Kirit Shelat
Odemari Mbuya
Arvind Pathak
Suresh Acharya *Editors*

ATMANIRBHAR- Self Reliant and Climate Smart Farmers

Roadmap for Agriculture: 2020-2030-India

Published by
Bhagwati Graphics
Ahmedabad

Dr. Kirit Shelat
Dr. Arvind Pathak
Dr. Odemari Mbuya
Dr. Suresh Acharya
Editors

ATMANIRBHAR-Self Reliant and Climate Smart Farmers

Roadmap for Agriculture: 2020-30 India

Published by:
Bhagwati Graphics
City Mill Compound, Kankaria Road,
Ahmedabad – 380 022
Phone : 079-25464992

ATMANIRBHAR-Self Reliant and Climate Smart Farmers

Roadmap for Agriculture: 2020-30 India

Editors

Dr. Kirit Shelat, I.A.S. (Rtd.)
National Council for Climate Change Sustainable Development and Public Leadership (NCCSD), Ahmedabad

Dr. O. S. Mbuya,
Professor and Director
Florida Agricultural and Mechanical University (FAMU) - USA

Dr. Arvind Pathak
Former Vice Chancellor – Junagadh Agricultural University, Junagadh

Dr. Suresh Acharya
CC Shroff Research Institute, Mandvi, Kutch (Gujarat)

First Edition : 25th October, 2020

Editors would be happy to receive comments and sharing of experiences from readers

Email: drkiritshelat@gmail.com

Rs. 325/-

Published and Printed by:
Bhagwati Graphics
City Mill Compound, Kankaria Road,
Ahmedabad – 380 022
Phone : 079-25464992

Acknowledgements:

Our thanks are due to many persons who have made this book possible.

- Hon'ble Prime Minister Shri Narendra Modi - who initiated *"Atmanirbhar Bharat"*.
- The contributors - the eminent scholars who had shared their visions. Some of the Papers are Presentation made in our Think Tank meets.
- Dr. P.K. Mishra, Principal Secretary to Hon'ble Prime Minister - who found time in his extremely busy schedule to write 'Foreword' of book.
- President of NCCSD, Justice B.P. Singh - formerly Judge - Supreme Court of India.
- NCCSD team led by CEO - Ms. Nisha Shah, assisted by Mohandas Kallingal, Dhwani Pandya and Nilesh Raval.
- Shri Shreyasbhai Pandya and Sahitya Mudranalaya Team - led by Shri Dineshbhai Patel.

We are grateful to *Param Adarniy* Mahant Swami Maharaj whose blessings encouraged us for this venture.

डॉ. पी. के. मिश्र
प्रधान मंत्री के प्रधान सचिव
Dr. P. K. Mishra
Principal Secretary to Prime Minister

सत्यमेव जयते

प्रधान मंत्री कार्यालय
साउथ ब्लॉक, दिल्ली-110 011
Prime Minister's Office
South Block, New Delhi-110 011

FOREWORD

Farmers of India have transformed India from a country of food shortages at the time of India's independence to a food surplus nation at present. Given the fragility and risks in agriculture, the Indian farmer has actually done very well. However, much more needs to be done to improve the prosperity, opportunities and well-being of those in rural areas.

Hon'ble Prime Minister's call for a self-reliant India has a clear vision of a rural and agricultural sector where reforms in regulation and investments in infrastructure for value-chain enable farmers to lead better lives. It is a vision to improve India's export imprint through organic products that have value world-wide. It is about freeing the markets and setting the farmer free to achieve the fullest potential of growth, development and incomes. It is about diversification of rural economy to transform lives and livelihoods.

This volume on "*ATMANIRBHAR*-Self Reliant and Climate Smart Farmers Roadmap for Agriculture: 2020-30 India" is important as it covers a wide range of challenges and opportunities in Indian agriculture. From evidence-based studies on various aspects of agriculture, to new pathways of development through climate resilient form of agriculture; from diversification of livelihoods and rural enterprises for higher incomes, to mitigating the risks to farmers and improving the access to credit; from diversification and intensification of agriculture to post-harvest technologies for higher returns; all are covered in a series of articles.

It also looks at social challenges like women in the farm sector, optimal water use through new technologies, promotion of natural farming, and application of technology in enhancing crop productivity. Through a series of essays, this volume lays out a roadmap for the Indian agricultural sector. The volume is also very timely, as sincere efforts are being made to create new economic opportunities in rural areas through higher incomes from farm and non-farm livelihoods. The volume offers an opportunity to explore sustainable

lives and livelihoods through a more focused approach to addressing the challenges of Indian agriculture through opportunities that reforms, investments and value chains offer.

I congratulate NCCSD to bring out this volume. NCCSD is doing very good work in conducting interaction meets on issues related to developing agriculture - with full involvement of farmers and other stakeholders and sharing outcome. I also congratulate Editors - Dr. Kirit Shelat, Prof. Odemari Mbuya from FAMU - USA, Dr. A.R. Pathak and Dr. Suresh Acharya.

October 2020 **[P.K. Mishra]**

Contents

About the Editors

Dr. Kirit Shelat

Dr. Kirit Shelat is Doctorate in Philosophy with Public Administration – is a public administrator. He has been awarded degree of D.Litt. – Doctorate of Science by Junagadh Agricultural University – India for his outstanding contribution in promoting Climate Smart Agriculture and Building Climate Smart Farmers. He had long spell of his carrier in Indian Administrative Service. He has hand into introduction in "New Extension Management – *Krishi Mahotsav*" approach in Gujarat as Principal Secretary – Agriculture – which doubled the income of farmers. He has designed and implemented large-scale projects for poor families, farmers and micro entrepreneurs and remote rural areas. He has authored more than 20 books related to agricultural and rural development and related to impact of climate change and ways to meet that challenge at local level – village level. He is Executive Chairman of National Council for Climate Change, Sustainable Development and Public Leadership (NCCSD).

Dr. Arvind Pathak

Dr. A. R. Pathak is Former Vice Chancellor – Junagadh Agricultural University, Junagadh & Navsari Agricultural University, Navsari. He is Ph.D in plant breeding & Genetics with distinction in MSc (Agriculture). As a Plant Breeder in various capacities developed 25 improved varieties in different crops viz; cotton, pulses, clusterbean, mustard, castor & rice. Besides also contributed in recommendation of 14 production technologies on castor, mustard & rice. Since 1971 worked in various capacities, plant breeder, crop specialist (Castor-mustard & rice), Director of Research & Dean PG – Anand Agricultural University, Anand and Vice Chancellor - Navsari Agricultural University, Navsari (2010-2014), Junagadh Agricultural University, Junagadh (2014-2019). More than 500 technologies including 60 varieties were developed under his guidance. He established five colleges of Agricultural & allied, polytechnics at Navsari Agricultural University, Navsari and Agriculture College & polytechnic at Junagadh Agricultural University, Junagadh. He received eight awards in the field of agriculture including Sardar Patel Research Award by GOG, e-krishi kiran by Govt. of India, The Gujarat Association for Agricultural Sciences (GAAS), Gujarat State Fertilizers and Chemicals (GSFC) etc. Conferred honorary "Colonel" NCC by Govt. of India. Acted as Member of Governing Body and Accreditation committee of The Indian Council of Agricultural Research (ICAR). Members in various committees of Universities including selection committee of universities and Agricultural Scientists Recruitment Board (ASRB), The National Bureau of Plant Genetic Resources (NBPGR) etc .Board of Director – Agricultural Research and Development Foundation (ASPEE) foundation. Vice President & President of Indian Agricultural Universities Association (IAUA), New Delhi. Guided PG students for Msc & PhD. Published more than 50 research articles and 6 books chapters. Visited Phillipines, Swedan USA, Bangkok for training and paper presentation.

Dr. Odemari Mbuya

Dr. Odemari Mbuya is a professor of Agricultural Sciences at Florida Agricultural and Mechanical University (FAMU) and a Courtesy Professor of Agronomy at the Institute of Food and Agricultural Sciences, University of Florida. Dr. Mbuya holds a B.Sc. degree in Crop Science from Sokoine University of Agriculture (Tanzania)and M.Sc. and Ph.D. degrees from the University of Florida (USA). Dr. Mbuya has worked in Tanzania as an Agricultural Research Scientist at CIAT (Centro International Agriculture Tropical) in Colombia as a visiting researcher, and as a consultant representing the United States Department of Agriculture in South Africa and India. In his tenure at FAMU, Dr. Mbuya has served in numerous national and international committees representing water resources, climate change, agricultural production and biofuels. He is currently the Director of the Center of Water Resources, Director of the Florida Climate Institute at FAMU (a consortium of 10 public universities in Florida, USA), and Program Leader of Agronomy, Soil and Water Sciences. Dr. Mbuya leads the faculty effort in integrating all concepts of sustainability in innovative research, teaching and outreach at FAMU and beyond. Among his many, Dr. Mbuya teaches several graduate and undergraduate courses, including Statistical Research Methods/Biostatistics, Plant and Soil Sciences. His research interests focus on phytoremediation, water resources, watershed processes and computer simulation modeling.

Dr. Suresh Acharya

Dr. Suresh Acharya is an expert in Crop Improvement and multi-disciplinary Research Management. After serving in five different SAUs of the country, he hung his boots in 2017 as Director of Research, SDAU, SK Nagar, Gujarat. At present he is working as Advisor & Member, Governing Council, CC Shroff Research Institute, Mandvi, Kachchh, Gujarat.

He has bred 19 versatile varieties (wheat, cotton and pulses), 81 R lines and 110 A lines in pigeonpea. He guided 12 Msc and 09 PhD students. He handled 15 diversified projects as Principle Investigator; and organized 16 National Level Workshops / Training Courses / Seminars as Organizing Secretary / Nodal Officer / Course Coordinator. He has been a member of 17 important committees that also included Extant Varietal Identification Committee, PPV&FRA, New Delhi. He was in the editorial panel of different National Journals and was Editor-in-Chief of GAU J Research.

Consequent upon his expertise, he was conferred ICAR Team Award (1994-96); Sardar Patel Award (2000); Cotton Growers' Award (2002); Hari Om Ashram Award (2006); Bharat Jyoti Award (2006); Best Pigeonpea Team National Award (2008); Best Coordinated Project Arid Legume Team (2009).

How to Make Substantial Progress towards Realizing Potential of India's Agriculture Sector in the Next Decade

• **Prof. Mukul G. Asher** •

Under India's constitution, agriculture is a state subject, and therefore even when the Union government takes initiatives, cooperation of the states is critical.

Initiatives by the Union and State governments, private sector, not-for-profit sector, and individual citizens are poised to usher in wide ranging transformation of India's agricultural sector in the next decade. The focus of agricultural policies has shifted from mitigating hunger to mitigating malnutrition, while enhancing profitability and incomes of those engaged in agriculture and related activities; and to making India a major agriculture power globally.

Overarching premises behind these initiatives are expanding economic freedom of the farmers and others involved in the agriculture sector; introducing new technologies in all aspects of agriculture activities, including technology of the Third Industrial Revolution, based on Internet of Things.

Traditional knowledge of India about crop diversity and nutrition; and accelerating hitherto neglected public investments in necessary infrastructure to make India a major agriculture power globally.

The Indian government launched the *Bharatiya Poshan Krishi Kosh* (BPKK) in November 2019. This project has two components – Development of a Food Atlas and Documentation of promising practices for *Jan-Andolan* for POSHAN *Abhiyaan*.

The Agro-Food Atlas is to act as a repository of diverse crops across 127 agro-climatic zones of the country having three parts- crops currently being grown, agro-ecological conditions (soil, organic carbon content, ground water availability, etc) and guidance on how a greater diversity of crops could be encouraged in a particular district or block to promote dietary diversity and nutrition.

The project includes diverse data sources like National Sample Survey, Agri-Census, Soil Health Cards, ISRO's Advanced Wide Field Sensor (AWiFS) and National Aeronautics and Space Administration's (NASA's) Moderate Resolution Imaging Spectro-Radio Meter. The project also documents social, behavioural and cultural practices that promote and reinforce healthy dietary behaviour.

Identification of promising practices with the help of a multi-disciplinary group of experts and developments of a tool kit to disseminate best strategies for Social and Behavioural Change Communication, specific to population groups in those regions is also a part of it.

The government has invited sharing of recipes of the family's favourite traditional dishes on innovate.mygov.in/poshanrecipe.

This will educate the people of the rich dietary tradition and variety of nutritious dishes available, and preserve local customs.

These three areas form an integrated strategy to expand India's agricultural share in global markets and to improve incomes of farmers and other stakeholders.

Agriculture sector covers a wide range, crops, fruits and vegetables, flowers, sericulture, honey, medicinal herbs and plants, livestock and poultry, fisheries, seaweeds and others. The policy initiatives suggest that this aspect has been incorporated.

Expanding Economic Freedom of Farmers

Several initiatives have been aimed at this goal. Three major initiatives to enhance economic freedom of the farmers were announced by the Finance minister on May 15, 2020, in the midst of the COVID-19 Pandemic.

The first reform concerns the Amendment of the Essential Commodities Act (ECA), a relic of the 1950s decade of Socialist shortages. As a result, the market for most food stuff is now deregulated. This means farmers and traders will be free to enter into export commitments without the fear that the government may turn the tap on or off based on domestic prices or production.

Stock limits will not apply to food processors or value chain players, thus ending the often convenient, but very weak argument that any price increase is the result of 'hoarding' by anti-social elements. This would restrict the government interventions in the agricultural market to exceptional circumstances.

It will facilitate farmers from having to sell at distress prices even when domestic prices are high. It will also make India a reliable supplier in the global agricultural markets.

The second initiative is to eliminate the barriers to inter-state agricultural trade with enabling central law. This will enable farmers to sell their produce in any favourable agricultural market and not just at the local state *mandi*. Currently, Agriculture Produce Marketing Committee (APMC) laws force farmers to sell only to government-licensed agents at these *mandis*, thus denying

them fair prices. As e-trading is allowed (discussed under technological initiatives) and deliveries can be made outside one's own state, farmers can sell at an acceptable price and deliver wherever it is advantageous to them.

There are indications that APMCs are losing market share. It is reported that during the June 6 and August 31 2020 period, after the three agriculture reforms were introduced, *mandi* arrivals fell markedly. The fall for fruits was 49 percent, vegetables 57 percent, and grains 45 percent .https://epaper.financialexpress.com/2812690/Delhi/September-7-2020#page/1/1 Accessed on 7 September 2020. Such a competition could spur reforms by the APMC and improve overall logistics efficiency.

The same article reports that in states such as Uttar Pradesh and Maharashtra, Farmer Producer Organizations and Companies, and small traders and aggregators are bypassing APMCs to sell directly. Some have closed their shops in the *Mandis*. Food processing companies are buying directly to a much larger extent than before. These developments should help farmer realize better incomes as APMCs monopoly has been broken.

The third initiative is that the government is also planning to create a legal framework where farmers can work out supply deals with retailers, food aggregators, exporters, and other processors so that contract farming gives both producers and buyers an acceptable price. This could permit both producers of food and consumers to benefit.

Many states have used these initiatives to introduce state-specific refinements. Thus, the B S Yeddyurappa- led Karnataka government has implemented an amendment to the Land Reforms Act, 1961. It is called Karnataka Land Reforms (Amendment) Bill, 2020.This has subsequently been converted into a law. As a result of this law, any Indian, or a trust, society, company or an educational institution can buy farmland in Karnataka regardless of the buyer's annual income from non-agricultural sources. It is estimated that as a result of the change in law, in Karnataka, a potentially three-year long process can now be completed in just 30 days.

The Gujarat state government brought in an ordinance that farmers can now sell farm produce anywhere. People can sell in APMC or private market outside the district. Merchants can also buy from outside farm. Gujarat Land Grabbing Prohibition Act", introduced on 26 August 2020 to curb land grabbing activity in the state is also expected to help the agriculture sector.

The Madhya Pradesh state government has promulgated an ordinance called the Madhya Pradesh Krishi Upaj Mandi (amendment) Act, 2020, which will facilitate direct procurement of agriculture produce from farmers' doorstep

by food processing companies, exporters, and wholesalers without having to bring them to the *mandis* to sell.

Rajasthan, Himachal Pradesh, Tamil Nadu, and Uttarakhand have also permitted direct marketing by traders, processors and FPOs, and has declared Primary Agriculture Cooperative Societies (PACS) as deemed markets.

As of 30 June 2020, at least 16 States have issued circulars to implement the Centre's three Ordinances on agricultural reforms.

There are indications that some states are shifting from highly water-intensive crops to less water intensive crops. Thus, some Punjab and Haryana are shifting from paddy to cotton. The recognition of such a shift should be more widespread among policymakers and farmers. Sugarcane is another highly water intensive crop which relatively water stressed states such as Maharashtra and Karnataka need to move away from.

The Union budget or 2020-21 has attempted to address some of the critical constraints facing agriculture. One of the most challenging issues in farm cultivation is managing water stress. As a result of climate change and erratic weather patterns over the last few monsoons India has experienced conditions where there is a drought like situation in the early part of the monsoon year, followed by delayed and then excessive rains often resulting in flooding.

In both conditions, the farmer loses his crop on account of water stress and more often than not, field of original crop has to be uprooted and replanted with a shorter duration crop in order to salvage the cropping season.

Under these circumstances, addressing water stress issues and providing comprehensive measures will have a significant positive impact on the agricultural productivity of the country. Impact of these measures would unfold over a medium term.

The 2020 Budget proposes to introduce comprehensive measures for 100 districts. India has a total of 733 districts (not all facing water stress) and these measures cover a significant portion of the cultivable area.

Technological Application to Agriculture

Among the important technological initiatives designed to widen the reach of the farmers are the National Agricultural Market (e-NAM), set up in 2016; and Karnataka-backed UMP (backed by Rashtriya e-Market Services), launched in 2014. UMP is restricted to farmers in Karnataka. UMP is likely to record a turnover of around INR 510 Billion in 2019.

Currently, UMP connects to over 200 markets in Karnataka. The platform has institutional buyers like Cargill, ITC, Reliance, Metro Cash & Carry and

Godrej Agro among others. In addition to this, traders from neighbouring states like Andhra Pradesh, Tamil Nadu, Maharashtra and Kerala are also allowed to participate and place orders for commodities on the platform.

e-NAM is managed by Small Farmer's Agribusiness Consortium (SFAC) with the help of technology provider Nagarjuna Fertilisers and Chemicals Limited (NFCL), under iKisan initiative. Karnataka platform UTM, on the other hand, is a joint venture of Government of Karnataka and National Commodity & Derivatives Exchange Limited (NCDEX). NCDEX is one of India's largest agriculture commodity exchange marketplace.

The existence of two e-market platforms permit competition and encourages experimentation, a transformative development for the agriculture sector.

In 2016, e-NAM agriculture trading platform started with 21 mandis in India. Already INR 1000 Billion worth of trade has been transacted through e-NAM. In May 2020, integration of 177 new mandis withe-NAM was launched to strengthen agriculture marketing and facilitate farmers to sell their harvested produce through the online portal. The total number of e-NAM mandis across the country in mid-2020 is. There are estimated 175 commodities which can be sold through e-NAM.

As of 9 May 2020, 17 million farmers, 0.13 million traders, 0.7 million Commission Agents, and 1005 Farmer Producer Organizations (FPO) have used e-NAM.

The e-NAM portal provides a single window service for all APMC related information and services which includes commodity arrivals, quality & prices, provision to respond to trade offers and electronic payment settlement directly into farmers' accounts.

Agricultural Marketing Information System (Agmarknet), which provides data of prices of various agricultural produce in all physical markets in the country, has been integrated with the e-NAM from 1 July,2020.https://swarajyamag.com/economy/16-states-give-go-ahead-to-centres-agriculture-reforms-apmcs-to-co-exist-with-new-farm-produce-trading-platforms Accessed on September 6, 2020.

The Same article reports that the Centre hopes at least 10,000 FPOs become operationalized. These FPOs can become aggregators of agricultural products and in turn will help farmers become businessmen. The Centre will also change the regulations for Warehousing Development and Regulatory Authority (WDRA) to allow village level storages to be established. Such a step will also bring in much needed private investment in storage systems.

Options trade begins for wheat, maize, mustard which allows farmers to set their own price for crops. This creates new trading platforms while enhancing economic freedom.

Individual farmers are reviving traditional techniques, while some are applying newer technologies to help improve productivity and profitability, and diversify crop production.

The rise in the use of digital technologies and Artificial Intelligence (AI) in several industries, necessitated by the pandemic has potential to be a game-changer. The move has accelerated the adoption of disruptive business models and innovative solutions, thus rendering traditional business models and manufacturing processes obsolete sooner than expected. Therefore, in the post-Covid world, India needs to create its own niches, including in agriculture, in the global market.

India has exhibited impressive improvement in its ranking in Global Innovation Index (GII). Its global ranking improved from 81 in 2015 to 48 in 2020 (https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2020.pdf accessed on 2 September 2020)

India also has the third largest start-up ecosystem in the world. Increasingly these would be used to make Indian agriculture more technology intensive. The entry of new technology-savvy farmers in Indian agriculture is expected to facilitate this.

A report by Omnivore, entitled, The future of Indian Agriculture and Food Systems: vision 2030, argues that

There will be eight trends that will disrupt the *status quo* of the Indian agricultural system by 2030, while meeting the objectives of climate-smart agriculture

1. Precision agriculture and automation will be the norm, even among smallholders, across the sowing to harvesting value chain.
2. Quantum leap in biotechnologies will produce plants that are more nutritious and resilient, and regulate farm health more efficiently.
3. Fragmented landholdings and asset ownership will go through widespread consolidation, real and virtual, to achieve economies of scale for smallholders.
4. Farmers will improve their relationship with global and local consumers, offer enhanced safety and quality, and improve income.
5. Agricultural labour will contract and move towards higher productivity jobs, higher up in the value chain; agricultural training will respond to cater to a younger farmer.

6. Production of high-value output such as leafy greens and cruciferous will become more specialized and protected, and have its own dedicated logistics chain.
7. Rising animal protein and dairy consumption will push technology adoption across the animal and fisheries value-chain, increasing diversity of diets, driving up efficiency and lowering costs in a safe and conscious manner.
8. Food science will pursue consumer-centricity, yielding affordable processed products that address malnourishment, lifestyle diseases and ecological concerns.

https://www.omnivore.vc/wp-content/uploads/2020/09/Vision-2030-report.pdf Accessed on 3 September 2020

Infrastructure Investment Initiatives

In addition to the ongoing infrastructure investment plans, including planned investment of INR 110 trillion (USD 1.5 trillion) between 2020 and 2025, https://dea.gov.in/sites/default/files/Report%20of%20the%20Task%20Force%20National%20Infrastructure%20Pipeline%20%28NIP%29%20-%20volume-i_1.pdf Accessed on 5 September 2020.

On 9 August 2020 Prime Minister Shri Narendra Modi launched a new Central Sector Scheme of financing facility under the Agriculture Infrastructure Fund (AIF) of INR 1 trillion.

The AIF is designed to support farmers, PACS, FPOs, Agri-entrepreneurs, and others in building community farming assets and post-harvest agriculture infrastructure. These assets will enable farmers to get greater value for their produce as they will be able to store and sell at higher prices, reduce wastage, and increase processing and value addition.

The AIF is a medium - long term debt financing facility for investment in viable projects for post-harvest management infrastructure and community farming assets through interest subvention and credit guarantee. The duration of the scheme shall be from FY2020 to FY2029 (10 years). Under the scheme, INR 1 trillion Crore will be provided by banks and financial institutions as loans, with interest subvention of 3% per annum and credit guarantee coverage under Credit Guarantee Fund Trust for Micro and Small Enterprises (CGTMSE) scheme for loans up to INR 20 million. CGTMSE has introduced a new "Hybrid Security" product allowing guarantee cover for the portion of credit facility not covered by collateral security.

The eligible borrowers include farmers, PACS, Marketing Cooperative Societies, FPOs, SHGs, Joint Liability Groups (JLG), Multipurpose Cooperative

Societies, Agri-entrepreneurs, Start-ups, and Central/State agency or Local Body sponsored Public-Private Partnership Projects.

India's processing of agricultural products is low. Thus, processing of Fruit and Vegetables is 2 percent, Poultry 6 percent, marine products 8 percent, and milk products 35 percent. The AIF and related measures could help increase these ratios.

In July 2020, the High-Level Group (HLEG) on Agricultural Exports set up by the Fifteenth Finance Commission to recommend measurable performance incentives for States to encourage agricultural exports and to promote crops to enable high import substitution, recommended that India should:

- Focus on 22 crop value chains – demand driven approach.
- Solve Value Chain Clusters (VCC) holistically with focus on value addition.
- Create State led export plan with participation from stakeholders.
- Private Sector should play an anchor role.
- Centre should be an enabler.
- Robust institutional mechanism to fund and support implementation.

The High-Level Group (HLEG) argues that,

- India's agricultural export has the potential to grow from USD 40 billion to USD 70 billion in a few years. India's agricultural exports to GDP ratio is 2 percent as compared to 4 percent for Brazil.
- The estimated investment in agricultural export could be in the tune to USD 8-10 billion across inputs, infrastructure, processing and demand enablers.
- Additional exports are likely to create an estimated 7-10 million jobs.
- It will lead to higher farm productivity and farmer income.

https://pib.gov.in/PressReleseDetailm.aspx?PRID=1642591#.XyQERQ4oTh9.whatsapp accessed on 30 August 2020

The Blue Economy Program: The term Blue Economy refers to utilization of a country's coast-line, inland waterways, and sea connectivity globally for more sustainable and broad-based economic development. This area to create new growth nodes, and expand exports and save on logistics costs, has been traditionally underemphasized in India.

A key component of the Blue Economy program in India is the Sagarmala program, initiated in July 201. It aims to use port-led development as an additional growth-node and as an avenue to expand exports.

There are 12 major ports and around 200 notified non-major ports in India. The navigable waterways are 14500 KM, with a coastline of 7500 KM, involving 13 (out of 36) States and Union Territories.

It aims to change India's modal mix, increasing the share of coastal and inland waterways in India's total cargo from 6 percent in 2015 to 12 percent by 2025. Under the Sagarmala program, 577 projects, with an estimated project cost of INR 8700 Billion (USD 126 billion) have been identified for implementation between 2015 and 2035 continuing (http://sagarmala.gov.in/sagarmala-overview) Accessed on 1 September 2020.

In NITI Aayog's 2020 Export preparedness index, among the top five states, four were coastal states. This underlines the importance of the Blue Economy program.

Concluding Remarks

India's agriculture sector and related activities are set to transform the sector with in this decade ending in 2030, through a set of well-integrated, coherent, technology based, and investment supported initiatives. As agriculture is under the states in the constitution, their role and support are vital.

With greater economic freedom available to the farmers, the sector is attracting a new group of educated, tech-savvy, and flexible entrepreneurs who aim to be profitable, and use modern tools of management to run their businesses. Their number is small at present, but it is expected to grow and begin to make significant difference.

•

Indian Agriculture Scenario

• Dr. Suresh Acharya •

- Agriculture is an incredible success story of alleviating poverty from 90% to 15%. It constitutes 48.9% of India's total workforce against about 75% at the time of independence. The share of agriculture to national income has declined from 55% to 17% of GVA during FY 50-51 and FY 18-19. About 70% of India's rural households depends on agricultural sector for their livelihoods. Therefore, any slump in consumers demand among agrarian community causes an enormous upheaval in economic growth. The agricultural GDP has grown at 2.7% per annum during FY 14-19.
- Agriculture ensures food and nutritional security. It has also given fillip to innumerable agro-based industries like seed, fertilizers, agro-chemicals, tractor/combine/field implements, food processing, agro-marketing, transport, storage including radiation and ozonation to name a few. They have progressed incredibly well but the farmer in the rat race of producing more from his limited resources, the farmer has trapped himself in the grievous economic distress than ever. Natural resource base, which is pivotal for sustainable production is the biggest causality and has been shrinking/degrading over time. It has adversely affected production capacity and ecosystem culminating in overall hardships in agriculture.
- Climate change, new innovations, consumers' food preferences, stress in natural resource base, migration of labour etc are the main current drivers of agriculture. The innumerable challenges like enormous income disparity, inflated conflicts and social unrest, etc need no underscoring. As such, it is afflicted with massive risks and uncertainties all along production and processing chain.
- Lately COVID-19 pandemic has added weird concern to the state of agriculture and food security. It has stalemated the farmer for both working in farm and gaining access to market due to lockdown. The farmer has the market surplus due to good production. However, it has disrupted procurement, collection of harvest from the farm due to shortage of labour and logistics. The market would overwhelm when it opens realising lesser price due to demand-supply conundrum. The biggest predicament right now is how the availability, accessibility and affordability of safe and healthy food is supported under the circumstances; particularly to the 15% vulnerable group.

- Both agriculture and its marketing are seasonal and labour intensive. Most of the time the labour is exported from states like Bihar and UP. The scare of infection and lockdown among the labour is immense. This has impacted agriculture and allied sectors. Fruits and vegetables are the most affected due to pile up of both harvested and unharvested perishables. Processing has also hit the roadblock. The small-scale farmers are at the receiving end of the economic loss. This could cause a domino impact and can further endanger the availability, accessibility and affordability of food grains and nutrition to the vulnerable group.
- Climate change is the major game spoiler in agriculture. COVID-19 pandemic has caused greater damage. However, still we are ignoring similar imminent pandemic like locust that could be a death knell for agriculture in the age of COVID-19. This is because the farmer in lockdown means leaving the locust unchallenged in obliterating the crops. The worst part is that each generation of locust is 20 times bigger than the previous one. If one does not control it early, it is arduous to manage it later. This is because it breeds like crazy (1000 eggs/sq m) and can travel over 150 km a day. One square kilometre swarm comprises about 40m locusts that can devour in a day as much food as 35,000 people assuming individual consumption of 2.3 kg food per day.
- New calamities like COVID-19 are likely to become new normal in agriculture. The virus cannot be wished away in a jiffy. It must be adapted with change in lifestyle with requisite precautions. The supply of farm inputs has been disrupted. The agrochemicals unit have been allowed to operate with limited staff under strict vigilance. This could lead to shortage of inputs as the units under the circumstances could run at the most 25% of their capacity. The inflation, rising unemployment, loss/cancellation of land leases in distress, costlier inputs due to demand-supply conundrum etc could further jeopardize the production, security and safety of food.

State of Resources

- India cultivates around 51% of its national geographical area as compared to 11% of the world average. It feeds 17% of the world's population with just 2.4% and 4% of the world's land and water resources, respectively. It has more than enough food reserves. The total stocks of wheat and rice with the FCI was 77.5 m tons during March 2020 as against the buffer norms of 21.04 m tons. Similarly pulses stock was 2.25 m tons.
- The net sown area has remained constant around 140 m ha since FY 70-71. Average size of the land holding has reduced to 1.08 ha from 2.28 ha

in FY 70-71. Small and marginal farmers are 86%. However, their share in operational area is just 44%. Average size of the land holding of marginal and small farmers is 0.38ha and 1.41 ha, respectively.

- The number of cultivators has doubled from 71.0 m in FY 50-51 to 145.7 m in FY 15-16. The number of marginal farmers (< 1 ha) increased by 2.76 times during FY 70-71 (36.2 m) and FY 15-16 (99.9m). However, the number of larger farmers (>10ha) reduced by 71.5%. This indicated huge fragmentation of land holdings. Further, the agricultural labour also increased from 47.5 m to 144.3 m during FY 70-71 and FY 10-11. The absolute number of people working in farming has increased from 118.5 m to 282.65 m during FY 70-71 and FY 10-11. Increase in numbers of cultivators and agricultural labour vis-a-vis no increase in GCA is the major reason for neutralizing the incredible gains of agricultural growth.
- Agriculture in India is predominantly rainfed. The rains are highly erratic in both space and quantum. India has the largest irrigation area in the world; 48% and 34.5% of the total agricultural land and total cropped area, respectively. The share of canal and ground water irrigation is 24 and 76%, respectively. 84% of the total groundwater extracted is used in agriculture. The water harvesting, conservation and utilization measure are not commensurate. The national dams and water structures have become old and inefficient. The present cropping intensity is 136%. It has registered an increase of 25% since independence.
- Water Use Efficiency (WUE) is 38% compared to 70-80% of USA, Brazil and China. The area under drip irrigation has risen to 6.28 m ha in FY 18-19. This comprises 9.2% of the total irrigated area (68.38 m ha). Lot of development in drip irrigation has happened during the last five years with Karnataka taking the lead (0.82 m ha) followed by Andhra Pradesh (0.72 m ha), Gujarat (0.70 m ha) and Tamil Nadu (0.56 m ha). The area under rabi crops is 38.8%. However, their contribution to production is 51.0% given greater access to irrigation.
- Innovation-based technologies, institutions, information and infrastructures are the major determinants of agricultural growth. Farmers are a mixed lot. Some are very rich, some are poor; some are technologies savvy, while others are laggard. However, the common feature is that they are hardworking. They have adopted high value agriculture like horticulture, vegetable, animal husbandry, etc. The predominant products of these sectors are perishable.
- There is a good back-up of agro-based industry. Role of infrastructures like

roads, irrigation facilities, marketing, etc cannot be overemphasized. The commensurate investments in refrigerated transportation, storage capacity and other logistics are poor. The public investment between FY12 and FY 17 has remained static around 0.3 to 0.4% of the GDP, while private investment fell from 2.7% to 1.8%, constraining the overall investment in agriculture from 3.1% to 2.2% of the GDP. It becomes still obvious from minus (-) 14% Producer Support Estimate (PSE), which is an indicator of the annual monetary value of gross transfer from consumers and taxpayers to agricultural producers measured at the farmgate level arising from policy measures during FY 00-16.

- There are technologies but only a few of them are reaching the farmer. At the same time new innovation-based technologies are required for breaking the yield plateau and increasing shelf life. The extension services and credit distribution are not up to the mark at grass root level. There are no customised farmers-centric decision support services to help the farmer on negotiating the impact of climate on agriculture and customized AgroMet Advisories at block level. At present there are many agencies that provide different information to the farmer. The hydra-headed communication often confuse the farmer rather than helping him. The dovetailing of NGOs and FPOs with appropriate disseminations of expert and customised information in buttressing production and value addition is fragile.
- India has experienced widespread drought every year since FY 14-15. About half of the national land area is drought prone encompassing 500 m people i.e. 40% of the country's population. The farm distress, exacerbated groundwater extraction, increased migration from rural to urban areas, and intensified water conflicts due to drought need no emphasis.
- India, being a peninsular country, almost 12.5% of its area (33.5 m ha) is prone to flood. The states like West Bengal, Orissa, Andhra Pradesh, Kerala, Assam, Bihar, Gujarat, Uttar Pradesh, Haryana and Punjab are more prone. Over the past few decades, central India has become familiar with incessant rains and flash floods.
- The salinity ingress has led to the degradation of land (107 m ha) and groundwater resource. India has 6.73 m ha salt-affected soils that could increase to 20 m ha in another three decades. Gujarat (2.23 m ha), Uttar Pradesh (1.37 m ha), Maharashtra (0.61 m ha), West Bengal (0.44 m ha) and Rajasthan (0.38 m ha) together account for almost 75% of saline and sodic soils. In most of the salt-affected environments, water quality (saline and sodic) is poor.

- Soil Health Card scheme was launched to address the soil heath issues. In Phase-I (FY 15-17) 107.4 m cards were distributed. In the second phase of the scheme 116.9 m Soil Health Cards have been distributed during FY 17-19. Soil health mobile application has also been launched.
- The agricultural market is highly volatile. The farmers are assured of MSP in some crops that is never demand driven and hence culminates in piling of stocks. The increase in production often dips market price, economically leading the farmer to the square one. As such, the gains of enhancement in agricultural production are rarely passed on to the farmer.
- Agriculture storage capacity has increased @ 4% between FY 14-17 to reach 131.8 m tons. Godown and silo capacity of 2.3 m tons 6.25 lakh, respectively, was also created during FY 14-15 and FY 17-18. An enormous amount of food produced goes waste in the food supply chain. According to one estimate, about half of all food produced is lost before and after it reaches the consumer. The heavy environmental footprint of food wastages, in terms of huge loss of water and nutrient inputs and the higher greenhouse gas emissions are unintended side-effects of the loopholes in food production and supply chain.
- eNAM, a pan-India digital trading platform, was launched by the government in FY16 to create a transparent and competitive price discovery system to help farmers get remunerative prices. More than 1.64 crore farmers (14% of total) and 1.24 lakh traders have registered on eNAM. Out of these, 49% have transacted on eNAM. 585 mandis in India have been linked while 415 additional mandis linkage is in pipeline. Trade and transport are the two major casualties during lockdown. This has led to favourable developments. Trade has been facilitated by adding some features to eNAM to enable the farmer to sell his produce at the premise of the warehouse and collection centres established by Farmers Producers Organisations (FPOs) or Panchayat at village level. This is in addition to the traditional commission agent system. Transport was addressed exploring innovative app-based solution (Kisan Rath Mobile) such as truck aggregators on the lines of Ola and Uber to connect farms with nearby mandis.
- The agrarian distress has been addressed with higher MSP, higher wages (Rs 182 to 202/day) under MGNREGS and annual income transfer of Rs 6000 to farmers under PM-Kisan. Crop insurance enrolment has doubled during FY 16-17 to 58m from 28m farmers. However, it reduced to 48 m during FY 17-18 with 1% reduction in acreage insured. The number of claims paid was 64% benefiting 29% of the farmers insured.

Farmers' Income

- The nexus between climate-soil-water-energy-agriculture-livelihoods security (CSWEALS) is overly complex in India. The current income has increased from Rs 0.12 lakh/farm household in FY 93-94 to Rs 1.20 lakh/farmhouse in FY 15-16. There was a conspicuous increase in current income in FY 11-12 (0.26 to 0.79 lakh/cultivator). The real income has doubled during the period FY 93-94 (Rs 0.22 lakh/farm household) and FY 11-12 (Rs 0.44 lakh/farm household). Livestock contribution to income was 52% and 71% in lowest and large land holding categories, respectively. Further, on an average 60% of income comes from farm activities while 40% comprises non-farm activities (wages, salary, non-farm business, etc).
- Staple crops (cereals, oilseeds, pulses) occupy 77% of GCA but contribute only 41% to output. It has been observed that area under high value crops (HVC) increased by 9.16 m ha during FY 04-05 and FY 13-14 at an annual growth rate of 3.31%. It has been estimated HVC gave return of Rs 1.42 lakh / ha compared to 0.41 lakh/ha from staple crops.

Farm Credit

- The long-term credit that was 23% during FY 08-09 has reduced to 7.9% during FY18-19. The share of the short terms loan has soared because of interest subvention scheme started in FY07-08. The interest subvention was meant to boost short-term loans (Production Credit) but it has culminated in fall of long-term loans (Investment Credit).
- Some states get 170-180% agriculture credit of their Agri-GDP indicating diversion of credit for non-agriculture use. This is because agriculture is getting concessional interest rate of 7%, 2% interest subvention and 3% prompt payments making the effective rate as 4% as compared to 10% in other sectors.

Agricultural Export

- Agricultural export grew @ 16.45 % over FY 10-18 to reach US$ 38.21 b in FY 18. In FY 19, agriculture exports were US$ 38.54 b. Share of agriculture export to total export was 12.27%. Spice exports from India reached US$ 3.1 b in FY 17-18.
- The top ten items contributing to export were basmati rice, spices and coarse rice (each 8.5±1.0%); cotton and sugar (each 4.2±0.5%); and fresh vegetables, coffee, groundnut, oil meals and cashew (each 2.4±0.1%).
- Export of basmati rice showed growth of around 23±1% per annum. Export of pulses has increased by 15 and 24% per annum during FY 17-18 and

FY 18-19, respectively. Tea exports reached a 36 year high of 240.68 m kg; while coffee exports reached record 0.395 m tons in FY 17-18. Guar gum and onion export grew by 12% each during FY 18-19. However, export of groundnut reduced drastically by 37.9 and 2.6% during FY 17-18 and FY 18-19, respectively.

Area

- Food crops occupy 69.4 % of the area (126±2 m ha). The area under rice and wheat has been static around, 42±2 m ha (23.5%) and 30.5±1m ha (16.5%), respectively, for the last decade. Pulses have shown conspicuous increase during FY 16-17 (29.46 m ha). Area under oilseed has oscillated around 26±1 m ha during the last decade. Area under groundnut has decreased to 5.31 m ha in FY 16-17. The area under cotton that has shown decreasing trends since FY 14-15 has been retrieved back during FY 17-18 (12.2 m ha). Sugarcane area is static around 4.70±0.40 m ha since FY 11-12.
- The area under horticulture, fruits and vegetable has doubled over FY 90-91 to 25.87 m ha, 7.22 m ha and 10.40 m ha, respectively, during FY 18-19. The increase in area shows changes in the consumption pattern. Among different fruits, area under banana, mango, citrus fruits, apple, pomegranate and grapes has stabilised around 0.87±0.02 m ha, 2.25±0.07 m ha, 0.99±0.02 m ha, 0.30±0.01 m ha, 0.24±0.01 m ha and 0.14±0.01 m ha, respectively. Among the individual vegetables, the area under potato (2.16±0.02 m ha), tomato (0.80±0.01 m ha), onion (1.29±0.02 m ha) and brinjal (0.73±0.01 m ha) has remained constant during FY 16-19. The area under flowers and aromatic plant that showed marked increase from 0.07 m ha in FY 02-03 to 0.95 m ha in FY 16-17. However, thereafter it has stabilised at around 1.00 m ha. The area under plantation crops is constant around 3.65±0.10 ma ha during FY 16-19. The area under spices has progressively increased from 3.67 m ha in FY 16-17 to 4.09 m ha in FY 18-19.

Productivity

- The productivity of total food grains and cereals quadrupled from 522 kg/ha and 408 kg /ha to 2153 kg/ha and 1784 kg/ha, respectively, during FY 50-51 and FY 16-17. Among cereals, productivity of rice and wheat increased over three (2450±50 kg /ha) and five times (3216 kg/ha) over FY 50-51. The productivity of pulses has doubled (779 kg/ha) and oilseeds tripled (1225 kg/ha) over FY 50-51.
- Groundnut productivity has been showing decreasing trends (1450±100 kg/ha) since FY 13-14. Mustard productivity has increased around 3 times from 368 kg/ha to 1324 kg/ha during FY 50-51 and FY16-17.

- Cotton productivity showed conspicuous improvements after advent of Bt-cotton during 2000s (517 kg/ha) and has been static thereafter. Sugarcane productivity has hovered around 70±0.1 tons/ha since FY 00-01.
- The productivity of horticulture increased by about one and a half times over FY 91-92 and has been static at 11.50 ton/ha for the last five years. The productivity of fruits has increased with a jump of around 2 tons during FY 14-15 (14.17 ton/ha) but is static thereafter. The productivity of banana is static around 37 tons/ha for the last decade. The productivity of mango that was static around 6.5±0.5 tons/ha since FY 01-02, increased to 8.5 tons/ha during FY 14-15 and has been hovering around that level. The productivity of vegetables has plateaued from 14.40 tons/ha in FY 01-02 to around 17 tons/ha since FY 16-17. Productivity of spices has also plateaued at around 1.90±0.10 tons/ha from 1.17 ton/ha in FY 01-02.

State of Production

- The production of food grains was 291.95m tons during FY 19-20 showing around six times increase over FY 50-51. Among the cereals, rice (117.47m tons) and wheat (106.21 m tons) has increased over five and fifteen times over FY 50-51. The coarse cereals production was 45.24 m tons during FY 19-20. The production of pulses has double (22±2 m tons) during the last decade.
- The production of oilseeds showed distinct increase of over seven times during FY 19-20 (34.19 m tons) over FY 50-51. Production of groundnut has decreased from 9.7 m tons in FY 13-14 to 7.6 m tons in FY 16-17. Mustard production has increased over ten times than FY 50-51. Cotton production increased particularly after advent of Bt-technology. It peaked at 39.8 m bales during FY 13-14 but reduced thereafter to 35.4 m bales during FY 19-20. The production of castor has hovered around 1.5±0.5 m tons during the last three years. Sugarcane production evinced over 6-times increase from 57.07 m tons in FY 50-51 with record production of 377.9m tons in FY 19-20.
- The production of horticulture has increased around three times (314.67 m tons) during FY 18-19 over FY 90-91. The production of fruit has stuck around 94±2 m tons for the last five years. The production of banana is static around 30.50 while mango increased from 10 m tons in 2001-02 to 22.75 m ton in FY 18-19. The production of total citrus and pomegranate has shown increase from 11.41 m tons to 12.26 m tons and 2.61 m tons to 2.87 m tons during FY 16-19, respectively. The production of apple (2.32±0.05 m tons) and grapes (2.94±0.01 m tons) is static during the last three years.

- Vegetable production increased over three times (187.48 m tons) over FY 90-91. Production of different vegetable viz; brinjal (12.50±0.50 m tons), chillies (3.70±0.05 m tons), okra (6.10±0.10 m tons), onion (23.00±0.50 m tons) and tomato (20±0.50 m tons) has been static during FY 16-19. Potato and flower production increased from 48.61 to 52.59 m tons and 2.39 m tons to 2.86 during FY 16-19, respectively. The production of aromatic and medicinal plants reduced from 0.97 m tons to 0.90 m tons during this period. The production of plantation crops is static around 18 m tons for the last three years. The production of spices has increased around four and half times (8.59 m tons) during FY 18-19 than 1.9 m tons in FY 90-91
- Milk production was 187.7 m tons during FY 18-19, indicating impressive growth of 227% over FY 90-91. The egg and fish production reached impressively at 103.3 b and 13.34 m tons during FY 19-20. Wool production peak at 48.4 m kg in FY 00-01. Thereafter, the wool production has been declining. The production was 46.4 m kg during FY 18-19.

