Haryana and Punjab). Pigeonpea is being grown in the North and West due to the release of hybrids and short-duration varieties but its cultivation can also be extended to other areas. Hybrid pigeonpea technology with greater yield benefits in Gujarat, Rajasthan and Haryana is another new option. Soybean cultivation in newer areas and effective coordination at national level would help accelerate soybean production. Also, crops like sesame, amaranths, finger millet, proso millet, foxtail millet, quinoa and moth bean need adequate attention. North-Eastern states are an important niche area for soybean but require suitable varieties and proper policy support. Another important policy-related issue is the use of GM soybean. Major soybean growing countries, such as the USA, Brazil and Argentina, have greatly benefitted from genetic gains from GM technology and its promotion in North-eastern India to diversify rice-wheat cropping systems is critical and urgently needed.

In the long term, there is a need for new yield and quality breakthroughs in major crops through genomics and gene pyramiding. Post-harvest technology, agro-processing and value addition to primary produce need to be given due attention. The emphasis should be on rainfed areas where introduction of catalytic technological and management interventions can make a striking impact. Mainstreaming nutritional considerations in the design of cropping and farming systems research is extremely important. There is a need to bring about a paradigm shift from the concept of food security at the aggregate level to that of nutritional security at the level of every child, woman and man. Articulating the public policies needed for achieving nutritional security, such as greater attention to pregnant women and infants (during the first 1,000 days in a child's life), financial support to nursing mothers for enabling them to feed the baby at least for the first 6 months, holistic approach to nutrition involving concurrent attention to balanced diets, clean drinking water, sanitation and primary health care is crucial. Drinking water security is an essential component of nutrition security. The School Mid-Day Meal program provides an opportunity for ensuring nutrition security to children. Dying wisdom and vanishing crops in relation to nutrition security should be protected. Steps should also be taken to prevent food losses both in terms of quantity and quality through safe storage and post-harvest handling.

2.4.3.1. Focused area approach

India's agriculture, which is currently growing at 2.9 per cent per annum, must grow faster based on improved productivity. Despite a four-fold increase in population, from 330 million to 1.35 billion, India has

produced 5.6 times more foodgrains, from almost 50.82 million tons in 1950-51 to the current level of 285.20 million tons in 2018-19 (www.agricoop.nic.in), but we need around 65-70 million tons more. This is almost 6-7 million tons per annum additional food grains to fulfil the future requirement (350 million tons) by 2030. This is indeed a major challenge but certainly achievable provided concerted efforts are made to expand both horizontally (area expansion) and vertically (productivity enhancement). Scope for both exists but would require a well-planned crop-wise, ecoregion-wise and demand-driven strategy supported by enabling policies, increased investments in R&D and infrastructure, and proper access to both knowledge and technological inputs. Once these are in place, India can produce additional 80-100 million tons of foodgrains to address the national food and nutritional security problem.

(i) Access to quality seeds and increasing seed replacement ratio

For sustainable agriculture, seed is the basic and most critical input. The response of all other input depends on quality of seeds to a large extent. It is estimated that the direct contribution of quality seed alone to the total production is about 20-25 per cent (http://seednet.gov.in) depending upon the crop and it can be further raised up to 45 per cent with efficient management of other inputs. Agriculture in India is backed by a strong seed improvement program involving both the public and private sectors. The Indian seed sector presently at about Rs 18,000 crore annually, is highly vibrant and is well recognized internationally. Future of agricultural production will largely depend upon development of improved varieties/ hybrids in various crops, supported by efficient, cost effective seed production technology and enabling environment for seed sector to grow. There is a need to bring in more players into the production of seeds, to improve their availability in the market and also reduce their prices.

Due to huge demand supply gap, India suffers from a dismal seed replacement ratio. It has been the effort of the Government and the private sector to improve the seed replacement ratio (SRR) in different crops and in different States. One of the important steps in this direction is that the old varieties and hybrids need to be denotified in a phased manner. The current SRR in different crops is given in Fig. 2.4.1. During 2010-2014, the average SRR was 52.80 per cent for rice, 23.14 per cent for wheat and 48.16 per cent for maize, respectively. The SRR plays a crucial role in increasing the yields in self pollinated crops where the farmer saves seed for use in the next year. The SRR has been going up steadily but it needs to be hastened up. Continuous education of farmers on the need to replace seed with new seed is the only way to improve SRR in self-pollinated crops. If these yield gaps between states have to be reduced, a few actions need to be taken: (i) large scale education of farmers in the states with lower yields and improving their capacity to absorb new technologies, (ii) timely supply of good quality inputs through a public/private partnership program, and (iii) providing institutional support to the farmers in the states with lower yields, in terms of access to credit, access to markets, scientific extension and similar matters.

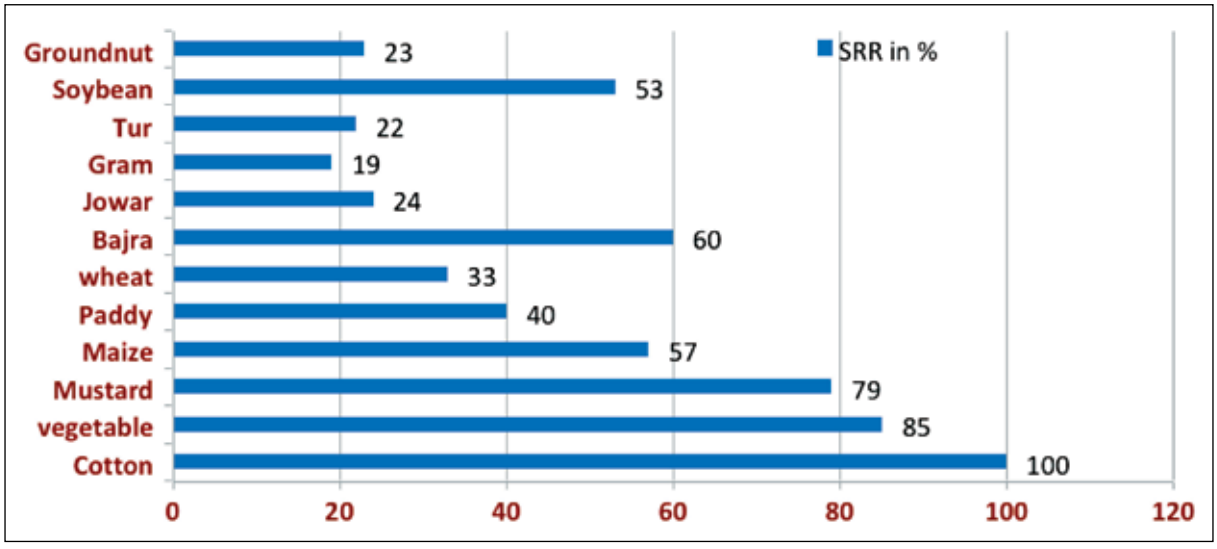

Fig. 2.4.1 Current SRR in different crops (%)

(Source: GoI, 2017-18)

Increase in SRR for high yielding varieties/hybrids in rice and maize will pave way for faster growth in production and productivity of these crops. Further, area needs to be expanded under maize, pearl millet, sunflower and castor for enhancing production. Higher SRR in HYVs of all pulses, groundnut and even wheat and barley is also urgently needed. Five year rolling/revolving plan for breeder, foundation and certified seed should be in place and it should have effective linkage with SRR activities. Also, there is need for farmers' participation in seed production and capacity development. Indenting for seed must be linked with lifting of seed by the indenters. The seed of improved varieties need to be replaced every 3-4 years. Demonstration of new varieties and hybrids in farmers' fields is very important and this may be effectively conducted and monitored by KVKs.

(ii) Expansion of proven varieties in newer/non-traditional areas

Past experiences have amply demonstrated that new area approach can lead to faster progress on account of quick adoption of technological packages. Increased wheat production is synonymous to increased food security. India can surpass China if we adopt an aggressive and well-planned strategy using both area expansion and productivity with greater emphasis on eastern and north-eastern region. In rice, main focus should be now on rainfed lowland in eastern region, viz., Uttar Pradesh, Bihar, Odisha, West Bengal and Assam. Fortunately, hybrid rice technology has demonstrated good potential in this region. There is a great need for area expansion of short-duration varieties of black gram in rice fallows, in coastal region of Andhra Pradesh, Odisha and West Bengal; green gram in north (Western Uttar Pradesh, Haryana and Punjab and Central India); pigeonpea in North West (Haryana, Gujarat and Rajasthan), central and Southern India and chickpea in central and peninsular regions; pigeonpea and lentils and peas in large areas in rice fallows in eastern India. This strategy adopted under NFSM for pulses during the last 2-3 years has yielded rich dividends and this year, an increase of 4.5 million tons of pulses could be possible due to a well-planned strategy which indicated the possibility of meeting annual shortage of around 4 million tons successfully. In groundnut, Odisha and Bihar offer new area option with higher productivity, which also needs to be explored. Expansion of area under rapeseed and mustard, in eastern states, viz., West Bengal, Assam and Bihar and North-Eastern states would help in higher production.

Hybrid technology could be exploited in the northern and western states. Support of one irrigation, preferably using sprinklers, higher dose of fertilizers and integrated pest management (IPM) approach would make all the difference, if Rajasthan, Haryana, Uttar Pradesh, Madhya Pradesh and West Bengal could be catalysed. Potential of sunflower has not been fully exploited so far in India. Improved early maturing hybrids of sunflower in northern states (Haryana, Punjab and Uttar Pradesh) can help in accelerating production growth rate. New niches for this promising crop could be Bihar, West Bengal, Assam and Odisha with higher productivity potential. Further, some neglected and underutilized crops having high production potential can help a great deal in increasing the diversification of food production, adding new species to our diets that can result in better supply of particular nutrients, i.e. essential amino acids, fibre, proteins. Crops like sesame, amaranths, finger millet, proso millet, foxtail millet, quinoa and mothbean need adequate attention. Areas like parts of Rajasthan, Gujarat, Karnataka and Andhra Pradesh with assured irrigation can do wonders, if some of the crops not popular in the region, may find place in the region.

Vast untapped yield potential exists in all crops in most of the states accounting for more than three-fourths of crop area. Emphasis is to be given to the states in which current yield levels are below the national average. Bihar, Odisha, Assam, West Bengal and Uttar Pradesh are the priority states accounting for 66 per cent of rice area which needs emphasis on bridging yield gaps to attain target demand and yield growth. For wheat, we need to focus mainly on Uttar Pradesh, Madhya Pradesh, Bihar and Rajasthan accounting for 68 per cent of wheat area. For coarse cereals, major emphasis must be given to Rajasthan, Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh and Uttar Pradesh. To meet the demand for pulses greater emphasis is needed in almost all the states with particular focus on Madhya Pradesh, Maharashtra, Rajasthan, Gujarat, Andhra Pradesh, Karnataka and Uttar Pradesh which have three-fourths of total pulse area. In cases of oilseeds greater emphasis is needed on Andhra Pradesh, Madhya Pradesh, Rajasthan, Maharashtra, Karnataka, West Bengal and Uttar Pradesh to increase the yield by about 4 per cent. The possibilities of developing processing industry for extracting edible oils from non-oilseeds commodities,

like rice bran etc., need to be explored. The introduction of palm cultivation for oil production may release pressure on traditional oilseed crops to meet future edible oil demand.

(iii) Exploitation of hybrid technology

While hybrids are high yielding, resistant to biotic and biotic stresses, unlike self-pollinated crops, they do not breed true and hence their seed is to be produced every year. As such, the farmers, have to purchase the seeds of hybrids every year from the open market. To feed the growing population and make farming a more sustainable and profitable business, hybrid seeds play significant role to increase crop yields in different weather and soil conditions. It has been observed that hybrid wheat has a significant yield advantage over self-pollinated varieties and its grain quality is also good. Against widespread belief, hybrid wheat technology does not require higher inputs and the technology is not biased towards larger farms. Large cultivation of hybrid maize is now being witnessed in the country and needs to be promoted so as to be comparable to the success story of hybrid cotton in the last decade. Hybrid cultivars in cereals (maize, sorghum, and rice), and oilseeds (sunflower) have revolutionized their productivity worldwide. Hybrid pigeonpea also has the advantages over varieties. There is a need to give a thrust to develop hybrid seeds in other crops also to increase the crop production significantly.

Both public and private sector institutions have been working on developing hybrid rice for almost 3 decades but the yield levels are much lower as compared to China. There is no strong support to promote hybrid rice by incentivizing the seed cost in a structured manner and better MSP for hybrids from the policy makers. There is a weak linkage between hybrid rice research, seed production and extension. Marginal heterotic gain of hybrids over varieties, ranging from 5 per cent to 20 per cent, just meets the requirements of the farmers. There is also a concern regarding acceptable grain quality of hybrid crops. It has been reported that every percentage point of genetic impurity in F_1 seeds could reduce hybrid rice yields by about 100 kg. The high price of F_1 seeds is the major obstacle to the adoption of hybrid rice by farmers, especially the poor smallholders.

The GoI has not fixed any target for increasing acreage of hybrid rice in the country unlike Philippines. However, efforts are being made to promote cultivation of hybrid rice through various crop development programs such as NFSM, BGREI and RKVY. From the initial level of 10,000 ha in 1995, area under hybrid rice reached one million ha in 2006, and exceeded 3+ million ha during 2016-17 which is about 6 per cent of of India's 44 million ha under the rice cultivation. Hybrid rice is getting popular in Uttar Pradesh, Bihar, Jharkhand, Madhya, Pradesh and Chhattisgarh. In case area is doubled to 6+ million ha, it will be around 14 per cent area covered under cropped rice area. In contrast, hybrid rice in China accounts for more than 50 per cent area under rice cultivation, yielding up to 30 per cent more than other cultivated varieties (Ma and Yuan, 2015). India also needs to take up similar approach. The Government of India is already focusing on hybrid cultivation in the eastern states and needs to extend this practice to the rest of the country. Currently, hybrid cultivation is limited to the eastern parts of India due to the nature of the grain, not preferred in many parts of the country. To expand the market, companies need to invest in research to develop hybrids suitable for western and southern India. Some of the 'must have' factors for entering and expanding India's presence in hybrid rice are high yield advantage over varieties, good genetic purity, suitability for a wider geographical area and resistance to biotic and abiotic stresses.

The following measures are suggested for increasing production: (i) GoI to undertake extension programs to popularize hybrid rice technology at every block level; (ii) make efforts to raise the yields of hybrids to more than 20 per cent over self-pollinated varieties; (iii) develop and provide good grain quality hybrids equivalent to the self-pollinated varieties; (iv) strengthen collaboration between public research, seed production and extension institutions and private seed production companies in the country; (v) involve well-organized farmers' associations and agriculturally oriented non-governmental organizations to effectively contribute; (vi) employ adequately skilled human resource specializing in hybrid rice breeding as well as F_1 seed production; and (vii) promote farmers participation in extension delivery services for the success of the hybrid rice program. It is expected that better hybrids of rice will be evolved to give at least 3-4 tons yield/ha advantage over the improved varieties with enhanced ability to fight drought and diseases. This will result in expansion of area under hybrid rice cultivation to the extent of over 20-25 per cent of rice cultivated area in India.

(iv) Developing disease/insect resistant and climate resilient crop varieties

The development and identification of disease resistant and climate resilient crop varieties, with enhanced tolerance to fungal/insect attack, heat, drought, flooding, chilling and salinity stresses are essential in order to sustain and improve crop yields to cope with the challenges of biotic/abiotic stresses. It is essential to bridge the yield gaps, enhance the productivity and profitability, minimize risk and improve the livelihoods of millions of people dependent on agriculture. Abiotic stresses such as drought, heat or cold may trigger a series of responses in plants that include changes in gene expression, signal transduction pathways, metabolic and molecular mechanisms as well as cumulative manifestations of these in terms of source and sink relations for adaptation. Ensuring seed availability of the resilient varieties in various crops at the appropriate time to the farmers is an important challenge to be addressed immediately. The ICAR/SAUs and private sector need to develop disease and climate resilient crop varieties suitable for different agroclimatic zones of the country, through farmer participatory plant breeding. There is need to apply cutting edge technologies like genomics, proteomics, metabolomics, phenomics for bringing precision and hasten genetic improvement for production of quality seed material. Breeding should target traits like nutrient use efficiency, biotic (disease and insect-pests) and abiotic (drought, heat, flood, salinity, alkalinity) stress resistance etc. Other specific areas include development of varieties for cultivation in non-traditional areas. Collection, conservation and utilization of genetic resources (especially wild relatives of crops) should continue to receive priority. Also budgetary allocation needs to be increased at least three-fold for short and long-term impact in this sector.

(v) Promoting use of biotechnology

Undoubtedly, biotechnology has a great potential in improving efficiency and profitability of agriculture through available techniques for production of disease free and high quality of planting material, hybrid seed production, rapid and accurate diagnosis of diseases, rapid breeding of new varieties, and incorporation of useful qualities in crops that cannot be done through conventional breeding. Molecular breeding has led to the development of several crop varieties with enhanced yield, improved nutritional quality, and resistance to biotic and abiotic stresses thus proving to be very valuable in complementing conventional breeding methods. While genetically modified crops are being increasingly adopted at the global level, those that confer resistance to pests and diseases, have ability to grow under stressed environmental conditions and have high nutritional qualities are of special significance to India. A meta-analysis of several studies on performance of GM crops (Klumper and Qaim, 2014) showed that adoption of GM technology has resulted in increased crop yields by 22 per cent, reduction in pesticide use by 39 per cent and increased farm profits by 68 per cent. New breeding techniques (NBTs) that unlike GMOs do not involve alteration of plant DNA in ways that do not occur naturally are being developed to address some concerns in some sections about the safety of GM technology. In this line of new techniques, special mention needs to be made of the new gene editing technology, CRISPR/Cas-9 which is being used increasingly on account of its precision and convenience, This simple, affordable, and elegant genetic scalpel is gaining more attention and is expected to be widely applied to enhance the production and productivity of most of the crops in the near future. This technique provides alternative approaches for delivering target genes into crops with no transgenic footprint.

With current regulatory system in the country, the interests of people cannot be protected. The GM food imports require approvals under two laws: i) Environment Protection Act of 1986 and ii) Food Safety and Standards Act of 2006 where the regulations of GM food products are yet to be developed. While the former covers environmental impacts of the food products, the latter concerns with the impact of food on human health. The advancing scientific knowledge about the environmental and food safety of GM crops and the safety implications of new breeding technique require adequate adjustments in the Indian biosafety approval system. Modified genes that have been found to be safe to environment and human health need not be tested over and over again for biosafety approval of a crop. Though the Ministry of Environment and Forest & Climate Change permitted to import GM soybean, corn and canola from 2007 with clearance from the Food Safety and Standards Authority, Bt brinjal despite having been found safe for cultivation and consumption by the biosafety regulatory authority is facing restrictions for several years. Similar restriction is faced by GM mustard.

To harness the benefits of GM crops, it is necessary that a clear policy on GM food crops is in place at the earliest. Also, concerted efforts are needed for creating public awareness about the use of GM crops and creating a trust in the regulatory system in the minds of public. The Biotechnology Regulatory Authority of India (BRAI) Bill also needs to be approved by the Parliament on priority. Government has to ensure that Genetic Engineering Approval Committee (GEAC) takes science based decisions and makes a time bound, predictable and enabling regulatory process effective. Use of Bt brinjal, GM mustard and other GM crops such as soybean, corn and canola must be allowed for the benefit of the farmers.

2.4.5 Recommendations

1. Concerted efforts need to be made to collect, characterize, evaluate and conserve diverse wild relatives and landraces of cultivated crops. In particular, efforts must go into advanced high throughput phenotyping and genotyping techniques. Also, there is need for effective use of germplasm conserved in the National Genebank. Only a fraction of this genetic diversity has been characterized and is being used. There is an urgent need to take-up its characterization and valuation to identify trait-specific germplasm for exploitation in the breeding program for developing varieties resistant to biotic (insect-pests, pathogens) and abiotic (drought, flood, heat, salinity, alkalinity) stresses, high adaptability to different agroecologies and better nutritional quality and other specific purposes. Efforts on germplsm enhancement/pre-breeding need to be intensified. For this, an effective and strong collaboration with crop based institutes needs to be established and enough resources (human and financial) need to be made available. National Agrobiodiversity Fund needs to be established in order to intensify efforts on collecting and acquisition, characterization, evaluation and conservation (both *in situ* and *ex situ*) for enhanced use of diversity of cultivated crops including diverse wild relatives and landraces. This will greatly help in making available the useful trait-specific germplasm to the plant breeders for use in breeding programs aimed at developing better varieties of different crops for specific purposes and well suited to different agro-ecologies.
2. Future of agricultural production will largely depend upon development of improved varieties/ hybrids in various crops, supported by efficient, cost- effective seed production technology. Greater thrust needs to be given to the development of high yielding, nutritive, biotic and abiotic resistant and widely adapted varieties of different crops for the 128 agroclimatic zones of the country, through farmer participatory plant breeding with support of ICAR/SAUs and private sector. Ensuring quality seed availability of improved varieties of various crops at appropriate time and at low cost to the farmers is an important challenge to be addressed urgently. This will be immensely useful in maximization of foodgrain production in the country. There is a need to bring in more players into the production of quality seeds, improve their availability in the market and also reduce their prices. Greater focus needs to be given toward developing better varieties of *rabi* sorghum and expanding their area under cultivation.
3. There exist significant yield gaps between different regions/districts/states in different crops which needs to be bridged to enhance production to meet future food requirements. In this context, hybrid technology needs to be exploited under public-private partnership mode. Efforts need to be intensified in a mission mode to develop high yielding and nutritive hybrids in rice, maize, pearl millet, sorghum and pigeonpea. In India, cultivation of hybrid rice needs to be expanded in over 20-25 per cent of rice cultivated area. Urgent attention is needed for promoting the rice hybrids through incentives on the seed cost, better MSP for hybrids, and strong linkage between hybrid rice research, seed production and extension agencies. There is also a great need to give thrust on developing single cross and QPM hybrids, suited to different agroclimatic zones. Also, the area under hybrid maize, particularly single-cross and QPM hybrids, is currently low (around 60 per cent) which needs to be increased so that production of maize hybrids can be doubled.
4. A national policy on agricultural biotechnology must be formulated highlighting its role in achieving crop improvement goals. Crops suffer from biotic and abiotic stresses resulting in low yields and thus losses to the farmers. Use of genomics, molecular breeding and other precision breeding tools need to be enhanced and made integral component of breeding programs. GM technology will be especially useful in developing insect and pest resistant varieties which will increase crop productivity and profitability of

farmers. New breeding techniques (NBTs), including CRISPR/Cas-9 gene editing technology, needs to be treated as non-GM crop improvement technology with no transgenic footprint, and be promoted for addressing specific improvement problems in major crops. Thus plants bred with NBTs would not face any regulatory hurdles.

5. For increasing farmers' adoption of new and improved crops and income therefrom, enabling policy environment for regulation of GM crops must be in place. Government should make its GM strategy clear and have clarity on priority crops and traits where GM crops have comparative advantage. Provision of IP protection for GM traits needs to be made so as to protect the interest of innovators and ensure benefit sharing. The Central Govt. has to create a common understanding and process among all states and other stakeholders on the priority areas where GM technology will be used in the country. These actions are essential for long term growth of the industry and for improving the profitability of the farmers on sustainable basis. Also, concerted efforts are needed for creating public awareness about the use of GM crops and creating a trust in the regulatory system in the minds of public. The Biotechnology Regulatory Authority of India (BRAI) Bill also needs to be approved by the Parliament on priority. Government should empower GEAC to take science based decisions and make a time bound, predictable and enabling regulatory process and allow the use of Bt brinjal, GM mustard and other GM crops such as soybean, maize and canola for the benefit of Indian farmers. Regulations should be dynamic taking into account the results of previous studies as also global developments in biosafety regulation. Also, intellectual property regime should encourage pursuit of excellence and innovation.

6. Crop diversification through the use of potential non-conventional crops may be enhanced in different parts of the country There are a number of underutilized pseudocereals (grain amaranth, buckwheat, quinoa), legumes (rice bean, faba bean, adjuki bean, winged bean, moth bean), and small millets (finger millet, foxtail millet, proso millet, little millet, barnyard millet, kodo millet) which have tremendous potential. These are hardy crops having resistance to biotic and abiotic stresses, high nutritional value and wider adaptability. However, relatively little attention has been given on research and development of these minor but potential crops of nutritional significance. There is an urgent need to give greater thrust on developing high yielding and nutritive varieties of these crops suited to diverse agro-climatic niches. Also, these could be exploited for transferring useful genes into related species for enhancing their production, nutritional value and adaptation.

7. There is urgent need for area expansion of short-duration varieties of chickpea in non-traditional areas of Andhra Pradesh, Bihar and Karnataka; inter- mixed cropping of black gram, green gram, pigeonpea and chickpea in central and peninsular regions; introduction of short-duration pigeonpea with groundnut in Gujarat, Maharashtra, Andhra Pradesh, Telangana and Tamil Nadu; and lentils and peas in large areas in rice fallows in Uttar Pradesh, Bihar, West Bengal and Odisha.

8. Greater thrust is needed to develop innovative strategies to combat the problem of malnutrition and ensure nutritional security. Biofortification of staple crops is an urgent necessity in view of the widely prevailing nutritional deficiency among the people. Breeding for protein and micronutrient rich varieties needs to be given greater attention. QPM varieties having twice the level of essential amino acids (lysine and tryptophan) compared to conventional maize varieties need to be promoted. Development of biofortified rice - high in iron and zinc needs to given a greater thrust to combat hidden hunger. The genetically modified rice variety developed in Australia has nearly 3 times more iron (3-5 ppm vs 15 ppm) and zinc (16-18 ppm vs 45 ppm) and does not suffer from yield penalty, corresponding to existing varieties and efforts need to be made to develop such varieties in India. Varieties of pearl millet enriched with iron, and wheat enriched with zinc will be very useful in addressing the problem of malnutrition and must be given focused attention. Use of anthocyanin rich black wheat varieties needs to be promoted in view of its richness in antioxidants which are very important in preventing several diseases. In order to harness benefits of biofortification, there is urgent need for elimination of policy bias, creating public awareness about their nutritional benefits, making provision of high premium, and inclusion of biofortified crop varieties under PDS under the Food Security Act.

2.5 Horticulture Sector

Horticulture sector is recognised to have the potential to raise the farm income, provide livelihood security and earn foreign exchange. However, focused policy interventions are needed to realise the potential of the sector. At present, in India, horticulture is contributing 30.4 per cent of GDP from 13.08 per cent cropped area. India has witnessed increase in horticulture production over the last few years. Significant progress has been made in area expansion resulting in higher production. Over the last decade, the area under horticulture grew by 2.6 per cent per annum and annual production increased by 4.8 per cent. During 2018-19, it rose up to 3.26 per cent at 25.87 million ha from 25.43 million ha. During 2017-18, horticulture production stood at record 311.7 million tons, which is 3.7 per cent higher than 2016-17 and 10 per cent higher than the past five years' average production. The production of fruits was 97.35 million tons, while that of vegetables at about 187.5 million tons during 2018-19. Onion production in 2018-19 was 23.62 million tons as against 23.26 million tons in 2017-18, while potato output was 52.58 million tons compared to 51.31 million tons in 2017-18. Tomato production is increased to 2 per cent to 20.51 million tons as against 19.76 million tons in 2017-18. Total horticultural crops production in the current year (2018-19) is 314.67 million tons (1% increase over previous year) grown in 25.87 million ha area (http://agricoop.nic.in) indicating a structural change in Indian agriculture. India witnessed the shift in area from food grain towards horticulture crops from 2012-13 to 2018-19. This is the seventh straight year of horticulture production surpassing that of foodgrains (285.2 million tons) in 2018-19 (http://pib.nic.in), which is almost 12-fold increase in production from 25 million tons in 1950-51.

The required increase in the net amount of food must occur in the face of several constraints, such as less land, less water and other resources and the unpredictable outcomes of climate change. India's varied agro-climatic zones coupled with enormous diversity of plant genetic resources and cuisines are very favourable for production of a large variety of horticultural crops. Over the years, horticulture has emerged as one of the most potential agriculture sector in accelerating the growth of Indian economy. Its role towards nutritional security, poverty alleviation and employment generation is becoming increasingly important. It offers a wide range of options for crop diversification and also provides huge scope for developing a large number of agro-based industries (secondary agriculture) which generate employment and increase profitability for farmers, agri-preneurs, women and youth. Currently, more than 350 million people continue to suffer from malnutrition, which is a cause of various types of diseases and premature deaths of children and women. Therefore, the country can only be food-secure if the citizens have economic access to nutritious food to meet their physical needs. In this context, horticultural crops have emerged as the best options, not only to provide required nutrients but also to enhance access to food through enhanced farm profitability. Changing food patterns (from predominantly cereal based diets to a richer mix of vegetables, fruits, eggs and meat) due to increased incomes and greater nutritional awareness, are steadily increasing the importance of horticultural production and trade. The sector has enormous potential to address Goal 2 of the Sustainable Development agenda, which seeks to end hunger and all forms of malnutrition, and to double agricultural productivity by 2030. Horticulture provides a wider choice for farmers and also complements the food sector, i.e. with potato, tuber crops, banana and vegetables. A new paradigm shift in farming in the recent past has been towards horticulture-based farming systems to ensure greening, environmental services and to provide nutritious food while enhancing farm profitability (GoI, 2011).

Initially, the Green Revolution addressed immediate food security issues, with particular focus on wheat and rice. However, from the late 1970s, horticulture was identified by the GoI as a promising sector for agricultural diversification to enhance profitability. This led to a structural change in Indian agriculture (Fig. 2.5.1 and 2.5.2). In 1984, GoI established the National Horticulture Board (NHB), which initiated various innovative programs/schemes to promote large-scale adoption of modern package of practices and processing/value addition in horticultural cops. With significant increase in budget allocation many developmental activities like micro-irrigation, schemes on fruits, vegetables, flowers etc., were taken up. In 1998, a Technology Mission on Integrated Development of Horticulture for North-East region (TMNE), including Sikkim, was launched. Later, it was renamed as Horticulture Mission for North East and other Himalayan States (HMNEH) with focus on end-to-end approach (from production to consumption). In 2005, the National Horticulture Mission (NHM) was launched with thrust on area-based, regionally

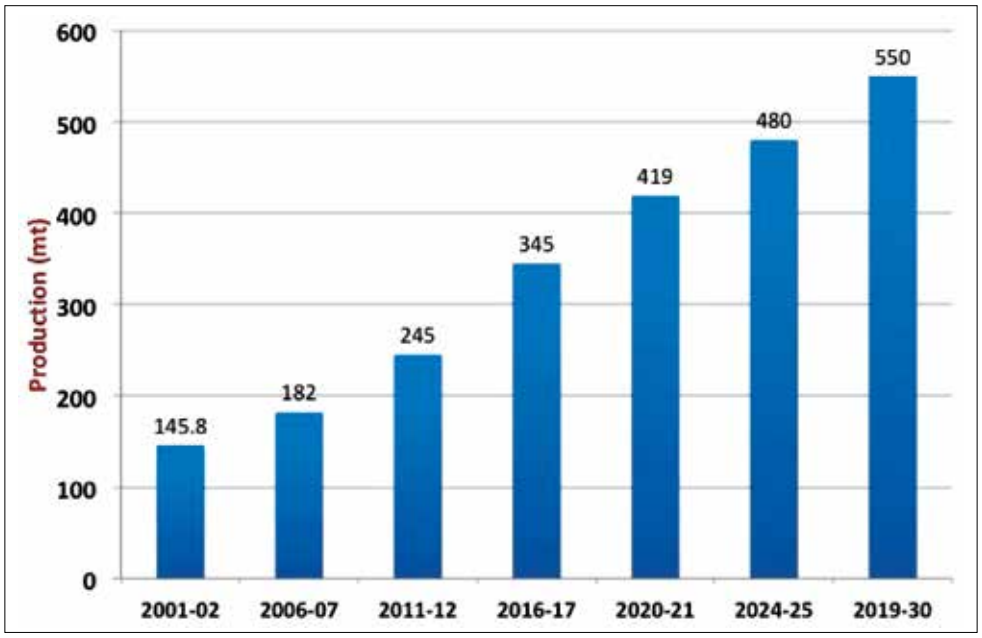

Fig. 2.5.1 Annual production during plan period and future projections (million tons)

(Source: GoI, 2011)

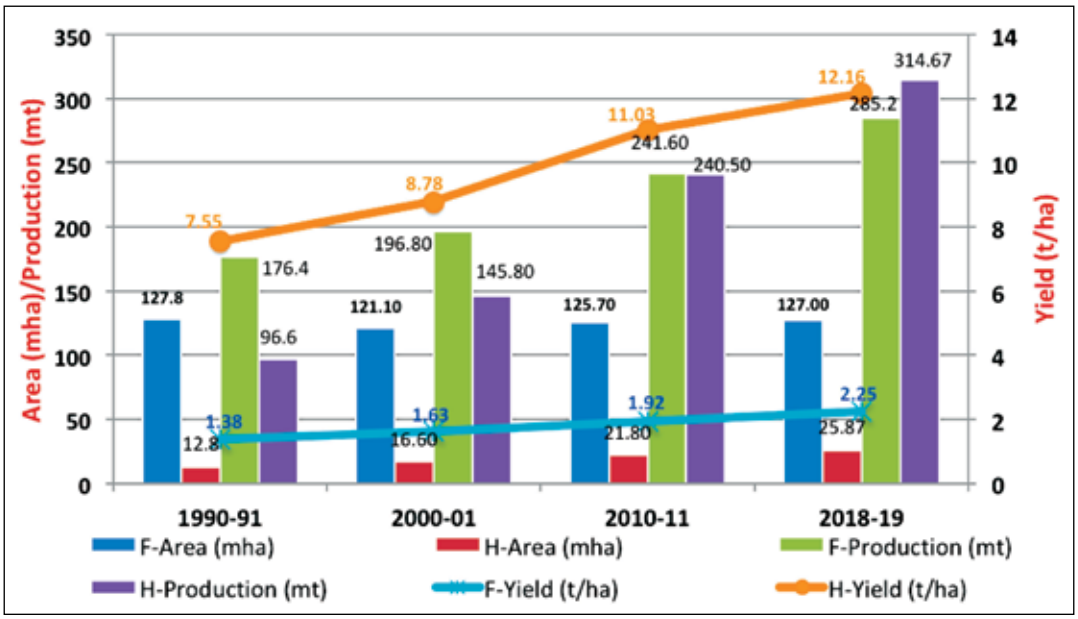

Fig. 2.5.2 Comparison of area, production and yield of field and horticulture crops in India in the last three decades

(Source: DAC&FW Annual Report 2018-19; GoI Website: www.agricoop.nic.in)

differentiated cluster approach for development of horticulture crops. These initiatives led to the "Golden Revolution" in horticultural production, providing opportunity for enhancing farm income, employment (especially for youth and women), schemes which contributed immensely to market information service and technology awareness, soft loans and credit linked back-end subsidy for commercial production, post-harvest management, processing and cold storages.Major factors contributing to the horticulture sector's progress include expansion of area, crops diversification, and technological interventions for production and post-harvest management. Thus, convergence between policy changes, horticulture missions, research institutions, and entrepreneurship have resulted in a significant increase in horticulture sectors' contribution to Indian agriculture.

Since 2014-15, MoA&FW is operating an overarching centrally sponsored scheme 'Mission for Integrated Development of Horticulture (MIDH), subsuming ongoing missions/schemes. The main objectives

of MIDH are to promote holistic growth of horticulture sector, through regionally differentiated strategies which include research, technology promotion, extension, post-harvest management, processing and marketing in consonance with comparative advantage of each state/region and its diverse agri-climatic features (Box 2).

It also encourages aggregation of farmers into farmers groups (FIGs, FPOs and FPCs) to bring economy of scale and scope, enhance horticulture production, augment farmer's income, strengthen nutritional security, improve productivity by way of quality germplasm, planting material and water use efficiency through micro-irrigation, support skill development and create employment generation opportunities for rural youth in horticulture and post-harvest management, especially in the cold chain sector. Capacity building of farmers and technicians is also supported for adopting improved technologies through existing institutions of ICAR, SAUs, State Horticultural Universities (SHUs), KVKs and Institutes with Department of Horticulture in States. Several technological innovations are available for use by farmers such as improved technology for orchard establishment, availability of true-to-type planting material, plant architecture engineering and management, mulching, fruit thinning, integrated nutrient management (INM), water management, integrated pest management (IPM) and disease management, post-harvest technology, and value addition, processing and marketing, etc.

2.5.1. Current Status

Globally, India is the second largest producer of fruits and vegetables (after China) and is the largest producer of mango, banana, coconut, cashew, papaya, pomegranate, peas, ginger, okra, etc. It is also the largest producer and exporter of spices (http://nhb.gov.in). Other major crops exported are mango, grapes, orange, apple, banana, sweet lime, onion, potato, tomato and pumpkins. Over the last decade, area under horticulture has grown by about 3 per cent per annum and annual production increased by 5.8 per cent, due to both area and productivity-led growth. The increase has been more significant in fruits and vegetables, accounting for 78.4 per cent of area and over 92 per cent of total production. The biggest buyers of Indian horticulture products are Bangladesh, Nepal, UAE, UK and Malaysia. The current production of fruits (97.35 million tons) and vegetables (187.5 million tons) not only meets the ICMR EAC 2008 recommended dietary allowance for the country with respect to fruits and vegetables (400 g/person/day) but also the current production is near achievement of projected demand of fruits and vegetables by ICAR in its vision 2030 (110 million tons of fruits and 180 million tons of vegetables) much in advance. Horticulture also provides about 37 per cent of the total exports of agricultural commodities (http://nhb.gov.in).

Box 2. Major interventions and activities supported under MIDH

- Setting up of nurseries and tissue culture units for production of quality seed and planting material
- Area expansion (establishment of new orchards and gardens for fruits, vegetables, and flowers)
- Rejuvenation of unproductive, old, and senile orchards
- Protected cultivation, i.e. polyhouse, greenhouse, etc., to improve the productivity and grow off-season high value vegetables and flowers to ensure availability and increased income.
- Organic farming and certification
- Creation of water resource structures and watershed management
- Bee-keeping for pollination
- Horticulture mechanization
- Creation of post-harvest management and marketing infrastructure

Further, efforts have been made to develop HYVs and hybrids of different horticultural crops for different regions. Many improved varieties have revolutionized the horticultural sector, such as regular-bearing mango hybrids, export-quality grapes, multiple disease-resistant vegetable hybrids, high-value spices and tuber crops for industrial use. High-yielding *Gauri Sankar* and *Sree Bhadra* sweet potatoes have focused on minimizing malnutrition and improving nutritional security. Similarly, breeding to develop grape cultivars suitable for vine making, and development of processing tomatoes etc. are some of the research programs being carried out. Hybrid technology has revolutionized the production of vegetable crops and demand for hybrid seeds is continually increasing. Hybrids of tomato, chilli, cucumber and muskmelon are being produced at several locations in different states in the country. Currently, the area under high-yielding F1 hybrids in important vegetable crops ranges from 17.8 per cent to 31.5 per cent, particularly in tomato (31.5 %), cabbage (31.39 %) and brinjal (17.8 %), and areas under capsicum and chilli are also under expansion. Use of meristem culture and micro-grafting is successful in citrus for elimination of viruses. Nutritionally improved transgenic potatoes have also been obtained by transferring the amaranth seed albumin gene (AmA1) from *Amaranthus hypochondriacus* into potato. RNAi biotechnology has succeeded in developing potato that does not sweeten at lower temperatures, and the RB gene transferred in two potato cultivars has given appreciable protection against late blight disease.

2.5.2 Challenges

As per a field survey, major problems faced by horticulture farmers in India are finance (31 %), marketing (30.5%), labour (18%), storage (15%), and others (5.5%) (DFI, 2018). Further, increased production has to be achieved with declining land and water. The challenges ahead are to have sustainability and competitiveness, to achieve the targeted production to meet the growing demands, in an environment of declining land, water and threat of climate change.

The Indian horticulture sector is characterized by small, segregated farms with low productivity and limited irrigation facilities. Low productivity is primarily due to inadequate availability of certified quality seed/disease-free planting material and slow adoption of improved high yielding cultivars/ hybrids. Merely producing fruits, vegetables and flowers is not sufficient. There is obvious need for higher investment (adequate capital flow), good market support, proper planning and inclusive development for 'plough to plate'. Moreover, increase in production does not always translate in increased profits; contamination of fruits and vegetables (e.g. pesticides, heavy metals) are also the issues to be addressed. Complementing the sector with food processing, cold-chain agro-logistics, agri-business, input related services, agricultural lending, insurance and value chain related services, remain a challenge. It is equally essential to ensure the development of trained and skilled manpower and availability of quality seed (including hybrids) and planting material suitable to the local agroclimatic conditions. Human resource development needs to be given thrust for capacity building of farmers, horticulture entrepreneurs/supervisors and field functionaries. Given the pre-dominance of small and marginal farmers in Indian horticulture, affordability becomes a significant constraint on technology adoption by farmers. The potential in India's horticulture is also stunted by lack of awareness among farmers for best horticulture practices to increase productivity and quality, as well as post-harvest management and primary food processing for value addition, due to poor linkage between R&D sectors, industries and farming communities. Another reason for not reaching full potential is because of the absence of a horticultural crop suitability map of India based on agroclimatic conditions depicting most suitable areas for optimum productivity of a particular crop.

Heavy post-harvest and handling losses also result in low productivity per unit area and high cost of production. About 30-40 per cent of total horticultural production gets wasted before consumption. India stores only 10 per cent of its horticulture products in temperature-controlled conditions, while China stores 15 per cent and Europe and North America store 85 per cent. During the peak production period, the gap (25 million tons) between the demand and supply of cold storage capacity is mind-boggling. From farm gate to a consumer, a horticulture product passes through seven different intermediaries, and at every step, there is a loss of 5-7 per cent. In addition, there are significant losses during processing. It is estimated that nearly one tenth of all horticulture produce rots in the absence of a countrywide cold-chain network. The biggest wastage happens during the transportation of horticulture products from the farm gate to *mandis* and thereafter.

Emphasis need to go for rural-based low-cost primary processing and value addition for better storage and good pricing, and also to avoid distress sale.

There is lack of structured secondary and tertiary industries related to processing of horticulture products in the vicinity of production areas. Industries involved in the processing of fruits and vegetables into products like pickles, jams, jellies, squash, etc. are in the unorganized or small/medium enterprises sector. Factors such as the lack of a traceability mechanism from the farm to the consumer, fragmented holdings and restrictions on direct procurement of products from farmers in some states makes it virtually impossible to ensure that products meet export quality standards. Corporate sector presence is meagre. Small farmers often complain about limited support from local government. There exist several bottlenecks hampering on-farm adoption of technology developed in public sector.

Horticulture crops are input-intensive, and farmers need hybrid seeds/planting material, pesticides (or organic inputs), micro-irrigation and some degree of mechanization and right quality inputs at the right time. Due to lack of one or more of these, farmers fail to get desirable productivity. The traditional retail channels have largely failed to meet farmers' emerging needs for high-quality inputs for horticulture. The input channels, therefore, need disruption and business model re-engineering to meet farmers' needs.

Problem in marketing and distress sale is another area of concern. Under the APMC, States do not allow free sale of produce. Price volatility due to poor market intelligence to small and marginal farmers, is a major risk factor in horticulture. Retail prices of common perishable commodities like onions, tomatoes and potatoes plunged below growing costs (farm harvest prices, FHP) several times in the past few years. Due to lack of any support price mechanism (like MSP), farmers have been forced to take extreme measures like dumping their harvest for want of buyers, leading to agrarian distress. In general, the current marketing system of horticultural produce in the country lacks a system approach, as retail and wholesale prices of perishables are at a large variance from each other, implying fragmented markets. There are about five to seven intermediaries between the farmer and the consumer in the horticultural trade. Fruit and vegetable growers receive only a small part of price paid by the consumers as lion's share is being taken by chain of intermediaries. Further, increase in horticulture production has put the infrastructure of existing market yards (farmers' markets/village haats, assembly markets, terminal markets and regulated markets like e-NAM) under severe stress. The majority of market yards are constrained for space, cold storage, and grading and sorting infrastructure. There is a dire need for the decentralization and modernization of market yards. Although India is one of the largest and lowest cost producers of high value horticulture commodities and yet has a minuscule share in global trade. The supply constraints, yield gaps and higher logistic costs are the areas where majority of problems persist.

2.5.3 Opportunities

India's long growing-season, diverse soil and climatic conditions comprising several agro-ecological regions provide ample opportunity to grow a variety of horticulture crops. Thus, efforts are needed in the direction to capitalize on our strengths and remove constraints to meet the goal of moving towards a formidable horticultural growth in India. Horticulture has been identified as a prime mover in increasing farmers' income. The report of committee on Doubling Farmers Income (DFI, 2018), estimates that by the year 2022-23, a production level of 451 million tons has to be achieved, which can be obtained through 2.8 per cent increase in area and 3.1 per cent in productivity. Between 2000 to 2016, horticulture growth rates of 5.8 per cent occurred owing to technological back-up, investment and policy environment. Past trend shows that target of production of 316.41 million tons envisaged for 2020-21 is easily achievable, as production of 314.67 million tons has already been achieved in 2018-19. There is a need to encourage diversification to high value crops (HVC) at the rate of 5 per cent every year. However, production targets translating into increased income for farmers, is an issue, which is yet to be addressed and resolved. This would require promoting innovation in technologies through institutional support as well as sharing of knowledge and technological backing for development through skill enhancement.

Productivity can be significantly boosted by greater adoption of hybrid and improved seeds/planting materials with high nutritional quality, enhanced productivity, resistance to pests and diseases and tolerance

to abiotic stresses, targeted seed replacement requirement (based on historical trends), introduction of new varieties and replacement of poor yielding varieties.To meet the demand, a 35 per cent increase in production of vegetables has been estimated for India over the next five years; given the constraints on increasing the area under cultivation, the growth would come through productivity augmentation, of which a major part has to be driven by greater adoption of hybrid seeds (https://m.economictimes.com). Shifting to hybrids has the potential to increase yields by 1.5 to 3 times and provide a significant increase in income. Similarly, rootstock technology, especially for fruit crops, has shown the capacity to double production and be resilient to climate stress in certain crops. Grafted vegetables combat diseases very effectively. Soil borne diseases such as bacterial wilt cause serious damage especially to tomato, chilli and brinjal. Grafting of scions of high yielding commercial F_1 hybrids/varieties onto resistant rootstocks increases crop yields by 10 per cent and net income by 35 per cent as compared with growing non-grafted tomato crops. Dynamic seed development plans based on crop-wise area, seed rate per hectare, desired/targeted SRR and crop-wise quality seed/planting material requirement would increase productivity and efficiency. States should aim to increase the SRR to 33 per cent for self-pollinated crops and 50 per cent for cross-pollinated crops in alternate years. Also, there is need to phase out old varieties and replace them with hybrid and improved seeds/disease free planting materials to enhance productivity. Model accredited nurseries for quality seed and planting material need to be established/strengthened on priority. A robust 'Seed Rolling Plan' comprising a network of efficient seed producers, across both public and private sectors is also required, along with upgraded seed testing to provide quality seeds in right quantity and at right time.

In order to enhance horticultural production, there is need to promote PPP, in areas like quality planting material and hybrid seed production. Farmers need to be able to access both public-bred and private seed company generated seeds. Increasing financial support to strengthen infrastructure for nucleus and breeder seed production program at ICAR institutes/SAUs would greatly enhance seed production, through agencies like National Seed Corporation (NSC).

Modernization of horticultural operations with enhanced investment has the potential to boost the Indian horticulture sector significantly. An integrated holistic approach to increase productivity of horticultural crops by adoption of growth enhancing technologies, pest management systems and precise farming practices would lead to 'Smart Horticulture'. Although many new technologies of seeds and planting material, drip irrigation and fertigation, greenhouse etc. have been adopted, these are sparse and the success stories need to be replicated on larger scale. Examples include banana in Maharashtra and Tamil Nadu, guava and tomato in Chhattisgarh, pomegranate and mango in Gujarat, pineapple in Nagaland, kiwi in Arunachal Pradesh and orchids in Sikkim, off season vegetables in Uttarakhand, etc. Operational approaches like sourcing of material from healthy nurseries, high/ultra density planting for fruit crops, vegetable grafts in soil-less medium, development of traceability mechanism of fruit crops for export, expansion and automation in micro-irrigation, urban and peri-urban horticulture, precision horticulture, vertical farming, soil-less horticulture has great potential to contribute significantly for economic development.

A major opportunity lies in promotion of protected cultivation, as it not only gives better dividends, but also brings pride to the profession and can attract youth including women as well. At present, only ~50,000 ha are under protected cultivation in India, whereas China has 2 million ha. There is need to increase 4 times the area (~2,00,000 ha) under protected cultivation in the next 4-5 years. Production under protected conditions not only provides high water and nutrient use efficiency but it can easily increase the productivity by 3-5 folds over open field cultivation. Of course protected cultivation technology requires very careful planning, maintenance and management. Use of plastic mulch (25 per cent more yield than no mulched), crop cover or low tunnels (for early crop and protection from low temperature), walk-in-tunnels (for temperate region off-season vegetables), naturally ventilated polyhouses (tomato, cucumber, tomato, flowers), net houses (for large number of vegetables and ornamental plant nurseries), environment controlled greenhouses (healthy nursery and foliage plants, vertical farming of lettuce, strawberry etc., soil-less farming (hydroponics and aeroponics, e.g. lettuce and potato seed production, aquaponics for vegetables), and vegetable grafts, are some important technological interventions that need to be scaled-up and adopted more widely.

A combination of above practices, along with information communication technology (ICT) tools leads to 'Precision Horticulture'. It is a holistic system designed to maximize production and productivity using advanced information technology along with various management practices. It includes protected cultivation, integrated crop-nutrient-water management, soil-less production system/vertical gardening (hydroponics, aeroponics, aquaponics) and post-harvest technology. Protected cultivation by way of greenhouses, polyhouses etc. needs to be promoted on large scale, especially as youth-centric enterprises. Plastic mulching and fertigation are progressively being practiced by Indian horticulture farmers. However, greater thrust is needed for micro-irrigation and water harvesting.

With rapid expansion of areas under cities and towns, development of sustainable peri-urban and urban horticulture (PUH) is another area of opportunity. It contributes for increasing access to food, advancing livelihoods and improving the environment (waste management, reduce CO_2 emissions). Designing of improved management (storage, packaging, processing and local marketing) will be crucial to the development of a sustainable PUH. Approaching PUH from a value chain perspective would create new opportunities for job and income creation, and is also crucial for generating access to fresh and nutritious food to a wider urban population.

Adoption of IPM technologies on larger scale would facilitate climate smart horticulture. These include biopesticides, diagnostics based on nanotechnology, nano-pheromone for insect-pests traps, and nano-sheets for packing, as some new opportunities. IPM also includes providing farmers with timely advisories based on weather data, crop phenology, physical and mechanical methods, agronomic techniques, use of trap and border crops, non-pesticides management, need-based chemical management and economics. Honeybees as pollinators enhance the crop yield (25-100%) and also provide honey and other products as additional income to the farmers. Therefore, bee keeping can be promoted. This will include bee colony management strategies, and value addition in honey, including quality management.

A boost in agricultural research budget from the current 0.3 per cent to 1 per cent of agricultural GDP can make a considerable difference in production and productivity. Horticulture sector should get higher, if not proportional allocation in future. The ICAR and SAUs can channelize it to develop climate resilient varieties of crops suitable for the 128 agro-climatic zones of the country, through farmer participatory plant breeding, adopting farm varietal trials, strengthening tissue culture labs, research on precision horticulture and developing models of integrated farming. The ICAR and SAUs should ensure implementation of activities across the farming value chain, energy friendly irrigation pumps, micro-irrigation, production, post-harvest processing and other value addition activities. Improving the understanding of interactions between native ecosystems and production systems and developing best practices to conserve biodiversity would also be beneficial. R&D on technologies such as sensors and internet of things (IoT) in greenhouses for remote monitoring of critical parameters in crop growth; mechanical tools for harvesting; imagery-based grading; solar dryer for fruits and vegetable processing; solar-powered micro cold storage, mobile pack houses, and smart packaging would be greatly useful in increasing productivity and reducing cost of production of horticultural crops.

Considering the growing demand for "organic food", there is opportunity in horticulture also to cater to this niche market. It can provide safe and nutritious food to consumers, improve food and income security of small and marginal farmers, provide employment opportunities for educated youth through small and medium enterprise; and also ensure ecological and economic sustainability of Indian agriculture. Government schemes like PKVY need to be supported further with certification of organic produce through accreditated testing laboratories.

Promotion of cold chain management would empower farmers to get better income from their farm produce, due to improved quality and extended shelf-life of perishable items.Harvest and post-harvest management and creation of integrated cold chain infrastructure would require cluster identification of horticulture produce and creation of infrastructure for aggregation of the produce, pre-conditioning-cleaning, sorting, grading, packaging, transport and/or storage facilities, integrated cold chain infrastructure, processing and market linkages. Cold storage facilites and mandis to have pledged facilities to avoid distress sale. Further, a thrust on secondary agriculture would be beneficial, as farmers can fetch higher price for their produce subjected to value-addition.

Expansion of e-NAMs and promotion of FPOs/VPOs/Cooperative Societies has great potential for promoting 'agri-hortipreneurs'. The creation of a unified national market, a freer export regime and abolition of the Essential Commodities Act would help in boosting agricultural growth. Many of the constraints in marketing of horticulture produce can be addressed by adopting the Model Agricultural Produce and Livestock Marketing (Promotion and Facilitation) Act (APLM), 2017, which provides for progressive agricultural marketing reforms, including the setting up of markets in the private sector, allowing direct sales to exporters/processors and customers, farmer-consumer markets, e-trading, single point levy of market fee, a unified single trading license in a state, declaring warehouses/ silos/cold storage as market sub-yards and the launch of the National Market for Agriculture.

Recent initiatives of the GoI to open foreign direct investment (FDI) in retail are expected to minimize some of problems related to export of horticulture produce. Provision of dedicated retail chains would improve the situation. The APEDA has been championing the development of export-oriented clusters with common infrastructure facilities, with functional end-to-end cold chain system along with processing facilities. There exists a shortage of testing laboratories, essential for health certificates for exports. As suggested by APEDA, agricultural universities need to get their labs accredited. Efforts must be made to set- up a green channel for perishable produce at identified airports handling cargo. Regulatory frameworks regarding use of pesticides, growth hormones, and antibiotics for horticultural produce need to be developed and implemented effectively to curb the rejection rate in the export market. Promotion of FPOs, export-based clusters and contract farming will go a long way towards ensuring traceability of farm produce, a key export requirement. There is need for long-term export policy and reforms in APEDA and also APMC Act.