Analysis of Agriculture Growth

- Overall, growth of agriculture is very impressive. However, there were huge variation ranging from minus (-) 12.8% during FY 79-80 to 15.6% during FY 75-76. Eleven of the seventy years since FY 50-51 exhibited negative growth rate. In this backdrop, the annual growth rate in real terms in agriculture and its allied sectors was 2.88% during last six years.
- The growth rate of pulses, cotton, milk, fruits and vegetables during FY 01-15 was higher i.e. 3.2%, 9.5%, 4.5%, 4.2% and 4.1% than the global rate of 2.9%, 1.6%, 2.3%, 3.1% and 3.9%, respectively. However, growth rate of cereals (1.5%) was lower (2.1%).
- Degradation of natural resource base has adversely impacted the growth rate. Therefore, use of a combination of resource efficient methods including dynamic cropping patterns, judicious use of chemical fertilisers and efficient irrigation systems cannot be underscored for sustainable agricultural production.
- The productivity of water is highly variable. Citing an example of water intensive crops like rice and sugarcane, the water productivity is extremely low in south India as compared the northern states. There are major concerns about over-exploitation of groundwater in agriculture as aquifer levels continue to drop. The focus on "irrigation water productivity' rather than 'land productivity is missing in agriculture.
- The fertiliser response ratio, which is an indicator of responsiveness of soil to fertiliser application has declined to <4 compared to 13.4 during 1970s.

The recent interventions like soil analysis-based fertiliser application, adoption of neem-coated urea, micronutrients, organic fertilisers, watersoluble fertilisers, fertigation etc can play pivotal role in revitalising the fertilizer use efficiency.

- The recent menaces like COVID-19 and locust incidences have added other dimensions to the problems in agriculture. The piling up of losses due the harvested/unharvested perishables during the current rabi season is over 15000 crores with a possibility of swelling further. However, grain market is very intact and can maintain growth rate around 2.9% during FY 19-20 despite a setback of 0.25% from the horticulture sector.
- The living standards have improved initiating new demands. There is, thus, an urgent need to do analyses of the problems to restore its vitality and put it back on higher growth trajectory. The problems are surmountable, particularly when new tools of science and state of art technologies have started offering tremendous opportunities for application in agriculture.
- There are many drivers of transformation in agriculture. Some of these transformations are desirable, while others are not. Therefore, in order to draw an effective strategy for upturns in agriculture, it would be worthwhile to categorize the drivers of transformation according to their desirable or undesirable impact on agriculture.

Desirable Transformation	Undesirable Transformation
1. New technologies:	**1. New menaces:**
• Increased use of nanotechnology and biotechnological tools	• Damage to crops
• Enhanced geo-spatial technologies like remote sensing, GIS and GPS	• Disrupted field operations
• ICTs tools	• Market inaccessibility
• Precision farming	• Inaccessibility to input & resources including labour
• Improved processing	**2. Climate change:**
• Branding and packaging	• Unpredictable and rise in temperature
• Bio fortification	• Capricious rainfall in quantum and space
• Landless farming (hydroponics, aeroponics)	• Unpredictable light radiation and cloudiness
• Organic agriculture	• Increase in concentration of

- Irradiation
- Ionization
- Resource conservation technologies
- Renewable energy
- State of art technologies for processing
- Technologies for regenerative agriculture
- Use of native microbes
- Improved irrigation technologies including sub surface irrigation

2. Demands

- Biofuel
- Customized product specific demands
- Area specific crop cultivations
- Changes in food habits
- Organic foods
- Good quality nutritious foods
- Food safety
- Nutraceutical food
- Food with C-4 & CAM crops
- Climate change resilient crops and varieties
- Enhanced shelf life
- Mall centric fresh vegetable/ fruits
- Vertical farming
- Health conscious foods

3. Better Access to information & traceability

- ICTs
- MOOCs

greenhouse gases

- Rise in sea level
- Unpredictable seasons
- Decrease in C:N ratio
- Extreme events like drought/ deluge, cold/heat
- Decrease in appropriate temperature window
- Change in seasons/reproductive cycle

3. Volatility:

- Production
- Policies
- Political support
- Input suppliers
- Price fluctuations & MSP

4. Energy:

- Vicious nexus of energy and agricultural production

5. Water:

- Scarcity
- Quality
- Cost
- Capricious rain fall
- Deep aquifer
- Frequent events of drought / deluge
- More evapo-transpiration losses

6. Land:

- Fragmentation
- Erosion & degradation
- Dissipated organic matter
- Deteriorated soil physical conditions

- Social networking
- Access to agricultural knowledge right from primary education
- RFID technology
- Increased emphasis on traceability
- Water and agro-chemicals footprints

4. Energy:

- Emphasis on renewable energy
- Energy auditing and efficient appliances
- Bio energy conversion, generation and utilization

5. Water:

- Better linkages of rivers
- Use of wastewater
- Reduction in microbial biomass
- Increase residues of agrochemical, heavy metals, effluents and sludge
- Increased alternate use of land due to urbanization, industrialization etc.

7. Finance:

- Inequitable resources
- Unorganized lending and borrowing
- Poor cash flow

Strategies for Agriculture 2020-30

• Dr. A. R. Pathak •

Agriculture in India is an important sector for providing food and nutritional security, sustainable development, poverty alleviation and employment generation. Since 2010, India continues to be trillion-dollar economy with nominal Gross Domestic Product (GDP) of US $ 2.62 trillion in 2017-18; the country has become the world's sixth largest economy overtaking France. Country has 7.5% growth rate, the world's largest growing economy, it is projected by World Bank to surpass the economics of UK and Germany and become the world's fourth largest economy in terms of nominal GDP by 2022. Indian agriculture contributes 8% to global agriculture gross domestic product supporting 18% and 15% of the human and livestock of world population, respectively, with just 9% of world arable land, 4% of water resources and 2.3% geographical area. Indian farmers have done a commendable job by providing food to a billion-population having food grain production increased by 4 fold; horticulture and milk each by 6 fold, fish by 9 fold and egg by 27 fold since 1950-51. However, Agriculture GDP decreased from 30% in 1990-91 to 14.6% but provides employment to 52% of workforce. Average annual growth of agriculture sector was less than half (3%) of overall growth of 6-7%.

Yields of different crops in India are just 30 to 60% of the best sustainable yield achieved in developed countries. With increase in population and rising per capita income the demand for food and processed food is increasing. The future requirement of food grain during 2030 would be 345 million tons i.e. 5.5 million tons increase per year and even for 2020 also growth rate of 1.2% is required to feed growing population. Similarly, demand for horticulture (Fruits & Vegetables), dairy (Milk & its product), livestock (meat), fish would be more by double. Growth rate of 3.71% and 2.41% would be required for fruits and vegetables, respectively.

Indian Agriculture is a diverse and most extensive sector. Since independence, it has become not only self-sufficient in food production but export too. India is the largest producer of cotton, pulses and milk (No-1 in world); second largest in food grains, fruits, vegetables and fish and third largest in egg production in the world. The production of horticulture is at a record 328 million tons in 2018-2019 surpassing the total food production. In terms of export, India is the the seventh largest exporter, which has grown at a rate 16.45% per annum during 2002-2016 to reach US $ 38.21 billion in 2017-18. Spices and basmati rice are monopoly of India.

Looking to future demand of food and change in food habit, processed food, and nutritional requirement on one hand and challenges to agriculture sector like shrinking of natural resources – land, water, energy coupled with climate change, small holding due to fragmentation of land, pressure on land due to other sector especially infrastructure, soil degradation due to soil erosion, salinity, water logging as well as imbalance use of nutrient especially N, P, K, exploitation of soil and water are great challenges for production.

In order to augment farmers' income, good production obtained in recent years in horticulture, dairy, fish production, which are perishable commodities need handling (storage, freezing), processing, value addition, packaging and marketing chain.

Above all climate change, frequent drought, floods, uneven rain, temperature increase, new pest disease etc. pose serious problem. In view of above, paradigm shift in agriculture sector with appropriate strategies are required.

Strategies

New vision of agriculture has FHNEE food, health, nutritional, energy and environment security.

Increasing the Productivity of Crop and Horticulture

- Increasing SRR by providing quality seed and planting material of improved varieties.
- Development of crop varieties/hybrids for input use efficiency, nutrition and resistant to biotic and abiotic stresses, using conventional and cutting edge frontier science technologies like- biotechnology, genetic engineering, marker assisted selection, GM crops, proteomics and functional genomics etc.
- Biofortified varieties/crop for health/nutritional security.
- Diversifying area towards high value horticulture crops.
- Adoption of high-tech horticulture-HDP, fertigation, soil less culture etc.
- Training to farmers to adopt non-monetary inputs like, selection of biotic and abiotic stress resistant varieties, timely sowing/planting, optimum plant geometry, irrigation at critical growth stages, appropriate plant protection, timely harvesting, grading etc.
- Establishing tissue culture labs, plug nurseries for production of quality planting materials in horticulture.

Maintaining and Upgrading Soil Health

- Soil health card (SHC) based fertilizer use, crop planning and selection of crop by farmers-centric SHC-based customized guidance.
- Use of GIS, GPS based soil sampling, availability and use of balance nutrients of recommended fertilizer and bio fertilizer at village level at reasonable price.
- SHC information may be linked to Aadhar and download at e-Seva in public domain
- Subsidy on the use of recommended dose of micro nutrients, bio fertilizer and organic inputs.
- Site specific and cropping system based nutrient management, IWM, INM.
- Use of efficient microbial consortia-based bio fertilizer.
- Standardize conservation/precision/organic farming system for different agro ecological situation.
- Residue management by use of effective microbial consortia.
- Use of green manure crop, provision for subsidy for green manure seed.
- Adoption of IWM, IPM, along with micronutrients.
- Use and technology development for Nano agro-chemicals.
- Promotion of organic farming and cow based farming in rain fed and irrigated areas.
- Use of crop residue for making biochar for soil health instead of burning.
- Leveraging precision farming and protected cultivation techniques in horticulture.
- Leaf tissue analysis based nutrient application.

Water Resources and Management

- Water is crucial for agriculture production. India will meet only 50% of projected demand of water 1498 billion cubic meter by 2030. Hence efficiency and conservation of water is pivotal by 2030.
- More crop per drop-adoptions of MIS and other water saving technologies including drought resistant varieties/use of gene editing, plant architecture, land leveling, mulching etc. For MIS increase subsidy.
- Compulsory drip for canal irrigation linked with subsidy.
- Water conservation practices should be made compulsory for house/farm/flat owner/buildings.

- Safe use of waste water through improved irrigation and agriculture practices.
- Use of bio-remediation measures resources and Nano bio molecules.
- Watershed-harvesting and river basin development.
- Construction/renovating/desilting of check dams/community ponds
- Cleaning canals
- Huge evaporation losses from open canal surface can be reduced by piping or by covering with solar panels.
- Enhance subsidy on 5 HP solar water pump to farmers.
- Conduct crop water demand-supply audit for optimal crop planning at taluka level.

Plant Health Management

- Prioritize integrated pest/diseases management through selection of resistant variety; use of trap crops/bio pesticides/mechanical control measures.
- Development/permission for transgenic variety
- Crop health clinics for diagnostics and e-surveillance.
- Engineering plants with immunity to pest and diseases.
- Identification and development of safe and effective novel agrochemicals and bio stimulants.
- Molecular approaches to multiple stress tolerance.

Farm Mechanization and Value Addition

- Labour availability is scarce. Need to develop and use farm machinery for different farm operation for small and marginal farmers use as well as to reduce women drudgery.
- Low cost, scale neutral precision machinery.
- Promote farm gate processing, clearing, grading etc.
- Incentivize low-cost processing, technologies through start-ups.
- Village level processing and value addition to FPS/PPS.
- Commercializing crop biomass e.g. stalks, shell, leaves.
- Prioritize research on residue recycling of fruit crops.
- Soil/plant sensor-integrated simulation model.

- Solar/wind energy based models for powering farm equipment/sensor/ pumps.
- Soil less and vertical agriculture.
- Standardize agriculture practices under solar panels and policy to purchase power from farmers
- Standardization of technologies for net/poly house farming including design of structure.
- Leveraging custom hiring centers at village level.
- Large scale investment in post-harvest infrastructure.
- Adoption of technologies for reducing post-harvest losses.

Marketing Policy

- Promote use of market intelligence and market information service in extension training programme for farmer.
- Use of e-extension programme like e-NAM, all markets to be linked.
- Business model to link farmers with market.
- APMC/market yard should collect farm produce at village level.
- Not compulsion to sale in APMC and market cess.
- Promote private players to buy directly from farmers.
- Leveraging FPOs by promoting exemption of APMC cess when trade is outside market yard.
- Promote contract farming and direct marketing by FPOs.
- Often price are of below MSP, hence need price support mechanism.
- Effective procurement mechanism required so that farmers get MSP appropriately.
- Establish group insurance schemes for members of FPOs and provide rate of interest benefits.
- Appointment of expert and certified advisory committee to suggest best agricultural practices for export quality yields.
- Unified trading license be given to the traders enabling them to transit their business in all APMC across the country.
- Permanent places should be given to the farmers for direct marketing at urban and peri-urban centers.
- Direct marketing by farmers without APMC/market yard taxes.

Credit

- In line with self-liquidating production loans, short duration marketing loans may also be considered.
- Increase the proportion of investment credit.
- Operationalize credit linked warehousing facilities at APMC level.
- Promote pledge financing through a network of rural godowns and negotiable warehousing receipt system to reduce distress sale.
- To improve farmers participation in derivative trading, banks should extend credit for purchasing price insurance.
- Leveraging PMFBY.

Climate Related Services

- Develop efficient crop and agromet advisory system and contingency advisory services.
- Early warning systems and advisores.
- Communicate agro met advisory to farmers through SMS, TV channels, daily at specified time. Include humidity, wind velocity, hot & cold spells, frost, dust, storms.
- Department of agriculture/universities should give detail advisories for crop sowing, fertilizer dose, irrigation, market information, GAP etc.
- Agro technologies and contingency planning for extreme weather events be given.
- Use of low carbon technologies for GHG mitigation.
- Refined methodologies for climate change vulnerability.

Livestock and Fisheries Sector

- Sufficient availability of feed and fodder.
- Proper housing management of animals.
- Health management of livestock / fish.
- Promote breeding, artificial insemination, use of progeny tested bull semen.
- Encourage small scale start-ups for value added dairy product units.
- Demand for desi cow milk (A2) is increasing 50 farmers should be promoted with all technologies and dairy cooperatives should help by providing incentive.
- Create infrastructure facilities like fish loading and unloading device. Fish transports are highly affected in covid 19 due to non-availability of ice. Hygienic fish collection, marketing and cold chain facilities are utmost importance.

- Promote cage and pan farming polices in reservoirs and lakes.
- Ensure economical and critical fish farming inputs.

On Farm Ancillary Activities

- Plan skill training programmes to reflect the market demand along with industries need
- Mushroom cultivation
- Apiculture
- Develop small scale enterprises in rural areas.
- Identify need of skilled / semi-skilled jobs in urban center like gardener, plumber, drivers etc.
- Self-employment training to youth for plumbers, tractor repairs, drip irrigation etc.
- Enhancing agro forestry in farm boundary, silvi- pastoral system, agri-horti systems, horti-pastoral system, and industrial agro-forestry system.
- Promoting agro-tourism.
- Simplify licensing procedures, laws and regulation for developing small scale enterprises in rural areas.

Impact of COVID-19 Lockdown on Agriculture & Food

- Packaged food industry and supply chain get disturbed.
- No export/import of food items, no cleaning work on port- No transportation of items by truck. Product requiring refrigeration is in damaged.
- Farmer produced like Wheat, gram, spices, fruits, orange, pomegranate, banana, grape, onion, tomato etc. are in field & harvested fruits, vegetables, flowers, spoiled due to non-availability of labour.
- Though APMC started, few farmers took products to market. Only few traders are participating hence no competition.
- For summer crop and kharif, inputs like seed, fertilizer, agrochemical irrigation delayed are not obtain timely.
- Harvested and unharvested perishable farm produce like fruit, vegetable due to non-availability of transport/market/supply chain resulted in to Rs. 15,000/- crore loss.
- 6 lakh tonnes of grapes and banana,chiku remained to be harvested.
- Export of even spices dropped from Rs. 15,000/- to Rs. 18,000/ qt to below Rs. 10,000/ qt.

•

Atmanirbhar Krishi – Role of Stakeholders: Road Map 2020-30

• Dr. Kirit Shelat, Dr. Odemari S. Mbuya •

India's agriculture has sustainable growth over the last seven decades (1960 -2020). India had subsistence farming, whereby it imported food grains and had 'Ration Shops' for food distribution. The Green Revolution in the 70's changed all these. The country started getting steady growth of 2% to 4% per annum at the inception of the Green Revolution. India started massive water harvesting programmes and diversified its agriculture including animal husbandry and fisheries. Although India has managed to come out of chronic food shortage and famine, and started exporting food, climate change has its own impacts on food security. COVID-19 has further aggravated the uncertainties.

Prime Minister Shri Narendra Modi took a series of measures to restructure the agriculture sector, particularly the marketing impediments. Huge resources have been allotted for infrastructure development with cheap credit facilities. Fisheries and animal husbandry have been given added support. Farmers have been given financial support, extended markets and infrastructure facilities. The challenge lies with the State governments and District Development Administration to support the farmer to become '*Atmanirbhar*', involving all stakeholders. It is important to understand the current situation in order to develop a road-map for 2020-30.

Indian farmers and farm income have often been under stress. The farmers are resilient, willing to adapt and face adversities. They have come out from adversities of drought and famine of early years of development, faced challenges and overcome them.

Agriculture and food production face uncertainties that raise serious questions and concerns about its performance and sustainability. Uncertainties revolve around different factors, including population growth, dietary choices, technological progress, income distribution, the state of natural resources, climate change, sustainability of peace, just to mention a few. Nobody knows with certainty how these factors will evolve overtime. However, they are sure to shape the future. Consequently different nations, international organizations, civil societies, intellectuals and researchers are increasingly trying to find out alternative options and new pathways for food and agricultural systems.

Changing Course

Population and income growth determine demand for food and the changes in people's dietary preferences. Persistent poverty, inequality and unemployment constrain access to food and hamper the achievement of food security and nutrition goals. Agricultural production is limited by the increasing scarcity and diminishing quality of land and water resources, as well as insufficient investment in sustainable agriculture. Climate change and COVID-19 are increasingly affecting rural livelihoods and further decrease working population on farms affecting productivity.

Changing course is critical - a more sustainable future both for short-term and long-term is attainable but getting there will not be easy. This will need more integrated, well planned out "micro level plans" and "business as usual" attitude will have to be changed. The rural families and communities will be required to refine the assets used for farm production and services, including livestock assets, accept new solutions and practices and implement innovative technologies and safety practices. Further we must commit to responsibility, sharing and accountability in implementing fundamental changes and schemes.

The transformative process requires bridging the 'gap' between "average" and "progressive farmers", villages, blocks, districts and states. The entire public administration will have to be involved in this process of "fundamental changes". New policies and programmes will have to be implemented with precision and old policies re-visited.

India Needs a New ROADMAP for Agriculture

- Agriculture provides more than food – it provides essential commodities, environmental support and socio-economic support for its overall economic growth, industrialization, and diversification. It provides demand for non-farm goods and services and fulfills basic needs of every family.
- With rapid urbanization and infrastructure development – we need to produce "More" with "Less" land and scarce water resources. We need to feed the hungry millions and meet the challenge of malnutrition.
- We need to bridge the gap of income and its growth between rural and urban populations and within rural sector – gap of income between progressive farmer and average farmer – in same village with similar land and water resources. That is why doubling income of farmers is the future of rural areas and for that matter future agriculture.
- We need to fully utilize irrigation potential created by big dams like *Sardar Sarovar* and *Ukia* project to ensure that farmers of command area plant three crops per year. Together they cover more than 50% of farmlands.

- We need to ensure that "Solar Scheme" reach out to farmers who can use it for farm operations and sell surplus energy to Electricity Companies and earn income round the year.

Goals

The New Vision for Agriculture is to harness the power of agriculture to drive food security, environmental sustainability and economic prosperity. Its aspirations are high, not least of which are to increase production by 10% per annum while decreasing greenhouse emissions by 10% and reducing the prevalence of rural poverty by end of 2030 as for long term perspective – but immediately we need to revive the activities on-farm and off-farm in rural areas.

The goal or intent is to build a powerful India. The *Atmanirbhar* India as Hon'ble Prime Minister calls it. In fact, food and food products will be in demand across the world and countries which can provide them will dominate the world. Food will be a more powerful weapon than the atom bomb. India with the second largest arable land with adaptive and resilient farmers supported by progressive government and public governance system can provide food and food products for the world.

Indian society is mostly dependent on agriculture. Agriculture is the foundation of the food chain and provides 60% of the jobs. From its inception, the purpose of agriculture has been to feed and fuel human activities. Driven by innovation and investment, agricultural productivity has increased substantially. Almost all our people have enough to eat today, up from old ration days and farmers in some parts have doubled or tripled their income. This unprecedented growth supported by progressive administration is now entering a new era marked by scarcer resources, greater demand and potentially higher price and supply volatility – we have to learn to produce more with less.

In recent time, salinity ingress, droughts, floods, poor agricultural practices by small holders – particularly growing sharecroppers have led to depletion of soil fertility, increased soil erosion and scarce water availability with poor quality. Meanwhile, broader environmental changes are affecting agriculture in ways yet to be fully understood. Climate change means farmers must adapt to changing rainfall patterns and fluctuations in temperature; yields could be reduced by more than 20% in many areas struck by drought, floods and/or heavy rainfall. Poor farmers are particularly facing severe outcomes and like to abandon farming. On the other hand, overall demand for food, dairy products, vegetables, fruits, spices, meat, poultry and fish is growing at rapid rate. The demand for processed – ready-to-eat food is increasing and so-called junk food is growing to higher rate.

An anticipated 70% of the India's population is expected to live in cities by 2050. Therefore, the need for robust and effective food distribution – linking growers to retailers to consumers – would intensify. Urban populations demand more processed and ready-to-eat food, as well as more diverse options. This would increase the role of processing, packaging and logistics providers in food systems. The multiple stakeholders are Public Sector, Cooperatives, Private Sector and Civil Society who have interaction with farmers for their own interest and that of farmers.

The scale of challenge that we have required is everyone in each group to step up their efforts and play a well defined role – we need immediate critical path and a long term well laid out perspective.

The Government being in leading position must set the direction to the transformation and create appropriate environment for it. In India we have multiple layers of governance – in a decentralized Public Governance System, multiple actions are needed at all levels.

The Public Governance

The public governance system includes elected and non-elected (Permanent) members of Public Administration.

The Public Governance

Central	]	
State	]	
District	]	Farmers
Taluka	]	
Village	]	

The Public Governance includes elected and non-elected members of Public Administration.

Multiple Actions		
Re-visit Policy Restructure Organizations	]	
New Agro-advisory	]	
Health Advisory	]	
Good Agricultural Practices	]	
Agri.Infrastructure	]	Farmer
Tools and Knowledge	]	
Finance	]	
Market	]	
Consumer Orientation	]	
Skilling, Re-skilling and Up-skilling Farmers	]	

The Government supports and facilitates the changes and implements supportive schemes; the cooperatives – including self-help groups organize farmers' joint economic activity to achieve higher earnings through better marketing and bargaining strength.

The Business group drives implementation through innovation, investment, competition and value addition.

The Civil Society mobilizes and organizes community support and individual initiatives. It helps to build local capacity – skill, re-skill and up-skill farmers, acting as a bridge between farmers and all other stakeholders.

The aspirations of Rural Society – particularly youth are growing and higher income has to be generated. Agriculture, therefore, needs value addition to generate more wealth by local level processing – rural and agro industries. Need of the hour is that they act together in an integrated manner with convergence of efforts and understanding that farmers need support to grow economically and socially. Not only that they have to be convinced about that need – they have to be prepared to face challenges that volatile adverse climate change bring about threat to their livelihood asset – land and livestock and that they have to change and update their conventional farming methods.

The key player – farmer – needs to develop desire to grow, adapt to changes, accept new ideas and remain alert as farming is increasingly becoming risky – but timely action provide rich dividends and increased income. Among them – there are poor farmers who need individual attention.

The Current Income Loss to Farmers

- **Transit Loss:** Post-harvest to market as per one estimate – 25% to 40% of produce is lost from farm to market due to poor transport, packaging and storage.
- **Distress Sale:** Sale to local intermediary – farmers sell their produce at village level to get cash and lose 15% to 25% in price at which they sell – compared to MSP or APMC.
- **Spurious Inputs:** As per one study of Department of Consumer Affairs – more than 50% of seeds, fertilizer mix, and bio-pesticides are fake or spurious and farmers lose in productivity.
- **Non-use of Drip Irrigation:** Drip / Micro Irrigation increases yield by 15% and also saves water that is available for one more crop.
- **Most Serious:** Challenge is adverse weather condition. In the year 2018-19 droughts affected 100 talukas of Gujarat, 279 talukas of Maharashtra and 156 talukas of Karnataka. Farmers lost their income by low productivity

crop loss. The recent locust attack in parts of Gujarat and Rajasthan – is new emerging serious threat.

- **Salinity Ingress:** Increased sea-water level on farmland in ocean areas – coastal areas is affecting root zone due to aboveground and underground ingress. Very serious in underground ingress which is affecting even hinterland and well/tube-well water is becoming contaminated. When such water is used for irrigation, productivity is negatively affected.
- **Decreasing Working Force on Farmland:** Males are increasingly moving for non-farm jobs and farming is done mostly by women – women farmers who are otherwise occupied in multiple household tasks – find it less time. Furthermore, agricultural tools and implements are men centric.
- **Protect from Animal Menace:** Stray cattle, nilgai, monkey and pigs are invading the ready to harvest crops – resulting into huge losses. In some areas (Gujarat and Rajasthan) locust attack is destroying crops – causing havoc.
- **Sharecroppers:** Due to rapid urbanization – developers are buying lands all around existing cities and potential areas – such lands are handed over to sharecroppers in which richer the cultivator or owner is interested in investing in land. As per one estimate sharecroppers are now about 30-40% of landholders.
- **Irrigation:** Inefficient Management of Canal Irrigation system – which has potential but limitation of connectivity to farms and transmission losses (about 40 per cent).
- **Covid-19 Impacts:** COVID-19 has no adverse impact on farmland, but the farmer and his family – the way of lifestyle need to change with health safety net.
- During lockdown there were problems related to – delivery of certified seeds, fertilizers, pesticides and farm tools and sale of perishables – like vegetables, fruits, eggs, etc. Again, APMCs were partially open but had limited traders – who did not accept all that is brought for sale.
- MSP – This has not started – farmers have stored produce – like wheat, chana, etc.

The list can go on and may vary from district to district or even village to village. But since opening of areas – the farming and farm operations have become normal with incredibly good rain during Kharif, sowing operation have started. The government has provided free food and that has relieved farmers from stress.

There are opportunities to increase income but there are threats -challenges that can reduce income. We need to address all these.

Stakeholders are already engaging on many interventions. However, we need further specific interventions in the value chain.

Research & Development

- High yield, stress-tolerant input
- Bottom of the pyramid designs
- Local varieties/adaptations
- Proper incentives for R&D
- High-caliber institutions
- Grants for nutritious orphan crops

Input Distribution and Adoption

- Agri-dealer networks
- Product bundling
- Risk mitigation purchasing
- Farmer producers/organizations – FPC/Cooperatives/SHG
- Model farms
- Direct credit of subsidy
- Action against spurious Input Distributors

Farming

- Contract/joint farms
- Crop selection based on soil health and water analysis
- Water efficiency
- Soil
- Livestock management
- Zero post harvest losses
- Crop insurance
- Good agricultural practices
- Train off-farm skills, diversification
- Extension services, capability building
- Monitor land use change
- Husbandry animal safety & nutritious feed
- Registering sharecroppers for subsidy and insurance

Trading and Processing

- Inform farmers about prevalent prices
- Trading businesses
- Local storage facilities
- Investments in "value-add" industries (e.g. oil refining)
- Cooperatives
- Grain exchanges

- Local processing
- Prudent procurement at village under MSP & by APMC or cooperative.
- MSP and APMC – collection at village level

Manufacturing and Retailing

- Fair trade pricing
- Local distribution channels
- Quality/safety standards
- Access to export markets
- Build Agri. Airports & ports – Civil storage facility.

Climate Related Services

- Information exists but limitation of communication to farm level
- Improve communication
- Comprehensive weather advisory followed by agro-advisory
- Use of local TV network

The Public Governance

- Centre
  State
  District
  Taluka
  Village
- Clarify role
- Timely action
- Reporting
- Monitoring
- Accountability

Atmanirbhar Krishi

The government has initiated services of measures and restructured the agricultural sector. State governments have supplemented that on their own. Further each group of stakeholders – with group each need to set responsibly to make India super food and agriculture power in notwithstanding uncertainties of climate and phenomena like COVID-19.

Operating of Markets

- Marketing reforms under Farmer Produce Trade and Commerce Ordinance – 2020, give farmer, trader, electronic trading platform to sell their produce inter-state, intra-state trade and commerce. So far farmers can sell only to APMC of his/her district. Further it enables any trader to buy directly from farmer and no market tax can be levied on such transactions. This act overrides provisions of APMC Act. It also covers fishery and dairy products for the first time.

- Separate provision 'Special Markets' in any market area for specified agricultural commodities. National Agriculture Market (eNAM) online trading platform for agricultural commodities launched to promote price discovery and help farmers realize the value of their product is still to take off. Similarly, Corporate Farming and Contract Farming have been introduced.

Crop Insurance

- To resolve the problem of unpredictable nature of farming and prevents farmers suicide in the country, there is liberalized crop insurance policy where non-loanee-farmers to insure their crops. There is accident insurance to cover farmers who die due to accident.

Energy

- Government initiated energy-efficient irrigation facilities to farmers, by providing solar pumps. The solar schemes also provide sale of surplus energy to DISCOMS and that make available additional source of income throughout the year.

Prakrutic Kheti

- For lowering costs and improving agricultural production, the government has also started a cluster approach, toward the mode of farming Paramparagat Krishi Vikas Yojna (PKVY). According to this approach, 50 farmers would form a group having 50 acres of land to implement organic farming. The programme aims to set up 10,000 clusters covering 5 lakh acres under organic farming in three years. Gujarat has provided special subsidy for prakrutic farming and supporting cattle.
- Several other government schemes such as, National Mission for Sustainable Agriculture (NMSA), *Pradhan Mantri Krishi Sinchayee Yojana* (PMKSY), Micro Irrigation Fund (MIF), Agriculture Contingency Plans, *Rashtriya Krishi Vikas Yojana* (RKVY), Soil Health Care Scheme, Crop insurance Scheme like *PradhanMantri Fasal Bima Yojana* (PMFBY), Financial inclusion for smallholder farmers, Kisan Credit Card (KCC) scheme.

FPOs

- The government has also promoted Farmers' Producers Organizations (FPOs), NABARD has been entrusted responsibility to promote and support them. The strategy is to form 10,000 new FPOs with one FPO in each block – to facilitate market and credit linkage. This will also promote cluster-based business and promote product. The FPOs are to be provided financial and credit support and capacity building of members.

Credit

- Kisan Credit Cards have been made popular for availing of credit. Apart from farmers – animals holders and fishermen are now covered under this. Govt. has provided interest sub-version for facilitating easily credit.

Godowns

- Farmers are provided support to construct godown on their own land. Gujarat Govt. has provided subsidy of up to Rs. 50,000/- for construction of godowns.

Transport and Storage

- For perishable agricultural products like fruits and vegetables special scheme provides 50% subsidy on transportation from surplus production to deficient markets and 50% subsidy on storage – including cold storage. Essential commodities Act – 1955 de-regulate – agricultural commodities like cereals, pulses, oil seeds, edible oils, onion and potatoes – from stock limits.
- Bee Keeping, Herbal Farming, Bamboo Cultivation, Medicinal Plants are supported for growing and marketing.
- Animal Husbandry Sector is brought under Public-Private Partnership – with support informative and 100% vaccination – Cattle, Buffalo, Goat, Sheep and Pigs.
- Contract Farming – new framework is created to help farmers to engage with processors – large retailers and exporters. This will help farmers to reach an agreement in advance with big traders at pre-agreed price of their produce – by contract farming.
- Rs. 10,000 crore scheme micro – food chain enterprises – local to global approach to promote exports.
- Fishermen are supported for better quality boats with cooling facility for fish catch, for cold chain, open market platform. Further they are encouraged to take aqua lube, grow seaweed – during non-fishing time.
- One other major reform is amendment to Essential Commodities Act – farm produce like cereals, edible oils, pulses, onion, potato – are deregulated.
- To summarize – the above measures are in addition to existing schemes and programme framework. There are multiple agencies of government and private working for agriculture – some time for same subject – there is overlap as given below:
- Government has taken lead – now the major responsibility is of District Administration, Agri. University and NGOs and Private Sector – involved

with agriculture. Of course, farmers have done remarkable progress – but much more is needed to achieve goal of becoming *Atmanirbhar*.

- The District Administration has a major role and is accountable to make available – deliver all these schemes at farmers doorstep. In fact, Gujarat did this under the leadership of Shri Narendra Modi – the then Chief Minister of Gujarat. He introduced *Krishi Mahotsav* Approach – new extension model based on science, technology and direct interface with farmers at village level. This has been abandoned since then and now needs to be revived.

The Role of different state holders is as follows:

Stakeholder	**Role – Responsibility**
State Agricultural University Vice Chancellor and Director-Extension through KVK	• Transfer new variety of seeds and climate resilient practices – promote "orphan crops" • Provide Weather Advisory followed by Agro-advisory every month – during season on day to day basis through local TV cable network – district-wise • Provide Agro-advisory to select crops which can be sustained by soil – based on soil health and water analysis – village wise soil data each village of all farmers is available
District Administration Dy. Directors of Agriculture, Horticulture, Animal Husbandry, ATMA & Fisheries cooperation along with their field staff Extension Officers and VLW (Village Level Workers)	• Ensure that all existing and new schemes to reach to village level and poorest farmers benefit first. • Ensure that farmers get quality – certified inputs and action against fraudulent sales of input is taken. • Follow *Krishi Mahotsav* approach – visit each village – inter-act with farmers and guide them – about Climate Smart and Good Agricultural Practices. • Provide Soil Health Card with guidance of crops – alternative crops that can be sustained by his soil. Provide data about price available under MSP, APMC and open market operation of last five years to enable farmers to take informed decision.

	• Promote Farmer Producers Organization – at least one for each block. Organize through FPO Tool Bank, Farm services, storage, grading & packaging and marketing.
The District Development Officer and Jilla Panchayat	• Monitor progress of all schemes related to agriculture and rural development and provide employment under MNREGA wherever needed – promote water harvesting schemes. He must ensure that farmers' benefit from new changes under APMC Act and get maximum price. He must lead Krishi team to villages during *Krishi Mahotsav*. Monitoring market operation and promote direct market operation by traders, FPO, Agro-industries retailers.
Collector	• Overall coordination of development and its implementation at village level and directly monitor implementation of MSP (Minimum Support Price) Scheme. Develop Micro – Level Block Plan by District PL Board. Implement link – project to provide rural employment. • Promote use of Solar Energy Pump Scheme
Gram Panchayat – Sarpanch & Committee Members	• Make aware and implement Covid-19 Health Safety Guidelines. • Keep village clean • Provide employment under MNREGA. • Regularly call Gram Sabha • Ensure that poor family get benefit of Govt. Schemes first. • Make all farmers to avail of insurance cover. • Provide weather and agro-advisory to farmers. • Organize farmers to fight locust menace • Organize water harvesting works. • Promote efficient use of water – drip irrigation.

NGOs	• Act as link between govt. agencies and farmers. Organize community works. Provide farmers' details of schemes and assist in applying and to get benefit. Promote Climate Smart and Good Agriculture Practices and water harvesting and efficient use of water by drip irrigation. Make farmers aware about fraudulent inputs.
Industry	• Agro-industry and big retailers may directly buy from farmers – without middlemen. Input dealers – need to provide quality certified inputs and make aware farmers about not buying cheaper fraudulent inputs. Promote local cleaning, sorting and grading.
Banks – Cooperative commercial NDFC NABARD	• NABARD needs to take lead to ensure that KISAN CARDS are availed by all farmers, animal holders, and fishermen. It needs to promote and assist credit to self employment, micro-processing units and service units.
Irrigation Dept. and SSNNL	• Connect all villages under command area. • Organize village link. • Make Gram Panchayat responsible for this • Promote drip irrigation • Reduce and monitor transmission losses
Gujarat Vidhyut Nigam	• Promote solar energy – to provide farmers zero cost energy and source of additional income.

The Atmanirbhar Farmer

In order to achieve the goal of '*Atmanirbhar*' – farmer is key to its success. He/she must realize his/her own role:

- **Alert:** He must keep himself up-dated for climate change, danger of spread of Corona, about benefits available under existing and new schemes of Govt.

- **Adaptation of New Technology:** Climate Smart Farming, Good Agriculture Practices, Drip and Sprinkler Irrigation and Solar appliances.
- **Knowledgeable:** Keep track of market price of inputs and agri-produce including that of MSP and select his crop based on its Soil Health analysis – selection of high value and low volume crop. Take benefit of all Govt. Schemes. Sell crops – directly to APMC, MSP or trader / industry whoever offers maximum price.
- **Resort to Multiple Sources of Income:** livestock, solar – sale of excess energy generated, bee keeping, handicraft etc. and take employment under MANREGA.
- **Safety:** Follow safety advice where is given by Health Dept. for himself, family, workers. And for safety of crops he/she must follow weather and agro-advisory and insure the crop.
- Add – value and get better price by cleaning, grading, sorting, properly packing and selling where the highest price is available.

We have some case studies which illustrate the concept of *Atmanirbhar* Farmers:

Closed Dolomite Mine Based Irrigation

The Chhota Udepur is a tribal area – it is known for dolomite mines. There are about 80 defunct dolomite mines lying unused. These are deep pits with water bodies and are good water reservoirs. Each mine has a potential to irrigate 50-60 ha of land. Shroff Foundation Trust [SFT] – an NGO identified one of mines and conducted a technical survey and prepared a feasibility plan. Local farmers, with guidance from SFT presented the plan to Gujarat CSR Authority which accepted the proposal to develop one mine as a pilot. A network of water distribution systems and pumping machinery were installed. The adjoining farms were connected with piped water supply. A 40 ha of land was brought under irrigation for kharif, rabi and summer seasons. Earlier only rain-fed crops were possible, now cash crops like cotton, groundnut, wheat, tur and vegetables have become possible. The baseline income per acre was Rs.21000, this has increased to Rs. 72000. In all 40 farmers have benefited. This is a replicable model. The country has a large number of such closed mines – which are reservoirs and can be used to meet water scarcity challenge and irrigation.

Pratap - A Progressive Farmer

Pratap is a progressive farmer, 38 years old, lives with his family of five in Chhota Udepur. He has a small land holding of one acre. His yield takes care of his family's food, nutrition and cash needs.

He has seven principles to earn more income from one acre of land holding mix cropping, natural farming, balancing consumption and cash requirements, self-working/labour, sell in local haats, multi cropping, early sowing and early harvesting.

Crops	No. of Picking	Yield/Picking (kg)	Total Production (kg)	Rate/kg (Rs)	Total Income (Rs)
Sponge Gourd	20	85	1700	30	51000
Guar	10	20	200	40	8000
Tur	4	25	100	40	4000
Paddy	1	600	600	15	9000
Maize	1	500	500	15	7500
Drumstick	4	15	60	30	1800
Brinjal	5	20	100	25	2500
Blackgram	1	70	70	40	2800
Total					**86600**

Impact of Agricultural Programmes

Pratap and like him other young farmers were guided by SFT in convergence with government agencies. Interventions in agriculture have focused on building capacities of farmers through demonstrations of the best management practices (BMPs) and training. Selected farmers were acquainted with crop planning and new cropping practices to save input costs and increase production. The farmers have adopted various measures such as the SRI concept in other crops, application of vermin wash and biomaterial; intercropping, vegetable farming and soil health management. The farmers have started adapting to climate vagaries and change crops and practices accordingly. The trend for cultivation of cash crops like soy bean, vegetables, cotton and fruit trees has increased proactive planning for the season. These are the most significant changes observed in the behavior and practice of the farmers.

The sample survey data reveals that farmers could double their income to Rs. 70000/- from Rs. 32000/- per acre in a year due to crop planning, balance inputs and marketing strategies.

Tractor Mounted Maize Sheller – Fateh Singh

Seizing the Opportunity: Fateh Singh earned Rs. 35 lakhs in 7 years.

Newly married, bursting with enthusiasm and aspirations to provide the best for his family, Fateh Singh was a 22-year-old tribal young lad in 2010. Groomed as an entrepreneur, he purchased a mini tractor and maize sheller with an investment of 4.70 lakhs. His in-laws live in a bordering village of MP – during his visits there, he realized that there was an unmet demand for maize shellers. He seized the opportunity – after providing services locally, he started providing Maize Sheller services in MP.

"I earn an average Rs. 5.00 lakhs a year. I have earned around Rs. 35 lakhs from maize shelling in the last seven years."

"I was able to purchase a new maize sheller, construct a pucca house and develop irrigation facilities on my land. My two children go to an English Medium School."

Data reveals that entrepreneurs of mechanized services have an income that ranges from Rs.50,000 to Rs. 2,25,000 per year, while in exceptional cases average income ranges between Rs. 3,00,000 to 5,00,000 per year. The entrepreneurs have earning opportunities for 6 to 8 months in a year.

Tractor Mounted Seed Driller – Pravin Rathwa

Mastery Matters: Paid back his loan in half the time.

Pravin Rathwa set forth as an entrepreneur in 2010 under the entrepreneur development programme. Twenty two year old, energetic and ambitious, like Fateh Singh, he chose the seed driller as the main attachment for his tractor. Groundnut is grown on a large scale in his cluster. Seed rate and spacing technique are very crucial to reduce input costs and ensure healthy crop growth. This is one of the focused areas in farmers' education in the region.

Pravin mastered the technique of seed drilling; considered an expert, farmers of his cluster insist he sow their groundnut and maize with the seed drill. Pravin trains the farmers who own seed drilling equipment in the seed drilling mechanism.

Pravin was able to pay his bank loan in half the timeframe and saved substantial interest. "I earn on an average Rs.4.75 lakhs per year after deducting all my operational expenses."

Their earnings are higher than income from farming.

Up-skilling – Rural Youth

In the year 2017-18 a skill training class was undertaken by Tribal Technical Trainers Institute set up by SFT with the help of Tribal Development Dept. known as VIVEC. It started to train 24 women in hand embroidery at village

Puniyavant. Post training, 10 artisans commenced work. The group, now working for two successful years is committed to maintaining quality and timeliness.

It is significant that Puniyavant is in the opposite direction from the traditional handicraft villages cluster from where SFT initiated the hand embroidery journey in 1996-97. The Puniyavant group has achieved third position in earning supplementary income from embroidery, an earning of Rs. 1,22,588/.

Manisha Rathwa, a 28 years old from Puniyavant earned Rs. 39,482/-, the highest among women in the region. Manisha belongs to a small farmer family struggling to meet basic needs; debts were spiraling as expenses for children's education, healthcare and agriculture inputs were adding up. "With a regular income from handicraft I can manage our day-to-day cash requirements".

She further says that she was able to save from her earnings to purchase agriculture inputs and other services on a periodic basis. Skill training and a steady stream of job work saved the family from sinking into a vicious debt trap.

Training at VIVEC Changed My Family's Fortunes.

Jayesh Rathwa's father is a building contractor, his mother died when he was 9 years old. His family consists of a younger sister, a brother, his wife and parents. His parents encouraged him to enroll in theskill training course in Electrical House Wiring offered at VIVEC. He completed his course in September 2016 and was placed in Motherson Pvt. Ltd. Sanand near Ahmedabad in October 2016. His wife and younger brother are also employed in Motherson. Thus, the family was able to earn Rs. 31,000/ month jointly.

Jayesh has seen his parents struggling to make ends meet. Managing basic needs was a daily struggle. "Today it is different. The financial status of my family has changed. I am happy to contribute to the family income".

Jayesh is aware of the importance of savings regularly, making long term investments plans and buying insurance. The Japanese Company where he works, has helped him to learn many good habits along with savings.

"The culture and values inculcated at VIVEC has broadened my perceptions. The training provided a decent employment for me and my family."

Dhaval could not clear the SSC board exam – not one to give up he decided to master a technical trade. He took up a job to earn some money to pay for his learning and subsequently joined VIVEC.

He has a younger brother. His parents have separated due to the constant financial constraints in the family. After completing his training at VIVEC, Dhaval joined a two-month training in TIG welding.

His uncle helped him to get a job in Western Railways Workshop, Vadodara Division. He joined as a welding technician at Pratapnagar, Vadodara Railway Station with salary of Rs.15,000 per month, with a bright roadmap for his carrier.

Dhaval says "it was painful to see my family broken, my parents separated due to financial problems. I want to see them unite again as our financial problems are over".

He is incredibly positive and satisfied that he had made an identity as an accomplished welder.

Technology Transfer: CSA

Amreli District of Gujarat is a drought prone area. NGO Vivekanand Research & Training Institute (VRTI) with convergence of efforts with Govt. Agencies introduced Climate Smart Agriculture which sustained crops and enhanced income of the farmers.

Laser Irrigation

Laser irrigation System under Ridge and furrow method:

Objectives: To demonstrate alternate cost-effective micro-irrigation systems for irrigation water saving and promote practices aligned for income enhancement.

Laser irrigation used in Groundnut, coriander, pulses, potato, lucerne, onion. garlic, carrots, etc.

Outcomes

Utilized 100% cultivable land

Ease in installation

Water saving up to 40%.

Reduction in electricity consumption.

Prevent soil erosion

Increase in productivity up to 30%

Mulching

Plastic Mulching with Grow Cover:

A covering, as of plastic sheeting, spread on the ground around plants to prevent excessive evaporation or erosion, enriches the soil, inhibits weed growth, etc.

Outcomes

Reduce weed infestation

Reduction in the leaching of fertilizer

Maintain temperature and conserve soil moisture

Improve crop quality

Rs. 1,06,000/ acre net profit

Transplanting Cotton

Aims: Increasing yield by transplanting approach

Activity: Prepare nursery for cotton seedling with different materials. About 10-15 days old cotton seedling were transplanted in the field.

Outcomes

- Better root growth,
- Unique growth and development of plant
- Reduce gap/duals
- Increase in yield
- Reduction in crop losses

Detopping

Aims: Enhancing yield by reduction in vegetative growth

Activity: In cotton, detoppings done when crop become 75-80 days old.Main stem upper portion bud is cut by hand. Total 800 farmers with 1600 acres area diddetopping.

Outcomes

- Increase in number of branches and bolls per plant
- 15 to 20 % increase in production

Grid Locking, Green Manuring and Mulching

- Aim: Increasing yield and improving soil fertility by conserving rain water
- Activity: In cotton, each 2.0 – 2.5 ft ridges are made with alternate 2.5 ft grid closure at every 10 ft. Cotton seed was sown at alternate 2.5 ft furrows.. After sowing of cotton, dhaincha crop was sown between cotton rows. About 40-45 days dhaincha crop (before flowering stage) was harvested and incorporated into the soil.
- Grid status per acre :

❖ Size: 8 ft x 1 ft x 0.5 ft

❖ Total grids: About 1950

❖ Per grid water capacity: About 112 L

❖ Total water conserving: About 2,18,400 L

- **Outcomes:**

– To conserve rainwater in the ground up to 10 lakh L/ha

– Increase in moisture holding capacity

– Improvement in soil properties and nutrient status

– Increase in ground water table

– Improvement in water quality

– Enhancement in biodiversity

Way Forward

Rural economy provides the robust base required for a rapid self-reliant and sustainable long-term growth of any big state in terms of geography and population. The country has always recognized this fact, but more so after the beginning of formal economic policy reforms in 1991. The strategy of providing quality electricity, water and road connectivity in rural areas has significantly lifted agricultural growth and hence the living standards of rural population. The consequent increase in purchasing power of the people resulted in the demand for hither to considered urbanamenity goods and mass mobility within the country. Industry, trade, transport and informal service sectors started growing rapidly and soon made urban centres across the country an irresistibly attractive destination for pulling migrant labour from all over the country. As result labour and skill got mobilized.

However, global adverse shocks due to oil prices, tariff war, climate change and COVID-19 adversely affected productivity in agriculture and increased rural-urban imbalance. It calls forth some urgent step store gain the lost balance. This needs to be addressed immediately within the next one to two years so that the rural areas can again become the growth engine of the economy in the background of series initiative taken by central and state governments to restructure agriculture and support rural families and youth.

Micro Level Plans

The various schemes of government are implemented at village level through different departments from Centre to State – District, Taluka and finally at Village Level to reach out farmers. There are overlapping schemes and responsibilities.

Planning Commission did introduce Micro Level Plan in the year 2012, known as District and Taluka Agriculture Production Plan, but that did not cover all related departments. Over a period of time this plan has perhaps been abandoned. However, Micro Level Plans – Block and Village Level Plans are key to restructuring. In that we need to know Block Level GCDP and target the growth. The Block Agriculture Development Plan need to integrate all activities related to Agriculture, Water, Solar, Fodder, Livestock Development and Finance – with the aim to increase income of individual farmer family and GDP of village. The challenge is to reduce gap of income between Progressive Farmer and Average Farmer in same village with similar land and water resources. There already exists District Planning Board. District Planning consists of all District Level Heads of Dept., MLAs, MPs, District and Taluka Panchayat presidents. It involves all elected and non-elected District Level

public governance. This mechanism exists for preparation of Micro Level Plan and made accountable to prepare plan and monitor its implementation.

Centre	State	District Collector & District Development Officer	Block/ Taluka	Village
-Agriculture -Rural Development -Water Resource -Agro Processing Power Science & Technology; CSIR Vigyan Prasar Commerce; -Spice Board -APEDA TEA & Coffee Board STC. -Fertilizer Chemical -Skill Development -External Affairs Civil Supply	-Agriculture -Rural Development -Water Resource -Agro Processing Power Science & Technology; -Fertilizer Chemical -Skill Development -Civil Supply Labour -Entrepre-neurship Development	-Dist. Planning Board -Irrigation -State Irrigation Panchayat -DRDA Watershed Elec. Company Dist. Supply Employment Exchange ITI -Deputy Director; Agriculture, Horticulture -ATMA. -KVK -DRDA -Rural Development -Dept. Watershed -Livelihood Agency	-Mamlatdar -Taluka Development Officer -Taluka Panchayat -Agriculture Cooperation -Rural Development	-Gram Panchayat VLW (shared) -Gram Sabha -Milk Cooperative

Knowledge Economy

- Digitalize all land ownership records with details of Cultivators and Owners.
- Satellite mapping of crops for Market Forecast – including information competitive areas and crop failures
- Satellite tracking of fish catch
- Satellite mapping of individual farmland insured under Crop Insurance for settlement of insurance claim.
- Use of Artificial Intelligence in Agriculture like diagnosis of diseases in plants and animals, sensors for monitoring storage condition of produces stored, climate related advisory based on simulation models.
- Our immediate objective is the Farmer – or for that matter any villager need not visit office at village level – block level and District level. The village panchayat need to operate online system and all can apply/get benefit through that.

Restructure – State Agricultural University

- SAUs Agriculture Universities have done outstanding work – both in research and development and technology transfer. Now emerging areas which need focus on –
- Water Management: Efficient use of water resources, undertaking test of quality of water and developing agro-advisory for its treatment before using for irrigation. Water analysis like soil health analyses key for sustainable agriculture.
- Agro-Processing: India is leader in horticulture production but processes only 6-7% of its total production. In contrast, Europe processes 70% its production. This has huge potential. Currently some of R&D labs on related subjects and like are under CSIR (e.g. CIFRI). This needs to be integrated with SAU. In fact entire Agro – waste which is being burnt can be used for industrial use – as fiber, fuel or compost. This can save a continuing environmental problem.
- Market Intelligence: Consumer – Local – Urban – Exports.
- Research – Crops – Processing – Market – Line – State Level.
- This will need restructuring current SAU labs and research centres – in short, each research centre need to have processing research unit for related crops and plants or along with market intelligence.

Rural Distress and Employment Opportunities

Currently several policy initiatives exit –but they are not integrated for creating rural jobs. There is a need for a scientific socio-economic survey carried out at regular intervals along the lines of the BPL survey for each block and each village to identify demand and supply of specific jobs. It will involve survey of urban and semi-urban localities and colonies for their demand for services or employment opportunities. There are clusters: semi-urban and urban – industrial – including ports. They have variety of service needs and small retail outlets for tea, ironing, repairs, vegetables and fruits, pan shops, etc. that need to be systematically identified. There are job opportunities for rural youth. These will generate massive employment and relax rural distress and discontent. Rural Development Department should take up this on immediate basis with the help of local colleges and universities in the state.

Corporate and Cooperative Farming

New changes by statutory provisions have made corporate and cooperative farming possible while protecting interests of farmers. Rural distress is growing because agriculture for small and marginal farmers is becoming non-viable due to small operational holding, prohibiting costs of applications of new technology, improved implements, HYV seeds and lack of capacity to adopt efficient farming practices resulting in low productivity. On the other hand, employment opportunities in urban centres, industrial areas and construction projects lure the adult workforce. As a result, majority of rural youth do not have interest in continuing with farming but have to cling to the small plot due to our land legislations. Sale or leasing of agricultural land should be freely allowed for better allocation and increasing productivity of the scarce land resource. Land market imperfections arising out of restrictive legislation should be removed at the earliest.

Moreover, corporate farming needs to be encouraged by easing of land ownership and land use regulations such that the farmers can retain ownership but lease out their land with or without labour for a longer term to receive either a share in the profits and/or a fixed income. This will not only help improve land productivity by allowing improved scale operations, access to funds, improved seeds, implements, HYV seeds and better agricultural management practices, but also create possibility of taxing agricultural income for augmenting the state revenues.

Sharecroppers and Agricultural Labour

One reason for low investment in agriculture is the growing number of sharecroppers. Since the land they till is not on their name in the village record,

they are invariably bypassed in all benefits of government schemes and projects. Legal status of sharecroppers need to be recognized to make them eligible for government schemes on loan subsidy without contradicting the existing Tenancy Act that makes the tiller the owner. Otherwise, it will result into owner keeping their lands un-cultivated with resultant loss in cropped area. NABARD has a scheme of providing credit to such farmers without collaterals if they can form Joint Liability Group. The RRBs, DCBs and PSBs route have not worked efficiently. The by-laws of the DCBs need to be a mended to relax the upper limit of 20% to 40% on the nominal membership, so that the credit can be extended to the share croppers and agricultural labour. Moreover, the FPOs including share croppers need to be promoted. The organized credit sector should provide credit against farm produce or output rather than land or inputs. The Rural Development Department should implement these recommendations.

Capacity Building of All Stakeholders

Stakeholders include crop and horticulture farmers, *pashu-palaks*, animal holders, poultry farmers and fishermen. They need to be skilled, re-skilled and up-skilled in the arena of climate change. Govt. has now made available cheap credit – animal holders and fishermen are covered. Capacity building should be carried out by the Agri. Development Department regularly covering a large proportion of stakeholders on the following aspects:

1. Understanding adverse impact of climate change and learn "Resilient Agriculture".
2. Understanding weather forecast to protect crops - horticulture – livestock – poultry and fisheries
3. Use of equipment -tools
4. Purchasing quality inputs for high productivity and value
5. Understanding need for change and accept challenges
6. Good Agricultural Practices
7. Sell where you get best price – free market forces

Waste Land Development

The country has huge resource of wasteland. If we take example of state like Gujarat or Rajasthan but those uncultivated and a huge proportion of the wasteland – cultivable waste, degraded forest land, and eroded areas such as marginal areas of desert and coasts (where sea has receded). Fortunately, technology is readily available that can grow specific tree species, grasses and vegetables, which are salinity resilient. In fact, certain fodder species grow very

well and vegetables can also be successfully grown. This can support huge livestock development programme to enhance production of dairy products and meat for which domestic and international demand is ever increasing. What is required is to make a concerted and conscious effort to facilitate use of such lands in the private sector. State governments should identify waste lands in every district and create land parcels by villages for auction or lease for 10 to 35 years to only registered companies involved in the food processing to facilitate vertical integration. This will create revenues for government and employment for local youth. Rural Development Department in close collaboration with the Revenue Department should implement these prepositions.

Issues in Supply Chain

Poor infrastructure leads to fragmented supply chains and ultimately results in poor returns to the farmers and other stakeholders. State governments must make sure that the cold chain infrastructure is appropriate for storage and movement of perishables so that their shelf life is not compromised until they reach the consumers. This in turn would generate better returns for farmers. The private sector investment or private-public partnership model can be attracted in the state to develop suitable infrastructure for movement of perishables.

A strong quality testing, grading and standardization program driven by consumer preferences to add value at the farm gate. The consumer preferences could differ for retail consumers, industrial consumers and international consumers depending on ethnicity, culture and tastes. But grading and sorting at farm level has to be encouraged since it enhances the bargaining capacity of the farmers. To facilitate this and lend credibility, it is further recommended that a certification for "Good Agricultural Practices" by creating an independent agency for certification for domestic sale and exports.

Warehouses

This is well known – but repeated here to emphasize that this can release farmers from clutches of money lenders. There is need to set up warehouses in every block and village cluster and promotion of Warehouse Receipt Financing by crops or products. This will help a) prevent losses, b) release product as per demand avoiding price crash, c) prevent income loss to farmers, and d) help in maintaining the quality of the produce. The bulk buyers can directly buy from the warehouses. The pledging of warehouse receipts shall enable farmers to wait for a better price. He can get a loan from the bank for the next crop or marketing operations, and later shall be able to pay the money electronically to the bank to release the pledge and then sell the receipt

on the same platform. In case of any default by the farmer, the bank is entitled to sell the receipt on the same platform.

APMC Act

The Central Govt. has passed an Act liberating farmers from APMC. The state has modified the APMC Act allowing contract farming and direct marketing. Farming as vital for farmers, particularly for small and marginal farmers and the Agricultural Department need to reach out to Agro and Pharma processing units which are currently procuring from traders to take advantage of the amended APMC Act. MACINS is a success story. It can be replicated for other products.

There is a need for agricultural market intelligence system in the state for all agricultural products, live stock and fisheries. State Departments of Agriculture, Animal Husbandry and Fisheries should provide these services to the irrespective stake holders promptly on regular basis.

Energy Generation and Utilization

Energy generation from agricultural waste has a great potential. Biomass Power and Bagasse Co-generation Programme can be promoted with the aim of recovering energy from biomass including bagasse, agricultural residues such as shells, husks, de-oiled cakes and wood from dedicated energy plantations. Similarly, Biogas and Organic Manure Programme with objectives to provide clean cooking fuel and to meet lighting, thermal and small power needs of farmers/dairy farmers/users including individual households and to improve organic manure system based on bio-slurry from bio-gas plants in rural and semi-urban areas by setting up of biogas plants need to be revived.

Solar Energy to Farmers

India has one of the best policies to promote solar plants at villages to improve farmers' income. Farmers are entitled to sell solar power to the grid for which the Discoms would pay them a predetermined tariff per unit. Though the programme is good, there has not been much progress and there is reluctance on the part of Discoms to buy solar power from small plants located at villages at a fixed price.

The government of India need to find away to resolve this impasse because there are several solar systems installed but not activated in rural areas. There is a need to search and develop innovative usage of solar energy such as for distillation to promote its demand. In fact, the Energy Department needs to give free hand to industries in rural and arid areas to use as much solar energy as possible.

Blue Economy

There is need for creating seawater based ecosystem sustaining on natural resources through developing sea weed cultivation centres across Gujarat's coastal line and providing a boost to the socio-economic development in coastal areas. More specifically this involves the following activities by the State Fisheries Department: 1. Identify the sites for developing the cultivation centres by working along with private ports and local villages; 2. Encourage coastal communities to participate in the cultivation of seaweed; 3. Develop seed banks for selected varieties of seaweed; 4. Provide a boost to private entrepreneurs to manufacture basic and supplemental products to ensure supply of industrial raw material; and 5. Mass-cultivate the selected varieties of seaweed in the open sea to create an industry for the same. This can be done along with development of Aquaculture. The new Fisheries policy provides extensive incentives and support.

Promote Urban Vegetation Cover

Vegetation gets removed in the process of expansion of urban limits and on the periphery of urban centres by developers. This reduces cropped area and CO_2 absorption attributable to vegetation. A clear Urban Vegetation Policy is required that mandates developers and new construction of houses, colonies and townships to: a) recharge rain-water; b) recycle wastewater; and c) create vegetative cover in 40% areas which they are required to keep open.

Tackling Salinity Ingress

Agriculture is under major threat of salinity ingress as the country has huge coastal areas. This is both aboveground and underground. For example, in Gujarat, as per BAISAG, 25 districts, 123 talukas and more than 8,000 villages are affected by salinity ingress. This is affecting water quality. It affects irrigation and root zone of crops and trees resulting into low productivity. This is a major problem which needs to be addressed by Rural Development and Irrigation Department.

Inclusive Development

A. Gender Equity

Govt. has recognized the role of establishing gender equity in the farming and related occupations and has several schemes to empower women. However, the progress on this front has not been satisfactory. The priority is desired in making women and particularly rural women aware about such schemes and about their equal status in the family through specifically targeted training

programmes informing them about climate change related risks and uncertainties, innovations for value additions, nutrition and health for family and their legal rights. Women need to be made aware not to let go their right of inheritance. Further women friendly agriculture tools need to be made available.

B. Accountability – Monitoring and Evaluation

With expansion of existing and new welfare schemes – the farmers have multiple opportunities. But despite this in the same village – with the same land and water resources – one farmer makes profit – while other lags behind – migrates, commits suicide or lives subsistence life. Same is true about villages, blocks and districts. This requires a strong administrative effort by Development Administration to reach out to all. But what it needs further is that tasks are assigned to each functionary – from village to state level is monitored – and communicated lapses and complemented achievements on weekly basis and realization made available to them that their accountability is measured from time to time – and related to their carrier progress and posting.

There was system of Programme Evaluation by Director Bureau of Economics. This should be revived. A start could be made to evaluate 'online' applications in different schemes to identify gaps and plug loopholes.

C. Smart Villages

There is a scheme called Shyama Prasad Mukherjee RURBAN Mission launched by the Government of India in 2016. The COVID-19 pandemic awakens urbanities to take maximum advantage of the scheme since by now all villages are well connected by rail and rural roads, electricity & LPG, mobiles and Wi-Fi, and TV channels. Now the question is how to use all these effectively to create production bases in rural areas and small towns, and meet aspirations of local youth for employment and prevent migration. There is a need for stepping up of smart connections in rural and small town areas by tailoring several elements modularly depending on local conditions and desires of local people. Urban Development Department in collaboration with the IT Department should aggressively implement this recommendation by targeting at least 20% of the potential villages and towns in the next two years. Fund available under New Smart Cities could be diverted here.

Such smart villages can come around existing Industrial Township and big cities. In fact, Urban Development Department should promote them looking COVID-19 adverse impact. There is already Urban Infrastructure Development Board. It may be given targets of smart villages. This will also provide simultaneously livelihood to large number of rural poor families.

Revive *Krishi Mahotsav*

Reinforce *Krishi Mahotsav* Approach which should include various activities such as:

- Village level guidance – by Agri. Team – once in each season – prior to sowing operations.
- Quality inputs to small and marginal farmers
- Activate MGNREGA–
- Cover all animal holders and fishermen under Kisan Credit Card
- Promote FPOs for horticulture crops, poultry, dairy products, fisheries & honey etc. one in each block.
- Promote drip irrigation, bring flood irrigation to minimum.
- Cleaning of canals, old community ponds, silted check damsetc.
- Village level purchase by MSP and APMC and direct purchase by trade/ industry from farmers at farm gate.
- Crop guidance based on soil health and moisture analyses.

Road Map 2020–30

Atmanirbhar Krishi

The Critical Path

- Both Central and State Governments have initiated series of initiatives – which has restructured the Agricultural Sector.
- The role is of State – District – Village level public administration to implement the initiatives. In the arena of Digital Economy, all applications, mutations in land ownership, extension message – need to be done by digital platform. Farmers need not to come to visit office - Mamlatdar, Taluka Development Officer or Dist. Agri. Office. The Village Panchayat can set up online system – for all villagers.
- The other stakeholders – private sector – civil society – cooperative sectors need to act for opening of market – provide farmers access to highest available price and provide information of demand – where they can sell. Similarly they need to provide advisory for adverse weather events.
- Maximum use of solar based agriculture tools – water pumps, driers and use of solar energy for rural electrification.
- Finally, farmers have to realize available support and opportunities. The farmer and his/her family need to realize that they have to increase income

and for that they will have to adapt to modern technology, implement good and climate resilient practices and produce what market needs and sell where they get best price.

- Some critical steps involve – re-introduce *Krishi Mahotsav* approach to have direct contact with farmer at his door-step. Round the year he may contacted and communicated through TV network, radio – social media. But three times in a year the agriculture team need to visit village and solve problems at village level.
- Communications of benefits and opportunities – farmers – but particularly poor farmers who are left out of development process. District Administration must check that they get first of all available subsidies under different schemes and are re-skilled and up-skilled.
- Strengthen climate related services – use actively local cable TV network and to provide weather and agro-advisory on day to day basis.
- Support market operation. Bring private players to directly deal with farmers without middle agents which ensure that there is no glut or excess supply brings down price. This is very important. Legally this has been done.

We can look forward for 10 per cent growth per annum in Agriculture Sector and all-round improvement in quality of life at village level. Reduction in poverty – employment to youth in non-farm sector.

India is emerging as a major supplier in dairy products, poultry, meat and fisheries – apart from vegetables, fruits and flowers and cereals, spices, edible and non-edible oils, ready to eat food, processed food and beverages, healthy food, organic food, tea, coffee, vanilla so and so forth as major agricultural nation.

India can emerge as a major provider of technology related to climate smart and good agriculture.

India rural society and economy will thrive with smart villages, *Atmanirbhar* Farmers and with reverse movement by urbanities to stay in villages to enjoy the environment. Rural India will emerge as sustainable – economically, socially and environmentally, and that will be in true sense *'ATMANIRBHAR'*.

•

Sustainable and Resilient Agriculture During and After Pandemic

• Dr. Govind Hariharan •

Introduction

Agriculture is a key sector in India providing employment to over half of its 1.3 billion people but accounting for less than one fifth of its GDP. Agriculture has also been a sector beset with challenges of providing a sustainable living to many of its predominantly small farmers. Lack of accurate predictions regarding amount of rainfall, natural disasters and crop prices during critical pre planting and harvesting seasons are uncertainties that farmers in India and elsewhere have been familiar with. Unexpectedly poor or excessive rainfall, earthquakes and cyclones, volatile global agricultural prices can and do have disastrous consequences to the health and wealth of agriculture reliant families. The impact on small farmers with insufficient savings for "rainy day" funds can often be irreversible and catastrophic.

Planning for the planting season is often based on the assumption that while the occurrence of an event is not known, the risk or probability of such an event is known (known-unknown). Uncertainty as opposed to risk refers to situations in which even the risk or probability of an event such as poor rainfall and the potential damage is unknown (sometimes referred to as an unknown-unknown). The difficulty in planning under conditions of uncertainty and the resulting impact on income often makes planting and harvesting decisions worse than a gamble and a sheer prayer for good conditions. Layer on top of these uncertainties, new ones pertaining to the future potential impact of climate change and pandemics such as the current COVID-19, the need for a framework to address agricultural planning under uncertainty is critical.

Planning for Uncertainty

In recent decades there has been increasing attention paid to measuring benefits, costs and risks when there is uncertainty. In the context of Climate Change, for example, the wide range of estimates on these prompted a call for addressing the uncertainty inherent in evaluating the benefit, risk and costs of various proposed measures to address climate change. One approach that has received a lot of attention was the Precautionary Principle which was a suggested framework for evaluation of policies to address the impact of catastrophic or irreversible events about which little is known with certainty. This approach suggests that when there are potential harms to health (climate)

precautionary actions should be taken even when precise scientific evidence does not exist since the harm to health (climate) may be irreversible.

Similarly, many regulatory actions undertaken by government agencies such as Occupational Safety and Health Administration and Environmental Protection Agency have developed approaches to uncertainty in the evaluation of such regulations. The US Food and Drug Administration (FDA) faced with uncertain or unclear evidence or measurement particularly in evaluating new drugs or medical devices for fast track approvals has in recent years been developing guidelines for conducting benefit-cost or benefit-risk studies under uncertainty.

In the context of pharmaceutical drugs for instance, Woodcock and Frey of the FDA, point out that scientific uncertainty can arise from a) Human variability- clinical trials may not capture real world heterogenous populations, b) clinical trials process- the trials may not capture what happens in the long run or may produce varying results, c) post market concerns- variability in post market data and health systems management of risky drug, and d) uncertainty- scientists may not know what to study, what data is missing and has been a major source of safety controversies.

The traditional or most prevalent approach to evaluating future harms and or benefits of actions or events is to use the "known unknown" or risk approach of calculating the expected harm (benefit) as the known Probability of the harm (benefit) occurring times the known Size of the Harm (benefit).

Expected Harm = P (Harm)* S (Harm)

But often, the probability P and or all the potential harms S are themselves not known prompting a call for an "unknown-unknown" or an uncertainty approach to calculating the potential harm (benefit). If there are say n distinct distributions of harm occurrence but it is not clear which of them is the true distribution, it may be feasible to calculate a very Probability of a Probability but that will entail a lot of imprecision and a very wide range of values.

Insurance to Address Risk in Indian Agricultural Income

When risk in income is measurable and diversifiable, the private markets for various insurance products abound that can bring about stability in income. That is also the case with some sources of fluctuations in Agricultural income such as crop prices. In order to ensure that access to such markets and the high cost of insurance premiums, the Indian Government has traditionally provided subsidized insurance products for many decades. In order to address the shortcomings of previous approaches, a more comprehensive agricultural insurance program called the *Pradan Mantri Fasal Bima Yojana* (PMFBY) was

introduced in 2014 after much study, with a significant premium subsidy from Union and State governments.

The PMFBY approach has been a sound mechanism to reduce downward fluctuations in crop income under risk but has been a very expensive programme. According to Mr. M.S. Pillai writing an opinion column in The Hindu, "Currently, crop insurance is the third-largest portfolio in the non-life insurance industry. The premium outgo at a gross level for 2016-17, 2017-18 and 2018-19, respectively, was approximately Rs. 22,015 crore, Rs. 26,065 crore and Rs. 29,065 crore. Gross loss ratios were at 78 per cent, 89 per cent and 100 per cent, respectively. In 2018-19, the total number of farmers covered was 56.4 million, with a gross cropped area coverage of about 30 per cent. Further, the premium for 2019-20 is estimated at Rs. 31,500 crore, with the gross claims ratio being over 100 per cent for kharif crop."

Policies to Address Uncertainty in Agricultural Income

Agriculture as an essential industry appears to have been impacted much less than many other industries by the unanticipated COVID-19 Pandemic. On May 2nd, 2020, Prime Minister Modi convened a select group to discuss ways to further reform in agriculture post pandemic. From Credit to infrastructure and marketing a wide range of issues were discussed with small and marginal farmers being an area of focus throughout. While this pandemic appears so far to not have had a significant deleterious impact on agriculture, this is a time to plan for future pandemics and catastrophic events. Private Insurance markets have traditionally been unable to provide reasonable insurance products when faced with uncertain regarding irreversible and catastrophic events such as with a Pandemic or Climate Change. This is true not just in India but globally as well. Some possible approaches for preparing and developing sustainable and resilient income for farmers include:

1. **Diversification of Family Income:** If there is likely to be variance in impacts across sectors, encouraging growth of opportunities for members of farming households to engage in alternative industries in addition to farming. This requires not only providing training to family members through Public-Private Partnerships but also encourage the location of alternative industries including manufacturing in areas adjacent to Farmlands.
2. **Technological Innovation in Agriculture:** In order for the diversification mentioned above to be effective without being detrimental to agricultural production, agricultural productivity needs to be enhanced through an emphasis on technological innovation, not only in superior and disaster resilient seeds but productivity enhancing technology as well. Such innovation

must also be reverse scalable so that it is beneficial to small farmlands as much as it is to large farmlands.

3. **Access to the Latest information:** While it may be impossible to avoid catastrophic events that occur without much prior warning, the sooner available information can be transmitted to the farmers on the ground, the more rapidly they can undertake measures to reduce harm. Much has been done in providing speedy weather forecasts etc., but more can be done.
4. **Planning Scenarios:** The participants in the agricultural sector should be trained in scenario based planning for resilience and mitigation. Under conditions of uncertainty, modeling and understanding how to manage different scenarios where they to occur can be of immense help in reducing damage if such a calamitous event were to arise.
5. **Stress Testing:** And lastly, just as banks and other financial institutions are stress tested for their ability to cope with a catastrophic event, every element of the agricultural sector needs to be stress tested on their ability to cope with such an event. Lessons from the stress tests can provide further guidance on which link in the food chain needs to be strengthened. One weak link can bring down the entire industry.

•

Impact of Climate Change, Adaptation and Mitigation on India's Agriculture

• O. S. Mbuya, K. N. Shelat, A. Anandhi, N. C. Patel and I. Mani •

Abstract

Agriculture is highly dependent on climate and inherently sensitive to climate change. The effects of climate change on agriculture are complex and difficult to predict, posing unprecedented challenges to farmers, researchers, educators, agricultural extension agents and policymakers. Climate change directly or indirectly affect agricultural producers as well as consumers, and the future of India's agriculture. Finding ways to prepare for and respond to changes in climate requires research, education, extension and outreach, risk management and strategic planning. The vulnerability of agriculture to climate change is strongly dependent on responses taken by humans to adapt and mitigate its effects and impact. Adaptive actions would offer the potential to manage the effects of climate change by altering patterns of agricultural activities to capitalize on emerging opportunities while minimizing the costs associated with adverse effects. The aggregate effects of climate change will ultimately depend on a complex web of adaptive and mitigation responses to local climate stressors. These adaptive responses may range from farmers adjusting planting patterns and soil management practices in response to more variable weather patterns, to seed producers investing in the development of drought and heat tolerant varieties, to increased demand for Central risk management programs, to adjustments in international trade as nations respond to food security risks. Understanding the complexities of such interactions is critical in developing effective adaptive and mitigation strategies. As global climate changes, sustainable food systems should be built on climate-smart agriculture based on science and technology.

Keywords:

Agriculture; Climate; Climate change; Monsoon; Adaptation; Mitigation; Temperature; Precipitation; Heat stress; Risk; Assessment; Management; Drought; Agro-climatic zone

Introduction

India's climate is generally characterized as monsoon type, but it ranges from tropical in the south to temperate and alpine in the north (close to the Himalayas). Fortunately, India has a climate that is ideal for agricultural production throughout the year. Major crops grown in India can be divided

into four major categories, namely, i) food grains (rice, wheat, maize, millets and pulses), ii) cash crops (cotton, jute, sugarcane, tobacco, and oilseeds), iii) plantation crops (tea, coffee, coconut, and rubber) and iv) horticultural crops (fruits and vegetables). Livestock and livestock products constitute a significant part of the agricultural sector as cattle (and calves) and dairy products are important source of revenue in India's livestock industry. Other agricultural sectors include poultry (broilers and eggs) and aquaculture (aquatic plants and fish). Agriculture is the largest sector in India's economy, followed by industry and service sectors. The Union budget of India of 2017/18 gave very high priority to the agricultural sector, targeting to double farmers' income by 2022.

Two major climatic drivers that have major direct effect on agricultural production are temperature and precipitation. All climate models show a trend of general warming in mean annual temperature as well as decreased range of diurnal temperature and enhanced precipitation over the Indian subcontinent. Greenhouse gases (GHGs) are a precursor to modification of atmospheric air temperature. India is both a major GHG emitter and one of the most vulnerable countries in the world to projected climate change (National Intelligence Council, 2009). India's average temperature has increased by 0.6 °C between1910 and 2018, and temperatures are expected to continue to rise by another 0.5 °C by the year 2030. The IPCC (2014) projected that for Indian region, temperature will increase by 0.7–2.0 °C by 2030s and 3.3–4.8 °C by 2080s.

A warning temperature increase of 2–4 °C is projected by the end of this century (National Intelligence Council, 2009). Some states have warmed more than others, some less, and some not much at all. For example, Central India (Madhya Pradesh) has been warming relatively faster than other regions. In general, the average temperature change data in India has shown that the entire country has warmed considerably compared to 20th Century average temperature. The country is already experiencing changes in climate and the impacts of climate change, including water stress, heat waves and drought, severe storms and flooding, and associated negative consequences on health and livelihoods.

Climate change predictions for rainfall have shown an increase in extreme rainfall intensity with greater increases near the coast and lower increases inland (Wang et al., 2013). Frequency and amount of rainfall have direct influence on available water for irrigation as well as the amount of irrigation needed to produce a crop. Rainfall that occurs with greater intensity may result in runoff thereby reducing the amount of rain water that can be used by plants due to the low water holding capacity soils. Shorter wetter periods and longer dry spells is another observed pattern associated with climate change. Very heavy rains within a short period of time can cause crop damage due to hail,

flooding and soil erosion, whereas longer dry spells can cause crop failure without supplemental irrigation. Adequate and fairly distributed rainfall throughout a growing season is important for agricultural production, especially for rain fed agriculture.

Indian farmers have reasons to be concerned about climate change since subtropical and coastal areas rank among the most vulnerable. India fits in these two criteria. Most of the crops and livestock produced in India are very sensitive to temperature and rainfall variability caused by climate change, in addition to cyclones and other extremes events. Although the mean annual temperature in India is about 26 °C, summer temperatures soar well above 46 °C, the critical point affecting crop yield and quality. High night temperatures have the potential to reduce crop yield due to flower abortion for some crops, especially vegetables and fruit crops. Temperature is also a driving force behind insect development, growth and behavior. Generally, high temperatures and humidity have the potential to increase the incidence of diseases and insect pests, thus affecting crop and livestock production. Some part of India are hot and humid, creating favorable environment for both insect pests and diseases. The cost of cooling greenhouses and barns used to raise livestock, especially poultry increases with high atmospheric ambient temperatures.

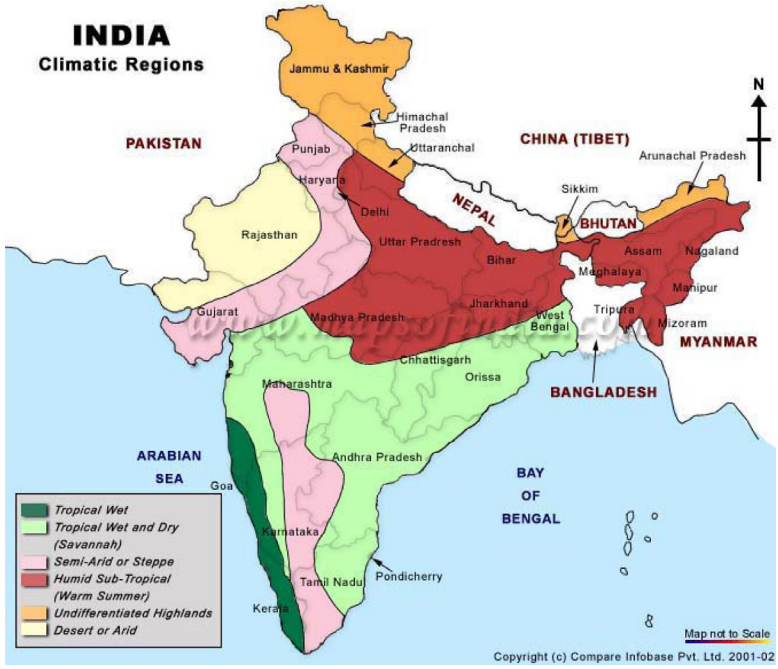


Figure 1. Map of climatic zones of India. (Adapted from Compare Infobase Pvt. 2001-02).

Extreme rainfall events are evident throughout India causing floods, soil erosion, excessive nutrient leaching and crop damage. There is meteorological evidence that India is experiencing stronger cyclones (severe tropical storms) due to climate change. The adverse impact of cyclones to India's agriculture cannot be overstated. For example, strong cyclones caused by climate change have the potential to rip through some of India's richest agricultural land, inflicting hundreds of millions of rupees in damages. Strong cyclone winds can destroy cash crop fruit trees, shatter greenhouses, smash barns, farm implement sheds and fences on farms and cattle ranches causing damages to crops, livestock and property, and sometimes death to livestock and humans. Like cyclones, thunderstorms, and wildfires, drought is part of climate change in India. Drought is a difficult concept to define, but it is typically defined as a prolonged period when there is a precipitation deficit from normal values. However, what is important in defining a drought is the duration of these below normal precipitation amounts and their impacts. Drought can affect water supplies, agricultural production, and fire danger levels and it is measured on the basis of the severity of its impact. Indian farmers must be provided with better weather forecast so that they can be prepared to adapt for the different types of drought.

Since India cannot immediately change the changing climate, it is incumbent upon our collective actions to find ways and means of adapting to climate change and mitigate its impact on agricultural production and food security. The vulnerability of India's agriculture and food security must be addressed accordingly based on science and technology. Involvement of scientists, policymakers, extension agents and farmers at all stages of agricultural planning and production is not only imperative but compelling.

The following sections will briefly discuss the potential impact of climate change in agricultural production, risk assessment and management, adaptation and mitigation strategies. Knowledge gaps and recommendations for future research and development (R&D) have been suggested accordingly.

Crop and Livestock Production and Productivity in India

India has the largest farmland (179.8 m ha) in the world followed by the United States (167.8 m ha). Approximately 82.6 m ha of India's farmland are under irrigation, the largest in the world. Agriculture sector accounts for 88.1% of total water consumption in India (TERI, 2017). Of the net sown area of around 140 m ha close to 68.4 m ha is irrigated. The rest is rain-fed with 9 m ha under drip and sprinkler irrigation (Anonymous, 2019). Groundwater in India provides about 60% of the country's irrigation needs (CGWB 2018). The generous

allocation of water to agriculture and the rapid growth in from other sectors is adversely impacting the water budgets and the environment in river basins. The production systems in the Indus and Upper Gangetic Plain are currently under hydro-stress due to over exploitation (Tyagi, 2017). The Indus, Cauvery and Krishna River Basins have reached the state of physical scarcity (Amarsinghe et al., 2004). The degree of surface water diversion (SWD) from the river systems as well as the level groundwater abstraction ratios (GWAR) have already crossed desirable limits. India's agriculture is very diverse contributing several hundred commodities to national and international markets. The diversity of India's agriculture is mainly attributed to the geographic location of the country and its varied climate (tropical to temperate). India's agriculture is typically rain fed and irrigated due to the wet and dry season climate in the country. Horticultural crops are predominantly irrigated. Although India has made tremendous strides in modern agriculture through the Green Revolution, today crop yields (production) and productivity (yield per unit area) of most crops are still lower than those in the United States, Europe and China. Key areas of potential improvement include, i) soil health, ii) efficient irrigation system/ water use efficiency, iii) comprehensive integrated fertilizer management, iv) integrated pest management (weeds, insects and diseases), v) seed quality, vi) post-harvest losses, vii) energy and viii) general good crop husbandry through extension and outreach. All these improvements are possible through science, technology and government policy.

3. Climate Change and Agriculture

Agriculture is vulnerable to a number of climate-driven events, including sea-level rise and catastrophic floods, drought, heat waves, winter storms, tropical cyclones, and tornadoes (Rosenberg, 1993; Ingram et al., 2015). While very heavy rains and flood can cause crop damage and loss, drier climatic conditions from decreased precipitation or increased evapotranspiration due to increased temperatures can lead to a drier landscape (Budny and Benscoter, 2016) and crop failure. These climate changes can impact agriculture through changes in the plant growth and development; crop yield and quality; increases in insect pests, diseases and weeds; livestock production and finally put the economy at risk.

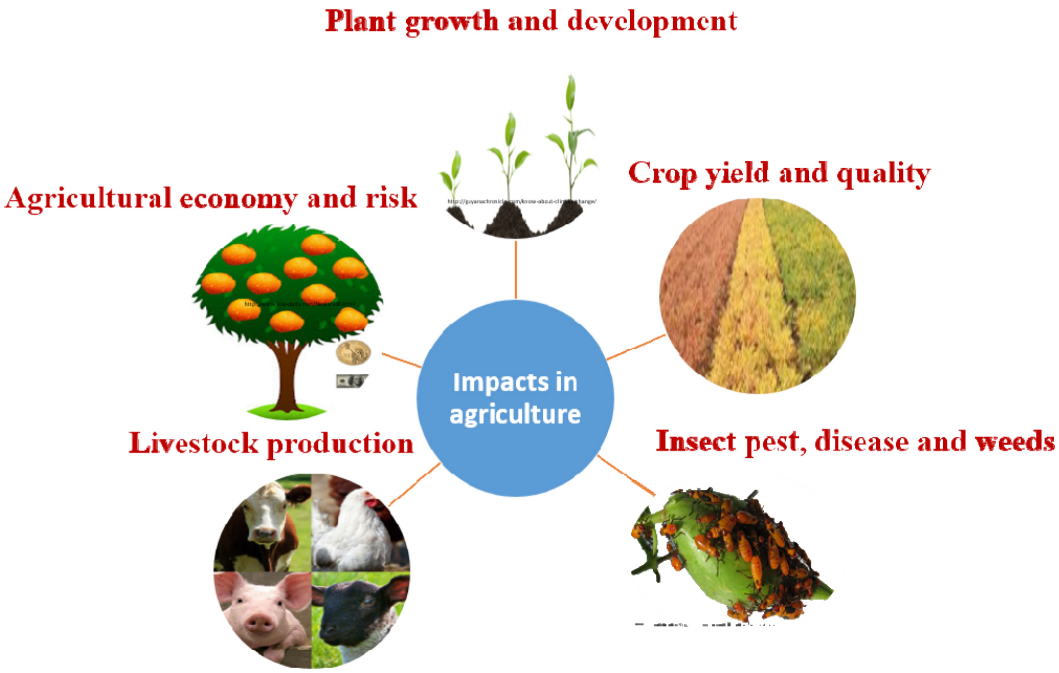


Figure 2. Various impacts of climate change on agriculture.

3.1 Plant Growth and Development

Rate of plant growth and development is primarily dependent on surrounding temperature (Hatfield and Prueger, 2015) and soil moisture due to rainfall and/or irrigation. There are temperature ranges for different plant species specified as minimum, maximum and optimum for growth and development. Plants are affected differently by temperature at different growth stages, and response to temperature differ among crop species (Prasad et al., 1999, 2001, 2002, 2003, 2006a, 2006b, 2008; Hatfield et al., 2008, 2011). Most crop species can survive sustained high temperatures of relatively narrow range of 40 to 45 °C. At temperatures beyond 45 °C, enzyme systems and cell membrane of most plants start to fail and potentially cause death (Abrol et al., 1991). Although the average annual temperature in India is approximately 26 °C, maximum temperatures in summer (approximately 46 °C) in several climatic zones are above the upper limit for plant growth and development. High night temperatures in India also have the potential to negatively affect flowering of certain crops and consequently lower crop yield.

Changing rainfall pattern impact the length of a wet/dry spells and cyclones, while the changes in temperature impact the length of a warm/cold spells, cardinal temperatures, frost dates (spring and fall), and growing season length (Anandhi and Blocksome, 2017). These changes impact crop growth and

development. Increasing temperature could also significantly alter plant phenology because temperature influences the timing of development, both alone and through interactions with other factors (e.g. photoperiod). Changing temperature and rainfall impact frost dates and growing season length which indirectly impact crop growth and development (Anandhi et al., 2013a; Anandhi et al., 2013b). Temperature impacts the crop's phenology (various stages of crop growth and development) differently with some stages affected more than others.

3.2 Crop Yield and Quality

Yield responses to temperature vary among crop species based on their temperature requirement. In general, temperatures warmer than the crop requirement will cause faster development, resulting in a shorter life cycle, smaller plants, shorter reproductive duration and consequently lowering yield potential. Many crop species are most affected by high temperature during their reproductive stage. For example, pollen viability of corn greatly decreases with temperatures above 35 ^{o}C, thus reducing grain yield (Herrero and Johnson, 1980; Schoper et al., 1987; Dupuis and Dumas, 1990). Maize (corn) kernel growth rate and size were reduced when air temperature was increased from 30 to 35 ^{o}C (Jones et al, 1984; Commuri and Jones, 2001; Kim et al., 1996). Rice and sorghum have exhibited similar sensitivities of grain yield, seed harvest index, pollen viability and success in grain formation (Kim et al., 1996; Prasad et al., 2006a, 2006b).

Based on the scientific literature available today, India is one among the countries that will be greatly affected by elevated temperature due to climate change. In a study it was found that even a rise of 1 °C in the mean temperature in month of March-April leads to reduction in the duration of wheat crop by seven days and yield by about 400 kg per hectare (Singh et al., 2011). Similarly, another analysis carried out for IGP indicates that with each 1 °C temperature rise there is risk that we may lose around 4–5 Mtons. of wheat production (Aggarwal, 2008). An increase of 3 °C in temperature, the loss is projected to be 19 Mtons. and with 5 °C increase, it will be around 27.5 Mtons. (Aggarwal and Rani, 2009). As temperatures increase during the next century, shifts may occur in crop production areas because temperatures will no longer occur within the range or during the critical time period for optimal growth and yield of grain or fruit (Walthall, 2012). Temperature and rainfall changes present unprecedented challenges to the adaptive capacity of agriculture by influencing crop distribution and production and by increasing the economic and environmental risks associated with a multitude of agricultural systems (Walthall, 2012).

Water supply for crop use is the primary factor controlling crop yield (Frank et al., 2013). Plant water requirements vary by development stage. Water stress occurring during different development stages of a crop may reduce final grain yield by different degrees, and the extent of yield reduction depends not only on the severity of the stress, but also on the stage of plant development (Çakir, 2004). For example, one day of moisture stress within a week after silking in maize can result in up to 8% yield losses, whereas a period of 3 to 4 days of severe moisture stress at this time can easily reduce final grain yields by 30% (Duncan et al., 2010). With water supply varying as production systems range from dryland through irrigated agriculture, selecting hybrids for optimum yield in the anticipated water environment is vital (Frank et al., 2013).