Greater thrust needs to be given on human resource development for capacity building of farmers, horticulture entrepreneurs/supervisors and field functionaries. Also, the establishment of crop-based Centres of Excellence (CoE) in each district through KVK/ATMA to serve as a hub for supply of quality seed and planting material and dissemination of technology to farmers needs to be paid urgent attention.India has to enter into futuristic agriculture for 'more from less for more', 'starch to protein to health goods'; 'stress agriculture to secondary agriculture to specialty agriculture', 'agriculture to food to nutrition to health to employment', one health (soil, plants, animals, man), and skill and youth in agriculture.

2.5.4 Recommendations

1. In order to ensure food and nutrition security, there is a need to increase area under horticulture by 20 per cent (at around 30 million ha from the current level of 25 million ha) in the next five years and increase the adoption of improved varieties and hybrids possessing high nutritional quality, enhanced productivity, resistance to pests and diseases and tolerance to abiotic stresses. Along with private sector vegetable hybrids, public sector bred varieties and hybrids need to be commercialized on priority. The NSC needs to strengthen vegetable seed production, demonstration and marketing of public sector varieties and hybrids to help farmers in their faster adoption and reducing the cost of production. ICAR institutes/SAUs need to be given adequate financial support to strengthen infrastructure for nucleus and breeder seed production. Measures must be taken to standardize and promote usage of rootstocks especially for fruit crops. Model accredited nurseries for providing quality seed and planting material need to be established/strengthened on priority. A robust 'Seed Rolling Plan' comprising a network of efficient seed producers, across both public and private sectors is also required, along with up-graded seed testing facilities to provide quality seeds in right quantity and at right time. States should aim to increase the seed replacement rate (SRR) to 33 per cent for self-pollinated crops and 50 per cent for cross-pollinated crops in alternate years.
2. Protected cultivation (PC) needs to be promoted on large scale through increased use of greenhouses, polyhouses, etc. especially as youth-centric enterprises. A sub- mission on 'Protected Cultivation ' needs to be established under MIDH to take it to a higher level, with target to increase the area to ~2,00,000 ha in the next 4-5 years which can be achieved through: (i) providing trained human resource, (ii) developing crop varieties/hybrids/grafts suitable for protected cultivation, (iii) propagating healthy planting material under controlled environment, (iv) adopting micro-irrigation and fertigation, (v) use

of low-cost structures such as plastic mulch, ploy tunnel and (vi) subsidizing inputs. More area needs to be covered under integrated crop-nutrient-water management, micro-irrigation and fertigation system, soil-less production system/vertical gardening in mission mode along with renewable energy, to enhance the income of the farmers. The micro-irrigation industry needs be declared as infrastructure industry and classified as priority investment, to give benefit to all the major, medium and minor projects and especially the farmers to get easy access to the funds. Also, peri-urban and urban horticulture (PUH) need to be given priority with focus on protected cultivation, waste-water/ rain-water management, landscape gardening, vertical farming/gardening, promotion of aeroponics / hydroponics, and nutrition/terrace/container/turf/roof gardening.

3. Research and development for improved cultivars using cutting-edge technologies like genomics, proteomics, metabolomics, phenomics for genetic improvement need to be adequately funded. Concerted efforts need to be made to reorient breeding programs to target the traits like enhanced productivity, seedlessness, canopy architecture, nutrient use efficiency, biotic/abiotic stress resistance, shelf-life improvement, and biofortification, etc. Other specific areas needing focused attention for improvement include development of varieties for cultivation in non-traditional areas standardization of aeroponics/ hydroponics techniques in fruits and vegetables production, genomics of indigenous crops like coconut, mango, banana, *parwal* etc. Dryland/arid horticulture needs to be given focused attention for which new varieties/hybrids and related cultivation technologies need to be developed on priority.
4. IPM strategies need to be promoted widely. It includes providing farmers with timely advisories based on weather data, crop phenology, physical and mechanical methods, agronomic techniques, use of trap and border crops, non-pesticides management, and need-based chemical management. Diagnostics based on nanotechnology, nano-pheromone for insect, pests and nano-sheets for packing are new opportunities for the development of processes and product, which are impossible to achieve through conventional system.
5. Thrust needs to be given on zone-specific cropping pattern to achieve higher production through encouragement for zone-wise area expansion of horticultural crops, ensuring increase in productivity. Further, change in the concept of 'Farm to Fork' to 'Fork to Farm', implying demand driven production would ensure efficient marketing and better price for the farmers. This would require knowledge empowerment, improved seed system, production management, inputs management, credit support, smart management for water, nutrient and plant health care, quality assurance, logistics, branding and delivery. States of Maharashtra, Gujarat, Karnataka and Andhra Pradesh, have been playing proactive role in taking up development through hand-holding of farmers, but this is lacking for eastern states. Thus, region-specific approaches need to be adopted for implementation of development program in horticulture.
6. Adopting a mini mission-mode approach on value chain management under MIDH is required to address all the activities starting from cultivation till the produce reaches to the consumers in an acceptable form. This requires hand holding of farmers in production and delivery by assuring new knowledge, inputs, logistics, credit and quality assurance, warehousing, pack houses, ripening chambers, reefer vans, and cold storages, including those set up at the village level. There is need to establish functional block level resource centres, including facilities for low-cost value addition (secondary agriculture), targeting clusters of villages along with social services. Processing of fruits and canning of vegetables can multiply their value 50 to 500 times. At present, only a fraction of total fruits and vegetables produced in the country are being processed. This will not only save post-harvest losses but also add to employment generation at the local level by engaging youth (including women) and creating village level entrepreneurs. Hence, there is urgent need for the government to improve required infrastructure on priority, particularly power supply, in order to have the effective value chain in management system in place to get desired results.
7. Policies to promote greater investment by the private sector and use of new disruptive technologies (e.g. gene editing, GM technology, robotics, sensor based decision systems, space technology) need to be in place. These have been the significant drivers of change in the past two decades for production

system management and to improve global competitiveness. Also, promotion of PPP in R&D, production technology and extension needs to be encouraged.

8. Greater thrust needs to be given on post-harvest management including storage, processing and marketing of horticultural produce, especially in vegetable and fruit crops. Backward and forward linked marketing with reform in APMC act, encouragement for contract farming are some of the important policy changes which will have significant impact on production, quality and competitiveness of horticultural produce. Other area of needed reform is the law pertaining to aggregation of land, which can help in better investment as well as adoption of technology. To enhance the delivery effectively, there is a need for innovations to be scaled in PPP mode for better adoption in horticulture. Involvement of youth for technical backstopping, input supply will be helpful.

9. The MoA&FW needs to draw up guidelines to promote warehouse based post-harvest loans and electronic negotiable warehouse receipt (e-NWR) under Digital India mission, and establish functional block level resource centres to create value chains targeting clusters of villages along with social services. It will create an integrated solution for the farmer to access his/her requirements for agriculture/horticulture and other services. It will also add to employment generation at the local level by engaging youth and women as agri-entrepreneurs which will result in rapid modernization of the horticulture sector.

10. There is need for effective coordination between the MoA&FW, Ministry of Food Processing Industries and Ministry of Commerce and Industry to develop strong procurement linkages, processing facilities, retail chains and better export environment. This will facilitate synergies between various initiatives such as the RKVY of the agriculture ministry, and cold chains; and warehousing infrastructure development of Ministry of Commerce of Industry. For aggregation of farm produce, there is a need for decentralization and modernization of market yards, railway freight operations need to be strengthened through temperature-controlled containers along with loading and unloading facilities, to reduce post-harvest losses and connect land-locked states to export markets. Private entrepreneurs should also be incentivized to establish small farm implement mechanization hubs for every 1,000 ha and big machinery hubs for every 5,000 ha of cultivated area.

2.6 Livestock Sector

India is blessed with large livestock population reared under diverse production systems and agro-climatic conditions. The country has 15, 58, 18, 7 and 5 per cent of world's cattle, buffalo, goat, sheep and chicken population, respectively. Present livestock wealth of India (19th Livestock Census of India, 2012) is depicted in Fig. 2.6.1. The total livestock population decreased during 2007 to 2012, though it increased in the poultry sector (Table 2.6.1). Livestock sector plays a multi-faceted role in providing livelihood support to more than 60 per cent of the rural population and employs 8 per cent of the country's labour force (11th Five Year Plan: 2007-12 report). Besides their monitory benefit and providing a steady stream of food and revenue for households, it provides employment to the family, acts as insurance during crop failures, contributes to gender equality by generating opportunities for women, generates *in situ* fertilizers for enhancing the soil fertility, contributes to day-to-day expenses of the farm family, recycles waste products and residues from cropping or agro-industries and supplies energy source for cooking and thus, provides a sustainable environment.

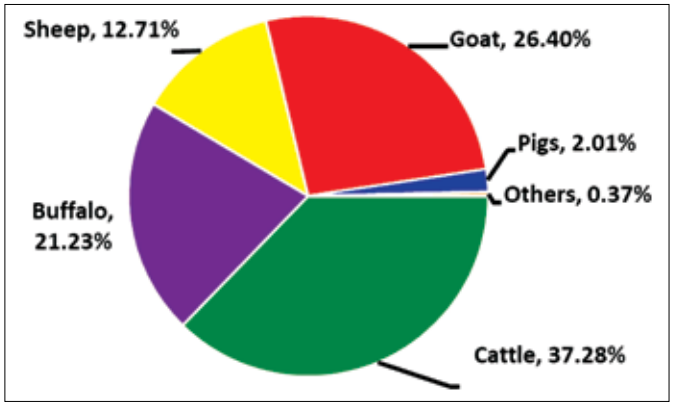

Fig. 2.6.1 Livestock wealth of India

(Source: Livestock Census 2012; DoAHD&F, 2012-13)

Table 2.6.1: Population growth of livestock

≈	Population (million)	
	2007	2012
Buffalo	105.3	108.7
Cattle	199.1	190.9
Goat	140.5	135.17
Sheep	71.6	65.06
Total Bovine	**299.9 (decrease by 1.57%)**	
Poultry	648.8	729.2 (12.39% increase as compared to 2007
Total livestock	**512.05 (decrease by 3.33%)**	

(Source: Livestock Census 2012, DoAHD&F, 2012-13)

Livestock and animal husbandry which has been an integral component of Indian agriculture is growing at an appreciable and sustainable rate and is ahead among all sub-sectors of agriculture. The livestock sector contributed 4 per cent to the total GVA and 26.7 per cent to the agricultural GVA in 2014-15. During the decade of 2004-05 to 2014-15, crop, livestock and fisheries have registered the growth of 2.93, 6.11 and 5.13 per cent per annum, respectively. The livestock sector never experienced a negative growth during the last over three decades and hence is likely to an emerge as engine of growth of agricultural sector which can be relied upon for risk mitigation and minimizing the losses to the farmers in case of even worst outcomes from others sub-sectors.

Goats and sheep play a significant role in food and nutritional security of the rural poor especially in the rainfed regions where crop production is uncertain, and rearing large ruminants is restricted due to acute scarcity of feed and fodder. There are about 33 million goat rearers in the country. Larger herd sizes are prevalent in areas, like tribal belts of Odisha and desert region of Rajasthan, where there is higher access to common property resources. However, the goat population density is the highest in Bihar and West Bengal. Goat rearing has distinct economic and managerial advantages over other livestock species because of its less initial investment, low input requirement, higher reproductive rate, early sexual maturity and ease in marketing. Goats are hardy animals and they are typically reared in regions that are considered ecologically vulnerable for other production systems. Despite being a strong contributor to the income and livelihoods of the poorest segments of the society, the sector has remained largely underinvested and neglected at various levels.

Poultry is one of the fastest growing sector of agriculture. In poultry Sector, India is leading with 10 per cent growth followed by Brazil (7%), USA (2%) and China (2.1%). It is now world's third largest egg producer (7% of the world) and the fifth largest producer of broiler (5% of world). This industry has grown largely due to initiative of private enterprise, huge indigenous poultry genetic resources, and considerable support from complementary veterinary health, poultry feed, poultry equipment and poultry processing sectors. A significant feature of India's poultry industry has been its transformation from a meagre backyard activity into a major commercial activity in just about four decades. This transformation has involved the sizeable investments in breeding, hatching rearing and processing. Farmers in India have moved from rearing non-descript birds to high yielding hybrids.

2.6.1 Status, Constraints and Opportunities

2.6.1.1 Livestock Production

(i) Milk

Cattle and Buffalo milk: India ranks first in milk production, accounting for about 20 per cent of total world milk production. There was steady and remarkable rate of growth in milk production reaching 176.35 million tons in 2017-18 (Fig. 2.6.2). Although, per capita availability of milk varies between 71 g/day in Assam to 1120 g/day in Punjab, the per capita milk availability at national level during 2017-18 was 375 g/day which is well above the Indian Council for Medical Research (ICMR) recommended level. Buffalo contributed 49 per cent of the total milk produced in the country, while cattle contributed 48 per cent. Indigenous buffaloes (13 recognized breeds) produced about 73 per cent of the milk produced from the buffaloes, while the remaining was from non-descript breeds. Among cattle, exotic and crossbred cattle contributed to 56.3 per cent of the total cow milk produced in the country. The contribution of indigenous breeds was to the extent of 25 per cent while the non-descript cows contributed 19 per cent of the total milk produced by the cattle.

Despite being the highest milk producer in the world, the average milk production/cow/year is around 1,200 kg (50% of global average) in India, compared with New Zealand (3,343 kg), Australia (5,600 kg), UK (7,101 kg), USA (9,332 kg) and Israel (10,214 kg). Empirical evidence based on the large sample surveys indicate that level of milk production for 36 per cent households is only ≤500 litres/annum, for 27 per cent between 500-1,000 litres/annum and only 15 per cent households produce >2,000 litres/annum which contribute 50 per cent of the total milk production. This indicates enough scope to improving the productivity. Uttar Pradesh is the highest milk producing state (29.05 million tons) followed by Rajasthan (22.4 million tons), Madhya Pradesh (14.71 million tons), Andhra Pradesh (13.7 million tons), Gujarat (13.57 million tons), Punjab (11.85 million tons), Maharashtra (11.1 million tons) and Haryana (9.81

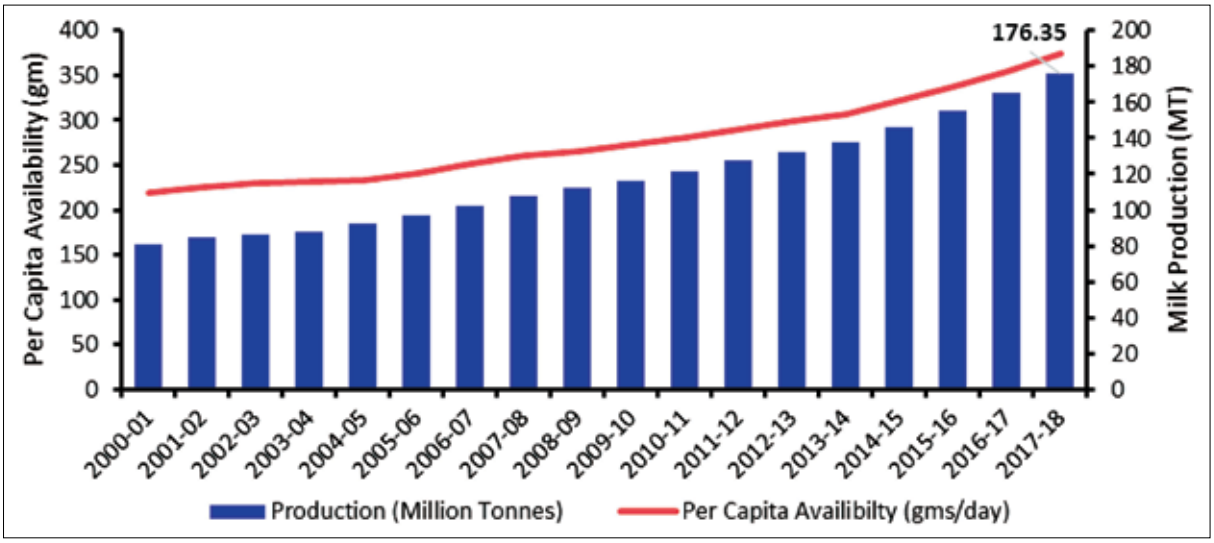

Fig. 2.6.2 Milk production in India during 2001-2018

(Source: DoAHD&F, 2017-18)

million tons). But, per animal productivity is the highest in Punjab and Haryana in all three types of milch animals i.e. buffalo, crossbred and indigenous cattle breed. This difference in productivity is mainly due to availability to feed and fodder, good germplasm of animal and better facilities of artificial insemination (AI) and health care of milch animals. The projected demand of milk in 2030 in India would be about 185 million tons which will be met if dairy sector continues to grow at the same rate, and the rise in number of non-productive animals is controlled.

Goats and Sheep: India stands first in goat milk production (45.9 lakh tons) and contributes 29 per cent share in the world though per animal productivity of sheep and goat milk is much below the world average. The advantage of initial low investment cost, high fertility, easy marketing and social acceptance of goat meat, goat farming would be ideal option for poor rural households, if common community land is developed for grazing of small ruminants.

(ii) Meat

The meat production showed a good growth rate during the last decade. According to the Department of Animal Husbandry, Dairying and Fisheries (DoAHD&F), the total meat production was only 1.9 million tons during 2001-02, which increased to 7.7 million tons during 2017-18 (Fig. 2.6.3). Uttar Pradesh contributes the highest share (15%) in national meat production followed by Maharashtra (12.1%), West Bengal (10.1%), Andhra Pradesh (9.3%) and Telangana (8.4%).

Bovines are the second largest source of meat in India after poultry, and ahead of goat and sheep. In 2015-16, poultry contributed 3.26 million tons, followed by bovine meat (1.94 million tons), chevon (0.94 million tons) and mutton (0.49 million tons). Pork accounted for 0.39 million tons.

India is second in the world in goat meat production (5.95 lakh tons) sharing 12 per cent of world share though per animal productivity of sheep and goat meat is much below the world average. During the last decade, the goat meat production has doubled (9.3% to 18.3%). The meat production from sheep and goat in India as estimated (BAH&FS 2016) is 485.53 and 942.91 million kg, respectively, that constitutes 7 per cent and 13 per cent contribution to more than 7,000 million kg of total meat produced in country. Share of sheep meat towards total meat production of the country has been quite stagnant since the last few years with 7.33 per cent in 2007-08 to 7 per cent in 2015-16.

Thus, the availability of meat in India is only about 2.96 kg/person/year against the ICMR recommendation of 11.0 kg/person/year. It is apparent that there exists a huge gap between demand and availability of meat. This necessitates more production of meat in the country. Moreover, by 2050, it is expected that the population in India would increase by 34 per cent and to fulfil the dietary recommended levels of the livestock products as per ICMR for a population of 1.8 billion people, the livestock sector should produce 186.2 million tons of milk, 18.7 million tons of meat and 306 billion eggs per annum.

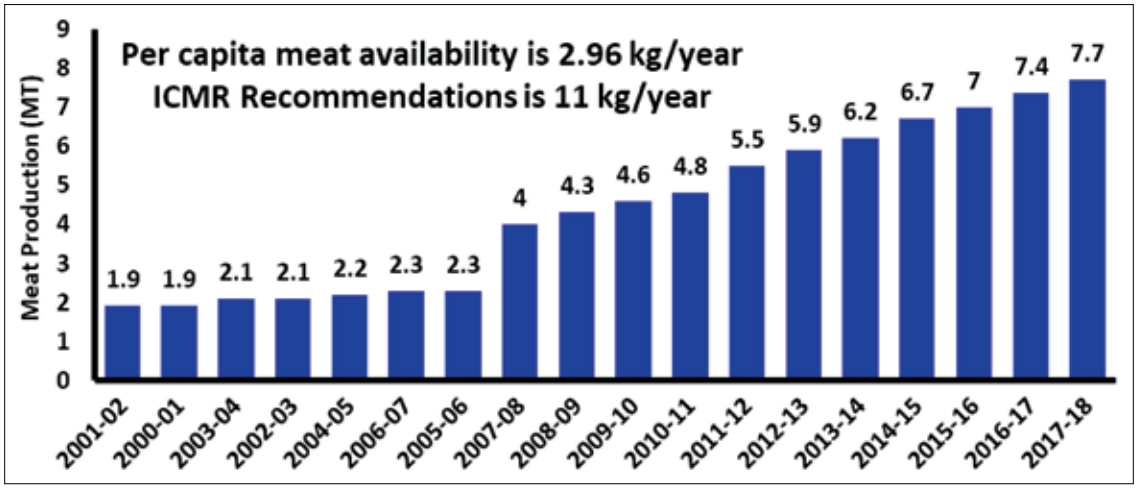

Fig. 2.6.3 Meat production in India during 2001-02 to 2017-18

(Source: NDDB, 2018-19)

(iii) Eggs

Egg production showed an impressive growth during the past few decades; 10 billion eggs during 1980-81, 39.1 billion during 2000-01 and 95.2 billion in 2017-18 (Fig. 2.6.4). At present, the annual production of eggs amounts to about 24 crore eggs every day of the year. If 60 per cent of India's population eat an egg every day, the production will need to be increased three-fold. Nationally, around 19 per cent of the egg production is from backyard poultry enterprises, in which 64 per cent are produced by indigenous (desi) fowl. Ducks contribute about 7 per cent of the eggs. The organized and commercial sector contributes about 81 per cent of the eggs produced. Andhra Pradesh is the highest egg producing state (17.78 billion) followed by Tamil Nadu (17.42 billion), Telangana (12.67 billion), West Bengal (7.64 billion), Maharashtra (5.7 billion), Haryana (5.59 billion) and Karnataka (5.56 billion). This difference is mainly due to large number of organized poultry farms and good market chains in high egg producing states.

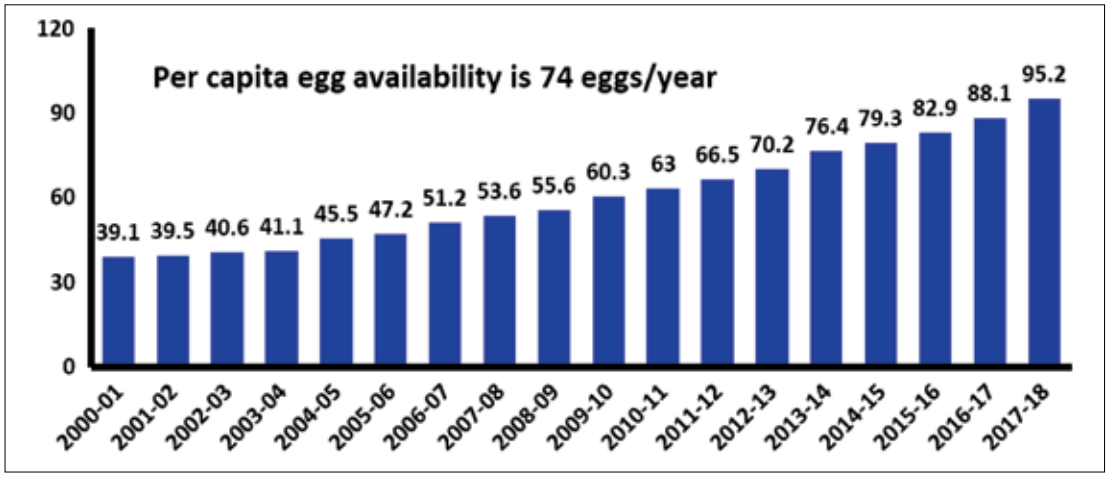

Fig. 2.6.4 Egg production (billion) in India during 2000-01 to 2017-18

(Source: DoAHD&F, 2017-18)

(iv) Value addition

Animals provide huge amount of food (milk, meat, eggs) rich in high quality proteins, minerals, vitamins and micronutrients (such as zinc, iron, calcium) and others, and thus, nutritional security to the human population. The importance of dietary animal protein can be well recognized because it contains essential amino acids that are deficient in cereals. Eating even a small amount of animal products corrects amino acid deficiencies in cereal-based human diets. Further, animal proteins are more digestible and metabolized more efficiently than plant proteins.

The newer technologies of composite dairy food, probiotic fermented dairy products, fortified milk and meat products developed by the National Dairy Research Institute (ICAR-NDRI), Central Institute for Research on Goats (ICAR-CIRG) and other institutes need to be scaled out for enhancing the farmers' income. Buffalo milk cheeses are becoming increasingly popular throughout the world as they display typical body and textural characteristics which are unique in nature. Mozzarella cheese made from buffalo milk is the most popular cheese for pizza toppings. Thus, there is great potential and opportunity for value addition in buffalo milk to earn handsome profits. Moreover, branding of buffalo milk can help to obtain better economic returns to the farmers. Addition of value to dairy products ranging from *dahi* to highly industrialized yogurt, cheese, powder, dairy probiotics and nutraceuticals has become imperative for the dairy industry. It is now a well-established fact that value addition helps to increase the profitability of the dairy enterprise and there is a huge scope for growth of the organized dairy industry in this area due to increased demand. Two key elements of marketing strategy for future are: (i) focus on premium brands and (ii) product mix expansion to include UHT milk, cheese, probiotic dairy drinks, ice creams, spreads etc. The changing marketing trends in future will see the shift from generic products to the packaged premium brands.

In the currently approved food parks/mega food parks, there are hardly any meat/poultry processors due to restrictions from other food commodity entrepreneurs about inclusion of meat and poultry. Exclusive animal protein food parks/food hubs for meat/fish/poultry/egg may be created.

(v) Farmers' producer companies for livestock products

Presently, there are around 5,000 FPOs including FPCs in existence in the country, which were formed under various initiatives of the Central Government, State Governments, NABARD and other organizations over the last 8-10 years. FPOs are farmers' collective organizations, with membership mainly comprising small/marginal farmers (around 70 to 80%). For the success of FPOs in case of livestock products, the need is to create some model FPOs in the country, may be on the lines of the famous 'milk cooperative'. Livestock FPOs need support from the government to stand on their feet. Today, many successful milk cooperatives in the country are surviving on their own while competing in the open market, but they have institutional support in the form of the National Dairy Development Board. Similarly, the government needs to create some other specific institutions for the benefit of FPOs created for production of livestock products other than milk. Formation of such SHGs and FPOs is more important in small ruminants farming, as there is complete absence of organizations of small ruminant's keepers. Formation of FPOs, cooperative societies or the SHGs based on the model demonstrated by the NDRI in dairy sector in villages, would enhance farmer's income and value addition. The producers should be linked to market. Further, clean milk production, traceability, adulterants detection kits and value addition of milk and milk products should be prioritized.

(vi) Export from livestock sector

India is the largest exporter of buffalo meat and third largest exporter of other meat after Brazil and Australia. India started exporting fresh and frozen meat since 1969 to several countries, of which the major buyers of Indian bovine meat and other meat are Vietnam, Malaysia, Thailand, Australia, UAE, Saudi Arabia and Egypt. Among Indian states, Uttar Pradesh has emerged as the major exporter of buffalo meat, followed by Punjab and Maharashtra. The country has exported the livestock and its products valued Rs 45,776.81 crore during 2017-18. The major export was from meat and edible meat offal (58.8%). There is tremendous scope of export of meat especially buffalo meat from India since India is having more than 50 per cent of world's buffalo population. There is a need to develop a specific breed of buffalo for meat purpose and the slaughter system, packaging and transport of these products. In the present situation, the registered slaughter houses need to be increased and improve them to bring at par with international standards. There is plenty of scope to export the dairy and poultry products with due value addition. Presently, the export of dairy and poultry products and honey is to the tune of Rs 2,363.60 crore (Table 2.6.2).

There is need to establish the special animal product economic zones and value addition in order to promote the export of livestock products. The "Special Animal Product Zones (SAPZ)" on the lines of "Special Economic Zones" are to be set-up in areas around breed speciality in their breeding tracks and

Table 2.6.2 Value of export and import of livestock and livestock products in 2017-18 (Rs in Crore)

Groups	Import	Export
Livestock	56.55	411.02
Meat and edible meat offal	29.99	26,921.75
Dairy and poultry products & honey	302.88	2363.60
Animal fodder and feed	3,558.07	9,384.01
Raw hide and skin & leather	3,967.71	5,636.67
Raw wool and animal hair	2223.96	1,059.76
Total	**10,139.16**	**45,776.81**
India's Total	**30,01,015.73**	**19,55,541.12**

(Source: APEDA, 2017-18)

may be linked with an export-based processing plants, compound feed industry, regulated animal market, veterinary polyclinics, semen bank, etc.

(vii) Livestock farms for registered breeds

Presently, the number of livestock farms for cattle, buffalo, sheep, goat, rabbit, pig, camel, horses, poultry and duck are 132, 23, 69, 161, 34, 366, 2, 14, 244 and 32, respectively under control of animal husbandry departments. Besides, livestock farms under control of other than animal husbandry departments are 53, 12, 19, 1855 and 6 for cattle, buffalo, sheep, poultry and duck, respectively. In spite of a large network of livestock farms, the herd/flock size in most of the farms is inadequate to take up genetic improvement programs. For cattle, a total of 6,495 *gaushalas* are also registered in the country. Therefore, there is a need to strengthen/establish sufficient number of farms with adequate strength of livestock (at least 1,000 heads of one breed), sufficient budget and man power to fulfil following mandate: (i) supply of germplasm of high genetic merit for genetic improvement of farmers' herds either in form of breeding males or semen/embryos; (ii) to act as a model demonstration unit of animal husbandry activities through training to the farmers; (iii) to act as conservation unit of a particular breed.

2.6.1.2 Livestock and poultry markets

There are about 2,000 markets for live animals, falling under the jurisdiction of state governments and managed by local bodies such as Municipal Corporations and Gram Panchayats. Most of these markets are irregular, lack transparency in transactions and are short of basic infrastructure and marketing facilities. In handling live animals, the role of available infrastructure is important to comply with animal welfare and to maintain the health of the animal. Further, lack of basic facilities in markets, for farmers as well as for animals also discourages producers to bring their animals to the markets. A considerable proportion of live animals, mainly small ruminants (sheep & goat) are exchanged amongst livestock farmers themselves and between farmers and intermediary traders. Intermediaries procure animals from farmers for further sale to larger traders as well as to slaughter houses and butchers. Sometimes, small producers assemble their produce to sell collectively to large buyers. Butchers-cum-retailers in small towns too procure live animals directly from producers. Unlike in case of fruits and vegetable farmers, direct sales to end consumers are rare. Ease of livestock movement, including the documentation to ensure safe transit, is also an aspect that livestock markets are expected to facilitate. Price of live animals, especially ruminants, is negotiated by buyers and sellers, taking into consideration the animal characteristics. However, no harmonized standard of the identified parameters is uniformly applied.

No doubt there is a well-established marketing and supply chain network for export of meat, however, the domestic marketing system does not demonstrate equal quality and standardization in these products. About half of the total meat production comes from un-registered, make-shift slaughter houses. Marketing and transaction costs of livestock products are high up to 15-20 per cent of the sale price. Bovine meat output in India, the second largest bovine meat producer in Asia, is increased by 1.2 per cent in 2017 (2.55 million tons), suggesting that the ban on selling cattle for slaughter and the crackdown on illegal meat establishments have not interrupted the existing supply channels (FAO, 2018).

The marketing of milk and milk products is comparatively organized. It is estimated that 48 per cent of milk consumed at production points and out of the remaining 52 per cent, dairy cooperatives handle 16 per cent, private organized sectors 14 per cent and unorganized sector 70 per cent. As per National Cooperative Dairy Federation of India Ltd. (NCDFI), there are at present 27 state milk federations, 218 district milk unions, 1.77 lakh village milk societies and 163 lakh dairy farmer members.

Marketing of poultry live birds is more organized where the producers have integrated their output into the supply chain of the poultry processing industry. Bulk of trade in live broilers and eggs takes place between producers and traders, directly or indirectly through commission agents, in designated markets or at the farm gates. In some states, poultry co-operatives also facilitate marketing, but on a limited scale.

Contract farming in poultry has emerged in big way for taking the poultry farming down to the path of industrial farming. Producers associations like Broiler Producers Marketing Association (BROMARK) set the daily harvest prices depending on the market. The majority of domestic consumers prefer poultry meat

from small butchers, and reports indicate that more than 90 per cent of chicken is sold freshly butchered at retail level. This allows smallholding farmers to continue trade in the live animals with small town butchers and wet market retailers.

2.6.1.3 Animal identification and recording

Till date, the country does not have effective mechanism to identify the animals and performance recording although small scale level progeny testing programs are existing at some places. The elite germplasm of all breeds needs to be identified, subjected to performance recording and systematic breeding program so that more numbers of elite germplasm are obtained and male offspring from these elite females can be used for future artificial breeding purpose. Also, large number of non-descript and non-characterized livestock population need to be worked out and performance recorded

2.6.1.4 Conservation of indigenous animals

The country has the largest livestock population and mega biodiversity. There is large number (184) of the registered indigenous breeds of cattle (43), buffalo (16), goat (34), sheep (43), camel (9), donkey (2), horse & pony (7), poultry (21), pig (8) and Yak (1). Out of total cattle population, 69.7 per cent are non-descript, 11.6 per cent recognized indigenous breeds, 15.7 per cent crossbred, 2.1 per cent upgraded with indigenous breed and 0.9 per cent exotic breed whereas among total buffalo population, 56.1 per cent are non-descript, 30.2 per cent registered indigenous and 13.7 per cent upgraded one. Despite these large number of breeds in livestock and poultry, considerable population exist in the country which deserve to be recognized and given a breed status. The exotic male germplasm of cattle was imported and cross-bred which led to increased cross-bred population and milk production. Population of cross-bred cows increased at the annual growth rate of about 7.5 per cent during 1982–2003 compared to about 0.1 per cent for indigenous cows. This threatens the loss of our valuable indigenous cattle breeds. India has vast population of 199.1 million cattle, which includes 39.73 million crossbred. The exotic/crossbred milch cattle increased from 14.4 million to 19.42 million, an increase of 34.78 per cent (19th Livestock Census- 2012).

Indigenous animals have the advantage of sustaining productivity under low inputs and are also known for their drought tolerance and disease resistance. Some indigenous cattle breeds are having good potential of milk production (*Gir, Sahiwal, Rathi, Red Sindhi, Thaprparkar*, etc); the milk yield of these breeds varies between 1,200-3,000 litres or even more. Such breeds need to be promoted and be used for grading-up of non-descript cattle in different parts of the country for improving their milk productivity. Besides the regular programs for conservation and improvement of indigenous cattle, the strength of having several *Gaushalas* can be converted into opportunity by involving them as focal point for development and conservation of indigenous breeds in their respective regions.

Genomic selection in breeding programs, for higher coverage and better accuracy, need to be initiated. In the meantime, for sheep and goat husbandry, community based breeding program should be implemented immediately. Further, there is an urgent need for scrub bull castration. *In situ* and *ex situ* conservation programs of important breeds of livestock and poultry should be undertaken in mission mode. Special focus also needs to be given on the conservation of migratory breed of sheep for future. “Early warning and response” system should be introduced. Breeder Association should be formed. The National Genebank of Livestock needs to be strengthened.

2.6.1.5 Breeding policy and protection Act

Livestock is a state subject and all the states develop their breeding policies for livestock as per broader guidelines of Government of India and as per need/capacity of the state. These are periodically reviewed and improved. All the states need to formulate comprehensive livestock breeding policy and review the same after every 5/10 years. Most of the states have developed breeding policy for bovines only. Hence, breeding policy needs to be developed for all the species and under different production systems and agroclimatic zones.

Since several agencies under public and private sectors are involved in implementation of breeding policy and difficult to control them, it is suggested to check standards of semen/embryo production in terms

of veterinary norms and genetic merit of breeding males by the government through legislative procedure. Further, the technical ability of artificial insemination (AI) workers is to be certified by the government so as to avoid long term problems in animals like disease and poor genetic improvement Therefore, besides bovine breeding policies, there is need to formulate Bovine Breeding Acts in each state as in Punjab.

Presently, different livestock species represent a big proportion of non-descript population, which as per the Breed Survey-2013 of GoI, is 59.3, 43.4, 61.3, 38.7, 73.1, 28.2 and 80.4 per cent in cattle, buffalo, goat, sheep, pig, camel and horses/ponies, respectively. Therefore, there is a need to complete the inventories of livestock by characterization and registration as breeds. Although the ICAR has initiated this process in 2008 but gazette notification of such registered breeds is not available. Therefore, there should be a legitimate authority to register and conserve all kinds of domestic animal diversity on the lines of Protection of Plant Varieties and Farmers' Rights (PPV&FR) Authority for plant varieties. Such Act will also protect livestock keepers' rights in the country.

2.6.1.6 Improving reproductive efficiency

As per 2012 livestock census, among the total breedable milch animal population, 1.6 million crossbred cattle, 6.03 million indigenous/non-descript cattle and 4.6 million buffaloes have not yet calved even once. This "calvable" but "not-calved" population accounts to nearly 10 per cent of the total breedable milch animal population. Conception rate through artificial insemination in buffaloes is very low when compared with cattle. Delayed age at sexual maturity (31-33 months in *Murrah* against 18-19 months in Mediterranean buffaloes, and poor expression of heat symptoms still remain as the major issues in achieving high reproductive efficiency in buffaloes. Summer infertility characterized by high incidence of silent heat (even up to 70%) is more common in buffaloes. On a conservative estimate, the country is losing 20-30 million tons of milk annually on account of anestrus and repeat breeding in cattle and buffaloes which translates to a loss of nearly Rs 40,000-50,000 crore annually. Artificial insemination for breeding purpose was started in 1940s but its coverage and conception rate is still very low. India has one of the largest breeding infrastructures in the world (51 frozen semen stations, 3,321 bulls and 94,688 AI Centers) with total production of about 90 million frozen semen straws per year, however we could cover hardly 25-30 per cent of the breedable population. To achieve national target of 50 per cent AI coverage by 2021-22, the quality semen production must reach to 140 million doses. The major limiting factor in achieving the required numbers of frozen semen straws production is the availability of high number of quality bulls.

In sheep and goat husbandry also, the availability of quality breeding males is very limited and the situation is further amplified by the poor quality semen produced by the breeding male. Goat keepers are unwilling to keep bucks due to high rearing cost. Further, there is no perfection in AI with frozen semen in goat industry. Hence, quality bulls/ quality breeding males in sheep and goat need to be reared and protected. To bridge the gap between demand and availability of male germplasm, a project/scheme to rear "the male calf to bull" needs to be initiated on priority by State Govt./ Central Govt. Similar schemes are also needed for goat and sheep husbandry for improved breed in their breeding track.

To enhance, reproductive performance all assisted reproductive technologies must be employed under field condition. In developed countries, the third generation reproductive technologies (e.g. *in vitro* embryo production) are being applied at farmer level. However, in India, still the first generation reproductive technologies (semen cryopreservation and artificial insemination) are being used and the other frontier technologies are mostly restricted to laboratories or a few pockets. Nevertheless, the time has come up to realize the full potential of these technologies for their successful application, wherever required, to multiply superior germplasm. Promising reproductive biotechniques like multiple ovulation and embryo transfer (MOET) and ovum pick-up and *in vitro* fertilization need to be utilized to the maximum extent at least for breeding bull production. Further, MOET and sexed semen and sexed embryos of available exotic germplasm (Holstein Friesian) should also be used for faster multiplication of superior germplasm of crossbred elite dairy animals and non-descript indigenous cattle.

The technology protocols of AI in goat, sheep, poultry and pigs are to be upgraded, strengthened and out scaled. The expert veterinarians are to be utilized for their expertise in specialized fields like precision livestock

production, treatment and health cover management and routine artificial insemination activities, may be taken up by trained para-veterinary staff and inseminators.

2.6.1.7 Shortage of feed and fodder

One of the major constraints in livestock farming is inadequacy of feed, both quantity and quality, particularly during the dry season. The area under fodder crops in India has stagnated at about 8.5-9.0 million ha during the past decade which is about 4.6 per cent of the total cultivated area. The projected demand of dry fodder, green fodder and concentrates for 2020 is 468, 213 and 81 million tons on dry matter basis whereas the availability is estimated to stand at 417, 138 and 44 million tons leaving a short fall of 11, 35 and 45 per cent, respectively. Although significant quantities of crop residues are produced, they don't meet the nutritional quality required for dairy cows. Scarcity of feed-fodder for sheep and goats and feed raw material at reasonable cost for poultry are also critical issues. Supplementation of mineral mixture is inevitable to achieve optimum health, reproduction and production of livestock and poultry. There is need to have GIS based record for area under fodder cultivation. At least 10 per cent of irrigated land should be used for fodder production. There is urgent need for a reliable assessment of the total requirement of feed and fodder and also to maintain the forage seed production chain.

In order to meet the nutritional requirements of animals, there is a need to increase the bioavailability of nutrients in the feeds and fodders using chemical, biological and biotechnological approaches. There is also need to have enriched feed/fodder banks like food/seed banks as technologies for compaction, enrichment and fortification are now available. Keeping in view the shortage of feed and fodder, a very well planned Government rogram to upscale and outscale the available technologies of "Precision Feeding" (bypass nutrients), alternate feed and fodder resources, area specific mineral mixtures are to be formulated and implemented. Availability of maize for poultry feed, is to be assured at affordable cost. The poultry producers may be encouraged to procure maize directly by using contract farming. Further, the following activities need to be undertaken on priority:

- The role of private sector for production of fodder/forage seed, as for seed in the food and vegetable sector of India must be encouraged.
- The technologies for fortification of crop residues for making good fodder for animals need to be out scaled and be provide at to farmers' doors. The program on ration balancing needs to be expanded in all districts.
- To ensure quality of feed, the standard and specificity of their ingredients should be set by BIS. Separate specifications for fodder blocks units and feed manufacturing units with separate identity should be formulated for providing subsidy.
- Licensing to fodder block units should be exclusive and not coupled with feed manufacturing units to minimize misuse of subsidy component.
- There is need for greater subsidy for fodder block units as relatively higher cost is involved in processing, transport and establishment.
- Roughage should be an essential component (about 30%) in the feed block units for granting subsidy.
- Promoting semi-intensive goat management system, to enhance the profitability of goat farmers and rejuvenation of grazing land/common property resources need urgent attention.

2.6.1.8 Need for Veterinary Health Services

Livestock sector is facing challenges of increased incidence of emerging and re-emerging animal diseases and vulnerability to exotic diseases. Further, it is also presumed that many diseases may surge upon during changed climatic scenario. The outreach of veterinary health care services to the livestock farmers is also low. Lack of awareness and timely non-availability of inputs for preventive measures have led to high incidence of diseases and epidemics. In India, it has been estimated that udder infection causes at least over Rs 6,000 crore economic loss every year and foot and mouth disease (FMD) about Rs 20,000 crore loss every year. Small, marginal and unorganized poor livestock farmers are the most sufferers by

these diseases. It also affects the export potential of the livestock industry. Milk and milk products, meats and hides are not accepted by the disease-free importing countries. If FMD is controlled, the milk production can be increased by at least 5 per cent annually and the export of meat could be enhanced by 3-5 times of the present level. In sheep and goat husbandry, the very high mortality can be reduced with prophylactic care, vaccination and improved method of goat rearing. PPR or goat plague is the most important disease of sheep and goats causing an economic loss to the tune of Rs 1,800 million per annum. The mass scale use of PPR vaccine resulted in reduction of >75 per cent disease incidence.

Although vaccination is the most promising way to control several diseases, it is not 100 per cent effective in preventing some of the diseases like brucellosis. Thus, vaccination coupled with good husbandry practices is essentially required to control the disease. For protecting livestock from several diseases and disorders, different institutes are coming up with advanced technical interventions which are to be scaled up and out scaled. Central Sheep and Wool Research Institute (ICAR-CSWRI) is intensively working for developing indigenous impregnated sponges for estrus synchronization, and overall package for prophylactic, curative health coverage of sheep. Similarly, Directorate on Foot & Mouth Disease (ICAR-DFMD) is working to ensure cheap and easy availability of diagnostic kits for surveillance and monitoring purpose. Indian Veterinary Research Institute (ICAR-IVRI) is coming in with specific technical interventions in the form of PPR Vaccine, FMD vaccine, Goat pox vaccine. National Research Centre on Equines (ICAR-NRCE) developed monoclonal based ELISA kit for diagnosis of rota virus infection in equines, Pregmare kit for pregnancy diagnosis in mares, recombinant antigen based ELISA kit for diagnosis of babesia equi infection in equines and equine influenza vaccine. For prevention of diseases among the goats, Central Institute for Research on Goats has developed ELISA kit for diagnosis of Para-tuberculosis and Brucellosis.

A comprehensive animal health cover system is possible only if there are adequate facilities for prompt diagnosis of livestock diseases. Facilities for specific and general disease diagnosis shall need to be strengthened by introducing good laboratory practices. In addition, an effective system for ensuring quality control on vaccines and diagnostics produced/imported need to be put in place. There is a need to improve existing vaccines, diagnostics, and therapeutics in terms of efficacy, long lasting immunity, thermostability, and easy delivery using advanced knowledge for use in national control program. Vaccines and diagnostics need to be produced in required quantities and made available at affordable cost. Quarantine facilities need to be further strengthened and zoo-sanitary and quarantine procedures has to be strictly followed to prevent ingression of exotic diseases. Mechanism of emergency preparedness against emerging and exotic diseases also needs to be in place. Further, launching of systematic disease control and eradication programs for OIE listed diseases along with effective disease surveillance on the lines of rinderpest eradication program, and strict enforcement of sanitary and phytosanitary conditions in processing the livestock products are critical in promoting the international acceptance and export.

A well-planned and operational livestock disease control program involving PPP mode could be an option to ward off huge economic losses due to changing climatic conditions and due to newer emerging and re-emerging diseases. Emphasis should also be given to prevent and control of zoonotic diseases. A comprehensive package about disease awareness, epidemiology surveillance, management and control measures is to be developed for education at farmers' level to control the disease incidence. Veterinary health service in small ruminants is very poor and requires immediate attention. Required quantity of vaccines against common diseases of cattle, buffalo, sheep, goats, pigs, horses and poultry are to be arranged either through import or manufacturing in India.

2.6.1.9 Improving condition of slaughter houses

As per APEDA, India has more than 1,176 slaughter houses and 75 modern abattoirs. As majority of slaughter houses are operated and managed by municipalities in cities and panchayats in rural areas, no standard practices are being followed and investment opportunities for improvement of infrastructure are difficult. As a result, there is low recovery rate coupled with wastage of by-products like blood, skins, tallow etc. The meat slaughter houses are basically linked to hide production and the leather industry. Schemes to improve slaughter houses framed by the Central and State governments in the past have been effective in refining the basic infrastructure like building/ lighting/ water supply/ drainage arrangement

etc. but slaughter houses which required repositioning under different schemes have not been effective primarily because the trader's associations resisted the centralized process of slaughter house. In the current system, small and medium traders bring their own animals for slaughter and they take back the meat and all by-products with them. To make this sector dynamic, merely targeting large slaughter houses will not serve the purpose. Value addition at the local level will be more important, as it will limit and reduce transport of animals, reduce environmental pollution, and help animal owners to earn more income by providing them uninterrupted admittance to local market. it is necessity to improve and enhance the private participation since at the industrial scale slaughter houses have been mainly successful in the private sector.

To prevent long distance transportation of live animals and birds and associated losses due to shrinkage, death and diseases, it is suggested to construct one hygienic slaughterhouse at each district place or in each cluster of 2-4 districts with all the facilities for efficient utilization of edible and in-edible by-products and effluent treatment plant. Instead of one big slaughterhouse in metropolitan cities, it is suggested to establish few modern slaughterhouses surrounding the city in peri-urban areas so that the small meat traders (with 3-5 animals) need not to transport the animals for long distance.

2.6.1.10 Strengthening policy support

Livestock sector did not receive the policy and financial attention it deserved. The sector received only about 12 per cent of the total public expenditure on agriculture and allied sectors, which is disproportionately lesser than its contribution to agricultural GDP. The budget allocation to livestock sector must be more than 30 per cent of agriculture, matching to its contribution in agricultural GDP. The sector too has been neglected by the financial institutions. The share of livestock in the total agricultural credit has hardly ever exceeded 4 per cent in the total (short-term, medium-term and long-term). The institutional mechanisms to protect animals against risk are not strong enough. Livestock extension has remained grossly neglected in the past. Only about 5 per cent of the farm households in India access information on livestock technology. These indicate an apathetic outreach of the financial and information delivery systems (Planning Commission, 2012).

Currently, only 6 per cent of the animal heads (excluding poultry) are provided insurance cover. As per Livestock Census, the total livestock population consisting of cattle, buffalo, sheep, goat, pig, horses & ponies, mules, donkeys, camels, *mithun* and yak in the country is 512.05 million numbers in 2012. The total livestock population has decreased by about 3.33 per cent over the previous census. Livestock population has increased substantially in Gujarat (15.36%), Uttar Pradesh (14.01%), Assam (10.77%), Punjab (9.57%) Bihar (8.56%); Sikkim (7.96%), Meghalaya (7.41%), and Chhattisgarh (4.34%). The total bovine population (cattle, buffalo, *mithun* and yak) is 299.9 million numbers in 2012 which shows a decline of 1.57 per cent over previous census. The number of milch animals (in-milk and dry) in cows and buffaloes has increased from 111.09 million to 118.59 million, an increase of 6.75 per cent. The number of animals in milk in cows and buffaloes has increased from 77.04 million to 80.52 million showing a growth of 4.51 per cent. The female cattle (cows) population has increased by 6.52 per cent over the previous census (2007) and the total number of female cattle in 2012 is 122.9 million numbers. The female buffalo population has increased by 7.99 per cent over the previous census and the total number of female buffalo is 92.5 million numbers in 2012. The buffalo population has increased from 105.3 million to 108.7 million showing a growth of 3.19 per cent. The exotic/crossbred milch cattle increased from 14.4 million to 19.42 million, giving rise to an increase of 34.78 per cent whereas the indigenous milch cattle increased marginally from 48.04 million to 48.12 million, an increase of 0.17 per cent. The milch buffaloes increased from 48.64 million to 51.05 million with an increase of 4.95 per cent over previous census. In 2014-15, 14.80 lakh animals were insured, the number came down to 7.65 lakh in 2015-16 and 7.44 lakh in 2016-17. Thus, it is clear that the number is less than miniscule.

The benefit of food processing sector should also be extended to dairy processing and meat processing sectors. The dairy cooperative societies should be exempted from the purview of income tax and Cess. In the list of food commodities covered under FTA with Australia and New Zealand, milk and milk products

should not be included. If we look at the comparison of Milk market size of India and New Zealand Export (as per USDA estimates) then we can understand the aftermath of bringing dairy products under FTA in India.

Further, the animal husbandry sector should be treated at par with agriculture sector, in all terms including investments, incentives and electricity and water and other charges.

Table 2.6.3 Comparison of milk market size of India and New Zealand Export (as per USDA estimates)

	Indian market size	New Zealand Export (million tons)
Skim milk powder (SMP)	3,00,000	3,58,000
Whole milk powder (WMP)	12,000	13,69,000
Butter including ghee	1,20,000	5,01,000
Cheese	40,000	3,22,000
Total	4,72,000	25,50,000

(Source: USDA Estimates-2018-19)

2.6.2 Existing Government Policies and Programs

Several policy interventions have been introduced along with systematic identification of domains where the probability of adoption is high. During XII Five Year Plan, Department of AH&D, is running two very important programs for livestock sectors in Mission mode. These are i). "Rashtriya Gokul Mission" for Bovine and, ii). National Livestock Mission for Non-bovine livestock species. National Livestock Mission and Rashtriya Gokul Mission are to address the problem of (i) availability of elite germplasm (of high genetic merit) of livestock breeds and poultry; (ii) problem of feed and fodder resources for genetically improved livestock and poultry including grazing land; (iii) health management - vaccination, de-worming and disease diagnosis & treatment; (iv) credit, insurance and marketing facilities to the farmers

A. *Rashtriya Gokul* Mission

It is the part of mega program "National Program for Bovine Breeding and Dairy Development (NPBBDD)". Major components of NPBBDD include (i) National Program for Bovine Breeding; (ii) National Program of Dairy Development and (iii) Rashtriya Gokul Mission. "Rashtriya Gokul Mission" started with development and conservation of indigenous breeds. The objective of the scheme is to provide breeding services at the farmers' doorstep for genetic improvement of cattle and buffaloes, providing multi-purpose AI technicians for rural India (MAITRIs) and streamlining of liquid nitrogen storage and distribution system. Two new "National *Kamdhenu* Breeding Centers" (one in Madhya Pradesh and one in Andhra Pradesh) has been established for which an amount of Rs 50 crore has been released.

B. National Mission on Bovine Productivity

This scheme was initiated in 2016-17 for a period of 3 years with a financial allocation of Rs 825 crores. The scheme has been currently subsumed under the umbrella scheme "Rashtriya Gokul Mission". The scheme aims towards faster genetic improvement of bovines for milk production in the country by using advanced breeding techniques.

C. Dairy Processing and Infrastructure Development Fund

Under this scheme, Dairy Processing and Infrastructure Development Fund (DIDF) of Rs10, 881crore has been set-up. Loan assistance is provided through NABARD at the subsidized rate of 6.5 per cent per annum to the milk cooperative institutions. The benefit of the scheme will be provided in 3 years (2017-18 to 2019-20). Under this scheme, 95 lakh dairy farmers will be benefited from additional milk procurement. A target of establishing 28,000 bulk milk coolers (BMC) in 50,000 villages has been envisaged. Additional milk chilling capacity of 140 lakh litres per day and additional milk processing capacity of 126 lakh litres per day will be set-up.

D. National Livestock Mission

The NLM has been formulated by subsuming and modifying 7 Centrally Sponsored and 7 Central Sector Schemes of non-bovine livestock species of Government of India. The NLM commenced from 2014-15 has major objectives of reducing the gap in demand and availability of feed and fodder; conservation and improvement of indigenous breeds; higher productivity and production in a sustainable and environment

friendly manner; enhanced livelihood opportunities, especially in rainfed areas; better availability of quality animal products to consumers; and overall socioeconomic upliftment of livestock rearers. Under the umbrella of NLM, there is need to augment the efforts of the states to allow small and marginal farmers to gain better price realization, access to markets, improved technologies for value addition and technical support. The scope and coverage of livestock insurance has been increased from 300 districts to all 716 districts. Coverage of livestock insurance has been extended from 2 to 5 milch animals/ other animals or 50 small animals. However, the marketing of livestock has not been given due attention either in National Livestock Mission or in Rashtriya Gokul Mission.

E. Animal Husbandry Infrastructure Development Fund

In Union Budget 2018, the provision for around Rs 2450 crores, for establishment of Animal Husbandry Infrastructure Development Fund (AHIDF) has been made. This is a unique initiative. This fund will enable the small and poor farmers and entrepreneurs, especially women, self-help groups, weaker sections to avail latest infrastructure facilities and to get better remuneration for their produce.