3.3 Insect Pests, Diseases and Weeds

Increased temperature due to climate change have the potential to increase the impact of crop insect pests by improving their survival, development, geographic range, and population size (Bale et al., 2002; Petzoldt and Seaman, 2010). High temperatures also have the potential of accelerating the growth and development of most crop insect pests, resulting in more generations per year and more crop damage. Lower winter insect mortality due warmer temperatures could be important in increasing insect populations (Harrington et al., 2001) and diversity. Warmer winter and spring seasons in India would likely increase the growing season and so reproduction of pests, including more generations of insects in each growing season. This could reduce the overwintering time of insect and increase their survival and time to attack crops. India climate is already suitable for most insects, but warmer winter and springs could probably increase damage to early season crops.

3.4 Livestock Production

Livestock and livestock products constitute a significant part of the agricultural sector in India. Most of the livestock produced in India are sensitive to temperature and rainfall variability caused by climate change. Cyclones and other extremes events of heat and cold, as well as extremes of drought and flooding which would potentially cause severe crop (used as livestock feed) and livestock damage. Heat stress is a major cause of lost production and lost profits in cattle (and dairy), poultry and swine production in tropical and subtropical areas. Dairy cows are particularly sensitive to heat stress, and the dairy sector has been estimated to bear over half of the costs of current heat stress to the livestock industry. For example, greater heat stress may lower milk production 0.6-1.3 percent by 2030.

4. Water Resources and Agriculture

Water is paramount to life and agricultural production. Less than 1% of all waters (surface and groundwater) on this planet is potable (Table 1). Approximately 70% of the potable water (<1% of total water) is used in agriculture for food production. A lot of water is required for crop production, as a plant uses up to 500 liters to produce 1 kilogram of biomass. Survival of any nation will largely depend on how efficient it manages its water resources. There is no doubt that water (quantity and quality) is a very scarce commodity in India and the world at large. Efficient use of water for any reason and activity cannot be overemphasized. India has the largest irrigated cropland in the world, but not the most efficient in terms of water use. Major improvements are required for efficient irrigation systems.

Table 1. Estimate of Global Water Distribution

Water source	Water volume (cubic miles)	Water volume, (cubic kilometers)	Percent of fresh water	Percent of total water
Oceans, Seas, & Bays	321,000,000	1,338,000,000	--	96.54
Ice Caps, Glaciers, & Permanent Snow	5,773,000	24,064,000	68.7	1.74
Groundwater	5,614,000	23,400,000	--	1.69
Fresh	2,526,000	10,530,000	30.1	0.76
Saline	3,088,000	12,870,000	--	0.93
Soil Moisture	3,959	16,500	0.05	0.001
Ground Ice & Permafrost	71,970	300,000	0.86	0.022
Lakes	42,320	176,400	--	0.013
Fresh	21,830	91,000	0.26	0.007
Saline	20,490	85,400	--	0.006
Atmosphere	3,095	12,900	0.04	0.001
Swamp Water	2,752	11,470	0.03	0.0008
Rivers	509	2,120	0.006	0.0002
Biological Water	269	1,120	0.003	0.0001

Source: Igor Shiklomanov's chapter

Peter H. Gleick (editor), 1993, Water in Crisis: A Guide to the World's Fresh Water Resources (Oxford University Press, New York).

(Percentages are rounded, so will not add up to 100%)

5. Irrigation

Irrigation is application of water to plants by humans. The International Panel on Climate Change (IPCC, 2001) indicated in their report that there is medium confidence that drought will intensify in the 21th century in some seasons and areas, due to reduced precipitation and/or increased evapotranspiration. With that in mind, irrigation can be considered as a potential alternative for reducing the risk of yield losses especially in soils with low water holding capacity as found in India. While irrigation requires considerable investment over dryland production, it can also result in considerable increase in yields and profits. However, irrigation management must be as efficient as possible to avoid losses and groundwater contamination. Center pivot, micro and subsurface irrigation systems require different investment costs and management practices compared to stream/channel and flood irrigation.

5.1 Micro or Drip Irrigation

Micro-irrigation is the slow, frequent application of water directly to relatively small areas adjacent to individual plants through emitters placed along a water delivery line. Water is generally conveyed in low-pressure, flexible plastic tubing. Generally, water must be of high quality to avoid clogging the small emitters; this is often managed with filtration and occasional chemical treatments. A leading advantage of drip irrigation is that non-beneficial evaporation meaning evaporation of water from soil surfaces and plant canopies that does not contribute to plant growth is greatly reduced when compared to sprinkler irrigation (Zotarelli et al., 2015). With subsurface drip irrigation (SDI) water is applied below the soil surface through drip line laterals that are installed at a depth of 30-45 centimeters (12-18 inches). Tillage, planting, and other field operations are not impeded by laterals because they are established at a sufficient depth to allow for field operations and long term use. Emitter flow rates for subsurface irrigation are generally less than 11.5 liters (3 gallons) per hour. SDI can have a useable lifetime of up to 20 years, making it the most economically competitive with center pivot irrigation of low-value commodity row crops (Lamm et al., 2010).

5.2 Center Pivot Irrigation

Center pivot irrigation consists of a galvanized steel lateral that rotates in a circle around a fixed point (pivot) in the center of the field. The lateral is supported above the crop on A-shaped steel frames using cables and trusses. Sprinklers are used to distribute the water across the field, as the area to be irrigated increases towards the end of the outer end of the lateral varied size or spacing of sprinklers is used to gradually increase the water application rate.

Variable-rate irrigation is an innovative technology that enables a center pivot irrigation system to optimize irrigation application. Most fields are not uniform because of natural variations in soil type or topography. When water is applied uniformly to a field, some areas of the field may be overwatered while other areas may remain too dry. Some farmers manage these individual zones by excluding these problematic areas from the acres cropped. However, variable rate irrigation technology gives farmers an automated method to vary rates of irrigation water based on the individual management zones within a field (Perry et al., 2015). Using a variable rate system can reduce the total irrigation water volume required to grow field crops in two ways. First, producers can exclude non-cropped or marginal areas from water application, and second, producers can lower application rates in low-lying areas or in soils with high water-holding capacity. Center pivot irrigations systems are suitable for large row crop farms (e.g. maize, wheat, sorghum, cotton).

6. Agricultural Economy and Risk

Although natural sciences can tell us how greenhouse gases may affect our climate and, in turn, our agro-ecosystems, we need economics to help us judge how important it may be to avoid or to cope with those consequences. Central to climate change decision making in the decades to come will be a weighing of the economic costs of adaptation against the residual damages of no action. Agriculture is one of the most important economic resources in India.

India's farmers will choose whether to adapt to climate change impacts, that is, whether to make investments today to offset negative impacts and to take advantage of positive ones in the future. The economic problem that climate change poses for India's farmers will be to raise their productivity and incomes, even as they cope with temperature and precipitation patterns that are increasingly likely to be unfavorable. To an extent, farmers have always tended with fluctuating weather and climate, and some of their tactics (as discussed in previous sections of this chapter) have been to alter animal management, fertilization, crop species, and to expand irrigated acreage. Such time honored approaches have allowed agricultural productivity to grow in impressively and unabated.

Unfortunately, climate change is unlike anything we have experienced before. An important source of information on historical assessments of climate and its social and economic impacts is the National Climate Assessment (NCA): a national, ongoing effort administered by the U.S. Global Change Research Program to assess the effects of climate change. It focuses on regions (e.g., Southeast) and sectors (e.g., agriculture) of interest. The most recent NCA report (2014) has concluded that climate change "is already affecting the American

people in far-reaching ways". As the NCA informs us, the nature of climate change is that the future will be unlike the past in the degree of coping we must undertake. So, a few questions arise:

1) Given that our agricultural systems are adapted to local resource conditions, including climate, will our adaptations take the form of relatively minor changes in inputs (e.g., crop varieties) or more substantial changes in technology (e.g., expansion of irrigation acreage)? If climate change renders our historical agricultural practices infeasible, then changes of the latter sort will be necessary, which are not only more costly but depend on local resource availability. In short, while a warmer climate may increase water demands, there may not be enough cheap water for everyone.
2) How will producers in rival producing regions be affected by climate change? Most agricultural commodities are traded on international markets. Not only will India growers be adapting to climate changes, but they will also be competing against growers elsewhere making their own adaptations. When we consider the economic prospects for, say, India's rice growers in the coming decades, we must consider our own climate but cannot overlook those of China, Malaysia and other rice growing countries.
3) How easily can workers and other resources move out of agriculture and into other sectors?
4) How will farmers cope with increased volatility? Rising temperatures are already having a discernable effect on production, and climate impacts on yields and prices are expected to increase (Lobell et al., 2013; Hatfield et al., 2011; Lobell et al., 2012). Even farmers already accustomed to production and market risk will need to become more resilient to more frequent and intense weather events.
5) How rapidly will our climate be changing? Adaption can work wonders but cannot occur overnight. At least initially, Indian farmers will adapt as they always have, by changing crops, altering tillage practices, or applying pesticides. Eventually, however, adaptation will become infeasible as the physiological thresholds of plant and animal species will be exceeded (Antle et al., 2004). Faster climate change would also mean that physical capital, and the technologies embodied in them, will depreciate more rapidly and become obsolete, raising growers' adaptation costs. Public and private sector investments are needed in the research and development of technologies that can transform agriculture. In addition, even if the technology to adapt exists, the social and economic capacity to adapt likely varies. Knowing that agricultural technologies may take decades to go from inception to implementation, such R&D efforts should prudently begin now.

Although some countries and regions will likely fare better than others against climate change, Indian farmers do have reason for concern, since semi-tropics and coastal areas rank among the most vulnerable areas (Antle, 2008).

India's agriculture has a long history of successful adaptions to the vagaries of weather and climate. However, climate change poses a challenge that is unprecedented in its magnitude and pace. As with any major change in global agricultural markets, the winners will be those who are able, with the help of their government and industrial leaders, to recognize and take advantage of opportunities and to cope with losses.

7. Adaptation Strategies

Adaptation is defined as "adjustment in ecosystem management in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC, 2001). The three levels of adaptation are i) incremental adaptation, which refers to changes in practices and technologies within an existing system (Kates et al., 2012), ii) systems adaptation, these are changes to an existing system, such as new crop types which are mapped against an increasing degree of change (Anandhi, 2016), and iii) transformational adaptation, which refers to the more radical end of a spectrum of change such as a change in land use.

The challenges in developing the adaptation strategies are: i) complexity in developing the strategies because of its sensitivity to spatial and temporal scales, with some strategies being more scale dependent than others, and ii) multi-disciplinary nature of the agro-ecosystems and its adaptive management. Understanding this nature requires biophysical, socio-economic and/or behavioral change information. The four pathways in agriculture involving nodes such as variables (inputs), indicators, models and concepts such as adaptation. Variables and adaptation (concept) are the two ends of pathways. Depending on the intermediate nodes (presence/absence of both nodes, or either of one of the nodes), models and indicators there can be four pathways (Figure 3).

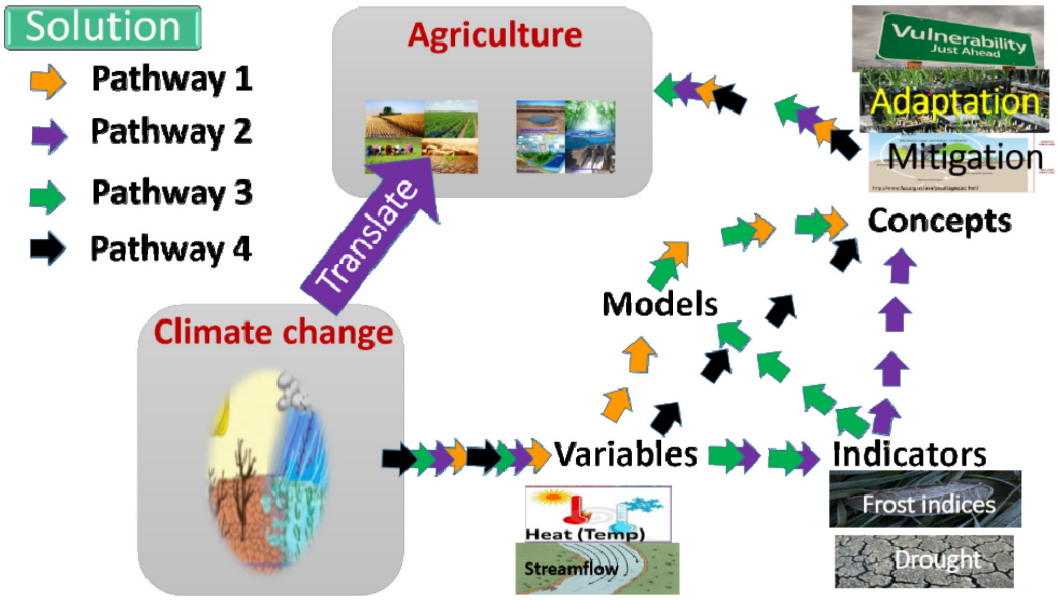


Figure 3. An overview of the four pathways for adaptation. The four pathways in agriculture involving nodes such as variables (inputs), indicators, models and concepts such as adaptation. Variables and adaptation (concept) are the two ends of pathways. Depending on the intermediate nodes (presence/absence of both nodes, or either of one of the nodes), models and indicators there can be four pathways. (Adapted from Anandhi, 2016)

7.1 Use of Agro-Meteorological Indicators for Adaptation

Effective adaptation depends on an understanding of projected climatic changes at geographic and temporal scales appropriate for the needed response (Anandhi et al., 2016). The complexity in developing the adaptation strategies, the multidisciplinary nature of adaptive management of ecosystems, and the knowledge gap existing in translating the biophysical information into adaptation strategies limit our understanding of "how to adapt" with regards to ecosystems. The indicator based methods can be used to address some of these challenges and improve our understanding of "how to adapt" by translating the biophysical information into adaptation strategies. In this method - Adapting agriculture to climate change and variability can be obtained by translating agriculture to concepts such as adaptation/vulnerability, representing climate change using variables and later to indicators (Figure 3). Finally translating the indicators/ variables to concepts such as adaptation (Figure 4).

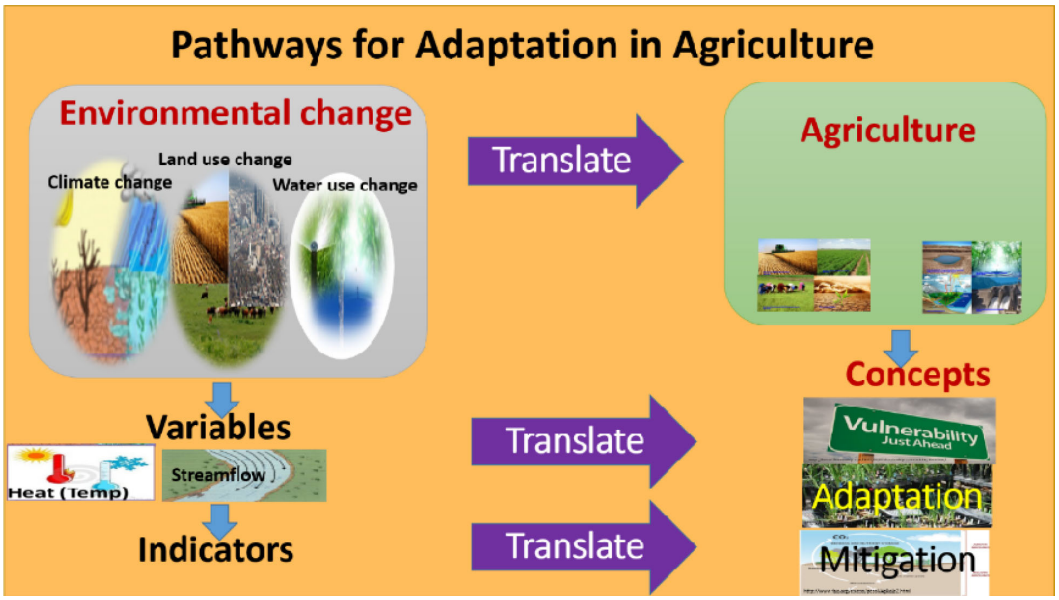


Figure 4. An overview of pathways for adaptation. The figure explaining the general methodology to translate environmental change to adaptation in agriculture using variables, indicators, concepts. (Adapted from Anandhi, 2016).

Indicators characterize the drivers, processes and connectedness in the three interrelated systems. Indicators are identified and selected to represent the complexity among and within the three systems namely: adaptation planning and management systems, agricultural systems, and the climate systems (Anandhi et al., 2016). Using indicators is valuable because; 1) indicators are powerful tools to communicate technical data in relatively simple terms which portray the interrelationships among climate and other physical and biological elements of the environment to help reveal evidence of the discernible impacts of change (Kadir et al., 2013); 2) indices often provide important insights on the factors, processes, and structures that promote or constrain adaptive capacity; 3) the index-based approach is also valuable for monitoring trends and exploring conceptual frameworks (Deressa et al., 2008; Luers et al., 2003); and 4) indicators are useful in combining both hard and soft thinking systems approach. For example, the data on low temperature variable can be used to represent the frost effect processes (measured/observed) using frost indicators (hard thinking). The definition of a frost day may be defined based on a threshold temperature (say = 0 ^{o}C, hard thinking approach). The definition may also be based on a combination of factors such on the type of crop, stage of crop growth, region, soil type and water availability, and some cases the relationship between these factors can be dependent on perceptions (soft

thinking). Also while combining various components to explain the processes/ drivers that are highly dependent on context and purpose (soft thinking). This will be dealt with by using one or more indicators to represent an element or combination of elements. Current studies use scientific methods and disciplinary specialization which has provided us with an enormous database on the biotic and a biotic composition of systems, often lacking the systems large scale interactions. The conceptual modeling framework for AS is based on the fact that hard system and soft system thinking using indicators are useful in represents the triple complexity of adaptive management of AS with regards to changing climate. Biophysical elements are emphasized in this study, and the methodology can be applied to include other elements as well.

Although differences of opinion about climate projections and the severity and timing of the potential effects of climate change will continue to exist, there is consensus that the occurrence of extreme weather events such as extreme rainfall events and droughts are likely to increase. A recent study by Dourte et al. (2015) demonstrated a significant decrease in the return period of months in which greater than half of the monthly total rain occurred in a single day in the Southeastern United States. The variability in spring and summer rainfall increased during the last 30 years, while winter and fall showed less variability in seasonal totals. In agricultural systems, rainfall is one of the leading factors affecting yield variability; so it can be expected that more variable rainfall and more intense rain events could bring new challenges to agricultural production. Preparing agricultural producers to adapt to expected changes is of paramount importance to the long-term sustainability of agricultural production in India.

Adapting to climate change can be achieved through a broad range of management alternatives and technological advances. While decision making in agriculture involves many aspects beyond climate, including economics, social factors, and policy considerations, climate-related risks are a primary source of yield and income variability. Researchers and Cooperative Extension Services must play a proactive role to cogenerate necessary responses and technologies that farmers will need to handle such future challenges. In addition to improving and/or developing management practices and technologies, it is also important to increase the climate literacy of extension faculty and producers and develop climate information and decision support systems to help the industry mitigate risks associated with climate variability and change.

Several management practices can help adapting and increasing the resilience of agricultural production systems to climate variability and change. Many aspects related to vulnerability, defined as the degree of sensitivity and ability to cope with climate variability, and adaptation, defined as adjustments

to environmental stresses caused by climate variability, can also be applied to climate change (Fraisse et al., 2009). Existing strategies, like the use of high-biomass winter cover crops, ex-situ biomass management of crop residues for improving soil health and animal health, conservation tillage, use of alternate fertilizers like liquid fertilizers using proper application systems including drones, sod-based rotation systems, efficient irrigation technologies and precision agriculture can help producers minimize the risks associated with climate variability and change as well as improve their resource-use efficiency. The following adaptation strategies are being suggested for India's agriculture.

7.2 High Residue Cover Crops

High-residue cover cropping is an adaptation of conservation tillage in which a high-biomass cover crop is grown during the winter and is rolled or cut down prior to no-till or strip-till planting in spring. Examples of winter cereals used as high residue cover crops include rye *(Secale cereal)*, black oats *(Avena strigosa)*, wheat *(Triticum)*, or triticale *(Triticosecale)*. High-residue cover crops and reduced tillage can lessen some negative impacts from climate and weather, such as high-intensity rainfall events, spring and summer dry spells, droughts, and extreme soil temperatures during critical crop reproduction periods. Keeping soil covered year-round with crop residue can reduce soil erosion, improve water infiltration, reduce evaporative moisture loss, and moderate soil temperature. Some benefits depend on the climate and soil types of the system, and these positive impacts can increase with repeated use of high-residue cover crops. The main differences between high-residue cover crops and traditional winter cover crops are the types of crops selected and the amount of fertilizer applied. A high residue system uses winter cereals with fertilizer applications, resulting in greater production of biomass than a traditional cover crop system. Many producers find the cost of high-residue cover crops are justified in dryland systems because of the improved water management and soil quality that result from the large amount of crop residues (Love et al., 2015).

7.3 Conservation Tillage

The USDA-NRCS (United States Department of Agriculture, Natural Resources Conservation Service) defines conservation tillage as a system that leaves enough crop residues from cover crops and/or cash crops on the soil surface after planting to provide at least 30% soil cover. Research has identified 30% soil cover as the minimal amount of residue needed to avoid significant soil loss, but greater residue amounts are preferred. The use of cover crops is critical to producing this additional plant residue. In addition to maximizing surface residues, conservation tillage can increase below-ground disruption to

eliminate compacted soil layers by maintaining plant roots and soil macropores. While conservation tillage can resolve the occurrence of a shallow plough-compacted layer in some systems, subsoil tillage may be required in some soils to manage compaction from vehicle traffic or from naturally occurring compacted layers. Together with cover crops, conservation tillage has the potential to reduce erosion, increase rainfall infiltration, reduce subsurface compaction, and maximize soil organic carbon (SOC) accumulation, which positively affects many soil physical and chemical properties. The main way that conservation tillage can reduce risks related to climate variability (particularly droughts and dry spells) is by increasing the water available to plants. Areas where conservation tillage is used will show a number of benefits including reduced erosion and runoff, increased water infiltration, more plant-available water, reduced soil water evaporation, and reduced diurnal temperature fluctuations (Balkcom et al., 2015).

7.4 Sod-Based Rotation

A sod-based rotation incorporates two or more consecutive seasons of a perennial grass into a conventional row-crop rotation. One example of a sod-based rotation is an adaptation of the conventional peanut/cotton rotation that farmers follow in North Florida. In a four-year, sod-based rotation, bahiagrass is grown for two years, followed by a year of peanuts, and then a year of cotton (Figure 4). For example, soils with high sand content, low organic matter, and compaction layers are more vulnerable to stresses from variability in climate, namely dry spells and droughts (Wright et al., 2015; Her et al., 2017).

The sod-based rotation can reduce climate related risks through improving soil water holding capacity, potentially reducing the negative effects of droughts and dry spells, increased water infiltration rate and reduced bulk density. The soil water holding capacity is improved through improved soil organic matter promoted by sod-based rotation. Increased infiltration rate and reduced bulk density results from increase in soil macropores due to greater root mass and biological activity for soils. Field data from 2002-2007 at Quincy, Filed Level (FL), show that water-use efficiency of peanut under sod-based rotation was 15% greater in irrigated fields and 19% greater in dryland fields compared to water-use efficiency of peanut in a conventional rotation (Zhao et al. 2008). Here, water-use efficiency is defined as the ratio of crop yield to the sum of irrigation and rainfall. This data suggest yield increases have resulted from improvements in soil water-holding capacity. In the very dry years of 2006 and 2007, peanut yields in a sod-based rotation were 13% greater than those under conventional rotation (Zhao et al. 2008).

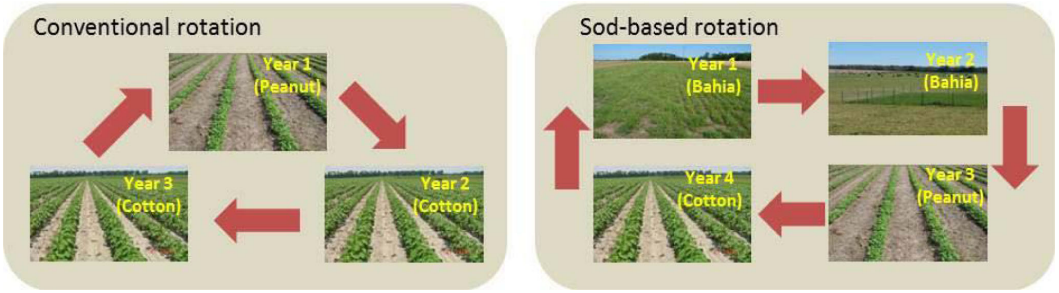


Figure 4. Illustration of conventional and sod-based peanut/cotton rotations in North Florida. *Credits: David Wright.*

7.5 Climate Information and Decision Support Systems

Climate information and decision support systems can be used to reduce production risk, increase resource use efficiency and the profitability of agricultural operations. However, simply providing better climate information and forecasts to potential users is not enough. Climate information only has value when there is a clearly defined adaptive response and a benefit once the content of the information is considered in the decision making process (Fraisse et al., 2016). For instance, Agro Climate (http://agroclimate.org/) is a web-based climate information and decision support system. The website includes seasonal forecasts, expected impacts of management options for different crops and climate scenarios, and a wide variety of interactive tools that help producers monitor current conditions and plan for the season ahead. Agro Climate was developed to serve agricultural stakeholders in a specific agro-climatic zone in United States (Breuer et al., 2009). Users can monitor variables of interest such as growing degree-days, chill hours, disease risks for selected crops, and current and projected drought conditions. Stakeholders can also use web based climate information to learn about the forecast of climate cycles affecting their area. Water and carbon footprint calculators can provide estimates of how efficiently water and energy are being used. Agro Climate can help producers develop a strategy for the coming season and track current climate conditions affecting crop development and yield. Based on the expected seasonal climate outlook or other climate information, producers adapt to expected conditions changing crop selection, planting dates, plant population, cover crop management, input purchasing, and nutrient management.

7.6 Use of Alternative Crops

When traditional crops are failing in an agro-ecological zone due to climate change, farmers have to look for something new to grow, alternative crops. Individual farmers should consider the following factors in determining

whether a crop might be a viable alternative in their particular situation; i) market availability in terms of demand for the product, market location and transportation to market, ii) projected cost of production versus projected yields and price, iii) farmer's resources in terms of land (suitable soil), irrigation capability, available labor, equipment, capital, and personal goals and interests, and iv) specific crop requirements and adaptation.

8. Impact of Climate Change on Food Security

Many people worldwide will face more limited access to food as humanity adapts to changes the future brings. Those changes may well be substantial. A recent report (Global Commission on the Economy and Climate, 2014) reminds us that over the next 15 years global production (defined as Gross Domestic Product) will grow by more than half, a billion more people will come to live in cities, and rapid technological advance will continue to change businesses and lives. In addition, climate change is already having serious economic consequences, especially in more exposed areas of the world.

The Food and Agriculture Organization of the United Nations (FAO, 2003, p. 29) has defined food security as: when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life. Household food security is the application of this concept to the family level, with individuals within households as the focus of concern.

Extensive evidence shows that climate change will continue to affect food production throughout the next century (Walthall et al., 2012). A recent report by Brown et al. (2015) on climate change and food security states: Climate change is likely to diminish continued progress on global food security through production disruptions leading to local availability limitations and price increases, interrupted transport conduits, and diminished food safety, among other causes. As part of a highly integrated global food system, consumers and producers in the United States are likely to be affected by these changes. The type and price of food imports from other regions are likely to change, as are export demands placed upon U.S. producers and the transportation, processing, and storage systems that enable global trade. Demand for food and other types of assistance may increase, as may demand for advanced technologies to manage changing conditions.

India's vast agricultural resources will be essential in feeding India and the world in the decades to come but will face challenges from climate change. The effects of climate on agricultural yields and prices, and follow on effects on food processing, storage, transportation, and retailing could have important implications for food security.

Climate change has rapidly affected India's agricultural performance over the past forty years and will probably continue to do so in the coming decades through increased or more intense occurrences of extreme events, such as drought, flood, and storms.

9. Recommendations

There are many knowledge gaps within the agricultural production system and food chain in general. Using relevant experts, identify location specific knowledge gaps based on the best current available knowledge on science and technology, adapt and/or adopt accordingly. The following recommendations are suggested.

- Improve water use efficiency in all aspects of crop production, particularly irrigation systems. Minimize water leakage, do not over-irrigate, use of appropriate irrigation system based on crop type, terrain and soil type. Primed acclimation is a deficit irrigation strategy applied at early stages of crop development and full irrigation amounts in the later portion of crop development (Rowland et al., 2012). Using primed acclimation can save up to one third of water use in crop production without reducing crop yield.
- India should put more emphasis on soil health. Soil health is the continued capacity of soil to function of a vital living ecosystem that sustains plants, animals and humans. To improve the soil health, there is need to increase nitrogen use efficiency fertilizers. Liquid fertilizers with proper application system may be beneficial in this approach. Excessive and inappropriate use of agrochemicals during the Green Revolution has adversely impacted soil health (soil physical, chemical and microbial properties) in India. Therefore, soil health management strategy is recommended.
- Agricultural production is carried out on top healthy soil. Loss of top soil through soil erosion will increase with increased extreme events of heavy precipitation and strong winds. Different techniques and methods are available to reduce soil erosion, including conservation (minimum or zero) tillage and physical structures (ridges, levees and wind breakers). Soil erosion has other unintended consequences, such as siltation of dams and eutrophication (elevation of nutrients in water bodies).
- Incorporation of crop residues into the soil and use of cover crops will increase soil organic matter, which in return improves soil physical properties (e.g. soil structure), water holding capacity and nutrient recycling, while reducing soil erosion and salinity.
- In addition to high yielding varieties (HYV), there is a need to breed for heat and drought tolerant varieties. Climate change is expected to increase global temperatures and duration of dry spells.

- Practice of conservation tillage will reduce soil erosion, moisture loss through evaporation and nutrient leaching. Technical details to be addressed by agricultural experts and communicated to farmers through extension services.
- Crop rotation needs to be reintroduced or adopted as it is an old tradition forgotten in modern agriculture. Avoid planting the same crop (mono cropping) on the same piece of land for many years. Crop rotation reduces disease and pest pressure build up while improving soil fertility and soil health.
- Improve rain harvest and storage technologies for domestic and agricultural production.
- Introduction of alternative crops in different agro-climate zones.
- Use of non-conventional technologies in agriculture, like artificial intelligence (AI), cloud computing, robotics and big data. Precision agriculture demands use of such technologies.
- Reduce the undue influence of the middleman in the agricultural production and distribution system in India.
- Reduce post-harvest losses. Implement primary and secondary processing of agricultural produce in rural areas.
- Science translation. Scientific inventions, technologies and innovations need to be conveyed to the end users (particularly farmers) via well trained extension experts/agents.
- In addition to satisfying the domestic market, India must continue to seek and expand international markets for her agricultural produce and products.

References

Abrol, Y. P. and K.T. Ingram. 1997. Effects of higher day and night temperatures on growth and yields of some crop plants. Global climate change and agricultural production. Direct and Indirect effects. Natural Resources Management and Environment Department. FAO Corporate Document Repository.

Abrol, Y.P., A.K. Bagga, N.V.K. Chakravorty, and P.N. Wattal. 1991. Impact of rise in temperature on productivity of wheat in India. In: Impact of Global Climatic Change on Photosynthesis and Plant Productivity. Y.P. Abrol et al. (eds.). Oxford & IBH Publishers, New Delhi. pp. 787-798.

Allen, S. C., V.D. Nair, D.A. Graetz, S. Jose, Nair, and P. K. R. 2006. Phosphorus loss from organic versus inorganic fertilizers used in alley cropping on a Florida Ultisol. Agriculture, Ecosystems and Environment 117, 290–298.

Anandhi, A. 2016. Growing degree days–Ecosystem indicator for changing diurnal temperatures and their impact on corn growth stages in Kansas. Ecological Indicators, 61, 149-158.

Anandhi, A., 2017. CISTA-A: Conceptual model using indicators selected by systems thinking for adaptation strategies in a changing climate: Case study in agro-ecosystems. Ecological Modelling, 345, pp.41-55.

Anandhi, A., M. S. Zion, P. H. Gowda, D. C. Pierson, D. Lounsbury, and A. Frei. 2013a. Past and future changes in frost day indices in Catskill Mountain region of New York, Hydrological Processes, 27(21), 3094-3104.

Anandhi, A., S. Hutchinson, J. Harrington Jr, V. Rahmani, M.B Kirkham, and W. Charles Rice. 2016b. Changes in spatial and temporal trends in wet, dry, warm and cold spell length or duration indices in Kansas, USA. International Journal of Climatology, 36: 4085–4101.

Anderson, S.A. (ed.). 1990. "Core Indicators of Nutritional State for Difficult-To-Sample Populations" Journal of Nutrition 120(11S):1557-1600. Report by the Life Sciences Research Office, Federation of American Societies for Experimental Biology, for the American Institute of Nutrition.

Antle, J. M., S. M. Capalbo, E. T. Elliott, and K. H. Paustian. 2004. Adaptation, spatial heterogeneity, and the vulnerability of agricultural systems to climate change and CO2 fertilization: An integrated assessment approach. Climatic Change, 64, 289-315, doi:10.1023/B:CLIM.0000025748.49738.93.

Antle, J.M. 2008. Climate Change and Agriculture: Economic Impacts. Choices 23(1): 9-11. Online: http://www.choicesmagazine.org/2008-1/theme/2008-1-03.htm.

Bale. J. S., G. J. Masters, I. D. Hodkinson, C. Awmack, T. M. Bezemer, V. K. Brown, J. Butterfield, A. Buse, J. C. Coulson, J. Farrar J. 2002. Herbivory in global climate change research: direct effects of rising temperature on insect herbivores. Global Change Biol. 8:1–16

Balkcom, K., L. Duzy, D. Dourte, and C. W. Fraisse. 2015. Conservation Tillage: A Management Option for Climate Variability and Change. University of Florida IFAS AgroClimate Management Factsheets (Online): http://agroclimate.org/management/Conservation-tillage.pdf

Breuer, N.E., C. W. Fraisse, and P. E. Hildebrand. 2009. Molding the pipeline into a loop: The participatory process of developing AgroClimate a Decision Support System for climate risk reduction in agriculture. J. of Service Climatology (On-Line), 1, 1-12.

Budny, M.L., and B.W. Benscoter. 2016. Shrub Encroachment Increases Transpiration Water Loss from a Subtropical Wetland. Wetlands 36, 631–638 (2016). https://doi.org/10.1007/s13157-016-0772-5

Cakir. 2004. Effect of water stress at different development stages on vegetative and reproductive growth of corn. Field Crop Research, 89(1):1-16. DOI: 10.1016/j.fcr.2004.01.005

Ingram, J., H. Jiang, H. Maletta, T. Mata, A. Murray, M. Ngugi, D. Ojima, B. O'Neill, and C. Tebaldi. 2015. Climate change, global food security and the U.S. food system. Washington, DC:USDA/OCE. Retrieved from http://www.usda.gov/oce/climate_change/FoodSecurity2015Assessment/FullAssessment.pdf.

Challinor, A., J. Slingo, T. Wheeler, P. Craufurd, and D. Grimes. 2003. Toward a Combined Seasonal Weather and Crop Productivity Forecasting System: Determination of the Working Spatial Scale. Journal of Applied Meteorology, 42(2), 175-192.

Commuri, P.D., and R. D. Jones. 2001. High temperatures during endosperm cell division in maize: A genotypic comparison under in vitro and field conditions. Crop Sci 41:1122–1130.

Datir, S., and S. Wagh. 2014. Monitoring and Detection of Agricultural Disease using Wireless Sensor Network. International Journal of Computer Applications, 87(4).

Deressa, T., R.M. Hassan, and C. Ringler. 2008. Measuring Ethiopian farmers'

Dourte, D., C. W. Fraisse, and W. Bartels. 2015. Exploring changes in rainfall intensity and seasonal variability in the Southeastern U.S.: Stakeholder engagement, observations, and adaptation. Climate Risk Management 7:11-19.

Dupuis, L. and C. Dumas. 1990. Influence of temperature stress on in vitro fertilization and heat shock protein synthesis in maize (Zea mays L.) reproductive systems. Plant Physiol. 94, 665-670.

FDACS. 2015. Florida Statewide Agricultural Irrigation Demand. http://www.freshfromflorida.com/Divisions-Offices/Agricultural-Water-Policy/Agricultural-Water-Supply-Planning.

Food and Agriculture Organization of the United Nations [FAO]. 2003. Trade reforms and food security: Conceptualizing the linkages. Rome: FAO. Retrieved from http://www.fao.org/docrep/005/y4671e/y4671e06.htm#TopOfPage.

Fraisse, C.W., J.H. Andreis, T. Borba, V. Cerbaro, E. Gelcer, W. Pavan, D. Pequeno, D. Perondi, X. Shen, C. Staub, O. Uryasev, and A. Wagner. 2016. AgroClimate – Tools for managing climate risk in agriculture. Agrometeoros J. 24(1): 121-129.

Fraisse, C. W., N. E. Breuer, D. Zierden, and K. T. Ingram. 2009. From climate variability to climate change: Challenges and opportunities to extension. Journal of Extension (On-line), 47(2) Article 2FEA9.

Global Commission on the Economy and Climate. 2014. The new climate economy. Better growth, better climate, http://newclimateeconomy.report/

Hansen, J. W. 2002. Realizing the Potential Benefits of Climate Prediction to Agriculture: Issues, Approaches, Challenges. Agricultural Systems, 74(3), 309-330.

Hansen, J. W., A. Challinor, A. Ines, T. Wheeler, and V. Moron. 2006. Translating Climate Forecasts into Agricultural Terms: Advances and Challenges. Climate research, 33(1), 27-41.

Harrington, R., R. Fleming, and I. Woiwod. 2001. Climate change impacts on insect management and conservation in temperate regions: can they be predicted? Agric. For. Entomol., 3: 233-240.

Hatfield J. L. and J. H. Prueger. 2015. Temperature extremes: Effect on plant growth and development. Weather and Climate Extremes (2015), http://dx.doi.org/10.1016/j.wace.2015.08.001i

Hansen, J. W. 2002. Realizing the Potential Benefits of Climate Prediction to Agriculture: Issues, Approaches, Challenges. Agricultural Systems, 74(3), 309-330.

Hatfield, J. L., K. J. Boote, P. Fay, L. Hahn, R.C. Izaurralde, B.A. Kimball, T. Mader, J. Morgan, D. Ort, W. Polley, A. Thomson, and D. Wolfe. 2008. Agriculture In: The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States.

Hatfield, J. L., K. J. Boote, B.A. Kimball, L.H. Ziska, R.C. Izaurralde, D.W. Ort, A.M. Thomson, and D.W. Wolfe. 2011. Climate impacts on agriculture: implications for crop production. Agron. J. 103, 351-370.

Hatfield, J. L., K. J. Boote, B. A. Kimball, L. H. Ziska, R. C. Izaurralde, D.W. Ort, A. M. Thomson, and D.W. Wolfe. 2011. Climate impacts on agriculture: Implications for crop production. Agronomy Journal 103: 351-370, doi:10.2134/agronj2010.0303.

Her, Y.G., K. J. Boote, K.W. Migliaccio, C. Fraisse, D. Letson, O. Mbuya, A. Anandhi, H. Chi, L. Ngatia and S. Asseng. 2017. Climate Change Impacts and Adaptation in Florida's Agriculture. In: Chassignet, E. P., Jones, J. W., Misra, V., & Obeysekera, J. (Eds.). (2017). Florida's climate: Changes, variations, & impacts. Gainesville, FL: Florida Climate Institute. https://doi.org/10.17125/fci2017.

Herrero, M. P., R. R. Johnson. 1980. High temperature stress and pollen viability in maize. Crop Sci. 20, 796-800.

IPCC. 2001. (Intergovernmental Panel on Climate Change) Climate Change 2001: Impacts, Adaptation, and Vulnerability, Summary for Policymakers and Technical Summary of the Working Group II Report. IPCC, Geneva.

Jones, R. J., S. Ouattar, and R. K. Crookston. 1984. Thermal environment during endosperm cell division and grain filling in maize: effects on kernel growth and development in vitro. Crop Sci 24:133–137.

Kadir, T., L. Mazur, C. Milanes, and K. Randles (eds. & comps). 2013. Indicators of Climate Change in California. Office of Environmental Health Hazard Assessment, California. Available at: http://oehha.ca.gov/multimedia/epic/pdf/ClimateChangeIndicatorsReport2013.pdf. (accessed on 21January 2014), 228pp).

Kates, R. W., W.R. Travis, and T.J. Wilbanks. 2012. Transformational adaptation when incremental adaptations to climate change are insufficient. Proceedings of the National Academy of Sciences, 109(19), 7156-7161.

Kim, H. Y., T. Horie, H. Nakagawa, K. Wada. 1996. Effects of elevated CO2 concentration and high temperature on growth and yield of rice. II. The effect of yield and its component of Akihikati rice. Jpn. J. Crop Sci. 65, 644-651.

Lamm, F. R., P. D. Colaizzi, J. P. Bordovsky, T. P. Trooien, J. Enciso-Medina, D. O. Porter, D. H. Rogers, and D. M. O'Brien. 2010. Can Subsurface Drip Irrigation (SDI) Be a Competitive Irrigation System in the Great Plains Region for Commodity Crops? 2010. Proceedings of the 5th National Decennial Irrigation meeting of the ASABE, Phoenix Convention Center, 5–8 December 2010, Phoenix, AZ USA.

Lobell, D. B., and S. M. Gourdji. 2012. The influence of climate change on global crop productivity. Plant Physiology, 160: 1686-1697, doi:10.1104/pp.112.208298.

Lobell, D. B., G. L. Hammer, G. McLean, C. Messina, M. J. Roberts, and W. Schlenker. 2013. The critical role of extreme heat for maize production in

the United States. Nature Climate Change 3: 497-501, doi:10.1038/nclimate1832.

Love, J., J. Dillard, K. Brook, D. Dourte, and C. W. Fraisse. 2015. High-Residue Cover Crops A Management Option for Climate Variability and Change. University of Florida IFAS AgroClimate Management Factsheets (Online): http://agroclimate.org/management/High-residue-cover-crops.pdf

Luers, A. L., D.B. Lobell, L.S. Sklar, C.L. Addams, and P.A. Matson. 2003. A method for quantifying vulnerability, applied to the agricultural system of the Yaqui Valley, Mexico. Global environmental change, 13(4), 255-267.

Meza, F. J., J.W. Hansen, and D. Osgood. 2008. Economic Value of Seasonal Climate Forecasts for Agriculture: Review of Ex-Ante Assessments and Recommendations for Future Research. Journal of Applied Meteorology and Climatology, 47(5), 1269-1286.

Misra, V., E. Carlson, R. K. Craig, D. Enfield, B. Kirtman, W. Landing, S.-K. Lee, D. Letson, F. Marks, J. Obeysekera, M. Powell, and S.-l. Shin. 2011. Climate Scenarios: A Florida-Centric View, Florida Climate Change Task Force. [Available online at http://floridaclimate.org/whitepapers/].

National Climate Assessment. 2014. http://nca2014.globalchange.gov/report.

National Intelligence Council (NIC). 2009. India:The Impact of Climate Change to 2030. A A Commissioned Research Report-NIC2009-03D, April2009.

Ojha, T., S. Misra, and N.S. Raghuwanshi. 2015. Wireless sensor networks for agriculture: The state-of-the-art in practice and future challenges. Computers and Electronics in Agriculture, 118, 66-84.

Perry, C., C. W. Fraisse, and D. Dourte. 2015. Variable-Rate Irrigation A Management Option for Climate Variability and Change. University of Florida IFAS AgroClimate Management Factsheets (Online): http://agroclimate.org/management/Variable-rate-irrigation.pdf

Petzoldt, C. and A. Seaman. 2010. Climate Change Effects on Insects and Pathogens. Climate Change and Agriculture: Promoting Practical and Profitable Responses. 616. http://www.climateandfarming.org/pdfs/FactSheets/III.2Insects.Patho gens.pdf., (2010).

Pilankar, D., T. Sawant, R. Sule, and S. Mahadeshwar. 2013. Implementing agricultural applications using wireless sensor network and securing them using advanced encryption standard. Journal of Engineering Research and Applications (IJERA), 2248, 9622.

Prasad, P. V., K. J. Boote, and L. H. Allen. 2006. Adverse high temperature effects on pollen viability, seed-set, seed yield and harvest index of grain-sorghum [Sorghum bicolor (L.) Moench] are more severe at elevated carbon dioxide due to higher tissue temperatures, Agricultural and Forest Meteorology, 139(3), 237-251.

Prasad, P., K. J. Boote, L. H. Allen, and J. M. Thomas. 2002. Effects of elevated temperature and carbon dioxide on seed-set and yield of kidney bean (Phaseolus vulgaris L.), Global Change Biology, 8(8), 710-721.

Prasad, V. P., K. J. Boote, L. Hartwell Allen, and J. M. Thomas. 2003. Super-optimal temperatures are detrimental to peanut (Arachis hypogaea L.) reproductive processes and yield at both ambient and elevated carbon dioxide, Global Change Biology, 9(12), 1775-1787.

Prasad P. V., P. Q. Craufurd, R. J. Summerfield. 1999. Sensitivity of peanut to timing of heat stress during reproductive development. Crop Sci 39:1352–1357

Prasad P.V., P.Q. Craufurd, V. G. Kakani, T. R. Wheeler, K. J. Boote. 2001. Influence of high temperature during pre- and post-anthesis stages of floral development on fruit-set and pollen germination in peanut. Aust J Plant Physiol 28:233–240

Rosenberg, N.J. 1993. Towards an Integrated Assessment of Climate Change: The MINK Study. Kluwer Academic Publishers, Boston.

Rowland, D.L., W.H. Faircloth, P. Payton, D.T. Tissue, J.A. Ferrell, R.B. Sorensen, and C.L. Butts. 2012. Primed acclimation of cultivated peanut (Arachis hypogaea L.) through the use of deficit irrigation timed to crop developmental periods. Agricultural Water Management 113:85-95.

Saleem, K., A. Derhab, J. Al-Muhtadi, B. Shahzad, and M.A. Orgun. (2015). Secure transfer of environmental data to enhance human decision accuracy. Computers in Human Behavior, 51, 632-639.

Schoper, J. B., R.J. Lambert, B.L. Vasilass, and M.E. Westgate. 1987. Plant factors controlling seed set in maize. Plant Physiol. 83, 121-125.

Southeast Climate Consortium. 2008. "Climate Change Basics for the Southeast U.S.A." https://climatecenter.fsu.edu/images/docs/ClimateChange-factsheet.pdf.

SSSA. 2015. "Where has all the soil gone? Long time passing" https://soilsmatter.wordpress.com/2013/11/11/where-has-all-the-soil-gone-long-time-passing/.

Walthall, C.L., J. Hatfield, P. Backlund, L. Lengnick, E. Marshall, M. Walsh, S. Adkins, M. Aillery, E.A Ainsworth, C. Ammann, C.J. Anderson, I. Bartomeus, L.H. Baumgard, F. Booker, B. Bradley, D.M. Blumenthal, J. Bunce, K. Burkey, S.M. Dabney, J.A. Delgado, J. Dukes, A. Funk, K. Garrett, M. Glenn, D.A. Grantz, D. Goodrich, S. Hu, R.C. Izaurralde, R.A.C Jones, S-H. Kim, A.D.B. Leaky, K. Lewers, T.L. Mader, A. McClung, J. Morgan, D.J. Muth, M. Nearing, D.M. Oosterhuis, D. Ort, C. Parmesan, W.T. Pettigrew, W. Polley, R. Rader, C. Rice, M. Rivington, E. Rosskopf, W.A. Salas, L.E. Sollenberger, R. Srygley, C. Stöckle, E.S Takle, D. Timlin, J.W. White, R. Winfree, L. Wright-Morton, and L.H. Ziska. 2012. Climate change and agriculture in the United States: Effects and adaptation. Technical Bulletin 1935. Washington, DC: USDA.

Wang, D., S.C. Hagen, and K. Alizad. 2013. Climate change impact and uncertainty analysis of extreme rainfall events in the Apalachicola River Basin, Florida. Journal of Hydrology 480: 125-135.

Wright, D. L., J. J. Marois, C. W. Fraisse and D. Dourte. 2015. Agricultural Management Options for Climate Variability and Change: Sod-Based Rotation. University of Florida IFAS Extension Service EDIS AE 492. http://edis.ifas.ufl.edu/ae492

Zhao D., D.L. Wright, J.J. Marois, C. Mackowiak, and T.W. Katsvairo. 2008. Yield and Water Use Efficiency of Cotton and Peanut in Conventional and Sod-Based Cropping Systems. In Proceedings of the 30th Annual Southern Conservation Agricultural Systems Conference, Tifton, Georgia, July 29-31, 2008, edited by D.M. Endale. http://www.ag.auburn.edu/auxiliary/nsdl/scasc/.

Zhang, X.C., M. A. Nearing, J. D. Garbrecht, and J. L. Steiner. 2004. Downscaling Monthly Forecasts to Simulate Impacts of Climate Change on Soil Erosion and Wheat Production. Soil Science Society of America Journal 68:1376–138.

Zotarelli, L., C. W. Fraisse, and D. Dourte. 2015. Agricultural Management Options for Climate Variability and Change: Microirrigation. University of Florida IFAS Extension Service EDIS HS 1203. http://edis.ifas.ufl.edu/hs1203

•

Challenges and Opportunities in Agriculture Credit

• Dr. Ajay Kumar Sood •

Investments in agriculture and allied sectors contribute to growth in production and income, mitigation of poverty and enhanced food security, both at the national and household levels. Capital, be it in physical or human form, greatly contributes towards increasing the efficacy of the productive effort. Credit is an important component for cultivation, procurement and marketing and, thus, access to affordable institutional credit is *sine quo non* for enhancing the prosperity of farmers. Empirical evidence suggests that output elasticity of farm credit is significant and positive; roughly every 1 per cent increase in agricultural credit produces 0.22 per cent increase in real agricultural GDP (with one-year time lag) and consequently aiding increased income.

Status of Agriculture Credit

Reports of NSSO and NAFIS reveal that among various sources of credit, there was high dependence on non-institutional channels. Till 2013, nearly 40 per cent of loans came from informal sources and 26 per cent were advanced by moneylenders. Households having marginal landholdings suffer most with only 15 per cent of their credit coming from institutional sources like government, cooperatives and banks while for households in the highest land class (with land more than 10 hectares), the ratio is 79 per cent. As per NAFIS report, though the proportion of indebted agriculture households has seen only a marginal rise, the proportion of loans coming from non-institutional sources has come down to about 28 per cent.

Indebtedness Status of Farmers

Indebtedness of farmer households	**NSSO-2003**	**NSSO-2013**	**NAFIS 2016**
Percentage of farmer households indebted	48.60	52.00	52.50
Average amount of outstanding	12,585	47,000	59,053
Loan (Rs.)			
Share of loans from institutional sources	57.70	60.00	72.00

(Source: NSSO - SAS, 59th round 70th round, NAFIS-2016)

Since the introduction of the policy of doubling of agriculture credit by the Government of India, there has been a healthy growth in the flow of agriculture credit which grew at an overwhelming rate of 35 per cent per annum during the doubling period (2004-05 to 2006-07). For the subsequent period (2007-08 to 2018-19), compound annual growth rate (CAGR) of agriculture credit was 15.60 per cent.

Challenges in Agriculture Credit

Despite the seemingly impressive performance in agriculture credit disbursement, the system faces many challenges. Some of important challenges are enumerated below:

a) Growing Marginalisation and Inclusiveness of Agriculture Credit System

The continued dependence of rising population and labour force on limited and non-expanding land base has resulted in a continuous decline in the availability of land per agricultural worker. The consequent growing marginalization has been observed largely under the size class of marginal holdings whose relative share in number of operational holdings has increased from about 51% in 1970-71 to 68.5 % in 2015-16. This has implications for access of this category to institutional credit. The coverage of small and marginal farmers in the agriculture loan accounts has increased from 60 percent in 2015-16 to 74 percent in 2018-19 (Provisional). Similarly, their share in loan amount has also enhanced from 42 percent to 50 percent during the same period. This seems impressive against their share in operated area (47%). Here, an important issue needs attention. Marginal farmers which constitute about 68 percent of total holdings have average holding size of 0.38 ha (about ¼th of the avg. size of small farmers). Thus, they can't be clubbed together with small farmers and need special focus. Presently, no separate data is available for marginal farmers. However, analysis of credit limit-wise outstanding agriculture credit of SCBs reveals that *"loan amount upto Rs. 25000"* (roughly corresponding to the credit needs of marginal farmers for crop cultivation) constitute only about 2 percent of the total agriculture loan outstanding and has been declining over the years. These figures speak of almost no access to institutional credit for marginal farmers despite contributing about one fourth to the operated area.

Credit Limit-wise Classitication of Outstanding Agriculture Credit of Scheduled Commercial Banks

As on March		Rs. 25000 and less	Above Rs. 25000 and upto Rs. 2 lakh	Above Rs. 2 lakh	Total
2011	Amt o/s (Rscr)	26609.15	164052.65	270360.08	461021.88
	% to Total	5.77	35.58	58.64	100.00
2012	Amt o/s (Rscr)	26164.00	210815.98	324954.S9	561934.87
	% to Total	4.66	37.52	57.83	100.00
2013	Amt o/s (Rrcr)	26420.18	268808.93	380946.96	676176.07
	% to Total	3.91	39.75	56.34	100.00
2014	Amt o/s (Rscr)	23858.29	322699.16	495289.63	841847.08
	% to Total	2.83	38.33	58.83	100.00
2015	Amt o/s (Rscr)	23407.59	361813.31	519050.80	904271.70
	% to Total	2.59	40.01	57.40	100.00
2016	Amt o/s (Rscr)	27477.13	382447.47	586241.57	996166.16
	% to Total	2.76	38.39	58.85	100.00
2017	Amt o/s (Rscr)	24492.92	409827.87	643863.04	1078183.84
	% to Total	2.27	38.01	59.72	100.00
2018	Amt o/s (Rscr)	24541.00	449125.00	725594.00	1199260.00
	% to Total	2.05	37.45	60.50	100.00

Source: Basic Statistical Returns of Scheduled Commercial banks in India (various years)

b) Regional Disparity

Agriculture credit as an indirect input into agriculture plays a significant role in aiding production and enhancing the income of the farmer. Flow of credit in agriculture has seen a steady growth. However, the growth in credit has been overshadowed by the gross regional disparity in absorption of credit among the various regions in the country. During the last 5 years, the share of agriculture credit disbursement in the Southern region has ranged from 37%-43% of the total agriculture disbursement although it accounts for only 17% share in GCA. Compared to it, the disbursement in Central region ranged 13-17% with 29% share in GCA. Similar pattern emerges for North-Eastern and Eastern regions.

c) Prevalence of Gold Loans

Against 9.50 crore outstanding crop loan accounts as on March 2019, the number of operative KCCs are 6.92 crore. The difference in numbers is mainly in south Indian states of Kerala, A.P., Tamil Nadu and Telangana where there is prevalence of system of Gold loans. Meenakshi and Pranav (2018) indicated that Gold loans are not the optimal choice of disbursing credit to the priority sector under the present circumstances from the point of view of farmers' welfare. The prevalence of gold loans ends up blocking access to essential credit for small and marginal farmers and making them more reliant on the informal credit sector, in which agents can forcefully repossess land and crops, and enforce strict and unfavourable lending terms. A study by NABARD observed that all the banking agencies treated Agriculture Gold Loans (AGL) at par with crop loan and enjoyed subvention benefits. The farm-hold background of borrowers indicate that the AGL borrowers are less serious farmers compared to KCC holders and had received more loan than what was required for agricultural operations.

d) Priority Sector Lending Certificates (PSLC)

To enable banks to achieve their specified target and sub-targets for priority sector lending in the event of a shortfall and also to incentivize the surplus banks to lend more to these sectors, the concept of PSLC was introduced during 2015. The total trade value of PSLCs was Rs. 49,800 crore during 2016-17. The volume of PSLC market leapfrogged to around Rs 1.86 lakh crore in 2017-18, 3.7 times higher than the previous year. During 2018-19, the trading in PSLC is expected to be around Rs. 3.3 lakh crore. Agriculture and SF/MF constitute about 40 percent in the total trade. The major seller banks in 2017-18 like Bandhan Bank, Kotak Mahindra Bank, Punjab National Bank had accelerated growth in PSL outstanding in 2017-18 as compared to 2016-17. This implies

that the above banks were motivated in extending PSL and earn additional income in selling PSLC to PSL deficient banks. However, majority of the "sellers" of PSLC do not rank high (except PNB) in terms of market share.

By trading in PSLC, banks in a way wean away from lending to the most needy and neglected sectors (Agriculture and SF/MF, MSME) and it does not lead to asset creation/capital formation. Depending on the area from which underlying loans for PSLC trading is drawn, it may have implications for regional distribution of agriculture credit in future.

Suggestions

Based on the above analysis, the following suggestions are made:

i. The foregoing analysis clearly brings out the lack of access to institutional credit for the lowest rung of the farming community. It is, therefore, desirable that the marginal farmers may not be clubbed with small farmers and separate target may be fixed for them.

ii. To address regional disparity in credit flow, there is a need for fixing state-wise targets for agriculture credit. The shortfall in PSL should also be dealt with at state level.

iii. Estimation of eligible loan amount with gold as collateral should strictly be based on scale of finance, crop cultivated and area operated. Multiple loan (both KCC and AGL) to same person needs to be avoided, by using stringent identification means and advancement in IT-enabled Services.

•

Investment Agriculture

• Prof. Seema Bathla •

Investments in the agricultural sector are undertaken mainly by the public and the private sectors in India. An overwhelming share in total investment is of private farm household sector at 82%, public sector at 15% and the remaining 3% of the private corporate sector. Recognising that investment is imperative for accelerating growth and development in any economic sector, the key concerns in agriculture remain (1) increasing private investment, through institutional lending and/or inviting the corporate sector, (2) 'crowding in' effect of public investments in agriculture and rural infrastructure on private investment, (3) cutting down of public investment due to expenditure on input subsidies, (4) rationalising input subsidies to positively impact private investment and productivity, (5) increasing efficiency of investments in major-medium irrigation systems, (6) estimating futuristic private and public investment requirements for doubling farmers' income, and (7) mitigating poverty and inter- and intra-regional inequalities in farm income and output through public investments.

Ample research has been done on each of these and policy implications are drawn. However, these have come to the fore due to persisting agrarian crisis in several parts of the country despite multiple increase in public spending (both investments and subsidies) on irrigation and rural development since 2003-04. Among twenty major Indian states, the average per ha real public expenditure (revenue and capital) each in agriculture & irrigation (including flood control) has increased from nearly Rs. 1900 during the eighties to Rs. 5100 during 2010/11 – 2015/16. The average per ha spending during 2010/11-2015/16 was the highest (>Rs. 8000) in Andhra Pradesh, J&K, Odisha, Chhattisgarh, Jharkhand and Uttarakhand and the least (<Rs. 4000) in Kerala, Madhya Pradesh, Rajasthan, Tamil Nadu and West Bengal. In terms of capital expenditure i.e. investment, average investment in agriculture has always been less than Rs. 500 per ha and sizeably increased in irrigation from Rs.1079/ha during the eighties to Rs. 3330/ha during the recent period. The annual rate of growth is remarkable from 0.25% to have reached more than 10%. Irrigation investment per ha is the lowest (<Rs. 4000) in Chhattisgarh, West Bengal, Assam, Bihar, Haryana, Punjab, Kerala, Madhya Pradesh, Rajasthan, Uttar Pradesh and Tamil Nadu and much higher (>Rs. 8000) in Andhra Pradesh, Jharkhand and Uttarakhand. It may indicate that government spending tends to be more towards day to day expenses and subsidies (under revenue head) rather than on investments.

Private investment, which positively responds to public investment has increased from average Rs. 2606/ha during the eighties to Rs. 16,434/ha during 2010/11-15/16, growing at from nearly 2 % to 8% per annum over the period. Like public investment, private investment is the lowest in Chhattisgarh, a little higher in Assam, Bihar, Odisha and West Bengal between Rs. 4000-8000 per ha and the maximum in other states, viz. Himachal Pradesh (Rs. 78,225), Kerala (Rs. 52,220), Uttar Pradesh (Rs. 31,081), Punjab (Rs. 29,238), J&K (Rs. 25,559) during 2010/11-2015/16.

Another noticeable aspect is a change in farmers' investment behaviour towards residential land and buildings, non-farm business, livestock and tractors/machinery is noticed. The NSS 2012-13 reveals that out of total investments made, residential land and buildings constitutes a sizeable share at 68% followed by farm business at 23.3% and non-farm business at 8.7%. Capital expenditure on residential land and buildings has grown at a much higher rate at 4.7% compared to that in farm and non-farm businesses at 2.52% and 3.31%, respectively, between 2002/03 and 2012/13. Growing urbanization, expansion in industrial activities and low income from farming may have made investment in land lucrative relative to farming.

Whether income accrued from allied activities is ploughed back into agriculture is not known with certainty. But farmers' changing investment priority has implications for agricultural growth as it seems to be done at the expense of assets. Also, we find large inter-state and farm size disparities in private investment. An increasing number of farmers and labourers are exiting agriculture, leaving farming at the hands of women and tenant farmers having meagre resources.

The outcomes of an increase in public irrigation investment is marginal when seen through a negligible 3% increase in the share of net canal irrigated area in total from 14% to 17% over time. The burden rests on farmers to invest in tube wells, which led to over extraction of water and hence falling water tables in many states. The investment support extended through RKVY-RAFTAAR, National Food Security Mission and National Horticulture Mission is also not able to make any dent across the states. The institutional credit has increased and is more inclusive compared to the past but the rate of growth in investment credit remains tardy. Agriculture output and farmers' income have not accelerated at the pace the input costs has increased over the years, thereby making farming unviable. The problem is supplemented with inefficiencies in the agriculture marketing system and price volatility that hardly enable remunerative prices to farmers for their produce in the state-led APMC markets. Crop diversification has been taking place in some states but it is

hardly backed with support on account of over production and fall in prices. The rate of growth in productivity, especially of cereals has also been on a deceleration. Climatic change has further added to farmers' woes.

In terms of real value of output from agriculture and livestock, the average annual rate of growth has hovered between 2.63% and 5.58% since 1981 though Andhra Pradesh, Madhya Pradesh, Gujarat, Odisha, Rajasthan, West Bengal, Jharkhand and Tamil Nadu have made significant strides in growth in recent years. An increase in the value of output in agriculture is attributable to livestock activities. Among the states, the average value of agriculture output has ranged from Rs. 74,324 per ha in Chhattisgarh to Rs. 2,59,855 per ha in J&K during 2010/11-2015/16. The states that have lower value of output (<Rs. 1,50,000 per ha) include Assam, Bihar, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Odisha, Rajasthan and Chhattisgarh, and higher (>Rs. 2,00,000 per ha) include Haryana, Himachal Pradesh, J&K, Kerala, Punjab, Tamil Nadu, West Bengal, Jharkhand and Uttarakhand. The eastern states and some of the districts in select states need considerable handholding of the government, which also suggests a need for area specific intervention through investments and subsidies. Given the investment outcomes and challenges persisting, it may be a humongous task to achieve the government's dream of doubling farmers' income by 2022-23. Private and public investments together with favorable incentive structure and infrastructure development exert positive and significant impact on income and output. The additional investment requirements for DFI by 2022-23 at 2015-16 prices are estimated to be Rs. 645 billion on private account and Rs. 1900 on public account including investments in agriculture R&D, irrigation, rural energy, and rural roads transport. These have to grow annually at 10.8% and 14.7%, respectively for the stated goal. The estimates differ widely across the states, necessitating lower quantum of investments in the eastern and rainfed states due to relatively higher additional returns per unit of capital (GoI 2017; Bathla 2017).

It is, therefore, important to uphold farmers' interest in agriculture keeping in view rapid changes in their investment priorities towards tractors (for use in non-farm activities in lean season), machinery, and livestock. The role of respective state governments stands crucial in identifying regions that require interventions, scaling up resource allocation on irrigation with an eye on assuring capital use efficiency, and increasing institutional credit to the small and marginal farmers for farm and non-farm business. Efforts should also be made to consolidate small holdings, which have been growing steadily and link them with the market.

•

Technological Networking in Agricultural Sector for Doubling of Farmers' Income

• Dr. C. J. Dangaria •

India dare to dream the doubling of farmers income by 2022 and is committed to translate it, into reality through the excellence in political, administrative and technological will under the dynamic leadership of vibrant Prime Minister, Shri Narendra Modi. The Central Government, through NITI Aayog is bestowed with the strategic frame-working of various policies and modules so that different stakeholders can contribute significantly. Indian soil, are not only thirsty but also hungry too. Rain is the main source of water for the irrigation for most of the area. Rain water reaches to the deeper part of the soil is lifted again and used for the irrigation. Therefore, substantial financial outlay was opened by the Central Government on the ambitious project aspiring "per drop, more crop" under the scheme of Pradhan Mantri Krishi Sinchayi Yojana. After water, seed and nutrients are the most important agricultural input for the crop production. *Paramparagat Krishi Vikas Yojana* has been planned and executed to address the need of quality seeds, nutrients based on soil health of each field (soil health card) and promotion of traditional farming practices. Agricultural Universities are bestowed with the responsibilities of developing location specific technologies and resolve complexities of scientific principles. Accordingly their Teaching, Research and Extension modules need to be molded vis-à-vis to the time bounded action plan. Our Teaching, Research and Extension strategies should focus on:

1. Enhancing Land and Input Use Efficiency
2. Eco-friendly Crop Protection Technologies
3. Modeling Agronomic Practices According to the Climate Change
4. Augmenting Crop Improvement Strategies
5. Post Harvest Processing and Value Addition
6. Excellence in Market Research and Crop Planning
7. Convenient Transfer of Technologies by using Information Technology

1) Enhancing Land and Input Use Efficiency

Land and Water are the two most critical inputs in the agriculture. The concept of "Per Drop More Crop" the brain child of Gujarat Government, now has become slogan of entire farming community of the nation. Fertilizers to

provide the essential nutrients are most important input in the agriculture. Among the different nutrients, Nitrogen, Phosphorous and Potash are the major nutrients. There has been a steady growth in the production and use of chemical fertilizers in the agriculture after the green revolution which is still continued. Among all the chemical fertilizers, Nitrogen, in the form of Urea is most used fertilizer. Microbes are the hidden and silent treasure for the agriculturists and ecosystem. There are certain group of highly efficient microbes which play a pivotal role in fixing atmospheric nitrogen and mobilizing phosphorous, potash and other nutrients. Department of Plant Pathology of N.M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat, initiated categorically efforts to revitalized soil and increase production by reducing the quantum of chemical fertilizers through use of Biofertilizers by using different bacteria viz., *Azotobacter, Acetobacter, Azospirillum, Rhizobium, Phosphate Solublizing Bacteria, Potash Mobilizing Bacteria* and a Plant Growth Promoting *Rhizobacteria, Pseudomonas*. The technology has potential to cut down the use of chemical fertilizers by fifty per cent and categorically reduced the quantum of chemical fertilizers in the soil. For the efficient use of microbes in agriculture, soil organic carbon is most critical. Due to the reduction in number of livestock and increasing in cropping area, the conventional sources of organic carbon viz., farm yard manure, compost and green manure is practically nor feasible. There must be some technological fusion for the conversion of non conventional source of organic carbon in the soil. Banana pseudostem sap produced from the banana pseudostem waste through mechano-microbial digestion is one of the best alternate which apart from the increasing soil organic carbon have many multifacet significance. Soil and Water Management Unit of Navsari Agricultural University, Navsari is pioneer in the work. This is the transformation of waste into the best as not only resolved the pollution issues created by the cumbersome banana pseudotem waste, but also is an excellent source of many essential plant nutrients and plant growth regulators. The fibre obtained during the process also fetch premium price and enhance the farm profitability.

2) Eco-friendly Crop Protection Technologies

In the middle of last century the use of chemicals as pesticides started in the agriculture. It has fatally mess up the entire ecosystem and proportion of various categories of organism substantially deviated from the ideal. There is dire need to introduce the safe chemicals through proper designing of target specific chemicals and amalgamating it with the Biopesticides. There are enormous microbes can be used as insecticides, fungicides, weedicides, nematicides, etc, need to be exploit unconditionally in the different ecosystem

and provision should be made to use the consortia of these suitably designed through research and participatory approach.

3) Modeling Agronomic Practices According to the Climate Change

Climate, with its regional and temporal variability, is a major determinant of agricultural production. With the climatic conditions change, production conditions are likely to change with possible positive or negative implications on agricultural production. Therefore, it is important to anticipate future changes in the agro ecosystem to be able to respond adequately and maintain its functionality. The need for "urgent action to combat climate change and its impacts" has recently been called for in the 13th of the 17 UN Sustainable Development Goals that were officially ratified in September 2015 and should be achieved over the next 15 years. This goal places particular emphasis on strengthening resilience and adaptive capacity to climate risks and natural disasters. In the context of adaptation in agro ecosystems, Goal 13 is linked to the second goal, which is to "end hunger, achieve food security and improve nutrition and promote sustainable agriculture". One of the targets to achieve this goal, which is clearly linked with the 13th Goal, is to "ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, help maintain ecosystems, strengthen the capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters, and progressively improve land and soil quality". Climate change adaptation is clearly also in the interest of individual farmers or farming cooperatives that rely on the revenue generated from agricultural production.

4) Augmenting Crop Improvement Strategies

All the efforts will lose their significance if the seed planted is not proper. Therefore, crop improvement strategies must be continued. Revolutionary benefits of the highly proclaimed information technology are not being utilized in the agriculture properly. Concomitantly, balance between demand and supply of a particular commodity at a particular time is highly distorted. This is more commonly observed in the popularization of newly developed superior variety and its timely replacement. These grievances can be addressed by the fusion of seed development, production, marketing and distribution channel. Conceptualization and implementation of seed village programme jointly by the breeders, seed production machineries marketers and farmers. A linear growth in the seed replacement ratio has been observed in the after implementation of the project by the different agricultural universities of the Gujarat which need to be replicated.

5) Post Harvest Processing and Value Addition

Developing food processing technologies that are environmentally friendly and efficient can substantially contribute to its value chain and food security. It can markedly reduce the agri product from the deterioration before it reaches to the consumer's mouth. Industrialization with proper crop planning, transportation and distribution by excellent coordination of the crop producer, marketer, food processor and supply chain machineries can substantially reduce the post harvest losses.

6) Excellence in Market Research and Crop Planning

Farmers must yearly allocate fields to different crops and choose crop management options based on the market demand. These decisions are critical because they modify farm productivity and profitability in the short and long run. To support farmers and efficiently allocate scarce resources, decision support models need to be developed. Decision support models will mainly based on two concepts, the cropping plan and the crop rotation decisions. These decisions concern crop choice, crop spatial distribution within the farmland and crop temporal successions over years. Decisions will have strong impacts on resource use efficiency and on environmental processes at both farm and landscape scales.

7) Convenient Transfer of Technologies by using Information Technology

Technologies are valued by the users and do not have any significance, if these does not reach to the users in its correct form. In agriculture, transfer of technology is still a great issue and is major cause of poor adoption of any technology. There is dire need to efficiently exploit significance of information technology in the agriculture for the better extension. An innovative initiative *"Mera Gaon Mera Gaurav"* has been planned to promote the direct interface of scientists with the farmers to hasten the lab to land process. We need to increase different categories of farmers, farm women and farm youth for two way communication so that their issues and problems can also be reached to the policy makers and scientists. This will lead to "shrinking of cost and swelling of benefit". Massive support of crop loan through Kisan Credit Card and insurance through *"PradhanMantri Fasal Bima Yojana"* will take these schemes to all the corners of the nation for diverse crop ecosystem to realize the dream of doubling farmers income into reality.

•

Diversification and Intensification in Agriculture for Doubling Farmers' Income

• Dr. V. P. Chovatia •

1. Introduction

Doubling farmers' income is a buzz word nowadays. India has set a very ambitious target of doubling farmer's income by 2022. Doubling real income of farmers by 2022-23 over the base year of 2015-16, requires annual growth of 10.41% in farmers' income (whereas, it was at 3.80% in 2016-17). This implies that the on-going and previously achieved rate of growth in farm income has to be sharply accelerated. Therefore, strong measures are needed to harness all possible sources of growth in farmers' income within as well as outside agriculture sector. Past strategy for development of the agriculture sector in India has focused primarily on raising agricultural output and improving food security. This strategy involved (a) an increase in productivity through better technology and varieties, and increased use of quality seed, fertiliser, irrigation and agro chemicals; (b) incentive structure in the form of remunerative prices for some crops and subsidies on farm inputs; (c) public investments in and for agriculture; and (d) facilitating institutions. The strategy paid dividends as the country was able to address severe food shortage that emerged during mid-1960s. During the last half a Century (1965 to 2015), since the adoption of green revolution, India's food production multiplied 3.7 times while the population multiplied by 2.55 times. The net result has been a 45% increase in per person food production, which has made India not only food selfsufficient at aggregate level, but also a net food exporting country.

The strategy did not explicitly recognise the need to raise farmers' income and did not mention any direct measure to promote farmers' welfare. The experience shows that in some cases, growth in output brings similar increase in farmers' income but in many cases farmers' income did not grow much with increase in output. The net result has been that farmers' income remained low, which is evident from the incidence of poverty among farm households. The NSSO data on Consumption Expenditure Survey for year 2011-12 reveals that more than one fifth of rural households with self-employment in agriculture as their principal occupation were having income less than the poverty line. The proportion of farm households suffering from poverty was quite high in some states (Fig. 1). The highest incidence was observed in Jharkhand where 45.3% of farm households were under poverty.

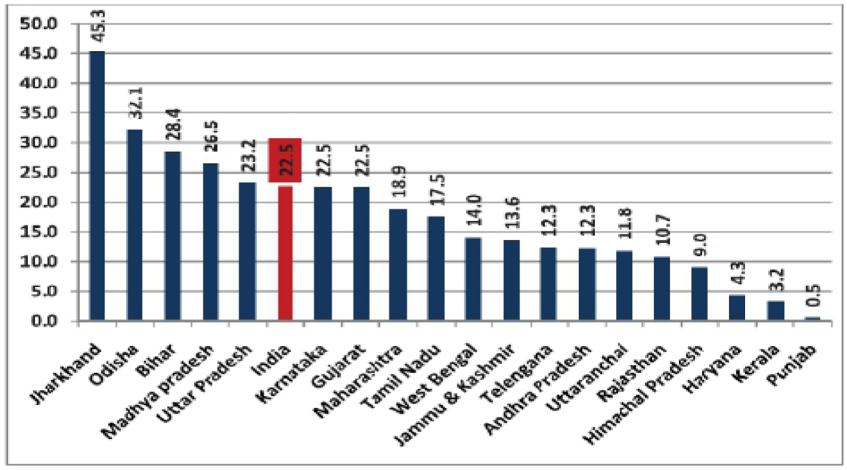


Fig. 1: Farm households with income below poverty line, 20-11-12. (Source: Chand, 2017)

Farmers' income also remained low in relation to income of those working in the non-farm sector (Fig. 2). During early 1980s, farm income per cultivator was just 34% of income of a non-agriculture worker. This disparity was quite large and required a policy response to raise farmers' income at a faster rate. This could be done in two ways - high increase in sectoral income and/or decline in number of the farmers to share the total income of all the farmers. However, this did not happen and the level of disparity remained unchanged in the following decade. After 1993-94, relative income of farmers worsened and reached one-fourth of income of nonagricultural workers. There was some improvement during 2004-05 to 2011-12, but no change over the 1983-84 level. The past four years (2012-13 to 2015-16) again witnessed deterioration in relative income of farmers.

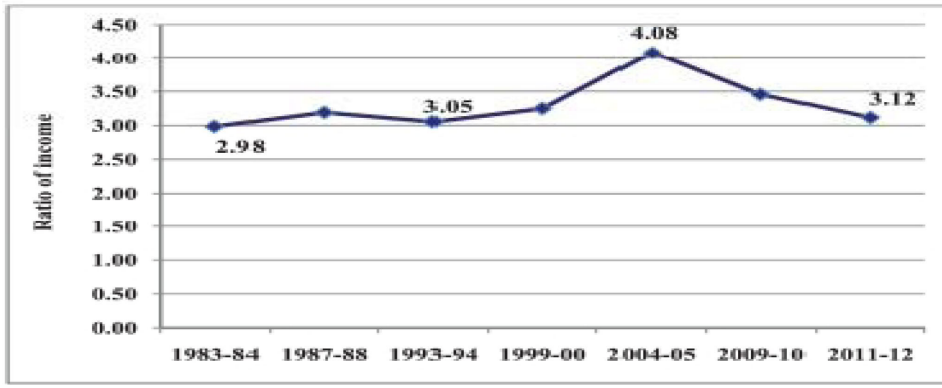


Fig. 2: Ratio of income per non-agriculture worker to income per cultivator. (Source: Chand, 2017)

Low level of absolute income as well as large and deteriorating disparity between income of a farmer and non-agricultural worker constitute an important reason for the emergence of agrarian distress in the country during 1990s, which turned quite serious in some years. The country also witnessed a sharp increase in the number of farmers suicides during 1995 to 2004 - losses from farming, shocks in farm income and low farm income are identified as the important factors for this. This period coincided with the sharp slowdown in the growth rate of agricultural output (Chand and Parappurathu, 2012). The low and highly fluctuating farm income is causing detrimental effect on the interest in farming and farm investments, and is also forcing more and more cultivators, particularly younger age group, to leave farming. This can cause serious adverse effect on the future of agriculture in the country.

Realising the need to pay special attention to the plight of farmers the Central government changed the name of Ministry of Agriculture to Ministry of Agriculture and Farmers Welfare in 2015. It is apparent that income earned by a farmer from agriculture is crucial to address agrarian distress (Chand, 2016a) and promote farmers welfare. In this background, the goal set by the Hon'ble Prime Minister Shri Narendra Modi to double farmers' income by 2022-23 is central to promote farmers' welfare, reduce agrarian distress and bring parity between income of farmers and those working in non-agricultural professions.

2. The Concept and Timeframe

The goal of doubling farmers' income by the year 2022 has been dubbed as impossible and unrealistic by some experts (Gulati and Saini, 2016). Some commentators have produced calculations that agriculture will require annual growth of 14.86% per year for five years to get farmers' income doubled and pointed out that this growth level hasn't been achieved even for one year in the history of Indian agriculture. It seems that critics and sceptics focused more on five years and ignored substantive aspects of the matter (Chand, 2016b).

It is also evident that the Hon'ble PM referred doubling farmers' income by year 2022, which is seven years away from the base year 2015-16. And, if anything is to be doubled by the year 2022-23, it will require an annual growth rate of 10.4%. Again, it is important to clarify what is sought to be doubled. Is it the income of farmers, or the output or the income of the sector or the value added or GDP of agriculture sector? If technology, input prices, wages and labour use could result in per unit cost savings then famers' income would rise at a much higher rate than the output. Another very important source of increase in farmers' income is the relative increase in prices of farm products

compared to the prices of non-agricultural commodities. Past estimates of farm income show a significant difference between growth in output and growth in farmers' income. During 2004-05 and 2011-12, agricultural output at constant prices increased by 34% while real farm income per farmer increased by 63% (Chand et al., 2015). In nominal terms, the output became 2.65 times while farmers' income tripled in the seven years period. Therefore, doubling of farmers' income should not be viewed as same as doubling of farm output.

It is obvious that if inflation in agricultural prices is high, farmers' income in nominal terms will double in a much shorter period. In the last 30 years, farmers' income at nominal prices almost doubled in five years twice, once during 1987-88 to 1992-93 and then during 2004-05 to 2009-10. Inflation in agricultural prices also leads to increase in real farm income if agricultural prices received by farmers increase at a faster rate relative to the prices paid by farmers i.e. when terms of trade for agriculture improves.

In a situation where non-agricultural prices do not rise, or, rise at a very small rate, the growth in farmers' income at real prices tends to be almost the same as in nominal prices. Anyway, the government's intention seems to be to double the income of farmers from farming in real terms.

3. Past Trend in Farmers' Income

The absence of adequate information on farmers' income makes it difficult to know adequacy, fluctuations and growth in farmers' income, and makes it impossible to know how various factors affect farmers' income. Some researchers have tried to fill this gap by preparing estimates of farmers' income. A notable study on this is by Chand et al. (2015). It provides estimates of total and per cultivator farm income for the period 1983-84 to 2011-12, and identifies sources of growth in farm income. They reported that increase in productivity, rise in real farm prices and shift of labour force from agriculture, are the important determinants of growth in farm income. Another important finding of this study has been that agrarian distress, as revealed by farmers' suicides, increased when growth in farm income was low and it went down when farmers' income experienced high growth rate. Thus, the level of farm income was crucial to address agrarian distress. The study observed that the income earned from agriculture was not adequate to keep as many as 53% farm households out of poverty, who operated on less than 0.63 hectare of land holdings. Two national level surveys of NSSO provide estimates of farmers' income from various sources including agriculture. According to SAS for the year 2012-13, the average annual income of a farm household from farm as well as non-farm sources was Rs. 77,112. Sixty per cent of total income of an agricultural

household was derived from farm activities (cultivation and farming of animals) and 40% was derived from non-farm sources (wages, salary, non-farm business etc.). In absolute terms, cultivation generated annual income of Rs. 36,938 and livestock provided Rs. 9,176, per agricultural household. According to this estimate, the share of livestock activity in total farm income of agricultural household was close to 19.89%. The most recent estimates of farm income were prepared by Chand et al. (2015) for the period 1983-84 to 2011-12. These estimates updated to year 2015-16 are presented in Table-1 at nominal prices as well as in real terms. Here it is important to mention that farm income in real terms is not the same as the income at constant prices. These estimates were further extended to year 2015-16 to arrive at income for the recent years. During the past 22 years, between 1993-94 and 2015-16, farmers' income in nominal terms increased 9.18 times. During the same period, CPIAL (Consumer Price Index for Agricultural Labour), which measures price change in rural India, increased 4.62 times. Taking away the effect of inflation, real farm income just doubled during past 22 years. Meanwhile, the farm income per cultivators shows a slightly higher increase due to the decline in the number of cultivators after 2004-05.

Table-1: Trend in Farmers' Income in India (1993-94 to 2015-16)

Year	Net value added at market prices (Rs. crore)	Wage bill at market price (Rs. crore)	CPIAL (2004-05=100)	Total farm income of all farmers' (Rs. crore)		Cultivators (Number in crores)	Farm income per cultivator (Rs)	
				Market price	Real price		Current price	Real price
1993-94	223709	45755	59	177954	303814	1439	12365	21110
1999-00	426582	90951	90	335631	372923	1388	24188	26875
2004-05	527289	93130	100	434160	434160	1661	26146	26146
2011-12	1409932	252804	183	1157128	632514	1462	79137	43258
2012-13	1558480	245750	220	1312730	596695	1436	91416	41553
2013-14	1753691	276532	245	1477159	602922	14.10	104763	42760
2014-15	1849931	291708	261	1558223	597020	13 85	112507	43106
2015-16	1940636	306010	273	1634625	598764	13.60	120193	44027

(Source: Chand. 2017)

The subsequent period till 2011-12 witnessed acceleration in total and per farmer income. Total income of all the farmers increased by 5.52% per year during 2004-05 to 2011-12. In a sharp contrast to the first decade of the reforms, the period 2004-05 to 2011-12 witnessed decline in the number of cultivators, which translated into much higher growth in per farmer income as compared

to the growth rate in income of all farmers. The rate of growth was 7.46% a year, which is a great step towards achieving goal of doubling farm income. The period 2004-05 to 2011-12 faced a very favourable combination of factors which constitute farm income. Growth rate in output was impressive, number of farmers to share farm income declined and prices received by farmers increased at a much higher rate than the increase in prices paid by rural consumers.

Table-2: Growth Rate in Farm Income in India (per cent per year)

Period	Agriculture value added at constant prices	Farm income of all farmers		Farm income per cultivator		CPIAL base 2004-05	Implicit price index for agriculture
		Market price	Real price	Market price	Real price		
1993-94 to 2004-05	2.52	8.45	3.30	7.04	1.96	4.91	5.65
2004-05 to 2011-12	4.19	15.03	5.52	17.14	7.46	9.02	9.80
2011-12 to 2015-16	1.60	9.02	-1.36	11.01	0.44	10.52	6.88
1993-94 to 2015-16	2.87	10.61	3.13	10.89	3.40	7.21	7.35

(Source: Satyasai and Mehrotra, 2016)

It is pertinent to mention that the latest data on number of cultivators is available only up to the year 2011-12. Therefore, while calculating per cultivator income, it is assumed that farm workers would continue their withdrawal from agriculture at the rate observed during 2004-05 to 2011-12. Interestingly, even with less number of cultivators in agriculture sector, real income per farmer showed insignificant increase during 2011-12 to 2015-16. Presently, per cultivator income has been estimated as Rs 1,20,193 at current market prices.

4. Sources of Growth in Farmers' Income

The possibilities of doubling farmers' income in real terms from above sources are explored in the following sections.

4.1 Diversification in Agriculture

The second source of growth to the farmer's income can be new crop cultivation and prices. Diversification talk generally concentrates on high value crops but the country needs three types of diversification: product (high value enterprises), process (precision farming), and time diversification (delinking from seasonality). Diversification of agriculture refers to the shift from the regional dominance of one crop to regional production of a number of crops/ enterprise, to meet ever increasing demand for cereals, pulses, vegetables, fruits, oilseeds, spices, fibres, fodder and grasses, fuel, livestock and fish products,

etc. It aims to improve soil health and a dynamic equilibrium of the agro-ecosystem. Crop diversification takes into account the economic returns from different value-added crops. It is different from the concept of multiple cropping or succession planting in which multiple crops are planted in succession over the course of a growing season. Moreover, it implies the use of environmental and human resources to grow a mix of crops with complementary marketing opportunities, and it implies a shifting of resources from low value of crops to high value crops, usually intended for human consumption such as fruits and vegetables. With globalization of the market, crop diversification in agriculture means to increase the total crop productivity in terms of quality, quantity and monetary value under specific, diverse agro-climatic situations world-wide.

(i) Integrated Farming Systems

Complementary relations exist among farm enterprises which are hardly exploited as we have been increasingly depending on purchased inputs and preferring solo enterprises rather than a mix of them. There is a need to conceptualize the concept of integrated farming system (system diversification) to synergize productivity and profitability, input use efficiency, cropping intensity, resource conservation, employment generation, environmental security and poverty alleviation, identification, evaluation and up scaling of integrated farming systems in different agro-ecological regions. Optimal combination of agriculture, livestock, poultry, fishery, forestry etc. is essential for various categories of farmers and farming situation with a viable basket of options.

The farming systems approach has tremendous potential for enhancing income for small holders especially in rainfed areas. The net income from groundnut based farming system can be Rs. 22000 per hectare compared to Rs. 5059 per hectare of groundnut alone (Table-3).

Table-3: Net Returns from Farming Systems

Crop	Income (Rs./ha)	Farming System	Income (Rs/ha)
Groundnut	5059	Groundnut + Dairy (1 animal) + sheep (8-10)	22000
Finger millet	7500	Finger millet crop (0.8 ha) + Dairy (1 animal) + Horticulture (0.2 ha)	24850
		1 ha Mango + 1 cow + 2 sheep + 10 birds	45925

(Source: Kiresur. 2016)

In spite of the advantages of adopting farming systems, adoption by farmers is not high due to limitation of available production technologies, biophysical or geophysical constraints, labour and input market constraints, financial and credit constraints, social norms, inter-temporal trade-offs, policy constraints, and constraints to knowledge or skills. Both supply and demand side factors impact farmers decisions (Bowman and Zilberman, 2013; Stoorvogel et al., 2004).

(ii) Diversification Towards High Value Crops

Diversification towards high value crops is required to improve income and improve resource use efficiency. Similarly diversification towards livestock, poultry and towards non-farm sector activities is considered ideal especially for small holders who do not possess adequate land to generate enough income for the family. Diversification of agriculture offers food & nutrition security, income growth, poverty alleviation, employment generation, judicious use of land and water resources, sustainable agricultural development and environmental improvement. It is the outcome of the net effect of many factors like: a) resource endowments especially of irrigation, rainfall and soil fertility; b) technology covering seed, fertilizer, water technologies as well as those related to marketing, storage and processing; c) household needs covering food and fodder self-sufficiency demands as also investment capacity; d) price factor covering output and input prices, trade and other economic policies that have direct or indirect impact on prices; e) institutional and infrastructure factors covering farm size, tenurial arrangements, research, extension and marketing systems and government regulatory policies; f) urbanisation; and g) changed dietary preferences. Another dimension of diversification is about obtaining income from multiple sources.

Augmenting income from additional avenues, thus, is not an automatic task. Comparatively, deriving some additional income from a non-farm job that gives wage or salary incomes may appear easier in short run than deriving income from farm or livestock activities. This is about distress employment in non-farm sector where people are employed in low paid jobs. However, getting a skilled job is a different story where professional training is required. Skilling, thus, assumes importance. Skilling is needed for preparing rural people for jobs throughout the value chain, input supply channels, farm machinery sale, operation and repair, agro-processing, farm trade and so on. Towards meeting the demand for skilled jobs, children of farmers not keen on continuing farming should be imparted trainings in their chosen fields for a longer duration, preferably along with the formal schooling. As agriculture is getting increasingly diversified and commercialised, the demand for processing facilities, trade related capabilities, agri-retailing, storage management, quality control skills and so on.