2.6.3 Human Resource Development

For effective transfer of technologies of animal husbandry and their implementation at end user level, it is important that adequate number of trained manpower and training facilities are ensured. Networking of institutions with KVKs and other local bodies may be an option in this line. In addition to graduates in veterinary, animal husbandry and dairy sciences, there is urgent need of a policy for developing trained para-veterinarians, inseminators, vaccinators, technology agents and the diplo mas in dairy processing units.

2.6.4 Recommendations

1. Shortage of good semen doses, which has resulted in about 10 per cent of the total breedable and calvable milch animals not being calved even once in their life, is due to non-availability of high number of quality bulls. As such, to maximize the use of available limited germplasm, the promising reproductive biotechniques like multiple ovulation and embryo transfer (MOET) and ovum pick-up and *in vitro* fertilization need to be utilized to the maximum extent at least for breeding bull production. MOET, sexed semen and sexed embryos of exotic germplasm also need to be used for faster multiplication of superior animal with high genetic potential either from crossbred or non-descript indigenous cattle. Further, to bridge the gap between demand and availability of male germplasm, a project/scheme to rear “the male calf to bull”, which is already in place in some states, needs to be initiated by all state governments or the central government by giving incentives to animal farmers. Similar schemes are also needed for goat and sheep husbandry for rearing males of improved breeds in their breeding track.
2. Presently, there is considerable shortage of veterinarians. Hence, the services of veterinarians need to be utilized only for specialized activities like precision livestock production, treatment and health cover and not for AI, vaccination etc. In order to ensure these field activities, the unemployed youth could be trained to work as para-vets to provide door-to-door AI and vaccination services, rather more efficiently.
3. Diseases like FMD and udder infection cause annual loss of at least about Rs 20,000 and 6,053 crores, respectively. By only controlling FMD, the milk production can be increased by at least 5 per cent annually and the export of meat could be enhanced by 3-5 times. However, there is a big gap between demand and availability of different vaccines to control them, as against the demand of about >1000 million doses of FMD vaccines, total doses produced in India is not more than 400 million. A strong program is therefore, needed to produce the required quantity of vaccines against common diseases of cattle, buffalo, sheep, goats, pigs, horses and poultry and if needed, the requirement may be met through import from other countries. PPP could offer great opportunities in planning and implementing livestock disease control programs. They can also be active partners in developing a comprehensive package about disease awareness, epidemiology, surveillance, management and control measures for knowledge empowerment of farmers.

4. The projected demand for dry fodder, green fodder and concentrate for 2020 is 468, 213 and 81 million tons on dry matter basis, whereas the availability is estimated to be 417, 138 and 44 million tons leaving a short fall of 11, 35 and 45 per cent, respectively. It is important that a very well planned program needs to be initiated by the Goverment to record the GIS based area under fodder cultivation and increasing the area to at least 10 per cent of irrigated land (as against present 4.6 per cent of the total cultivated area) under fodder production. For this, better coordination and management between crops and animal science sectors is required, quality forage seed production chain must be maintained, a five year rolling plan be prepared and the role of private sector, as in other seed sectors, must be encouraged. Further, in view of the higher demand of fodder seed, emphasis need not be given only on certified seed but truthfully labelled seed may also be permitted in some specific cases.

5. Presently, different livestock species are having a big proportion of non-descript population. As per the Breed Survey-2013 of Government of India, the proportion of non-descript population is 59.3, 43.4, 61.3, 38.7, 73.1, 28.2 and 80.4 per cent in cattle, buffalo, goat, sheep, pig, camel and horses/ponies, respectively. Indigenous animals have advantage of sustainable production under low input and are known for their drought tolerance and disease resistance. Therefore, there is a strong need to complete the inventories of livestock and poultry by characterization and registration as breeds and to establish a legitimate authority to register and conserve all recognized breeds of all kinds of domestic animals and poultry diversity, similar to PPV&FR Authority for plant varieties. Such Act will also protect the Livestock Keepers' Rights in the country.

6. Livestock is a state subject and all the states are developing its breeding policies for livestock following the broader guidelines of government of India and as per the need and capacity of the state. Most of states have developed Breeding Policy but for bovines only. It is recommended that- i) the Livestock Breeding Policy needs to be developed on priority for all species (including indigenous animals for their conservation, improvement and upgradation) and under different production systems and agroclimatic zones; ii) Livestock Breeding Acts under Livestock Breeding Policy be formulated in each state as has been done in Punjab, iii) the standards of semen/embryo and its production system in terms of veterinary norms and genetic merit be checked by the government through legislative procedure as a lot of agencies of public and private sectors are involved in its implementation and iv) the technical ability of AI workers be certified by government so as to avoid any type of long term problem to animals in terms of disease and poor genetic improvement.

7. As per ADEDA, India has more than 1,000 slaughter houses (big and small) with very few as modern abattoirs where the small and medium traders bring their animals for slaughter and take back the meat and all by-products with them. To make this sector dynamic, it is recommended that- i) in addition to large slaughter houses, improving the small ones at local level will be more important, as it will limit and reduce transport of animals, reduce environmental pollution, and help animal owners to earn more income by providing them uninterrupted admittance to local market; ii) to construct at least one modern and hygienic slaughterhouse at each district place or in each cluster of two or more districts with all the facilities for efficient utilization of edible and non-edible by-products and effluent treatment plant that will prevent long distance transportation of live animals and birds and associated losses due to shrinkage, death and diseases, and environmental pollution; iii) to improve and enhance the private participation, since at the industrial scale slaughter houses have been mainly successful in the private sector, and iv) exclusive animal protein food parks/food hubs for meat/fish/poultry/egg may be created as in the currently approved food parks/mega food parks there exist hardly any such units.

8. Value addition to dairy products ranging from branding of milk, *dahi* to highly industrialized yogurts, cheese including Mozzarella, whey powder, dairy probiotics and dairy nutraceuticals have provided handsome returns and therefore, became imperative for the dairy industry. To harness the full potential of livestock products, it is recommended to establish the "Special Animal Product Zones (SAPZ)" for value addition in order to promote the export of livestock products, on the lines of "Special Economic Zones", in areas around breed specialty in their breeding track and may be linked with an export

based processing plants, compound feed industry, regulated animal market, veterinary polyclinics, semen bank etc.

9. Livestock sector though very important for sustainable development of agriculture and nutritional security has not received the policy attention and funding support as it deserved. It received only about 12 per cent of the total public expenditure on agriculture and allied sectors, which is disproportionately lesser than its contribution to agricultural GDP. The sector has been neglected by the financial institutions too. The share of livestock in the total agricultural credit has hardly ever exceeded 4 per cent in total (short-term, medium-term and long-term). The institutional mechanisms to protect animals against risk are also not strong enough. Currently, only 6 per cent of the animal heads (excluding poultry) are provided insurance cover. Livestock extension has remained grossly neglected in the past as only about 5 per cent of the farm households in India access information on livestock technology. Therefore, it is recommended that: (i) the budget allocation to livestock sector must be more than 30 per cent of agriculture, matching to its contribution in agricultural GDP; (ii) all the benefits and incentives including credit at low interest rate, free water, free electricity etc. of agriculture sector must be extended to livestock sector; (iii) all the benefit of food processing sector should also be extended to dairy processing and meat processing sectors, the dairy processing plant and/co-operative societies should be exempted from the purview of income tax and Cess , and (iv) in the list of food commodities covered under FTA with Australia and New Zealand, milk and milk products should not be included.

10. Presently, Department of Animal Husbandry and Dairying, Govt. of India is running two major programs for livestock sectors in mission mode. These are: i). "*Rashtriya Gokul* Mission" for bovine and, ii). National Livestock Mission for non-bovine livestock species. There is a need that both the missions should be merged under one umbrella i.e. "National Livestock Mission", which will have different sub-units including (i) Bovines Mission, (ii) Small Ruminants Mission, (iii) Fodder Mission (with possibility of having corporation like functioning, as NSC or the National Seed Corporation or NSC may have one separate section for fodder seed), (iv) Processing and value addition of livestock products (including infrastructure development for modern abattoir and dairy plants), and (v) Export-import of live animals and livestock products.

2.7 Fisheries Sector

Fish, known to be an important source of high-value protein, essential micronutrients and polyunsaturated omega-3 fatty acids, constitute about 17 per cent of animal protein supply globally and 6.5 per cent of total consumption of protein by human being. India contributes to about 6.3 per cent of the global fish production and is the second largest fish producer in the world. The phenomenal 20-fold growth registered by aquaculture in just over three and half decades, i.e. 0.37 million tons in 1980 to about 7.5 million tons at present, was the principal driver to the fish production in the country. However, as one of the SDGs is to aim for a better aquatic balance, India has a long way to go to become a country which uses 100 per cent sustainable fishing practices. As a result of overfishing and unsustainable fishing practices such as trawling (that damage aquatic life to a large extent), the aquatic ecosystem and the fishing communities (specifically in Maharashtra and Tamil Nadu) have suffered for a long time. With a highly unregulated and informal supply chain, the fishery laws are left up to the communities to interpret without any enforcement. A law under India's Marine Fishing Regulation Act orders "prohibition on certain fishing gear, regulation on mesh size, establishment of closed season and areas, demarcation of zones for no trawling, in addition to other measures such as the use of turtle excluder devices and designation of no fishing areas", most of which are highly unregulated.

2.7.1 Current Status

The fishing industry in India employs over 14 million people, according to a survey conducted by FAO. Fish production in India since independence has shown overwhelming 16-fold growth, with increase in production from 0.75 million tons in 1950-51 to 13.7 million tons during 2018-19 of which 65 per cent was from inland sector (Fig. 2.7.1 & Fig. 2.7.2). Almost 50 per cent of inland fish production is from culture fisheries which constitutes 6.5 per cent of global fish production and 5 per cent of global trade. The sector contributes about 0.9 per cent to the national GVA and accounts for 5.23 per cent share of agricultural GDP (2018-19). The export earnings from the sector have reached a new high of US$ 7.08 billion (Rs 47,620 crores) during the financial year 2018-19, with shipment of 1.38 million tons of seafood, mostly frozen shrimp and frozen fish

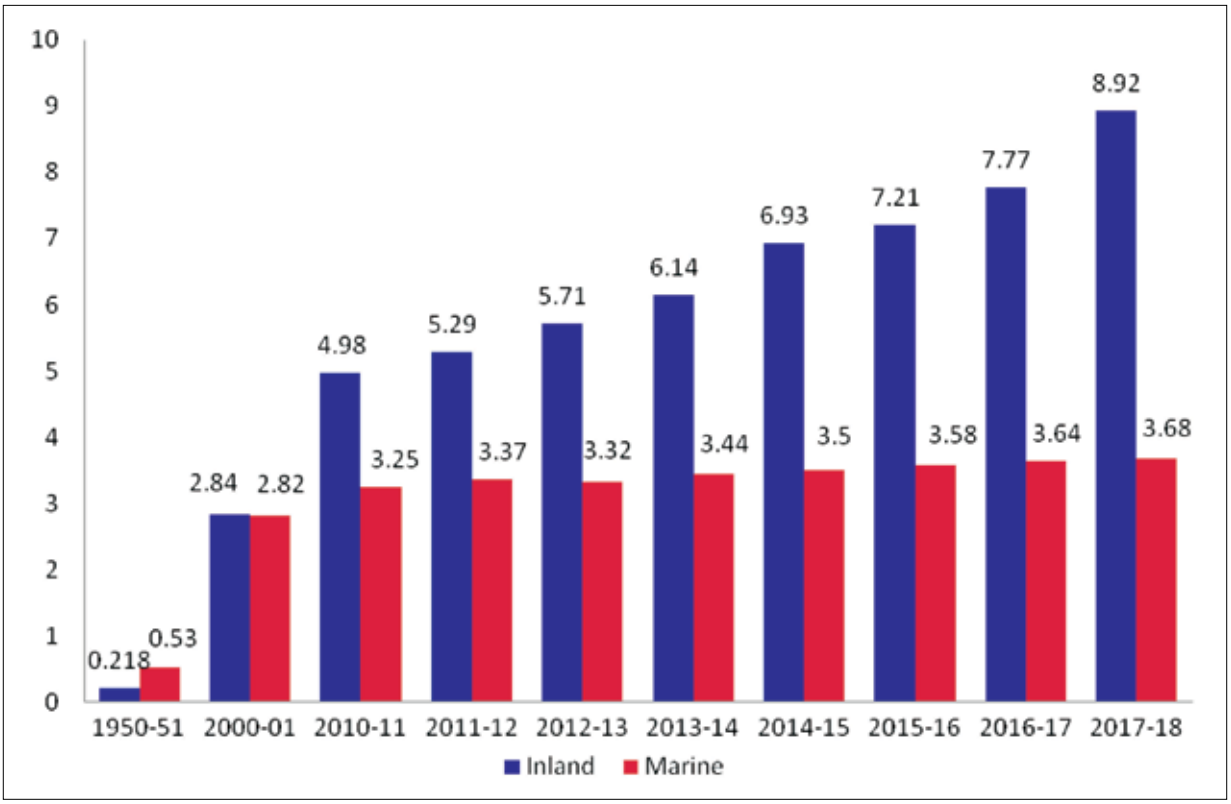

Fig. 2.7.1 Inland & Marine Fish Production in India

(Source: DoAHD&F, 2017-18)

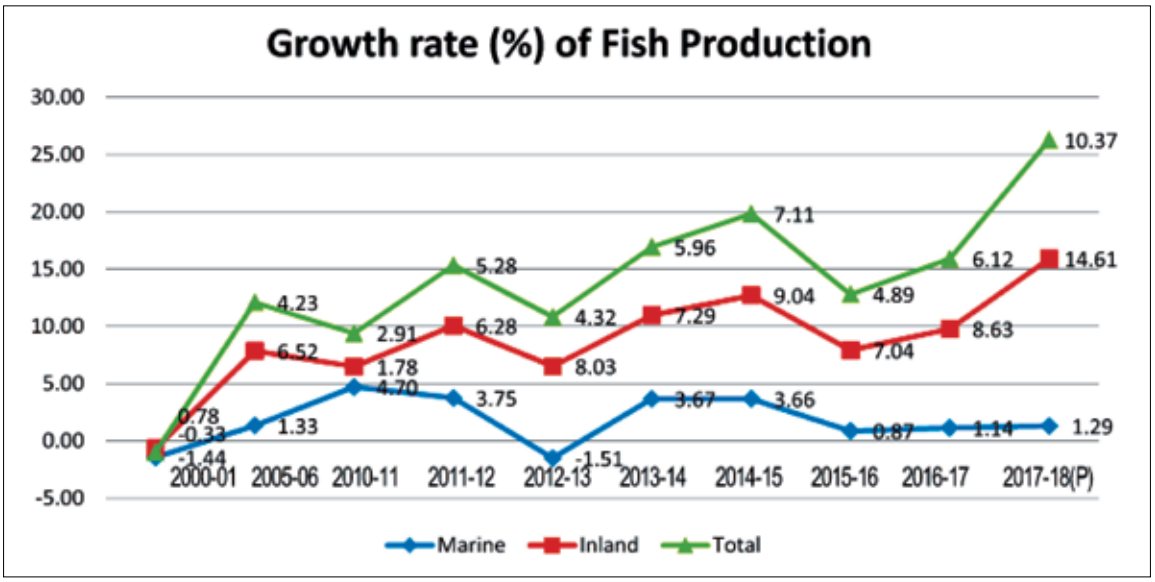

Fig. 2.7.2 Growth Rate of Fish Production in India

(Source: DoAHD&F, 2017-18)

as the major items. Fishery is a fast-growing sector in India, which provides nutrition and food security to a large population of the country besides providing income and employment to more than 14.5 million people.

While the growth in marine sector is stagnating with CAGR of 2.5 per cent, the inland sector has been growing at CAGR of 5.74 per cent supported by the impressive growth in aquaculture. The shift from marine fisheries to inland has occurred due to stagnation and over capitalization in marine sector which is mostly capture oriented, while the inland sector has expanded at a faster rate due to the unparalleled growth in aquaculture. Among the states, Andhra Pradesh is continued to be the leading state in total fish production followed by West Bengal, Gujarat and Kerala. The support of research institutions through development and dissemination of need based technologies to the stakeholders associated with both capture fisheries and aquaculture, together with implementation of an array of governmental policies have been pivotal in keeping the pace of growth of the fishery sector.

The marine capture fisheries production of 3.84 million tons (Fig. 2.7.1) of the country from the 8,129 km long coast line is primarily being exploited through small-scale fishing. With regards to the contribution in terms of quantity, the production from freshwater aquaculture has been growing over years, with carps contributing major share of about 75-80 per cent of the of total aquaculture production. The initial stage of aquaculture expansion was possible through adoption of two major technologies i.e. composite fish culture for increasing productivity and induced breeding for making seed available. Since then, sector has changed in the multidimensional space with large number of players. With adoption of semi-intensive carp polyculture practice, production levels of 5-6 tons/ha/yr. is generally achieved, although several progressive farmers succeed higher production levels of 10-15 tons/ha/yr. Commercial farming of Pangs catfish, *Pangasianodon hypophthalmus* under monoculture system at commercial levels with production levels of over 20 tons/ha/year has become very common among the entrepreneurs, especially in the state of Andhra Pradesh. The states of Punjab, Haryana, Rajasthan, Chhattisgarh and Jharkhand have also shown impressive growth in recent years. The scale-neutrality of the available aquaculture technologies have been able to suit all group of farmers and entrepreneurs.

A range of diversified culture systems like feed-based monoculture of carnivorous species, integrated farming and hill-stream based flow-through fish culture are also making freshwater aquaculture an increasingly growing activity. Adoption of integrated farming systems with animals and horticultural crops, and thereby recycling of manure and feed resources, has not only demonstrated in reducing production cost of fish substantially, but also raising the income levels per unit area. Recent years have also witnessed increasing thrust on diversification with several regionally-important minor carps, catfishes and other non-conventional species due to their higher consumer preference and market price.

The share of coastal aquaculture which remained as shrimp-centric, although has not been quite significant in terms of quantity (about 6.0 lakh tons during 2017-18), the sector has remained as a major export earner. Today the shrimp farming by and large has been confined to the exotic Pacific white shrimp (*Litopenaeus vannamei*) due to the possibility of its farming at higher stocking density and availability of specific pathogen free (SPF) seed.

In view of the huge potential for fisheries development in the country, particularly in aquaculture, coastal and marine fisheries and export of sea food, the Fisheries Department under Ministry of Animal husbandry, Dairying & Fisheries (MoAHD&F) of the Government of India is implementing a mega scheme under the umbrella of Blue Revolution for overall development of the fisheries sector including improving the livelihood of the fishers. The National Fisheries Development Board (NFDB) under the MoAHD&F is implementing this scheme which covers quality seed production, aquaculture in ponds and tanks, reservoir fisheries development, cage & pen culture in open-waters, coastal aquaculture, mariculture, etc. The fisheries and aquaculture sector possesses great potential to contribute many of the SDGs, covering poverty, hunger and food security protection, restoration and management of inland and marine water resources, ecosystems and biodiversity, economic growth, employment, climate change etc.

2.7.2 Challenges and Opportunities

(i) Aquaculture

Aquaculture is one of the fastest growing food production sector in the world. There are immense opportunities to enhance aquaculture production in the country through both horizontal expansion as well as intensive farming using improved strains and new candidates, new aquaculture cluster sites, promoting new technologies, i.e. re-circulatory aquaculture system (RAS), integrated multi-trophic aquaculture (IMTA), cage culture, and above all technology upscaling and enabling policy environment to support entrepreneurship. This has to be across the aquatic ecosystem including freshwater, brackishwater and mariculture.

Although large percentage of fish farmers in the inland sector resort to grow-out fish farming in ponds, the necessity of multi-tire nature of farming practice provides enormous scope for the small/marginal farmers resorting to the nursery rearing of fry and also fingerlings/juveniles production, wherever feasible. Further, with the culture of exotic Pangas catfish exhibiting tremendous potential for its farming in cage culture system, it is envisaged that over 3.0 million ha of available reservoir resources in the country would be effectively brought under this economic enterprise. With current utilization of just 15 per cent of the potential area under coastal land-based shrimp farming, the sector looks for horizontal expansion and also species diversification with cultivable brackishwater finfishes. Demonstrated feasibility of economic utilization of inland saline areas for shrimp farming ensures vast opportunity for economic utilization of this large available resources in the states of Haryana, Punjab, Rajasthan and Uttar Pradesh. Successful demonstration of cage culture of marine finfishes, viz., seabass, tilapia cobia, groupers and pompano, and availability of the technologies of their large-scale seed production would attract more investments for commercial enterprises all along our coastal waters and inland saline areas.

Considering increasing deficit of fingerlings and juveniles of cultivable species, it is necessary that more farmers are encouraged for taking up fingerlings and yearlings production. With increasing thrust on diversification, seed production of new candidate species need to be intensified through incentivizing new hatchery establishment and their seed production chain. Seed availability need to be assured through commercial production of as many species from 60 fish and crustacean species for which the technologies of breeding and seed production are already available. 'Mission Fingerling', the program launched recently by the National Fisheries Development Board (NFDB), and varied promotional schemes of the State Fisheries Departments encouraging fingerling production are important steps forward for increasing assured fingerlings supply.

Necessity of hatchery accreditation and seed certification, though emphasized time and again, has not bee given due attention and there is urgent need for necessary action for their effective implementation

to ensure the seed quality and its traceability. Genetic stock improvement through selective breeding has demonstrated to be an effective tool for increasing production potential of the fish species. In this direction, apart from the successful production of improved *rohu* 'Jayanti', efforts are on for improving catla and freshwater prawn. Therefore, it is appropriate that similar programs are undertaken in other potential fish species, ensuring required investments.

The coldwater aquatic resources of the country comprises of 10,000 km of stream/rivers, 20,500 ha natural lakes, 50,000 ha of reservoirs and 2,500 brackish water lakes. This is a huge untapped resource. Besides promoting public-private partnership in trout farming, hatcheries have to be established for seed production of coldwater fishes such as common carp (improved strain), snow-trout and mahseers. Rehabilitation and development of mahseer sport fishing for the economic benefit of hill population are required. The states which have declared *mahseer* as State Fish, viz., J&K, Himachal, Uttarakhand and Arunachal Pradesh should prepare a time bound strategy with central and state funding for its realization.

The issue of scarcity of water for inland aquaculture and fisheries is the most serious one. India is already a water scarce country with village ponds and tanks getting dried up and ground water going down and facing increasing competition from industry and urbanization. There is a need for recharging of traditional ponds and efficient water harvesting systems through appropriate efficient technologies and water budgeting. In addition, identification of species and their domestication requiring less water especially for their culture and survival are suggested to be promoted. The country at present produces over 48 billion of fry, mostly of carps, and is considered self-sufficient. However, availability of adequate fingerlings of desired species which is recommended for stocking for grow-outs has been an issue, largely due to shortage of rearing space and problem of long distance transportation. Therefore, most of the resources are stocked with fry, leading to poor survival and low production. The other challenges include diversification in aquaculture including species and new technologies, which remains vital in the context of reduced availability of several species of regional importance in the nature. There has been shrinkage of water table, frequent drought situation, and changes in climatic and rainfall pattern which are important for fish farming. Although the consumptive water use in aquaculture is low, adequate quantity of quality water is a prime requisite. In such situation, increasing aquaculture production in the country through competition for water share with agriculture and allied sectors is going to be the most important challenge in the future. Budgeting water requirement in the different types of fish seed and grow-out production system has been a long pending research issue in the freshwater sector. Consideration of water availability can be the major deciding factor in future for determining the level of aquaculture intensification while ensuring the environmental sustainability.

A technology adoption and upscaling for commercial seed production of fish species presently used in mariculture is required to meet the growing demand of sea food. In order to realize the blue economy potential of the coastal states, we need to intensify our effort in finfish, shellfish and seaweed culture in the sea and a program in mission mode is strongly recommended

(ii) Integrated farming

Integration of fish with horticulture, poultry, pig, paddy, etc. has demonstrated high returns. Currently when doubling farmers' income is being emphasized, focus on integrated fish farming will play a significant role in this endeavour. Farming system research and promotion through technology development in integrating fish with others and dissemination has great potential for higher profitability of the farmers. Paddy-cum-fish culture is successfully practiced in eastern and North-Eastern parts of the country which needs upscaling. Fish-cum-pig farming, has become very popular in some North-Eastern states as there is no social taboo for pork. Duck-cum-fish culture, poultry-cum-fish culture are also proven technologies with immense potential for upscaling. Integrated fish farming is better option for utilizing the small farm units for generating livelihood, nutritional security and higher income. These systems are used by rural households in Odisha with good success. Integrated fish farming is most suitable at small and medium scale operation in tribal areas where traditional livestock farming is part and parcel of livelihood. And for this, skill development training has to be organized for various aspects. In addition, insurance for livestock and fish and measures for disaster management and awareness for healthy hygienic product has to be

created amongst the stakeholders. However, care must be taken against possible emergence of inter-specific transmittal of pathogens causing disease like swine flu.

(iii) Value added products, trade and export

Ready-to-cook and ready-to-eat fish products including product branding with required nutrition, taste and flavour as per the need and preference of consumers hold great promise and would be a major contribution of the sector both for domestic as well as the international markets in the years to come. The current commercial value added products in the market include, fish fingers, fish cutlets, fish balls, and fish nuggets besides the fish and shrimp pickles. The emphasis needs to be on new coated products, cold chain facilities, innovative value addition and packaging such as smart packaging techniques and effective post-harvest management for increased shelf life.

Domestic marketing infrastructure is not adequate considering the perishable nature of fish products. Lack of domestic storage, marketing and cold chain infrastructure leads to distress sale by farmers/fishermen incurring losses. Development of hygiene fish markets and associated supply chain throughout the country, especially in urban areas, must be given greater thrust, since this would ensure round the clock availability of quality fish for the consumers. The National Fisheries Development Board has undertaken this aspect under the Blue Revolution scheme of the Government of India. The processing facilities for value added products needs higher investment to promote value chain and cold-chain infrastructure. Modernization of processing facilities to maintain high quality control norms as per the international standards is imperative but requires heavy investment. Development of domestic markets across the country with high hygiene including promotion of live fish market needs to be taken up on top priority.

India is one of the leading country in sea food export. The key export markets for India include USA, South East Asia, EU, Japan and Middle East. Our major exports are in frozen and chilled form with only 10 per cent or so in the value added form. Efforts leading to more value addition in export items will bring higher value per unit and thus enhancing the income towards foreign exchange.

(iv) Capture fisheries

The inland water resources in India include 29,000 km of rivers, 3.15 million ha of reservoirs, 2.35 million ha of ponds and tanks and 0.2 million ha of flood plain wetlands. The inland capture fish production has reduced considerably due to anthropogenic changes in the freshwater ecosystem. However, the reservoirs and floodplain lakes offer an opportunity for enhanced fish production provided these water bodies are stocked with seed of required size and quality.

The marine capture fisheries is currently plagued with declining catches and excess capacity of fleets besides pollution and climate variability. Region-specific management plans need to be made and implemented jointly by central and state governments providing solutions for over-capacity of fishing fleet, use R&D data for the recovery of depleted resources, co-management and ecosystem approach to fisheries management and alternate livelihood options for the coastal communities. It is extremely important to tap the potential of the blue economy. India has strategic location in Indian Ocean Region (IOR) and on this basis, it endorses growth of blue economy in sustainable, inclusive and people centered manner through framework of Indian Ocean Rim Association (IORA). The initiatives of the GoI, namely, Sagarmala, Blue Revolution and the newly announced *Pradhan Mantri Matsya Sampada Yojana* (PMMSY) are aimed to address the critical gaps in the value chain including infrastructure modernization, traceability, production, productivity, post-harvest management and quality control.

The capture fisheries resources and production have come down drastically for many species affecting the livelihood of the small-scale fishers, both in inland and coastal states, with increasing indebtedness. Since the scope of increasing capture fisheries related to small-scale fishers is limited, alternate options for livelihood have to be provided. The economic empowerment of fisher women is one such priority where capacity building and their involvement in value addition and other skill related professions will be extremely important and needs to be encouraged.

Climate change is impacting the pelagic catches in the coastal states as has been revealed by studies under ICAR-NICRA Project, threatening the livelihood of fishermen. The findings of the ICAR-NICRA project on climate change have to be taken to practical solutions by the appropriate interventions of research and development departments besides the policy support. Fishermen life matters most than his livelihood. The marine fisheries policy has not realized and addressed the seriousness of the life of fishing communities. Fishing in the sea is one of the most dangerous activities. Erratic weather conditions, because of the global warming will add to the problems of fishing in coastal regions, sea and ocean. Thus, safety at sea needs immediate intervention. Fishermen training programs in all maritime states on accident prevention, response in emergencies and survival at sea need to be given priority. Small-scale fisheries in terms of provision of training and equipment comparable to that of in large-scale fishing to be given more priority. FAO reports that about 11-26 million tons of fish comes under illegal, unreported and unregulated (IUU) fishing. This is one of the serious challenges. This undesirable activity is invariably done in open-seas and oceans by advanced fishing vessels of various countries. India being one of the forerunners in space technology, there is a great need to explore the possibility of satellite surveillance to prevent and catch the culprits. Further, country needs to have a strong surveillance of the fishing activities in the open seas and monitoring of fish catch in landing centres.

(v) Fish nutrition and health

Fish feed accounts more than 60 per cent of the operating cost in aquaculture. Hence, development of economical/cost effective feeds for various stages of cultured fish remains elusive and needs top priority. Availability of low cost feed will contribute significantly to the endeavour of doubling the farmers' income. Hence, new feed mills to produce cost effective feed using local resources with existing scheme of Blue Revolution across the country in all major fish producing states can meet the local requirements and boost aquaculture production. Necessary technical support is instrumental for greater adoption of farm-made feed by the small farmers using local ingredients. Cost-effective feed for aquaculture remains a challenge for several years. Supplementary feeding constituting over 60 per cent of the input cost of fish culture operation. The farmers continue to use raw feed mixture of oil cake and rice bran to safeguard the profit margin and often compare the cost of the conventional mixture with that of pellet feed without considering feed conversion ratio (FCR). The adoption of use of farm-made feed by the small farmers using local ingredients has remained low

Fish health care and water quality maintenance are of paramount importance in commercial aquaculture. The parasitic and microbial disease in aquaculture remains a major problem, which sometimes wipes out the entire crop and without exception it is found to affect the growth of the cultured species substantially. Diseases like epizootic ulcerative syndrome (EUS) in freshwater aquaculture and white spot syndrome virus (WSSV) in coastal shrimp culture are a few such examples those have been serious causing concern in Indian fish culture systems. The disease and water pollution take a heavy toll on aquaculture operations. The local expertise in fish health and water quality management is lacking at present. The KVKs of ICAR are to be equipped with such expertise /positions in both coastal and inland areas where fish farming is practiced. Establishment of disease diagnostic labs at state level and in cluster of aquaculture important districts, with adequately trained experts would be necessary to have proper disease diagnosis and taking corrective measures. Further, disease surveillance needs to be strengthened for whole country in order to have greater preparedness for any endemic and new disease outbreaks. Risk of new disease outbreaks, especially due to trans-boundary movement, diversification, intensification and poor water quality remains a major challenge. Easing incidence of fish disease has been major threat in aquaculture systems. Disease outbreaks by WSSV, acute hepatopancreatic necrosis disease (AHPND) and enterocytozoon hepatopenaei (EHP) in coastal shrimp farming over the years are a few

The country has set its ambitious target of fish production of about 17 million tons by 2030. Although the marine production after long period of stagnancy has shown a little sign of improvement, the entire additional supply has to be catered largely by aquaculture. Bridging the deficit in fish supply, particularly when the marine capture has reached a plateau, is definitely a challenging task. This is particularly important as the increase in the production has to be made against the odds of emerging challenges. By 2030 aquaculture will be responsible for nearly two-thirds of India's fish production, according

to projections by the FAO. Low investment capacity of the farmers, inadequate knowledge and skill on modern technologies, limited access to technological know-how, reducing per capita land holding, credit market and public goods like irrigation and power supply, appropriate extension services, etc. have been some of the perpetual issues those our small aquaculture farmers encounter in most part of their farming operations. The major challenges of the sector include effective utilization untapped resources, technology dissemination, diversification in aquaculture, climate change and enabling policy framework along with sustainability of the resources and the systems. A comprehensive reassessment and development of the water bodies in the inland sector usable for aquaculture at district level is needed along with revamping of policy for leasing of these resources. Reservoirs, ponds and wetlands are resources having considerable potential. Similarly, in the marine sector, the deep sea resources have largely remained unexploited due to constraints of resource specific vessels and skills requiring considerable investment and technology import/tie-up. The expansion of the mariculture activities which hold great promise in coastal states need appropriate policy support for leasing of potential areas and greater investments. In the absence of appropriate technology and policy framework, major aquaculture resources such as inland open water bodies (reservoirs, lakes, beels) and marine resources (open-sea) for cage farming are yet to be exploited.

(vi) National Mission on Fishery Development

The National Mission on Fishery Development (NMFD) for integrated development and management of fisheries, (2015-16 to 2019-20) along with the *Pradhan Mantri Matsya Sampada Yojana* (PMMSY-2019) should factor in the sustainability challenges and exploit the blue economy for considerably improving the standard and quality of life of the coastal fisherman along with strengthening the infrastructure and overall fisheries management framework. The allotment of government land to willing fishery graduates and entrepreneurs besides the cooperative societies for aquaculture by the state governments will be a game changer for entrepreneurship development and meeting the targets of blue revolution. Urgent attention is needed for effective monitoring and evaluation of the activities under the mission to harness the maximum gains. Sufficient allocation of resources be made available and concerned Coastal States be asked to match the grant by 50 per cent for the various activities linked to fishery sector development. Life insurance for all the fishermen be made compulsory.

2.7.3 Recommendations

1. The quality of fish seed used in aquaculture as well as for stocking in natural waters is a major concern at present. This is the reason for low productivity in reservoirs as well as in pond culture. Therefore, accreditation of hatcheries and seed certification by an agency is an urgency of paramount importance to ensure seed quality. The upscaling of the culture technology of species of regional importance is to be achieved as comprehensive diversification plan in a mission mode with collective efforts of research and development departments including the ICAR and the state governments to meet the emerging needs of diversification in freshwater, brackish water and sea farming. The increasing interest of the farmers in intensive culture of sea bass and tilapia in inland saline areas are required to be addressed by seed availability of the desired quality.
2. Improved feed management through development of cost-effective feeds along with efficient feed management systems needs special emphasis because feed accounts for more than 60 per cent of the operating cost in aquaculture. Hence, research and development to reduce input costs and provide nutritive diets for both larval and brood fish is the need of the hour. A public -private partnership in establishing feed mills in every state with targeted objectives is recommended with financial support from National Fisheries Development Board (NFDB) under the Ministry of Animal Husbandry, Dairying and Fisheries, Government of India.
3. The development of improved strains of fish and shellfish with efficient dissemination strategies are critical for enhanced aquaculture production, food security and income of the farmers. The development and dissemination of the seed of GIFT Tilapia and Jayanti Rohu are success stories in Asian aquaculture. The seed of Jayanti rohu, an improved strain developed by ICAR needs to be widely distributed to the farmers for enhanced production and income which is a constraint at present.

4. The loss due to disease amounts to be around 10-15 per cent of the production cost in aquaculture and in severe cases even the entire crop is lost. The National Fisheries Development Board has funded a network project on national surveillance program for aquatic animal diseases involving about 25 national/state institutes across 15 states of aquaculture importance in the country. The main objective of this program is to collect information on the spread of disease in aquatic animals and sample analysis by the organizations of the identified partners for the data base. It is recommended to create a network of field and referral laboratories for fish and shellfish disease management in the major aquaculture states under both public and private entrepreneurships by NFDB. The existing disease surveillance program needs to be strengthened with a strong training and capacity building at farmer's level for better health and pond management practices.

5. The modern fish harbours and markets apart from ensuring nutritional and food security will minimize the post-harvest losses, increase revenue, provide employment and promote improved hygiene leading to food safety. Presently, the fish markets and harbours are unhygienic with poor storage and handling facilities. Availability of refrigerated vehicles, good quality ice, waste disposal system etc. are inadequate. The NFDB has supported and created markets in some states which needs to be strengthened further coving all states. The modernization of fish markets and harbours is a must for the safety and health of both the fishers and the consumers. Live fish marketing is to be promoted in the country for fresh supply to the consumers as well as better returns on the products to the fishers.

6. India has enormous potential in ornamental fish trade because of rich biodiversity of species, favourable climatic conditions and cheap labour. Presently, the states of Kerala, Tamil Nadu, Maharashtra and West Bengal are involved in this trade. The North Eastern region, a biodiversity hotspot needs to be developed as ornamental fish production and trade hub for employment generation entrepreneurship. This is necessary because 85 per cent of the freshwater ornamental fish species are caught from natural waters for export from this region badly affecting the natural resources. The programs on ornamental fisheries are to be linked to the industry through public–private partnership for technology upscaling and business modules in a mission mode.

7. Mariculture is the key area expected to contribute significantly to blue economy and providing food and nutrition security to the coastal population. The sea cage farming initiatives in the country needs to be commercialized along with enabling policy support for the benefit of the fishers. The national marine fisheries policy 2017 has also laid great emphasis on mariculture to meet the growing demand of sea food.

8. The new technologies, namely, RAS, IMTA, Bio floc are to be popularized amongst the farmers with required training by all concerned organizations and financial support from the development departments.

9. Fish processing, vale addition and trade of innovative products needs special focus as increasing public awareness of the importance of fish in the diet and human health is driving fish consumption upwards. Establishment of modern fish processing, vale addition and packaging centers will play a pivotal role in efficient post-harvest management.

10. National Mission on Fishery Development for integrated development and management of fisheries, overaching all Central Sector Schemes like Integrated Development and Management of Fisheries, Development of Inland Fisheries and Aquaculture (DIFA), Development of Marine Fisheries, Infrastructure and Post-Harvest Operations (DMFI & PHO), National Scheme on Welfare of Fishermen (NSWF), and along with the PMMSY 2019 should factor in the sustainability challenges and exploit the blue economy for considerably improving the standard and quality of life of the coastal fisherman along with strengthening the infrastructure and overall fisheries management framework.

2.8 Agro-ecology based Agricultural Planning

India is gifted with heterogeneous landforms and variety of climatic conditions such as high mountains, riverine deltas, different altitude forests, peninsular plateaus, variety of geological formations, with temperature varying from arctic cold to equatorial hot, and rainfall from extreme aridity with a few cm (<10 cm) to per-humid with world's maximum rainfall (1,187 cm). These varying environmental conditions have resulted in a great variety of soils and, therefore, land use systems manifesting the agroecology of a habitat. Considering huge variability in the geographical, topographical, social and environmental factors in different parts of the country, and that agriculture being the main livelihood option for our rural population, it is necessary to develop and delineate our major farming practices according to regions/zones in the country so as to improve agriculture, and make it demand driven as well as sustainable.

2.8.1 Status of National Classification for Crop Planning

For crop planning, FAO (1983) considered an agroclimatic zone as a land unit defined in terms of major climatic and growing period, which is climatically suitable for certain range of crops and cultivars. It classified 14 different climates during the growing period under the three main climates i.e. tropical, sub-tropical and temperate, based on temperature and seasonality of rainfall for suitability of crops. There are four climates in tropics, eight in sub-tropics and two in temperate region. It was realized that the requirements of particular crops will depend much on aerial (temperature, radiation, humidity etc.), edaphic (soil, moisture and aeration), pedologic (soil depth, soil reactions), technological (fertilizer, pesticide) and other factors.

Planning Commission of India (1989), aiming at the regionalization of the Indian agricultural economy and to bring integration of the plans of the agroclimatic regions with the State and National Plans, has identified 15 broad agroclimatic regions based on physiography, soils, geological formation, climate, cropping pattern and development of irrigation and mineral resources for broad agricultural planning and developing future strategies. These climatic zones included- West Himalayan region, Eastern Himalayan region, Lower Gangetic Plain region, Middle Gangetic Plain region, Upper Gangetic Plain region, Trans-Gangetic Plain region, Eastern Plateau and Hills region, Central Plateau and Hills region, Western Plateau and Hills region, Southern Plateau and Hills region, East Coast Plains and Hills region, West Coast Plains and Ghat region, Gujarat Plains and Hills region, Western Dry region and Island region. More emphasis was given on the techno-agroclimatic considerations, rather than other social and administrative criteria. In this, the sub-zones were carved out on the basis of the characteristics of soil, topography, climate and water resources. The agroclimatic classification of the Planning Commission was primarily for the developmental purposes.

The ICAR under the National Agricultural Research Project (NARP) funded by the World Bank (1979-1986), divided the country into five broad agro-ecosystems (Arid, Coastal, Hill & Mountain, Irrigated and Rainfed). These were further divided into 14 production systems with each system covering more than one state as existed in 1991. Even the districts of each state within each production system were identified. Subsequently, 128 agroclimatic zones with each state having more than one zone were carved out in the country. The concept of zoning was mainly based on ecological land classification, recognizing various components like soils, climate, topography, vegetation, crops. etc. as major influencing factors. For planning the location-specific research, a status report was prepared for each zone covering information on the natural resources, major crops, farming systems, production constraints and socio-economic conditions. Different farming situations were identified, classified and mapped in each agroclimatic zone. Further, to upgrade each agroclimatic zone, a zonal research station was started as the focal point for generating location specific and need based research relevant for specific agro-ecological situations.

With a view to capturing the importance of socioeconomic endowments, market support and service sector in agricultural development, the ICAR has focused research programs under National Agriculural Technology Project (NATP), 1998 onwards, on the production systems approach, but goes beyond it by integrating all the system components for determining the system productivity and profitability. Under NATP, the country was divided into five agro-ecosystems *viz*., Arid, Coastal, Hill and Mountain, Irrigated and Rainfed agro-ecosystems. The production system, as a concept, takes into account different components

such as crops, trees and livestock, and various factors of production such as soil, water, labour, capital, energy and other resources, and the interaction among themselves as well as with the physical, biological and socioeconomic factors. It is holistic, acknowledges location-specificity of technological solutions, emphasizes on testing and adaptation of technological solutions based on agroclimatic and socioeconomic specificities, is farmer participatory, concerned with `bottom up' strategy, is interdisciplinary, emphasizes extensive on-farm activities, is dynamic, gives weightage to indigenous traditional knowledge (ITK) system, focuses on actual adoption and sustainability. It basically aims at generating and transferring technologies to improve the productivity on a sustainable basis.

Subsequently, ICAR-National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), Nagpur, categorized the country in 54 agro-ecological zones with the concept that an agro-ecological zone is super imposed on physiography and kinds of soils and soil conditions that act as modifiers of climate and length of growing period. Later, ICAR-NBSS&LUP based on the soil data at 1:1 M scale and climatic resource database of 600 weather stations, revised them to 20 agro-ecological regions (AERs) of the country putting emphasis on the bio-climatic regions and the length of crop growing periods (LGP). Out of these 20 AERs, the arid ecosystem covers the first three (AER 1-3), followed by AER 4-9 in semi-arid, AER 10-15 in sub-humid, AER 16-18 in per-humid and the AER 19-20 in the coastal ecosystem. These 20 AERs are further divided into 62 agro-ecological sub-regions (AESRs), based on the sub-physiographic region, length of growing period and bio-climate conditions, for refining regional and national planning. Emphasis on removing imbalance in research efforts through eco-regional inter-institutional approach is given.

Under ICAR's National Innovations on Climate Resilient Agriculture (NICRA) project, district level contingency plans of all states of India have been developed which define strategies to be taken up by farmers in response to major weather related aberrations such as delay in onset and break in the monsoon causing early, mid and late season droughts, floods, unusual rains, extreme weather events such as heat wave, cold wave, frost, hailstorm and cyclone. The project comprised four components: (i) strategic research on adaptation and mitigation, (ii) technology demonstration on farmers' fields to cope with current climate variability, (iii) sponsored and competitive research grants to fill critical research gaps, and (iv) capacity building of different stakeholders.

Presently, the 15 agroclimatic regions as delineated by the Planning Commission with corresponding 128 NARP zones are being considered for agricultural R&D. Inclusion of crops, animals including fisheries in the form of integrated farming system supported well by the socioeconomic considerations is the basis. For sustainable and secure agriculture, it is imperative that location- specific R&D efforts with farmers' active participation be further strengthened.

2.8.2 Opportunities

While agroclimatic zone is a land unit in terms of major climate, superimposed on length of growing period (moisture availability period) (FAO, 1983), the agro-ecological zone is the land unit carved out of agroclimatic zone superimposed on landform which acts as modifier to climate and length of growing period. Therefore, a systematic appraisal of agro-ecological regions has tremendous scope in grouping relatively homogenous regions in terms of soil, climate, physiography and conducive moisture availability periods (length of growing season) in planning appropriate land use, while involving local farmers and communities. Hence, participatory approach while following three principles of ecology: *Holism*= meaning everything is interconnected, *Diversity*-foundation of resilience and *Interdependence*-the win-win principle, becomes critical need to ensure adoption of appropriate cropping and farming systems that are both secure and sustainable.

Agro-ecological based planning is very important for the holistic and sustainable development of national agriculture. Modern agriculture requires precise information of various agroclimatic parameters like soil types, rainfall, temperature, water resources, available genetic diversity, traditional agricultural practices, etc. These parameters affect the vegetation and fauna in an area which constitute an important part of ecological unit. Viewing the agro-ecosystem as a functional system of complementary relations between living organisms and their environment that are managed by humans with the purpose

of establishing agricultural production provides a basis for integrating the overlapping ecological and environmental traits with sociological, economic, political, and other cultural components of agriculture. All of these may vary across space and time. Consequently, varieties and management methods have different optima in different places. The site–season or site–year can be considered as the basic unit of the environment. At any given site, there are aspects that are invariant and stable, e.g. landform, soil type, etc., and aspects that vary with the seasons, e.g. temperature, rainfall and incidence of pests and diseases. Also, the severity or timing of aspects may fluctuate from year to year, depending on, for example, diseases, length of the growing season, etc. These give rise to a potentially infinite number of environments, but only part of the variation is of practical importance. Lack of recognition of such site-specific characteristics, which can have a major influence on crop productivity, had frequently led to adverse consequences in the past.

Considering this, it is suggested to adopt 20 AERs with about 62 AESRs delineated by the ICAR-NBSS&LUP which will help mainly to (i) make a quantitative assessment of the biophysical resources upon which agriculture and forestry depend; and (ii) identify location-specific changes necessary to increase food production, through a comparison of farming systems and production alternatives. With AERs and AESRs, we can make a fairly good estimate of the actual potential for crop production in different areas by (i) setting priorities for use of increased inputs that are needed to increase agricultural production, and (ii) identifying the less favoured environments, in which rural populations are ecologically and environmentally disadvantaged, and the priorities for their development.

The current challenges however, include assessment of yield potentialities of different crops, crop combination in agro-ecological regions/zones; formulation of future plan of action involving crop diversification; dissemination of agricultural research and agro-technology to other homogenous areas, and determination of the crop suitability for optimization of land use in different agro-ecological regions/zones. Thus, an enabling policy environment is required to develop a procedural framework for local assessments under different input levels and climate scenarios for the assessment of (i) land suitability, (ii) risk zoning and hotspot identification (e.g., for biophysical threats), (iii) crop duration and potential, (iv) potential yields and (v) yield gaps for multiple crops, breeds, trees, etc.

Although the soil and climate characteristics and the potential crop productivity in many of the AERs around the country offer much hope for enhancing future food production, the current population increase and the expansion of cultivation of crops not suitable and requiring higher resources, as well as growing of crops into marginal lands is putting increasing pressures on land resources. Continued land degradation will present problems not so much for global supply as for development in particular sub-regions. In these hot spots, land degradation poses a significant threat to food security for large numbers of poor people, to local economic activity, and to important environmental products and services. Future policy should focus on such hot spots. Many bright spots can also be identified–areas where land quality is improving or degradation has slowed down, usually in connection with improvements in rural investment incentives and supportive policies.

The enabling policy should include a strategy to follow the AER approach linking the multiplicity of agronomic, economic and environmental criteria that determine the performance of an agro-ecosystem, and then determine the nature and extent of changes that need to be introduced to achieve greater productivity. For more efficient use of land resources in the future, three points of view should be confronted and integrated in order to diagnose the situation in a given AER, and to establish some of the following trends:

(i) The first important point relates to dynamics of land use and land cover. This refers mainly to the state of the natural resources;

(ii) The second is the dynamics of the production systems, including farming systems as well as the storage and market issues. These refer mainly to the management of natural resources;

(iii) The third important point relates to changing policies, including the problems of equity. This refers mainly to the access to natural resources. Remote sensing developments in the recent years now make it feasible to routinely monitor the dynamics of land use and land cover. On-farm surveys and rapid rural appraisal techniques could be used to establish the dynamics of production systems.

For improved, sustainable and secure agriculture, integrated farming system based on agro-ecological considerations be our future strategy and implemented urgently. This aspect though recognized but has not been actually put in practice on a large scale. For future sustainable agriculture, scientific land-use planning based on available natural resources would be extremely important to achieve the desired success.

2.8.3 Recommendations

The agro-ecology based agricultural crop planning would help us to understand the inter-relationships between agronomic, economic and policy factors, in order to develop conservation-effective and sustainable production systems to meet the food, fodder and fuel needs of the future. The ecologically smart agriculture would require focus on three "A"s i.e. adaptation, awareness and adoption, thus, requiring reorientation of research agenda around farmers needs and most suited farming practices for a defined ecology. Based on the need for agro-ecological awareness and implementation coupled with a requirement for increased communication across stakeholders, a three step process for immediate initiation of ecologically-sustainable agriculture is proposed:

(i) Characterization of agro-ecological zone (AEZ) coupled with establishment of regional AEZ databases.

(ii) Scaling of farmer-led innovations through community and stakeholder involvement using three-way approach of higher adoption, greater relevance and cost-effectiveness and enhanced income in agro-ecology-based agricultural crop planning and implementation.

(iii) Effective use of State Agricultural Extension Offices, e.g. KVKs and ATMAs for information generation, knowledge dissemination and exchange of AEZ based agricultural advisory system for effective mainstreaming to ensure sustainable intensification of agriculture.

2.9 Role of Youth and Women

India presently has the largest global youth population of 356 million between 10-24 years' age group in the world (UN Report, 2014) with greater proportion of nearly 200 million young people living in the rural areas. This obviously be seen as an opportunity for provided they are motivated and attracted to agriculture and allied fields. Contrary to this, only around five per cent of youth is currently involved in agriculture. This is because they do not find agriculture a creative, profitable and above all a respectable profession. In addition, agriculture is currently faced with numerous daunting challenges. Therefore, there is an exodus of rural youth to urban areas in search of alternative employment/option. Youth can be retained in agriculture only when required knowledge and education, technical skills, sustained encouragement and enabling policy environment are provided. In addition, the required policies, incentives and rewards need to be put in place to attract young talents to undertake innovative farming that is not only profitable and sustainable but also respectable. Thus, the new strategy should be to reorient present-day agriculture from crop based to farming system based with emphasis on 'Plough-to-Plate' approach which is more relevant, efficient, demand-driven, productive, competitive and profitable. It must also ensure food, nutrition and environmental security for all, being important to achieve SDGs.

Women are farmers, workers and entrepreneurs, but almost everywhere they face more severe constraints than men in accessing productive resources, markets and services. This "gender gap" hinders their productivity and reduces their contributions to the agriculture sector and to the achievement of broader economic and social development goals. Closing the gender gap in agriculture would produce significant gains for society by increasing agricultural productivity, reducing poverty and hunger and promoting economic growth. Women, like men, need to be considered "productive resources". Women do play a crucial role in agricultural development and contribute in the field of agriculture, food and nutritional security, horticulture, livestock, fisheries, processing, sericulture and other allied sectors. Rural women are thus the most productive work-force in the economy of the country. Gender equality is a SDG in its own right, and it is directly related to the achievement of the SDG targets on reducing extreme poverty and hunger. Agricultural policy-makers and development practitioners have an obligation to ensure that women are able to participate fully in, and benefit from, the process of agricultural development. At the same time, promoting gender equality in agriculture can help reduce extreme poverty and hunger. Equality for women would be good for agricultural development.

Women continue to play a key role in conservation of basic life support systems such as land, water, flora and fauna. The nature and extent of their involvement differs with varied agricultural production systems. In the over-all farm production chain, women's average contribution is estimated at 55-66 per cent of the total labour with percentages much higher in certain regions. Despite women's extensive and varied participation in agriculture, they continue to have lesser access than men to modern agricultural technologies. As a result, their labour intensive efforts invariably yield meagre economic returns. The women invest almost 10 times more of their earnings than men on the well-being of the family, including family health, child health, education and nutrition (Akter *et al*., 2017), yet, they have less access than men to agricultural related assets, inputs and services. Equal access and participation not only can help reduce gender inequality, but also boost crop productivity by 20-30 per cent (TAAS, 2018); and raising of overall agricultural output in developing countries by 2-4 per cent. Women's empowerment thus has a direct impact on the agricultural productivity and household food and more so on nutritional security

2.9.1 Challenges and Opportunities

The principal challenges to retain youth in agriculture include: insufficient access to knowledge, information and education; limited access to land; inadequate access to financial services; lack of formal and informal on-job trainings; limited access to markets and limited involvement of youth in decision-making and policy dialogues. Multiple risks associated with agriculture intensify the challenges owing to over exploitation of natural resources interlinked with rapidly increasing globalization, soaring fuel and food prices, volatile markets, growing climatic extremes and smaller land-holdings. In the past few decades, because of rapid industrialization and urbanization, both youth and agriculture are experiencing

unprecedented transformation. Another important factor is poor social image of agriculture and hence, rural youth are moving towards urban sector, looking for alternative and better opportunities. Overall, the current agricultural policies do not provide attractive and sufficient avenues for engaging youth in agriculture.

On the contrary, youth provides tremendous opportunity as a great resource to be gainfully used for agricultural development. In India, the grand success of "Green Revolution" was achieved due to policy support, and infrastructure as well as human resource development especially of youth. Youth has the capability and capacity to make significant changes in agriculture but needs right policies and proper guidance and training. It is evident through successful business models of leading public and private sector organizations as well as multi-national companies (e.g. IT sector) that youth are more innovative, productive as well receptive to contribute towards new technologies and advancements. Youth power has to be harnessed by motivating them through advancement in innovation, capacity development, partnership, and above all the participatory approach through enhanced skills and positive attitude towards their role in overall agricultural and rural development. This would require developing long-term, consensus-based, and integrated youth policy which should include. creating awareness about emerging opportunities in agriculture, making compulsory agricultural education in schools, improve existing administrative structure, prioritize research and development agenda, enhance public and private funding, and proper policy advocacy. Overall, there is an urgent need for strong political will and enabling policy environment for greater involvement of youth in the AR4D initiatives. Greater thrust needs to be given on foresight, research partnership and capacity development.