Skilling in farming is equally important. Perhaps, farming is one profession that is almost taken up by inheritance. Once anyone is borne into a farmer's family and is not good at studies, his/her fate is more or less sealed for agriculture and further learning is only by doing in the traditional way. Can modern agriculture be practiced without proper skilling and professionalization of the people who have to organise resources, collect and leverage information, take crucial decisions and bear the risks? Farming is increasingly skilled job with agricultural markets evolving in the digital space, consumer preferences going global, all entrepreneurial functions demanding technical and managerial skills and value chains becoming sophisticated. Often, it is reported, farmers express the desire that their children shall not be farmers. About 40% of farmers expressed desire to discontinue farming. Not so adequately educated children of farmers also prefer a city job, however difficult the living may be there. This reflects the drudgery, low returns, uncertainties and low dignity for the profession in the general public eye. Under such circumstances, can people who are forced into the agriculture as a profession deliver? Hence, farmers and future farmers should be trained in agriculture and related aspects. Dignity should be present initiatives such as farmers' field schools, Life Long Learning for Farmers (L3F) etc., are limited to a few locations in a few states and necessary scaling up did not happen.

There are several training arrangements in the country. But there is a need for unified training system, may be along the lines of RSETIs or under their aegis for catering to all types of trainings. Besides, there can be distinct modules in school curriculum that teach about our agricultural traditions and practices.

(iii) Value Addition and Food Processing

Farm income can be accelerated by engaging farmers in allied activities, thereby insulating them against risks of vagaries of climate. Rapidly growing purchasing power, both in urban and rural centres, has effected shift in demand pattern in favour of products of allied sector, value added products, ready to cook and ready to eat products thus moving away from traditional staple food varieties. The opportunities available has to be tapped with appropriate investments in dairy, poultry, sheep-goat, piggery, rabbit rearing, fishery, value addition, food processing, etc.

India, second largest producer of fruits and vegetables in the world, has registered a growth in area under horticulture of about 3.8% per annum and production by 7.6% per annum over the last decade. The country is also the highest producer of milk in the world, accounting for 17% of the world's production. GoI had launched the National Livestock Mission in 2014–15 for sustainable and continuous growth of the livestock sector by emulating the

success achieved in the dairy and poultry sectors across species and regions. There is increasing significance of poultry and livestock products in the context of diversifying farm and non-farm activities in the agriculture sector to increase livelihood security. Fisheries constitute about 1% of the total GDP of the country and 5.08% of agriculture GDP. The GoI plans to further this by implementing an umbrella scheme under its Blue Revolution initiatives, covering inland fisheries, aquaculture, marine fisheries including deep sea fishing, mariculture, etc.

Recent discourses on the doubling of farmers' income in India has led to a few prominent commentators mentioning that these sectors hold vast potential to create and stabilize income generation in farmholds.

4.2 Intensification in Agriculture

There are two sources to increase in agricultural output viz., area and productivity. Due to rising demand for land for non-agricultural uses and already high share of arable land in total geographical area of the country, further expansion in area under cultivation is not feasible. Rather there is a decline of about 10 lakh hectares, as agricultural land has been diverted to non-agricultural uses since the year 2004-05. Therefore, agricultural output has to be increased through improvement in productivity per unit of land.

(i) Enhancing Productivity

Productivity of most of the crops in the country is low and there is considerable scope to raise it. Except wheat, productivity of other crops in the country is below world average and much lower than agriculturally advance countries. Even, within the country there is large variation in yield across states. A large variation in yield across states is due to variation in access to irrigation but even for the states with similar irrigation coverage, productivity show significant variation.

Variation in productivity at same level of irrigation and lower yield in India compared to the world average are due to poor level or low adoption of improved technology. Enhancing access to irrigation and technological advancement are the most potent instruments to raise agricultural productivity and production in the country.

a) Bridging Yield Gap

Increase in yield or productivity of crops and other enterprises is the single most important factor that can increase income. Since the area cannot expand much either through increase in net sown area or through increase in cropping intensity, enhancing the productivity is the only route available to enhance production. While varietal improvement through conventional breeding or

biotechnology is a long term option, bridging yield gaps through adoption recommended agronomic practices, planning profitable crop mix that can maximise aggregate income and reducing crop losses through integrated pest management are short/medium term options that can bring additional income.

Several studies have indicated existence of sizeable yield gaps between the attainable and actual yields on farmers' fields. For instance, a study reported that the yield gaps ranged from 28.22% (wheat) to 212.04% (jowar) among cereals, from 115.39% (chickpea) to 225.41% (green gram) among pulses, from 24.41% (rapeseed & mustard) to 180.84% (sunflower) among oilseeds, from 57.56% (potato) to 172.92% (onion) among vegetables, and 20.88% (jute) to 495.46% (cotton) among fibre crops across four different states studied (Satyasai and Mehrotra, 2016). These gaps tend to be huge in underdeveloped regions and on smaller farms. Several constraints for bridging the yield gaps such as water shortage, shortage of skilled labour, lack of power supply, etc., were identified.

Global Yield Gap Atlas (www.yieldgap.org) reported huge yield gaps of over 50% even in case of irrigated rice. Perhaps, practices like System of Rice Intensification (SRI) may step up yield levels. In spite of favourable reports about the performance of SRI in increasing rice yields (even for other crops for that matter) based on trials, its adoption rate by the farmers does not seem be on expected scale. Hence, the technique needs to be tested and mainstreamed. System of crop intensification should be adopted in cotton, sugarcane etc.

Yield gaps in drylands and rainfed areas which are characterised by low productivity are another cause of concern. The yield gaps can be bridged with simple agronomic measures. Intercropping, crop rotation, line sowing, weed control, applying secondary and micronutrients are some of the strategies for bridging yield gaps.

b) Biotechnology

Apart from increasing the production and productivity of agricultural produce and products, agro-biotechnological applications have a great potential in enhancing the value of agricultural products in terms of quality and nutrition. Biotechnology, in agriculture, is a powerful and immensely useful tool to keep pace with the ever burgeoning population for meeting the food and nutritional security, compensate for dwindling natural resource base and meeting the challenge of escalating biotic and abiotic stresses. Biotic and abiotic stress resistant varieties of important crops will have to be developed. Timely availability of quality seeds of high yielding varieties/hybrids to the farmers is the need of hour.

(ii) Leveraging Water Resources for Enhancing Farm Income

Water resources are very scarce in relation to size of arable land and population and also the swelling demands from other users such as industry, domestic segment for drinking, sanitation and washing, public uses such as parks and gardens and hospitality industry. With growing demands from competing water users the water risks have been growing in our country which is the most waterchallenged in the world. A few facts would put the issue in perspective: (i) 54% of the country face high to extremely high water stress and the same proportion of wells face groundwater decline, (ii) more than 100 million people live in areas of poor water quality. With the growing demands from industry and domestic users, the pressure for managing water available for agriculture in judicious manner is mounting. One can get an idea of future water demand given that by 2050 the global agriculture needs to produce 60% more and 100% more in developing countries. This can be met only by improving water productivity and right policy mix. Role of irrigation in mitigating certain risks and imparting stability to agricultural production is well known. Due to scarcity of water and heavy demand pressures on it, we need to focus on micro-irrigation systems like drips and sprinklers. Hardly 10% of the potential area that can be brought under microirrigation is presently covered. With the 'more crop per drop' being the urgency now, the irrigation development efforts should simultaneously focus on expanding irrigated area and improving the efficiency. Expanding irrigation cover to larger tracts should be through water saving techniques as there are limits for expanding irrigated area. An additional acre brought under irrigation can increase output and thereby income through area, productivity and cropping pattern effects.

(iii) Intensive Cropping Systems

Crop intensification is essential to develop sustainable agricultural systems, but it can have various meanings in different contexts. Intensification in sustainable agricultural systems generally refers to the fuller use of land, water and biotic resources to enhance the agronomic performance of agro-ecosystems. While intensification may involve increased levels of capital, labour and external inputs, the emphasis here is on the application of skills and knowledge in managing the biological cycles and interactions that determine crop productivity and other aspects of agro-ecosystem characteristics. In meeting the concurrent goals of increased productivity and reduced environmental risk, intensification can occur in both temporal and spatial dimensions. Farmers can intensify the use of the resources available to them at different times by using more diverse rotations and optimal harvesting schedules. They can intensify the use of resources spatially by adopting techniques and growing crops that

take fuller advantage of available sunlight, moisture, nutrient reserves and biotic interactions, both aboveground (e.g. mixed cropping) and belowground (e.g. use of legumes and deep-rooted tree crops). Efficient new intensive cropping systems according to different regions should be developed (Table-4).

Table-4: Efficient Intensive Cropping Systems Recommended for Different Regions of India

Station	Recommended Cropping System			Equivalent yield	B:C ratio
	Kharif	Rabi	Summer		
East					
Jorhat	Rice	Pea	-	120.36	2.31
Jorhat	Rice	Onion	Cowpea (F)	121.74	3.06
Kolkata	Jute	Paddy	Tomato	-	1.53
Patna	Rice	Tomato	Bottle gourd	404.4	2.89
Bhubaneshwar	Rice	Maize	Ccwpea	174.31	2.30
West					
Navsari	Rice	Fenugreek	Okra	257.3	3.83
Parbhani	Soybean	Onion	-	199	2.70
Rahuri	Peartmilet-Soybean	Onion	-	41.59	6.21
Dapoli	Rice	Maize	-	124.85	1.93
Central					
Jabalpur	Rice	Berseem (F)	Berseem (S)	110.99	3.55
Hoshangabad	Soybean	Pea	Sugarcane	110.60	2.84
North					
Jammu	Rice	Marigold	Frenchbean	301	2.90
Srganganagar	Guar	Wheat	-	33.42	3.50
Tonk	Groundnut	Wheat	-	101.4	2.22
Lucknow	Rice	Potato	Japanese mint	266.40	1.37
Lucknow	Pigeonpea	Menthol mint	-	31.68	1.26
Faizabad	Rice	Lentil	Green fodder	187.67	2.43
South					
Nizamabad	Maize	-	Groundnut	121.82	2.33
Coimbatore	Maize	Cowpea	Tomato	73.59	2.08
Hyderabad	Rice	Maize	-	111.3	2.90
Thiruvananthapuram	Rice	Rice	Green manure	-	2.46

(Source: Gangwar and Singh, 2011)

(iv) Special Focus on Dryland Areas

Dryland areas are home to 43% of our population and receive rainfall between 150 mm to 1000 mm per annum. Ten states (Rajasthan, Madhya Pradesh, Maharashtra, Gujarat, Chhattisgarh, Jharkhand, Andhra Pradesh, Karnataka, Telangana and Tamil Nadu) account for 80% of the drylands in the country. These areas are resource poor with poor soils and scarce water resources. But, they have to cater to about 40% of national food demand by

2020 even under the most optimistic scenario. The additional demand should come through increasing productivity of rainfed agriculture. This is a catch situation where drylands have very limited irrigation and soil resources and productivity improvement needs irrigation facility, good soils and technology. The irrigation sources (basically groundwater) have been overexploited in several parts of the country. As a result, groundwater table declined irreversibly and water is being mined.

There are a few options which have been successfully tried in pockets but could never reach a reckonable scale. They are watershed development including soil-water conservation measures, water harvesting and efficient use and dryland technologies. Water management interventions for drylands consist of: i) adopting an efficient watershed management approach, ii) reducing vulnerability through rainwater harvesting and storage, iii) recharging depleted groundwater and aquifers and strictly regulating groundwater extraction, iii) pricing water and power to reflect their opportunity costs, v) enlisting government support for water saving options, vi) specifying and enforcing clearly defined water rights in watershed communities, vii) enabling stronger collective action for community development in agriculture and resource management, and viii) enhancing the scientific and technological support to watershed programmes.

Watershed programmes displayed reasonable spread across the country. They are principal tools for poverty reduction in rural areas. Watershed development is imperative to meet the poverty reduction challenges in drylands though it is often felt that one-size fits all approach is followed. Further, watershed development instead of focussing on sustainable water management remained alternative name for dryland development. However, several impact studies highlighted the positive contribution of watershed development programmes. Watersheds improved availability of water and the water table levels improved significantly making available additional groundwater. Thus, irrigated area expanded between 5.6 to 68%. Also, the productivity levels of crops improved about 7 to 17%. Incomes improved by around 29% (Satyasai and Mehrotra, 2016). Country-wide studies revealed that watershed programmes improved land use, irrigation, availability of fodder and fuel, livestock population, brought changes in cropping pattern towards remunerative crops, and improved income by up to 50%. While conserving soil and water, the programmes drought proofed their command areas. The benefits are amplified and rendered investments durable with effective people's participation. Water harvesting is another important intervention especially for drylands. It was done within and outside watershed programme with differential impact. Farm ponds are very

important among them. Small ponds dug to capture rainwater for use in times of need could lead to significant benefits on irrigated area and income. Protective irrigation is one of the benefits it could provide to save the standing crop. A study of farm ponds across 7 locations in the country revealed substantial benefits accruing from the investment (Kumar et al., 2016). Due to availability of additional water, improved varieties are grown and the portfolio of enterprises on the farm was diversified with additional fruit and vegetable crops, tree species and additional animals. The initial investment ranged from Rs. 33,800 to 99,225. Productivity of crops increased post-farm ponds, as also the net returns. Utility of farm ponds has been highlighted by success stories of withstanding drought during the last year coming from different parts of the country.

Farm ponds, though useful for drought prone areas are not received well by farmers due to various reasons such as: lack of awareness and knowledge, lack of funds for initial investment and long payback period, reluctance to allocate land for the structures, small net benefits from small rainwater harvesting structure and difficulties in accessing technical and financial support. It pays to encourage farm ponds, especially, on sharing basis. Traditionally, the village tanks used to serve the same purpose. But with their deterioration overtime due to neglect, disintegration of control systems, encroachment of catchment area, tank bed and the channels, etc. Reviving the tank systems and involving people in their management would go a long way in rainwater harvesting and water resources management.

Groundwater in drylands is a precious resource with limited scope of recharge from surface water resources. Water intensive cropping pattern adopted in these areas coupled with free or cheap power encouraged indiscriminate pumping leading to mining. Participatory management of groundwater as successfully proved in Andhra Pradesh is one solution for managing the resource. In fact, the paradigm inmanaging water should change towards viewing both groundwater and surface water as a single resource.

Another strategy that did not percolate well in drylands has been the technology adoption. There are several available technologies which can be grouped into: Improved Crop Management Practices (ICMP); Improved Livestock Management Practices (ILMP); Improved Soil and Water Conservation Practices (ISWCP) and Improved Energy Management Practices (IEMP). A field study revealed that these technologies had positive impact. Energy management practices appear to be most rewarding as shown an elasticity of gross income with respect to cost of 5.73. Most of the practices across different zones showed an elasticity of above one which shows that the 1% of additional costs on

implementing these practices yielded more than 1% of gross income. That is, it pays to adopt them and add to income of farmers.

Table-5: Impact of technology across zones in Karnataka

Zone	Technology				
	ICMP	IEMP	ILMP	ISWCP	Overall
Elasticity of Gross income to cost					
North East Dry Zone (NEDZ)	1.98	-	309	-	1.98
North Dry Zone (NDZ)	0.92	-	1.68	-	0.92
Central Dry Zone (CDZ)	1.32	-	0.46	1.56	1.18
Eastern Dry Zone (EDZ)	1.37	-	-	2.67	1.39
South Dry Zone I'SDZ)	1.62	573	066	1.14	1.56
Impact of technology on (across zones)					
% increase in Resource use efficiency	14 to 28	15	10 to 35	10 to 27	14 to 28
% increase in profitability	14 to 35	30	13 to 60	10 to 34	14 to 39
% increase in standard of ivinq	11 to 18	10	8 to 24	5 to 13	11 to 18
% increase in women partic ojation	6 to 23	5	4 to 50	7 to 60	6 to 23
% reduction in womens' drudgery	4 to 12	2	3 to 15	4 to 20	3 to 12

Note: ICMP: Improved Crop Management Practices; ILMP: Improved Livestock Management Practices; ISWCP: Improved Soil and Water Conservation Practices; and IEMP: Improved Energy Management Practices.

(Source: Satyasai and Mehrotra, 2016)

In spite of the potential and the balanced regional development compulsions, rainfed areas are neglected at policy level. Current approaches and practices to rainfed agriculture have been ineffective and not targeted at the emerging farming groups (Reddy and Chiranjeevi, 2016).

(v) Enhancing Resource Use Efficiency

a) Smart Nutrient Management

Indian soils are increasingly deficient in micronutrients and the NPK balance is away from the norm of 4:2:1 and skewed towards nitrogen. Wani et al. (2012) concluded that widespread secondary and micronutrient deficiencies have led to a deteriorated soil health which is reason to low fertilizer response and crop yields in rainfed areas of India. The degrading soil health trend can be reversed through a science led approach of adoption of soil test based application of deficient secondary and micronutrients to harness existing productivity potential on a sustainable basis. The change to nutrient based subsidy system is being implemented to regain the balance. Also, fertiliser

application is not often based on scientific lab tests. Following soil test based use of fertilisers may not reduce cost of fertilisers and in fact it may increase in the short run as we increase P and K doses to correct the imbalance.

Soil health in totality needs to be taken care of and the soil health cards being introduced across the country addresses this issue. Makadia (2012) studied in Gujarat where the soil health card programme was introduced in 2005 reported that farmers with health cards have used all major nutrients close to recommended doses compared to those without cards. Yields were significantly higher on their farms. Fertiliser use efficiency too was high on their farms. However, there are several challenges for the successful implementation of the programme such as huge investment needs, testing lab capacity, technical manpower and training needs. Creating awareness among farmers is important as the real challenge to soil health card system is the attitude of farmers. Hardly 11% of farmers have favourable attitudes towards soil health cards programme (Patel and Chauhan, 2012).

b) Nanotechnology

Agriculture sector now facing several challenges like growing demand for increase in production, safe and healthy food, threat from changing weather conditions, increased risk of diseases and pests to plants etc. Nanotechnology can be gainfully employed in tackling these problems by facilitating research at below molecular level. Nano-materials, nano-tools and nano-devices would become a blessing to agriculturists. Nanotechnology can revolutionize agriculture for improving the ability of plants to absorb nutrients, rapid disease detection, molecular treatment of diseases, efficiency of herbicides and pesticides, developing most efficient farm machinery, facilitate exact quantity of pesticides application, food processing and value addition etc.

c) Precision Farming

Precision agriculture is a management strategy that employs detailed, sitespecific information to precisely manage production inputs. This concept is sometimes called precision agriculture, prescription farming, or site-specific management. The idea is to know the soil and crop characteristics unique to each part of the field, and to optimize the production inputs within small portions of the field. The philosophy behind precision agriculture is that production inputs (seed, fertilizer, chemicals, etc.) should be applied only as needed and where needed for the most economic production. This system requires the utilization of sophisticated technology including personal computers, telecommunications, global positioning systems (GPS), geographic information systems (GIS), variable rate controllers, and infield and remote sensing.

d) Conservation Agriculture (CA)

CA consisting of minimum mechanical soil disturbance, soil cover with plant biomass/cover crops and diversified crop rotations or associations is viable and more sustainable cultivation system than the conventional cultivation system. CA reduces soil erosion, improves soil quality, reduces soil compaction, improves rain water use efficiency (RWUE), moderates soil temperature, gives higher and stable yields, saves inputs, reduces cost of cultivation, and helps in climate change mitigation and adaptation.

Empirical evidences suggest that zero tillage (ZT) based agriculture along with crop residue retention and adoption of suitable crop rotations can be productive, economically viable and ecologically sustainable given that farmers are involved in all the stages of technology development and dissemination. The CA specifically aims to address the problems of soil degradation due to water and wind erosion, depletion of organic matter and nutrients from soil, runoff loss of water and labour shortage. Moreover, supporters of CA movement claim that CA is able to address the negative consequences of climate change on agricultural production through improved RWUE and timely performance of agronomic operations. However, there is need to identify, evolve and disseminate region specific CA practices through active involvement of farmers along with researchers, technicians, machinery manufacturers and policy makers.

Conservation Agriculture (CA) has been identified as a promising technology for sustainable crop intensification worldwide. But in India sufficient work has not been done on the subject except remarkable work being done in irrigated rice-wheat zone across the Punjab, Haryana, Uttar Pradesh and Bihar with the support of international development agencies since last few years. Thus, there is need to focus more on dryland production systems where the applicability of CA is even more considering their higher vulnerability to climate change effects and need to reverse the process of soil degradation in drylands which are expected to play more crucial role in food security of the nation in days to come (Jat, 2015).

e) Mechanization

Mechanization is a potential source of improved labour productivity, higher input use efficiency by timely and precise farm operation. Hence, mechanization has become a very crucial input to further the development of agriculture. This transition from animal power to mechanical power in some states has made the agriculture capital intensive. But, it has played a key role in modernization of Indian agriculture due to its benefits of improved labour efficiency and

productivity, efficient use of expensive farm inputs, reduction of human drudgery and timeliness of operations. India is considered as one of the top countries in respect of agricultural production but in term of farm mechanization, it is behind the world average. Thus, it is observed that there is significant opportunities and scope for mechanization of equipments. Indian agriculture is dominated by small and marginal farmers, thus required steps for setting up custom hiring centres or high tech machinery bank so that small and marginal farmers can benefits of farm mechanizations.

f) Organic Farming - Low Input Agriculture

The cost of cultivation has been on the rise eroding the profits. Lowering the costs without compromising on the output can increase the net income. And, it is possible to do so as there is a general tendency of farmers to use overdoses of inputs especially fertilisers and pesticides expecting higher yields. Organic farming is being promoted overtime to reduce chemical use. These interventions remained sporadic and limited to a few geographies. National Programme for Organic Production was launched in the year 2001 involving the accreditation programme for certification agencies, norms for organic production, promotion of organic farming etc. Cultivated area under certified organic farming has grown almost 28 fold in last 12 years i.e., from 42,000 ha in 2003-04 to 11.80 lakh ha in 2015 (Willer and Lernoud, 2017). States like Uttaranchal, Karnataka, Madhya Pradesh, Maharashtra, Gujarat, Rajasthan, Tamil Nadu, Kerala, Nagaland, Mizoram, Sikkim have been promoting organic farming of which Sikkim has been declared 100% organic.

g) Zero Budget Natural Farming

After witnessing the harmful effects of chemical farming, newly introduced agriculture technique among farmers is, Zero Budget Natural Farming (ZBNF), also known as, Zero Budget Spiritual Farming (ZBSF). It has attained wide success in southern India, especially Karnataka where it was firstly evolved (Kumar, 2012). Now, it is spreading all over India, so rapidly and dynamically. Zero Budget Natural Farming, as the name implies, is a method of farming where the cost of growing and harvesting the plants is zero. This means that farmers need not to purchase fertilizers and pesticides in order to ensure the healthy growth of the crops. The method dictates locally obtainable natural biodegradable materials saturated with scientific knowledge of ecology and modern technology with traditional farming practices based on naturally occurring biological processes. This concept was pulled into the light by Shri Subhash Palekar, for which he was honored with Padma Shri in 2016 (Anon., 2016).

Zero budget farming proposes that only a single cow is needed to cultivate 30 acres of land. Four aspects that are integral to ZBNF are: (1) *Beejamrut*, or microbial coating of seeds using cow dung and urine based formulations, (2) *Jeevamrut*, or the application of a bioinoculum made with cow dung, cow urine, jaggery, pulse flour, water and soil to multiply soil microbes, (3) Mulching, or applying a layer of organic material to the soil surface in order to prevent water evaporation, and to contribute to soil humus formation, and (d) Waaphasa, or soil aeration through a favourable microclimate in the soil. For insect and pest management, ZBNF encourages the use of various *kashayams* (decoctions) made with cow dung, cow urine, lilac and green chillies. The cow dung and urine used in the preparation of natural inputs are only from indigenous cows. These practices have been shown to have a positive effect on the quality of the soil, improving its fertility and water retention capacity. This is likely to reduce the reliance on resources such as water and electricity for irrigation.

Substituting chemical fertilizers and pesticides with natural inputs might reduce input costs and farmers' exposure to credit risks; the increase in net income will improve the cash flow of poor and vulnerable farmers, and may enhance their ability to deal with economic shocks; and the reduced resource-dependence and improved soil quality might then help farmers adapt better to extreme climate events.

(vi) Reducing Post-Harvest Losses

Post-harvest losses generally range from 5 to 10% for non-perishables and about 30% for perishables. This loss could be and must be minimized. Let us remember, a grain saved is a grain produced. One of the biggest problems of farmers is storage after harvesting; as a result, they are forced to sell their products at a lower price. Therefore, the government is encouraging farmers to use warehouses and avoid distress sales. Loans against negotiable warehouse receipts are being provided with interest subvention benefits. The focus is on storage facilities and integrated cold chains in rural areas.

The challenge is in handling of fresh produce after harvest with emphasis on reducing losses, value addition, maintaining quality and marketing. Agro-processing is now regarded as the sunrise sector of the Indian economy, in view of its large potential for growth and likely socio economic impact specifically on employment and income generation. Some estimates suggest that in developed countries, up to 14% of the total work force is engaged in agro-processing sector directly or indirectly. However, in India, only about 3% of the work force finds employment in this sector revealing its underdeveloped

state and vast untapped potential for employment. Properly developed, agro-processing sector can make India a major player at the global level for marketing and supply of processed food, feed and a wide range of other plant and animal products.

(vii) Climate Change and Sustainable Agriculture

Climate change is one of the most important areas of concern for India. Significant negative impacts have been implied with medium-term (2010-2039) climate change, predicted to reduce yields by 4.5 to 9%, depending on the magnitude and distribution of warming. This yield loss roughly translates to 1.5% of GDP per year. Global warming is likely to lead to a loss of 1.5-2.0 million tonnes in milk production by 2020 and 15 million tonnes by 2050. It may also affect fish breeding, migration and harvests. New and innovative adaptation measures to climate change include (i) changes in agricultural practices to improve soil fertility and enhance carbon sequestration; (ii) changes in agricultural water management for more efficient water use; (iii) agricultural diversification toward enhanced climate resilience; (iv) agricultural science and technology development, agricultural advisory services, and information systems; and (v) risk management and crop insurance. Innovative policies include: (i) changing investment allocation within and across sectors, (ii) increasing the focus on risk-sharing and risk-reducing investments, (iii) improving spatial targeting of investments, (iv) eliminating existing detrimental policies that will exacerbate climate change impacts, and (v) reducing greenhouse gas (GHG) emissions from agriculture and increasing the value of sustainable farming practices through the valuation of carbon and other forms of agricultural ecosystem services such as water purification and biodiversity.

Climate Change resilience can be built in through i) stabilisation and management of the natural resource base with an ecosystems-based approach to Participatory Watershed Management as a central point of activity, ii) assessing vulnerability of a cluster of villages/sub-region to climate change, iii) integrating a package of climate smart agriculture practices into ongoing programmes such as weather-based locale specific agro-advisories, contingent crop planning, promotion of low-external input technology, water budgeting, livelihood diversification, and promotion of local agro-biodiversity (Watershed Organisation Trust, 2013).

(viii) Cultivation under Controlled Atmosphere

Indian agriculture continues to be under the control of monsoon. With close to 55% of its arable area under the mercy of rain, its variations play a crucial role in the success of an agricultural season. There is a need to decouple

agricultural output from the fluctuation of climate to ensure higher and stable income to the farmers. Location specific cost effective methods of cultivation practices under net shade/controlled atmosphere need thrust.

Considering the growing importance of horticulture and hi-tech agriculture in the Indian economy, it is pertinent that protected cultivation is encouraged in all parts of the country, specifically in the North, North-East and Hilly Regions. Moreover, focus should be on identifying and developing suitable varieties of horticulture crops for protected cultivation. Further, crop nursery practices could be standardized under protected environment to optimize the use of available space.

REFERENCES

Anonymous. 2016. "Venkaiah Naidu congratulates farmer on winning Padma Shri". Indian Express.

Bowman, M. S. and Zilberman, D. 2013. Economic factors affecting diversified farming systems. Ecology and Society, 18(1): 33.

Chand, R. 2016a. Addressing Agrarian Distress; Sops versus Development, 23rd Dr. B.P. Pal Memorial Lecture, May 26, 2016 at Indian Agricultural Research Institute, New Delhi.

Chand, R. 2016b. Why doubling farmers' income by 2022 is possible? Indian Express, Opinion Page, April 15, 2016.

Chand, R. 2017. Doubling farmers' income: Rationale, strategy, prospects and action plan. NITI Policy Paper No. 1/2017.

Chand, R. and Parappurathu, S. 2012. Temporal and spatial variations in agricultural growth and its determinants. Economic and Political Weekly, Review of Rural Affairs, 47(26 & 27): 55-63.

Chand, R., Saxena, R. and Rana, S. 2015. Estimates and analysis of farm income in India: 1983-84 to 2011-12. Economic and Political Weekly, 50(22): 139-145.

Gangwar, B. and Singh, A. K. 2011. Efficient alternative cropping systems. PDFSR, Modipuram, Meerut (U.P.).

Gulati, A. and Saini, S. 2016. From Plate to Plough: Raising farmers' income by 2022, Indian Express, March 28, 2016.

Jat, R. A. 2015, Conservation agriculture for sustainable crop intensification: An overview. Indian Journal of Fertilizers, 11(2): 48-55.

Kiresur, V. R. 2016. Resource Management Options for Optimization of Dryland Farming in Karnataka. Study Report Submitted to NABARD, College of Agriculture, Vijaypur, University of Agricultural Sciences, Dharwad.

Kumar, Nanda . 2012. "Subash Palekar's zero budget no-till rice farming".

Kumar, S., Thiagarajah, R., Ramarao, C.A., Rao, S. and Whitbread, A. 2016. Farm level rainwater harvesting across different agro climatic regions of India: Assessing performance and its determinants. Agricultural Water Management, 176: 55-66.

Makadia, J. J. 2012. Regional imbalances and impact of soil health card on fertilizer consumption in Gujarat. Ph.D. thesis submitted to the Navsari Agricultural University, Navsari, Gujarat, India.

Patel, J. K. and Chauhan, N. B. 2012. Attitude of farmers towards soil health card (SHC) programme. Asian Journal of Soil Science, 7(1): 114-116.

Reddy, R. V. and Chiranjeevi, T. 2016. The Changing Face of rainfed Agriculture: Need for Integration of Science, policy and Institutions. In: Ramasamy, C. and K.R. Ashok (Ed), Vicissitudes of Agriculture in the Fast Growing Indian Economy: Challenges, Strategies and the Way Forward. Indian Society of Agricultural Economics, Academic Foundation, New Delhi.

Satyasai, K. J. S. and Mehrotra, N. 2016. Enhancing farmers' income. A lead paper presented at Foundation Seminar on Doubling Farmers' Income by National Bank for Agriculture and Rural Development (NABARD) on July 12, 2016 at Vigyan Bhavan, New Delhi.

Stoorvogel, J. J., Antle, J. M., Crissman, C. C. and Bowen, W. 2004. The trade-off analysis model: Integrated bio-physical and economic modelling of agricultural production systems. Agricultural Systems, 80: 43-66.

Wani, S. P., Chander, G. and Sahrawat, K. L. 2012. Soil health awareness: Soil science at doorsteps of the farmers. In: National Seminar on Soil Security for Sustainable Agriculture, 27-28 February, 2012, College of Agriculture, Nagpur.

•

Enhancing Farmers' Income: Experience and Experiments with Genetically Engineered Cotton

• Dr. V. Kumar •

Agriculture plays a pivotal role in Indian economy and is vital to inclusive growth of the country. Success of green revolution and hybridization technology in field crops made the country self sufficient in most commodities despite growing demand of the burgeoning population. Of late, increasing prices of agricultural inputs, stagnation in yields (technology fatigue?) coupled with low returns of produce have compounded the miseries of farmers. To improve the economic condition of farmers, Government of India initiated an ambitious programme to double farmers' income by 2022. However, lot remains to be done in this area as the issue is complex and so is the solution. Basically, there are three broad approaches by which farmers income could be doubled - bring down the cost of production, increase productivity and appropriately market the produce besides growing more remunerative crops, intensive cropping and collective/co-operative farming.

Bringing down cost of production is a multi dimensional approach right from timely sowing to tap maximum solar energy, to use bio-fertilizers and biopesticides, recycling of farm waste/by-products, micro-irrigation, use of genetically engineered (GE) seeds to reduce pesticide usage, adoption of technologies for efficient use of farm inputs and to blend traditional wisdom of cultivation with modern technology to reduce dependence on chemical based farming. Adoption of these methods/techniques/steps will have a definite and positive effect not only on cost of production but on productivity of crop, as well. Besides these, there are non-monitory measures that influence yield potentiality like deep ploughing once every 2-3 years, splitting fertilizer doses as per crop requirement, watering as per crop stage needs and use of GE seeds to avoid insects induced yield losses.

GE seeds - a product of biotechnology have emerged as powerful tool to reduce cost of cultivation, increase productivity and farmers income. Other biotech products like tissue culture, bio-pesticides and bio-fertilizers made little dent in agriculture but could not make any perceptible change at ground level. It was finally in 2002 that the first genetically engineered product of India- the Bt Cotton was released for commercial cultivation. It took the country by storm for the next decade, the euphoria is still alive and so is the controversy shrouded around it. I will dwell upon Bt cotton how it transformed cotton

scenario in the country to the advantage of concerned stake holders and how the technology could prove an important component of doubling farmers' income.

Prior to the development of hybrid cotton in 1970-71, average cotton production during 1951-71 (pre-hybrid era) was 47.75 lakh bales/annum. Hybrid cotton gave a fillip to it and it doubled reaching 94.75 lakh bales/annum during 1971-2002 (hybrid era). But hybrids with Bt gene (hybrid+Bt era) emerged as real game changer and during 2002-17 average cotton production exceeded 300 lakh bales/annum. In other terms, during hybrid era, it added 1.52 lakh bales to the national kitty every year over pre-hybrid era whereas during hybrid+Bt era, it added 13.76 lakh bales every year over hybrid era showing a CGAR of 2.24% and 8.01%, respectively. The figures of lint productivity kg/ha are no less startling. During 1951-71 average productivity was a mere 106.97 kg/ha which reached 206.66 kg in hybrid era. But real breakthrough happened during hybrid+Bt era (2002-17) when average productivity reached near 500 kg/ha (498.50 kg). This increase in terms of lint kg/ha/annum was 3.15 in hybrid era and a whopping 19.59 kg in hybrid+Bt era over previous eras. Post Bt era gains in cotton production and productivity have few parallel in annals of Indian agriculture. The country emerged as a net exporter of cotton from an import dependent nation. In addition to economic gains, GE cotton also had some positive environmental implications. Reduced use of pesticides in Bt cotton led to substantial reduction in CO_2 emission and environment impact quotient (EIQ). According to Brooks and Barfoot (2017) India is estimated to have reduced the active ingredient use in Bt cotton by 99.3 million kg and in EIQ by 36.7% during 2002-15. Insect resistant transgenic have potentiality to substantially reduce emission directly through less use of pesticides and indirectly through manufacturing and transportation. IR transgenic use same resources like water and fertilizers more efficiently through protection of fruiting bodies from insect damage and therefore, yield more. Nearly 5.5 million farmers of the country can not fault for seventeen long years if they continue to grow Bt cotton without economic gains. Despite visible gains and benefits, there has been enduring debate over efficacy and safety of GM crops in various countries. Certain section of society/NGOs believe that Bt cotton are not profitable, leads to soil degradation, resistance development, and health problem in human and animal. Despite the fact that 170 M ha GM Corn, Canola, Cotton and Soybean is under cultivation in 29 countries mainly US, Canada, India, Argentina and Brazil and scientific consensus, the safety of consuming GMOs continues to be issue that elicits greatest controversy. In 2014, an analysis of 147 studies around the world for last 20 years concluded that GM technology

adoption reduced chemical pesticide by 37%, increased crop yield by 22% and farmers profit by 68% (Klumper, 2014). Over a hundred Nobel Prize winners in June 2016 urged Green Peace and its supporters to re-examine the issue of GM crops and abandon their campaign against GMOs. World Health Organization and several reputed organizations/bodies widely echoed the opinion that GM plants are not harmful to human health or the environment. India is a signatory to Paris Agreement on climate change wherein India is committed to take measures to bring down carbon emission to contain temperature rise below 2^{o}C. Bt technology could be a useful tool to contribute to achieve this goal besides enhancing farmers income. Other transgenic products/technology in various stages of development in the country could also handsomely contribute to this task. Gene editing using CRISPR technology is the latest tool which has vast potential to augment agricultural production and farmers' income.

•

Role of State Level Agricultural Universities with Focus on Education, Research and Extension Education Development

• Dr. K. B. Kathiria and Shri A. L. Patel •

In the Gujarat state, there are four Agricultural Universities viz., Anand Agricultural University, Junagadh Agricultural University, Navsari Agricultural University, Sardarkrushinagar Dantiwada Agricultural University as well as Kamdhenu and Organic University are working for welfare of farmers, students and entrepreneurs communities. All Universities have vision for agriculturally prosperous Gujarat and India, search for new frontiers of Agricultural Sciences, undertake basic research to breakthrough newer areas of knowledge and development of excellent human resources as well as innovative technological services to farming community. The role of Agricultural Universities in development of Education, Research and Extension Education is as follow.

Agricultural Education

Under-Graduate and Post-Graduate Education

1. All Agricultural Universities are providing quality education in the areas of Agriculture, Horticulture, Veterinary, Dairy, Food Processing Technology and Bio-energy, Agricultural Engineering and Technology, Agricultural Information Technology, Fisheries, Agroforestry, Home Science, Agricultural Business Management and allied fields. The SAUs are committed to develop competent human resources to serve the society in general and farmers and food industry in particular for sustainable livelihood, efficient use of natural resources, ensuring food security and safety for the nation.
2. Imparting education in the prescribed areas of agriculture viz., environmental engineering, natural resource management, renewable energy resources, climate change, organic farming, nano-technology, agro tourism and sustainable agriculture.
3. Under taking collaborative projects with reputed institutions which can offer opportunities for long-term interaction with academia and industry.
4. Strengthening of experiential learning and entrepreneurship/skill development through hands-on-training in agriculture and allied sciences.
5. Imparting education in the prescribed areas of veterinary sciences and animal husbandry with focus on newer areas like; Wild Life Management, Pet Animal Management, Dentistry, Ophthalmology, Radiology and Imaging,

Ethno Veterinary Medicine, Metagenomics, Transcriptome and Gene Expression Studies, Endocrinology etc.

6. Imparting education in the prescribed areas of Dairy and Food Sciences viz., Designer Foods, Functional Food Ingredients, Prescription Foods Based on Metagenomics Study of the Consumer, Microbial Foods, Food Process Equipment Design and Food Business Management.
7. Activity based projects to students for identifying local agriculture/animal husbandry/dairy/food processing related problems and seeking their solutions.
8. Started Post Graduate Diploma in Dairy Business Management (PGDDM) with the collaboration with IRMA, Anand.
9. Establishment of Centre for Agricultural Market Intelligence.

Agricultural Research

Agricultural research has played an important role in enabling the country to increase the agricultural production. On the other hand, growing population, ever increasing food, feed and fodder requirements, natural resource degradation, climate change, emergence of new pest and diseases, slow growth in farm income, quality consciousness leading to change in consumption patterns and new global trade regulations are diverse challenges and constraints, which demand major changes in formulating and implementing the agricultural research programmes. The emerging scenario necessitates the agricultural universities to have perspective vision which could be translated in to reality through proactive, novel and innovative research approaches using cutting edge technologies. This can be achieved by systematic focus on the following areas:

1. Improved Varieties and Hybrids

The agricultural research in plant breeding, seed technology and extension; farmers' show keenness to accept new varieties/hybrids released by the SAUs of Gujarat. Our efforts are to give sustainable solutions through high yield, disease and insect resistance with better quality hybrids and varieties to the farmers of the Gujarat state. The breeder seed of different varieties and parents of the hybrids is produced to channelize it to meet the requirement of the farmers.

2. Development of Agricultural Technologies

State Agricultural Universities have developed number of need based agricultural technologies in the areas of Agriculture, Horticulture, Veterinary, Dairy, Fisheries, Food Processing Technology, Agricultural Engineering and Technology, Agroforestry, Home Science, Agricultural Information Technology,

Agricultural Business Management and allied fields. The farmers/livestock holders/entrepreneurs of Gujarat state have widely adopted the technologies developed by agricultural universities and benefited.

3. Testing of Hybrids/Varieties Developed by Private Companies

Department of Agriculture, Government of Gujarat also fix the criteria that to test/evaluate variety/hybrid in SAUs of Gujarat for register/release/selling of particular variety/hybrid of private seed company in Gujarat. In this context, SAUs of Gujarat conduct private seed company's trials in Bt-cotton, Rice, Maize, Bajra and other crops and evaluated their varieties/hybrids at university farms under the supervision of concerned crop scientist. This will strengthen the private seed industry and farmers of Gujarat would get quality seeds of different crops.

4. Distant Hybridization

First time in the country, full-fledged department of Distant Hybridization is started to utilize the wild genetic resources for disease and pest resistance, quality and other important traits to incorporate in the cultivated species. This department has given very good outcome in the crops like tomato, okra, desi cotton, cucumber, chilli and fruit crops.

5. Plant Tissue Culture

The tissue culture protocol for date palm, banana, pomegranate, bamboo, sandal wood, spine gourd, pointed gourd, stevia and potato are developed by Anand Agricultural University. The tissue culture plants of date palm, banana, pomegranate, bamboo, sandal wood, spine gourd, pointed gourd and stevia are raised and provided to the farmers. Development of tissue culture protocols in coconut and oil palm initiated in tissue culture laboratory which are likely to be come out within short period.

6. Pesticide Residue Laboratory

The NABL accredited Pesticide Residue Laboratory is established in the university which determine "Maximum Residue Limit (MRL)" of pesticides by conducting field trials under supervision of scientists adopting Good Agricultural Practices (GAP) in conjunction with the data obtained from the toxicological studies as well as screen agricultural produce drawn from farmers' field in order to judge, the pesticide usage pattern, so as to educate and train the farmers and extension workers in proper handling and use of pesticides.

7. Food Quality Analysis

New established Food Quality Analysis Laboratory is NABL accredited. This laboratory focuses on R&D activities on technology development for

functional foods, isolation and characterization of promising microorganisms for functional food formulation, effective agro-food industry waste treatment, pathogen prevalence survey, genetically modified foods status study in food products, survey of pesticides residues, drug residues, heavy metals, artificial colours in food products, application of plasma in decontamination of food product surfaces, standardizing protocols for chemical and microbial analysis of food products etc.,

8. Biofertilizer

Biofertilizer laboratory is strengthened and liquid biofertilizer technology developed which is unique in the country. First time in the country, liquid biofertilizer consortium prepared and patented.

9. Organic Farming

Universities are also focus on organic farming research and organic farming projects. Under this project, various demonstrations are conducted and trainings are organized on organic farming to provide the information to the farmers.

10. Soil and Water Quality Laboratory

The state of art facilities developed for soil and water testing laboratory with infrastructure for the research and to help the farmers for soil and water analysis.

11. Biopesticides

Universities have developed *Tricoderma* biopesticide which is used for control of soil and seed borne plant diseases. Overwhelming response received from resource poor farmers as well as progressive farmers to this low cost input technology. Reduction of environment pollution by the use of this biopesticide for control of soil borne plant diseases.

Agricultural Extension Education

One Year Input Dealer Certificate Course

1. Input dealers are door step advisor to the farmers and they trust on them due to purchase of inputs regularly. Hence, if input dealers are well equipped with information on latest technologies developed by the universities, then they can deliver to the farmers on right way, within shortest period and well conversation. This programme becomes most popular, efficient and effective. This certificate course is also useful for them to get/renew of the licence for input dealership. During this course, interface between stake holders and faculty which act as a platform to reach out each other for better realization of needs, problems and facilitation for exchange of ideas.

2. Transfer of agricultural research and allied technologies developed by the university through *kisan mela, kisan goshthi,* exhibitions, film show, demonstrations, farmers' seminars, workshops, group meetings, lecture delivered as a resource person, newspaper coverage, TV and Radio talks, popular articles, extension literatures, advisory services, scientists visits to farmers' field, farmers' visits to KVKs, crop diagnostic visits, animal diagnostic visits, exposure visits and video films on package of practices for various crops are also arranged under extension education programmes for upliftment of farming community.
3. The Comprehensive District Agricultural Plans (C-DAPs) for all districts of Gujarat State have been prepared by taking into account the present status of various practices and further development in agriculture and allied sectors in the districts.
4. *Krushi Mahotsav* programme is organized every year to bring awareness to the farming community about recommended scientific technology, new varieties and agricultural technologies for the rapid transfer of knowledge from lab to land.
5. Capacity building for use of ICTs to provide customized knowledge, skills and solutions to stake holders through extensive use of social networking.
6. Use of hi-tech devices for faster agricultural information dissemination, formulation of effective extension strategies, socio economic and psychological trait studies in respect of hi-tech communication devices.
7. Developed farmer friendly interactive learning software and web portal for major crops to disseminate the agricultural knowledge efficiently.
8. Popularize distance education for effective transfer of technologies to the farming communities.
9. Short term training courses
10. To impart training to the extension workers/officers of line department, to update with latest technologies generated by universities.

•

Doubling Farmers' Income by Management of Milk Animal and Dairying

• Dr. Mayur Vyas •

Our honorable Prime Minister Shri Narendrabhai Modi has given challenge to all of us to double the income of farmers. Agriculture has been becoming non-attractive in spite of substantial rise in MSP. The main reason is rise in input cost which reduces the net earning of farmers. Farmers have lots of agriculture waste which is non-productive. Farmers by and large burn or destroy agriculture waste. If this waste is made productive, farmer income will rise. The best way to make it productive is by helping farmers to keep milk animals. It is not easy to make milk animals produce economical milk production only by way of feeding agriculture waste. Farmers need thorough training in managing milk animals, need subsidies to buy milk animals as cost of cows and buffalos is rising day by day. Infrastructure to take care of milk animals during drought period as well to take care of animals once they become unproductive. This is a complex village economy which is not only knowledge driven but also driven by cooperative dairies and climate.

Impact of Climate Change

Climate Smart Livestock Practices Livestock contribute to food security and livelihood. It is no longer supplementary source of income. In fact it provides cash income on weekly basis based on how well the marketing infrastructure is laid out. Historically, for arid and semi-arid areas are known as drought prone areas like Kutch district of Gujarat, every year government-initiated cattle migration which was organized due to lack of drinking water. But livestock are prone/sensitive to changes in climate :

I. Main Impacts • Causes - Increased temperature - Shifts in rainfall distribution - Increased frequency of extreme weather conditions. • Impact - Low productivity with increased heat stress - Quality and availability of feeds and fodder - Emergences livestock disease - Increased competence with other sector for water source results in exhaustion of water. - The grazing area – Gauchars – get minimum yield of grass, they become barren due to over use. Reduced water availability leads to increase in disease and even migration as cost of feed go up.

II. Adaptive Measures • Grazing Areas - The community has to reduce number of animals for free grassing depending on grass available - Government has to set-up. **Fodder Banks** and provide fodderduring drought period and

store surplus fodder during good monsoon period. This may require planned fodder banks. In Kutch, up to year 2000 systematic cattle migration was practical. But with water supply from Narmada Dam pipeline and with Fodder Bank/Fodder Depots, cattle migration is minimized. • Early Warning System and use of weather information can help local administration to plan fodder banks and water supply within districts or work out a planned migration.

III. Cattle Insurance : At present cattle insurance covers cattle death but cost of forced migration needs to be brought under insurance cover.

IV. Breed Selection : The cross breed animals – particularly from European – American breeds are very sensitive to heat. It may, therefore, be necessary to focus on native cattle breeds which are climate resilient and can endure heat stress or have capacity for long travel. The native cattle breeds of Gujarat – Geer & Kankrej cows are suitable for this purpose.

V. Promoting Community Bio-gas Plants : Cow dung can be converted into slurry and developed as bio-gas plant – which provides gas for cooking and slurry can be converted into vermin compost which can be marketed.

VI. Landless Animal Holders : They are most vulnerable – as they depend on community grazing areas which get depleted – will need special assistance.

Effect of Climate Change on Milk Animals

Summer

Milk Animals; The summer is the period when temperature of atmosphere is very high which directly affects the reproductive health of milk animals, poultry and fish. The animal uses its energy to keep body temperature cool and hence it does not get the typical symptoms of coming in heat to do artificial insemination. The milk production reduces for buffalos and slight increase of milk production for cows. If summer-monsoon gets delayed or summer is followed by drought then milk animal health is severely affected which leads to consistently reduction in milk production. During heat and cold wave, the feed intakes reduce considerably which reduces milk production. **Poutry and Fisheries;** Summer effects the growth of the birds and production of eggs. Birds' mortality also increases and disease resistance reduces. During high temperature period growth of pond and marine fish gets affected. The reproduction of fish and disease resistance also reduces.

Monsoon

Monsoon is good period to get green fodder which is available in plenty, farmers try to feed excessive green fodder which is not in balance of fat carbohydrate and protein. Hence it leads to reduction in fat in milk and also

animals get frequently sick. If excessive rain leads to flood and also causes outbreak of diseases

Winter

Milk Animals: Winter is highly favourable to milk animal and particularly to buffalo. Milk production of buffalo increases where as milk production in cows slightly decreases. Winters are also the best period for fertility of milk animals. During extreme cold it is necessary to protect milk animals by keeping them in warmer place or covering them with warm covers.

Effect of Climate Change or Milk Animals, Poultry and Fisheries: With time human needs increase resulting in increased industrialisation and urbanisation which started producing green house gases harmful not only to humans but also hazardous to the ecosystems. This has lead to increase in the earth's atmospheric temperature which has also gradually affected the milk animals. Temperature and humidity have direct effect on milch animals. Milch animals get stressed as temperature and humidity start rising. We will discuss how these affect the milk animals and how to identify the level of stress:

1) **Mild Heat Stress:** When the animal have increased respiration rates panting, sweating, leaks body surface and drinks water frequently that means animal is under mild stress.
2) **Moderate Heat Stress:** During moderate heat stress animal will have perfuse sweating, rapid breathing and reduction in milk production.
3) **Severe Heat Stress:** If animal is having open mouth breathing with panting, stop eating feed means that it is under severe heat stress.

Effect on Milk Production: Milk production of cow and buffalo declines as the temperature and humidity index rises. 10 to 30% decline in milk production can be seen for long exposure of milk animals to high temperature and humidity.

Effect of Feed Intake: As the temperature rises the feed intake of milk animal starts declining which leads to decline in milk production and also poor reproductive health.

Effect of Reproductivity Health of Milk Animals: Temperature affects the reproductive health of milk animals. It leads to decline in conception rate. Animal needs repeat service to conceive. Long exposure to heat will lead to high calf mortality and reduces weight gain. It will also lead to decline in milk production of next generation and delay in maturity of calf. Heat will reduce the sperm count in male.

Effect of Health and Diseases: Rise in Temperature and Humidity Index will lead to reduced immunity and outbreak of infectious diseases.

Protection against Climate Change: It is not in one's hand to prevent the changes in climate that are taking place but knowing that these changes will affect our milk production, poultry and fisheries production which will affect our economy, one can prepare to protect the milk animals, poultry and fisheries against the changes that are taking place by adopting the prevention as describe.

1) Selection of Milk Animal Breed

In Gujarat we have two major climatic zones for milk animals. North Gujarat where climate is hot and dry and second is Saurashtra, Central and South Gujarat where climate is hot and humid. While selecting animals care must be taken that animal suitable for the zone must be selected i.e. if one wants to buy buffalo in Sabarkantha, then it must be from Mehsana or Palanpur and those in Saurashtra should buy Surati buffalo. Indigenous cow breed suitable for our weather is breed of cattle like Kankrej, Gir and others which sustain and yield well in adverse climate.

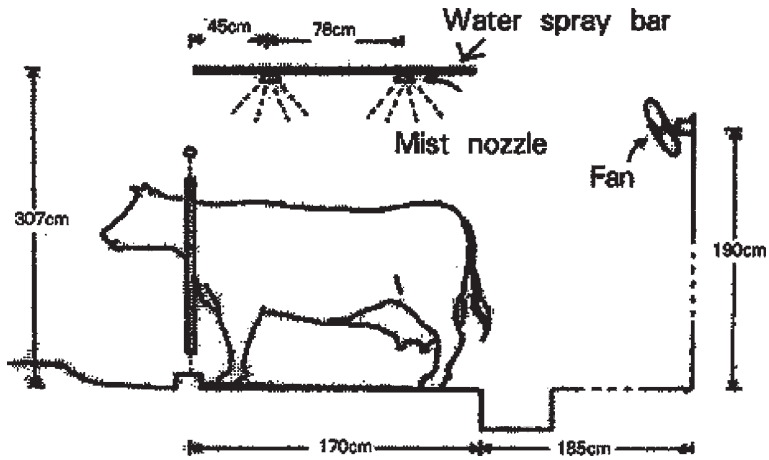
2) Shelter for Milk Animals

The shelter for the milk animals is very important. If proper shelter is provided, one can eliminate 50% effect of climate changes. The shelter must have following features:

1) Shelter should be in wind direction i.e. east to west so the morning sun light gives good lighting and also being in wind direction will have good ventilation.
2) Shelter must have proper roofing covered with 3 inch dry grass to reduce the heat when sun is hot. Before putting grass paint the roof with cement and lime solution
3) Shelter must have little slope towards drain and preferably covered with wood slits.
4) Shelter sides toward south north preferably closed with windows so that during afternoon and during extreme cold winter it can be closed to provide protection.
5) Shelter should have good spacing to comfortably house the milk animals. Minimum of 3 m by 1.5 m space is required per animal. The height of the roof should not be less than 3 m.
6) The shelter should be provided with cooling fan, water spray and large water tank with provision for drinking water.

7) Shelter should be surrounded by fodder trees which not only give conducive environment but also gives fodder during drought and summer.

8) There are many animal holders who may not have their own land. Community shelter could be constructed in village grazing land for housing their animals. This can be perhaps be undertaken under MGNAREGA. A typical sketch showing requirement of shelter is given below:



Shelter for Milk Animals

Fans Arrangement

A typical fans and spray arrangement

A cooling pond near the shelter

3) Feeding Practice

The feeding practice is very important to protect the milk animals against the climate change. One has to ensure that a total feed is given to animal all through 24 hours which should be properly prepared. The feed has to be balanced with urea treated dry fodder properly cut mixed with silage green fodder, concentrated feed and mineral mixture. Fresh, palatable, high quality

feed with high biological value should be provided in the feed bunk at all the time to provide maximum opportunity for feed consumption Reduce the use of poor quality straws in the diet of livestock. Feeding frequency should be increased rather feed to be made available all 24 hours.

Mixing the Ration: It may be useful to shift feeding times to match animal behaviour. Animals tend to change meal patterns and eat more feed during the cooler times during the day hence make feed available all 24 hours of the day. Grain and fiber recommendations are as follows:

Precautions to be taken during Extreme Heat for Milk Animals: • Dietary fat content should not exceed 5 to 6% of the total diet dry matter • Do not exceed 55-60% concentrates in ration • Bypass protein and bypass fats are recommended • Water mix feed • Provision of cold water Precautions to be taken during Extreme Cold for Milk Animals: • Cold weather increases feed needs of cows. Hay provides more heat during digestion than concentrate feeds. • Cows need dry, draught-free resting area. • Use ample amount of good, dry bedding • Having dry teats when the cow leaves the parlor is important. One way to lessen the risk is to dip the teats, allow the dip of about 30 seconds and then blot dry using a paper towel.

Precautions to be Taken During Drought Period for Milk Animal: • Preservation of fodder • Preserve water resources • Feeding of chaffed fodder • Prevents feeding of poisonous plants and feed • Prevents feeding of pre-mature jowar (cyanide poisoning) • Prevent feeding of mouldy grains or fodder (aflxicosisato) • Prevent over feeding due to starvation during extreme monsoon.

Flood Care which is to be Taken for Milk Animal: The Animals should be free or taken to high areas The sufficient stock of feed to be stored at sufficient height to avoid the flood water damaging feed. The store area should be dry and water tight.

4) Drinking Water Availability

Proper sized drinking water tank with availability of fresh water should be provided inside the shelter. Care should be taken that water remains fresh and cool. Milk animals should have access to water all 24 hours. Fresh water should be available to cows after milking. Water intake may increase by 20 to 50% during heat stress conditions.

5) Breeding Practices

Care must be taken while breeding the milk animal. One must regularly record the milk per lactation of the milk animal and then decide about the

semen doze. While getting artificial insemination one should know the pedigree and progeny of male whose semen is being used for AI. If the cow produced by the male must give more milk than the animal being serviced. It is advisable to carry out AI in late evening or early morning. This will give better result in summer. AI must be done by knowledgeable AI Worker to avoid repeat AI. Natural services should be avoided as far as possible.

6) Rearing Practices

Rearing of calf is very important. If you properly give feed and vaccination, calf will mature within 18 to 24 months and also will give good milk production. Expenses on feeding and rearing of calf to be considered as the investment and will generate good profit.

7) Vaccination and Preventive Health Care

The milk animals must be regularly vaccinated as advised by Veterinary Doctors from time to time and also deworming treatment must be given every six months. Milk animal must be washed regularly and shelter should be maintained clean. Regular treatment must be given to arrest fly and other insects.

Poultry – Suggested Measures: Rise of temperature and moisture of the atmosphere have direct effect on poultry production and its price. The rise of temperature leads to reduction of eggs production as well as it also affect the growth of birds. It reduces the mortality of birds as well. There is indirect effect that grain will become costlier due to less production during drought which will make poultry farm economically inviable. Rise in moisture will lead to diseases outbreak which again will affect the farm economy. Hence both drought and heavy monsoon are bad for the poultry farming. Farmers has to safeguard the birds by taking necessary protection. As the ambient temperature reaches 34°C mortality of birds are affected as given below: • Heavy meat type chickens (8.4%) • Light layer type (0.84%) • Native type (0.32%) chickens. Feed Consumption: Decreases in feed consumption i.e. At 31.6°C : 108.3 g/bird/day At 37.9°C : 68.9 g/bird/day.

Egg Production: Egg production decreases as given below : decrease in broiler 7.5% : decrease in layer 6.4% • As the shed temperature rises from 28 to 42°C, the body temperature of birds increase from 41 to 45°C during heat periods which lead to reduction in eggs production. • Naked neck birds perform significantly better than the normal birds at high temperatures with respect to • Thermo tolerance • Growth • Feed efficiency.

Immunity During Extreme Heat the Care which is to be Taken in Poultry :
• Decrease crude protein 2% and energy 100-150 Kcal/Kg in feed composition • Feeding early in the morning and gives water mix feed 3-4 times in day • Poultry shed: white wash • Plant shade tree which gives cooling during summer and warming during winter. • Use of sprinkler between 11.00 to 18.00 hrs in poultry shed and 5 mt surrounding area • In deep litter system, thickness of litter should be reduced to 7-8 cm • Use of ceiling fans. • Use of anti stress compound electrolyte and vitamins mix with water or feed • Decrease 10 % birds during extreme cold care which is to taken in Poultry: • Increase crude protein and energy in feed composition • In deep litter system, thickness of litter should be increased to 15 cm • Use of electric heater, bookhari etc for provision of heat • Increase 10 % strength of birds • Cover the shed and open area to prevent direct effect of chilled blow HEAT STRESS During Flood and heavy rain care to be taken for Poultry Ensure that the floor of the shed is at least 3 feet above the ground floor to avoid flooding of shed. The sufficient stock of feed should be stored in dry and protected building. Store the feed on iron stand away from wall to avoid increase in moisture and mould. Take the proper insurance of poultry sheds, equipment and mortality of birds due to drowning in flood water.

VII. Fisheries – Suggested Measures: Drought: Provide water linkage to all the ponds either by water through tankers or by pumping water from nearby reservoir. Alternatively capture the mature fishes and send to market to reduce stocking density or transfer others to alternative water ponds. In case of Capture Fisheries i.e. both marine and inland fishes either migrate or not survive.

Flood and Cyclone: In case of capture fisheries the flood will have positive impact but flood will affect culture ponds which are situated nearby the river. It damages the ponds and also contaminate the culture. In such case harvest the culture fish and wild fish which come with the flood water. Repair the ponds, disinfect the ponds with chemicals after the flood and recharge the fresh water.

Heat Wave and Cold Wave: Heat and cold wave affects the fish stock, in case of capture marine and inland fishes will migrate to safer place where as culture fisheries will have large effect as fish growth will be retarded as well as breeding and rearing of fish larvae will be severely get affected. In such case one has to exchange the water from time to time during heat wave. During cold wave provide heaters with thermostat to maintain constant water temperature and aerator to maintain the oxygen level. Increase the fish density. Provide probiotics as well as fresh and live feed.

Conclusion: Compared to crops – which fail completely if rainfall fails and drought occurs, cyclone or heavy floods wash away standing crops, livestock are more resilient with proper planning they can continue to support livelihood. The most important supportive action is to provide drinking water and bring fodder from outside and make available through Fodder Depots. But in case this does not become possible forced migration is only solution. Livestock do discharge high quantity of methane gas. This can be mitigated by setting up of individual bio-gas plants and community biogas plants.

Dairy Lavel

At dairy level many measures are required to increase the price of milk and earning by farmers

1) Dairies must be encouraged to build logistic farms having facilities of dry stores, cold stores, silage production and storage for green fodder, urea molasses treatment of dry fodder and its storage This will help farmers to store their agriculture produce and sell when good price is available in market. It will also facilitate their requirement of silage (Green fodder in summer) and dry fodder throw-out the year.
2) Encourage dairies to have their captive solar power production by providing easy loans, subsidies and government to give pro dairy policy so that money spent on power is saved and transferred to farmers in form of milk price.
3) Encourage dairies to have indigenous cows and bull mother farms to provide to farmers their need of good desi breeds and semen for artificial insemination.

•

Women in Farm Sector

• Dr. Niti Mehta •

Sardar Patel Institute of Economic and Social Research, Ahmedabad Women play a significant and crucial role in agriculture including crop production, livestock production, horticulture, post-harvest operations, agro/social forestry, fisheries, etc. Women worldwide are engaged in non-mechanized farm occupations that include sowing, winnowing, harvesting, and other forms of labour-intensive processes such as rice transplantation, cotton picking etc. Food and Agriculture Organization estimates that "women produce between 60 and 80 percent of the food in most developing countries and are responsible for half of the world's food production." In India around 80 per cent of farm work is undertaken by women (Oxfam, 2013). Women constitute over 42 per cent of the agricultural labour force in India, but own less than two per cent of farmland (NCAER, 2018). Yet women's immense contribution to household food security in country's such as India remains largely invisible.

Women today play a pivotal role in agriculture - as female agricultural labour, as farmers, co-farmers, female family labour and (with male outmigration, widowhood, etc) as managers of farms and farm entrepreneurs. Three-fourths of women workers are in agriculture. Women work extensively in production of major grains and millets, in land preparation, seed selection and seedling production, sowing, applying manure, fertilizer and pesticide, weeding, transplanting, threshing, winnowing and harvesting; in livestock production, fish processing, collection of non-timber forest produce (NTFP) etc. In animal husbandry, women have multiple roles ranging from animal care, grazing, fodder collection and cleaning of animal sheds to processing of milk and livestock products. Keeping milch animals, small ruminants and backyard poultry is an important source of income for poor farm families and agricultural labourers. Landless women agricultural labourers play a pivotal role as they are involved in most of the agricultural operations. Landless women also lease in land for cultivation. The majority of workers involved in collection of non-timber forest produce (NTFP) are women, particularly tribal women. Women also augment family resources through tasks such as collection of fuel, fodder, drinking water and water for family members and domestic animals.

While women have always played a key role in agricultural production, their importance both as workers and as managers of farms has been growing, as an increasing number of men move to non-farm jobs (Planning Commission 2007).

Table-1: WPR (UPSS) in Agriculture (in per cent) (NSS round)

Year	Male	Female
1977-78 (32)	80.6	88.1
1983-84 (38)	77.5	87.5
1987-88 (43)	74.5	84.7
1993-94 (50)	74.1	86.2
1999-2000 (55)	71.4	85.4
2004-05 (61)	66.5	83.3
2009-10 (66)	62.3	79.2
2011-12 (68)	59.3	74.9

It has been intensively critiqued that agriculture sector has a declining role in supporting livelihoods, necessitating adoption of diverse sources of income (Basole, 2017). Hence, there has been a significant shift in rural occupational distribution away from this sector. But the data for 2011-12 (NSSO) shows that rural females in India continued to crowd the agriculture sector for livelihoods. However, the magnitude had declined over the years and the female worker participation in this sector was 75 percent in 2011-12 declining from 88 percent in 1977-78. In absolute numbers agriculture sector recorded a decline by nearly 24 million female workers in rural areas alone.

Participation of women in agriculture, however, continues to be high unlike men who have livelihood opportunities in sectors other than agriculture. There are significant barriers to entry of rural women in non-agricultural jobs, in the nature of lack of education, skills etc. that makes them ineligible to be engaged in non-farm jobs. Mechanization of agricultural operations has played a role in reducing the labour absorption in farm based activities, showing up as gradual decline in employment in the farm sector and contributing to overall decline in females' work. Amongst the social groups, according to the NSSO (2009-10) the work participation ratio of the female agricultural workers was the highest for STs (31%) followed by SC and OBC categories (21% each) in rural India. Thus, the opportunities to work in more remunerative non-farm jobs are the least in case of rural tribal women.

Table-2: Female agricultural workers (UPSS) by level of education, 2011-12

Level of education	% share	WPR
Not-literate	60.6	25.4
Literate without formal schooling	0.1	8.5
TLC	0.1	19.6
Others	0.2	13.5
Below primary	9.7	10.2
Primary	11.7	16.2
Mliddle	10.0	16.1
Secondary	5.1	14.3
Higher secondary	1.9	9.8
Diploma/Certificate course	0.1	6.2
Graduate	0.5	6.5
Post graduate & above	0.1	4.8
Total	**100.0**	**18.6**

Source: Computed from NSSO Unit level data

Due to their poor human capital, females are worst affected by the crisis of quality of livelihoods in the rural sector. With regard to level of human capital of women farmers, Table 2 gives a view of their education status. Nearly two-thirds of all women agricultural workers are illiterate, with around 10 to 11 percent having primary and middle schooling. This severely impairs their capacity to engage in more remunerative farm related jobs, but confines them largely to carry out jobs that involve drudgery such as weeding, sowing etc. This is also reflected in the WPRs of the female agricultural workers, that are the highest for (25%) for the females who are illiterate. Furthermore, the employment of women in agriculture is confined to traditional low-yielding production of food crops, besides animal husbandry. The mechanized, export-oriented or commercial sub-sector of cash crops employ men, pushing female workers further into casual low paying wage work. Women involved in agriculture related activities are not allowed to play an equal role in the production process, nor do they have control over land. Moreover, the work of women performing tasks in their own farms largely goes unrecorded and is indivisible from the domestic and productive work performed by them.

Table-3: Annual average daily wage of agricultural workers in India

Year	Male	Female
1987	9.46	7.05
1993	21.52	15.33
2014	221.1	169.7
2015	233.8	178.9
2016	248.3	191.6
2017	264.0	205.3
201S	275.0	215.0
2019*	281.8	220.8

Source: Wage rates in rural India Note: *wages reported till the month of May, 2019

Women farmers face task related discrimination in agricultural jobs due to their poor capabilities and this is reflected in the average annual daily wages. There continues to be a significant gap in the male-female wage rates, even though it has narrowed down of late (Table 3).

Women in agriculture are affected by issues of recognition in the absence of land rights. Official lack of recognition of the female agricultural worker, results in their exclusion from rights and entitlements, such as institutional credit, pension, irrigation sources, etc. The draft of the National Women's Policy (2016), prepared by the Union Ministry of Women and Child Development recognised the importance of land rights for women. "The property rights of the Indian woman depend on which religion she follows, if she is married or unmarried, which part of the country she comes from, if she is a tribal or nontribal, and so on," it is argued.

Overall, the share of operational holdings cultivated by women has increased from 11.7 per cent in 2005-06 to 13.9 per cent in 2015-16. Most of the women farmers (around 14 % of total landholders) are resource poor (Table 4). As per the information from the agricultural census of the females owning land, marginal holders predominate, nearly 72 percent of female cultivators have marginal holdings, followed by 17 percent as small and semi-medium holdings.

Table 4: Operational land holdings of females by size-class (% to total)

Size class	2005-06	2010-11	2015-16
Marginal	69.7	71.6	72.2
Small	17.6	17.0	17.0
Small-medium	9.0	8.2	17.5
Medium	3.3	2.8	2.6
Large	0.4	0.4	0.3
All	15115	17683	20213
Classes	(11.7)	(12.3)	(13.9)

Source: Agriculture Census, Various years

Figures in brackets are share of female operated holdings to total.

There are other important challenges affecting the economic empowerment of women in agriculture eg. when the control is often vested with the husband of the elected woman representative under the aegis of Panchayati Raj Act. Traditionally institutionalised gender roles, low female literacy and awareness, male dominance in administrative, judicial, and other public decision-making bodies at all levels restricts women in exercising their legal rights (Bina Agarwal 1993). This is also coupled with the improper maintenance of land records, poor management of data, and limited digitisation of land records, which affects implementation of agricultural schemes meant to uplift farmers in general, as such challenges make identification of beneficiaries difficult.

According to the Food and Agricultural Organization (FAO, 2011), empowering women through land and ownership rights has the potential of raising total agricultural output in developing countries by 2.5 to 4 per cent and can reduce hunger across the world by 12-17 per cent. It is found in W Bengal that merely ensuring sufficient space in land certificates to enable listing of both husbands and wives as owners had a huge impact, leading to the inclusion of women in a majority of the land titles in the state. Such schemes could lead to a ripple of positive developments for women such as enhanced decision-making power, better child nutrition and household food security, improved educational attainment for girls (Anupama Mehta, NCAER 2018).

•

Role of Organic Farming in Doubling Farmers' Income with Special Reference to Zero Budget Natural Farming

• Dr. B. R. Shah and Dr. Waseem Sheikh •

Organic Farming is a treasure trove conferred to mankind by the nature since the inception of galaxy. It can be defined as a farming system which is primarily aims at cultivating the land and raising crops in such a way, as to keep the soil alive and in good health by use of organic wastes (crop, animal and farm wastes, aquatic wastes) and other biological materials along with beneficial microbes (biofertilizers) to release nutrients to crops for increased sustainable production in an eco-friendly pollution free environment. According FAO "Organic agriculture is a unique production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity, and this is accomplished by using on-farm agronomic, biological and mechanical methods in exclusion of all synthetic off-farm inputs".

The modern concept of organic farming combines the tradition, innovation and science. Although, history states that the movement for organic way of life recognized in 1905, it could gain ground after realizing the ill effects of modern agriculture in the late 1990's. In 1905, the British botanist Sir Albert Howard, often referred to as the father of modern organic agriculture, documented traditional Indian farming practices, and came to regard them as superior to conventional agriculture science. During 1940, in Japan, Masanobu Fukuoka, a microbiologist working in soil science and plant pathology, quited job as a research scientist, returned to his family's farm, and devoted the next 30 years to develop a radical no-till organic method for growing grain, now known as "Fukuoka farming". Many other practices such as Rishi krishi, Natural farming, homa farming, *panchagavya krishi*, bio dynamic and Zero budget natural farming are associated with organic agriculture.

Zero Budget Natural Farming (ZBNF) is a set of farming methods, and also a grassroots peasant movement, which has spread to various states in India. It has attained wide success in southern India, especially the southern Indian state of Karnataka where it first evolved.

Privatized seeds, inputs, and markets are inaccessible and expensive for peasants. Indian farmers increasingly find themselves in a vicious cycle of debt, because of the high production costs, high interest rates for credit, the volatile

market prices of crops, the rising costs of fossil fuel based inputs, and private seeds. Debt is a problem for farmers of all sizes in India thus a deep agrarian crisis that is making small scale farming an unviable vocation. In India, farmers income remained low as compared to non farm sector (Chand, 2017). Realizing, the need of this fact, the prime minister of India stated that the income of the farmers should get double by 2022. Doubling farmer's income till 2022 over the base year 2015-16 needs annual growth of 10.41% in farmers' income, under such conditions, 'zero budget' farming promises to end a reliance on loans and drastically cut production costs, ending the debt cycle for desperate farmers. The word 'budget' refers to credit and expenses, thus the phrase 'Zero Budget' means without using any credit, and without spending any money on purchased inputs. 'Natural farming' means farming with Nature and without chemicals. Zero budget farming was also stressed in the 2019 budget speech and the finance minister of India urged to replicate this innovative model reminding its potential in doubling farmers' income. The ZBNF basically relies upon cow dung & urine (of local breeds), straw, leaves essentially procured locally. Botanicals are also relied upon. While one can consider the benefits accrued from natural farming, it would be naïve to assume that zero budget farming with its one stroke can double the income of farmers. While it is true that it negates the necessity of many of the store bought inputs, it is still difficult to believe that it works on 'Zero' budget. The labour charges that go into the elaborate preparations of the special concoctions utilizing good amount of cow dung and urine has been unaccounted for. The system also prefers local breeds of cows and hence their access and procurement would also be a difficult issue. The produce from this farms are technically organic and hence would be unfair to be sold in conventional markets where they do not fetch a premium price. Moreover, the yield study must be done with existing modern technology.

ZBNF is at experimental stage in certain pockets of the country. Without any scientific data to back, the Zero Budget Natural Farming (ZBNF) may not yield comparable results across the nation. The results may not be reproducible and hence it would be a fallacy to assume that the adoption of ZBNF would raise the farm incomes substantially.

Strategies for Doubling Farmers' Income through Organic Farming:

1. Implementation of organic farming policy or initiatives to create farmers' interest in organic production.
2. Ensure organic seed supply to farmers
3. Participatory group or community approach in organic farming
4. Soil and water conservation and soil health management

5. Promotion of Integrated Organic Farming System (IOFS)
6. Increase in productivity and production
7. Intensification/Diversification
8. Eco-Safe crop protection
9. Protected cultivation of crops
10. Farm mechanization on cluster basis
11. Enhancing farm produce price
12. Creation of Organic Agriculture Economy Zones (OAEZ) and capacity buidling
13. Organic certification
14. Risk mitigation measures
15. Refinement and validation of ITKS

Conclusion

Organic Farming may pave a new way for doubling of farmers' income but requires a scientific evidence for validation of different type of methodology existing in organic farming. Micro-environment study can corroborate the chances of doubling farming income. Hence, long term strategies must be evolved for the implementation of organic farming on large basis and harvesting its benefits.

•

Innovative Agricutural Extension: Road Map (2020-30)

• Dr. V. V. Sadamate, Dr. R. N. Padaria and Ms. Priti Priyadarshni •

Agriculture & Allied Sectors: Impressive Performance

The performance of farm sector in India is quite impressive (Annual Report DAC & FW, 2018-19) in terms of its achievements in crops and allied sectors over the years. Food production has touched a new height of 284.83 Million Tonnes (MTs), with record score of pulses (25.23 MTs) and oil seeds (31.31 MTs) production. The fruit (100 MTs) and vegetable (166 MTs) sectors have recorded significant achievements (DAC & FW, 2018). India is now the World's largest producer of milk (176 MTs) with per capita availability of 337 grams as against the Word average of 300 grams (Annual Report, DAHD & F, 2018-19). The fish production has touched the level of 11 MTs with 7 MTs of inland and 4 MTs of marine (Annual Report, DAHD & F, 2018-19). The meat production in the country is at 10.5 MTs whereas the egg production has gained a record height of 90 Billion eggs per annum with per capita consumption of 63 eggs per annum (Annual Report, DAHD & F, 2018-19). Like other crucial inputs, the technology dissemination services, both public and private have played a significant role in the achievements cited above. Though the performance of extension delivery varied from State to State.

Farm Sector: Current Concerns

Agriculture Sector as a whole faces formidable challenges, despite record achievements. These include: shrinking land and water resources, adverse impact of climate change, skewed development in various agro-climatic zones, emergence of farm distress though sporadic, stagnant productivity in some crops/areas, increased production costs, dwindling natural resources, market uncertainties and need for reforms in technology delivery systems across States and sectors. The major concerns revolve around the following:

GDP Contribution of Farm Sector Sliding Down

Contribution of agriculture & allied sector in GDPis sliding down (14.39% at constant prices & 15.87 at current prices, MOS & PI, 2018-19); still around 60% population depends on it. Allied Sectors are contributing significantly, hence need adequate programmatic and investment focus.

Shrinking Land Holdings and Serious Strain on Natural Resource Base

Predominance of small holders in Indian agriculture continues to rise.

Average size of land in India has reduced to 1.30 hectare per farm holding. Small and marginal farmers now comprise of 83% of total land holdings and they occupy about 41% of area under all operational holdings (Agril. Statistics, 2017-18). Natural Resource base that sustains farming is under increasingly serious strain. Land, water, soil health and biodiversity resources are shrinking and deteriorating. Due to over-exploitation, the ground water levels are going down even in irrigated areas in several parts of the country. Continuing imbalance in use of fertilizers and over doses of PP Chemicals has adversely affected soil health. Thus, long term sustainability demands that land and water are used judiciously and efficiently.

Regional Imbalance

Present level of productivity of most of the crops and other sectors is significantly low as compared to what is attainable and also are being attained by some other countries. This production potential is believed to be very large, for example, in the eastern and central regions. Regional imbalances in growth and productivity are high in rainfed conditions. Dryland areas that are home to a large section of marginalized communities continue to be in disadvantageous position in terms of desired development interventions.

Sustaining Food and Nutritional Security

India ranks at 103rd as per Global Hunger Index (IFPRI, 2018) amongst 119 nations, Nepal (72) and Bangladesh (86) are ahead of us. Half of the children (51%) in India are malnourished, over 55% married women suffer from anaemia and 30% adults suffer from protein - energy malnutrition. Food availability to BPL families and supply and distribution apparatus in disadvantaged areas along with food quality standards are basic concerns. Access to food and affordability of the impoverished families to harness the social entitlement are also issues that need greater attention to expand the income and livelihood options for such category of people. Horticulture, milk, meat, poultry and nutri-cereals may provide an excellent opportunity on nutritional improvement; however, the awareness and reach are still limited. Concerted extension efforts are needed to bring in supply chain management, ensure availability, access and affordability (AAA). Malnutrition particularly with reference to essential minerals is a major problem, which can be addressed by inclusion of coarse cereals and millets in PDS, food fortification and propagation of nutrient-dense foods. Farm women could play an important role in managing and sustaining house hold food security and extension services need to be oriented that way.

Rainfed Farming and Its Sustainability in the Context of Climate Change

Nearly 60% cultivable area would continue to be rain fed - typically

characterized by vulnerable natural resource base, inhabiting 40% population, giving 40% food grain output and sustaining about 60% of livestock. Watershed has been taken up as a key intervention for development of such areas. Climate change and adaptation are dominant issues in farm sustainability (AESA,2019). Better convergence and programme delivery below the sub-district levels are urgently called for. Recent innovative programmes like NICRA, NMSA & PMKSY have demonstrated good potential that need to be mainstreamed into the future strategies. Technology transfer models adopted so far have not been able to make any perceptible dent in rain fed areas. It calls for alternative thinking in policy framework and delivery mechanism.

The Agricultural Distress, though Sporadic

Agricultural distress reflected in some parts of the country needs to be addressed by alternate strategies as the normal programmatic formulation seems did not work there. The focus would need to be on the conservation technologies, alternate crops and cropping patterns, crop diversification, convergence and enterprise combination suiting to local resources and alternate livelihood options. It needs well defined extension strategies with focus on training of farmers and farm women for alternate livelihoods.

Efficacy of Programme Delivery & Extension Systems

Efficacy of programme delivery mechanism is another serious concern across the sectors. Both, the public and private sector extension service providers are constrained on the issues like funding, manpower, linkages (backward/forward), HRD/ICT strategies, outreach to small producers, desired impacts on the targeted beneficiaries, etc. Extension outreach observed to be either very weak or practically absent in sub sectors like Animal Husbandry & Dairy (AH&D) and fisheries, though these sectors are contributing significantly.

Growth of Agricultural Extension Programmes/Services

Extension services, like other crucial inputs have played a very major role during pre- and post-Green Revolution stages. The technological backstopping for this credible gain has primarily came from the NARS System. There is a huge network of the extension functionaries accounting to public sector (1.19 lakhs) and private sectors (over 1 lakh) at various levels. The State Agricultural University System and the training framework in GOI and the States have played significant role in training and capacity building of extension manpower and farmers.

Agricultural Advisory Services, in Pre-Independent India, were operated mostly through voluntary efforts in various parts of the country. Massive

agricultural development efforts, in earlier parts of post-independence period were organized through Grow More Food Campaign (GMFC) in 1947, followed by Community Development Programme (1952) and National Extension Service (NES) blocks in 1953. Subsequently, Pre-Green Revolution interventions came in, like Intensive Agricultural District Programme (IADP, 1961) and Intensive Agricultural Area Programme (IAAP, 1964). Then, came the period of Green Revolution of 1967, supported by intensive extension efforts like National Demonstrations (1965), Farmers Training Centres (FTC, 1966), Small and Marginal Farmers Development Agencies (SFDA, 1971), *Krishi Vigyan Kendra* (KVK, 1974) and Lab to Land Programme (1979).

Presently, the technological backstopping at the district level has been strengthened by augmenting and expanding KVK Programme in the country (713 by now) for supporting front line extension services. These are operated by the specialized teams of SMSs based at the district level promoting technology options in micro agro climatic situations covering the range of production systems. The KVK Team comprises of a Programme Coordinator and SMS (6) in various subject matters like agronomy, plant protection, extension, home science, horticulture, animal husbandry, etc. Each KVK has an experimental/demo farm and live production units. The major activities include: On farm testing and validation of technologies, carrying out Front Line Demonstrations, Training of farmers, farm women, farm youth and field functionaries. KVKs in turn are backed up by the SAU/ICAR network and by the Agricultural Technology Application Research Institutes (11).

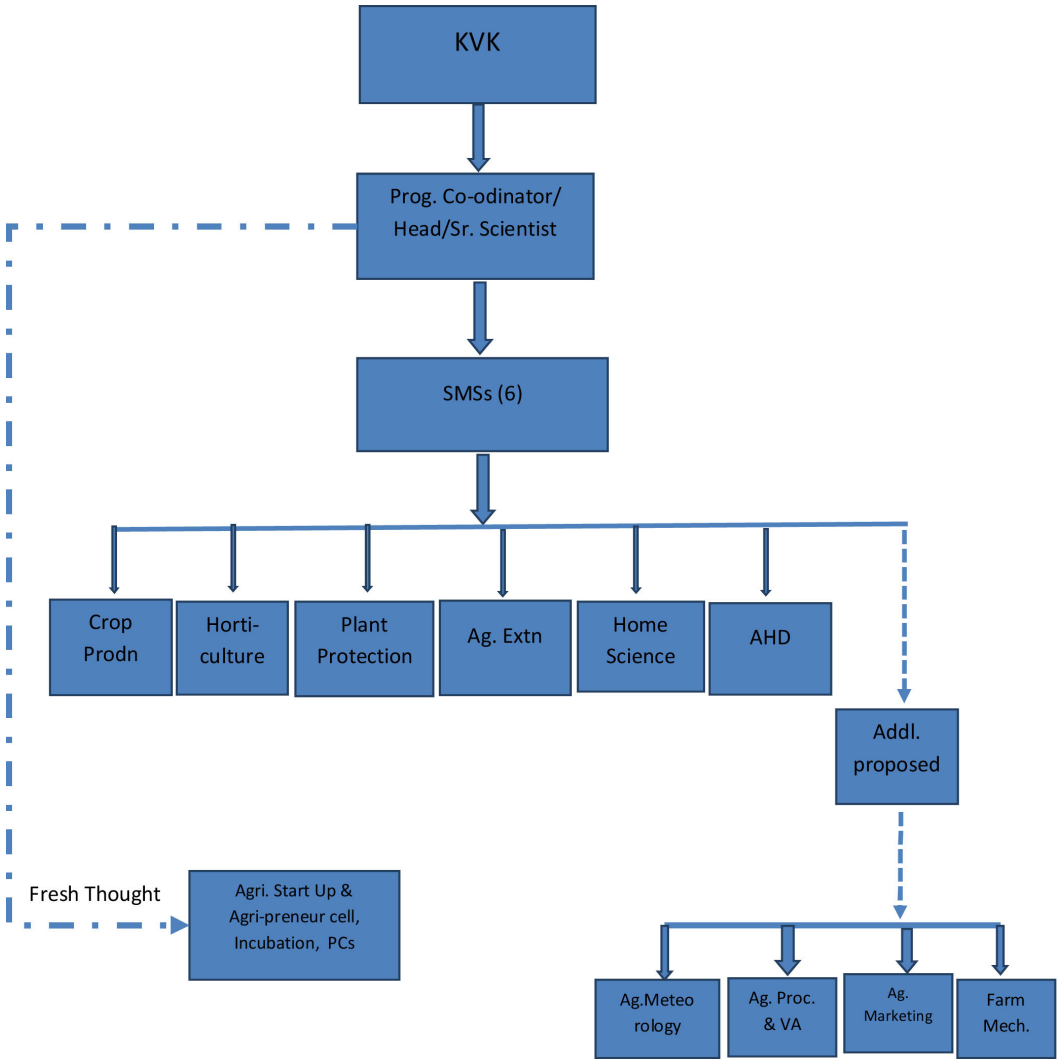


Fig 1: Organisational Structure of KVK (Indicating additional SMSs)

Around the mid-seventies (1974-75), the very major Extension intervention through Training and Visit (T&V) System of Extension was implemented in Madhya Pradesh and Rajasthan on pilot basis for strengthening field extension services. This World Bank funded initiative prescribed periodic training of field functionaries, their scheduled visits to the farmers, research back up, extension training/information, mobility/infrastructure support, inbuilt M & E arrangements, etc. Following significant impacts, the same was expanded throughout the country from 1984 to 1995 through the World Bank supported National Agricultural Extension Project (NAEP), whereas the research back up was supported by National Agricultural Research Project (NARP).

Subsequently, the process of Extension Reforms was initiated under National Agricultural Technology Project (NATP, 1998) in a pilot mode with integrated extension delivery attempted under Agricultural Technology Management Agency (ATMA) at district level, now covers 676 districts in 29 States and 3 UTs under National Mission on Agricultural Extension & Technology (NMAET). The Chairperson of ATMA Society is the District Collector. However, there is a full time Project Director (PD) to execute the extension programmes and activities assisted by the Deputy PDs. At the block level there is a Block Technology Manager and three Assistant Block Technology Managers. Their field programmes are operated through Village Extension Workers and selected Farmer Friends (1 for 2 villages). The ATMAs are supported by the block level and district level farmer committees who are involved in programme management and in providing feedback.

The field functionaries at the senior level are trained at the National Institute of Agricultural Extension Management (MANAGE) and the middle ones at State Agricultural Management and Extension Training Institutes (SAMETIs). The extension and communication trainings for field functionaries are conducted at Regional Extension Education Institutes (EEIs) and farmers are trained at KVKs and FTCs.

Other important programmes and schemes of the Extension Division/ Directorate of Extension of the Ministry of Agriculture include: Mass Media Support to Agricultural Extension, Promoting Agri Clinic and Agri Business Centres (ACABCs), Kisan Call Centres (KCCs), National Gender Resource Centre in Agriculture (NGRCA) and National, State and Regional Exhibitions.

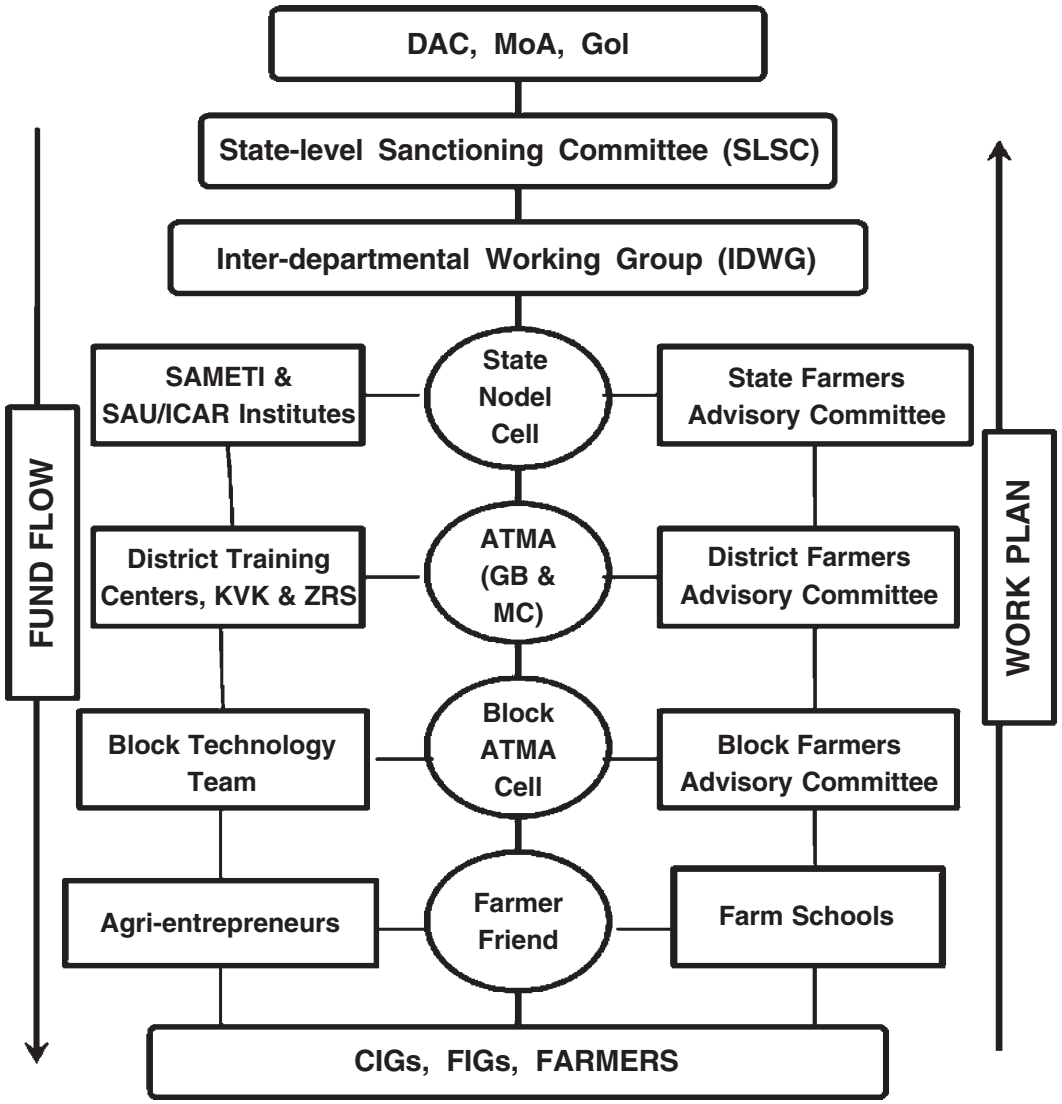


Fig 2- Framework of ATMA

Major concerns: convergence platform with requisite operational flexibility, capacity to address emerging field level challenges, broad based extension delivery including crops and allied sectors.