Women are farmers, workers and entrepreneurs, but almost everywhere they face more severe constraints than men in accessing productive resources, markets and services. They remain one of the most vulnerable and deprived groups. Women shoulder entire burden of looking after livestock, bringing-up children and performing other household chores. In India, women shoulder the most strenuous activities in farming such as almost 50 per cent transplanting and threshing; 27-30 per cent harvesting, most of fodder and livestock management activities and more than 60 per cent in post-harvest operations. The nature and extent of their involvement differs with the variations in the production systems. However, the exact contribution both in terms of magnitude and nature is often difficult to assess, and shows a high degree of variation across regions. Secondly, their access to material and social resources as well as involvement in decision-making is indeed limited. In India, land ownership most often is with men, and they influence and dictate decisions concerning farming and family affairs. The agricultural produce marketing activities are often controlled by men, thus depriving women of the financial resources.

Women work in agriculture as farmers on their own account, as unpaid workers on family farms and as paid or unpaid labourers on other farms and agricultural enterprises. They are involved in both crop and livestock production at subsistence and commercial levels. They produce food and cash crops and manage mixed agricultural operations often involving crops, livestock and fish farming. Women's hard work has not only been unrecognized but also remained mostly unpaid. They are invariably paid lower wages than men for the same agricultural work, and even not getting access to credit, since often they do not own land. On an average, only 11 per cent women have access to land holdings, that too mostly as small and marginal farmers (World Bank and IFPRI, 2010). With grossly inadequate access to education and technology, a host of other socioeconomic factors have adverse impacts on the lives of women-farmers. This gender inequality comes at a huge cost, not just for women, but society as a whole. Women for societal/cultural reasons are less involved in decision-making. Technology generation and dissemination in agriculture is often gender-blind, not addressing specific needs and constraints of women.

2.9.2 Motivating and Attracting Youth in Agriculture

The challenge to retain youth in agriculture is a global problem which prominently figured first in 2006 during the Global Conference organized by Global Forum on Agricultural Research (GFAR) in New Delhi, India and later in the First Global Conference on Agricultural Research for Development (GCARD1) at Montpellier, France in 2010 and GCARD2 at Punta del Este, Uruguay in 2012. Deliberations at GCARD

1 led to the formation of Young Professionals in Agricultural Research for Development (YPARD). As a follow up to the GCARD2 discussions, the ICAR and the Trust for Advancement of Agricultural Sciences (TAAS), organized a national workshop on 'Foresight and Future Pathways of Agricultural Research through Involvement of Youth in India' at New Delhi in 2013 and one of the major outcomes of this workshop was the initiation of "Attaining and Retaining Youth in Agriculture (ARYA)" Project which is being implemented in 25 states through KVKs, one district from each state. Subsequently, a Regional Workshop on "Youth and Agriculture: Challenges and Opportunities" was jointly organized by the Asia-Pacific Association of Agricultural Research Institutions (APAARI) and Pakistan Agricultural Research Council (PARC) at Islamabad, Pakistan in 2013 in collaboration with other co-organizers and a Regional Conference on Motivating and Attracting Youth in Agriculture (MAYA) at New Delhi in August 2018 by the TAAS and ICAR jointly with other co-organizers. These workshops/conferences covered a wide range of disciplines and issues related to Indian agriculture-natural resource management, crop improvement and protection, horticulture, post-harvest technology, livestock and fisheries development, agriculture engineering and implements, and ICTs and socioeconomics and put forth useful recommendations for engaging youth in agriculture.

As an initiative to empower the youth in agricultural and allied subjects the Student READY (Rural Entrepreneurship Awareness Development Yojana) program was started by the ICAR in 2015-16. Student READY is an essential course module for the award of degree at Bachelors level to ensure hands on training and practical experience depending on the requirements of respective disciplines in the SAUs. This is a step forward for articulating education into entrepreneurship and employability. The Student READY program includes five components, viz., experiential learning, rural awareness works experience (RAWE), industrial attachment, hands-on training, and student project.

The rural youth are an important human capital for accelerating agriculture and rural development and hence effective channelization of this resource for constructive activities can contribute to increased prosperity for all. On the contrary, the current developmental models spur migration of educated and skilled youth away from agriculture, leading scarcity of skilled and progressive farmers/entrepreneurs in rural and agriculture sector. Rural youth including women have been deprived of minimum facilities, needed opportunities and encouragement for innovative farming over the years. As a result, there is an on-going exodus of rural young men and women from villages to town and cities affecting adversely rural development, in general, and agricultural growth, in particular. Therefore, motivating and attracting youth in agriculture is a multi-dimensional task and demands for an efficient mechanism in a mission mode that can bring about better coordination between its various elements, institutions, departments and ministries.

2.9.3 Women's Role in Innovation Systems

Women play an important role in the innovation systems. Mechanisms for enabling women to exert influence over the setting of agenda in the innovation process are of crucial importance. Women's role in post-harvest management, processing/storage and marketing are increasingly important in achieving production to nutrition and income-generating outcomes. For example, in the dairy sector, innovations can bring refrigerated trucks, cooling tanks for safe storage as well as equipment for value-added products such as yogurt, ghee, cheese, etc. All these require a serious rethinking about women's role for future growth of agriculture. Farming systems have to be considered in more inclusive and holistic way, covering the broad range of issues that would enable women-led innovations for accelerated rural development. These include women's role in the household, in particular, for child nutrition, patterns of household food security and consumption, and contributions to rural income and emphasis of children's education, especially of girls thus addressing indirectly the check on population growth.

2.9.4 Empowering Women in Agriculture

At the global level, there is a growing realization and commitment of the global community to achieve more sustainable and broad-based agricultural growth by addressing gender- related issues in agriculture (World Bank, 2012). One of the important global initiatives for transforming agriculture to empower women and deliver both nutrition and income security was initiated by the GFAR, called as Gender in Agriculture

Partnership (GAP). The GAP highlights the women farmers as the backbone of agricultural and rural sustainability.

India is at the forefront for acknowledging role of women in agriculture. The ICAR had established the World's first Central Institute for Women in Agriculture (ICAR-CIWA) in Bhubaneswar way back in 1996. The Institute has been engaged in developing methodologies for identification of gender implications in farming systems approach and developing women friendly technologies under different production systems. The ICAR in partnership with the GFAR and the APAARI had organized the First Global Conference on Women in Agriculture (GCWA) in New Delhi during March 2012 in which around 600 women-farmers, scientists, policy-makers and leaders from more than 50 countries participated. The importance of reducing gender gap in agriculture was highlighted in the Conference to ensure that men and women are equal partners in food and nutritional security. The programs on gender empowerment be initiated jointly in consultation with enlightened women. Empowering women deserves a high priority in national developmental agenda. Since the past decade, there has been some significant growth in women SHGs and enrolment of girls in agricultural education system. There is an urgent need to support women education and SHGs to develop future professionals, entrepreneurs, and farmers. In India, currently more than 40 per cent girl students are studying in SAUs.

2.9.5 Women and Household Nutritional Security

Empirically a strong linkage among agriculture, nutrition and empowerment of women is well established. Malnutrition is a big problem in the developing countries, and especially in girls in rural areas. Nutritional insecurity is a complex issue and involves a multi-sectoral solution. Control of women over household income is linked invariably with improved nutrition, health and education of children. For household nutritional security, efforts are needed to integrate scientific and socioeconomic aspects to empower women and form "nutrition umbrella base", which can help develop an integrated strategy. Enhanced government investment, awareness, capacity-building, and micro-enterprises should help these endeavours. At the same time, the scientific institutions should produce effective technologies, database, knowledge on nutrition-rich food, and value-addition by involvement of women groups for nutritional security. There is thus a need to re-visit current agricultural education system, to encourage innovations in research-outscaling-marketing pathways and to augment role of women in policy planning and decision making.

2.9.6 Ensuring Visibility of Gender

Agricultural policies and R&D programs in many countries continue to be gender-blind, ignoring importance of women's work, and complexity and sensitivity of many of the barriers that constrain farm-women's abilities to perform and contribute efficiently and effectively to improve economic status of their families and also the society. Ironically, most of the rural-women are not so conscious of the economic and social importance of their work, and hence hesitant to demand any recognition, or rights for their contribution. Hence, to address these concerns, complementary strategies and mechanisms are needed which can help increase women's visibility and role in: (i) agricultural value- chains (crops, horticulture, livestock, forestry, fisheries); (ii) in household food, nutrition and health security; and (iii) research, education, extension and policy-making organizations. The roles and status of women in agriculture and rural areas vary widely by region, age, ethnicity and social class and are changing rapidly in some parts of the country. They play a vital role in wide range of agricultural activities, thus contributing to sustainable agricultural development. To achieve inclusive agricultural growth, empowering women for their greater participation, gender issues, drudgery and health and nutritional status is extremely necessary. Thus, investments in women and overcoming their drudgery are perhaps the best actions towards achieving SDGs.

2.9.7 Skill Development and Empowerment

In India, non-farm employment has grown much slower than addition to the work force, and therefore, most of the youth are adopting farming out of compulsion than professional interest. Recent surveys revealed that about 40 per cent farmers want to get out of farming, and do not want even their children to

remain in farming. This leads to urban migration and brain drain from rural sector of India. Contrary to this with current population explosion by 2030, India will need to produce almost 30 per cent more food from less land, degraded natural resources, and under stressed environment due to climate change. Current scenario demands a paradigm shift from traditional agriculture to high value and specialty agriculture. The shift from traditional agriculture is possible with innovative technological breakthrough, use of modern ICT tools, entrepreneurial mind and enabling policies. The elder and lesser skilled farmers are reluctant to transformative, innovative, knowledge-intensive production techniques to address the sustainable climate-smart food production challenges. Contrary to this, young people are innovators and risk-takers. Therefore, a critical mass of youth must remain in agriculture to ensure food security in the country through adoption of modern agriculture. Overall youth needs agriculture as much as agriculture needs youth. Therefore, youth and agriculture are the twin pillars of agricultural sustainability in India.

But there are wide knowledge gaps for youth in agriculture. Empowering youth through skill development is important for bridging these knowledge gaps. One of the first steps for skill development includes reorientation of agricultural education system which has to be initiated from the school education with compulsory introduction of agricultural subject in schools with hands-on practical classes. The higher education system must include an entrepreneurial component besides R&D and be linked with trans-disciplinary subjects as Bachelor of Education (B.Ed.) in agriculture, journalism in agriculture, marketing and value addition in agriculture, etc. Secondly, the skill development needs for youth in agriculture are different in different agroecologies and states. This needs to be factored in while developing skill-development programs for youth which will help in developing technologies and mind-set of generating more value from less land, improving financial services and providing information on markets in different regions. Agriculture needs to be made remunerative, agri-infrastructure needs to be improved, and public and private sector investment must be increased. However, it cannot bring about the desired result by itself unless there is enabling environment and policies which fosters higher investment in the sector – both public and private. Reorientation of agricultural system along with enabling policies will be helpful to bridge the existing knowledge gap in agriculture sector.

The National Policy for Skill Development and Entrepreneurship (2015) provides an umbrella framework to all skill enhancement activities within the country, and to align them to common standards, and link with demand centres. Most of the youth who remain in agriculture have invariably limited knowledge and skills, and are being forced to find new opportunities for better livelihood in the other sectors. Considering huge knowledge and skill gap in the agriculture sector, there is an urgent need to assess skills required in the sector to make it sustainable, entrepreneurial and attractive to youth. The skill development and entrepreneurship program thus needs greater emphasis on vocational trainings of the rural youth which will prove immensely useful in retaining and motivating youth in agriculture.

2.9.8 Start-ups and Entrepreneurial Initiatives

India is one of the five largest start-up destinations of the world with 70 per cent of the start-ups with founders less than 35 years' age. There has been a substantial rise in agri- and agri-product start-ups. The National Academy for Agricultural Research Management (NAARM) has initiated a new platform for agri-start-ups in collaboration with Department of Science and Technology (DST), Biotechnology Industry Research Assistance Council (BIRAC), Indian Institute of Management (IIM) Ahmadabad and other line departments, which works with association for innovation development of entrepreneurship in agriculture (A-IDEA) concept. The A-IDEA aims to help entrepreneurs sensitize, ideate, incubate, accelerate their innovative early stage start-ups that are scalable to become competitive food and agribusiness ventures through capacity building, mentoring, networking and advisory support. NAARM focuses on entrepreneurship in agriculture starting from sensitization to seed funding is dedicated to provide agri-business environment for new generation youth. NAARM has started two specific postgraduate diplomas (PGD) in management in agriculture and PGD-technology management in agriculture, where 100 per cent placement is ensured. The institute is also working on acerbated programs e.g. Agri-*Udan*. The way forward for agri-entrepreneurship should include the awareness, opportunities, continuity in incubation support, seed funding and addressing the sustainability issues. The SAUs and the ICAR institutes have also established agri-business-innovation

centres, which are the part of ICAR's Agri-Business Innovation (ABI) Network, where different start-ups can initiate their business on a pattern similar to ICAR-NAARM. The KVKs and other line departments are supporting rural youths for making their business profitable. The agricultural extension opened the door for rural youth by their involvement in transfer of technology to other farmers. There are several examples of success of youth agri-entrepreneurs in diversified fields as organic farming, polyhouses, vermicomposting, beekeeping, biopesticides, conservation agriculture, crop protection, dairy farming, mushroom cultivation, veterinary and fisheries, etc. Agri-clinics is one of the important area to attract rural youth as it not only provides professional advice and services but also helps in enhancing productivity and income in different agricultural enterprises, viz., soil health and application; cropping practices; plant protection; clinical services for animals, feed and fodder management, etc. The agri-clinics can be linked with agri-centers as commercial agri-ventures, which further help in income generation and entrepreneurship development. The NABARD is making sincere efforts to cover activities of the scheme under the Credit Guarantee Trust Fund (CGTF). Also, there is a need for an effective reward and award system to attract young agri-preneurs to adopt agri-entrepreneurial activities.

The CGIAR Research Programs (CRPs) are also emphasizing on a sound youth engagement strategy and taking new initiatives to motivate and attract youth (men and women) in agricultural research activities. All CRPs are experimenting on youth entrepreneurs, rural service provider business models, mainstream into national social programs and social inclusion lens to access to extension and other services. There is a need for a systematic research to address the youth-agriculture nexus for their greater involvement in agriculture. Young Professionals for Agricultural Development (YPARD) is another online platform that facilitates the exchange of information and knowledge among young professionals across disciplines, professions, age groups and regions through the website, newsletters, bulletins, face book page and face book groups, YouTube Twitter, Google + and the LinkedIn page and group. YPARD helps in promoting agriculture among youth (men and women) and addresses critical development issues through youth globally. YPARD stresses on reorienting agricultural research for result (AR4R) into agricultural research for agri-innovation, agribusiness and entrepreneurship and also creating awareness amongst the youth, through the help of media, regarding emerging opportunities in agriculture. It stresses on enabling policies that need to be designed for involving youth in decision making processes at the national, regional and global levels and empower them to become 'job creators' and not 'job seekers'.

The key action points for reorientation of agricultural research, education, skill development and enabling policies to motivate and attract young men and women in agriculture need to be addressed on priority.

2.9.9 Recommendations

1. There is an urgency to have a 'National Mission on Youth in Agriculture' with an aim to impart better knowledge and skill to youth on: (i) sustainable, secondary and specialty agriculture, (ii) efficient knowledge dissemination, including information communication technology (ICT), (iii) technical backstopping for innovative farming, (iv) new agri-business models, and (v) entrepreneurship as well as linking farmers to markets through value chain. Under the Mission, concerted efforts are needed to build new skills of youth for innovative agriculture through both formal and informal education. The best option for this is to impart agricultural education right from school level. In addition, the central and state agricultural universities and ICAR institutes must initiate entrepreneurship training through vocational and formal diploma programs. Also, the university curriculum needs to be revisited to address the emerging needs and aspirations of present-day youth and markets.
2. Priority attention needs to be given to develop a new research agenda for 'Youth-Agriculture Nexus' which (i) delineates different contexts for youth-oriented agricultural research, (ii) identifies opportunities for young people's engagement in agricultural research and innovation for development (ARI4D), and (iii) determines youth's future pathway for attaining sustainable agricultural growth and income.
3. Involvement of youth in 'Plough-to-Plate' initiative can help in doubling farmers' income. Hence, their greater involvement as entrepreneurs will be the key to future growth and development. For this, greater

thrust needs to be given to networking for knowledge sharing/ dissemination, participation of youth in outscaling of innovations through their validation using technology parks/innovation platforms, use of ICT, creation of agri-clinics, much needed support for mentoring/hand-holding, and awareness regarding intellectual property rights (IPRs).

4. There is need for a paradigm shift from narrow focus on 'youth as a farmer' to 'youth for value chain developer'. To provide better economic opportunities for rural youth in the changing agricultural scenario, there is an obvious need to move beyond the plot/field level agriculture i.e. from production to post-production level and to link with market for better income opportunities. The combination of agricultural value chains, technology and entrepreneurship will unlock vast economic opportunities for youth in both the farm and non-farm sectors and hence youth need to be encouraged to set-up agri-service centres to offer custom-hire services for small and marginal farmers for mechanizing their farm operations to enhance production at reduced cost.
5. There is an urgent need to 'institutionalize incentives' and 'award/reward system' in order to reward highly successful agricultural entrepreneurs and innovators. This will inspire as well as attract the youth to adopt agriculture as a profession for their happy living. Such an approach should be a strategic priority at the local, state, and country level to ensure youth-led inclusive growth in agriculture.
6. The successful entrepreneurs also need to be recognized and encouraged to act as role models and help in capacity development/ technical back-stopping for other youth to be equally successful. In this regard, a compendium of youth-led success stories/case studies of young agricultural entrepreneurs and innovators in various sectors of agriculture from different eco-regions of the country be brought out on priority and made accessible to others.
7. The private sector has also to play a proactive role in creating much needed 'Agri-Youth Innovation Corpus Fund' as part of their corporate social responsibility (CSR) and enhance rural employment through special projects. Such an effort would enhance rural employment opportunities through small agri-business start-ups, public-private as well as private-private entrepreneurship. They may also help through soft loans and mentoring programs for involving rural youths as input dealers/suppliers as well as paid extension agents.
8. It is high time that the MoA&FW creates a separate 'Department of Youth in Agriculture'. This will ensure collaboration and coordination with concerned line departments in other Ministries such as Science and Technology, Skill Development and Entrepreneurship, Food Processing Industry, Rural Development, Commerce and Industry, Chemicals and Fertilizers, etc. so as to meet the aspirations of youth in agriculture. Such an institutional mechanism, with funding support through the proposed 'National Mission on Youth in Agriculture' will help in motivating and attracting youth in agriculture and allied fields.
9. Concerted efforts are needed to build new skills of youth for innovative agriculture through both formal and informal education. The best option for this is to impart agricultural education right from school level. In addition, the central and state agricultural universities and ICAR institutes must initiate entrepreneurship training through vocational and formal diploma programs. Also, the university curriculum needs to be revisited to address the emerging needs and aspirations of present-day youth and markets.
10. The role of well trained and competent youth, with expertise in ICT application for e-NAM, Start-up, Stand-up and skill development schemes, agribusiness enterprises, etc. is extremely important. Youth would thus need enabling policies for long-term investments, availability of easy and soft credit, provision of subsidy upfront to the entrepreneurs, farmer exchange visits, easy market accessibility, land law reforms for entrepreneurs, no taxation system for rural-based primary value addition involving youth, review of Agri-Clinic support system by the NABARD, reforms in marketing laws such as scrapping of APMC Act, provision of ready insurance for covering risk of 'start-up' entrepreneurs, etc. would immensely encourage youth to embrace agriculture.
11. *Mahila Kisan Mandal* (Women Farmers' Cooperative) needs to be established in villages to educate women on different aspects of agriculture and related activities, including future predominant role in agricultural marketing to benefit producers and consumers.

12. Sincere efforts need to be made for removing drudgery of farm women by ensuring access to new tools and implements that increase efficiency and higher productivity. Also, ARI4D agenda needs to be reoriented to make it gender-sensitive and pro-women.
13. An urgent attention is needed to address the discrimination through appropriate policies, legislation, enforcement mechanisms and establishing women's rights (e.g. access to markets, ownership of land). It must be ensured that the institutions and legal support mechanisms are in place to promote women's ownership and control of resources (e.g. land, bank accounts, farm implements). Women Farmers' Entitlement Bill 2011 proposed by Prof. M.S. Swaminathan as a policy reform to create enabling environment needs serious consideration of the Government.
14. Social, educational and cultural institutions also must change to create an environment where women realize their full potential. Engendering farm-women thus is a high national priority. For this, investment in women's human capital through education and training for skill development and empowerment is very critical for productive use of their abilities, time and energy. There is need for providing efficient and cost effective farm implements, tools and small machinery to enhance their work efficiency. Also, establishment of custom-hire centers will help a great deal to help women farmers engaged in agriculture. Enabling environment is also needed to form women FPOs and SHG and provide support for linking them to markets.

2.10 Private Sector Participation

Public private partnership (PPP) is indeed critical to harness diverse talent and modern technologies, backed by resources, corporate work culture and business skills in perusing SAD objectives. There have been significant efforts in the past for forging public private partnership in general and AR4D in particular in respect of seed, germplasm improvement, GM technology, crop protection, plant nutrition, micro-irrigation, farm mechanization, rural energy, agri-output management including food processing and value addition. However, initiatives towards building partnerships have not yielded desired results on account of lack of trust, needed incentives, inflexible rules and procedures and inordinate delay in decision making by the Government. Therefore, there is need to build trust, create enabling environment and level playing field in terms of supportive policies, needed incentives (prices, taxes etc.), improved terms and conditions (enhanced ease of doing business), taking right decisions without fear or favour and with least delay.

Private industry has played significant role towards overall agricultural development by bringing new technologies and making available required inputs at the farmers' door step. Development of agriculture in India since Green Revolution has seen significant contributions from the private sector, which has grown gradually over the years. The Green Revolution was essentially driven by the public institutions and policy support of the Government – the research infrastructure of the ICAR, the seed multiplication and distribution system through Central and State Seed Corporations, the public extension system, MSP and procurement system. Subsequently, the role of the private sector increased with hybrid technology and seed production and marketing of crops like cotton, sorghum, millet, sunflower, maize and vegetables. In essence, the private sector became vibrant through hybrid technology while working with public institutions in increasing seed production and distribution of quality seeds of both hybrids and varieties.

Indian agriculture has witnessed significant transformation over the past few decades but this has not been accompanied by changes on the institutional and policy front. Private sector holds potential to mobilise investments in infrastructure and R&D as well bring in the desired efficiencies in agricultural value chain through timely service delivery. The National Agricultural Policy 2000 also envisaged promoting private participation in agriculture through contract farming, land leasing arrangements, direct marketing and setting-up of private markets to allow accelerated technology transfer, capital inflow and assured market for crop production. Conducting research, introducing improved technologies, provision of credit through cooperatives and self-help groups, creating infrastructure (for seeds, fertilizers and pesticides, transportation and processing), helping in extension services, dissemination of accurate and timely information, and diffusing crop insurance are the key areas where private sector can play an important role in future.

PPP has been recognized as one of the most effective mechanisms to achieve accelerated growth in agriculture. Increasing yield and productivity is a crucial need, with India still addressing the concerns of food insecurity and poverty. Technology, better inputs and improved farming practices including mechanisation can make this possible. There is an urgent need to promote innovations through partnerships between the private and public sector, farmers and the government to accelerate India's agricultural growth. In fact, a large number of farmers got benefitted by improving their yields and income due to public-private partnerships. The private sector has been continuously increasing investments in seeds and other inputs like pesticides, fertilizers, irrigation equipments, farm machinery, agricultural output and food processing and offering new products and services to the farmers which contributed towards all round agricultural development in India. To achieve SDG's goal, private sector-led innovations can solve sustainable development challenges. Also, social, economic and environmental business practices helps create stable societies and markets, and partnerships between governments, businesses and civil society is crucial to succeed with the SDGs.

2.10.1 Current Status

The organized seed market has grown to a size of Rs 18,000 crore and almost 80 per cent of it is now contributed by the private sector. It invests more than Rs 600 crore annually on research for developing new

varieties including climate resilient and hybrids having higher genetic potential for yields and resistance to pests and diseases. The private industry has also invested in bringing GM technology resulting in huge success of Bt Cotton since 2002. In this context, the PPV&FR Act of 2002 has also given much needed confidence to the industry to invest more in seed research.

The pesticide market has also grown to Rs 17,700 crores, all exclusively by private industry. Some of the modern pesticides that are effective and safer have come into the market after the introduction of product patents in 1996. We now have both old generation products in the market along with some of the modern and safe new products. While new products are invariably developed outside India, the transfer of technology is facilitated by companies located in India.

The fertilizer industry has a mix of public and private enterprises with increasing role now being played by the private sector. However, the sector has been benefitted due to subsidy policy but leading to nutritional balance. As a consequence, the nitrogen consumption is much beyond the requirements due to which the industry is devoid of innovation and new product development. The irrigation industry is predominantly developed by the private sector. The micro-irrigation systems have penetrated the market backed by subsidy programs of the Government. However, large scale use of flood irrigation continues to be a great source of worry. Viable alternatives like Hose Reel system and Pivot have not made much progress.

2.10.2 Challenges and Opportunities

There are various challenges facing Indian private sector engaged in agriculture. Some of these are (i) meeting nation's food security (food demand of about 350 million tons by 2025), (ii) change in consumer preferences towards healthy foods (5-6% CAGR of fruits & vegetables and pulses) (iii) increased stress on agri-production due to scarcity of resources (decreasing size of land holdings, agri- labour migration to non-farm jobs), (iv) climate change (54% of India faces high or extremely high water stress), (v) food wastage across the value chain (fruits & vegetables up to 37% and cereals up to 25%), (vi) lower profitability for the farmers, (vii) lack of rural infrastructure to support farm and non-farm activities (viii) stagnant yields in many important crops (ix) lack of interest in agriculture among youth, and (x) adverse impact of agriculture on environment, especially on soil health and on food safety.

In this context, there is need for reorientation of agricultural policy defining a comprehensive framework which sets clear objectives and goals for the stakeholders of agriculture industry (farmer, government, agri-input & output industries) to address the challenges. The key imperatives and policy intervention areas in Indian agriculture in the short run include: (i) making Indian agriculture globally competitive and creating greater rural employment, (ii) enhance marketing options and reduce financial and pricing risks for farmers, and (iii) simplification of the regulatory landscape; certain and predictable regulatory environment.

2.10.2.1 Responsibility of private-agri-input industry

The private agri-input industry has the major role and responsibility in the following areas:

- Investing in research and technology transfer in the areas of plant breeding, biotechnology and cutting-edge innovations which can be of high value to Indian farmers, enhancing current levels of research investment (about 3% of revenue) to the global levels (10-12% of revenue) and develop high potential varieties, bringing modern crop protection products and their delivery systems to the market, developing soil and environment friendly plant nutrition products, and developing irrigation and water management systems that will help the farmer to grow more crop per drop.
- Investing in developing and popularising modern, science based agronomic practices that will help in establishing sustainable agriculture as a financially viable option for farmers and developing plant varieties with suitable architecture to fit into the new agronomic practices being propagated for the benefit of farmer and the environment.
- Creating intellectual property that is legally valid in India and in the export markets and to have the cultural and ethical practices of respecting others' intellectual property.

- Providing effective technical advisory services so that farmers are able to adopt good agronomic practices (GAP) in cost-effective manner.
- Producing and distributing input products of high quality that live up to the legal standards and the expectations of the farmers.

2.10.2.2 Seed and biotech industry

The organized seed industry is in existence now for more than 50 years in India. However, it has seen faster growth only in the last two decades. The current outlay of the industry is estimated at Rs 18, 000 crores. The public enterprises like National Seed Corporation and several States Seed Corporations are involved in producing and supplying large volume of seed of high volume, low value crops like wheat, rice, mustard, groundnut, pulses, soybean, maize, vegetables, millets, etc. On the other hand, the private seed industry is focused on research, production and supply of high value, low volume hybrid seeds of crops like cotton, maize, sorghum, pearl millet, rice, vegetables, chilli, etc. Details of crop-wise seed market in India are given in Table 1.

Table 2.10.1 Crop-wise seed market in India

Crop	Market 2018 (Rs Cr)	Estimated Market 2022 (Rs Cr)	CAGR	Key Players
Vegetables	4500	6300	8%	BASF, Seminis, Syngenta, Mahyco, VNR, Namdhari, Indo American, Accen HyVeg, Advanta
Cotton	3000	3500	6%	Rasi, Kaveri, Nuziveedu, Mahyco, Ajit, Shriram Bioseed, Ankur, Seedworks, Tierra, Metahelix
Maize	2400	3100	10%	Corteva, Bayer Monsanto, Syngenta, Shriram Bioseed, Kaveri, Limagrain, Rasi
Rice	2200	2900	8%	Bayer Monsanto, Corteva, VNR, Mahyco, Syngenta, Savannah, Metahelix, Rasi
Others	5900	9200	9%	Advanta, Crystal, Corteva, Bayer Monsanto, Metahelix
Total	**18000**	**25000**	**10%**	

(Source: Industry estimates)

The key players consist of both multinationals and Indian companies. With more than 550 seed companies operating in the country, only about 15 per cent make investment in research totalling almost 80 per cent of the total research investment in seeds and biotech and catering to more than 65 per cent of the total market demand. The growth of the industry has been characterized by two main innovation drivers, namely, hybridization and GM technology. Hybridization of crops started more than 50 years back. In fact, India is known to be the first in cotton, pearl millet, castor and pigeonpea hybrid technology. Yet, the level of hybridization varies from crop to crop, being almost 95 per cent in cotton and relatively less in others.

2.10.2.2 Growth of seed markets

Private industry played a key role since the start of Mahyco in the mid-1950s. Hundreds of breeders who work in the private seed industry developed new, high yielding hybrids and varieties over the last few decades which helped in increasing the yields and incomes for the farmers. The private seed industry trained lakh of farmers in thousands of villages on seed production techniques, created rural employment, improved the quality of seed production over a period of time, invested heavily in quality and processing infrastructure and found innovative methods of convincing farmers to use modern and high yielding seeds. Overall the industry has played a significant role in enhancing agricultural production in the country. The impact has been particularly high in crops like cotton, pearl millet, sunflower, maize, sorghum, chilli, vegetables through hybrid technology. In the past 10 years, there has been an effort by the private industry to develop new, high yielding varieties in crops like wheat, soybean, rice and mustard.

Currently, the seed replacement ratio (SRR) in different crops varies significantly from state to state. The SRR has been going up steadily but it needs to be hastened speedily to bridge the yield gaps. For this, farmers need to be educated and made to understand the importance of using quality seed by resulting in higher SRR.

After the enactment of PPV&FRA, the flow of elite lines from outside the country and development of high yielding single cross maize hybrids in the country has been a great success story. GM cotton is another area where the private sector had made significant contribution. The technology development, regulatory clearance, production and marketing of Bt cotton has been an event of tremendous success in the history of seed industry in India.

2.10.2.3 Constraints and issues

- The seed industry currently has only about 15 per cent good R&D companies. This has been a reason for lack of trust in the industry from the Central and State Governments.
- Invariably, the existing variation in the implementation of the Seed Act across states causes serious problems to the seed industry. Product approval requirements in different states vary and affect the new product introductions, especially in vegetables.
- Research investments in crops like wheat, rice, soybean, pulses, some oilseeds, some vegetables, etc. are very low from the private seed sector, may be due to lack of value capture mechanism.
- The IP in seeds is protected through the PPV&FR Act. However, the processes involved in receiving applications, granting protection, enforcement of protection in the field, etc are invariably weak and unclear. Lately, the lack of protection of IP of research based companies is an area of concern which is restricting research investments. IP on GM traits has also come under a cloud in the last few years.
- The Bt Cotton Seed Price Control Order of December 2016, brought out by the Ministry of Agriculture, GoI, has fixed the maximum retail price of Bt cotton seeds. This decision by the Government has shaken and rather discouraged the seed industry to a greater extent and viewed as counterproductive.
- The regulatory process for GM crops has become very slow since 2010. In fact, no new GM products have been approved since 2005 after Bt Cotton II was approved. Bt Brinjal developed by MAHYCO and GM Mustard developed by Delhi University were approved by GEAC but did not get final approval of the Government for commercial production. Also, the long pending BRAI bill has not been passed yet by the Parliament. This would have created a science based robust regulatory environment in the country. As a result, seed industry has rolled back research and developmental work in this area which is detrimental to the interests of Indian farmers in the long run.

2.10.2.4 Policies impacting seed industry

(i) Seed Act

- The current operating Seed Act 1966 has been effective in helping the development of private seed industry. However, there was no provision to register seed varieties under this Act. Implementation of Seed Act is not uniform across states and needs to be harmonized. The Government has to find a method of recognizing good companies and support them. To bring in some improvement in the Seed Act, a new Seed Bill was introduced in the Parliament in 2004, tabled again in 2014, but it has not yet been approved by the Government. In this context, while the seed industry has welcomed the measures to bring in mandatory registration of seed varieties, the industry has some concerns to be addressed. In the proposed Seed Bill, some of the concerns are:
- Performance of the seed is to be assured by the company selling the seeds and same has to be indicated on the pack. Agriculture being vulnerable to varying environmental stresses beyond the control of the seed company, any lack of field performance can lead to award of high compensation to the farmer and/or jail to the Managing Director. This, therefore, needs reconsideration.
- Imported seeds should go through testing in multi- location tests before they can be sold. This would lead to delays, especially with vegetables which are imported in large numbers.
- Price control on seed proposed in the Act is likely to be counter productive and rather major disincentive. On the contrary, pricing issue be left to the market and fair competition.

(ii) Biological Diversity Act 2002/Rules 2004

While the industry supports the principles and the objectives behind this Act, some serious concerns expressed are mentioned below:

- Access to biological resources for usage in research programs like insect pests/pathogens for screening of susceptibility in plants, for statutory trials in seeds and agrochemicals and for conducting bioefficacy trials – applications for such purposes should be treated separately.
- Industry specific guidelines for agriculture sector should be issued by NBA. Also, agri-industry can make specific contributions to support conservation and sustainable use of biological resources.
- Implementation of ITPGRFA exemption be done in letter and spirit – conventional breeding is exempted under section 2(f) of BDA – access to these crops to be governed by MoA&FW. Thus, the term of conventional breeding is to be clearly defined.
- Transfer of results of research to section 3(2) Company – this should be exempted from restrictions on transfer and from imposition of ABS.
- Access of biological resources during mergers and acquisitions should be kept out of the purview of BDA. Also, the timelines for processing and disposal of different types of applications be defined.

(iii) Policy on GM Technology

The approval of GM crops for cultivation in India has been practically on hold for the last one decade when in 2010, the Bt Brinjal was put under moratorium. GM technology being a scientific issue must be handled pragmatically by the concerned Ministries involved. Presently, policy support for release of GM crops is not forthcoming.

2.10.2.5 Crop protection industry

The crop protection industry has made rapid strides over the past 50 years. Today this is a Rs 17,700 crore industry dealing in cutting edge technologies to protect the crops of the world contributing in a significant manner to productivity enhancement and food security. Currently, the insecticides market is Rs 8,275 crore followed by fungicides at Rs 4,465 crore herbicides at Rs 3,900 crore and plant growth regulators at Rs 890 crores. The seed treatment market is estimated at Rs 190 crores. The herbicide market is the fastest growing segment because of increasing shortage of labour. Andhra Pradesh (including Telangana) and Maharashtra are the largest users with about 19 per cent share each. Rice is the largest consuming crop with 28 per cent share followed by cotton at 12 per cent, soybean at 8 per cent and chilli at 6 per cent. The crop protection Industry will play a critical role in doubling the agriculture growth in India, which is so essential for food security and improving the quality of life.

On an average, leading crop protection companies spend around 7.5 per cent of sales on research and development for new crop protection products. This ratio places the crop protection industry among the most R&D intensive businesses across industry segments. Globally, every new crop protection product takes nearly 10 years at an average investment of US$ 286 million from discovery to market. In India, however, it takes an additional 5-8 years because of the regulatory process. In India, 18 out of the hundreds of crop protection companies are R&D driven and practically responsible for 95 per cent of the molecules introduced in the country.

While partnering with the Government in achieving sustainable agriculture, the crop protection industry proposes the following for consideration: (i) precision agriculture- satellite driven, big data analytics and digital solutions are helping farmers globally to make better and more informed decisions with regard to weather, soil nutrients, pest and diseases, (ii) usage of personal protective equipment (PPE) and responsible use of crop protection products should be made mandatory by law in view of the current hazardous waste management practices, and (iii) regulatory reforms through early clearance of Pesticides Management Bill, (iv) support introduction of safe and new molecules : exclusive data protection for the first 5 years of new product introduction; reduction of registration timelines; introduction of International best practices in regulatory approvals like grouping of crops for regulatory approval of a product; easier registration norms for minor changes in formulations and harmonization of data.

2.10.2.6 Plant nutrition industry

Plant nutrition industry, currently dominated by chemical fertilizers, has a great role to play in offering solutions that are less expensive and better suited for promotion of sustainable agriculture. Fertilizer was one of the major ingredients of green revolution, besides high yielding varieties and irrigation. There was rapid increase both in fertilizer consumption and expansion of fertilizer industry in the decades of 1980s and 1990s. Fertilizer consumption increased from 3.2 million tons in 1976-77 to 26.6 million tons nutrients in the year 2017-18. As a result, food grain production increased from 111 million tons in 1976-77 to 285.2 million tons in 2017-18.

The cost of production or imports of fertilizers continue to rise due to price control. Urea which accounts for 50 per cent of all fertilizer used in the country is subsidized to the extent of 75 per cent of its cost, while subsidy on other fertilizers has been brought down during the past 9 years to 30-40 per cent of their costs. This has resulted in imbalanced use of primary nutrients- nitrogen (N), phosphorus (P) and potassium (K). Non-judicious use of fertilizers ultimately leads to environment problems. Stifling controls have also affected the operating environment for the industry. In the anxiety to control fertilizer subsidy, government has continued to deny the legitimate costs of the industry. In fact, fertilizer sector has become unattractive for investment and there are practically no new fertilizer plants for more than 20 years.

India being the second largest fertilizer consumer in the world cannot afford to be dependent substantially on import of fertilizers. Fertilizer availability is crucial for food security and even survival of Indian agriculture. Therefore, there is need for major revision of present policies. Though direct benefit transfer (DBT) has been implemented for fertilizers but in true sense yet the subsidy continues to be paid to the fertilizer manufacturers. The direct transfer of subsidy to the farmers and decontrol of the industry in near future will be in the best interest of Indian agriculture. This will also encourage industry to bring in new products and services to the farmers.

It takes almost 4-5 years to get new products registered under the FCO and delivered to the Indian farmer. Any delay means Indian farmer is deprived of accessing the latest technology available in the global market. This process is to be reformed through amendments to Fertilizer Control Order to facilitate modernization of product development and introduction.

2.10.2.7 Micro-irrigation industry

There is no doubt that flood irrigation must now be discouraged. Hence, micro-irrigation will play a key role for efficient water management. Focus should now be on increase in irrigation efficiency, water productivity and value creation, while designing irrigation projects. Drip Irrigation, Hose Reel and Pivot based irrigation systems are to be promoted. Good agricultural practices need to be adopted which includes reduced water consumption, better yields, better fertilizer efficiency, better soil health, better crop growth and ultimately better water use efficiency and better water productivity. Transplanted rice needs to be replaced with direct seeded rice to reduce the amount of water consumed for rice production. Increased water productivity and ultimately increased value creation should be the only criteria for finalization of the irrigation projects. This will not only increase the water productivity and GDP of the country but will also give opportunity to the bidders to work on merit basis.

Micro-irrigation systems because of its multiple benefits and absolute necessity should be given high priority status. Treated waste water use for agriculture should be mandatory. Necessary technical guidelines for waste water use in agriculture be a priority to avoid wastage of water. Renewable energy such as solar energy needs to be integrated with micro-irrigation systems to ensure sustainability of irrigation systems. Encouragement for research based irrigation companies through access to bank finances for making systems available on lease and custom hire methods.

2.10.2.8 Farm mechanization

Farmers need region and crop-specific machines and farm implements for various pre and post-harvest operations. Also, there is need for women friendly implements/tools which can reduce drudgery, save time,

enhance output and can be easily operated and handled. Agri-entrepreneurs including farm graduates and progressive farmers could be encouraged to provide farm machinery, tools and implements to smallholder farmers on a custom-hire basis. Private sector can play an important role in the manufacturing of low cost farm machinery and implements and also set-up centres in different locations for providing custom hire services as affordable charges.

2.10.2.9 Solar and wind power industry

Solar power in India is a fast developing industry. The country's solar installed capacity reached 29.41 GW as of 31 May 2019. India has become globally the lowest cost producer of solar power. The average current price of solar electricity dropped to 18 per cent below the average price of its coal-fired counterpart. India is developing off-grid solar power for local energy needs. Solar products have increasingly helped to meet rural needs such as solar lanterns; street lighting systems, solar cookers, etc. Solar power can be used for operating agricultural machinery and implements, and more importantly irrigation pumps. In this context, private sector can play an important role in the PPP mode which needs to be given due attention for the benefit of farmers.

The wind power potential constitutes 30.2 per cent of total renewable power generation potential. The efforts to promote renewable energy production have mainly concentrated in the non-farm sector. The potential of wind power can be harnessed for various agricultural purposes.

2.10.2.10 Agri- output industry

Agri-output industry comprises of various stakeholders involved in commodity procurement and trading (public and private trading companies, intermediaries, aggregators, FPOs, etc.), primary, secondary and tertiary processing companies and exporters, etc. Favourable policy framework that supports agri-output industry to enable Indian agriculture sector to be profitable and sustainable include: (i) developing sustainable food production systems by partnering with private agri-industry players to safeguard human health and environment; (ii) institutional support and crop planning tools to facilitate farmers to take informed decisions; (iii) development of macro-level policy framework to foster market linked production and boost agricultural productivity (total factor productivity) and optimize price realization; (iv) creation of a central data base of all the farmers in the country which provides information on agri-produce; (v) supporting agri-industry players to provide integrated solutions in crop production value chain to benefit marginal and small farmers through public- private partnerships; (vi) government should encourage private players to implement agri-related schemes; (vii) incentives towards contract farming and private sector Involvement in direct buying of agri- produce; (viii) providing real time agri-extension services to the farmers by integrating public and private extension efforts; (ix) enforcing food safety norms and standards effectively by collaborative efforts between centre, states and private sector; (x) maximizing value capture and minimising the wastage by effective post- harvest management; (xi) flourishing agri - food processing sector of the country through public private partnerships; (xii) directing the orientation of agriculture R&D to meet the changing consumer interests, raw material requirements of food processing industries and to ensure national food and nutritional security; (xiii) supporting private R&D sector by allocating dedicated budget to work on tailoring the available advanced technology to Indian field conditions in agri-technology and farm mechanization solutions; and (xiv) need for a systems approach to R&D to enable a holistic research-development, technology transfer continuum involving other foreign institutions and companies.

2.10.2.11 Food processing industry

The food processing industry will play a critical role in stabilizing price discovery for the farmers and in turn improve their profitability. This industry can be energized through pre-harvest agri and allied value chain (agri-extension, farm machinery, agri-insurance and credit), post-harvest development for value capture (agri-marketing linkages, agri-warehousing logistics), and synergizing food processing sector for value addition (waste reduction, value addition, cold chain, food retail). Appropriate projects/programs for short, medium and long-term need to be developed and implemented.

2.10.2.12 New business models

(i) Service as a business model

Instead of selling products to the farmers, agronomic services may be offered at a cost. Some companies have started offering these services with crop protection products along with technical advice This will require policy support in terms of ease of doing business. Another area where the service model is being used is with agricultural machinery. With the availability of farm labour going down and their cost going up, farm mechanization is poised to become more and more important during the next 10 years. This is a working capital-intensive business and the Government needs to provide easy access to working capital for the success of such model.

(ii) Agri-innovation and entrepreneurship

Many incubators and accelerators in the country are encouraging innovation and entrepreneurship in food and agriculture sector. Several youths with technology and science background are working hard to find solutions to bridge technology gaps that will reduce drudgery for the farmer, improve precision in agriculture and create new opportunities to the farmer. Use of several technologies like satellite technology, sensor technology, ICT and others will be useful in this regard. This will need government support in terms of seed funding of such enterprises.

2.10.3 Recommendations

1. There is an urgent need to improve the quality of seeds through effective use of modern science and technology. Regulatory process for GM approval has to be debottlenecked through:
   - (i) Declaration for a national GM policy and suggesting priority areas of application considering the country's needs and then to fast track regulatory processes. This will create a predictable policy environment for the technology and invite more investments,
   - (ii) Government needs to consider withdrawing the cotton seed price control order and make seed pricing market driven to increase investments by private sector in the technology and to play a crucial role in doubling farmers' incomes and reduce the risk involved in agriculture,
   - (iii) IP protection for GM traits must be ensured by the Central Government by amending Clause 3(j) of Indian Patent Act,
   - (iv) Consider declaring a clear, science based and time bound regulatory policy on GM and new genome editing technologies which will help the industry in introducing more traits that could transform the lives of our farmers,
   - (v) Need to make a specific effort to approve technologies (both GM and non-GM) that create resource use efficiency particularly in crops like rice, sugarcane, wheat, maize and others which consume more fertilizers and water, thereby making our agriculture more sustainable,
   - (vi) After due consultations with all stakeholders, the Biotechnology Regulatory Authority of India (BRAI) Bill pending for long needs to be cleared. The revised Seed Bill needs to be revisited once again in order to address current concerns after taking into account the feedback from stakeholders. Till then, MoA&FW could consider bringing out a revised New Seed Policy Bill to accelerate growth of seed sector. This will help in making the entire seed regulatory framework more efficient and relevant,
   - (vii) There is also need to build quality control capabilities in states through modernization of infrastructure, people and processes by establishing at least one ISTA accredited lab in each state, and
   - (viii) A collective effort by the Centre and States be made to build capacity in the States to enforce IP laws in agriculture.
2. There is an urgent need to consider taking the following decisive steps to introduce safer crop protection products in the country and phase out old products with higher tax profile:
   - (i) After due consultations with stakeholders, the Pesticide Management Bill may be got approved by the Parliament since it will facilitate introduction of safe and new pesticides,

(ii) There is full justification for improving the quality of crop protection products by encouraging introduction of new, effective and environmentally more sustainable agro-chemicals and their formulations through a progressive new regulatory policy including data protection, reduction in registration timelines, and implementation of international best practices like crop grouping, minor change in formulation, and harmonization of data. OPEX model will help in ease of doing business,

(iii) There is an urgent need to consider making mandatory for spraymen to use personal protective equipment (PPE) and use of crop protection chemicals responsibly,

(iv) Considering the current hazardous waste management practices in India, disposal of pesticide containers may be done through recycling using appropriate equipment,

(v) There is need to constitute a task force on priority for curbing the menace of spurious pesticides and biological laced agrochemicals which would ensure standardization of sampling procedures, improvement in working and quality of laboratories, and stringent action against those involved in supplying non-genuine pesticides and bio-products.

3. Access to innovative and efficient fertilizers especially the customised fertilizers is quite important to achieve sustainable agricultural practices and to improve health of our soils through the following:

(i) There is an urgent need to make the registration process easier for such products. Govt. may consider issuing general specifications as has already been done in the case of water soluble fertilizers. All new fertilizers including micronutrients that are outside the subsidy scheme should be covered under the general specification for fertilizers. Automatic approval based on total minimum nutrient content, importer/producer should self-attest and upload the specifications of the products onto MoA&FW website/inform via post/email. In order to stop delays at the State Government level, a letter of intimation should serve as Form A1 and an acknowledgement should be considered as an approval to provide such fertilizers to the farmers in the state.

(ii) The current subsidy structure makes it more attractive for the farmers to apply more of nitrogen which leads to imbalanced nutrition to the plants. It will be desirable to consider decontrolling the entire cost structure of different fertilizers and making them free from all subsidies. Efficiency in fertilizer production system and market-based pricing is to be promoted in this sector. Fertilizer companies have to be incentivized to bring modern technology-based solutions into the market with emphasis on minimizing adverse impact on environment and maintaining good soil health, apart from increasing crop yields. All fertilizers have to be registered under the Fertiliser Control Order (FCO) before supplies are made to the Indian farmer.

(iii) Introduction of modern plant nutrition products must be promoted henceforth through progressive regulatory process by bringing balance into nutrition application by reducing subsidy on nitrogenous fertilizers and bringing a relative competitive situation among different fertilizers based on cost of production, desired cost levels for farmer and balanced plant nutrition, encouraging innovation and promoting use of micronutrient coated fertilizers.

4. The Government needs to consider creating a national grid for market intelligence and crop planning to address issues of glut and scarcity. There is need for leveraging the big data analytical tools to advise farmers on planting area and selling the produce based on crop-wise estimated demand and price trends. There is need to establish a National Farmers Commission having effective representation of stakeholders, like agri-industries, Farmer Associations, Govt. Dept., SAUs / ICAR, etc. This Commission could serve as a bridge between Government and all stakeholders.

5. There is need to accelerate the agri start-up sector to digitalize agri-farm value chain in the country. The Government may consider incentivising agri-tech companies / start-ups to boost investment in hi-tech farming (robotics, autonomous farm machinery, IoT, advanced farm data analytics, AI based smart solutions etc.). For this, a National Agriculture Innovation Fund (NAIF) be created urgently by the Government to exclusively promote and scale-up agri-tech start-ups by aggregating several agri-tech innovation centres, incubators and accelerators that are working in the country. Agri-industry players need to be supported to provide integrated solutions in crop production and value chain

to benefit marginal and small farmers. Suitable public private partnerships may be promoted for this purpose. Appropriate measures need to be taken for supplying farm inputs (seeds, fertilizers, pesticides and agro-chemicals etc.) on credit and debit basis, providing scientific crop advisory for crop production and protection, facilitating access to credits and linking to capital markets.

6. A suitable mechanism needs to be developed for providing real time agri-extension services to the farmers by integrating public and private extension efforts. Providing real time location-specific agri-extension services is very important in the present context. The large KVK network is to be leveraged to achieve scale in providing high quality extension services to the farmers. Through the option of CSR as well as PPP, each KVK could become a strong knowledge centre through a PPP model where the private industry and the public research institutions will showcase new technologies and agronomic practices, train farmers in modern practices and impart knowledge to farmers, traders, agricultural extension workers and other stakeholders.

7. There is need to promote privatization of agriculture in the country. This could be done by dedicating specific zones, villages/districts to private players, especially involving youth, who are interested in contract farming. Government may consider incentivizing those who are willing to pool their resources to improve efficiency and increase productivity. This will bring in technology transfer, establish market-oriented production system, play a critical role in price stability and ensure environment sustainability.

8. In order to ensure a single window system, Government could consider creating a separate division in the Ministry of Agriculture and Farmers Welfare (MoA&FW) to set right the entire policy environment, enhancement of private sector's role for capital investment and increased use of modern science and technology in agriculture that can increase agricultural growth to 4 per cent per annum. Also, effective involvement of private sector in on-going Missions on seed technology, horticulture, livestock, fishery, farm mechanization, agriculture extension etc. would be highly useful.

9. There is an urgency to create an enabling environment for developing strong public-private partnership (PPP), for which there is need to build mutual trust and initiate some PPP projects, especially on intellectual property and royalty structures, making technologies generated in the laboratories of public research institutions accessible to private industry, through mutually accepted access and benefit sharing (ABS) system. Opportunity also exists through corporate social responsibility (CSR) to launch ambitious and large PPP projects in areas like rural infrastructure, creating Agri-Clinics, paid extension, linking farmers to markets and in technology development involving youth, including women, for increasing farmers' productivity and profitability.

10. There is huge opportunity to develop export of agricultural products for which a long-term export policy linked with incentives and single window system is fully justified. A well planned strategy will create a positive impact on the ability of private sector to develop India as an export hub for agricultural products. Plant quarantine policies, PRA related matters, quality laboratories and similar measures are needed to promote exports of various agri- inputs.

11. A platform for regular interactions with private industry involved in agriculture will facilitate constructive discussion between the Government and the industry to achieve a fully integrated approach to improve Indian agriculture and farmers' incomes.

12. The private industry working in agriculture, covering both inputs and outputs, has a significant spend on the CSR activity. Currently it is spent on different activities as per the plan of each company. It would be prudent to channelize the CSR spend of this industry, in a pooled fashion and in a PPP mode, into priority areas that can help the farmer to gain access to grassroots level knowledge to achieve sustainable agriculture. This money may be invested in strengthening the KVKs, in helping to establish Agri-Clinics, in creating water shed management assets in villages and in promoting good agronomic practices (GAP) among farmers. This investment will create a significant multiplier effect on the incomes of farmers

2.11 Institutional Mechanisms and Reforms

The National Policy on Farmers 2007 emphasized the importance of grouping farmers at the grass root level. The grass root level groups could be self-help groups (SHGs), farmers' associations or cooperatives which can function in different areas, namely, seed banks, community-managed seed villages, community foodgrain banks for potential underutilized crops, trade information and value addition, cooperatives for supply of inputs, production, value addition and marketing, group farming by SHGs, cooperative farming or services, smallholders' estate – promote group cooperation among farmers in a village or watershed, etc. The National Commission on Farmers (NCF) in 2006 advocated paradigm shifts to address the plight of Indian farmers. A change in the approach in farmer extension services from a top-down approach to participatory research coalition between researchers, extension officials, marketing professionals and farmers was considered the most important paradigm shift after the research and technology domain for renewed agricultural development of the country.

A healthy coalition of the stakeholder groups is critical and will be possible only when there is marked change in the present system of implementation of farmer extension services including modification in the structure and composition of grassroots institutions, and building capacities of farmers. While the country observes Mahatma Gandhi's 150th birth anniversary this year, it will be the appropriate time to launch the New India Agriculture Mission to realize his dictum of "*Gram Swaraj* which is the pathway to *Poorna Swaraj*". One of the recommendations of NCF in this direction was to train one woman and one man from every panchayt/local body to become *Bharat Nirman* Corps and organize them to spearhead a sustainable agriculture and food production movement. The core objective of such training should be demystification and handling of new technologies like biotechnology and information, communication technology (ICT) and developing a cadre of rural farm science managers at every panchayat. Appropriately mobilized farmer organizations, women self-help groups, and Panchayati Raj institutions and mass media should be able to take forward the agriculture reform movement in every village of this country to make increased growth and improvement in farmers' income and welfare.

2.11.1 Current Status

Keeping in view the SDGs, all agriculture policies and programs should essentially have sustainable agriculture as an explicit goal and make appropriate strategies to achieve the goal. Further, given that the large majority of our farmers are small and marginal, promotion of grassroots institutional mechanisms for the realization of economies of scale has to be an important strategy.

There are many traditional practices and institutional mechanisms followed by the farming community related to crop choice, seed systems, cultivation, labour system, and marketing, and certainly their demands change accordingly. The urgent need to modernize such practices and mechanisms is now being realized by farmers and farmer institutions themselves in many states, in order to bring about shifts in skilled on-farm, off-farm and non-farm jobs. This is all the more important in case of the smallholder farmers, and building assets like land, livestock or fish pond, necessary rural infrastructure, electricity, connectivity etc; for landless men and women.

The 73rd Amendment Act to the Constitution of India vests the responsibility of agriculture and agriculture extension with panchayats. Kerala is a good example where the power of *gram panchayats* is explicit in agricultural production. There are multiple stakeholders and institutions working for agriculture development in the state. This includes informal collectives of farmers (including exclusive men farmers, exclusive women farmers), formal collectives of women farmers' groups (under Kudumbasree Mission), farmer collectives (crop-based- *padasekara samithi* for rice farmers, *kuurumulaku samithi* for pepper farmers) promoted by the DAC&FW, farmers' groups promoted by different boards constituted by the Central Government (e.g. coffee farmers under coffee board, rubber farmers under rubber board) and farmers' groups/ associations promoted by NGOs (e.g. organic farmers' groups, farmers' groups under FPOs.

Recently, GoI has promoted the approach of collective action in the institutional form of FPOs to enhance smallholders' competitiveness and increase their advantage in emerging market opportunities. It

was first included in the 12th Five Year Plan and later it has been adopted as a strategy to achieve the target of doubling the farmers' income by 2022. Data as on 31st October 2017 showed that about 6.77 lakh small and marginal farmers had been organized into 39,853 farmer interest groups (FIGs) and federated into 741 FPOs, of which 666 had been registered and 75 were under registration process.

FPOs have been evolved as a prototype to increase farmer's income and reduce risks in both marketing as well as in production. Both global and national level organizations have recognized FPOs as a platform to bring together smallholders with the aim of achieving the economy of scale by harnessing collective action through social capital. Government of India has started adopting the promotion of FPOs as one of the key strategies in 'Doubling the Farmers' Income' agenda. Field level learnings have shown that such a platform has potential for farmers to actively participate in the value chain by overcoming the intermediaries in the market up to three levels. MSSRF's experience shows that their participation in the market as a collective is helping to gain significant increase in profit compared to non-members. Diverse marketing strategies were tried, starting with aggregation, grading, processing to a certain level with a quality check to direct and delayed marketing. Fine tuning the marketing strategies by FPOs is, however, a time-consuming process and during this period, handholding is required for which FPOs need be paid more attention.

The cooperatives are the 'people-centred enterprises owned, controlled and run by and for their members to realize their common economic, social, and cultural needs and aspirations' (https://www.ica.coop). The UN SDGs recognize the role of cooperatives in realizing the SDG Agenda. The UN General Assembly in a resolution on Cooperatives in Social Development, adopted in December 2017, recognized that "cooperatives, in their various forms, promote the fullest possible participation in the economic and social development of local communities and all people, including women, youth, older persons, persons with disabilities and indigenous peoples, and are becoming a significant factor of economic and social development and contribute to the eradication of poverty and hunger (https://www.un.org).

In India, the Cooperative Credit Societies Act passed in 1904 was followed by the Cooperative Societies Act in 1912 that gave recognition to credit societies, provided for non-credit services to be provided and for the formation of a federation of cooperatives. The Maclagan Committee on Cooperation (1914-15) recommended that there should be a cooperative for every village and that every village should be covered by a cooperative. Cooperatives have an important role to play in banking, input supply, marketing, agro-processing, and other agribusinesses to protect farmers from the vagaries of existing imperfections in the supply of inputs, production, value addition, and marketing.

Cooperatives are found in various sectors of the economy such as banking and credit, dairy, fertilizers, sugar, agricultural value addition and marketing, fisheries, handlooms/handicrafts, and housing. Operation Flood project which helped India become the largest producer of milk globally has largely been led by dairy cooperatives. Milk is today processed and marketed by 170 Milk Producers' Co-operative Unions and 15 State Cooperative Milk Marketing Federations (https://archive.india.gov.in). The power of the cooperative is that it can help connect with the last person. The network of Primary Agriculture Credit Societies (PACS) across the country, for instance, is far more widespread than the rural branches of scheduled commercial banks. The outreach (both grassroots network and credit exposure) of the cooperative credit sector in terms of reaching out to small and marginal farmers is higher than that of commercial banks and regional rural banks. There were 94,384 rural cooperatives, including short-term and long-term -cooperatives in 2017 (RBI 2017).

According to UN, women agricultural workers are overwhelmingly in informal employment, without social protection, decent working conditions, and reliable employment and income. They often undertake difficult physical labour, working long hours in unsafe conditions and are paid lower wages compared to men, if they are paid at all. Women are much less likely to be in a position to control productive resources necessary for agriculture and are more restricted in access to and control over land, energy, water, pasture, forests, agricultural inputs, credit and insurance services, information, technology, and markets (http://www.unwomen.org).

As part of *Manila Kisan Sashaktikaran*, MSSRF organized women farmers including widows of male farmers from 60 villages across three blocks in the districts of Wardha and Yavatmal into 215 women

farmers' groups (*Mahila Kisan Samitis*) with a membership of 3265 women farmers during 2009-2017. The groups received training and capacity building on sustainable agriculture practices, household food security and institution building and have been federated into three block level federations. A key transformation observed was the realization amongst the Samiti members of the centrality of women in the agriculture process and they are asserting themselves by way of decision making, which earlier was seen as the prerogative of the male members of the household. Greater participation of women members in local government, being recognized as trainers by the State Rural Livelihood Mission and adoption of recommended practices of mixed cropping and sustainable agriculture for enhanced food security was witnessed (Rukmani *et al*. 2018).

Among several initiatives across the country, the Self Employed Women's Association (SEWA) (http://www.sewa.org) and Kudumbashree are two examples of initiatives for women's empowerment that include empowerment of women in agriculture. Women are at the center of the Community Managed Sustainable Agriculture Program (CMSAP) in Andhra Pradesh initiated under the Society for Elimination of Rural Poverty (SERP). Many other states, e.g. Bihar, Jharkhand, have set up Livelihood Promotion Societies with organization and empowerment of women in agriculture as a key focus.

2.11.2 Challenges

Some of the agriculture policies and programs in a few states of India do have a provision of farmer level and grass-roots institutional mechanisms, clarity on their role and strategy for achieving the necessary shifts in farming is largely missing. The required progress towards sustainable agriculture is not visible which is largely due to poor implementation mechanisms. While a lot is happening on the ground, the challenges remain. Technological and skill development of women in agriculture is required at one level; this can, however, be sustainable only if they are recognized as women farmers and have right to land and access to credit and input services. India today has a network of organizations for recognition of women farmers' rights – *Mahila Kisan Adhikaar Manch* (MAKAAM) (http://makaam.in) - that engages in advocacy.

Politicization and control by dominant lobbies have however damaged the fabric of the cooperative credit structure. However, realizing their potential, there have been several committees that have recommended the restructuring and revival of the cooperative credit structure. The Vaidyanathan Committee in the last decade made detailed recommendations with regard to restructuring both short-term and long-term cooperative credit structure to make them viable. Another High Powered Committee on Cooperatives chaired by Shivajirao Patil constituted in 2004 to commemorate a hundred years of the cooperative movement in the country in its report submitted in 2009 endorsed that only through certain amendments in the Constitution it would be possible to ensure that the state cooperative laws provide for enabling the autonomous functioning of the cooperatives.

2.11.3 Opportunities

The National Policy on Farmers advocates the need for cooperatives of farmers for income enhancement. Farmers' organizations and other entities like cooperatives and small farmers' estates need to be encouraged so that farmers can get a fair deal and enjoy the economies of scale. However, the policy does not mention about the promotion of grass-roots institutions for sustainable agriculture, other than SHGs.

The National Mission for Sustainable Agriculture (NMSA), 2010 focusses on the judicious utilization of resources through community-based approach in areas such as water use efficiency, pest management, improved farm practices, nutrient management, agricultural insurance, credit support, markets, access to information and livelihood diversification as thrust areas. However, the NMSA does not indicate about the importance and role of GRIs which is indeed very important.

There are also on-going initiatives like Globally Important Agricultural Heritage Sites such as FAO's-GIAHS, CBD enabled *Satoyama* sites or otherwise the Socio-Ecological Production Landscapes and Seascapes (SEPLS). Similar kind of mechanisms and framework can be adopted to identify nationally and locally important agricultural heritage sites. Such examples demonstrate the importance and recognition

of on-farm conservation of agrobiodiversity, and also recognize the overall spirit of sustainable utilization of biodiversity and heritage practices to address the issue of livelihoods, income, food, nutrition, and climate resilience. Comprehensive agro-ecological landscapes or individual farms that are maintained with diverse land uses and land cover heterogeneity, agroforestry systems, integrated/mixed food production practices with strong community and family farmers' involvement can qualify for this recognition.

2.11.3.1 Farmer producer organisations

Following globalization, the agribusiness sector has been dominated by private players with a decline in the role of the state in ensuring the interest of the farmers. The private sector participation was promoted and institutionalized by the amendment of Agricultural Produce Marketing Committee (APMC) Act in 2003 in the form of contract farming. The approach was advantageous to the private sector at the expense of small producers (Hellin *et al*., 2009) which was not supportive to smallholders and they are largely excluded (Pritchard and Connell, 2011; Singh, 2009, 2012). In this backdrop, the Government of India (GoI) shifted the approach to support smallholders by promoting collective action among producers. The earlier models of collective action based on cooperative principles faced limitation in effectively harnessing the benefits of collective power, especially in the cropping sector.

Given the enabling policy context and push from the government, the "Small Farmers Agribusiness Consortium (SFAC)" an exclusive body was established in 1994 by Ministry of Agriculture, Cooperation and Farmer Welfare by GoI to promote FPOs, also several government schemes, development agencies, and NABARD have been promoting FPOs across the country.

India needs a minimum of 100,000 Farmer Producer Companies (FPCs) to transform Indian Agriculture. FPOs have emerged as the most appropriate institutions that mobilize farmers and build their collective capacity in production and marketing. But, the weak area is still the marketing on a scale, since it is limited for a few commodities only like vegetable and fruits, others required further processing. There are many crops or products have geographic and agroclimatic zone specificity which will be a comparative advantage for the farmers of such locations. Capacity development of the present FPOs with this objective will help the farmers to focus on production and marketing of those crops or products and provide supply of such materials in sufficient volumes. The agricultural cooperatives should get more autonomy and capital support to accomplish a responsible and remunerative production and marketing system.

The infrastructure to promote farmers' market (Uzhavar Sandhai in Tamil Nadu and Puducherry) to implement the strategy for FPOs is not given adequate attention in the country. Also in APMC or market yards, the FPOs are not getting selling space both in the grain as well as vegetable/fruits. On the whole there is an insufficient regulated market access to farmers across nation. The all-India average area covered by a regulated market is 487.40 sq km which is quite high and the variation across states ranges from 118.78 sq km in Punjab to 11,125 sq km in Meghalaya. The distance as well as inadequate space discourages FPOs to access the facility and adopt the strategy of delayed marketing. The National Commission for Farmers (2004) recommended that the density of the regulated market facility should be available to farmers within a radius of 5 km (corresponding market area of about 80 sq km) for easy access. Currently, the regulated market is accessed predominantly by the licensed traders or big farmers which reduce the opportunity for the FPOs with potential buyers. Following are some key opportunities for this transformation.

- Strengthening and promotion of direct selling initiatives for FPOs through establishing additional infrastructure such as setting up regular farmer markets in suburban areas and building their capacity in branding
- Considering FPO transactions as equal as the transaction of farmers in government schemes, warehouses, credit facilities and market places and also, having an exclusive body to handle and provide the credit linkages for FPOs with the understanding of FPO positioning in the agriculture sector;
- Providing access to grading, pre-processing, processing equipment and facilities to FPOs with transportation support in the initial period of their establishment in business;

2.11.3.2 Women self-help groups

The National Policy for Farmers (2007) has recommended that for capacity building and livelihood, women working in the farms need appropriate support services like crèches and child care centers. The Policy calls for joint *pattas* for both homestead and agricultural land 'for empowering women to access credit and other services'. But progress on this front has been tardy.

The UN SDG Agenda to which India is a signatory, under SDG #5 on gender equality one of the important target is to "undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws". Dr MS Swaminathan had introduced a Women Farmers' Bill in Parliament, during his tenure as a Member of Parliament, but it lapsed. Recognition of women as farmers and title to land is a critical gap that has to be addressed for women farmers' groups to sustain and play a more effective role in realizing the goal of sustainable agriculture, which is composed of SDG #2.

Women play an important role in agriculture. With globalization and migration of men in search of employment, the feminization of agriculture is a prevalent phenomenon across developing countries with large population dependent on agriculture. The *Mahila Kisan Sashaktikaran Pariyojana* is a sub-component of the National Rural Livelihood Mission (NRLM) that strives to empower and build the capacities of rural women for sustainable agriculture through strong community-based institutions. There are many state initiatives in India that focus on organization of women farmers. Women self-help groups (SHGs) and women farmers' groups (WFGs) are two examples of such community-based institutions. While SHGs are necessarily savings and credit groups, women farmers' groups highlight the identity of women as farmers. These women may also be members of SHGs. The SHG approach of organizing women farmers is, however, the more popular approach. There should be women focused initiatives to promote the establishment of community food and water banks operated by women SHGs, based on the principle 'Store Grain and Water everywhere'. Women also would help in conserving, enhancing and improving crops and farm animals as well as fish stocks through breeding.

2.11.3.2 Farmer cooperatives

A further amendment to the Multi-State Cooperative Societies Act of 2002 was also suggested to mitigate some practical problems (GoI 2009). The National Commission on Farmers (2004-06) also identified cooperatives as an important grassroots institutional structure for serving the needs of the farmer community across different sectors of crop and animal husbandry and with regard to both production and marketing. The importance and promotion of cooperative institutions figures in the agriculture policies of many state governments, although a clear strategy is missing in most cases.

Given the basic tenet of cooperative principles and the experience of their successful operation in the dairy sector, there can be no denying of their potential. The policy and legal framework under which cooperatives are functioning should be reviewed so as to create an enabling environment for them to attain autonomy and run their operations in a business-like manner, subject to the provisions of law. The management of the cooperatives needs to be made professionally competent, with clear demarcation of functions of the elected members and the managers. The audit and accounting systems need be improved and made transparent so as to give greater confidence to all the members of cooperatives. There are instances of PACS operating as viable entities.

The effective revitalization of the cooperative credit sector can help address the vacuum in rural credit to a considerable extent (Vaidyanathan Committee on cooperative credit). The PACS are in the nature of local banks with an understanding of the local area and demand. Cooperatives also have the potential to be vibrant banking institutions as shown by the operation of some of them (http://mcrbms.com). They also have the potential and scope to be viable multipurpose societies servicing needs beyond just credit and are an important grass root institution structure for sustainable agriculture.

Under Farmer Cooperatives, the strategy of land pooling to maximise production needs to be in place. Land pooling can help create large tracts that can put in use for enhancing the sustainability of both

small holder farming and large scale agriculture. Small holder farmers are usually more willing to change unsustainable farming practices if the can be assured of increased economic returns and reduced risks. The fragmented lands pose big limiting factor now to increase income and improve sustainability. How to make it contiguous the production lands by protecting the legal rights and land ownership and tenure patterns is the critical question. Farmers have to be organized in the form of a joint stock-company to do small scale agri-business with legal protection of individual farm lands. State has to device appropriate mechanisms and strategies to pool small land parcels and promote participatory land management. The Small Farmers' Agribusiness Consortium (SFAC) functioning under the Department of Agriculture and Cooperation & Farmers' Welfare (DAC&FW), Government of India can take a leadership role here.

Farmers' collectives and innovative strategies are needed for changing the quality of value chains in agriculture. Small farmer participation in the value chain development in mountain agro-ecosystems as an innovation for conservation and market development of herbs and medicinal plants needs to be developed. The concept of Bio-Valley, which is derived from Silicon Valley, the home of many technology corporations and start-ups in the IT sector can be emulated. There is need to make attempts on similar lines, but underpinned by the principles of a circular agriculture approach and to be targeted to the sector of bioresources for creating sustainable production in the historical mountain valleys of India. The project has to create sustainable livelihoods by promoting an integrated approach of conservation, cultivation, consumption and commerce in production and marketing of heritage nutri-grains, herbals and spices. This approach can help to establish nation-wide Nutri- Grains and Herbal Farmers' Forums tasked through Farm Field Schools, FPOs and KVKs.

2.11.4 Recommendations

1. The National Farmers' Commission chaired by Prof. M.S. Swaminathan through the period 2004 to 2006 analysed in detail the farming and farmers' issues at national level and recommended a number of path breaking reforms to address the issues of both farmer distress and sustainable agricultural production. However, many of these reforms have not been implemented which needs to be done in view of the diversity of farming systems, the socioeconomics, as well as the geographies of the country, and the rapid changes happening in the development sector during the past 10-15 years, there is urgent need for constituting Farmers' Commissions at the centre and in the states to look into all aspects relating to farmers and farming. These commissions will review and recommend the necessary reforms for sustainable agriculture, address the causes of farmers' distress, and productivity loss as well as measure of income enhancement under diverse production systems across the different agro-ecoregions of the country. The commissions should also reflect a farming system specific policy reforms to achieve the goal of sustainable agricultural production and profitability.
2. National and state agriculture policies need to recognise and give due importance to farmer extension services and farmer targeted institutions as a strategy for the promotion of sustainable agriculture. Traditional systems that have functioned well over the years need to be revisited and their positive elements incorporated in government policies and programs. The extension of services should not remain in a single farm or collective farm in smaller area based, rather it should be across large landscapes that have a mosaic of land uses. There is also urgent need for convergence between the extension services of the Departments of Animal Husbandry, Fishery, Horticulture, and Soil and Water Conservation. The approach of the services also should help to maximise biodiversity in agricultural landscapes. *Panchayati Raj* institutions can play a major role in this context by fostering a coordinated extension and skill development approach at district and block levels. The agro-services like decentralised organic fertilizer and pesticide production and application, crop insurance and credit support (including KCC), facilitation for quality and traceability for exports, value addition and processing technologies and techniques including maintenance and lending of farm machinery and equipment should be managed and extended under the supervision of trained agriculture science experts and elected members of panchayats and gramasabhas. There should be conscious efforts from the part of local elected governments to promote sustainable land management (SLM) practices such as (i) improving water use efficiency and productivity; (ii) restoring and enhancing soil fertility; (iii) maximising yields; (iv) maximising conservation of biodiversity; (v) strengthening

resilience to climate change; (vi) improving farm income and other economic outputs in agricultural ecosystems. For the successful implementation of the existing schemes under the sustainable agriculture at the national and state levels, the need for a perfect mix of several ingredients is very visible in the present extension schemes. Strategic partnership with existing agricultural institutions, farmers' associations, women groups, and elected local panchayts becomes critical and so the enabling conditions like specialized technical support and market related incentives to adopt existing production systems in such a way that enhance biodiversity and support sustainable practices.

3. Agricultural Technology Management Agency (ATMA) operates at district level in 720 districts in 28 States and 3 Union Territories for technology dissemination. The present norm of up to 10 per cent of allocation on recurring activities through NGOs, FPOs and *Panchayati Raj* institutions to be raised to at least 50 per cent with appropriate private partnership. The current 10 per cent of financial contributions from the beneficiaries to be shifted to the partnering agencies like NGOs and private sector agencies. The converged platform of ATMA and KVK should be able to provide all the necessary and demand driven and gender sensitive agro-services. Convergence between the activities of KVKs, and ATMA needs to be ensured through proper monitoring mechanism. This present district level agency should become truly a farmer driven institution with more power of autonomy entrusted. KVKs and ATMA the two legs of farmer extension at district/block level need to have better coordination and convergence so as to be more effective in dissemination of new agriculture technologies.

4. The Agro-Clinic services need to be strengthened with trained professionals and active formal involvement of knowledgeable farm men and women. Capital support to start necessary infrastructure for processing and packing houses to be provided at district or collective level. The activities of present Agri-Clinics, Agri-business Centres, Farm Schools, ATMA scheme, and KVK and State Agricultural University extension services at district level should be brought under the purview of *Panchayati Raj* institutions especially up to block level with all activities stated above, and be integrated with expanded scope of services. The present ATMA platform in many states looks deplorable and becoming a place for keeping the State Extension Department officials, mostly who are nearing their service retirement. This situation needs to be improved on priority and it should be ensured that at least 60 per cent of the plan fund is used for on-the ground actions.

5. The small holder farm or fishery villages need to be transformed into 'Bio-Villages' to offer a "solution designer approach" in achieving sustainable agriculture and fisheries goals. The Agri-Clinic-Business Support Centres (ACBSC) for adoption of locally relevant technologies for sustainable agricultural production practices and integrated intensive farming system need to be established/strengthened. This is possible through empowerment of men, women, and youth to innovate and enterprise the agriculture and fishery production and marketing. An important component of coastal bio-villages should be the establishment of "Aquaculture Estates" which can help to confer the power of scale to fisher families in the production, processing and marketing of fish. The need to promote ecosystem and location specific soil health can be achieved under this umbrella by empowering village youths. Every village should get a trained cadre of sustainable agriculture promoters who have mastered in the best management practices like SLM that improve soil quality such as reducing nutrient and soil losses, improving soil fertility and productivity, and improving soil moisture. The SLM practices will help to promote resilient agriculture by improving the quality of soil organic matter and soil structure, which needs continuous monitoring, enrichment/ and replenishment.

6. It is absolutely essential to strengthen the Seed Village concept for hybrid seed production and community seed management in order to protect landraces and traditionally saved seeds across all agro-ecological zones of the country to ensure quality seed production and on-farm conservation of genetic diversity. There are several successful examples around country on farmer level seed businesses as seed cooperatives on a wide range of crops i.e. cereals, legumes, vegetables and fruit crops. As a participatory enterprise between the public institutions, private sectors and producers with well-defined scientific package of practices from varietal selection to breeding, processing, storage, certification and marketing has to be promoted. A major gap lies towards this objective is in famer mobilization, technology transfer and scientific seed management practices despite that the

village level seed production is a mandate for the KVKs. By keeping the lessons learnt from the recent PepsiCo case of potato seeds, intensive training programs need to be organized at every district level to empower every farmer to function as a breeder, conserver and cultivator who has rights to save, use, sow, re-sow, exchange, share or sell the seeds.

7. The supplementation of financial needs of small and marginal farmers through the existing schemes like *PM Kissan Nidhi* to be directed to those who are engaged in promoting a farming system approach, and nutrition and health promoting farming methods. There is an urgent need for giving thrust to nutrition sensitive agriculture by mainstreaming the nutrition dimension in agriculture policies and programs, including the promotion of nutrition sensitive agri-food value chains. The local KVKs can be the institutions that manage such incentive mechanism which help to promote a Farming System for Nutrition (FSN) approach for the food and nutrition security of smallholder farm families. Setting up of location-specific FSN models in KVK across the country is required. This approach can also help to transform the present kitchen garden approach in to nutrition garden approach with cultivation of seasonal fruits and vegetables. The *Mahatma Gandhi National Rural Employment Guarantee* (MGNREG) scheme also needs to be effectively linked for setting-up at village level by way of cultivating/ planting seasonal fruits and vegetables on common land in villages.

2.12 Knowledge Dissemination and Capacity Development

An inclusive agricultural growth would demand innovative, cohesive and synergistic extension system for knowledge dissemination and skill development. To achieve sustainable food and nutritional security, and to address effectively the adverse impact of climate change and widening knowledge gaps, agricultural research for development (AR4D) now needs a paradigm shift to agricultural research and innovation for sustainable development (ARI4SD) duly supported by reinvigorated agricultural research, education, extension, skill enhancement and knowledge dissemination system. The current multi-faceted challenges in Indian agriculture including moving away of youth from agriculture have led to gradual decline in total factor productivity and consequently low income of the farmers. The complexity of these challenges cannot be overcome by routine transfer of technologies and traditional degree programs by the SAUs and ICAR. Hence, a forward looking, innovative and participatory extension and skill development system, using modern ICT tools, is urgently required for pluralistic technology transfer, polygonal skill enhancement and primary rural agri-entrepreneurship development. This demands for policy reorientation to reorient agricultural extension and capacity development programs into multi-stakeholder innovation platforms imparting knowledge and education; agri-entrepreneurship and livelihood; and institutionalize facilitation of interactions and market linkages for farmers' welfare. Accordingly, a demand driven multi-stakeholder approach towards integrated farming systems and agri-entrepreneurship is considered a way forward.

Experience of Green Revolution reveals that effective and efficient agricultural extension and advisory services are critical to achieve higher and sustainable productivity and promote agricultural trade to help raise the farmers' income. Over the years agricultural extension has been in the domain of public sector and catering merely 15 per cent of the total mandated area of extension system. The problem is further exuberated due to huge skill gaps in agriculture sector. The existing formal human resource development programs by SAUs and ICAR mainly address capacity building of individuals and improvement of specific subject expertise within the existing institutional context. But in the recent past, the scope of agricultural extension and education has undergone certain fundamental changes with growing number and diversity of extension service providers like private sector, NGOs, farmers, social media, etc. and private agricultural education system. Private sector and civil society play an important role in innovations but their services are yet to be optimally organized and mainstreamed for effective use. With increasing challenges, agricultural extension and farmers' welfare is critical for the large-scale adoption of highly scientific, resilient, productive and remunerative secondary and specialty agriculture by the farming communities. This would require enhanced use of advanced technologies and harness power of ICT in agriculture. It is also clear that the knowledge sharing on good agronomic practices, without dissemination loss, would indeed be critical to achieve better success in agriculture sector for which role of print, social media like radio and TV, ICT (especially mobile phones) is important and is being increasingly considered essential for faster dissemination of information.

Therefore, a real transformation in the existing extension system requires demand-driven, multi-dimensional, multi-agency, market-oriented, pluralistic, and an out-of-box approach with special emphasis on women and youth empowerment. This demands for 'paid extension services'; especially when there is scope to increase farmers' income, for which an enabling policy environment is now emerging for the private extension system in the form of 'agri-clinics' through small scale entrepreneurs as technology agents and input providers.

2.12.1 Current Status

Since agriculture is a State subject, the responsibility of implementation of Central Government (GoI) schemes launched from time to time also lies with the State Governments. As on date, about 102 missions, schemes, and programs are in operation, which various Central and State Government agencies operate through their line departments, research institutions, state agricultural universities, NGOs and private sector. The main responsibility for agricultural extension and advisory services also lies with the

State Government. However, the Central Government also provides assistance and needed advisory/ financial support through the ATMA scheme now operating in 676 districts and other programs such as RKVY, Technology Missions etc. In addition, the ICAR has also evolved an extensive frontline extension system, which is considered to be a unique institutional model at the district level. With the establishment of first KVK in Pondicherry in 1974, there are now 720 KVKs in almost all districts of India; some larger districts having even two KVKs. The KVK activities include on-farm testing to identify the location specificity of agricultural technologies under various farming systems, frontline demonstrations to establish the production potential of improved agricultural technologies on farmers' fields, and training of farmers and extension personnel to update their knowledge and skills. Besides, KVK works as a knowledge and resource centre of agricultural technologies for supporting farmers and providing backstopping for improving their agricultural production and livelihood.

In order to make KVKs more effective and functional institutional mechanism, around 28 of them were recognized as ATMA centres under the National Agricultural Technology Project (NATP), funded by the World Bank in 1998 with the objectives: (i) to accelerate the flow of technology from research, and extension to farmer, (ii) improve the dissemination of location specific and sustainability enhancing technologies, (iii) decentralize technical and decision-making authority to the district level for better ownership, (iv) create an effective and financially sustainable public extension system, and (v) promote privatization of certain technology transfer activities. Based on its success, it was envisaged that all the KVKs should have plant health clinics and biocontrol laboratory, soil and water testing laboratory; and grading & packing unit and hi-tech greenhouse/polyhouse, etc., and it would run on ATMA model. The scheme promotes decentralized farmer-driven and farmer accountable extension system through an institutional arrangement for technology dissemination at district level. Under ATMA scheme, grants-in-aid is released to the states with an objective to revitalize existing extension system in the states by making available the latest agricultural technologies to the farmers through activities such as: farmers' training, demonstrations, farmers fairs, exposure visits, mobilization of farmers groups and setting-up of farm schools.

The country's institutional arrangements in support of capacity development have been mostly formal through SAUs (64), Deemed-to-be-Universities (5), Central Agricultural Universities (3), Central Universities with Agriculture Faculty (4) and KVKs (720) for short-term trainings of stakeholders. The formalised human resource development in agriculture sector began before independence but extensive emphasis was put after development of ICAR, an apex body for coordinating, guiding, and managing research and education in agriculture. In SAUs, CAUs and ICAR, capacity development is mainly focused on training individuals through Master's and Doctral programs with strong focus on technical and natural sciences,whereas, in the emerging agricultural scenario, lack of skilled manpower to address the new and emerging challenges and deliver the technology and information at grassroots level is clearly visible. Empowering farmers, especially the youth (including women), through skill development is indeed very important for bridging these knowledge gaps in the rural parts. In the recent past, several initiatives have been taken up by the National Bank for Rural and Agricultural Development (NABARD) through Rural Entrepreneurship Development Programs (REDPs) and Skill Development Programs (SDPs) and by the Ministry of Skill Development & Entrepreneurship (MSDE) through Agriculture Skill Council of India (ASCI) established in 2013 through skill development programs to develop the desired human resource in agriculture sector. In the past two decades, 8.71 lakh unemployed rural youth have been trained in different agriculture and allied fields through 33,812 REDPs/SDPs by NABARD,whereas, ASCI has trained and certified over 1.2 lakh youth and professionals for 86 agriculture sector related skills and jobs. Currently, more than 6.2 lakh rural youth and farmers are enrolled with ASCI training partners.

Currently, there is large gamut of applications and eGovernance workflow systems that can harness power of ICT in agriculture (Box 3). Such applications are domain specific, like marketing, integrated nutrient management (INM), seeds, farm mechanization, extension, pest control, livestock and animal husbandry, fisheries, water resource, fertilizers, farmers' welfare, census, etc. However, all applications and datasets relevant to agriculture are currently decentralized, and there is urgent need to consolidate these at the state and national levels.

Box 3. Major existing ICT platforms in agriculture sector

- Pradhan Mantri Kisan Samman Nidhi – https://pmkisan.gov.in
- Integrated Fertilizer Management System – http://urvarak.nic.in
- Livestock Census – http://livestockcensus.gov.in
- Agriculture Information Portal – http://agrionline.nic.in
- Soil Health Card – http://soilhealth.dac.gov.in
- Participatory Guarantee System India – http://www.pgsindia-ncof.gov.in
- Direct Beneficiary Transfer – http://dbtdacfw.gov.in
- DBT Farm Mechanization – https://agrimachinery.nic.inhttp://fishcraft.nic.in/
- Agri Clinics and Agri Business Centres – http://acabcmis.gov.in
- Extension Reform Management System (ATMA) – http://www.extensionreforms.dacnet.nic.in
- HORTNET under MIDH – http://hortnet.gov.in
- SeedNet Portal/DBT Seed – http://www.seednet.gov.in
- FARMAP – http://farmap.dac.gov.in
- AGMARKNET – http://agmarknet.gov.in
- Computerized Registration of Pesticides – https://pesticides-registrationindia.nic.in
- Plant Quarantine Clearance System – http://plantquarantineindia.nic.in
- Seed Export Import – http://seedexim.gov.in
- Crop Area Coverage Information System – http://aps.dac.gov.in/AreaCoverage

2.12.2 Challenges and Opportunities

In order to achieve higher productivity, input use efficiency, sustainable agriculture, post-harvest processing and value addition for better marketing and income to the farmers, effective and innovative extension service is now urgently needed. A well-coordinated technology-led farmer-centric extension system, coupled with needed policy and financial support, needs to be in place for improving the livelihood of smallholder farmers. For this, a single window institutional approach becomes critical to serve the farmers in each of the districts.

The farmer wants new knowledge, skills and technical backstopping. One of the reasons for poor productivity and low income of farmers is the lack of proper knowledge on efficient production technologies, judicious use of natural resources (soil, water, energy, biodiversity etc.) and production inputs (seeds, fertilizers, pesticides etc.). Often, they lack skills on agricultural diversification, secondary and specialty agriculture. In addition, they have poor knowledge about ongoing schemes of Central and State governments that can benefit them. To address these needs, what is needed is to have an institutional mechanism as well as coordinated management system which can holistically meet the varying needs of farmers.

To overcome the multiplicity and increasing complexity of problems being faced by the farmers, what is now needed is a 'Farmer FIRST' approach to better understand the critical needs of farmers, and to identify options that can address these needs in a manner that would benefit all involved in agricultural value chain. Multi-disciplinary, inter-institutional efforts towards translational research must be accelerated with required policy and financial support, especially to outscale innovations after validation and needed refinements. Conscious deployment of rural youth, women, farmer professors, authorized/trained /certified input providers be ensured through innovative approaches, such as formation of farmers' SHGs, FPOs,

farmers cooperatives, farmer producer companies, farmer-to-farmer trainings, agri-clinics, etc., to catalyse skill development and speedy technology transfer, at local level. Also, the foresight approach to ensure a shift from top-down to bottom-up be adopted to meet new demands for innovations, products, information, skills and extension services.

Concerted efforts are urgently needed to implement the recommendations of High Power Committee on Management (HPCM) of KVKs to ensure improved efficiency; effective monitoring and required farmer-science connect on priority. Also, there is an urgent need to revamp agricultural extension related education by initiating new courses on rural entrepreneurship, agricultural journalism, agri-business management etc. to bring innovative concepts and new economic options for rural youth, including women. Teaching agriculture as a subject for science students in High Schools would generate the much needed awareness on the role and contribution of agriculture towards household food and nutritional security at the national level.

Private sector participation in the national agricultural extension system can be encouraged through their corporate social responsibility (CSR), and also through much needed PPP, supported well by an enabling environment. Greater emphasis needs to be laid on documentation and wider dissemination of successful extension models under diverse agro-ecologies and farming situations. Similarly, lessons learnt from the failures in the past also need to be critically assessed to take corrective measures. Extension research should now go beyond production to post-production extension. Communication systems in rural areas (ICT, TV, smart phones, print media, newspapers, etc.) be enhanced to play more proactive role in effectively reaching the farming communities through excellent linkages with SAUs/colleges, ICAR institutes, NGOs, private sector, and other key R&D players.

The e-Choupal mechanism empowers farmers with relevant, up-to-date information on weather forecasts, best practices, and most importantly, on prices– knowledge that expands choice, enables them to make informed decisions and improves risk management. This information is available right at the village level, through ITC's custom-designed website accessible via computers placed in the homes of selected farmers. There are currently 6,500 such 'internet kiosks' – a digital network used by four million farmers across the country that is helping them to raise quality, productivity and incomes.

2.12.2.1 ICT for knowledge empowerment

The tech-savy skilled rural youth is the key for timely knowledge dissemination, linking to markets and bring eGovernance in agriculture sector for sustainable agriculture. A gamut of applications and eGovernance workflow systems harnessing power of ICT in agriculture as mobile app, IoT, big data analytics, geo-informatics and block chain technology for effective marketing are being used in a decentralized and independent manner. Mobile apps for soil health card, custom hiring centres of farm machineries, tablet based survey capturing for livestock census, farmer app, mobile app for advisory, commodity pices for farmers, biometric authentication through *aadhaar* and capturing sales through PoS devices by retailers of fertilizers are already developed and being implemented. Interactive mobile apps are being used both to and fro i.e. to capture farmer/user information and also for information dissemination. There is huge potential for application of mobile based technology in all types of census like agriculture, irrigation, etc. Scalability to other functional areas of agriculture domain like comprehensive farmer app, agri extension activities like awareness and education. Internet of things (IoT) is another ICT tool for farmers through smart phone gadegts to provide better control over the process of growing crops, making it more predictable and improving input efficiency through continuous field and weather data monitoring. IoT based sensors can be attached to animals for on farm movement monitoring as well as health performance. RFID can be used as e-seal for samples of fertilizers, pesticides, seeds, etc. for making it tamper proof. NIC has proposed use of RFID special tags for sealing the Pesticide samples in Central Pesticide Analysis Information System (CPAIS) for unique identification of e-seals. Use of barcode is also proposed for tracking of the samples inside the laboratory. Fertilizer movement can be monitored through IoT devices on logistics attached to IT systems dashboard for getting up-to-date information of availability of fertilizers to farmers. The availability of large historical databases in agriculture, fertilizer, water resources has provided opportunity for applying data analytical techniques to study the various trends and draw inferences. This analysis can be helpful for formulation of Government schemes accordingly. Block chain technology can provide reliable information

regarding the origins of agriculture commodity, especially the organic and the exact journey it took from farm to table. Additionally, the improved supply chain transparency could also greatly benefit farmers by increasing consumer credibility of produce/farm product, traceability of transactions, quality control, transparency, reduced leakage and faster processing of claims/bills. Some of applications have been used by the private sector to facilitate in delivering faster, reliable and accurate information in a user-friendly manner to farmers and linking them to markets as e-Choupal by ITC, Digital Green, etc.

2.12.3 Recommendations

1. There is need to encourage farming systems extension with the help of inter-disciplinary and inter-institutional extension teams comprising subject matter experts, as was followed under earlier Institution-Village Linkage Program, for effective dissemination of information and technologies.
2. Farmers' participation needs to be ensured at the grass-root level and greater confidence needs to be built among the farming communities to adopt more scientific and resilient farming technologies. Simultaneously, enabling policy environment needs to be created for providing incentives for critical inputs by all stakeholders and market players.
3. Urgent attention needs to be paid for promoting knowledge sharing on good agricultural practices aimed at minimizing the dissemination loss for services relating to inputs, technologies, insurance, processing, value-addition, markets, etc. Also, there is need to provide innovative alternate knowledge/information dissemination systems with authentic contents in farmer-friendly communication mode such as Kisan TV channel, ICT, smart phones, print media and radio to ensure their farthest reach and effectiveness.
4. Vocational training/skill development institutes in agriculture need to be established on priority to impart training on various important aspects such as value-chain, dairy farming, poultry farming, farm mechanization, and alternative use of energy, etc. to bridge knowledge gaps of farmers on innovative technologies including crop production, horticulture, livestock, fishery, and agroforestry, etc. and skill development of youth to cater the emerging needs and use of latest technologies.
5. Priority attention needs to be given to encourage required partnerships amongst the key stakeholders to promote demand driven, multi-stakeholder oriented agricultural extension around integrated farming systems. This needs to be ensured through in-built incentives to adopt innovative technologies that would optimise the use of natural resources, though requiring more adoption time to assess, refine and diffuse NRM related technologies on the farmer's fields.
6. Greater emphasis needs to be given on linking farmers to market, as a key step towards inclusive market oriented development (IMOD) for smallholder farmer. Also, there is need to design women and youth-centric programs for their active role in market oriented agri-food value-chains with provision of right and timely incentives.
7. Establish a dedicated body/mission/authority/SPV to administer the entire ICT in agriculture sector. Such an authority would monitor and plan data management activities, existing ICT applications and portals, adoption of innovative technology and convergence among different portals in agriculture and allied sectors. Establishment of cloud based dedicated datacentre for agriculture domain would ensure timely knowledge dissemination, interoperability of applications, data security, and data sharing policies.
8. The National Mission on Agricultural Extension (NMAE) under the MoA&FW should undertake and promote collaborative extension interventions by public (KVK, ATMA), private, NGOs and progressive/innovative farmers, and oversee the coordination and convergence of various state and district level extension activities by these players in a mission mode approach to accomplish *inter-alia* the following:
    - ❖ Farmer Professors to facilitate farmer-to-farmer knowledge extension and skill transfer without dissemination loss, provide vocational trainings to rural youth and farm women under the 'Skill-up India' and 'Stand-up India' initiatives, build capability of panchayats, and ensure better support of existing institutions for technology/input delivery, credit, subsidy insurance, value addition, marketing, etc. To begin with, around 5-10 Farmer Professors could be inducted in each district.

- Skill gap mapping studies need to be initiated by the National Agricultural Skill Council (NASC) to document current gaps, constraints being faced, emerging needs for farmers and suggest future strategies.
- There is need to transform KVKs into knowledge-cum-innovation centers, and capacity and business development centers rather than their further multiplication. Agri-clinic concept should be initiated at all 720 KVKs in a PPP mode to promote 'paid extension' services. In fact, all KVKs should have plant health clinics and biocontrol laboratory, soil and water testing laboratory; grading and packing unit and hi-tech greenhouse/polyhouse, etc. For the sector-wise strengthening of much needed site-specific programs/activities, there is need to enhance cadre strength to 8 at least ten scientists (relevant disciplines) in each KVK and to redeploy some subject matter specialists in technical cadre to take care of diversified relevant areas such as: business management, agri-preneurship, horticulture, agroforestry, animal science, fisheries, post-harvest processing, social science etc.
- There is great need to revisit ATMA of GoI and KVKs under the ICAR and to consider for a suitable mechanism for their convergence for better coordination with needed reforms concerning allocation of resources to meet the contingent and exigency needs for training and knowledge/information sharing related to agriculture and other line departments with local farmers through KVKs and to shed redundancy and improve efficiency in all district/ local level agricultural extension activities.
- There is urgent need to establish Agricultural Technology Information Centres (ATICs) in all KVKs so as to promote land-lab linkages and to reap the benefits of research through promoting new innovations.
- The FPO members, single window service providers, and agri-input dealers must be skilled through short-term diploma programs by SAUs and KVKs to bridge the grassroot level extension providers gaps at each Panchyat level.
- ITIs and polytechnics should be strengthened with additional vocational courses on agri and agri-entrepreneurial courses.

3. Recommendations and Proposed Reforms

Agriculture directly contributes to inclusive growth and SDGs, particularly no poverty, zero hunger, and life on land. Sustainable agricultural growth can help achieve these SDGs, arrest desertification, moderate emission of green house gases (GHGs) and ensure household food and nutritional security. However, the production-centric approach of the Green Revolution is no more relevant today. The new development strategy has now to focus on efficient growth in agriculture through application of science and technology, incentives for ecological services, institutional innovations to support agriculture and bold policy reforms for linking farmers to markets and services. Time has come to reward the farmers for their ecological services to the nation. Similarly, time is ripe to ensure livelihood security, dignity and respect to farmers who are the backbone for sustaining our food and nutritional security. This shall involve a paradigm shift from production centric to farmer-centric approach aimed at accelerated growth and future sustainability.

Doubling farmers' income is a welcome policy shift, which cannot be business as usual. It would require enhancing farmers' income through productivity gains, product and farming diversification, reduction in cost of inputs, production through increased resource use efficiency, post-production management for reducing losses , value addition and possible export to global markets, particularly for the commodities in surplus, and skill development of farmers for both farm and non-farm income opportunities. An eco-regionally differentiated strategy backed with adequate investment, technological and institutional innovations linked to bold policy decisions that are well coordinated, closely monitored and evaluated shall be the way forward. Diversification of income sources including non-farm income, entrepreneurship and skill development of youth, creation of rural agro-processing clusters and value chains and seamlessly connecting farmers to markets should now be the highest priority. Developing good rural infrastructure and connectivity, leveraging information communication technology (ICT) for reaching farmers with good knowledge, motivating youth for secondary and specialty agriculture and to be the entrepreneurs, post production management and value chain involving partnership with stakeholders, especially the private sector, would henceforth be the key determinants of farmers' prosperity and future agricultural growth so critical to attain a US$ 5 trillion economy by 2024, as envisioned by the Prime Minister.

The important recommendations made in this section elaborate mainly those technical, development and policy related aspects, if implemented quickly, would accelerate sustainable agricultural development (SAD), being key pre-requisites for achieving desired SDGs and for doubling the farmers' income. More detailed justifications for each of the recommendations and also some additional sectoral recommendations are provided in respective technical write-ups in Section 2.

3.1. Policy Reorientation and Institutional Reforms

3.1.1. Revisiting National Agricultural Policies

The National Agricultural Policy (2000) and the National Policy for Farmers (2007) shall have to be revisited as these are more than a decade or two old. Moreover, as stated earlier, new challenges have emerged needing bold policy orientation and new directions. New challenges have emerged in Indian agriculture which need innovations to make a difference. Now it is not only production but post-production management and value addition that demand a paradigm shift from 'Farm to Fork', production to processing, including value chain and traditional to new efficient and sustainable farming. Therefore, business as usual will not do. Agricultural growth will have to be accelerated beyond 4 per cent per annum. Hence, a comprehensive "National Agricultural and Farmers' Welfare Policy (NAFWP)" must now be formulated to achieve SDGs through secure and sustainable agriculture. The new policy must reflect foresight and clear action plan to make India a developed nation through accelerated growth and development in agriculture.

In the process, a thorough review be made to see which of the goals set in the earlier two policies have not yet been made and what reorientation would now be critical to make agriculture a profitable business for the smallholder farmers.

3.1.2. New Institutions Recommended

3.1.2.1 Creating National Agricultural Development and Farmers' Welfare Council

Agriculture being a State subject, often difficulties are being encountered for implementing central schemes and national programs for overall agricultural growth and farmers' welfare. On the contrary, issues relating to soil health, water use and quality, agrobiodiversity conservation, generation and use of power, addressing climate change, production of quality seeds, fertilisers, pesticides, educational reforms, MSP, subsidy, agricultural marketing etc. are simply not confined to state boundaries but are issues of national importance needing policy decisions at the highest level. Hence, in the national interest, there is an urgent need for the inter-state, centre-state and inter-ministerial coordination and convergence. For this, a "National Agricultural Development and Farmers' Welfare Council (NAD&FWC)", on the pattern similar to GST Council, is proposed to be created soonest to ensure effective decision making, monitoring and implementation possible. The composition of NAD&FWC is proposed as: Prime Minister as Chairman; Vice-Chairman NITI Aayog and Minister of Agriculture and Farmers' Welfare as Vice-Chairmen; Chief Ministers/Ministers of Agriculture of all States/Union Territories and Ministers of all concerned central ministries as Members; and Member (Agriculture), NITI Aayog as Member Secretary. To begin with, this council must ensure that water being a national asset is brought on the concurrent list in order to address long standing water related inter-state disputes as a matter of high national priority and also take policy decisions relating to efficient and judicious use of water henceforth in agriculture.

3.1.2.2. Establishing Farmers' Welfare Commissions at National and State Level

Rising concerns of increasing farmers distress and disconnect between policies and programs with real needs of farmers' demand an effective interface with the farmers for periodic need assessment, regular feed-back and redressal by the Government through appropriate policy reorientation, interventions/corrections/reforms. Hence, there is critical need for each state to establish a "State Farmers' Welfare Commission (SFWC)". The 73rd Amendment Act to the Constitution of India vests the responsibility of agriculture and agricultural extension with Panchayats. Haryana, Punjab and Rajasthan States have already established such a commission with very significant results. Kerala State has already evolved a successful institutional mechanism (Kudumbasree Mission) to promote agriculture at Gram Panchayat level. Similarly, other states need to establish such an institutional mechanism.

To provide a national level forum to discuss the issues and advise the Central Government, a standing "National Farmers' Welfare Commission (NFWC)", with statutory powers as those for commissions for women, SC/ST, OBC etc. be established at the earliest possible. The SFWC in turn will establish a close and continuous dialogue with Gram Panchayats and other grass root level institutions/multiple stakeholders like SHGs, farmers' cooperatives, FPOs, etc. to elicit their needs and aspirations and solicit feedback on progress and problems of implementing various development related programs and other initiatives. The SFWC will thus be an effective interface mechanism between farmers and the state, whereas NFWC will be at the central level. The NFWC will also coordinate well with SFWC. In true sense, both NFWC and SFWC will serve as institutions to provide neutral platform and build much needed confidence among the farmers to take care of their needs more effectively. In order to ensure their speedy establishment, the Central Government may take the responsibility of providing adequate funding support initially for the first five years.

3.1.2.3. Independent Strategic Planning, Monitoring and Evaluation Unit

Experience has shown that due to lack of effective implementation and assigned responsibilities for supervision, monitoring and evaluation, the Government programs are either delayed or they do not achieve their desired goals and objectives. Hence, invariably various investments are not able to yield desired results. It is, therefore, suggested to set up an independent "Planning Monitoring and Evaluation Unit" to review all missions, programs and important national schemes related to agriculture and allied fields. Such

a unit be established under NITI Aayog to ensure independent and timely implementation. This Unit be headed by a senior agricultural executive and have provisions to invite experts for technical evaluation and monitoring. Causes of poor implementation must be identified and corrective measures taken periodically, including closure of the non-performing schemes.

3.1.2.4. Creating Agricultural Education Council of India

The need for generating knowledge and skill empowered individuals at present is more than ever before. In essence, agricultural education must aim at producing professionals and academicians who can contribute towards higher agricultural growth and overall prosperity of farmers. However, recent mushrooming of private colleges and universities is inconsistent with the above stated goals and objectives set for present day agricultural education. These quickies entice academically mediocre students for admissions into various courses and charge them exorbitantly high fee, which is un-proportional to the infrastructural facilities and quality of education they offer. More worrisome features of this development are: (i) the ill-conceived legalization of affiliation of private colleges by certain SAUs against the provisions under the Model Act of ICAR for State Agricultural Universities, (ii) prevailing disregard to ensure existence of a minimum physical plan before private institutions are licensed to begin imparting education and (iii) absence of an enforcing mechanism to accredit these institutions after they have been established. Additionally, with profit as the prime motive, private institutions end up hiring substandard human resource for teaching. Hence, there is an urgent need for establishing an "Agricultural Education Council of India (AECI)" by the Parliament which will be a regulatory authority to maintain quality of agricultural education on the lines of Veterinary Council of India (VCI). Alternatively, the mandate of VCI could be extended to all the disciplines of agriculture and placed under the Department of Agricultural Research and Education (DARE) along with current functions of Education Division of ICAR to make it a single window system for higher agricultural education at the national level, so critical for creating competent human resource for future growth of Indian agriculture.

3.1.3 Reorientation of Existing Institutions

3.1.3.1 Elevating the Indian Council of Agricultural Research

ICAR is an apex organisation responsible for research, education and extension at the national level. Thanks to policy support and periodic reforms, ICAR is today one of the finest organizations globally, with tremendous achievements to its credit. Providing household food security is in no way less important than national security. Yet, the stature provided to it is not equivalent to organisation such as Bhabha Atomic Research Centre (BARC). Accordingly its elevation to the same level of autonomy is fully justified to meet emerging challenges and the expectations of stakeholders. The time is ripe for its reorientation and expected reforms for improved efficiency and accountability. In the past, a number of high power committees on ICAR, ASRB and KVKs were constituted. They have submitted their reports which need to be considered for their faithful implementation. Also, the resource allocation for AR4D needs to be doubled urgently to ensure excellence in research which is critical for the sustainability. It must reorient now to embrace corporate culture such as those of Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA) in Brazil and Malaysian Agricultural Research and Development Institute (MARDI) in Malaysia. At the same time, the strength of ICAR at no stage be compromised or allowed to get disintegrated through on-going efforts to divide it into different sectoral councils or to reduce the number of its institutions that are so essential for generation of technology and human now resource so critical for future growth and make India globally competitive. It is difficult to create new institutions but more difficult to sustain them for desired outcomes. Hence, we must nurture them well rather than diluting their mandate and roles.

3.1.3.2 Strengthening State Agricultural Universities

The State Agricultural Universities established on the land grant system, since 1962, numbering currently 64, besides around 8 central and deemed universities, need to be supported well for building competent human resource so critical to meet future challenges, including SDGs. In this context, the bifurcation of SAUs into different universities on sectoral (animal science, veterinary, fishery, horticulture,

etc.) basis is indeed a retrogrative and counter productive step. This trend, therefore, needs to be stopped and quickly corrected. Also, these institutions need trained manpower and nurturing by the State Governments. Current curricula would also need to be made more flexible and diversified, and initiatives for informal/vocational training through diploma/certificate/short courses be encouraged. Agriculture should be taught as a subject in schools to create awareness and interest among children about the role of agriculture for human welfare. Moreover, most of these universities are more than 50-60 years old and hence renovation and modernisation is urgently needed for which 'one time' catch up grant of Rs. 50 crore each, besides approval of filling all positions vacant since decades to have young faculty in place in the areas of new science.

3.1.3.3 Expanding the Mandate of KVK

In order to achieve higher productivity, input use efficiency, sustainable agriculture, post-harvest processing and value addition for better marketing and income to the farmers, an effective and innovative extension service is currently called for. In fact, a real transformation in the existing agricultural extension system requires demand-driven, multi-dimensional, multi-agency, market-oriented, pluralistic and an "out-of-box" approach. Hence, a well-coordinated technology led farmer-centric extension system, coupled with needed policy and financial support, is the need of the hour for improving the livelihood of small holder farmers. For this, a single window institutional approach becomes critical to serve the farmers in each of the districts. Currently, there are 720 KVKs under ICAR, in almost all the districts of India, and 676 ATMA centres, funded by DoAC&FW, which are operational at the district level. Besides, each state has district level extension functionaries linked to different development activities.

For knowledge empowerment and faster delivery of efficient and well proven technologies for profitable and sustainable agriculture to farmers, there is an urgent need for these institutions to function more effectively in a well-coordinated way at the district level. These institutions should provide: knowledge on good agronomic practices, training and skill development, technical backstopping, custom-hire service, facilitation of Agri-Clinics, needed support for youth (men and women) entrepreneurship, timely supply of quality inputs, promoting value chain and linkage of farmers to the markets.

To carry out these functions more effectively, there is an urgent need for effective coordination and convergence between all district functionaries including KVK and ATMA. Hence, to ensure better execution of programs/activities for desired outputs and coordination, the mandate and functions of KVKs need to be expanded. This will contribute significantly towards removing the distress of farmers, provide solutions of their problems at one place and ensure their income enhancement. In view of the increased responsibility and functions, KVKs need to be considerably strengthened and their cadre strength need to be revised with additional expertise in social behaviour, ICT and digital agriculture, agri-preneurship, value addition & post-harvest management, and business development experts, as suggested by the high power committee on KVK in 2014 to revitalize agriculture from livelihood to entrepreneurial mode. The KVKs could thus be mandated to function as "Knowledge-Skill-Innovation Centres" and house Agri-Clinics to provide efficient private extension service to the farmers for higher production and profitability. For establishing Agri-Clinics in each KVK, an initial support of Rs 5 crore be provided in a phased manner (150 KVKs each year) thus needing Rs 750 crore annually for the first five years. Eventually, the successful models of Agri-Clinics would get expanded on their own in different parts to serve the farmers more efficiently.

3.1.3.4 Panchayati Raj Institutions

As per the Constitution Amendment Act 1992, Panchayati Raj Institutions (PRIs) are mandated for seven agricultural development related activities including the land reforms & conservation, extension services, water & watershed management, animal husbandry, fishery, social & farm forestry and minor forest produce. The Planning Commission task force set-up the guidelines for PRIs in central and state government agricultural schemes and integration with NGOs in 2001. But, the implementation varies among the states and even most of them have not integrated PRIs in agricultural development. In this context, it is recommended to constitute a High Power Committee to revisit the implementation strategy to make PRIs important players in agricultural and rural development by fostering a coordinated extension

and skill development approach at village level, developing strategic ground level partnership between existing institutions, farmer associations, FPOs, SHGs, NGOs and elected Sarpanch. PRIs should be strengthened through at least one village level worker (VLW), the position which existed before, specially for agricultural technology dissemination, bridging knowledge gap between farmer and researchers, linking farmers to markets and making farmers aware of innovations and policy related matters. The earlier position of VLW, which got converted in Panchayat Secretary, meant for agriculture and rural development work must, therefore, be revived urgently and Kisan Information Centre in each village be got established.

3.1.4 Reorienting/Reviewing Current Missions

3.1.4.1 National Missions on Food Security, Oilseeds, Horticulture and Extension

A quick review of existing Missions do reveal that either they currently lack specific focus, being diffused, or have no more Mission oriented time bound action/zeal so critical for their success. For example. the National Food Security Mission currently has focus on cereals, pulses and oilseeds. Thus, its efforts are diverse and diffused. It will be better if this Mission continues its focus on foodgrains (cereals and pulses) only especially when there is a separate Mission on Oilseeds, which seem to be diverse and not focussed as it covers also oil palm and tree borne oilseeds. In the mid-nineties, the Oilseed Mission had led to self-sufficiency in just 5-7 years. Currently, India imports oil worth Rs. 70,000 crore which is a matter of concern. Hence, a well-funded Mission on Oilseeds, with better coordination and monitoring be a national priority, in order to ensure oilseed production within India, for which good potential exists but would require both a missionary approach and policy support for less import of oil from abroad, especially the palm oil.

Similarly, the Mission on Agricultural Extension & Technology has four rather unrelated sub-missions, which are on different/ diverse themes, thus losing its main focus and becomes quite unwieldy. In fact, the Sub-Mission on Seed and Planting Materials, Sub-Mission on Agricultural Mechanisation, and Sub-Mission on Plant Protection all deserve to be independent missions in their own right with defined goals and timelines.

In the past more than two decades, similarly National Horticulture Mission yielded significant results. Currently, with its revised mandate as Mission for Integrated Development of Horticulture (MIDH) with sub-missions on Horticulture, Agro-forestry and Bamboo, including even an institute, has resulted in dilution of efforts. In fact, a Mission on Integrated Development of Horticulture is justified in its own right, but to bridge a big gap of over 60-70 per cent in availability of quality planting material so critical for boosting horticulture production exponentially, two new Mini-Missions on 'Quality Planting Materials' and 'Protected Cultivation' need to be created under it. Protected cultivation program, being youth centric, will enable youth to remain attracted in agriculture. Further, already existing National Agro-forestry & Bamboo Mission (NABM) needs to be strengthened to meet the national target of 33 per cent area under forest cover, which otherwise will be difficult to achieve unless there is major focus to promote agro-forestry as per the policy of 2014. This will also meet the expectation of Prime Minister regarding "*Har Med Par Ped*".

3.1.4.2 National Mission on Agricultural Extension and Skill Development

The National Mission on Agricultural Extension and Technology (NMAET) was initiated during the 12th Five Year Plan by integrating 17 different agricultural technology related schemes of DAC&FW with an outlay of Rs. 13,073 crore. Unfortunately, it has four unrelated sub-missions, namely, 1. Sub-Mission on Agricultural Extension (SMAE), 2. Sub-Mission on Seed and Planting Material (SMSP), 3. Sub-Mission on Agricultural Mechanization (SMAM), and 4. Sub Mission on Plant Protection and Plant Quarantine (SMPP). Under the Umbrella of Agriculture Technology Management Agency (ATMA), the scheme envisions farmer driven and farmer accountable extension system through delivery of appropriate technology and improved agronomic practices to farmers. But the current scenario suggests that public sector driven top-down agricultural extension model is the weakest link for sustainable agricultural production systems and leads to wide dissemination losses and knowledge gap. On the contrary, farmers do demand for new knowledge

and skills. Therefore, SMAE must be upgraded to a full-fledged mission to disseminate knowledge and provide skills to farmers, specially the youth in a public-private-producer partnership mode by trans-disciplinary and multi-institutional approach with better convergence and coordination at the district level through KVK and ATMA integration. The mission should envision each KVK to become "Knowledge-Skill-Innovation Centres" at the district level with an additional role of private "paid" extension wing to be managed by young graduates as "Agri-Clinics" to extend expertise for digital agriculture, agripreneurship, value addition, and marketing. The Start up India, Skill India, National Agriculture Skill Council, FPOs, ATICs, Agri-Clinics, and CSR should be all extended wings of the Mission. The mission should encourage engagement of rural youth with ITIs and polytechnics for skill development. The new concepts of 'Farmer Professor', Institution-Village Linkage Program (IVLP), farming system's models, secondary and specialty agriculture along with farmer-friendly communication mode such as Kisan TV channel, ICT, smart phones, print media and radio to ensure their farthest reach and effectiveness. To achieve an inclusive market oriented development (IMOD) for smallholder farmers be also an important goal of this Mission. There is also a clear need for greater facus by Kisan TV on scaling innovations and providing new knowledge to farmers, especially youth, about secondary and speciality agriculture and value chain for linking farmers to markets.

3.1.4.3 National Agricultural Mechanization Mission

The famous quote "Everything can wait but not agriculture" signified the importance of timeliness of farming operations even during the Pre-Green Revolution era; when labour for farming was not an issue. Labour is the most vital inputs in agriculture today. Due to changing trends in family size, urbanization and migration, the need for labour is increasing. Moreover, among all the efficiencies in agriculture, 'time efficiency' is one of the most significant, not only for improving productivity and profitability but also to build resilience of the smallholder production systems. Mechanization is the only way to improve time efficiency of agricultural systems. Moreover, under the growing uncertainties of weather due to projected climate change scenario, the future farming will rely heavily on timeliness of farm operations. Therefore, to address these issues and preparing future generation farmers, immediate steps are to be taken-up for value chain mechanization (Seed to Seed and Farm to Fork) of agricultural operations. The efforts and investments on mechanization made by the Governments in the past through 'Sub-Mission on Mechanization' have not helped in addressing the concern of labour and timely farm operations effectively. Therefore, concerted efforts on farm mechanization has to be targeted through launching a full fledged new "National Agricultural Mechanization Mission (NAMM)". Through NAMM, there is a need to promote scale appropriate value chain mechanization specially focused on (i) planting and crop establishment, (ii) inter-culture and agro-chemical applications and (iii) harvest and post harvesting operations by establishing regional manufacturing hubs as well as creating geographically differentiated scale appropriate machinery banks and service centres around villages. The service windows and business models for aggregating agricultural mechanization (like Ola, Uber models) involving youth (including women) through their skill development would help farmers to access much needed mechanization solutions for sustainably enhancing both production as well as income.

3.1.4.4 National Livestock Mission

For greater focus on livestock development related aspects such as: genetic enhancement of local breeds, production of sufficient proven bulls for meeting semen requirements, greater availability through subsidy of sexed semen, accelerated vaccine production to eradicate Foot and Mouth Disease (FMD), where current production is only 40 per cent of total requirement, support for better housing structures/barns, insurance of all productive animals, skill development and financial support to para-vets, through creation of Agri-Clinics in each KVK, support to small scale dairies managed by self-help groups (SHGs), cooperatives or farmer producer organizations (FPOs), creation of modern abattoirs and cold warehouses for storage of milk and meat products would accelerate the pace of livestock development much faster. As such, it is recommended that all above aspects become an integral component of the Livestock Mission, with doubled allocation of funds than at present, considering the role of livestock sector to be almost 30 per cent in total agricultural GDP.

3.1.5 Proposed New Missions

3.1.5.1 National Mission on Fishery Development

The centrally sponsored umbrella scheme on "Blue Revolution: Integrated Development and Management of Fisheries" approved for five years from 2015-16 to 2019-20 along with the *Pradhan Mantri Matsya Sampada Yojana* (PMMSY) announced in the Union Budget 2019 needs to be upgraded as a National Mission on Fishery Development. Under this Mission, all activities need to be taken up in a mission mode with a transformative implementation plan including timelines and milestones with quantifiable outcomes. It is also imperative to factor in the sustainability challenges and exploit the blue economy for considerably improving the standard and quality of life of the coastal fishermen and fisherwomen along with strengthening of infrastructure and overall fisheries management framework. The allotment of Government land to willing graduates and entrepreneurs, besides the cooperative societies, for aquaculture by the state governments will be a game changer for entrepreneurship development and meeting the targets of blue revolution. The United Nations Decade of Ocean Science for Sustainable Development (2021-2030) provides an added opportunity to use ocean science for fishery development.

3.1.5.2 National Mission on Conservation Agriculture

Agriculture in India faces multiple stresses which include plateauing crop productivity, deteriorating resource base- soil health, water, environment and labour shortages, climate change induced weather risks. There are also serious emerging social issues – rural youth moving away from dusty practices and labor-intensive farming. These stresses do not act in isolation but are interdependent and of multidimensional in nature, therefore require a paradigm shift in the way crop management practices are followed. Conservation agriculture (CA) has emerged as an alternative to an inefficient tillage-based conventional agriculture. CA embodies three major principles – reduced or zero tillage for all crops in the system, organic ground cover at all times, and judicious crop rotation. The concept of CA currently adopted over 180 million ha globally, was coined in the 1990s, but the idea to minimize soil disturbance has its origin in 1930s during the Dust Bowl in the United States of America and have paid dividends in arresting land degradation in South America and North America. In India, CA was introduced some 25 years back to address the second generation problems of Green Revolution in rice-wheat system with some good successes in adoption of zero-tillage in wheat. However, unlike major CA adopters in rainfed systems of the rest of the world, it has not reached yet in rainfed areas of India. However, during the past 2 decades, a significant research for development efforts has been made on CA. CA is a knowledge intensive technology needing multi-disciplinary, multi-stakeholder participatory action to harness its full potential towards 'More (quantity & quality) with Less' and increase farm income while restoring natural resources. A "National Mission on Conservation Agriculture" must, therefore, be launched, with greater facilitation role of National Rainfed Area Authority (NRAA) to; (i) facilitate large scale farmers participatory demonstrations of proven CA practices through national initiative on CA, (ii) provide a common platform for convergence of the investments on sustainable, soil and crop management practices for faster adoption of CA by the farmers in both irrigated and rainfed farming systems, (iii) provide sound science based strategic support to the government for incentivizing farmers for eco-systems services, (iv) serve as a capacity development & knowledge network through bringing together the consortium of research and development public and private institutions for last mile delivery, and (v) effectively monitoring and periodic tracking of CA adoption.

3.1.5.3 Mini-Mission on Protected Cultivation (under MIDH)

Protected cultivation needs to be promoted on large scale through increased use of greenhouses and polyhouses especially as youth-centric enterprise. Hence, the proposed sub-mission on 'Protected Cultivation' could target an area of about 200,000 ha (4 times) than current ~50,000 ha. For comparison, China has 2 million ha area presently under protected cultivation. A major opportunity lies to attract youth including women as they can easily increase the productivity by 3-5 fold or even more.

3.1.5.4 A New Mini-Mission on Quality Planting Material (under MIDH)

Horticulture sector is being looked at as a harbinger to ensure household nutritional security, providing sustainable income to the farmers, generating employment, empowering the youth and farm women and

earning the valuable foreign exchange through export. Despite the rising need for horticultural crops in India, the sector is facing an acute shortage of quality planting material. Most of the nurseries are unorganized and government agencies are unable to provide adequate quantity of quality planting material. Currently, there is a gap of 60-70 per cent between the availability and the requirement. Thus, it is recommended that under this Mini-Mission, concerted efforts need to be made to produce quality planting material through establishment of model accredited nurseries both in public and private sector.

3.1.5.5 National Mission on Youth in Agriculture

Currently, youth is not interested to take-up agriculture as a profession. Hence, there is an urgency to have a "National Mission on Youth in Agriculture" (NMYA) with an aim to impart better knowledge and skills on: i) sustainable, secondary and specialty agriculture, ii) efficient knowledge dissemination through information communication technology (ICT), iii) technical backstopping for innovative farming, iv) developing new agri-business models, v) entrepreneurship vi) business management for linking farmers to markets. Under the Mission, concerted efforts are needed to build new skills of youth for innovative agriculture through both formal and informal education. The best option for this is to impart agricultural education right from school level. In addition, the central and state agricultural universities and ICAR institutes must initiate entrepreneurship training through vocational and formal diploma programs. Also, the university curriculum needs to be revisited to address the emerging needs and aspirations of present-day youth to link them to markets. This Mission must focus on 'Youth as an Agri-Enterpreneur, and 'job provider than just a job seeker'. Under the Mission, a "National Agricultural Innovation Fund" of Rs. 10,000 crore must be established to provide seed money for validation and scaling youth led innovations on lines similar to National Innovation Fund (NIF) established almost two decades ago by the Central Government with great successes to its credit.

3.2. Socioeconomic and Market Reforms

3.2.1. Farm Subsidies as Incentives

Farm subsidies have been growing very fast and now gobbling the resources which should have been used for the investment purposes. In addition, there are issues relating to targeting of these subsidies and inter-regional disparities. It is believed that part of the subsidy is not reaching the intended beneficiary farmers and large farmers in irrigated regions have mainly benefitted from these subsidies. In order to address these issues, it is suggested to transfer subsidies directly to farmers. It is proposed that Rs 15,000/ha can be provided to all the farmers directly, for purchase of inputs, insurance and other welfare schemes. This amount is arrived using current level of subsidy of Rs 2.41 lakh crore by both centre and State Governments.

In addition, farmers need to be incentivized to follow sustainable farm practices for carbon sequestration through efficient crop management practices; conservation agriculture based sustainable intensification, agri-horticulture and agro-forestry. On an average, these practices would annually sequester about one ton carbon per hectare in the soil. Additionally, soil conservation measures will also reduce soil loss (currently 16.3 t/ha) and inclusion of legume crops can fix nitrogen up to 30kg/ha. Using an international price of carbon trading at $50/t (slightly higher for tropical condition) and $ 5/t for soil loss reduction and Rs 18.9/kg subsidy on N fertilizer, the value of all these ecosystem services shall be Rs 9,807/ha or say Rs 10,000/ha. Therefore, farmers need to be compensated with an additional support of Rs 10,000/ha. This would cost Rs 1.12 lakh crore per annum additionally, which considering significant contributions made by these ecosystem services is fully justified in view of India's Nationally Determined Contributions (NDCs) under the Paris Agreement. In addition, there shall be significant human health benefits due to control of straw burning, increase in crop yields due to improvement in soil fertility, larger green cover restricting desertification, and moderating impact of climate change. Moreover, timely availability of funds with farmers shall enable them to invest in agriculture, without depending upon borrowed funds or loan waiving.

The committee thus strongly recommends a total of Rs. 25,000 per hectare (or Rs. 10,000/acre) to be given to all the farmers annually as incentives linked to sustainable farming practices subject to

a ceiling of 4 ha per farming family. This amount should be transferred as DBT and linked mainly to the sustainable and efficient farm practices like laser land levelling, conservation agriculture, precision input management, adoption of agro-forestry, and other measures to control soil, water and nutrient loss. Further, this incentive support (instead of subsidy) should also be linked to input price inflation and adjusted periodically.

3.2.2. Ensuring Agricultural Credit

In spite of a number of reforms undertaken by the government like priority sector lending, creating multiplicity of rural institutions, and an apex bank for agriculture (NABARD), nearly half of farmers only have access to institutional credit. Rest of the farmers, particularly small and marginal, still depend on informal sources of credit, often paying exorbitant rate of interest. KCC scheme has been initiated by the Government to provide an easy access to farmers to institutional credit. Despite this good initiative, so far only 6.9 crore cards are active. It is, therefore, recommended that KCC in the form of ATM cards should be provided to all farmers for all purposes of loans and credit limit for concessional interest rate (4%) should be increased to Rs five lakh from Rs. three lakh as at present. Further, the maximum limit be revised upwards every three years. There should be efforts to increase term loans for land development, irrigation, farm mechanization and hitech horticulture. In order to address inter-regional disparity in credit, the network of institutions be strengthened in eastern India. Also, Primary Agricultural Credit Societies (PACS) should be revived by providing adequate working capital, qualified staff and professional management cadre. In this context, NABARD as an apex organization must be made responsible, and it should ensure that priority sector lending target should be achieved. Further, to ensure reforms in credit and banking system, the whole issue be got reviewed by a high power committee to examine the existing system and how either Cooperative Banks or Kisan Banks in rural areas across the country could be established and made functional. Model of Grameen Bank in Bangladesh be examined and possibly be replicated with needed reforms in order to ensure easy credit to smallholder farmers in each village or in near vicinity. Scheme like MUDRA should also be initiated by PACS to cater to credit needs of marginal farmers with land up to one acre.

3.2.3. Needed Market Reforms

Linking farmers to markets and ensuring them MSP have indeed been a major reform – though a big challenge for policy makers. Still a large proportion of crop produce is sold to local traders in most of the states and market prices have been lower than MSP particularly in the eastern region. On the other hand, Government's budget for market interventions are rising over time, but mostly confined to paddy and wheat. It is only recently that procurement of pulses and oilseeds has started. It is recommended that crops eligible for MSP should be reviewed by a high power committee in the context of crop production scenario and natural resource degradation, and MSP should in all cases be 1.5 times of cost C2. The allocations for procurement at MSP should be doubled for pulses and oilseeds, and state agencies should be involved in the procurement of commodities. Also, PM ASHA should be made operational and farmers selling produce below MSP should be compensated through 'Price Deficiency Payment System'. The schemes for other commodities, e.g. vegetables and fruits, should be integrated for uniform application of price support and stabilization interventions and size of the operation should be upscaled particularly to handle seasonal gluts and deficits.

In some of the states such as Punjab and Andhra Pradesh, *mandi* taxes are as high as 14 per cent and, therefore, these raise the prices without adding many utilities. These *mandi* taxes should be rationalized in the range of 6-8 per cent and the Model APLM Act and Contract Farming Act need be adopted by all the states. The APLM act encourages private sector participation, direct purchase by aggregators or industry from farmers, and for the first time brings livestock under the act. Similarly, the contract farming act aims to protect farmers against any discriminatory practice of the industry. Online trading through eNAM has be made mandatory and all wholesale and regulated markets should be linked to eNAM with no restriction for inter-state movement. In this context, a high power committee should review all the Acts regulating marketing of agricultural produce for their relevance. The commodities under ECA should now be covered

only on the basis of their price and availability. Further, as per existing provision, the warehouse receipts can be used for pledged loan to farmers up to 75 per cent of the value of produce, but this mechanism is not somehow used by farmers because of varying degree of implementation by different states and agencies lack of awareness among farmers and existing distance to registered warehouses under the scheme. It is, therefore, necessary to expand coverage of warehouses in all the regions and educate farmers about the provisions and benefits of the scheme.

3.2.4 Promoting Agricultural Exports

The country has new export policy with a target of doubling agricultural exports by 2022. This can be achieved if there is focus on (a) long-term export strategy with no restrictions on exports, except in only very exceptional cases of products in shortage, (b) there is increasing participation of private sector in markets, value chains and exports, and (c) efforts to ensure quality and safety of products as per international standards. The trade policy also requires streamlining to specify roles and responsibilities across different ministries and agencies to iron out inconsistencies and simplify the procedures, move away from use of un-favourable export-import restrictions in order to create a stable and predictable market and trade environment. Market information and trade promotion are necessary to be a significant player in the global markets. India's export of agri-products till 1980s was US$ 2.6 billion, which increased to US$ 6.2 billion by 2000 and US$ 39.4 billion by 2018 with an average growth rate of 2.43 per cent. Rapidly increasing trend occurred in fish, meat, spices and rice. Hence, with long-term strategy and enabling environment with expected higher growth rate of 3.5 per cent, India could emerge as an important global player in the next decade (by 2030) with expected export of around US$ 60 billion. It is, therefore, suggested that APEDA being key central agency be strengthened to take the responsibility of creation of export clusters, market intelligence, monitoring and public awareness. Also, there is highly justified need to have a position of Agricultural Counsellor created in the Embassies of those countries having potential for import of agricultural commodities from India. Liberal import of edible oils such as palm oil need to be restricted through higher import duty as its large scale import has a dressing effect on domestic prices and thereby causing disincentive for the farmers. A similar situation may arise for dairy products in case RCEP agreement provides access to Indian markets. Therefore, especially the oilseeds and dairy products be protected under such trade agreements in future.

Participation of private sector in value chains and exports shall depend upon business opportunities, policy environment and regulatory system. Business opportunities are rising with commercialization of agriculture and private sector should be encouraged by improving 'ease of doing business'. In agro-processing and value chains, considering enormous potential for export, the GST rate should be kept at 5 per cent and sale of produce by farmers directly to processing industry or aggregators be permitted. Export-oriented agro-processing industry with strong farm linkages should also attract a low rate of corporate tax (15% only).

3.2.5 Ensuring Efficiency of Input Markets

Input markets urgently need modernization, which should be encouraged for better efficiency and easy access. However, seed and biotechnology products are currently faced with uncertainty of pricing, quality assurance, uncertain policy environment and protection of intellectual property. This must be addressed immediately and new Seed Bill, Pesticide Bill and BRAI Bill must be taken up on priority for approval by the Parliament, while taking into consideration the concerns of the Industry. Similarly, regulations for pesticides, particularly for registration and deregistration should be more robust and uniform. There are regulations to assure quality at the stages of production, storage and sale. But farmers often end up buying spurious or poor quality products. Therefore, these regulations, particularly for point of sale inspection should be made very effective and consumer protection mechanism needs to be strengthened. Use of bio-agents in crop management needs strong incentives for their cost, safety and environmental advantages, and regulations for their multiplication, storage and use should be made explicit. In the event of concentration of proprietary products and their protection, interest of input markets be protected. Therefore, the government should monitor market conditions and intervene whenever necessary to ensure healthy competition.

3.2.6 Land Ownership Reforms

Land reforms have been very important source of growth in agriculture. The reforms include land to the tiller and consolidation of holdings; the former has become obsolete now and the latter has a merit to improve investments on farms and reduce the cost. Consolidation of holdings should, therefore, be a national prime agenda and it be implemented faster. In this context, benefits of consolidation had been much greater as in Punjab, Haryana and Western U.P. Further, the fragmentation of holding below one ha should in no case be allowed being uneconomical and counterproductive. Thus, a law to this effect would be in the national interest. Instead, there is need to make collective family farming of holdings less than one ha compulsory. Though this is a drastic step in an economy with property rights, but quite necessary to maintain an economic size of holding. The cultivator should compensate other owners/shareholders and the government need to protect their land rights. Another method of increasing operational size of holdings is implementation of the Modal Land Leasing Act by all the states. The act shall make tenancy a legal arrangement and protect the rights of land owners, and farmers who have surplus labour and capital (machinery, tube well etc.) can optimize the use of resources by leasing-in lands. Extending land rights to women be also encouraged. In order to implement Model Land Leasing Act and other land reforms, updation of land records and enforcement of land rights are essential. Also, provision of long-term lease (5-10 years at least) will encourage tenants to invest on land and infrastructure development so necessary for improving soil health and sustainability

3.2.7 Risk Proofing

Risk in agriculture arises mainly from erratic weather and makes the crop yields unstable. This is more so in rainfed regions. This risk is increased by volatile and uncertain prices, particularly for non-MSP crops. Technology and farm practices can moderate yield risk but financial arrangements are needed to manage price and other risks. *Pradhan Mantri Fasal Bima Yojana* (PMFBY) has expanded the scope and regional/area coverage of risk, but still there are questions arising from crop and area specificity. Therefore, farmers should have choice for selecting crops and the nature of risk for opting for insurance. The procedure for loss assessment and settlement of claims should be made easy and transparent using technological advances like satellite, drones, artificial intelligence, big data etc. Repayment of loans be allowed for adjustment against the claims. Further, there should be a comprehensive coverage of risk associated with crop products, assets, livestock and fish produce. All the productive milch animals should compulsorily be insured for mortality under National Livestock Mission, being a major risk for the resource poor farmers. Also, the life and health insurance schemes to a minimum of Rs. 10 lakh be extended to all farmers through needed support under PM-Kisan.

For management of risk by farmers, weather and price forecasting services are required to be institutionalized in all states. This should be supported by long-term commodity outlook exercise predicting demand and supply scenario in short to medium terms, which shall help farmers as risk coping strategy through needed government interventions. For price risk in non-MSP commodities, allocations for market intervention and price stabilization schemes be at least doubled from current allocations and its effective and timely use be ensured.

3.2.8 Public Investment and Corporate Social Responsibility

3.2.8.1 Public investment

Public investment in agriculture has been and will continue to be a major source for accelerating growth. Its growth has, however, slowed down and the corporate investment is not picking-up as expected. Farm household investment though rising but not in the areas of sustainable agricultural development. In fact, in some cases private household investment has generated negative environmental externalities like over use of groundwater. Moreover, private investment can not fill the gap. Therefore, it is recommended to double the public investment in agriculture during the next five years. The priority areas are: the eastern, north-eastern, hill and dryland regions, and the suggested themes could be: agricultural R&D, water, market development, power, rural infrastructure and connectivity. Higher public investment needs to be

accompanied with the measures to improve its use efficiency. In particular, efficiency of surface irrigation, timely completion of infrastructure projects including roads, power, rural institutions to deliver inputs and services to farmers, accountability of technology systems, and rural warehouses deserve high priority.

3.2.8.2 Private sector investment

The private industry working in agriculture, covering both inputs and outputs, has a significant expenditure on the Corporate Social Responsibility (CSR) activity. Currently, it is spent on different activities as per internal plan of each company. It would be prudent to channelize the funds of the private industry earmarked for CSR activities in a pooled fashion and in a public-private partnership (PPP) mode, into priority areas that can help farmer gain access to informed knowledge for achieving sustainable agriculture. This money be now invested in important priority activities such as strengthening of the KVKs for better knowledge dissemination through ICT, field demonstrations and input supply, helping to establish agri-clinics on each KVK, creation of a cadre of quality input dealers, custom hire centres for promoting good agricultural practices (GAP) among farmers etc. Thus, investment through pooled CSR, to begin with, aimed at Rs. 10,000 crores, will create a significant multiplier effect on the productivity and incomes of farmers.

3.3 Harnessing Science, Technology and Innovation for Future Gains

Harnessing Science, Technology and Innovation (STI) should be in the drivers' seat for SAD. Unlimited opportunities in harnessing unexplored frontiers of science exist to make new gains from application of STI, and scaling-up of already proven technologies like hybrids, biotechnology, conservation agriculture, organic farming, micro-irrigation and feeds and fodder, production shall help in extending the gains. Adequate investment in emerging technologies should be our priority to harness their full potential for human well being. Some such sciences, include: precision agriculture, sensor technologies, bioinformatics, water smart technologies, nanotechnology,genome editing, remote sensing, crop scouting, decision support system, artificial intelligence, agriculture biowaste disposal/ recycling farm waste, peri-urban/terrace farming, biofortification, predictive agricultural analytics, biosecurity and safety, robotics and drones in agriculture, urban agriculture, smart farms, vertical farming, hydro and aeroponics, space agriculture, big data management, protected cultivation (PC), use of sexed semen in livestock, etc. Institutional innovations combined with visionary policies will speed up the gains by improving farmers' access to new knowledge and technology, good governance of technology systems and social accountability. In addition, specific actions are needed for (a) strengthening scientific manpower particularly in SAUs, (b) revisiting R&D regulations to make them least restrictive for speeding transfer and commercialization of technology, and (c) fostering partnership with private sector for rapid commercialization of technology and access to proprietary foreign technology. The public system is fraught with multiple demand for limited resources and, therefore, public funding to agricultural R&D be at least doubled to make the intensity one per cent of Ag GDP. A large part of these additional resources should be used as competitive research grant for filling gaps in strategic research, augment operational resources and foster partnership with the private sector. India has now reached a stage when it can assume greater international role and promote south-south collaboration.

Increasing income, especially of 86 per cent farmers, who are small and marginal, having holdings less than 2 ha, would require technologies and innovations by which they can economize on cost of inputs and have more income by higher productivity, better quality of produce, and value chain to link better with the markets. Thus, there is need for scaling following innovations on priority basis:

3.3.1 Harnessing Hybrid Technology

Hybrid seeds give higher yield, tolerance to climatic change, better resistance to diseases and pests, and better food and income security. In recent past, hybrid seeds of Bt cotton, covering almost 100 per cent area, has resulted in higher production, productivity and more income to millions of smallholder farmers, leading to even large scale exports. Similarly, large scale cultivation of single cross maize hybrids has more than doubled the production with around only 60 per cent coverage. The yield of maize can still be doubled

if area under hybrids is increased to 90-95 per cent. Scope of scaling this technology in other crops like rice, bajra, sorghum (especially *rabi* sorghum), etc. and a large number of vegetables exists, but would require special mission on seeds and an enabling environment for private seed sector to play its significant role. Ensuring IP protection for innovation, plant breeder's right for hybrids, incentives on par for hybrid seed production and timely availability as otherwise available to public seed sector and exclusive rights for producing seeds of public institution bred hybrids would go a long way for increasing both the productivity and profitability of farmers.

3.3.2. Biotechnology for Genetic Gains

Use of biotechnology is helpful for the development of biotic and abiotic stress resistant varieties and hybrids. In this context, use of genome editing (using CRISPR/Cas 9 technology) needs to be promoted extensively for which a clear national policy to keep this innovation out of regulatory regime and building of partnership with innovators having IP protection would go a long way to harness the potential of unlocked genetic variability existing in our land races and wild species. In this context, the Central Government has to have a common understanding with all states and stakeholders concerning important role of GM technology as well as full confidence in the nation regulatory system including promotion of GM crops for increasing productivity. It is recommended to extend policy support for testing and release of GM food crops (such as maize, soybean, mustard, brinjal etc. in the best national interest. Also, a National Policy on Agricultural Biotechnology needs to be formulated highlighting its role in achieving SDGs. Further, the Biotechnology Regulatory Authority of India (BRAI) Bill has to be expedited for approval by the Parliament at the earliest possible.

3.3.3. Conservation Agriculture for Sustainable Intensification

India has a potential to adopt CA in 40 million ha in next half a decade (15 million ha in irrigated, 20 million ha in rainfed and 5 million ha in rice fellow ecologies. Adopting CA helps in arresting soil degradation, restoring soil health, conserving and efficient use of water and nutrients, building resilience against climate risks, reducing costs of cultivation, increasing farmers income and meeting the goal of reducing GHG under the Paris Agreement on climate change. Launching urgently a 'Mission on Conservation Agriculture' is recommended to disseminate proper knowledge and skills through trained extension specialists, including youth, service providers and farmers, make available farm machinery on custom hire basis and the quality seeds of crops that adapt well and enable sustainable intensification. Strategy must, therefore, target: (i) creating awareness among farmers about benefits of CA through frequent farmer-scientist-industry meets, (ii) strengthen capacity building programs on CA involving youth and (iii) much needed policy advocacy about the importance and long-term benefits of CA. The farmers must be compensated for their environmental services on par with carbon trading in many advanced countries. The lessons learnt elsewhere (like USA, Brazil, Argentina, Australia, Canada, Kazakhstan, etc.), covering almost 180 million ha area, reveals that adopting CA for sustainable intensification is the only recourse left for restoring our degraded soil health both in dryland and Green Revolution regions having very low soil organic carbon (SOC).

3.3.4 Agro-ecology based Land Use Planning

Intertwining challenges of climate change and competition for land, water and energy require attention towards bridging the attainable gap between actual and potential productivity, innovation and knowledge, and national and international research and development initiatives for sustainable agricultural growth and natural resource management. Accordingly, based on the need for agro-ecological awareness and implementation coupled with a requirement for increased communication across stakeholders, a three step process for immediate initiation of ecologically-sustainable agriculture consists of : (i) characterization of agro-ecological zones (AEZ) coupled with establishment of regional AEZ databases, (ii) initiation of farmer-led innovations through community and stakeholder involvement in agroecology-based agricultural crop planning and implementation and (iii) utilization of locally available information for most sustainable cropping/farming practices. It is, therefore, suggested that greater emphasis needs to be given now on eco-regional scientific land use planning that is farmer and stakeholder participatory and ecologically sustainable in long-term.

3.3.5 Reversing Soil Degradation

Comprehensive strategies would be needed for reversing soil degradation in agriculture worth an annual loss of ~US$ 10 billion. This necessitates an action plan integrating 'Sound Land Utilization Policy', strengthen and rigorously implement 'land-zoning system' for scientific land use planning and sustainable management using an 'eco-regional approach' considering natural resource endowments and management domain of the technologies aligned with soil health cards and protecting agricultural lands from being converted to non-agricultural purposes. For sustainable use and management of natural resources, spatial and temporal mapping of land use pattern, soils and water resources and associated management parameters in each agro-eco regions using modern tools and techniques such as remote sensing & geographical information system (GIS) to design sustainable cropping/farming systems and their appropriate market linkages is the first and foremost step. There should be a mechanism in place to bring out *'State of Soil Report'* every 5 years to capture spatial and temporal changes on an agro-eco regional basis and revisiting recommendation to align with policies and investments. Reclamation of 25 million ha acid soils and sustainable intensification of 25 million ha of fellow lands alone can help produce 75 million t additional foodgrains in the next 5 years' worth US$21 billion in addition to reducing pressure on other lands and delimiting land use changes to help arresting degradation.

3.3.6 Managing Acid Soils

About 15 per cent of soils within India's geographical area exhibit acid reaction (pH < 7.0). While all acid soils do not pose problem for agriculture, but it adversely influences sustainable crop performance, when raised on soils suffering from severe acidity i.e., soils having pH below 5.5. In order to revitalize productivity potential of such soils, of the several options, neutralizing acidity with lime treatment is the most practicable. Currently, ~ 25 million ha area suffers from severe acidity and needs liming for resurrecting lost productivity. More importantly, major concentration (13.5 m ha out of 25 m ha) of soils of acute acidity are located in NE Hill States. Eastern India is another key region, where soil acidity constraints productivity growth. In fact, in these water abundant regions average yield of rice is about half of the national average. Unattended soil acidity is a major impediment to realize response to other inputs and a cause of prevailing state of uneconomical farming. Revival plan calls for liming, costing Rs 4800/ha (@3 tons/ha). One-time treatment would last for 3 years and total cost for 25 million ha works out equal to Rs 1200 crore, once in 3 years. Since farmers of these regions are largely poor and have limited capacity to bear the cost of liming, it is recommended that Central Government bears the entire cost whereas the respective States and the beneficiary farmers pay for freight and application charges. The pay-back period of this investment is projected to be < 2 years in terms of expected rise in productivity and farm income.

3.3.7 Managing Soil Organic Carbon

Soil organic carbon (SOC) is fundamental to the maintenance of soil health, resilience against climatic aberrations and sustainability of agro-ecosystems. The Paris Climate Summit 2015 categorically highlighted the importance of soil carbon sequestration to mitigate the climate change and sustainable food production. Land use/land cover change are the major factors affecting SOC pools remarkably resulting in large carbon footprints from agriculture (18% in India). The current cultivation practices result in a loss of 21- 60 per cent SOC in various agro-climatic regions of India. The SOC content has reduced to a meagre 0.2 to 0.4 percent in intensively cultivated North-Western India and also the dryland areas. In this context, policy measures supporting zero-diversion of ecologically productive lands for other uses, enacting legislative measures obligating residue burning, agroforestry (*har medh pe pedh*), and recycling of rural and urban waste (waste to wealth) are recommended. The conservation agriculture being practiced on 180 million ha area globally, has shown promising results in India to improve SOC stocks and stop residue burning. The CA need to be disseminated at large scale along with balanced use of fertilizers and legume intercropping. Nourishing soil with organic manures (FYM, vermi-compost, green manure), promoting community based biogas units, maintaining green cover by planting crops and trees and integrated farming systems do play a significant role in enhancing SOC stocks and hence must be adopted on large scale. A subsidy of Rs 10,000/ha has been recommended above as an incentive for such sustainable farm practices to reduce GHG emissions.

3.3.8 Promoting Organic Farming

Organic agriculture (OA) occupies a place of pride in India. The country has the largest number of organic producers in the world. It is home to more than 30 per cent of the total organic producers in the world (835,000 vs 2.7 million). With 1.5 million ha area under OA, out of 10 countries in the world, India stands at ninth place. To promote OA, there is a need to develop specialized certified organic farming clusters in the de-facto organic areas. For example, tribal belts of west eastern and north eastern Hill States (all kinds of produce), parts of Rajasthan (spices), Kerala (cashew, spices and condiments), Tamil Nadu, Karnataka (coffee) Assam (tea), etc. Also, the guidelines of national standard for organic production should be reviewed to facilitate product certification and 'regional referral organic agriculture quality laboratories' should be established for analyzing the quality standards of the organic produce and help farmers for fetching better price and easy marketing. For accelerated adoption of organic farming for integrated crop management in intensive agricultural areas (food hubs) will positively contribute to the cause of soil, human, livestock and ecosystem health, the basic objective of organic agriculture. To strengthen this, there is need to initiate a new program as "Modern Organic Agriculture Development Initiative (MOADI) for sustainable agriculture.

3.3.9 Doubling Water Use Efficiency

Pradhan Mantri Krishi Sinchayee Yajana (PMSKY) with a universal moto of *'More Crop Per Drop'* should be further strengthened with introduction of water auditing system, delimiting subsidy on water and energy in a phased manner and incentivizing whole farm water use efficiency (farm and village level water budgeting based incentives though village panchayats). There is an obvious need for a policy mechanism to regulate ground water extraction considering water being a national asset. Also, we need to introduce energy use based incentives, by metering electricity and using pre-paid cards. The appropriate policies, programs, technologies and strategies in intensively irrigated (north-west), water congested ecologies with sub-optimal water use (eastern India) and rainfed agro-ecosystems (south, west and central India), a five pronged strategy (i) precision water management practices (micro-irrigation, laser levelling, automation), (ii) land treatments lessening water wastage due to flooding by shifting to irrigating furrows separating cultivated beds, (iii) cropping systems optimization and diversification, (iv) induction of solar pumps replacing solar/diesel pumps for lifting surface-water and abstraction of groundwater, and (v) capturing and effectively utilizing rainfall-runoff through field bunding would be warranted. Precision water management technologies (conservation agriculture, raised-bed and furrow irrigation, precision land levelling, micro-irrigation including sub-surface drip under CA and field bunding), and an option for enforcing ban on flood irrigation may further help in doubling water productivity. Also, there is need to effectively treat all the 22 Bm^3 of waste water generated every year in India's towns and an option for cities for its safe and efficient use in agriculture, which would demand a major national initiative on war footing. Incentives, therefore, have been proposed for the adoption of water efficient crop/farming management practices.

3.3.10 Increasing Nutrient Use Efficiency

It is high time to invest in ARI4D for customized fertilizers, slow release fertilizer, liquid fertilizers and integrated nutrient management (inorganic fertilizers with biofertilizers, vermi-compost pit and organic fertilizers etc.), which are more efficient and climate smart. The current blanket fertilizer recommendation has to be stopped and linked with cropping system-based nutrient recommendation using soil health card and yield potential in area-specific production zone. Mechanization for sub-surface drilling (basal dose) supplemented by plant-demand based top dressing using decision support tools and instruments as leaf colour chart (LCC), green-seeker, and switch to fertigation system in a phased manner will further enhance NUE. This necessitates institutionalization of fertilizer research through development of a "Fertilizer Innovation Centre" in public-private partnership mode. Another most awaited, yet difficult to materialize is "Fertilizer Subsidy Policy Reform" through rationalized nutrient based subsidy (NBS), subsidy linked with soil health card and direct benefit transfer (DBT) with wider usage of ICT tools and Aadhar Card. This process can be achieved by alternative business model through wider involvement of FPOs, Agri-Clinics and the fertilizer dealers to infuse better rural employment and agri-entrepreneuship. These institutional

and policy reforms may help in doubling nutrient use efficiency and save foreign exchange of around Rs. 220 billion. Overall, these institutional and policy reforms would also contribute to almost nine SDGs.

3.3.11 Meeting Feed and Fodder Requirements

One of the major constraints in livestock farming is inadequacy of feed and fodder both in terms of quantity and quality, particularly during the dry season. Although significant quantities of crop residues are produced, they do not meet the nutritional requirement for dairy cows. There is urgent need to have an authentic estimate of the total requirement of feed and fodder and plan for their production. Forage seed indent and production chain must be maintained through better coordination and advance planning. In order to meet the nutritional requirements of animals, which constitute 60 per cent of the total cost for dairy animals, there is need to increase bioavailability of nutrients through feeds and fodders using chemical, biological and biotechnological advances. Keeping in view the shortage of feed and fodder, a well-planned and closely monitored program on forage development under the on-going "Livestock Mission" must be initiated and monitored closely.

3.3.12 Identification, Conservation and Upgradation of Indigenous Livestock

Presently, different livestock species are having a big proportion of non-descript population. As per the Breed Survey-2013 of Government of India, the proportion of non-descript population in cattle, buffalo, situation goat, sheep, pig and horses/ponies are 59.3, 43.4, 61.3, 38.7, 73.1, and 80.4 per cent, respectively. Indigenous animals have advantage of sustainable production under low input situation and are known for their drought tolerance and disease resistance. Therefore, there is an urgent need to complete all the inventories of livestock and poultry by characterization and registration as breeds and to establish a legitimate authority to register and conserve recognized breeds of all kinds of domestic animals and poultry, and provide breeders rights similar to those under PPV&FR Authority for plant breeders and their varieties. Such an Act will also protect and encourage the Livestock Keepers' Rights in the country. Further, it is recommended that the non-descript animals should be immediately upgraded and improved through use of desirable germplasm of registered indigenous breeds.

3.3.13 Livestock Disease Control through Vaccination

There is a big gap between demand and availability of different vaccines to control the bacterial and viral infectious diseases in animals. A strong program is, therefore, needed to produce the required quantity of vaccines against common diseases of cattle, buffalo, sheep, goats, pigs, horses and poultry and if needed, the requirement may also be met through import from other countries. Public-Private Partnerships could offer great opportunities in planning and implementing livestock disease control programs. They can also be active partners in developing a comprehensive package about disease awareness, epidemiology, surveillance, management and control measures for knowledge empowerment of farmers.

3.3.14 Bioenergy and Biofuel

Energy intensity of agriculture is rising fast, which shall increase cost of production and emission of GHGs. Therefore, promotion of renewable sources of energy like solar, wind, biodiesel, ethanol etc. can reduce dependence on fossil fuel. Expansion of solar energy can meet energy requirement of farmers and can also generate additional income by sale of electricity to the power corporations. Technological options are available for use of crop residue for production of biodiesel and power co-generation. This is a win-win situation as it would stop farmers from burning crop residue and thus protect our environment, and contribute to the national energy security. These co-power generation and ethanol production activities should be backed with liberal credit and commensurate incentive for reduction of carbon emission. Blending of ethanol with petrol and attractive price regime for ethanol are mandatory for out scaling the production and decision of the Government for mixing up to 10 per cent is a welcome decision. In this context, time is now ripe to possibly divert around 20 per cent of sugarcane and maize for ethanol production, thus helping economically both the farmers and consumers alike. In this regard, ultimately nation will gain and address quickly the goal of reducing GHGs, as per commitment under the Paris Agreement.

3.3.15 ICT for Knowledge Empowerment

Real time access to knowledge and information to value chain actors in farming is critical for keeping pace with new challenges and harnessing opportunities for sustainable agriculture. There is large gamut of applications and eGovernance workflow systems that can harness power of ICT in agriculture. Such applications are domain specific, like marketing, integrated nutrient management (INM), seeds, farm mechanization, farm extension, education, pest control, livestock and animal husbandry, fisheries, water resource, fertilizers, farmers welfare, census etc. However, all applications and datasets relevant to agriculture are currently decentralized, and hence there is an urgent need to consolidate these at the state and national levels. In order to realize a secure and sustainable agriculture, innovative ICT policies and frameworks are required to be put in place. Therefore, there is a need to promote: (i) Form factor Independent Mobile Device Apps, (ii) Internet of Things (IoT) for monitoring and automation of farming activities, (iii) Big Data Analytics & Dashboard for administrators for planning and monitoring the impact of schemes, (iv) Blockchain in agriculture for transparencies & increased trust level, and (v) GIS technology in agriculture for mapping farming activities including sowing, soil nutrition, water stress and irrigation requirement, need for use of pesticides and disaster damage assessment. Big data and AI can also be used for monitoring and forecasting of agriculture outlook and commodity prices, monitoring pests and global trends in agriculture.

3.4. Broadening Partnership

Partnership at local national, regional and global level is must for future successes. In fact, Green Revolution was an outcome of partnership between ICAR and international centers like CIMMYT and IRRI. Even goal 17 of SDGs emphasises the importance of building partnership for future successes. Hence, broadening partnership with farmers, private sector, farmer organizations and women and youth, to make the development related programs people oriented, will be the key for future success. SDGs can only be realized with strong global partnerships. Improving access to technology and knowledge is an important way to share ideas and faster innovation. Hence, it is extremely important to build strong partnerships with all the stakeholders for accelerating growth in agriculture.

3.4.1 Partnership with Farmer's Organizations

Public sector forging partnership with SHGs, FPOs/FPCs and private sector would create a win-win situation to every partner and thus be vigorously pursued. To make such partnership enduring and successful, providing handholding by the public sector in the initial 3-5 years, liberal credit/financial support, equipping with technical and management skills, extending technical backstopping, etc. are very critical. Aggregation of produce is a major constraint, which FPOs can address to some extent. In this context fiscal incentives like tax benefits be extended to FPOs on the same pattern of cooperatives. The target set in the Union Budget for establishment of 10,000 FPOs in the next five years be realized and FPOs should be provided adequate capital, managerial skills and technological support, besides handholding for initial 3-4 years. In the absence of this support, FPOs can hardly establish, improve their bargaining power and venture into significant post-harvest value addition operations being critical to overcome the role of middlemen in trade and marketing and thus benefitting both producers and consumers.

3.4.2 Partnership with Private Sector

Significant efforts by public sector to forge partnership with private sector has not yielded desired results for several reasons, but the partnership can be useful in infrastructure, AR4D, promotion of value chains and exports. The experience suggests that there is an urgent need to build trust, create enabling environment with more incentives, create level playing field with supportive policies, flexible rules and procedures, and enhance ease of doing business with speed. Special efforts to attract private participation in commodity value chains and export promotion deserve high priority. Currently, private sector is helping in several areas such as seed production, farm implements and machinery, disease diagnostics and vaccines, value-addition and post-harvest processing in cereals, pulses, oilseeds, fruits and vegetables, milk, meat and fish, product testing and evaluation. One big advantage of Public-Private Partnership (PPP)

of the technology is that achievement can be taken to the farmer very rapidly. In case of development of new seeds, the private partner can arrange seed production to reach the farmer faster. It could help spur the development of the food processing industry. The food processing industry may do more than just increase the shelf life of food, preserve food nutrients and provide fortified products. Instead, supported by government and private investments, it should also look at providing farm extension services, enhance price realization, cut out intermediaries and improve the supply chain through forward and backward linkages. Considering PPP to be a win-win scenario in the present context, serious efforts are needed now to build much needed mutual trust and confidence through enabling policy environment. Time is ripe to overcome alien syndrome and move forward jointly for accelerating agricultural growth.

3.4.3 Partnership with Women and Youth

Women almost constitute 50 per cent of rural population and have been contributing to agricultural and socioeconomic development in villages. Somehow, they have not been adequately, actively, explicitly supported and involved in agricultural development initiatives. It is high time to empower them with needed capacity development, rights to land, credit, business and other agricultural and non-agricultural income generating opportunities. It is recommended to form *Mahila Kisan Mandals* (Women Self Help Groups) for improving their livelihood. Similarly, non involvement of youth (including women) in rural areas for innovative farming and allied activities for overall agricultural development is indeed a missed opportunity. Hence, time has come to motivate and attract them to become agri-preneurs, extension agents to be knowledge, input and service providers, agriculture specialists in Agri-Clinics, to form FPOs/FPCs, and to serve in agro-industries, etc. To make them competent and successful, their skill development, access to credit/financial support and linkages with markets are very critical requirements which need to be met. In this context, a fully justified "National Mission on Youth in Agriculture (NMYA)" has been recommended.

3.5 Way Forward

India has achieved Green, White, Yellow and Blue Revolutions and the problem of food inscarcity has been resolved to a great extent. As such, the era of famines and food shortages is left far behind. However, the problems of smallholder farmers seemed to have magnified, the real income is under stress and natural resources are depleting fast. To reverse this trend, there is a need for a clear strategy and a Road Map of actions, that can lead to efficient, sustainable, and profitable farming. Also, accelerating agricultural growth is critical for achieving SDGs, especially no poverty, zero hunger and environmental security. Hence, greater emphasis on agricultural research and innovation for development is necessary to accelerate the growth which is currently hovering around 2.9 per cent, albit with considerable year-to-year fluctuations. In fact, Indian agriculture continues to remain in the forefront of development as it still provides livelihood to half of India's population.

At present, increasing productivity and doubling farmers' income are the two major challenges despite decline in average size of land holdings. What is needed now is to increase productivity, decrease the cost of production and increased income of the farmers by linking them to markets. Also, we need to ensure these gains to be sustainable, which is not all that easy. As such, bold policy decisions to do business differently are needed to support new science such as biotechnology, information technology, nanotechnology, bioinformatics, etc. and innovations like conservation agriculture, micro-irrigation, protected cultivation, tissue culture, genetically modified crops, hybrid technology, precision nutrient management, integrated pest management, etc.

On a positive side, new opportunities are unfolding in the form of increased demand for agricultural commodities both in domestic and global markets. The growing international demands for rice, wheat and maize besides cotton, soy meal, fruits, vegetables, fish, meat, poultry, etc. have opened up enormous opportunities for boosting agricultural exports. In addition, the increasing demand for high-value commodities such as fruits, vegetables, milk, meat, flowers, etc. and agri-processed products in the domestic markets point out towards potential prosperity that can be brought about in the farm sector. The entry of corporate sector in developing and delivering market-driven technologies, contract farming,

agro-processing, organized retailing and exports is providing a new dimension and impetus to Indian agriculture. Some of these encouraging developments are taking place around the value chain on the concept of 'farm to fork' and moving towards a 'fork to farm' production decisions. Failing redressal to the constraints and emerging challenges can lead to delay the development process and accentuae distress of farming community. Hence, the only recourse left is to have in place innovative policies, appropriate institutional arrangements and market-driven initiatives, to harness untapped growth opportunities and provide needed benefits to smallholder farmers. Agriculture can liberate India from the triple burden of poverty, hunger and malnutrition while ensuring conservation of natural resources and environmental security, being integral part of SDGs.

Institutional innovations are important to accelerate the gains possible through adoption of science, technology and innovations (STI). Some key institutional reforms and policy support recommended for urgent action include: (i) review of existing agricultural policies and evolving a New Policy on Agriculture and Farmers' Welfare; (ii) needed reorientation of on-going missions, including creation of some new missions; (iii) establishment of a new National Agricultural Development and Farmers' Welfare Council (NAD&FWC) under the chairmanship of Prime Minister on the lines of GST Council, needed urgently for effective coordination and convergence since agriculture is a State subject; (iv) creation of Farmers' Welfare Commissions both at the Centre and in the States for needed interface; (v) establishment of Independent Strategic Planning, Monitoring and Evaluation Unit in NITI Aayog; (vi) expanding the mandate of KVKs to effectively function as Knowledge-Skill-Innovation Centres and house Agri-Clinics to provide efficient private extension service to the farmers for higher production and profitability; (vii) converting all Farm Subsidies as Incentives for the benefit of smallholder farmers with a provision of direct benefit transfer; (viii) passing the important Acts by the Parliament, namely, Seed Act, Pesticide Management Bill, Fertilizer Act, Biotechnology Regulatory Authority of India (BRAI) Bill; (ix) doubling of long awaited resource allocation for agricultural research and innovation for development (ARI4D); and (x) creation of National Agricultural Innovation Fund (NAIF) to attract youth in agriculture. All these are key for accelerating agricultural growth and hence be accorded the highest priority for implementation by the Government in next six months to one year.

Finally, agriculture be seen as an important sector of national economy, which has a direct role to contribute towards SDGs, promote inclusive development and welfare of millions of smallholder farmers and accelerate economic growth for a five trillion dollar economy by 2024. This would, however, need mobilizing more resources for investment, incentives for sustainable farm practices, ease of doing business, market reforms and improved governance, particularly balancing centre & states relations and Strengthening public-private partnership efforts. This report has made recommendations to promote needed agricultural transformation and welfare of farmers. The report also provides an action plan for policy reforms, institutional changes and technology-led solutions to the development constraints of different sub-sectors of agriculture. It is hoped that timely implementation of the suggested reforms shall help accelerate agricultural growth to improve the livelihood of majority of our smallholder farmers and to meet SDGs successfully by 2030.

4. Action Plan for Policy Reforms and Scalable Innovations

In addition, to the major recommendations given in Section 3, there are some important innovations which have great potential for scaling to accelerate agricultural growth and desired impact on farmers income. The details of these innovations, their expected outcomes and impact along with action plan are provided in this section.

(A) Policy and Institutional Reforms

S. No.	Innovation	Expected Outcomes and Impact	Action Plan		Expected Time Frame
			What	By Whom	
1.	Improved governance and coordination	• Better policy environment, implementation and centre-state coordination ensured	• Formulation of 'National Agriculture and Farmers Policy' • Create 'National Agricultural Development and Farmers Welfare Council' • Create 'Farmers' Commission' at Center and all States	• GoI	6 months – 1 year
2.	Higher investment in agriculture	• Productive capacity of agriculture strenthened • Agricultural production increased considerably • Private sector attracted to invest in agriculture due to ease of doing business and tax incentives	• Increase public allocations to agriculture to reach a target of Rs 25 lakh crores • Double intensity of public research expenditure • Attract business investment in agriculture by ease of doing business and tax incentives • Increase term loan to farmers for higher farm household investment; raise limit of concessional credit to Rs 5 lakhs	• MoF • State Governments • Financial institutions (e.g. NABARD)	1-5 years
3.	Direct benefit transfer to farmers	• Public funds and incentives for sustainable farm practices made available to farmers barring intermediaries • Farmers benefitted considerably to meet immediate needs for farming	• Provide Rs 25,000/ha per farm household upto 4 ha, linked with sustainable farm practices • Ensure that the incentives are provided based on good agronomic practices linked with efficiency (*details provided under section B.1)*	• MoA&FW • MoF	1-2 years

S. No.	Innovation	Expected Outcomes and Impact	Action Plan		Expected Time Frame
			What	By Whom	
4.	Market reforms	• Access of farmers to markets increased • MSP at 1.5 times of cost C2 for all commodities ensured	• Review MSP scheme and strengthen market interventions for price support and stability • Implement eNAM and Model APLMC and Contract Farming Acts • Strengthen warehousing facility and pledge loan system	• MoA&FW • State Departments of Agriculture • Public Agencies (CWC, SWC) • Financial institutions	2-5 years
5.	Export promotion	• Agricultural exports doubled to manage surplus produce • Farmers got beneftted	• Attract private investments and strengthen APEDA for export information system • Implement food safety and quality standards • Improve competitiveness of commodities and promotion of export clusters	• MoC&I • State Goverments • APEDA	3-5 years
6.	Land reforms	• Economies of scale and farm household investment enhanced considerably	• Modernise land records and promote consolidation of holdings • Restrict fragmentation of operational holding not below one hectare but secure land rights • Enact 'Model Tenancy Act'	• State Governments	3-5 years

(B) Sector-wise Innovations

1. Natural Resources Management

S. No.	Innovation	Expected Outcomes and Impact	Action Plan		Expected Time Frame
			What	By Whom	
1.	Promoting conservation agriculture (CA) both in irrigated and rainfed areas	• Sustainable intensification of cropping systems • Restoration of soil health and sequester carbon • Saving on water, labour and energy	• Create a National Mission on Conservation Agriculture (NMCA) as permanent demonstration-cum-training and knowledge sharing and capacity development platform across diverse agro-ecoregions • Establish geographically differentiated, scale appropriate and customized CA based farm machinery centers on custom hire basis	• MoA&FW • NRAA • ICAR • SAUs • KVKs	3-5 years

S. No.	Innovation	Expected Outcomes and Impact	Action Plan		Expected Time Frame
			What	By Whom	
		• Resilience built against climatic risks • Environmental footprints reduced • Cost on inputs reduced and farmers income increased • Area under CA increased to about 10 m ha of irrigated, 20 mha of rainfed and drylands and 5 m ha of rice-fallow lands	• Promote CA through incentivizing carbon foot prints and payment for environmental services with special emphasis in low biomass producing/rainfed areas • Promote CA education from school level and initiate vocational training on CA	• State Departments of Agriculture • Private Sector • Manufacturers and Service Providers	
2.	Improving water use efficiency (WUE)	• With 20% increase in WUE, 129 Bm^3 of water will be saved, equivalent to 12% of the total quantity of fresh water resources • Significant reduction in GHG emissions • Fertilizer use efficiency significantly increased • Significant saving in energy to government • With effective treatment of wastewater, 22 Bm^3 of good quality irrigation water will become available • Food production and farmers income increased	• Demotivate flood irrigation through phasing out subsidy on irrigation water and power; make direct benefit transfer as incentive to efficient users by adopting efficient technologies like micro-irrigation (MI), laser levelling, conservation agriculture and diversification through low water requiring crops • Make MI an independent and comprehensive scheme under PMKSY for packaging (i) back-ended incentives to famers opting for MI, (ii) mandate manufacturers to provide free maintenance for 3 years, (iii) facilitate establishment of village-based service centres, (iv) make mulching and solar powered pump compulsory part of MI package for subsidy/incentives benefit • Support rainwater conservation by linking MGNREGA with on-farm and community based water conservation/ harvesting ancient water harvesting structures, bunding, and groundwater recharge • Establish cost-effective wastewater treatment plants for entire volume before discharge; develop decentralized wastewater market through private sector involvement	• MoA&FW • MoJ • MoRD • MoEP • MoUD • MoF • NRAA • ICAR • SAUs • KVKs and other advanced institutions • State Departments of Agriculture • Private Sector	2-3 years

S. No.	Innovation	Expected Outcomes and Impact	Action Plan		Expected Time Frame
			What	By Whom	
3	Improving nutrient use efficiency (NUE)	• A 25 % increase in NUE would lead to saving of fertilizer subsidy worth Rs 30,000 crore annually • Environmental foot prints (groundwater pollution and gaseous emissions) reduced • Cost of inputs reduced with increased output and farmers income	• Infuse precision nutrient management using soil health cards and right placement through drilling in root zone, optimizing nitrogen application through precise application using decision tools, Green Seeker and use of fertigation by linking to drip irrigation and support manufacturers of water-soluble fertilizers with subsidy benefit as available to urea-N. Also, discourage broadcasting and promote use of ferti-cum-seed drills linked to subsidy • Promote multi-nutrient fertilizer sources by facilitating manufacturing of customized fertilizers (dry granulation by compressing); modify rules and procedures allowing synthesis of compacted tailored multi-nutrient fertilizers at local level • Rationalize NBS by extending subsidy benefit to all deficient nutrients and their sources including biofertilizers • Facilitate availability of quality biofertilizers, supported well by accredited labs	• MoA&FW • MoFC • SAUs • ICAR • KVKs • Fertilizer Industry • Fertilizer Manufactures	2-5 years
4.	Accelerating adoption of organic farming practice	• Use of agro-chemicals in agriculture reduced for ensuring more sustainable farming and clean environment • Employment opportunities and farmer's income increased • Safe food and better human health ensured • Accelerated adoption of organic farming for intensive agricultural areas (food hubs) will positively contribute to the cause of soil, human, livestock and eco-system health	• Develop 'specialized certified organic farming' clusters' in the de-facto organic areas (hills, rainfed/ dryland) • Develop guidelines on national standards for organic production and certification • Establish 'regional referral organic agriculture quality testing laboratories' which are accredited • Promote rural youth led businesses/entrepreneurships by linking them to various Government schemes	• MoA&FW • MoC&I • MoFPI • NIOF • APEDA • NOFRI • NCOF • SAUs • ICAR • KVKs • State Governments • GoI's National Missions • North-Eastern Council	2-5 years

S. No.	Innovation	Expected Outcomes and Impact	Action Plan		Expected Time Frame
			What	By Whom	
5.	Liming of acid soils in the Eastern and NE Hill regions (around 25 m ha)	• Increase in productivity by 0.5 t/ha will lead to an additional food production of 12.5 mt worth Rs 2500 crore • This will help in reducing pressure on cultivated land significantly	• Apply lime to acid soils once in 3 years costing Rs 4800/ha • Make provision of investment of Rs 1200 crore for ameliorating entire 25 m ha acid soils by the Central government • Make provision of meeting the cost of freight on sharing basis, 50% each by the beneficiary farmer and the State Governments • Disseminate technical advice on lime treatment by SAUs and ICAR Institutes	• MoA&FW • MoM • ICAR • SAUs • KVKs • Land Development Departments of the States • Private Sector	2-5 Years

2. Crop Production

S. No.	Innovation	Expected Outcomes and Impact	Action Plan		Expected Time Frame
			What	By Whom	
1.	Increasing the use of HYVs and hybrids	• Production of foodgrain crops increased by about 65-70 mt by 2030 • Replacement of old varieties with those of new high yielding disease and pest resistant varieties and hybrids through higher seed replacement rate ensured • Greater area coverage achieved under hybrids possessing high yield potential, adaptation to climatic change and resistance to diseases and pests	• Ensure availability of adequate quantity of quality seeds of improved varieties/hybrids to farmers • Create greater public awareness regarding the benefits of new varieties/hybrids and replacing seed of old varieties periodically • Denotify old varieties unless there is significant demand of those still having some area under cultivation. Develop a 5 year rolling plan to produce seeds of new varieties/hybrids • Promote large-scale cultivation of available rice hybrids in Eastern India. Make efforts to double the area under hybrid rice cultivation in next 5 years • Develop super rice hybrids (like in China) with better grain quality and significantly higher yields for use in Eastern India	• MoA&FW • DAC&FW • ICAR • SAUs • State Governments • NSC and SSC • Private Seed Sector	2-5 Years

S. No.	Innovation	Expected Outcomes and Impact	Action Plan		Expected Time Frame
			What	By Whom	
			• Ensure greater participation of private seed sector in developing improved varieties and hybrids using modern technology through enabling environment and incentives like exclusive licensing of public bred hybrids of crops for specific regions/zones and defined period (3-5 years) and sharing of benefits up to 10% of profits • Encourage both Public and Private Seed Sector R&D companies to lay greater thrust on developing high yielding hybrids (single cross) of maize, sorghum (including rabi sorghum), rice, sunflower, and pearl millet • Strengthen seed production, processing and seed storage facilities • New Seed Bill (2004) to be cleared by the Parliament at the earliest		
2.	Increasing productivity and profitability of farmers through cultivation of GM crops	• Productivity of crops increased considerably • Cost of cultivation reduced by 30-50 % due to less use of pesticides • Crops able to withstand better both biotic and abiotic stresses • Environmental pollution reduced considerably • Higher profitability of farmers ensured	• Create enabling policy environment for regulation of GM crops and their release for cultivation • Take urgent regulatory steps to release GM crops such as corn, soybean, mustard, brinjal, etc. • Create public awareness regarding benefits of GM crops and build much needed trust in the minds of public • Provide IP protection for innovation of GM traits in order to protect the interest of innovators • BRAI Bill to be got approved by the Parliament on priority	• MoA&FW • MoEF&CC • DBT • ICAR • SAUs • Private R&D Seed companies	1-2 Years

S. No.	Innovation	Expected Outcomes and Impact	Action Plan		Expected Time Frame
			What	By Whom	
3.	Promoting cultivation of promising food crops in some non-traditional areas	• Cultivation of promising crops in some non-traditional areas expanded to increase production • Foodgrain production increased considerably	• Expanding the cultivation of maize and rice in eastern and northeastern states to enhance production • Expand cultivation of short-duration chickpea in Andhra Pradesh, Karnataka and Tamil Nadu; and short-duration pigeonpea in Haryana, Rajasthan and Gujarat • Adopt the cultivation of rapeseed-mustard in rice fallows in northeastern region; hybrid maize to replace rice in north western states; mungbean in rice-wheat cropping system; and sunflower and maize hybrids in spring season in Haryana and Punjab. • Adopt inter or mixed cropping of black gram, green gram, pigeonpea and chickpea in Central and Peninsular regions; lentils and peas in rice fallows in Uttar Pradesh, Bihar, Jharkhand, West Bengal, Odisha and Assam; and soybean in northern states (Punjab, Haryana and western U.P.) to replace rice in rice-wheat cropping system	• MoA&FW • DAC&FW • ICAR • SAUs • State Departments of Agriculture	2-3 Years
4.	Promoting cultivation of biofortified crops	• Problem of malnutrition including protein, mineral and micro-nutrients deficiency addressed • Household nutrition security achieved • Farmers income increased due to premium price of biofortified varieties	• Expand cultivation of biofortified crops like QPM maize with high lysine and tryptophan, iron and zinc rich rice, iron rich pearl millet, and zinc rich wheat etc. • Create public awareness for nutritional benefits of biofortified crops • Ensure higher premium for biofortified crops/varieties • Include biofortified crops in PDS under the National Food Security Act with required policy decision to use in mid-day meals program • Give greater thrust on underutilized crops like amaranths, finger millet, proso millet, foxtail millet, quinoa, mothbean etc. for diversification to provide mineral/micro-nutrient rich food	• MoA&FW • MoC&I • MoFPI • MoCAF&PD • ICAR • DBT • SAUs • State Governments • Private Sector	2-3 Years

3. Horticulture Production

S. No.	Innovation	Expected Outcomes and Impact	Action Plan		Expected Time Frame
			What	By Whom	
1.	Providing quality seed and planting material	• Production and productivity increased significantly leading to increase in farmers' income • Engagement of youth in production and distribution of seed/planting material assured • Farmers' employment and income enhanced	• Establish sub-mission under MIDH on 'Quality Planting Material' to ensure large scale production of quality planting material in different horticultural crops, especially using tissue culture technology • Establish accredited regional/state horticultural nurseries, both by public and private sector for large-scale production and distribution of quality seed and planting material • Make provision of supplying seeds of parental lines of hybrids bred by public institutions to private sector through exclusive licensing	• MoA&FW • ICAR • SAUs • NHM • NHB • HMNEH • State Departments of Agriculture • Private Seed Companies • Trained Nursery Men and Women	3-5 Years
2.	Expanding protected cultivation technology	• Area under protected cultivation increased 4 times (from 50,000 ha to 2,00,000 ha) • Higher production and profitablility achieved • Protected cultivation being youth centric, young men and women got motivated to adopt horticulture as their profession • Farmers' income enhanced almost by 3-4 times	• Establish sub-mission under MIDH on "Protected Cultivation" • Provide technical backstopping with human resource development • Develop varieties specifically designed for protected cultivation of high value crops • Adopt and enhance the use of low-cost technologies for protected cultivation for example plastic mulch, low tunnel, walk in tunnel, naturally ventilated polyhouses, nethouses, environment controlled green houses, and soilless farming	• MoA&FW • ICAR • SAUs • NHM • NHB • HMNEH • State Departments of Agriculture • Private Sector Companies	3-5 Years
3.	Rejuvenating old/senile orchards and promoting high density planting	• Old senile orchards, hitherto, unproductive will become productive • Production and productivity increased significantly	• Rejuvenate old/senile and unproductive orchards by thinning and canopy management along with plant protection measures. • Undertake top working on species with long life. Short-lived and diseased trees not suitable for top working	• MoA&FW • Horticultural Institutes of ICAR • SAUs/SHUs/CAUs	2-6 Years

S. No.	Innovation	Expected Outcomes and Impact	Action Plan		Expected Time Frame
			What	By Whom	
		• Profit of farmers enhanced due to higher yield from improved orchards and high density planting	• Adopt reiterative pruning, light and second level limb removal, boudreaux pasting of cut portion. • Make provision of incentives for rejuvenation activities and during the non-bearing period. • Disseminate technological information on management of orchard to farmers • Adopt proven technologies for high density planting in different fruit crops.	• NHB • State Horticulture Departments	
4.	Promoting rural based, low cost primary processing and value addition	• Primary processing technology adopted for perishable produce in rural areas to avoid distress sale • Processed food items made available at reasonable cost • Over production of fruits, vegetables and other horticultural crops is better managed and post harvest losses reduced • Respite to farmers in distress due to loss of produce (perishable items) • Farmers' income increased and consumers interest protected	• Establish units and FPOs/FPCs for primary processing, value addition, low cost storage, grading and packaging in production catchment areas • Establish low cost post-harvest technology units (Initially 100% grant-in-aid) • Adopt to entrepreneurs/FPOs rural-based processing/ value addition technologies like dehydrated fruits, vegetables pickles, jams, jellies, puries, squash etc. • Devise improved management strategies (storage, packaging, grading, processing and local marketing)	• MoA&FW • ICAR/KVKs • NHB • NHM • State Horticulture Departments	2-4 Years

4. Livestock Development

S. No.	Innovation	Expected Outcomes and Impact	Action Plan		Expected Time Frame
			What	By Whom	
1.	Increasing conception rate through fertility ensured frozen semen	• Use of Flow Cytometer in semen analysis found successful in differentiating high from low fertile semen • Fertility ensured and predicted semen increased high conception rates as compared to traditional semen straws. This will more calves per cows or buffalo in their life span	• Make provision of "Flow Cytometer" for rapid and accurate analysis of sperm functions at semen stations (one Flow Cytometer costing around 40-50 lakh) • Provide the training on "Flow Cytometry Applications" for semen analysis (costing around <Rs. 1 lakh/person)	• MoAHD&F • NDDB • ICAR-NDRI • SAUs • Veterinary Universities	2-3 Years
2.	Promoting controlled breeding programs and assisted reproductive techniques (ART)	• Controlled breeding protocols and ART restored fertility in poor reproductive performing animals. • Incidences of repeat breeding, anestrus, endometritis and other reproductive diseases reduced • Repeat breeding and anestrus affecting about 30-40% of livestock managed well and the loss of nearly Rs. 50,000 crore annually prevented	• Make sufficient availability of controlled internal drug release devices and hormones at affordable cost • Develop recombinant hormones to assure safety issues and improve response • Make provision of indigenous production of hormones such as GnRH, FSH, LH and prostaglandins to cut down the cost • Provide sufficient availability of trained manpower and training facilities for ART	• MoAHD&F • ICAR Animal Research Institutes • NDDB • State Agriculture/ Veterinary Universities • Indian Pharma Industries • State Animal Husbandry Departments	5-6 Years
3.	Promoting the use of area specific mineral mixtures (ASMM)	• Awareness created among the farmers about advantages of area specific mineral mixture • The productive efficiency of animals significantly enhanced and their reproductive performance improved • Diseases like repeat breeding, failed/ poor conception rate, mastitis, endometritis, anestrus, calf mortality will get significantly reduced • Production of ASMM will provide self employment and income	• Enhance the production of ASMM in different regions as per technologies generated • Impart the training to youth and FPOs for production of ASMM.	• MoAHD&F • ICAR-IVRI • ICAR-NDRI • KVKs • NDDB • State Agriculture/ Veterinary Universities • State Animal Husbandry Departments • Private Sector	3-5 Years

S. No.	Innovation	Expected Outcomes and Impact	Action Plan		Expected Time Frame
			What	By Whom	
4.	Enhancing the use of improved/ thermo-tolerant vaccines for Foot and Mouth Disease (FMD)	• The thermo-tolerant vaccine would be effective in controlling FMD even when there is breakage of cold chain under field conditions • Saving in economic loss of about Rs 20,000 crores/year due to FMD • Income of livestock keepers enhanced due to effective control of FMD	• Conduct extensive testing of thermo-tolerant FMD vaccine candidates under field conditions • Encourage commercial production of thermo-tolerant FMD types A, Asia 1 and O vaccine candidate by Govt. institute or by the Private Sector	• MoAHD&F • ICAR-IVRI • ICFMD • State Agriculture/ Veterinary Universities • State Animal Husbandry Departments • Private Sector	2-3 Years
5.	Promoting the use of combined PPR + goat pox + sheep pox vaccine	• Combined vaccine would help in covering small ruminants against three major diseases in one injection • The diseases like PPR, goat pox and sheep pox will be eradicated • Income from sheep and goat rearing will be increased significantly	• Test the efficacy of combined vaccine (PPS + goat pox + sheep pox) under field conditions. • Manufacture the combined vaccines at commercial level • Bring awareness among farmers	• MoAHD&F • ICAR-IVRI • ICFMD, Mukteswar/ Bhubaneswar • State Veterinary Universities • Private Sector Industries	2-3 Years
6.	Value addition in milk of cow, buffalo, camel, goat and sheep and also meat of goat and sheep	• Regular supply of quality, value added and nutritive milk, meat and their products will be maintained for nutritional security of Indian population • Continuous emerging demand for value added livestock products such as iron and zinc fortified milk, mozrella cheese from buffalo milk, yogurt and different meat products will be addressed • Export of value added products enhanced for higher income	• Impart training to youth for HRD/Capacity building • Create and upgrade the value addition unit in milk and meat processing plants • Establish marketing opportunity/ selling centres • FPOs and entrepreneurs to enter in food processing and marketing area	• MoAHD&F • ICAR Institutes • State Animal Husbandry Departments • Private Sector	2-3 Years

5. Fishery Development

S. No.	Innovation	Expected Outcomes and Impact	Action Plan		Expected Time Frame
			What	By Whom	
1.	Increasing species and systems diversification for higher productivity	• Production and productivity of aquaculture increased from 3.0 t/ha/yr to 4.0 t/ha/yr • Number of species under domestication increased • Income of the farmers enhanced significantly	• Ensure availability of quality fish seeds and adopt scientific farming suitable for freshwater ponds • Promote intensive farming with availability of quality fish seed and feed • Upscale technology in public -private partnership for species for which technology of captive breeding and seed production has been standardized • Ensure the availability of genetically improved rohu seed to farmers across the country	• MoAHD&F • ICAR - Fishery Institutes • SAUs • State Governments • KVKs • Private Sector	3-5 years
2.	Strengthening cage culture in reservoirs and sea	• Extensive use of reservoirs (manmade open waters) for fisheries development • Increased fish production through cage culture • Utilization of untapped potential of open water bodies and sea immensely contributed to higher production and employment generation, both in inland and coastal regions • Indigenous development of cost-effective and innovative cages will reduce production cost considerably	• Make available the seed of required marine fish species for commercial cage farming • Build capacity of the fishers (farmers and coastal fishermen) in cage farming • Increase area coverage under cage farming – both in inland and coastal regions	• MoAHD&F • MoA&FW • ICAR-Fishery Institutes • NFDB • State Governments • Entrepreneurs/Fishers	2-3 years
3.	Expanding re-circulatory aquaculture systems for high density fish culture	• Amount of water and space required for intensive production of fish considerably reduced by using the re-circulatory aquaculture systems (RAS) operated by filtering water from the fish or shellfish tanks	• Develop and strengthen public –private partnership in the production and installation of indigenous cost- effective systems • Undertake capacity building/skill development of the small holder farmers/fishers with financial support from NFDB	• MoAHD&F • ICAR • NFDB • Farmers Entrepreneurs	2-3 years

S. No.	Innovation	Expected Outcomes and Impact	Action Plan		Expected Time Frame
			What	By Whom	
		• Cost of production of fish or selfish significantly reduced and higher benefits to farmers ensured • Women empowerment, nutritional and livelihood security considerably improved		• Private Sector	
4.	Promoting sea weed production	• Cultivation of sea weed significantly increased • Livelihood of coastal community, especially the women, improved due to better nutrition potential of sea weed .	• Identify suitable sites for promoting seaweed cultivation • Provide technical support and capacity building of fishers, preferably women on cultivation, processing, value addition and marketing.	• MoAHD&F • ICAR • SAUs • KVKs • State Governments • R&D Organizations • NGOs • Private Enterpreneurs	2-3 years

(C) Cross-Sector Innovations

1. Eco-regional Planning

S. No.	Innovation	Expected Outcomes and Impact	Action Plan		Expected Time Frame
			What	By Whom	
1.	Characterization and creation of sustainable agro-ecological zones (AEZ)	• AEZ characterized and regional AEZ databases developed. • Ecoregional land use planning within and across state boundaries leading to better production systems that are sustainable	• Identify at state or district level boundaries and geographies of AEZs for specific sustainable cropping/farming systems • Coordinate within those zones to identify stakeholders, including farmers, consumers, suppliers, distributors and researchers • Conduct meetings with stakeholders to identify potential future crops and commodities for each region on the basis of: i) dynamics of land use and land cover, ii) dynamics of the production systems, including the farming • Collate data on abiotic and biotic aspects	• MoA&FW • DoLR • DoRD • ICAR • SAUs • KVKs • Panchayats	2-5 Years

S. No.	Innovation	Expected Outcomes and Impact	Action Plan		Expected Time Frame
			What	By Whom	
			• Collect any missing data on soil chemistry, water availability and usage, agrobiodiversity of interest, traditional and historical commodities of the region, and animal and microbial biodiversity • Establish an open access AEZ database for each ecoregion, with regular updates to account for environmental and biotic changes in the ecoregion.		
2.	Scaling farmer-led innovations	• Community and stakeholder involvement increased in agroecology-based agricultural crop planning and higher production for profit to the	• Involve farmers at all levels in the assessment of farmer-led innovations • Validate and modify innovations for ecosystem needs around natural resource management • Promote proper record keeping and online databases management • Provide inputs like seeds of crop varieties, communication and information exchange among farmers based on farmer led innovations	• MeitY • DAC&FW • DoLR • ICAR • SAUs • KVKs • NABARD • State Governments • Village Panchayats • Farmers	3-5 Years
3.	Promoting role of district agricultural extension offices and KVKs		• Details given in "Knowledge Dissemination and Capacity Building" Section	• Details given in "Knowledge Dissemination and Capacity Building" Section	• Details given in "Knowledge Dissemination and Capacity Building" Section

2. Private Sector Participation

S. No.	Innovation	Expected Outcomes and Impact	Action Plan		Expected Time Frame
			What	By Whom	
1.	Expanding the use of modern crop protection products and formulations	• More precise application of crop protection products with minimum damage to environment	• Provide enabling regulatory policy environment for safer pesticides to be introduced in the country	• MoA&FW • MoC&I • ICAR	5-10 years

S. No.	Innovation	Expected Outcomes and Impact	Action Plan		Expected Time Frame
			What	By Whom	
		• Control of pests and diseases significantly improved • Safety of farmers, spray operators, animals and consumers enhanced cost of production for the farmer • Less pesticide residues in food	• Introduce international best practices like data protection for first 5 years; grouping of crops for registration of new products and easier registration for minor alterations in formulations, which will encourage research based companies to bring new products and formulations • Provide supportive environment for introduction of safe formulations using fast track registration and required IP protection • Encourage R&D companies to bring in superior products and formulations ensuring IP protection and regulatory support	• State Departments of Agriculture • Pesticide industry	
2.	Increased use of modern agri-tech and digital technology	• Data and environmental variables managed more precisely • Farmers well connected to markets for better price realization • Timely and precise extension and technical advice made available to farmers	• Provide a platform for innovators and entrepreneurs to develop and bring the Agri Tech solutions for use by farmers • Establish a National Agriculture Innovation Fund (NAIF) of Rs. 10,000 crore to help young entrepreneurs to be successful • Set up large incubators where innovators and entrepreneurs work together to develop new Agri- Tech solutions • Ensure a regulatory framework for use of drones in agriculture which will help in improving input use efficiency and farmer's incomes • Encourage public and private investment in research through clearly defined targets of developing new digital technological solutions that can debottleneck the areas that are the reasons of main concern to farmers	• MoA&FW • MoI&B • MoC • MietY • ICAR • SAUs • State Departments of Agriculture • Private Industry	5-6 years
3.	Hybrid technology and biotechnology in seed sector	• Yield and other traits improved • Crops can fight abiotic and biotic stresses better • Use of pesticides and fertilizers reduced • Quality and profile of agri output improved • Food security ensured • Improving farmers income • Environmentally safer agriculture with reduced chemical usage	• Details given in Crop Production Section	• Details given in Crop Production Section	Details given in Crop Production Section

3. Role of Youth and Women

S. No.	Innovation	Expected Outcomes and Impact	Action Plan		Expected Time Frame
			What	By Whom	
1.	Promoting youth as agri-entrepreneurs	• About 2 lakh start-ups established in next five years • Rural youth employment enhanced • Migration of youth to urban areas reduced • Empowered youth will be "Job-creator" rather than "Job-seeker" • Technology adoption in agri-food sector enhanced • Contribution of youth for achieving SDGs increased • Information on latest technologies and practices provided to farmers for better output and higher income	• Establish National Agriculture Innovation Fund of Rs. 10,000 crore to validate and scale farmer led innovations • Allocate 20% of startup funds for agriculture related startups with emphasis on rural sector (Rs. 2000 crore) • Provide vocational training to 3 million rural youth under PMKVY • Provide training for skill enhancement to 2 lakh agri-entrepreneurs under PMKVY, SAUs, ICAR, KVKs, CSR • Create awareness, and better knowledge on policies and easy access to funding • Develop/strengthen entrepreneurial skill enhancement programs through business incubators, industrial parks, and public-private partnership • Propagate market oriented and demand driven innovative entrepreneurship • Mainstreaming agricultural and agri-business education • Convergence of all government schemes as Prime Minister's Employment Generation Program; National Rural Livelihood Mission, *Swarna Jayanti Shahri Rozgar Yojana* and *Mahatma Gandhi National Rural Employment Guarantee Act*, Skill India, Start-up etc. for better implementation and monitoring	• MoA&FW • MoC&I • MoS&T • MoFPI • MoSD&E • DBT • DST • ICAR • SAUs • KVKs • NABARD • State Governments • CSR Funds of Private Sector	3-5 years
2.	Engaging youth as knowledge, input and service providers	• More than 15 lakh rural youth engaged as knowledge, input and service providers in agri sector covering almost 50% of total Indian villages – 5 youth per village • Rural self-employment enhanced and migration to urban areas reduced	• Create knowledge, input and service provider centers for youth using 20% CSR and funds from respective corporate sector • Prioritize current investment and policies for creating FPOs engagement of youth as service providers • Re-orient vocational training programs through SAUs and KVKs towards agriculture and youth	• All Concerned Central Ministries relating to Corporate Sector engaged in agriculture • SAUs • KVKs	3-5 years

S. No.	Innovation	Expected Outcomes and Impact	Action Plan		Expected Time Frame
			What	By Whom	
		• On-farm and off-farm income of the farmers enhanced • Facilitated in wider and faster adoption of latest technology by farmers • Digital and modern technology usage in agri-sector enhanced • Contributed to sustainable agri-production and enhancing farmers income	• Initiate new certificate and diploma programs in SAUs with special emphasis on rural youth empowerment • Develop new skills in rural youth to excel in agricultural career by providing training and capacity building under Skill India program	• Nationalized Banks • Cooperative Banks • NABARD • State Governments • ITIs and Polytechnics • Private sector • FPOs	
3.	Establishing Agri-Clinics	• More than 50,000 graduates trained based on agri-clinic concept • Agri-Clinics started in 140 KVKs each year over a period of five years (700 agri-clinic in 5 years) • Rural employment provided to 1400 youth each year with total of 7000 in five years • Paid extension services proved effective in bringing the best innovations to the farmers. • Innovative agri-business model made operational in rural sector especially for youth. • Agri-Clinics linked with Govt. schemes, policies, e-NAM etc. proved successful. • Better infrastructure and knowledge sharing centers in rural India established	• Upgrade KVKs (720) to facilitate the agri-clinics in a public-private partnership mode • Allocate Rs. 5 crore to each KVKs out of which 3 crore for infrastructure development and 2 crore for youth to develop laboratory, and purchase machines, equipment etc. • Link current investment and policies like FPOs, farm mechanization etc. with agri-clinics, soil health laboratories • Make provision of interest-free loans (initially for 3 years) for youth to initiate agri-clinics as well as full financial support for training and hand holding of young graduates/entrepreneurs. • Provide credit at low interest rate by NABARD and other banks to initiate special youth empowerment program to establish agri-clinics	• MoA&FW • MoSD&E • ICAR • SAUs • NABARD • KVKs • ITIs and Polytechnics • Private Sector • Other Concerned Ministries	4-5 years

S. No.	Innovation	Expected Outcomes and Impact	Action Plan		Expected Time Frame
			What	By Whom	
4.	Removing drudgery of farm women	• Work efficiency of farm women increased through adoption of efficient tools, implements and technologies • Women empowered socially, economically and technologically • Women participation in decision making enhanced • Holistic rural development approach ensured through gender participation	• Create awareness about women friendly tools, implements and technologies • Large scale prototype manufacturing and easy availability of farm tools amd machinery • Provide new knowledge and skills through on- and off-farm trainings (short-term) • Provide soft loan for landless women farmers to purchase tools, and equipment's etc on low interest rate by NABARD and other Banks	• MoA&FW • MoSD&E • Allied Ministries • ICAR • SAUs • KVKs • NABARD • Cooperative Banks • Private sector	2-3 years

4. Institutional Mechanisms

S. No.	Innovation	Expected Outcomes and Impact	Action Plan		Expected Time Frame
			What	By Whom	
1.	Stronger influence of Panchayati Raj institutions in the promotion of sustainable agriculture	• Panchayati Raj Institutions become major players in agriculture by fostering a coordinated extension and skill development approach at district and block levels • Agro-services becoming more efficient and effective • Strategic partnership with existing agricultural institutions, farmers' associations, women groups, and elected local panchayts strengthened considerably	• Make sure that the extension of services expanded across large landscapes that have a mosaic of land uses • Take conscious efforts for convergence between the extension services of the departments of Animal Husbandry, Fishery, Horticulture, and Soil and Water Conservation • The approach of the services should also be oriented to help maximise biodiversity in agricultural landscapes • Foster partnership between farmers, public institutions and NGOs working in different sectors of agriculture • Link the activities of Biodiversity Management Committees at panchayat level and the schemes in agriculture to make the latter sector biodiversity compatible	• MoRD • MoA&FW • ICAR • SAUs • KVKs • State Governments • State Departments of Agriculture, Livestock and Fisheries • State Biodiversity Board • District Collector • Gram Panchayats • Villages	2-3 years

S. No.	Innovation	Expected Outcomes and Impact	Action Plan		Expected Time Frame
			What	By Whom	
2.	Farmer driven district level extension system through reorganization of ATMA	• District level decentralized agency becoming truly a farmer/stakeholder driven institution with more power of autonomy entrusted • Convergence established between the extension services of the departments of Animal Husbandry, Fishery, Horticulture, and Soil and Water Conservation • Farmers participation/ inputs into program planning and resource allocation enhanced at district level • Coordination and linkages between research and extension line items including KVKs enahced • ATMA-KVK dual system becoming more coordinated and effective for farmer driven training and extension system in the country	• Ensure that the ATMA operates fully at district level in 614 districts in 28 States and 3 UTs for technology dissemination • Raise the present norm of up to 10% of allocation of recurring activities under ATMA through NGOs, FPOs and Panchayati Raj Institutions to at least 50% with appropriate private partnership • Shift the current 10% of financial contributions from the beneficiaries to the partnering agencies like NGOs and private agencies engaged in extension • Place appropriate monitoring mechanism to ensure convergence between the activities of KVK and ATMA • Provide demand driven and gender sensitive agro-services	• MoA&FW • ICAR • SAUs • ATMA • KVKs • State Departments of Agriculture	3-4 years

5. Knowledge Dissemination and Capacity Building

S. No.	Innovation	Expected Outcomes and Impact	Action Plan		Expected Time Frame
			What	By Whom	
1.	Reinvigorating KVKs to 'Knowledge-Skill-Innovation (KSI) Centres'	• Rural advisory services infrastructure developed for better knowledge sharing and skill development • Farmers better linked with markets, agri-preneuship, value addition, ICT and forecasting services etc. • Paid extension system in public-private-producer partnership model developed through agri-clinic concept initiated • Rural employment enhanced considerably • Linkages with schemes in other ministries better established • Farming system changed from source of livelihood to agri-preneurship mode	• Strengthen National Mission on Agricultural Extension to undertake public-private-producers partnership extension model for bottom up approach • Revise cadre strength of KVKs with additional expertise in social behavior, digital agriculture, agri-preneurship, value addition and post-harvest and business model expert • Stregthen KVKs to evaluate and propogate farmer innovations at district level • Initiate new paid extension wing and laboratory services at each KVK through revised institutional mechanism as agriclinics • Link current investment and policies like FPOs, farm mechanization etc with agri-clinics • Provide credit at low interest rate from NABARD and other banks	• MoA&FW • ICAR • SAUs • ATMA • NABARD • NGOs • Private Sector	2-5 Years
2.	Promoting farmer professor (Farmer FIRST) strategy	• Farmer knowledge and innovations disseminated to the public on a wider scale • Bottom-up approach of farm, innovations, resources, science and technology adopted and disseminated • Community level research for extension system developed • Better linkages between agri-stakeholders (farmer-researcher-extension worker) developed	• Promote farmer learning school (FLS) concept through cross regional and out country visits of farmers • Block level adoption and integration of farmers knowledge and innovations initiated by ICAR and SAUs • Evaluate NRM technologies at farmers fields as adaptive trials involving farmer professors in participatory mode	• MoA&FW • Allied Ministries • ICAR • SAUs • NGOs • Private sector • Village Panchayats	5-10 years

S. No.	Innovation	Expected Outcomes and Impact	Action Plan		Expected Time Frame
			What	By Whom	
3.	Promoting village seed hub concept	• Village based seed enterprise (VBSEs) established • Quality seed made available to farmers at low cost • Seed based village agri-preneurship developed • VBSEs concept linked with FPOs, Agri-Clinics, Govt diversification and subsidy schemes • In longer run VBSEs concept propagated into agri-preneuship on agri-inputs and post-harvest value addition business model	• Incentivize and provide soft loans to FPOs to initiate VBSEs • Enhance capacity of rural youth for seed production locally • Develop enabling policies for marketing of farmer produced seed	• MoA&FW • ICAR • SAUs • KVKs • Agrinnovate • NSC • State Departments of Agriculture • Private sector • FPOs • Village Panchyats	5 Years
4.	Creating efficient crop advisory service through paid agricultural extension system	• More than 20 lakh youth empowered for the agricultural advisory services as extension agents • Productivity enhanced by 20% through better advisory and input services • Input cost reduced by 25% through better inputs and need based diversification • Farmer income enhanced considerably • Innovative paid extension system for doorstep delivery developed	• Change agricultural education curriculum and make it more multi- and trans-disciplinary with additional expertise in digital agri, AI, social behavior, business models, big data, farm mechanization, etc. • Bring in major reforms in innovative extension system for better knowledge delivery • Initiate certified crop advisory (CCA) services at SAUs, KVKs and ICAR with a continuous education program through licensing renewal after every 5 years	• MoA&FW • MoC&I • MoS&T • MoFPI • MoSD&E • DBT • DST • ICAR • SAUs • KVKs • NABARD • State Governments • Private sector	5- 10 years
5.	Promoting use of ICT in agriculture	• Automation of farm activities will help reducing reliance on farm worker, increase in time efficiency and enhanced productivity • Farmers can gain by better control regarding decisions on growing crops, making it more predictable and improving its efficiency, raising livestock • Farmer empowered through informed knowledge • Production significantly enhanced through use of ICT tools and technologies	• Promote the use of factor independent Mobile Apps • Promote automation of farm activities through internet of things (IoT) • Expand the use of big data analytics and dash board • Undertake mapping activities including mapping soil, nutrition, water, biopesticides and disaster damage assessment	• MoC • Central and State Governments • Private Sector • Concerned Stakeholders • Government Agencies	2-5 Years

Annexures

Office Order for Constitution of Committee

Office of the Principal Scientific Adviser
to the Government of India
* * * * *

Dated 12th February, 2019

OFFICE MEMORANDUM

Sub: *Committee for "Agricultural policies and action-plans for a secure and sustainable agriculture"- Regarding*

UN Sustainable Development Goals (SDG's) have become priority areas needing national attention. Adopting and propagating advanced technologies that are available in India, would benefit the farmers economically, also ensuring food security.

2. Considering the importance of technologies for sustainable agriculture, Principal Scientific Adviser to the Govt. of India would be steering discussions, implementing the suggestions.

3. To suggest/rollout action plan for secure and sustainable agriculture and agricultural policies, following committee has been approved by competent authority.

Composition of the Committee

Chairman

i. Dr. R. S. Paroda
Chairman, TAAS (Trust for Advancement of Agricultural Sciences), New Delhi.

Members

ii. Dr. J.C. Katyal
Former, Vice-Chancellor,
Chaudhary Charan Singh Haryana Agricultural University, Hisar

iii. Dr. A.K. Srivastava
Member, Agriculture Scientists Recruitment Board (ASRB), Krishi Anusandhan Bhawan-I, Pusa, New Delhi-110012

iv. Dr. Ram Kaundinya
Director General, Federation of Seed Industry of India

v. Dr. S. Ayyappan
NABARD Chair Professor, ICAR-National Dairy Research Institute, Southern Research Station (ICAR-NDRI SRS) Bengaluru

vi. Dr. Suresh Pal
Director, ICAR-National Institute of Agricultural Economics and Policy Research (NIAP), New Delhi

vii. Dr. S.R. Rao
Scientist 'H', Senior Adviser, Department of Biotechnology, New Delhi

viii. Dr. Anil Prakash Joshi
Founder, HESCO (Himalayan Environmental Studies and Conservation Organization), Dehradun

ix. Dr. Nadesa Panicker Anil Kumar
Executive Director, M.S Swaminathan Research Foundation, Chennai

x. Dr. Shannon Olsson
Associate Professor, Naturalist-Inspired Chemical Ecology-(NICE) National Center for Biological Sciences, TIFR, Bangalore

xi. Dr. Gitanjali Yadav
Staff Scientist IV, National Institute of Plant Genome Research, New Delhi

...2/-

xii. Dr Anuradha Agrawal,
Principal Scientist, Officer In-charge, Tissue Culture and Cryopreservation Cell, National Bureau of Plant Genetic Resources, New Delhi

xiii. Dr. A. Arunachalam
Pr. Scientific Officer to Secretary (DARE) & DG (ICAR), Room No. 101, Krishi Bhawan, New Delhi- 110 001

Member Secretary

xiv. Dr.Ketaki Bapat
Scientist 'F', O/o the PSA to GOI

4. Terms of Reference for the Committee shall be:

I. Functions:

a. To review the existing policies related to agricultural development and identify gaps for required reorientation
b. To suggest strategies relating to role of agriculture in achieving sustainable development goals (SDGs)
c. To develop an action plan/road map for a secure and sustainable agriculture for improved livelihood of smallholder farmers.
d. To suggest measures/mechanisms for effective implementation of policies and action plans
e. To consider any other suggestions that are relevant or offered by the Principal Scientific Advisor (PSA)

II. Modes Operandi:

a. The tenure of this committee will be for six months (February- July 2019).
b. Chairman of the Committee may invite additional experts/specialists for its meetings, as considered essential
c. Services of a consultant may be obtained, as required, for compilation of technical information, preparation of draft report, editing, printing etc.
d. The discussion meetings shall be facilitated by the PSA office and if required can be conducted at other convenient locations
e. TA/DA as per GoI rules and honorarium @ 4000/day, would be provided to all the Committee members as well as invited experts by the O/o the PSA to GOI.
f. The report to be submitted by 31 July 2019 to PSA by the committee

12.02.19

(Ketaki Bapat)
Scientist 'F

...3/-

Distribution:-

1. Dr. R.S.Paroda,Chairman Trust for Advancement of Agricultural Sciences New Delhi
2. Dr. J.C. Katyal, Former, Vice-Chancellor, HAU, Hisar
3. Dr. A.K. Srivastava, Agriculture Scientists Recruitment Board (ASRB), Krishi Anusandhan Bhawan-I, Pusa, New Delhi-110012
4. Dr. Ram Kaundinya, Director General, Federation of Seed Industry of India
5. Dr. S. Ayyappan, NABARD Chair Professor, ICAR-NDRI SRS, Bengaluru
6. Dr. Suresh Pal, Director, ICAR-National Institute of Agricultural Economics and Policy Research (NIAP), New Delhi
7. Dr. S.R. Rao, Adviser, Department of Biotechnology, CGO Complex, Lodhi Road, New Delhi - 110 003
8. Dr. Anil Prakash Joshi, Founder, Himalayan Environmental Studies and Conservation Organisation, Village-Shuklapur, P.O. Ambiwala, Via: Prem Nagar, Dehradun, Uttrakhand
9. Dr. Nadesa Panicker Anil Kumar, Executive Director, M.S Swaminathan Research Foundation, Chennai
10. Dr. Shannon Olsson, Associate Professor, Naturalist-Inspired Chemical Ecology-(NICE), National Center for Biological Sciences, TIFR, Bangalore
11. Dr. Gitanjali Yadav, Staff Scientist IV, National Institute of Plant Genome Research (NIPGR), Aruna Asaf Ali Marg, New Delhi
12. Dr Anuradha Agrawal, Prn.Scientist, Officer In-charge,Tissue Culture and Cryopreservation Cell, National bureau of plant genetic resources, New Delhi
13. Dr. A. Arunachalam, Principal Scientific Officer to the Secretary DARE, DG (ICAR), Krishi Bhawan, New Delhi

Copy to:-

- Addl. PS to PSA, Office of PSA to GOI
- PA to Scientific Secretary, Office of PSA to GOI

12.02.19

(Ketaki Bapat)
Scientist 'F

Prn.SA/Sus. Agriculture/2019

Office of the Principal Scientific Adviser
to the Government of India

* * * * *

Dated 5th April, 2019

REVISED OFFICE MEMORANDUM

Sub: *Committee for "Agricultural Policies and Action-plans for a Secure and Sustainable Agriculture"- Regarding*

UN Sustainable Development (SDG's) have become priority areas needing international and national attention. Propagating and adopting advanced technologies that are available in India, would benefit the farmers economically ensuring food security.

2. Considering the subject matter to SIT and SDG is being handled by O/o PSA, would be steering these discussions and implementing the suggestions promoting sustainable agriculture.

3. The following committee has been approved by competent authority to suggest/roll out action plan for Secure and Sustainable Agriculture and Agricultural Policies.

a. **Composition of the Committee**

i. **Dr. R.S. Paroda** — Chairman
Chairman, TAAS (Trust for Advancement of Agricultural Sciences), New Delhi.
Email: raj.paroda@gmail.com

ii. **Dr. J.C. Katyal** — Member
Former, Vice-Chancellor, HAU, Hisar
Email: jc_katyal@rediffmail.com

iii. **Dr. A.K. Srivastava** — Member
Member, ASRB, New Delhi
Email: memberasrb.as@gmail.com

iv. **Dr. Ram Kaundinya** — Member
Director General, Federation of Seed Industry of India
Email: ram@kaundinya.in

v. **Dr. W.S. Lakra,** — Member
Former Vice Chancellor,
ICAR-Central Institute of Fisheries Education, Mumbai
Email: lakraws@hotmail.com,

vi. **Dr. Suresh Pal** — Member
Director, ICAR-NIAP, Delhi
Email: spl.econ@gmail.com

vii. **Dr. S.R. Rao** — Member
Scientist 'H', Senior Adviser, Department of Biotechnology, New Delhi
Email: srrao@dbt.nic.in, srrao.dbt@nic.in

viii. **Dr. Anil Prakash Joshi** — Member
Founder, HESCO (*Himalayan Environmental Studies and Conservation Organization*), Dehradun, Email- dranilpjoshi@gmail.com

ix. **Dr. Nadesa Panicker Anil Kumar** — Member
Executive Director, MS Swaminathan Research Foundation, Chennai
Email: anil@mssrf.res.in; anilmaruthur@gmail.com

...2/-

x. **Dr. Shannon Olsson** Member
Faculty Coordinator, Tata Institute of Fundamental Research, Mumbai
Email: shannon@gracie.se

xi. **Dr. Gitanjali Yadav** Member
Staff Scientist IV, National Institute of Plant Genome Research, Delhi
Email- gy@nipgr.ac.in, gy246@cam.ac.uk

xii. **Dr Anuradha Agrawal,** Member
Principal Scientist, Officer In-charge,
Tissue Culture and Cryopreservation Cell,
National Bureau of Plant Genetic Resources, New Delhi 110012.
Email: anuagrawal1@yahoo.co.in, Anuradha.Agrawal@icar.gov.in

xiii. **Dr. A. Arunachalam** Member
Principal Scientific Officer,
to the Secretary DARE, DG (ICAR)
Krishi Bhawan, New Delhi
E-mail: aa.icar@mail.com

xiv. **Dr. Ketaki Bapat** Member Secretary
Scientist 'F', O/o PSA to GOI

4. Terms of Reference for the Committee shall be:

I. Functions:

a. To review the existing policies related to agricultural development and identify gaps for required reorientation
b. To suggest strategies relating to role of agriculture in achieving sustainable development goals (SDGs)
c. To develop an action plan/road map for a secure and sustainable agriculture for improved livelihood of smallholder farmers.
d. To suggest measures/mechanisms for effective implementation of policies and action plans
e. To consider any other suggestions that are relevant or offered by the Principal Scientific Advisor (PSA)

II. Modes Operandi:

a. The tenure of this committee will be for six months (February - July 2019).
b. Chairman of the Committee may invite additional experts/specialists for its meetings, as considered essential
c. Services of a consultant may be obtained, as required, for compilation of technical information, preparation of draft report, editing, printing etc.
d. The discussion meetings shall be facilitated by the PSA office and if required can be conducted at other convenient locations
e. TA/DA as per GOI rules as approved by IFD, MHA and honorarium @ **2500**/day, would be provided to all the Committee members as well as invited experts by the O/o the PSA to GOI.
f. The report to be submitted by 31 July 2019 to PSA by the committee

05.04.19
(Ketaki Bapat)
Scientist 'F'

...3/-

Distribution:-

1. Dr. R.S. Paroda, Former Director General,Indian Council of Agricultural Research, Krishi Bhavan, Raisina Road, Opp Rail Bhavan, New Delhi, Delhi 110001
2. Dr. J.C. Katyal, Former, Vice-Chancellor, HAU, Hisar
3. Dr. A.K. Srivastava , ASRB, New Delhi
4. Dr. Ram Kaundinya, Director General, Federation of Seed Industry of India
5. Dr. W.S. Lakra, Former Vice Chancellor, ICAR-Central Institute of Fisheries Education, Mumbai
6. Dr. Suresh Pal, Director, ICAR-NIAP, Delhi.
7. Dr. S.R. Rao Adviser, Department of Biotechnology, CGO Complex, Lodhi Road, New Delhi - 110 003.
8. Dr. Anil Prakash Joshi, Founder, Himalayan Environmental Studies and Conservation Organisation, Village- Shuklapur,P.O. Ambiwala, Via: Prem Nagar, Dehradun, Uttrakhand.
9. Dr. Nadesa Panicker Anil Kumar, Executive Director, MS Swaminathan Research Foundation, Chennai.
10. Dr. Shannon Olsson, Faculty, Tata Institute of Fundamental Research, Tata Institute of Fundamental Research, Homi Bhabha Road, Navy Nagar, Colaba, Mumbai 400005
11. Dr. Gitanjali Yadav, Staff Scientist V, NIPGR, Aruna Asaf Ali Marg, New Delhi, Delhi 110067
12. Dr Anuradha Agrawal, Principal Scientist, Officer In-charge, Tissue Culture and Cryopreservation Cell, National Bureau of Plant Genetic Resources, New Delhi 110012.
13. Dr. A. Arunachalam, Principal Scientific Officer to the Secretary DARE, DG (ICAR), Krishi Bhawan, New Delhi

Copy to:-

- Addl. PS to PSA, Office of PSA to GOI
- PA to Scientific Secretary, Office of PSA to GOI

(Ketaki Bapat)
Scientist 'F'

List of Members of the Committee and Consultants

A. List of Members

1.	**Dr. R.S. Paroda** Chairman, Trust for Advancement of Agricultural Sciences (TAAS), New Delhi Email: raj.paroda@gmail.com	Chairperson
2.	**Dr. J.C. Katyal** Former, Vice-Chancellor, Chaudhary Charan Singh Haryana Agricultural University (CCSHAU), Hisar Email: jc_katyal@rediffmail.com	Member
3.	**Dr. A.K. Srivastava** Member, Agricultural Scientists Recruitment Board (ASRB), New Delhi Email: memberasrb.as@gmail.com	Member
4.	**Dr. Ram Kaundinya** Director General, Federation of Seed Industry of India (FSII), New Delhi Email: ram@kaundinya.in	Member
5.	**Dr. W.S. Lakra** Former Vice-Chancellor, ICAR-Central Institute of Fisheries Education (CIFE), Mumbai Email: lakraws@hotmail.com	Member
6.	**Dr. Suresh Pal** Director, ICAR-National Institute of Agricultural Economics and Policy Research (NIAP), New Delhi Email: spl.econ@gmail.com	Member
7.	**Dr. S.R. Rao** Former Scientist 'H', Senior Adviser, Department of Biotechnology, New Delhi Email: srrao@dbt.nic.in	Member
8.	**Dr. Anil Prakash Joshi** Founder, Himalayan Environmental Studies and Conservation Organization (HESCO), Dehradun Email: dranilpjoshi@gmail.com	Member
9.	**Dr Nadesa Panicker Anil Kumar** Executive Director, MS Swaminathan Research Foundation (MSSRF), Chennai Email: anil@mssrf.res.in	Member
10.	**Dr. Shannon Olsson** Faculty Coordinator, Tata Institute of Fundamental Research (TIFR), Mumbai Email: Shannon@gracie.se	Member
11.	**Dr. Gitanjali Yadav** Staff Scientist IV, National Institute of Plant Genome Research (NIPGR), New Delhi Email: gy@nipgr.ac.in; gy246@cam.ac.uk	Member

12. **Dr. Anuradha Agrawal** — Member
Principal Scientist & Officer-in-Charge, Tissue Culture & Cryopreservation Unit,
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13. **Dr. A. Arunachalam** — Member
Principal Scientific Officer to the Secretary DARE, DG (ICAR), Krishi Bhawan, New Delhi
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14. **Dr. Ketaki Bapat** — Member Secretary
Scientist 'F', Office of the Principal Scientific Adviser (PSA) to GoI
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B. List of Consultants

1. **Dr. Bhag Mal**
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2. **Dr. R.K. Mittal**
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3. **Dr. Mruthyunjaya**
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4. **Dr. Umesh Srivastava**
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Email: srivastavaumesh@gmail.com

Proceedings of the Committee Meetings

Minutes of 1st Meeting

Minutes of the 1st Meeting of "Agricultural Policies and Action-plans for a Secure and Sustainable Agriculture" held on 25th Feb. 2019, at Meeting Room. No. 319-A, Vigyan Bhawan Annexe, New Delhi

The above meeting was held on 25th February, 2019 at Office of the Principal Scientific Adviser to the GoI and following people participated in the meeting.

Participants

- Prof. K Vijayraghavan, PSA
- Dr. R.S. Paroda, Chairman, TAAS New Delhi
- Dr. J.C. Katyal. Former, Vice-Chancellor, HAU, Hisar
- Dr. A.K. Srivastava, Member, ASRB, New Delhi
- Dr. Ram Kaundinya, Director General, Federation of Seed Industry of India
- Dr. Suresh Pal, Director, ICAR-NIAP, Delhi
- Dr. S.R. Rao, Scientist 'H' & Sr. Adviser, Dept. of Biotechnology, New Delhi
- Dr. Anil Prakash Joshi, Founder, HESCO, Dehradun
- Dr. Nadesa Panicker Anil Kumar, Exe. Dir., MSSRF, Chennai
- Dr. Shannon Olsson, Faculty Coordinator, TIFR, Mumbai
- Dr. Gitanjali Yadav, Staff Scientist IV, NIPGR, Delhi
- Dr Anuradha Agrawal, Principal Scientist, Officer In-charge, Tissue Culture and Cryopreservation Cell, NBPGR, New Delhi.
- Dr. Ketaki Bapat, Scientist 'F', Member Secretary, O/o PSA to GOI

Session 1. Interactive meeting of the Committee

1. Member Secretary welcomed all to the meeting and said that the Expert Committee has been constituted to suggest appropriate actions for sustainable agriculture and requested Dr. Raj Paroda to chair the meeting.
2. Chairman Dr. R.S. Paroda said that PSA has given a task to recommend actionable suggestions for sustainable agriculture, with the help of knowledge, policy and technologies. He expressed that the given task has wider scope to consider and requested expert members to suggest.
3. Experts exchanged their thoughts and suggested various areas to be prioritized in the DPR like MSP, Animal husbandry sector, sensors, use of soil health technologies, AI, mechanisms for effective penetration of knowledge, empowering farmers, Govt. Policies and integration, perspectives for achieving better economy and ecology etc.

Session 2

4. Chairman Prof. K. Vijayaraghavan, PSA welcomed all to the meeting and said that agriculture ministry very comprehensively looking for transformation in agriculture sector using appropriate technologies also considering effects on environment, ecology etc. He suggested that the Committee should prepare an action oriented report with implementable suggestions. Brainstorming sessions could be planned to gather community feedback using collective knowledge, he added. The DPR should mention problems and solutions can be demonstrated at selected sites at different geographical regions. The concept of agro climatic zones, nature of soils may be considered while selecting the areas

for demonstrations, he said. He mentioned that lot of initiative by DBT, DST, ICAR are already in place and can be integrated to deliver better results. He said that required logistic support would be borne by PSA office to carry out the task.

Dr. Raj Paroda said that the earlier reports need to be relooked and gaps needs to be addressed. The farmers to be benefitted and empowered with new techniques and supported with scalable innovations. The report needs to mention about National agriculture policy, measures to strengthen fishery, animal husbandry sector, linking farmer to market etc.

Actions for the Committee suggested:

i. The committee would prepare a detailed project report DPR for "*Agricultural Policies and Action-plans for a Secure and Sustainable Agriculture*" and may like to refer readily available support material prepared and recommended by NAAS/TAAS.

ii Report would have various sections recommending doable and short term goals for sustainable agriculture like-

a. New technological options for sustainable agriculture, market linkages, management of natural resources, crop cycles, integrating S& T and data collection, connecting science and society.

b. Policy matter-IPR related matter considering private sector interest, suitable recommendation of seed act pesticide bill. Sectoral imbalance.

c. Mechanisms–Institutional mechanism for empowering farmers with knowledge, mechanism for effective interstate co-ordination, land use etc.

d. Dialogue with agriculture stake holder groups, involving entrepreneurs, NGOs, Farmers, Technical experts, M.S. Swaminathan Foundation, Relevant institutions etc. can be planned.

iii. The required support for DPR preparation would be would be borne by PSA office. Committee may submit the requirement of funds, which would be presented to finance by PSA office.

iv. The next Committee meeting would be organised at O/o PSA to GoI on 11th March, 2019.

v. The Committee would submit the report to PSA in July 2019.

The meeting was concluded with vote of thanks to the chair.

Minutes of 2nd Meeting

Minutes of the 2nd meeting of committee on "Agricultural Policies and Action-plans for a Secure and Sustainable Agriculture" held on 11th March 2019 in the Meeting Room. No. 319-A, Vigyan Bhawan Annexe, New Delhi

1. The above meeting held on 11th March 2019 was chaired by Dr Raj Paroda. Dr. Ayyappan expressed his apology due to prior commitment. The following members attended the meeting.

Participants

- Dr R.S. Paroda, Chairman, TAAS, New Delhi
- Dr J.C. Katyal, Former, Vice-Chancellor, HAU, Hisar
- Dr A.K. Srivastava, Member, ASRB, New Delhi
- Dr Ram Kaundinya, Director General, Federation of Seed Industry of India
- Dr Suresh Pal, Director, ICAR-NIAP, Delhi
- Dr S.R. Rao, Sr. Adviser, Dept. of Biotechnology, New Delhi
- Dr Anil Prakash Joshi, Founder, HESCO, Dehradun
- Dr Nadesa Panicker Anil Kumar, Ex. Dir., MSSRF, Chennai
- Dr Shannon Olsson, Faculty Coordinator, TIFR, Mumbai
- Dr Gitanjali Yadav, Staff Scientist IV, NIPGR, Delhi
- Dr Anuradha Agrawal, Principal Scientist, ICAR-NBPGR, New Delhi
- Dr Ketaki Bapat, Scientist 'F', Member Secretary/o PSA to GoI

2. Member Secretary welcomed the members to the meeting. Chairman in his opening remarks mentioned that agriculture, in general, covers wide range of issues but the report of the committee should address mainly the TORs, specific gaps, current status of available technologies for scaling and the recommendations for ensuring secure and sustainable agriculture for improving the livelihood of smallholder farmers and meeting the SDG. Hence, the task assigned to the committee is indeed important and we need to be very specific in recommending technological options and needed policies for their faster adoption for impact. During the meeting, all members expressed their view points relating to the area of specialisation. They also were of the view that report should be precise and specific on key interventions needing policy support and scaling for desired agricultural growth.

3. **Following issues were discussed :**

- Importance of agriculture sector for achieving SDGs
- National policy document (Annexure 1) and need to have same revisited, review of sectoral imbalance, existing government Policies/ Regulations/Acts and suggestions for their improvement
- All Member experts shared their views, experiences and evaluated Indian scenario in the context of global vis-a-vis Indian agricultural developments. Two brief write ups were provided by Dr Kaundinya and Dr Katyal, which were explained in detail to the committee members. These were well received (Annexures 2 & 3).
- The need to organise a few brainstorming meetings with representatives of different stakeholder groups was considered necessary.
- For smooth functioning, the logistical details, including hiring of senior consultants (about 3), technical/secretarial support and the financial requirements of the committee meetings were considered urgent.

4. **Allocation of Responsibility**

i) **Dr. Suresh Pal –** Review of existing policies and programs for scaling innovations, supply of inputs, incentives for adoption of efficient/ good agronomist practices, availability of credit, MSP, procurement, capital investment in agriculture, institutional innovations for linking farmers to markets etc. Also review and

suggestions to overcome sectoral imbalances in terms of their role in national economy vis-a-vis improvement in the livelihood of smallholder farmers.

ii) **Dr. A..K. Srivastava –** Livestock development and its importance in agriculture, different technical options and policy interventions, including present Livestock Mission. The specific gaps concerning the household nutrition security, risks, value chains, marketing, export etc., to be specifically addressed.

iii) **Dr. S.R. Rao, Dr Gitanjali Yadav and Dr Anuradha Agrawal -** Technological options for genetic enhancement for productivity, biotic and abiotic stresses to ensure sustainable crop production using effectively the Agrobiodiversity, new technological options/ innovations, regulatory systems and incentives, including protection of IP, ABS etc.

iv) **Dr. Anil Kumar -** Institutional and policy reforms needed for secure and sustainable agriculture at the grassroots level. Suggestions to increase the income of smallholder farmers, and their specific needs concerning knowledge sharing, capacity/skill development and role of youth (including women).

v) **Dr. J.C. Katyal -** Strategy and action points for integrated natural resources management, especially to address concerns for soil health, nutrition, water, environment etc. Also to suggest ways for scaling innovation related to conservation agriculture, WUE including emphasis on micro-irrigation, fertigation, etc., NUE including use of fertiliser use based on soil health cards, agricultural diversification etc. Also to suggest required amendments/ incentives in existing schemes/laws relating land, water, fertiliser, climate change etc to ensure sustainable agriculture.

vi) **Dr. Anuradha Agrawal -** SWOT analysis for horticulture sector and its future role, options of scaling innovations for productivity enhancement, diversification, value addition, marketing, export potential and increased income to farmers.

vi) **Dr. A.P. Joshi –** Farmers voice, their specific concerns and possible options/ strategy to improve their livelihood.

vii) **Dr. Shanon Olsson -** Ecological and social considerations, eco-regional planning, scaling of grassroots innovation, strategy for natural resource use, scientific knowledge dissemination, and ways to achieve SDGs.

viii) **Dr. Ram Kaundinya -** Input availability system's efficiency, future scan of scientific solutions, strengthening PPP, Private sector's specific role and responsibilities, including CSR and capital investment in agriculture. Required reforms in rules/ regulations / Acts for providing incentives/ rewards for innovation towards increased productivity, seed/fertilise/ pesticide availability and their distribution.

5. General Decisions

a) Dr W.S. Lakra to be included as a member representing fishery sector in place of Dr. Ayyappan in the committee (Action – Member Secretary).

b) To budgetary details must to be worked out and financial concurrence taken on priority for smooth functioning of the committee (Action- Member Secretary in consultation with Chairman).

c) The next committee meeting to be held on 5th April, 2019.

Minutes of 3rd Meeting

Minutes of the 3rd meeting of Committee on "Agricultural Policies and Action-plans for a Secure and Sustainable Agriculture" held on 5th April, 2019 in the Meeting Room. No. 319-A, Vigyan Bhawan Annexe, New Delhi

1. The 3rd meeting of the Committee was held on 5th April, 2019 under the Chairmanship of Dr. R.S. Paroda. Three members, Dr. J.C. Katyal, Dr. S.R. Rao and Dr. Nadesa Panicker Anil Kumar expressed inability to attend the meeting due to their prior commitments. The following members attended the meeting:

- Dr R.S. Paroda - Chairman, TAAS, New Delhi
- Dr A.K. Srivastava, Member, ASRB, New Delhi
- Dr Ram Kaundinya, Director General, FSII, New Delhi
- Dr Suresh Pal, Director, ICAR-NIAP, Delhi
- Dr Anil Prakash Joshi, Founder, HESCO, Dehradun
- Dr Shannon Olsson, Faculty Coordinator, TIFR, Mumbai
- Dr Gitanjali Yadav, Staff Scientist IV, NIPGR, Delhi
- Dr Anuradha Agrawal, Principal Scientist,ICAR-NBPGR, New Delhi
- Dr. A. Arunachalam, PSA to DG, ICAR/Secretary, DARE, New Delhi
- Dr Ranjana Nagpal, DDG, NIC (Invited non-member)
- Dr. R.K. Mittal, Sr. Consultant, TAAS, New Delhi
- Dr. Bhag Mal, Senior Consultant, TAAS, New Delhi (Invited non-member)
- Dr Ketaki Bapat, Scientist 'F', O/o PSA to GOI, Member Secretary

Opening remarks

2. The Chairman welcomed the participants and appreciated their efforts in attempting the write-ups as per their responsibilities decided in the last meeting. He emphasized that the Committee should focus on mainly addressing the terms of reference (TOR). The report should clearly bring out the existing gaps, challenges and opportunities, ways and means to overcome the difficulties being faced by farmers, how to empower them, increase their income, enhance public and private sector investments and ensure institutional and policy reforms.

Approval of minutes of 2nd meeting

3. Dr. Paroda asked the participants for their observations/comments on the minutes of the 2nd meeting held on 11th March, 2019. Since there were no comments, the minutes were taken as approved.

Action taken report

4. Dr. Ketaki Bapat, Member Secretary presented the action taken report. She informed that as suggested during the last meeting write ups from the committee members on the topic- (i) policies (ii) livestock development, (iii) technological options for genetic enhancement, (iv) institutional reforms, (v) integrated natural resource management, (vi) SWOT analysis for horticulture sector, (vii) farmers' voice and concerns, and (viii) input availability system's efficiency and private sector's negotiations and the specific role. She informed that renovation work in the PSA office has been started and therefore arranging meeting in the Committee room will not be possible hereafter. Therefore, preparing report on a project mode implemented by agency is being worked out. It will help for carrying out the planned activities smoothly.

Review of assigned responsibilities

5. The Chairman requested the concerned members to brief the participants about progress made in areas of responsibility assigned. Accordingly, members briefly appraised the progress made so far.

6. Dr. Ram Kaundinya emphasized on food security, profitability, sustainability, livelihood and scalability of the technologies for addressing emerging challenges in agriculture and we need to find out appropriate solutions through enabling policies. He mentioned that his write-up is being further refined. He also mentioned that about 20 important needs of the farmers be identified for which science based solutions be suggested in the report.

7. Dr. Suresh Pal mentioned about reviewing the programs for scaling innovations, inputs and incentives, credit, MSP, capital investment, institutional innovations for linking farmers to markets and sectoral imbalance. He also highlighted the need for centre-state coordination, and effective policies to be in place. The Chairman stated that in some states, the State Farmers Commissions have taken up farmers' problems to the State government for possible solutions.

8. Dr. Shanon Olsson emphasized on eco-regional approach and mentioned about the problems faced relating to soil, water and environment in different agro-ecological regions and suggested that greater focus be given now to (i) adaptation (ii) awareness and (iii) adoption. The Chairman informed that an agro-ecological approach was adopted in the NATP project by ICAR, for which the NATP document be consulted.

9. Dr. Gitanjali Yadav informed that there was good interaction among the experts who participated in a discussion held at NIPGR on 4 April 2019. She highlighted the importance and need to promote emerging technological options such as CRISPR, digitization and App development, biotic and abiotic stresses, artificial intelligence and image analysis, block chain technology, robotics and drone technology.

10. Dr. A.K. Srivastava emphasized on enhancing investment in livestock and dairy sector, need for reviewing existing policies and gaps, scaling of technologies and the mechanism to get rid of unproductive and wild animals which have become a menace in several regions. He also informed that report of livestock sector will be further refined in consultation with selected experts in the livestock sector.

11. Dr. Anil Joshi highlighted on the importance of interactions with different groups of farmers concerning their perspective especially with regard to: (i) single window system for dealing with the problems of farmers and their possible solutions, and (ii) focus on marginal and sub-marginal farmers.

12. Dr. A. Arunachalam mentioned that there are several problems regarding forest management and there is need for ecology based problem oriented solutions for which strong coordination between research and development departments is necessary. He also mentioned that the KVKs be linked with village resource centers for effective implementation of programs and faster dissemination of technologies to the farmers.

13. Dr. Anuradha Agrawal also informed that the write-up on SWOT analysis for horticulture has been developed which will be refined further based on the inputs of brainstorming meeting of concerned experts.

14. Dr Ranjna Nagpal informed that digitization portals at NIC have the immense potential to positively impact agriculture, through access to digital technology, stemming from an increasingly robust infrastructure and service platform. Artificial intelligence can be used to map the entire district for disaster management along with soil and water analysis for drought occurrence which has a great practical value from the farmers' perspective.

15. Dr. Bhag Mal pointed out that the youth are moving away from agriculture to find alternative jobs in cities and there is a great challenge to retain youth in agriculture which needs to be addressed. He also emphasized on the need for enhancing farmer's income and develops innovative extension system for faster delivery technologies to farmers.

16. Several other important issues such as empowering/knowledge to farmers, entrepreneurship, credit, land reforms, public-private partnership, private participation in innovative extension, technological

options such as biotechnology, natural resource management (water, soil, seed), productivity improvement through hybrids and varieties, integrated pest management, protected cultivation, vertical farming, peri-urban agriculture, agri-clinics, post-harvest management, linking farmers to markets, ITK, generation and validation of data, artificial intelligence for resource management, policy on drones etc. were also discussed.

Major action points agreed

The Chairman highlighted that agriculture contributes 17% and supports 45% of our population and thus agriculture sector could become important contributor to national economy. The KVKs can be effectively used for vocational training and entrepreneurship, off-farm and on-farm activities need to be identified, the population dependent on agriculture needs to be brought down, contract farming needs to be looked into, and Producer Company Act and Tenant Act need to be reviewed and improved. These aspects need to be given due consideration for developing the policies for a secure and sustainable agriculture the important action points emerged are as follows:

a. The following brainstorming meetings involving area-specific experts should be organized by the identified lead persons as early as possible to deliberate at length and come out with write-up of the respective groups giving the background importance, challenges and opportunities, and specific implementable recommendations.

- Crops and Seeds, including Role of Private Sector – Dr. Ram Kaundinya
- Horticulture – Dr. Anuradha Agrawal
- Livestock– Dr. A.K. Srivastava
- Fishery – Dr. W.S. Lakra
- Policy Reforms – Dr. Suresh Pal

b. Dr. Anil Joshi assigned the responsibility for Farmers' Perspective and Dr. Gitanjali Yadav for Emerging Technological options informed that they had detailed in-depth discussions already and there is no need to have further brainstorming meetings. However, as needed, they would consult the concerned stakeholders.

c. Dr. Shannon Olsson and Dr. A. Arunachalam agreed to jointly discuss and bring out a write-up on strategy and action plan for eco-regional development.

d. Dr. J.C. Katyal and Dr. Anil Kumar will take care of further refinement of write-ups on Natural Resource Management and Institutional Reforms, respectively and may initiate dialogue with concerned experts, as needed.

e. It was strongly felt that the agricultural policies should be based on "Farmer First" principle in order to have a secure and sustainable agriculture. For this, as suggested by Dr. Kaundinya, the farmers specific 15-20 needs be indentified. Some of the important needs of farmers discussed were: better knowledge, easy credit, land tenure, water use efficiency, electricity, availability of improved seed and planting materials, access to farm implements and machinery, pesticides and insecticides, fertilizers, value chain and rural based processing/product development, direct marketing, transportation, storage etc. There could be additional needs. Focus on these shall be appropriately reflected in the agricultural policies.

f. The Chairman desired that a write-up on role of youth (including women) and entrepreneurship should be developed by Dr. Bhag Mal, giving the background and the major recommendations which could be considered for including in the report appropriately.

g. Regarding the structure of the final report, it was agreed that the terms of reference (TOR) of the Committee be kept into focus and be more specific on action needed. Accordingly, the following broad format was agreed:

- Introductory – importance of agriculture
- Challenges and Opportunities to harness
- Accelerating Agricultural Growth – Sectoral Contributions
  - ❖ Crops and Seeds
  - ❖ Horticulture
  - ❖ Livestock
  - ❖ Fishery
  - ❖ Scaling Technological Options

- ❖ Natural Resource Management

- Policy and Institutional Reforms
- Recommendations
- Way Forward

h. The following logistic arrangements were also discussed and agreed:

- ❖ Logistic arrangements for organizing the committee meetings need to be firmed-up. Budgetary details for holding 5 sectoral group brainstorming meetings, and 3-4 committee meetings along with hiring two consultants for a period of 4 months April –July, 2019 (Inputs-Committee, Action: Member Secretary).
- ❖ The next Committee meeting will be held at TAAS office, IARI Campus, New Delhi on 29 April, 2019 and incurred expenses would be borne by the PSA office as usual.
- ❖ The meeting ended with a vote of thanks by the Member Secretary of the Committee.

Minutes of 4th Meeting

Minutes of the 4th meeting of Committee on "Agricultural Policies and Action-plans for a Secure and Sustainable Agriculture" held on 22nd July, 2019 at NIAP, Pusa Campus, New Delhi 110012

The 4th meeting of the Committee was held on 22nd July, 2019 under the Chairmanship of Dr. R.S. Paroda. Four members, namely, Dr. S. R. Rao, Dr. Anil Joshi, Dr. A. Arunachalam and Dr. Shannon Olsson expressed their inability to attend in view of other pressing commitments. The following participants attended the meeting:

- Dr R.S. Paroda - Chairman, TAAS, New Delhi - Chairman
- Dr J.C. Katyal, Former Vice Chancellor, CCSHAU, Hisar (Haryana)
- Dr A.K. Srivastava, Member, ASRB, New Delhi
- Dr Ram Kaundinya, Director General, FSII, New Delhi
- Dr W.S. Lakra, Former Vice Chancellor, CIFE, Mumbai
- Dr Suresh Pal, Director, ICAR-NIAP, Delhi
- Dr Nadesa Panicker Anil Kumar, Executive Director, MSSRF, Chennai
- Dr Gitanjali Yadav, Staff Scientist IV, NIPGR, Delhi
- Dr Anuradha Agrawal, Principal Scientist, ICAR-NBPGR, New Delhi
- Dr. R.K. Mittal, Sr. Consultant, TAAS, New Delhi
- Dr. Bhag Mal, Senior Consultant, TAAS, New Delhi (Invited non-member)
- Dr Umesh Srivastava, Consultant, TAAS, New Delhi (Invited non-member)
- Dr Ketaki Bapat, Scientist 'F', O/o PSA to GOI, Member Secretary

Opening Remarks

At the outset, the Chairman welcomed the participants and thanked Dr. Suresh Pal, Director, NIAP, for hosting this meeting. He apprised the members that several eminent experts/peers were consulted within India and abroad to go through critically the write-ups of respective sectors developed by the members and provide their valuable inputs for needed refinements. In addition, peer review meetings were also held on various sectors, namely, Natural Resource Management (NRM), Horticulture, Livestock, and Private Sector Participation. The Chairman emphasized that the draft report circulated to members is still evolving and the draft write-ups for different sectors will need to be re-looked critically and revised in the light of comments/suggestions received from peers and also the points/suggestions emerging from today's discussion. Also to avoid some repetition, the consultants would suitably shift some parts at appropriate places.

Major Points raised during Discussion

The Chairman requested the concerned members to brief the participants about their observations and viewpoints on the draft report containing write-ups on different sectors provided to them and additional suggestions, if any, to improve and fine tune the write-ups.

Dr Ram Kaundinya emphasized that focus on farmers' needs and possible solutions will have to be clearly highlighted. Although Dr Anil Joshi had already made wide range consultations with farmers and farmer groups and provided a consolidated write-up about their problem and required policy changes, it was felt that possibly one meeting should be held with representative of farmers associations and other stakeholders to ascertain their viewpoints and needs. For this, representatives of state farmers' commissions, private sector like FAI, seed sector, pesticide sector, ICFA, Bharat Krishak Samaj, Bhartiya Kisan Sangh etc. may be invited.

On NRM write up, Dr JC Katyal pointed out that he refined the write-up and considerably reduced the length. However, he felt that certain important points need to be elaborated. Dr RK Mittal clarified that all important points have been retained in the revised write-up. In general, it was felt that we need to restrict the length up to max. of 10-12 pages except that for NRM, which could be slightly longer.

Dr Ketaki Bapat drew attention to the press coverage on Zero Budget Natural Farming (ZBNF) that reduces cost on farming, improve land quality, and increases farmers' income. She further wanted Committee to know about the constitution of a Committee of Chief Ministers on Agricultural Policies and Action-plans by the PM. She informed that she will find out if our Committee could provide input to this Committee.

Dr Paroda emphasized on several issues which need to be addressed aggressively such as Green India Mission, about important role of agro-forestry (which is missing in the report), including the Delhi Declaration, Forest Act, Water Conservation, Paris Accord for reducing Green House Gas (GHG) emission up to 30-35%, carbon sequestration, suggestion for a Mission on Conservation Agriculture (CA) in drylands, climate change, reducing pressure on non-renewable energy,and incentive to farmers for adopting GAP. He also reiterated that Big Data and artificial intelligence (AI) can help getting reliable information which certainly will guide for better action oriented programs in future. Artificial intelligence can be used to map the entire district for disaster management along with soil and water analysis for drought occurrence which has a great practical value to overcome risk from the farmers' perspective.

Dr Paroda further stated that grey areas need to be made green such as dryland areas. He specifically requested members as to what new strategy we need to propose for dryland areas, and also for the eastern and northeastern regions of India having great potential for future green revolutions.

Dr N.P. Anil Kumar highlighted on the importance of women in agriculture and the need for a separate chapter on women. Further, he stressed that there should be two parts of report, one big report and another Executive Report/Synthesis report. Big report may be again in 2 parts, Sector related and Management related. These suggestions were well taken by the members but it was felt more appropriate to include women component along with youth and hence to have a chapter on Youth and Women. Since, there will be an Executive Summary of the report, there is no need to have a separate Executive Report.

Dr. AK Srivastava emphasised on the need for greater focus on enhancing investment in livestock sector and dairy sector, farmer cooperative sector, skill development and capacity building, scaling of technologies and the mechanism to get rid of unproductive and wild animals which have become a menace in several regions. There was discussion on waste from livestock sector. It was suggested to manage it through vermicomposting etc. A suggestion was made by Dr Paroda that there should be a paradigm shift in future from export of meat to that of live animals export as practiced now in Australia. Further, he emphasised that mozzarella cheese processing and export may be intensified both in Haryana and Punjab states. Also, several Missions are in place like Rashtriya Gokul Mission, National Mission on Bovine Productivity, Dairy Processing and Infrastructure Development Fund, and National Livestock Mission. It was felt to have only one 'Livestock Mission' subsuming all other missions, including a sub-mission on Feed and Fodder with provision of effective implementation and monitoring.

There was consensus to have 'National Agriculture Innovation Fund (NAIF), National Farmers' Commission, and State Farmers' Commission which will serve better for upliftment of farming community. The Chairman stated that in some states, where State Farmers Commissions exist, they have taken up farmers' problems to the State government for quick solutions.

On the suggestion for support on Marketing and Essential Commodity Act, Dr Suresh Pal mentioned about marketing reforms, inputs and incentives, credit, MSP, capital investment, institutional innovations for linking farmers to markets and sectoral imbalance. It was also emphasised that MSP may be linked with procurement and government's subsidy is to be linked with input based expenditure, for which a kind of rider is to be in place. He also highlighted the need for centre-state coordination, and effective policies to be in place. Dr Paroda emphasised that all forms of subsidy be examined and be converted as incentives, besides loan waivers, and linked to DBT for efficient management of farming operations such as need based fertiliser use, use of micro-irrigation in place of flood irrigation, adoption of conservation agriculture, land leasing, bunding of fields, saving on use of power, farm mechanisation etc. and be considered as incentive for providing environmental services by the farmers. For this, Dr Suresh Pal was requested to review and suggest the

best option as support to be provided to farmers for efficient GAP to the farmers per acre per year and it be through well drawn mechanism of DBT. It was also thought that there should be GST exemption on rural based processing (low cost value addition) of farm produce especially of perishable items. *Mandi* tax must also be rationalised and made uniform instead of existing large variation from state to state.

Dr. Gitanjali Yadav highlighted the importance and need to promote emerging technological options and offered to provide her write-up soon to be incorporated suitably in the report. Promoting use of GM food crops like canola, soybean and maize can help addressing the issue of food security. It was agreed that a suitable recommendation on adoption of biotechnology and GM crops be made in the report. For this, Dr Kaundinya and Dr Gitanjali were requested to draft a suitable recommendation.

Dr. Anuradha Agrawal informed that based on discussion and feedback received from other experts, the write-up on horticulture will further be refined, including the suggestions made by the members in the meeting. She in association of Dr Umesh Srivastava will provide the revised draft soon.

Dr Umesh Srivastava pointed out that MSP and Crop Insurance may be extended to other commodities like perishable horticultural crops, animal and fish products, rather than only to a few crops. Today there are only 23 commodities in the list for MSP + 50% formula based on realistic estimates of production cost (Dr Swaminathan's recommendation).

Dr AK Srivastava also emphasised on this issue and mentioned that it should not be restricted to few commodities but made applicable to all commodities with which farmers are concerned and can be benefitted. On rice cultivation in Punjab where water scarcity will be a major problem in future, it was felt to replace rice with improved hybrids of maize or new HYV of soybean.

Dr Paroda also informed that the Planning Commission around 2013-14 had recommended to GoI to double the allocation for the next plan for ICAR from about ₹12,000 crore to ₹25,000 crore considering the dire requirement of R&D to boost agricultural production in the country. Unfortunately, this never got materialised.

Discussion on Overarching Recommendations

After detailed discussion on several issues relating to secure and sustainable agriculture, Dr Paroda highlighted several important overarching recommendations which were agreed upon by the members. These are given below:

- It was unanimously agreed that GoI would create "National Agricultural Development & Farmers' Welfare Council (NADFWC)" on the lines of council on GST. The NADFWC may be chaired by Prime Minister, Vice Chairman, NITI Aayog as its Vice Chair; Union Cabinet Ministers relating to Agriculture & allied Ministries, and all Chief Ministers as its Members and Member (Agriculture), NITI Aayog as its Member Secretary.
- There is need to increase allocation of funds for agricultural research by GoI considerably with rider of 60% on fixed cost and 40% on research contingency.
- There is need to establish National Farmers' Commission/Farmers' Commission in each state to look into problems of the agriculture. Such Commissions exist in Haryana and Punjab and a few other state(s) where farmers are in distress, and hence GoI must consider establishing the farmers' commission at the centre and in the states.
- Pledged cold chain from farm gate to *Mandi*, tax exemption on agro-processing. APLMC and Contract Farming Act are important aspects to be considered on priority.
- There is dire need to link farmers to market so that farmers can realize the worth of their produce. There is an urgent need for marketing reforms. Provision needs to be made for storage of farm produce on charge basis to avoid distress sale by farmers.
- MSP and Crop Insurance may be extended to other commodities like perishable horticultural crops, animal and fish sector rather than mostly to crops. Today there are only 23 commodities for MSP + 50% (Dr Swaminathan's recommendation) in the list which may be extended to commodities in above stated sectors. MSP should be linked with procurement.
- It was emphasized to have only one 'Livestock Mission' subsuming Rashtriya Gokul Mission,

National Mission on Bovine Productivity, Dairy Processing and Infrastructure Development Fund, and National Livestock Mission, for its effectiveness and proper monitoring. Also Animal Breed Act should be in place.

- Country must have Agricultural Policy on Farmers to achieve SDG by 2030. Country has to invest more in non-green revolution areas. SDG will require social development goal, means better electricity, better road, better facility for marketing, clean water availability etc.
- The export of commodities is relatively very poor and needs to be promoted in a big way. For this, an Agriculture Councillor needs to be posted in each country for creating awareness and facilitating the export of agricultural commodities from India to other countries for which appropriate policy needs to be made on priority.
- Dr. J.C. Katyal, Dr. Anil Kumar and Dr RK Mittal will further reduce and refine the NRM Sector write-ups without losing the very essence. All other sectors' report will also have to be refined by the concerned members in the light of discussions and suggestions made during the meeting.
- Several other important issues such as empowering/knowledge to farmers, credit, land reforms, public-private partnership, private participation in innovative extension, technological options such as biotechnology, productivity improvement through hybrids and varieties, protected cultivation, input use efficiency, vertical farming, peri-urban agriculture, agri-clinics, post-harvest management, artificial intelligence for resource management, multiple pledging for credit from banks, were also discussed and important recommendations for these need to be made.

Discussions of Scalable Innovations

Sector-wise scalable innovations were presented by the respective members. The Chairman pointed out that this part is not well developed and in several cases, the innovations mentioned are indeed not scalable and the actions to be taken are not clearly defined along with suggested time frame. Hence, it was decided that the scalable innovations need to be critically looked into and only 3-5 most important innovations be included under each sector/area in the defined format (Table of Innovations).

It was agreed that the final version of the sector write-ups and the table of scalable innovations should be reviewed again by the respective members and submitted latest by C.O.B. 27 July as the time left is short.

Format of the Report

In view of various suggestions for inclusion of separate chapters in the report, Dr. Bhag Mal emphasized on the need for discussion and finalization of the format of the report. Accordingly, it was discussed and agreed that the terms of reference (TOR) of the Committee be kept into focus and there is need to be more specific on actions needed. Accordingly, the following broad format was agreed:

Chapter 1: Role of Agriculture in Attaining SDG 2

Chapter 2: Review of Agricultural Policies and Identify Gaps for Needed Reorientation

Chapter 3: Accelerating Agricultural Growth –

Sectoral

- Natural Resource Management
- Crops
- Horticulture
- Livestock
- Fishery

Cross cutting

- Eco-regional Land Use Planning
- Private Sector Participation
- Role of Youth and Women
- Institutional Mechanisms and Reforms
- Knowledge Sharing and Capacity Development

Chapter 4: Recommendations

Chapter 5: Scalable Innovations and Action Plan

Chapter 6: Way Forward

It was also decided that a meeting with the farmers representatives or some farmers associations need to be convened around 10 August. Also the final meeting of the Committee could possibly be convened around 19-20 August to finalise and submit the report to PSA Dr Vijayraghavan.

The Chairman concluded the meeting and thanked all the members and invitees for their valuable contribution. He also thanked Dr Suresh Pal and staff of NAIP for providing the logistics for holding the meeting.

Minutes of 5th Meeting

Minutes of the 5th meeting of Committee on "Agricultural Policies and Action-plans for a Secure and Sustainable Agriculture" held on 12th August, 2019 at NIAP, Pusa Campus, New Delhi 110012

The 5th meeting of the Committee was held on 12th August, 2019 under the Chairmanship of Dr. R.S. Paroda. Dr. S.R. Rao, Dr. Anil Joshi, Dr. A Arunachalam, Dr. N.P. Anil Kumar, Dr. R.K. Mittal and Dr. Ketaki Bapat expressed their inability to attend the meeting due to other pressing commitments. The following participants attended the meeting:

- Dr R.S. Paroda - Chairman, TAAS, New Delhi - Chairman
- Dr J.C. Katyal, Former Vice Chancellor, CCSHAU, Hisar (Haryana)
- Dr A.K. Srivastava, Member, ASRB, New Delhi
- Dr Ram Kaundinya, Director General, FSII, New Delhi
- Dr W.S. Lakra, Former Vice Chancellor, CIFE, Mumbai
- Dr Suresh Pal, Director, ICAR-NIAP, Delhi
- Dr Gitanjali Yadav, Staff Scientist V, NIPGR, Delhi
- Dr Shannon Olsson, Faculty Coordinator, TIFR, Mumbai
- Dr Anuradha Agrawal, Principal Scientist, ICAR-NBPGR, New Delhi
- Dr. Bhag Mal, Senior Consultant, TAAS, New Delhi (Invited non-member)
- Dr Umesh Srivastava, Consultant, TAAS, New Delhi (Invited non-member)
- Dr ML Jat, Principal Scientist, CIMMYT, NASC Complex, New Delhi (special invitee)
- Dr Yash Sehrawat, Principal Scientist & Country Manager, ICARDA, NASC Complex, New Delhi (special invitee)

At the outset, the Chairman welcomed the participants and appreciated Dr Suresh Pal, Director, NIAP for hosting this meeting. He apprised the members that the draft after several rounds of discussion is much improved but still needs to be re-looked critically by the concerned members to improve it further, only in 'track mode' and send back to TAAS Secretariat by COB 15 August, 2019 for final editing, processing and submission to the PSA on 20th August 2019. He appreciated all the members for their valuable inputs and cooperation. The chairman further emphasized that the draft has also been perused by over 110 experts from within India and non-resident Indian experts.

After detailed discussion on several issues relating to secure and sustainable agriculture, several good suggestions were put forth by the members. The draft report was reviewed critically, discussed at length and changes were suggested wherever felt necessary. As desired by the Chairman and agreed by the members, the draft report is to be further refined urgently by the members. They were requested to make addition/deletion/modification/and avoid duplication appropriately in 'track mode' keeping in view the following points.

A. Main Report

- The text in the respective sections and elsewhere in the report may be reduced wherever possible without losing the essence with good language flow and deletion of general statements.
- Recommendations pertaining to respective sections may better be given in order of priority, and only those that are very important.
- References given as links may be avoided and author(s) and year be given at relevant places in the text.
- Experts who have developed particular chapter(s) may provide abbreviations/acronyms pertaining to respective chapters. Dr Umesh Srivastava will compile a table of GoI's Missions, Central Sector Schemes, New Programs and Acts etc to be provided in Chapter 1 to replace current table.
- Dr Anil Joshi may be requested to provide the contact details of farmers and farmer groups whom he had contacted. Dr Gitanjali Yadav will provide information on all those who had attended her meeting to Dr Anuradha Agrawal.

- Dr Gitanjali Yadav would develop a write up on use of ICT in agriculture, along with table of 3-4 important scalable innovations. She may use the write-up provided by Dr Ranjana Nagpal.
- Additional recommendations are to be formulated on the following aspects:
  - Export policy and globalization- Dr Suresh Pal
  - Agro-ecology based land use planning- Dr Shannon Olsson
  - Reorienting extension system- Dr Yash Sahrawat
  - Doubling farmers income- Dr Suresh Pal
  - Pledged Storage and Warehousing- Dr Suresh Pal
  - Youth and women as drivers of change – Dr Yash Sahrawat
  - ICT and knowledge empowerment- Dr Gitanjali Yadav
  - Review of existing missions and any gaps- Dr Umesh Srivastava
  - CSR linked to agricultural extension- Dr R. Kaundinya
  - Agricultural educational reforms- Dr J.C. Katyal
  - National innovation fund- Dr Yash Sahrawat
  - Doubling of allocation for R&D - Dr Suresh Pal
  - MSP and eNAM – Dr Suresh Pal
  - Livestock Mission (under institution section)- Dr AK Srivastava
- A graph depicting investment in Agricultural R&D (comparative figure in other countries like China) may be given at appropriate place in the draft. - Suresh Pal
- Under Paris Agreement, Green House Gas (GHG) emission and non-fossil fuel issues are on track. Forestry cover for carbon sequestration is important for reducing GHG emissions but a challenge is that we don't have area to expand forest. Hence, the role of agro-forestry in agriculture be emphasised. Dr Katyal may highlight this in his write up.
- Under Chapter 1 on SDGs, social progress index be reflected.
- For doubling farmers' income, there is need to add one paragraph on diversification for secondary and specialty agriculture.
- Domestic production of edible oil is necessary. Oil import is too high presently (Rs 70,000 crores). Import of oil palm, which is much cheaper presently, is leading to mixing with other oils and sold at high rate. It needs to be restricted in the interest of our farmers.
- GoI Missions already in existence have probably lost their missionary zeal. They have to be re-vitalized. It was suggested to highlight oilseed and pulses mission now again with more vigour. This needs to be properly reflected.
- Pesticides and Fertilizer Acts need to be re-visited. They must facilitate promotion of biopesticides, biofertilisers and composite/ customised fertilisers.
- National Rainfed Area Authority (NRAA)'s mandate and functions are be revisited and strengthened further with thrust on oilseeds and pulses in rainfed/arid areas. This needs to be highlighted suitably.
- EXIM policy should be a long term one and in the national interest. There must be a strong recommendation for harnessing the benefits of globalization.
- Coastal agriculture requires more attention. There is need to have a Mission for Coastal Ecosystem Development, with greater focus on Fishery sector.
- Professional backstopping for the FPOs required. There are over 3000 FPOs in existence but only 55 FPOs are actually functional. FPOs may be provided access to knowledge, mentoring and hand-holding, with required technical backstopping, and credit support
- In chapter 3, RKVY, MGNERGA, NFSM, NHM part should not be in 'Grassroot Knowledge Empowerment paragraph'. It may be shifted appropriately.
- We have storage capacity to the tune of only 157 mt. We should have modern silos as well. Capacity of warehouses is to be raised exponentially by creating warehouses/ modern silos around *Mandi*'s/Block offices etc. Private sector be encouraged for active participation. There is an urgent need for marketing reforms. Provision needs to be made for pledged storages for the farm produce on charge basis to avoid distress sale by the farmers

- Long term weather forecast based on big data will be helpful and crops may be grown accordingly linking with e-NAM and APMC.
- CSR of Corporate Sector may be linked for technology dissemination, outscaling, agri-clinics and related activities.
- Pledged cold storage chain from farm gate to *Mandi*, tax exemption on agro-processing. APLMC and Contract Farming Act are important aspects to be considered on priority.
- MSP and Crop Insurance may be extended to other commodities like perishable horticultural crops, animal and fish sector rather than only to crops. Today there are only 23 commodities for MSP + 50% (Dr Swaminathan's recommendation) in the list which may be extended to other commodities and be calculated on C-2 basis. MSP may also be linked with procurement. This aspect be considered and properly reflected by Dr Suresh Pal.
- Provision of incentives, in place of subsidy to the tune of Rs 25,000.00 per ha/year be considered and included as strong recommendation.

B. Scalable Innovations

- Sector-wise scalable innovations were also presented and reviewed The Chairman emphasized that this part is to seen again very critically and only 2-3 important innovations which are scalable may be included with clear action and exact time frame. This table should have clarity on each item mentioned in the Table.
- The immediate action points stated above may be provided by the respective experts/ members preferably within 2-3 days, since the time left is rather short.

The Chairman concluded the meeting and thanked all the members and invitees for their valuable contribution in the meeting and also to Dr Suresh Pal for hosting and providing all the logistics for the meeting.

List of Senior Agricultural Experts and Farmers Consulted

A. Agricultural Experts

1. **Dr. S. Ayyappan**
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B. Farmers (Consulted by Dr Anil Joshi during Kisan-Kisani Meetings)

Location 1: Boko, Assam

1. Salam Rajaha
2. Nigathoujam
3. U Ramabola
4. U Dhaneshwari
5. Diptishikha
6. Priyanka
7. Rini Sharma
8. Prakash Meelhi
9. Omprakash
10. Himanshu Nath

Location 2: Chakrata, Kalsi Block, Rikhad, Uttarakhand

1. Mahaveer Singh Chauhan
2. Chaman Singh Chauhan
3. Nain Singh
4. Virendra Singh Rawat
5. Pratap Singh
6. Tulshi Singh
7. Ramesh Singh
8. Bhim Singh
9. Attar Singh
10. Kundan singh
11. Ramesh Chauhan
12. Dinesh Tomar
13. Hukum Singh
14. Diwan Singh
15. Tikkam Singh

List of Participants in Peer Review Meeting on New and Emerging Technologies

Venue: NIPGR, New Delhi

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List of Participants in Peer Review Meeting of Private Sector Organizations and Institutions

Venue: Bayer House, Arabhi, Thane

Date : April 22, 2019

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Government of India's Authorities, Missions, Central Sector Schemes, New Programs and Initiatives, Policies and Acts related to Agriculture and Allied Sectors

Aayog

National Institution for Transforming India (NITI) *Aayog*; *Rashtriya Kamdhenu Aayog* (RKA).

National Authorities

National Biodiversity Authority (NBA), Protection of Plant Varieties and Farmers' Rights Authority (PPVFRA), National Rainfed Area Authority (NRAA), National Disaster Management Authority (NDMA), Agricultural and Processed Food Products Export Development Authority (APEDA), Marine Products Export Development Authority (MPEDA), and Coastal Aquaculture Authority (CAA).

National Missions

National Food Security Mission (NFSM) with Mini Mission (Rice), Mini Mission (Wheat), Mini Mission (Pulses), Mini Mission (Nutri-cereals), and Mini Mission (Oilseeds & Oil palm); National Mission on Oilseeds and Oil Pam (NMOOP), launched in XII Plan, has become part of NFSM as NFSM (Oilseeds & Oil palm); National Mission on Sustainable Agriculture (NMSA) with *Paramparagat Krishi Vikas Yojana* (PKVY), Soil Health Card (SHC) & Soil Health Management (SHM) Schemes, Rainfed Area Development (RAD), and *Pradhan Mantri Krishi Sinchayee Yojana* (PMKSY); National Mission on Agricultural Extension & Technology (NMAET) with Sub-Mission on Agriculture Extension (SMAE), Sub-Mission on Seed and Planting Material (SMSP), Sub-Mission on Agricultural Mechanization (SMAM) and Sub-Mission on Plant Protection and Plant Quarantine (SMPP); Sub-Mission on Skill Development, Technology Transfer and Transfer Extension (SMSDTT&E), Green Revolution - *Krishonnati Yojana*, and Integrated Scheme on Agriculture Census, Economics and Statistics (ISACE&S); *Rashtriya Gokul Mission* (RGM); National Livestock Mission (NLM) Sub-Mission on Livestock Development, Sub-Mission on Pig Development in the North-Eastern Region, Sub-Mission on Feed and Fodder Development (SMFFD), Mission for Integrated Development of Horticulture (MIDH) with National Horticulture Mission (NHM), National Horticulture Board (NHB), Coconut Development Board (CDB), Central Institute of Horticulture (CIH), National Agroforestry & Bamboo Mission (NABM); National Rural Livelihood Mission (NRLM), Integrated Scheme for Agricultural Marketing (ISAM), Agricultural Marketing Infrastructure (AMI), National Agriculture Market (e-NAM), National e-Governance Plan in Agriculture (NeGP-A), *Pradhan Mantri Fasal Bima Yojana* (PMFBY), *Pradhan Mantri Kaushal Vikas Yojana* (PMKVY), Pradhan Mantri Employment Generation Program (PMEGP), *Swarna Jayanti Shahri Rozgar Yojana* (SJSRY), and North Eastern Council (NEC)

Central Sector Schemes

National Crop Insurance Scheme (NCIP), Integrated Scheme on Agriculture Cooperation (ISAC), Integrated Scheme on Agriculture Marketing (ISAM), Mission Organic Value Chain Development for North Eastern Region (MOVCDNER), Central Herd Registration Scheme (CHRS), Establishment of Agri-Clinics & Agri-Business Centres (ACABC), Integrated Scheme on Agriculture Census, Economics and Statistics (ISACE&S), Soil and Land Use Survey of India (SLUSI), Blue Revolution: Integrated Development and Management of Fisheries, Development of Inland Fisheries and Aquaculture (DIFA), Development of Marine Fisheries, Infrastructure and Post-Harvest Operations (DMFI & PHO), National Scheme on Welfare of Fishermen (NSWF); Integrated Scheme on Agriculture Census, Economics and Statistics (ISACE&S), and *Rashtriya Krishi Vikas Yojana* (RKVY) along with Bringing Green Revolution to Eastern India (BGREI), Reclamation of Problem Soils (RPS), Saffron Mission (SM), Peri-Urban Horticulture (PUH), Additional Fodder Development

Programme (AFDP), Remunerative Approaches for Agriculture and Allied sector Rejuvenation (RAFTAAR); National Seeds Corporation (NSC); Quality Mark Certification Scheme (QMCS); Central Sheep Breeding Farm Scheme, 19th Livestock Census Scheme (LCS), Integrated Sample Survey Scheme (ISSS), and Agricultural Technology Management Agency (ATMA).

New Programs & Initiatives

PM's Fasal Bima (Crop Insurance) *Yojana* to minimize risk in agriculture sector and along with Unified Package Insurance Scheme (UPIS), Restructured Weather Based Crop Insurance Scheme (RWBCIS), Coconut Palm Insurance Scheme (CPIS), and National Agricultural Insurance Scheme (NAIS); *Pradhan Mantri Krishi Sinchai* (Irrigation) *Yojana* for efficient access of irrigation and increased water efficiency and with Per Drop More Crop component (PDMC), Accelerated Irrigation Benefit Programme (AIBP) of the Ministry of Water Resources, River Development & Ganga Rejuvenation (MoWR,RD&GR), Integrated Watershed Management Programme (IWMP) of Department of Land Resources (DoLR), On Farm Water Management (OFWM) of DoA&FW; Soil Health Card Scheme (SHCS) to improve soil fertility on a sustainable basis; Soil Conservation, Micronutrient Management (SCMM), Seed Production (SP); *Paramparagat* (Indigenous) *Krishi Vikas Yojana* (PKVY) to support organic farming system; Organic Farming (OF);) Mechanization and Technology (M&T).

Agricultural Credit (AC) : Joint Liability Group Financing (JLGF); Production of Neem Coated Urea (NCU); Plant Protection (PP); Training and Extension for Farmers (TEF); Mobile Aps for Farmers (MAF); and Sustainable Farming (SF); National Programme for Bovine Breeding (NPBB), National Programme for Bovine Breeding and Dairy Development (NPBB & DD), National Project for Cattle and Buffalo Breeding (NPCBB), National Project on Rinderpest Surveillance and Monitoring, Animal Quarantine and Certification Service (NPRS & MAQCS), Foot & Mouth Disease Control Programme (FMD-CP).

Krishi Kalyan Abhiyan (KKA), Policy initiatives for increasing the flow of credit (PIIFC); National Cooperative Union of India (NCUI), Crisis Management Plan (CMP) for Drought (National), National Platform for Disaster Risk Reduction (NPDRR), National Institute of Agricultural Extension Management (MANAGE), National Bank for Agriculture and Rural Development (NABARD); *Kisan Call Centre* (KCC), Soil Health Card Scheme (SHCS), Soil Conservation, Micronutrient Management (SCMM), National e-Governance Plan– Agriculture (NeGP-A).

Agricultural Marketing –eNAM or National Agricultural Market linking farmers to market;, Agricultural Marketing with Integrated Scheme for Agricultural Marketing (ISAM), Agricultural Marketing Infrastructure (AMI) , Marketing Research and Information Network (MRIN), Strengthening of Agmark Grading Facilities (SAGF), Agribusiness Development through Venture Capital Assistance (VCA) and Project Development Facility; Small Farmers' Agribusiness Consortium (SFAC): Goods and Services Tax (GST) with Ministry of Commerce; Preferential Trade Agreements (PTAs)/Free Trade Agreements (FTAs), *Swachh Bharat Abhiyan* (SBA), Training and Extension for Farmers (T&EF), Mobile Aps for Farmers (MAF), Sustainable Farming (SF), Farmer Producers Organization (FPOs), Equity Grant Scheme and Credit Guarantee Fund Scheme for Farmer Producer Companies (CGFSFPC); *Kera Suraksha* Insurance Scheme (KSIS) for Coconut Tree Climbers (CTC), National Gender Resource Centre in Agriculture (NGRCA), Dairy Processing & Infrastructure Development Fund (DIDF), Women in Animal Husbandry, Dairying & Fisheries Sector (WAHD&FS); Central Poultry Development Organization (CPDO), Rural Backyard Poultry Development (RBPD); Intensive Dairy Development Programme (IDDP), Dairy Entrepreneurship Development Scheme (DEDS), National Programme for Dairy Development (NPDD), National Action Plan-Dairy Development (NAPDD), and Delhi Milk Scheme (DMS); Directorate of Aquatic Animal Health and Quarantine (DAAHQ).

Indian Ocean Tuna Commission (IOTC), Fish Farmers Development Agency (FEDA), *Mastyajibi Unnayan Yojana* (MUY), Rural Infrastructure Development Fund (RIDF) (20% state share : 80% NABARD), National Scheme for Welfare for Fishermen (NSWF) (State share: Central share), Development of Marine fisheries infrastructure & Post-harvest Operation (DMFI&PHO) (State share: Central share), Development of Inland Fisheries & Aquaculture (DIF&A) (State share: Central share).

National Boards

National Dairy Development Board (NDDB), National Fisheries Development Board (NFDB),

National Livestock Development Board (NLDB), National Horticulture Board (NHB), Coconut Development Board (CDB); National Oilseeds and Vegetable Oils Development (NOVOD) Board; Tea Board (TB); Coffee Board (CB).

Policies & Acts

National Agriculture Policy, India- 2000; National Policy for Farmers, India- 2007; Intellectual Property Rights Policy-2016; Policy and Process for Farmers' Producers Organizations-2013; The State Agricultural Produce Marketing Act-2003; State Agricultural Credit Corporation Act 1968; Agricultural Pest and Diseases Act 1969; Agricultural Tenancy Act 1964; The Insecticide Act-1968; Model Agriculture Land Leasing Act-2016; National Rehabilitation and Settlement Policy-2007; Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Settlement Act-2013.

National Oilseeds and Vegetable Oils Development (NOVOD) Board Act, 1983; The Insecticides Act, 1968; New Model APLM Act 2017; Fertilizer Control Order-1957; Essential Commodity Act-1957; New Urea Policy-2015; Nutrient Based Subsidy Policy-2010; Neem Coated Urea Policy-2015.

The Biological Diversity Act, 2002; The Protection of Plant Varieties and Farmers' Rights Act- 2001; Copyright Act-1957; Patent Act- 1970 (amended in 2005); Trademark Act-1999; The Designs Act, 2000; The Geographical Indication of Goods (registration & Protection) Act-1999; The Information Technology Act-2000.

Agriculture Schemes under Indian States

Andhra Pradesh : Seed Management, Intensified mechanization, Integrated vegetable programme, and Induction of milch animals

Arunachal Pradesh : Area expansion by land terracing for paddy, Development of way side market sheds for fruits and vegetables, Development of commercial fish farms through private fish farmers

Assam : Shallow Tube Wells with electrically operated pump sets - increase in irrigated area and crop production in areas where SWT have been installed, Establishment of Organic agriculture produce market, and Agri mechanization through increased use of power tillers

Bihar : Farm mechanization especially Power tillers, Seed production and distribution programme, and Dairy activities undertaken under RKVY

Chhattisgarh : Establishment of model villages '*Adarsh Gram*', and Performance linked incentives to AI workers

Goa : Establishing modern rice mill processing facilities, and Incentivizing paddy cultivation through SHGs

Gujarat : Water & Soil Conservation Project including reclamation of degraded Bhal areas and checking of salinity ingress in coastal areas and farm ponds; Export oriented clustering and infrastructure in PPP mode for banana; Large animal surgery at Anand; and Soil testing lab. operated in PPP mode

Haryana : Providing assistance on laying underground pipeline system for water conveyance so that water losses can be avoided and additional land brought under cultivation from the irrigation channels; 100% treatment of certified wheat seed , and Cattle health management to optimise fertility

Himachal Pradesh : Construction of low cost green houses/ poly houses, Organic cultivation Micro/ minor irrigation and water harvesting

Jammu & Kashmir : Construction of low cost green houses/ poly houses, Organic cultivation Micro/ minor irrigation and water harvesting

Jharkhand : Micro Lift Irrigation and Vermi-composting

Karnataka : Karnataka Seed Mission project, Automated weather monitoring system, Rainfed agriculture – *Bhoo-chetana*, and E-tendering project

Kerala : Paddy cultivation in fallow lands by leasing land to Padasekaram Samities; Farm mechanisation for paddy harvesting, includes custom hiring of farm machinery by KAICO and giving agricultural machinery to district Panchayats and *Padasekarams* for collective use.; Development of fishery seed farms, seed production and group mobilization

Madhya Pradesh : Micro irrigation schemes - Percolation tanks, minor irrigation tanks; Seed replacement Development and promotion of hybrid rice varieties, and *Kisan* Call Centers

Maharashtra : Construction of farm ponds Creation of low cost onion storage structures; Surveillance

and Monitoring of Pest and Disease on soybean and cotton , and AI delivery system

Meghalaya : Water conservation structures mini irrigation check dams, Horticulture hubs, and Fisheries

Odisha : Development of 100 new watersheds, Acidic soil treatment, and Renovation of horticulture farms

Punjab : Animal insurance, and Conservation of irrigation water

Rajasthan : PPP for innovation in olive, date palm and jojoba; Operation golden rays; PPP for livelihood of 7.5 lakh families through hybrid maize; Diggi Programme

Sikkim : Hi-tech green houses, and Integrated farming system for sustainable agriculture

Tamil Nadu : Precision Farming sugarcane, banana; Automated weather stations in 224 Blocks Promoting SRI through conduct of demonstrations in 40,000 ha; and Use of Paddy transplanters in outsourced mode

Tripura : SRI Pineapple cultivation; and Development of demonstration unit on piggery

Uttar Pradesh : Production of high value vegetable crops through nursery production in low tunnel; Polyhouses; Land Reclamation of Katri Area Adoption & certification of Organic Agriculture; Management System Saghan; and Mini Dairy Yojana

Uttarakhand : Strengthening organic vision

West Bengal : Prani Bandhu Scheme, Hybrid paddy seed production involving NGOs, and Implement hub at block level