The cafeteria of activities covered by ATMAs include: multi agency extension and convergence strategies, promoting IFS approach, gender mainstreaming and farmers' centric activities like training, exposure visits, demonstrations, farm schools, organization of farmer groups, etc.

Emerging Pluralism in Extension Services

Agricultural extension is no longer only a public sector phenomenon. It now involves a more complex range of actors providing a wide range of services, together bracketed as Extension Advisory Services (EAS). These include organizations in the private sector dealing with agricultural inputs, agribusiness, and financial services, non-governmental organizations (NGOs international as well as local); producer groups, cooperatives and associations; consultants (independent as well as associated with or employed by agri-business/producer associations) and information and communication technology (ICT)-based services. The job expectations from extension professionals have thus changed now and now demanding various competencies.

Currently, the agricultural extension services are moving on a pluralistic platform, enabling provision of defined role space for all players. Doubling Farm Income Committee (DFI Committee, 2018) has proposed to transform agricultural extension as an important engine for doubling the farmers' income while ensuring national food and nutritional security through sustainable means.

Extension Models and Approaches in India and World

Agricultural Extension Models World Over

(i) Knowledge Generating Systems (KGS) Specialists directly work with the farmers: West Europe, US (ii) Transmission from KGS - Field functionaries (SDAs) – Farmers: South Asian countries like India, Pakistan, Bangladesh, etc., (iii) Farmer Producer Organizations playing significant role in extension services: Latin America, (iv) Farmers Associations playing significant role in Extension: South East Asia, (v) Transmission of Extension Messages: MOA - Field functionaries the Provinces – Farmers: Developing African countries and (viii) Other Models.....All over, Donor Driven, NGO Driven, ICT Driven (internet Platforms & Social media)

Extension Models in India

Public Sector Extension Service Providers (ESPs)

Research Institution Outlets

SAUs, SHUs, SVetUs ICAR/CGIAR institutes, KVKs: Primary Functions: Generation & testing of Technologies, Frontline extension services

Development Department Outlets (State Sect, CS & CSS Schemes)

Agriculture, Horticulture, Animal Husbandry Dairy & Fisheries, Sericulture etc. Primary Functions: Adoption of tested technologies & Up-Scaling

Private Sector Extension Service Providers

Agri-Entrepreneurs, ACABCs, Agri Start-ups, Internet Platforms, Input Agencies, Companies & Corporates. Primary Functions: Supplement extension efforts while promoting their respective products and services.

Farmers/Farmer Organizations

Progressive/Innovative/Entrepreneur Farmers, Farmer Organizations, CIGs, FPOs, FPCs, etc. Farmer Cooperatives (PACs /Commodity Cops). Primary Functions: Organized farmer involvement, extend benefits to the member farmers & others

Non-Government Organizations (NGOS)

Directly working with the farmers, International NGOs/ Mother NGOs/ Field NGOs. Primary Functions: Mobilization of Communities, Organizing them as SHGs, CBOs, etc.

Media/ICTs

Print Media/Electronic media Radio/Television, Internet based Applications& Apps, Social Media, etc. Primary Functions: High speed, good for creating mass awareness & for information/publicity/networks.

Learning and Lessons Emerged through Implementation of Various Models

(i) Realizing that extension is process equilibrium and not mere TOT, (ii) Realizing pluralistic approach/Chains of ESPs, (iii) Each has a defined role space/No substitute, (iv) Making ESPs Supplement & Complement, (v) Focus on allied sectors, inadequate, (vi) Marketing, business & income opportunities need to be brought in, (vii) Bottom up/participatory processes in planning and implementation, (viii) Making it respond to the emerging extension scenario at the micro agro situations, (ix) Feedback documentation/analysis, (x) Operational flexibilities for convergence, (xi) Right Extension priorities for dynamic actions, (xii) Orienting AESs to the extension needs of farm youth and farm women and (xiii) In build M&E and correctives

Innovative Reforms and Strategies in Agril. Extension

Farmer Empowerment & their Intensive Use in Extension Network

Empowerment of Farmer Organizations (FOs)

Farmers could be empowered by various methods like organizing them into SHGs, FOs, FPCs, Coops, etc., by providing training & capacity building, by making them partners in decision making and by providing role space in extension operations. Finance Minister's budget speech 2019 focused on promoting 10,000 FOs with present strength being 5000 (NARBARD 2019-20).

There is need for re-orienting extension services to address extension needs of farm women and farm youths and their organized groups.

Pressure on Demand & Supply Chains

The organized farmer groups in the form of Farmer Organizations (FOs), Commodity Groups (CGs) and Farmer Producer Companies (FPCs) have great scope to put the adequate pressure on the demand & supply chains. Murray (2008) observed that producer organisations can be a potential solution for enhancing value addition in agricultural commodities coupled with utilizing the perishable produce.

Farm Youths and their Organized Groups for High Tech Farming (FY- HTF)

It has been observed that the Farm Youths and their Organized Groups are taking interest in secondary agriculture (processing, value addition, mechanization, aggregator, producer company operator, etc.) as opposed to primary agriculture. Extension services may need to address this dimension too as it gives farm youth the sense of social equilibrium at par with his/her urban peers.

Farmer Producer Companies (FPCs)

Successful and mature FOs could be converted into a Farmer Producer Companies with focus on organized approach to the extension operations and integrating their efforts with technologies and markets. FPCs have brought in income and business orientation in extension and production operations. Over 3000 FPCs are in operation in the Country and the number is growing.

Farmer Cooperatives, Collectives and Aggregates

Farmer Cooperatives are found to be a great success in the States like Maharashtra, Gujarat in fruits, commercial crops, vegetables and milk sectors. AMUL, MAHAGRAPES, etc., are examples of merit and performance. The farmer collectives and aggregates have a major role in linking the farmers to the markets resulting in enhanced incomes.

Intensive Use of Farmers Field Schools (FFSs): Farmer to Farmer Extension

This is one of the effective methods of technology dissemination wherein the innovative and progressive farmers could share the technological information with the fellow farmers. FFS is an effective extension tool, practiced widely, needs to be up-scaled as it provide an opportunity for farmer to farmer extension. The Farmers Field Schools are organized on the fields of innovative farmers where they become the host and the teachers for the technology in which they have already excelled or have had a unique experience and achievements. The host farmer needs to be properly oriented about his roles

and responsibilities in promoting the technologies demonstrated on his field. The fellow farmers would have to have a faith and access to the host farmer, his competence and in the results obtained on the farmers' field schools.

Priyadarshni et. al (2019) found utility of FFSs in enhancing social learning that included improved participation, engagement and collaboration among the farmers. It enabled development of favourable attitude towards local knowledge and building of mutual trust among the members. They stated further that when the farmers, scientists and extension agents are involved in social learning process a better understanding of risks and solutions could be created.

FFS differs from demonstration since it lays more emphasis on experimentation, science based learning, sharing of knowledge and skills in adoption of technologies. Now, the issue is how to promote, encourage & fund FFSs under various programmes. One of the methods tried by the ATMAs and KVKs was to involve such farmer innovators in the validation process by the research system and using them as training resources & disseminators.

Promoting Farmer Facilitators and Para Techs

There is a strong need for promoting informal sources of technology delivery like farmer friends, model farmers, lead farmers, *Kisan Sahayyaks* (farmer facilitators), etc across the states/sectors, to enable faster technology transfer at the cutting edge levels. There are different models promoting farmer facilitators at the community levels. NGOs like Ramakrishna Mission have trained young boys and girls from the rural areas, built their capacities and used them as local farm volunteers. Every three months these young volunteers are brought back to the local KVKs for training and retraining. The Department of Agriculture, Andhra Pradesh have selected local practicing farmers as Model farmers (Adarsh Raytu) for technology transfer. *Kisan Sahayyaks* (Farmer facilitators) are used in the States of Uttar Pradesh, Bihar etc. In fisheries and in the animal husbandry sectors the States like West Bengal are promoting *Matsya Mitras* (Fish friends) and *Prani Bandhus* (Animal brothers).

These facilitators would need to be properly selected and trained for the specific task. They should be innovative, practicing farmers and should have acceptability of the community. So the selection process would need to be far fairer. He/She needs to be oriented to handle community level extension advisories and therefore, need periodic updating of their knowledge and skills. The field extension agencies like ATMAs, KVKs, NGOs, farmer organizations would need to promote the Farm Facilitators and use them at community levels.

ATMA has a formal provision to promote Farmer Friend (FF), one for two villages. He/she gets and honorarium and incentives under ATMA Scheme.

The challenge is how best these resources can be groomed for technology dissemination and their capacities built and their involvement in the frontline and field extension programmes activated.

The States may consider taking a few pilots in selected blocks and systematically promote farmer facilitators (FFs) and demonstrate how effectively they could take on extension and technology transfer functions at the community level. This would largely fill up the extension gaps at the community level especially in the remote areas, hill and mountain eco-systems and tribal areas where the extension services remained weak.

Targeting FPOs/FPCs

It is proposed to target a FO per village and a FPC per 10 to 15 villages to be promoted by both the public and private extension service providers.

Enhancing Outreach of Ongoing Models (Front Line & Field Extension)

Enhancing Outreach of Extension Models in Operation and their Interplay

There is need to improve performance of extension models in operation to their optimum levels with focus on: (i) R&D linkages, (ii) research backstopping, (iii) widening the sectoral and area coverage, (iv) resource sharing, (v) training coordination, (vi) convergence & programme delivery, and (vii) improving penetration to the small & marginal producers.

Promote Chains of Service Providers

Field formations, by themselves are not able to penetrate down the line, especially to the small and the marginal farmers, and across the sectors and areas. This has resulted mainly due to inadequate numbers, their quality and limited outreach. Therefore, it would be better if extension services promote chains of extension agents, formal/informal for enhanced coverage (Fig-3). Agents in Extension chains may include Progressive Farmers, Entrepreneurs, FOs, FPCs, Cooperatives, Start-ups, IT platforms, etc.

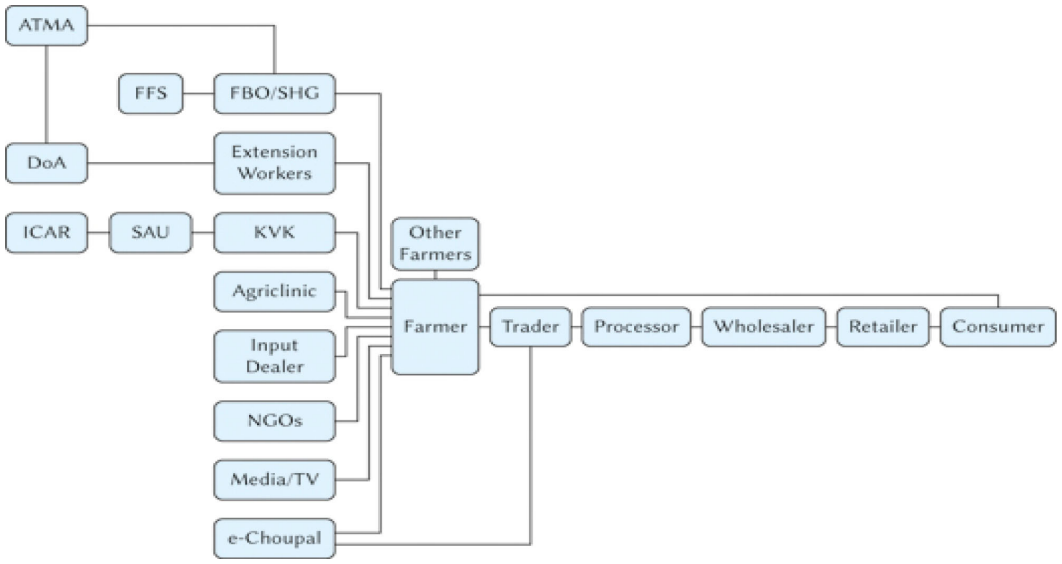


Fig-3: Farm Information Sources for the Farmers and Chain of Service Providers (Glendenning et. al, 2010)

Field Formations to Supplement and Complement Each Other

Field formations of various extension streams would need to supplement and complement in selecting programme sites, identification of beneficiaries, joint diagnosis & problem solving, information support, training and capacity building of FFs, BTMs, and ABTMs. Sharing of training resources, providing mentoring support by the KVK/SAU Scientists to the block level formations (e.g., RSKs of Karnataka & Krishi Bhavans of Kerala) in the specialized areas may also be thought of. As above is far more applicable in case of KVK and ATMA field operations.

Focus, Clarity & Interplay of Front and Field Extension Management Interventions

Extension operations at the field levels need lots of clarity in appreciating finer elements of frontline (Research driven) & field extension (Development department driven). What has been demonstrated by the front line efforts at the micro environment would need to be up scaled by the field extension agencies. At times, these equations do not get properly focussed and translated into action leading to duplication of extension efforts.

Extension Services in Allied Sectors

With all its adequacies and inadequacies there is Agricultural Extension System exists for Crops sector. However, in allied areas like horticulture, animal husbandry, dairy, poultry, fisheries etc, its either weak or missing, though the

allied sectors are contributing significantly in agricultural growth. Hence, Extension needs to be re-organized thoroughly by way of (i) additional SMS support to KVKs/ATMAs in potential areas, (ii) promoting growers, breeders, fishers' groups and associations, (iii) use of milk/fish cooperatives, (iv) use of entrepreneurs, progressive farmers, etc.

Growers Associations, Commodity groups, Entrepreneurs as extension agents. AHD Extension: Besides Cattle & buffaloes, bringing in extension focus on; Sheep & Goats, Small ruminants like pigs and rabbits, CB of small producers, including farm women. Dairy Cooperatives and Commercial dairy owners as extension agents. Fisheries Extension: Focus on cooperatives, fish entrepreneurs, market integration, etc.

Market Led Extension Strategies for Enhanced Incomes

Future Extension Strategies must focus on organizing producer aggregates at various levels. This would provide strong backward and forward linkages including market integration strategies for enhanced income opportunities to the farmers. Such Farmer Aggregates would also provide adequate pressure on the R&D agencies making extension operations demand driven and participatory. Market-led extension system establishes its position by helping the farmers realize high returns for the produce, minimize the production costs and improve the product value and marketability (Kumar et. al, 2012).

Demand Supply projections for farm produce like grains, pulses, oilseeds, fruits, vegetables, milk and milk products, meat, fish etc. if worked out in advance for micro/macro situations may streamline the market behaviour and farmer may not face glut and distress sale situations.

Aggregated approach may provide proactive involvement of farmers & entrepreneurs and may provide opportunities like better price negotiating power to the farmers, pressure on provision of quality inputs and after sale services.

To realize the benefit of higher prices, farmers need to access a wider range of information, related not only to production technologies but also to postharvest processes, access to remunerative markets, price information and business development (Sulaiman and van den Ban 2003).

Extension for Dis-advantaged Areas/Groups

Farmer distress and challenged areas need clear extension strategies/ advisories including climate adaptation (Sulaiman, et.al. 2019). It would need micro level technology options along with credit-market linkages. Appropriate enterprise combinations would need to be worked out for the blocks, clusters

and the micro level agro situations to be promoted by the extension operations. This would need re-orientation of the extension machinery and improved programme delivery. Similarly, the tribal areas, the hill and mountain areas, the rainfed areas, the desert areas and the border areas would perhaps need regionally differentiated and location specific extension strategies.

Innovative extension solutions for challenged / disadvantaged areas and groups may include: (i) ESP Combinations, (ii) involving NGOs, (iii) intensive use of ICTs (iv) intensive use of Para Techs, (v) participation of local communities and institutions, etc.

Benchmarks for Extension Performance & Extension Accountability

Performance standards need to be set for Extension Performance, in a given cluster, block and district. It would make the extension services accountable to the local area and farming communities, enabling extension services to respond to the emerging extension challenges: Performance benchmarks like extent of adoption, extent of convergence, enhancement of production and income of the farmers and farm women, enterprise combination, market linkages, etc would need to be set for agriculture and allied sectors too.

Further accountability parameters may also include: Enhanced penetration of extension efforts to small and marginal producers, farmermotivation on accessing extension services and putting user's pressure, attitudinal /behavioural changes obtained in a given micro ecology, farm women and youths organized and their capacities built, etc.

Integrating Private Sector Efforts in Extension Management

Bring in PPPs in Extension Management Systematically

PPPs are required down the line to promote participatory extension arrangements between the public and private extension service providers. It is expected that large number of MoU based PPPs must come up at various levels to make the extension services respond to the local situations. However, PPP operations need policy directions and clear instructions on partnerships (otherwise provisions do not get translated as it has been seen in some ATMAs). ATMAs can be a good platform for working out operational flexibilities & resource sharing, keeping in view large number of government, private & NGO extension players in the field. The input support agencies, the companies and corporate, the NGOs, the Agri Clinics and Agri Business Centres (ACABCs), etc., can also play an important role in promoting and operating PPPs in Extension management covering agriculture and allied production systems (Fig-4).

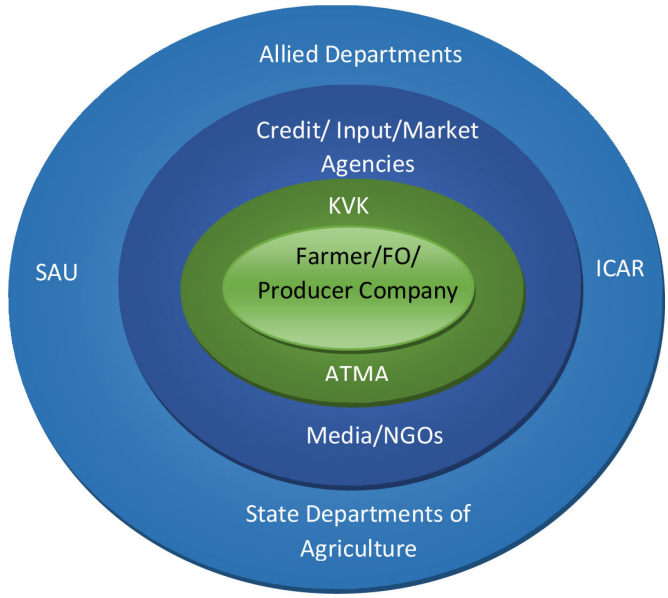


Fig-4 Aligning Public and Private Extension Services for Farmer Centric Approach

A serious focus is required to understand the extension spirit of public and private extension efforts. Proper understanding of each other's efforts and mutual benefits that would be accrued is essential element in such efforts. Sometimes there is a provision; however, in the absence of field understanding such partnerships do not operate. Perhaps there is need to spell out the MOU based partnership parameters at the local level. Farmer Groups, input industries and other private extension service providers would need to be encouraged by the public extension platforms for mutual and upscaled benefits to both. Private ESPs may establish Demo units in the jurisdiction of all KVKs/ATMAs on PPP mode, promoting large number of MOU based extension operations.

PPPs in Extension involving the input dealers and dairy/fish farmers may focus on breeding, feeding and health care areas. Public sector extension agencies would need to be thoroughly oriented on importance & contribution of PPPs in promoting IFS. Special PPP Extension Provisions would need to be made under flagship programmes of the Federal and State Governments.

PPP is a pragmatic and programmatic approach to the delivery of extension services. For example, development of the value chains will require technical expertise that goes beyond the capacity of the current extension functionaries. Hence, they may require trained experts from private and NGO sectors to provide services like value chain management, market linkages, product planning, etc.

Private agents' capacity can be improved by strategic alliance with government institutions. Such PPP provisions can be highlighted in SREP and SEWP through ATMA mechanism according to local needs. Example: training centre in Khurda district strengthened by Paradeep Phosphate by providing training faculty and infrastructure, for farmer training activities.

Seeing the limited approaches by public sector in agricultural extension, process of privatization of extension can be taken as alternative for improving extension effectiveness. It is expected to improve by: reorienting public sector extension with limited and well-focused functions, more number of extension providers (institutional pluralism) resulting from active encouragement by the public sector to initiate, operate and expand, more private participation leading to the availability of specialised services hitherto not available from the public system, user contributions to extension leading to improved financial sustainability, and support and control by clients leading to client orientation, (Sulaiman & Sadamate 2000).

Several parameters like who initiates PPP, sharing of responsibilities and benefits, mutual trust, who takes lead, who supports, dispute resolution mechanisms, etc., play an important role in sustaining PPPs (Sadamate, 2003).

Use Input Dealers, Entrepreneurs & Start-ups in Promoting Extension

There is adequate space for promoting Dealers, Distributors and Extension Entrepreneurs in extension services especially in motivating other non-users while promoting their own product and services. Extension through ACABCs & Agri Start-ups is also gaining ground in commercial crops. It has been observed that a successful venture deploys 10 workers directly and about 40 indirectly, covering about 200-500 farmers. Farm Entrepreneurs & Agri Start-ups could play major role in extension services across the production systems.

It has been observed through various studies that agri-preneur being highly motivated person could take on activities like aggregated production models, providing better forward linkages, driving market led extension strategies, better price realization to the farmers (Chandrasekra, 2014).

Strengthening R&D Linkages

Enhanced Research Backstopping to Extension

Enhanced research backstopping to the field formations is required so as to facilitate a strong technological input in the extension processes. The scientists interface with field functionaries and with the farmers would need to be augmented. Technology options would need to be generated for the micro level farm situations. Also, validation of farmers own innovations needs to be

prioritized and mainstreamed. Farmer Entrepreneurs / Innovators need to be promoted in extending extension services by using them in training and capacity building activities.

R&D Linkages: Activating Existing Forums & Follow-up

There are various R& D linkage mechanisms available in agriculture and allied sectors at various levels as follows: National: (i) Pre-Kharif & Pre-Rabi Interfaces between DAC & FW and ICAR, (ii) Regional: ICAR Regional Committee Meetings, (iii) State Level: Pre-Seasonal Meetings (Agro - Climate Zone Wise), (iv) District Level: SAC of KVKs, GB/Management Committee of ATMA & District level ATMA FACs and (v) Block Level: Block Level FACs of ATMAs. Experiences in various States indicate that the performance of these forums needs lots of improvement so that they function efficiently in contents and coverage. It is also necessary that both research and development sides participate pro-actively in improving R&D agenda, making these forums dynamic & responding to the agenda as per needs of farmers. ATMA was proposed to be a platform for broad based & intergraded extension operations, the States and the districts would need to think on this proposition seriously.

Technology Mapping over Socio Economic Dimensions of The Farming Community

Technology options for Agro-Climatic Zones and Sub-Zones needs to be systematically worked out and integrated into programme delivery mechanism, as per specificity of each micro agro- eco situation. Socio-economic dimensions and technology options if matched to the extent possible, would address extension operations effectively. This would bring in enhanced focus in extension processes as opposed to mere TOT approach.

Feedback Management

Feedback collation from the farmers, field functionaries is generally weak in the extension system. So also, its systematic documentation and analysis. It needs to be strengthened at all the level. The collation of feedback (both positive and otherwise) may begin with the farmers from various categories and from various macro and micro farming situations, followed up from the field functionaries (Fig-5).

Systematic documentation at KVK/ATMA level and analysis at SAMETI/ ATARI level would not only improve the relevance of the research, but also, it would make the extension operations flexible and far more relevant, demand driven and productive suiting to the various agro ecologies and categories of farmers. It may also facilitate giving appropriate signals to the senior management, research agencies and policy makers.

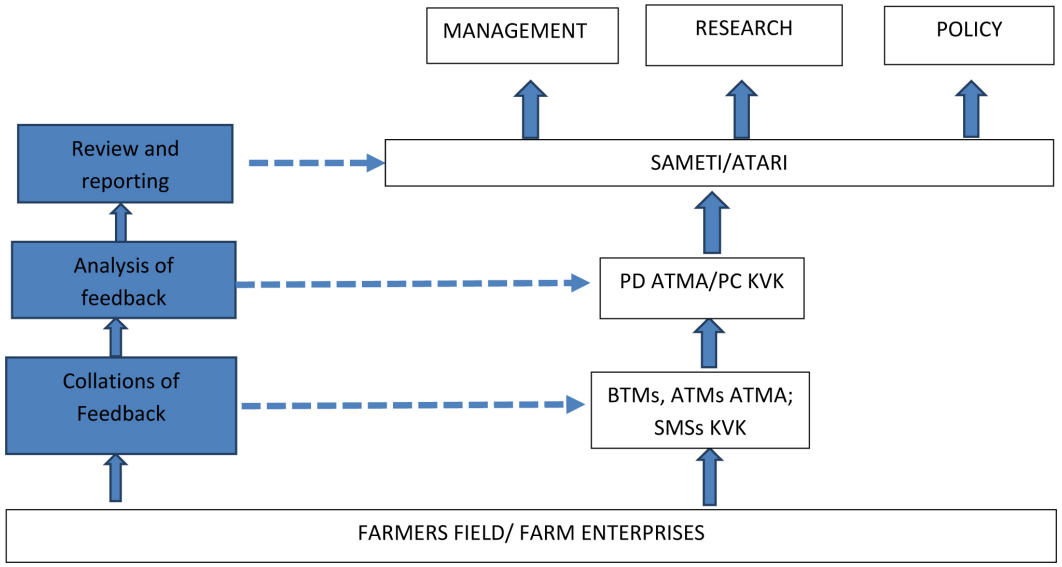


Fig-5: Feedback Management

Re-Visiting Training and Capacity Building Efforts
Re-Visiting Training Strategies
Training and Capacity Building is a Huge Task

We have various categories of Farmers (140m), Field Functionaries (Public 1.19 Lakhs + Private 1.00 Lakhs), Farmer Friends 3.3 Lakhs, 660922 villages, 7069 blocks, 722 districts. Training Programmes presently operate with low coverage, lacking serious Training Needs Analysis (TNA) exercises in vulnerable areas, inadequacies of infrastructure, experienced faculty and updated lesson plans.

Training Framework

We have a Training Framework at the National, State and District levels as: MANAGE, SAMETIs, ATARIs, EEIs, KVKs, FTCs, NGOs etc. Interplay of these institutions would need to be worked out systematically, sharing the output- input relationships and sharing the experiences. Capturing International experiences/success stories in the training strategies is another strong dimension. Farm Women training needs focus on access, empowerment, CB, & market linkages. Farm Youth training focus should be on promoting youth for commercial enterprises across the production systems.

Capacity Building of Field Functionaries

It is estimated that over 1.19 lakh field functionaries are operating for the field extension work in agriculture and allied departments in all the Sates. This would include about 7,069 Block Level Officers, about 722 District Agriculture Officers, about 21,207 ATMs (3 per block). Further, it is assumed that there

would be about 3.3 lakh Farmer Friends (one for two villages, total villages being 6,60,922) are engaged in the field extension services from the development side. This apart we have about 1 lakh private extension service providers in private sector in various sectors. Besides we have about 713 KVK PCs and 4,278 SMSs, 6 per KVK. The training and capacity building of such a huge manpower is a gigantic task which could be taken up by the SAUs and ICAR Institutes in a systematic way. This issue needs to be focussed adequately. The scientific institutions like SAUs and ICAR Institutes have a great scope for updating technical competence of the SMSs and middle level functionaries. The management input would need to come from the MANAGE & SAMETIs. Modalities may have to be worked out jointly by the ATARIs & SAMETIs under the guidance of Extension Division of ICAR and MANAGE. Similarly, the KVKs and FTCs of the State Departments of Agriculture could take on the training and capacity building task of the huge number of Farmer Friends, Farmers/ Farm Women and Farm Youth.

Training for Farm Woman

Farm Women play major roles in farming and their presence is increasing in all the farm operations (agriculture, horticulture, animal husbandry, dairy, poultry, fisheries, sericulture, etc.) due to a variety of socio-economic factors. Male migration to towns and cities is one of the main reasons. Farm women need to be empowered by various means like grouping them into SHGs, Farm Women Groups, Farm Women Organizations, etc. Further, the extension services are manned by male workers, barring a few States & the development services are not reaching the women farmers at the desired level. Serious attention needed to improve the access of farm women to the extension services, both public & private and across the sectors.

There is a need to orient these services in favour of women farmers training & capacity building and customized training & capacity building modules need to be operated as per the needs of the farm women at a micro level. Therefore, there is need for intensive capacity building and empowerment efforts for women and women groups at every level that should include re-orienting farm services, improving their access to credit, technology, inputs, markets and gender friendly mechanization. It may call for feminization of farm extension services enabling effective women extension workers for better participation and extension delivery. Farm women including women from weaker sections need to be given adequate representation in various programme management forums at all the levels. The ongoing programmes and schemes should ensure greater gender coverage through improved participation, financial allocation and well defined extension strategies.

Training of Farm Youth

Farm Youth is no longer interested in primary agricultural operations. Rather, he/she is looking for opportunities in commercial agriculture, high tech horticulture, commercial dairy and fisheries etc. Farm Youth are found to be taking up lots of interest in farmer empowerment models like Farmer Organizations, Producer Companies, mechanized operations, processing and value added activities, etc. Such operations would give him/her a better comparative social scale in comparison with his/her urban counterparts and peers. Training for farm youths and subsequent follow up should be oriented accordingly. ICAR initiative like ARYA, entrepreneurship windows opened up under RKVY, ACABCs, Skill Mission, Dairy entrepreneurships, etc. are a few such examples, these are needed to be systematically popularized and expanded.

Training Co-ordination- Segregated Responsibility, the Directorates of Extension of SAUs to Lead the Process

Farmers training responsibility down the line in agricultural and allied sectors is shared by the large number of agencies and organizations. For example, at the district level the farmers are trained by the agencies like KVKs, ATMAs, SAU Outposts, FTCs, Input Support Agencies, NGOs, etc. Can we think of focussed and segregated training responsibility? Could Director Extension, SAUs, ATARIs, EEIs & SAMETIs take a call in respective State and address this challenge? MANAGE & Extension Division of ICAR may take an overview and guide the process. It would streamline the whole training function and deliver it better.

The Directorates of Extension of SAUs would need to play an important role in coordinating the training function in a State in collaboration with the SAMETIs. Even their role in outreach programmes is observed to be centred around the KVKs. The role of these Directorates in training management, information support, field/outreach programmes that were visible in mid-eighties would need to be revisited/reworked in the changing agricultural extension demands. They may have to focus on PPPs, promoting entrepreneurships, start-ups, incubations, R& D linkages, extension in allied areas, studies and action research, media management including social media, etc. Accordingly, the manpower and investments in their operations would need to be enhanced.

Extension Planning/ Prioritization and Convergence

Extension Planning & Prioritization

Extension issues must reflect in Block Extension Plans (BEPs), at the cutting edge levels, defining role space of various ESPs. There are series of district

level planning instruments available as follows: (i) Comprehensive District Agricultural Plans (C-DAPs) under RKVY, (ii) Strategic Research and Extension Plans (SREPs) under ATMA, (iii) District Profiles (DPs) prepared under KVK Programme, (iv) Detailed Project Reports (DPRs) developed under Watershed Projects, (v) Potential Linked Credit Plans (PLPs) developed by NABARD for the districts and (vii) District Irrigation Plans (DIPs) developed under PMKSY. The District/Block extension functionaries may scan these instruments for capturing the extension priorities & integrating the same in the convergence & programme delivery strategies.

Convergence and Operational Flexibilities

Agricultural Technology Management Agency (ATMA): Convergence Platform

Programmatic Convergence down the line is essential for wider coverage and to benefit from each other's strengths. Policies & instructions are necessary to drive it. Convergence appears to be most effective at the Block/Cluster level. Matrix mode/MOU based approach is recommended to make it happen at the field level.

There is need to revisit the contents and methodology for development of Block Action Plan (BAP) which shall invariably indicate role space for both public and private sector extension service providers, including technical inputs from KVKs and financial support from all sources. Accordingly, the Block level, Cluster level and Village level extension operations will need to be streamlined to meet emerging challenges in farming system within the respective blocks.

ATMA shall promote both Public and Private Extension Service Providers (ESPs) to facilitate coverage of extension operations in entire district, in view of manpower and resource constraints. These Extension Service Providers may include Agri-preneurs, Agri-Start-ups, Farmers Knowledge Groups, Farmer Producers Companies, Agri-business Companies, Farmer Organisations, Media Channels, Exporters, CSR Foundations, NGOs, Achiever Farmers and SHGs. A systematic data base, Competency Development Plan and their location specific involvement may be worked out as per demands of BAP. Perhaps, similar recommendation is applicable for KVK also. ATMA has to maintain directory of Private Extension Service Providers including Agri-preneurs in the district.

Convergence Matrix (CM) may be prepared which will list out scheme and component wise allocations and activities. Every proposal for funding under existing schemes or new schemes shall be accompanied by a Convergence Matrix relating to that Department with a detailed explanation about to what extent convergence has been achieved. Every authority scrutinizing and

approving the programme must do convergence scrutiny to satisfy himself/ herself that convergence has been brought about. Departments and institutions in the convergence matrix shall co-opt the departments and the related institutions in decision making.

The following need to be attended for convergence as per DFI Committee Report-2018: (i) Monitoring of convergence arrangements between ATMA, KVK and Line Departments may be accorded highest priority. The process may be reviewed in every SAC of KVK and ATMA GB meeting, (ii) Implementation of Convergence Guidelines (17.06.2015) jointly issued by DAC&FW and DARE/ ICAR may be taken up with ATMA Officials and KVK Scientists at State / District level with SAMETI/MANAGE facilitation; and (iii) This may pave way for inclusion of convergence module in the regular training programme of MANAGE, SAUs, ATARIs, EEIs and SAMETIs etc.

Convergence with Other GOI Programmes

Agriculture development programmes and related programmes of other departments like rural development; Panchayati Raj, Social Development, etc. generally operate in vertical silos, with very little or no horizontal convergence, especially at the block level and below. Hence, field level convergence is one of the major challenges existing today across the departments and levels. The major task, therefore, would be to reorient the district and the block functionaries for the task and provide them operational flexibilities and opportunities for experience sharing across the departmental boundaries so as to obtain required coherence.

Likewise, the programme delivery is crucial in disadvantaged areas, far flung areas, tribal areas, hill and mountainous areas, desert areas, etc. Hence, Extension Strategies need to be re-oriented and strengthened accordingly on convergence mode. Flexibilities are required to be promoted to the field formations to respond to the emerging local extension challenges. Thus, making extension operations accountable to the local situations/ farming communities. Operational flexibilities may facilitate entering local MOU based PPPs which are essential to make the extension interventions work locally.

Fig 6: Action Research on Convergence based Extension under NASF

Block Extension Plans (BEPs) as an Instrument of Convergence

Convergence requires proper role space and resources amongst stakeholders for mutually agreed action plan, drawn from SREP. Matrix mode approach is required to be operated which would indicate the ongoing programmes and activities of the stakeholders and the gaps. The resources would need to be pooled accordingly and the roles and responsibilities defined in Block Extension Plan (BEP). The private and public extension service providers would need to agree for the area and location specific roles as per competence and presence of their system. The decentralised extension system with farm schools, farmer friends and PPPs needs to be exposed to the contemporary technological developments and timely and accurate advisory services.

Besides ATMA led field extension services at the district, block and cluster levels, it would require careful harmonization of work plans of the *Rashtriya Krishi Vikas Yojana* (RKVY), national missions, and other related State schemes and their resource allocation and schematic support to succeed convergence of activities. This will not only increase the operational resources for effectively targeting the ATMA activities but also will help national schemes to meet their objectives and make ATMA sustainable in the long-run (Babu et al, 2013)

Media Management/Information Support in Agricultural Extension

Information support to Technology Dissemination in agriculture and allied sectors broadly falls in three categories namely print media, the electronic media

and the other media like social media. Each having large scope to influence farmers and farm women by depicting success stories, entrepreneurial experiences, etc.

Information Sourced by the Farmers

Smallholder farmers were found to rely mainly on local sources of information, such as progressive farmers (16 per cent) and input dealers (12.6 per cent), along with the radio (12.4 per cent). In case of medium-size and large farmers, the major sources of information in addition to those above were television (15.3 and 22.4 per cent), newspapers (10.3 and 15.9 per cent) and extension agents (9.8 and 12.4 per cent). To put it differently, only 4.8 per cent of smallholders viewed the extension worker as a primary source of information, as compared to 9.8 per cent of medium farmers and 12.4 per cent of large farmers (Adhiguru et al. 2009). Glendenning et al. (2010) concluded from a review of agricultural extension in India that despite the variety of agricultural extension approaches that operate in parallel and sometimes duplicate one another the majority of farmers in India need improved access to information.

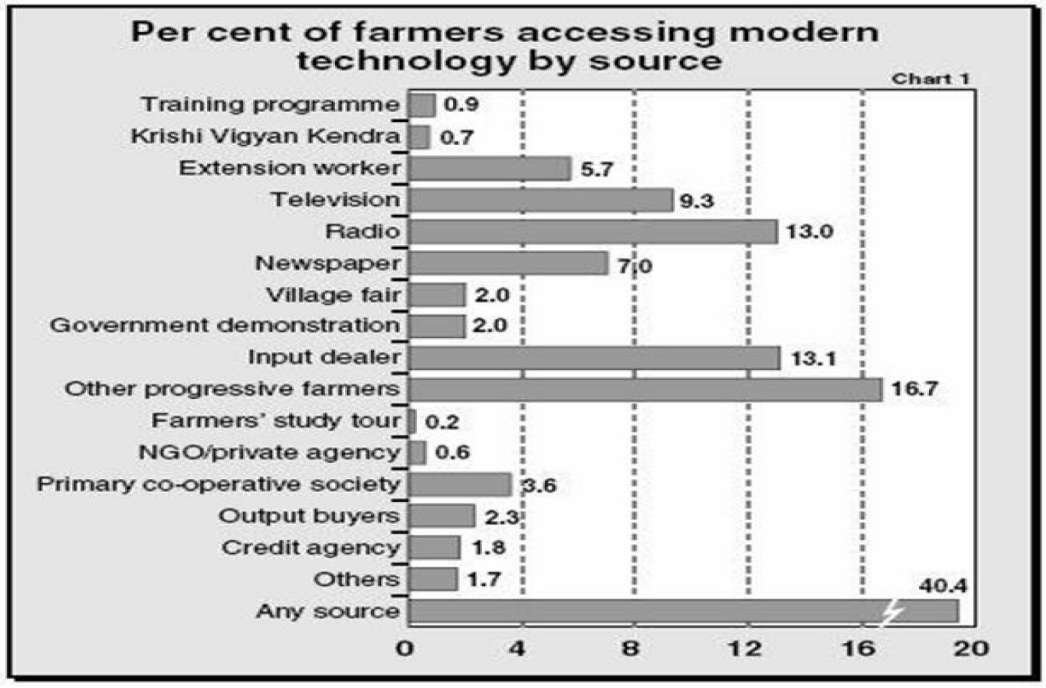


Fig 7. Information Sourced on Modern Technology by Farmers, 2003 NSSO Survey

Media Management for Promoting Extension

(i) Present media coverage to allied sector is <10-15%, (ii) Subject centric contents, programme treatment and delivery needs to be improved, and (iii) Intensive use of the following is suggested: Internet technology & internet platforms, Social media & Apps, Champion's approach and its publicity and Portal indicating services and linkages.

Krishi Darshan and DD Kisan

Krishi darshan programme is being telecast 5-6 days in a week through national (1), regional (18) and HPT/LPT transmitters (180). Recently launched DD Kisan channel provides 24-hour agriculture based information to the farming community covering research updates, extension advisories, market rates and weather updates

Community Radio Station (CRSs)

All India Radio through their Kisan Vani Programme broadcasts farm programmes 6 days in a week through 96 FM stations.

Community Radio Stations (CRS) provide updated agriculture information which is location specific to a group of villages. CRS can reach local population instantly through time and cost effective means. ATMA made provisions for establishment of CRS in all the districts by providing funds for infrastructure and content development for two years. However, response is discouraging. Only few CRS stations have been established. Some of the important obstacles are delay in obtaining the license, restrictions on advertisement time and challenge in creating attractive content. CRS should be the mouth piece of all the public and private developmental departments working in the coverage area. This approach provides opportunity for disseminating varieties of information from different departments. Thus, financial viability of CRS will be enhanced. All SAUs, ICAR Institutes may consider having CRS for location specific broadcasts for dissemination of farm information.

Field Days, Campaigns, Use of vernacular press and traditional folks may also be used strategically.

Kisan Call Centres

A country-wide common eleven-digit Toll free number 1800-180-1551 has been allotted for Kisan Call Centre. This number is accessible through all mobile and land line telephone networks including private service providers. Replies to the farmers' queries are given in 22 local languages and the calls are attended from 6 AM-10 PM on all the seven days of the week at each KCC.

The experience of rural tele-centers in the developing world shows that

ICT can help in enabling rural development workers to gather, store, retrieve, adapt, localise and disseminate a broad range of information needed by rural families (Davison et al 2005). The ICTs in extension can lead to the emergence of knowledge workers that will result in the realisation of a bottom-up, demand-driven paradigm for technology generation, assessment, refinement and transfer (Meera et al 2004). It is estimated that there are 251 million internet users are in rural India which is expected to reach by 290 million by 2019 (The Economics Times, 6th March, 2019). There are a number of initiatives in operation using mobiles to communicate information directly to farmers

Social Media

Social media is a powerful communication tool that widens lines of communication, enhances user network, engages a large number of people quickly and has a great potential to reach out farmer's/farm women and stakeholders.

e-Platforms

Emails, WhatsApp Groups, Facebook, Blogs, Instagram, Twitter handles, Commercial apps etc. are also gaining importance in farming.

A study on WhatsApp enabled social media by (Chander, 2016) indicates that by the use of WhatsApp farmers are able to seek information on farm operations, clarify their doubts on plants/livestock disease symptoms and are having immediate access to market related information. In the Indian State of Karnataka, the Department of Agriculture has made it mandatory for its development officials to have a smartphone so that they could share information, messages, and circulars through WhatsApp. WhatsApp can be used to offer context-specific information by linking farmers on one side and resource persons of different disciplines on the other interlinked through a common mediator. The role of the mediator would be to receive the queries from the farmers on one side and sending them individually to different experts. After receiving the queries from different experts, the mediator can share the pooled advice in an easily understandable form to the farmer clienteles (Thakur, 2016).

Farm portals are also available for dissemination of information, e-commerce and distance learning are also promoted. Information given includes crop production and protection technologies, inputs, prices, e-commerce, extension needs, etc. Portals vary widely in their contents, updates, user friendliness and use of visuals.

ICTs in Extension Cycle

ICTs and Media combos should be promoted as per need of the extension cycle (Awareness/Interest /Evaluation/Trial/Innovators/Early Adopters/Early

Majority/Late Majority & Laggards). ICTs are also being used to strengthen the capacity of extension officers and NGO field staff to reach farmers with timely and accurate information and, at the same time, help capture data from the field (Chander, 2016). ICT has the ability to reach farmers directly, can enable two-way information sharing processes, has greater storage capacity, is faster, and can increase market efficiency by addressing information gaps and blockages (Chapman and Slaymaker 2002). The e-Choupal initiative has had positive effect on the incomes of participating farmers, as the system has brought efficiency to the supply chain by removing intermediaries and reducing transaction costs (Bowonder, Gupta, and Singh 2007). ICT has lots of scope in future extension strategies, especially at the awareness & interest stages of adoption process. However, content development, validity and delivery in respect of print and electronic media is crucial. ICT is becoming very popular day by day, however, the pertinent question is how to increase its access and reach to the large number of farmers. Mobile applications, internet access, development of apps and their intensive use in extension need to be expanded.

Common Service Centres (CSCs)

There are 1.57 lakhs Common Service Centres located at village level providing citizen services to villagers. These are operated by village level entrepreneurs. The CSCs possess minimum IT infrastructure to provide IT enabled services to people on payment basis. CSC is great national resource available at village level, managed by entrepreneur which could be used for providing agricultural extension services by value addition to the concept. For this transformation, CSC entrepreneur has to be trained in basic agriculture and should be made aware about information sources in agricultural extension. With this empowerment, CSC can serve agriculturalextension related services.

Farmer/Farm Women Knowledge Groups (FKGs/FWKGs)

There is need to organize Farmer Knowledge Groups (FKGs) and Farm Women Knowledge Group (FWKGs) in the villages facilitating/improving arrangements for knowledge interpretation and knowledge sharing.

Addressing Extension Process Equilibrium & Future Research in Extension

Sequential Extension Process Equilibrium

Future Extension strategies must address extension needs of areas having high yield potentials but performing at lower levels. Extension strategies must follow sequential extension process equilibrium as: Technology Validation (TV), working out technology Options (TOs), Technology Dissemination, Participatory Processes & obtaining feedback for further improvement. There is need to organize large number of FFSs/FOs & FPCs in potential areas. Extension

functionaries must identify potential areas for export opportunities (for progressive farmers) and involve processing and export industries in such assessments. Promotion of forward linkages through appropriate extension interventions and enhancing outreach to small and marginal farmers would be essential. Hence, focus on social dynamics would be required.

Future Extension Strategies should Focus on Crucial Technologies & Concerns

Field extension functionaries from agriculture and line departments would need to be adequately oriented in promotion of crucial technologies like Climate Change, especially adaptation strategies in the context of increasing vulnerabilities. The approach would benefit the farmers in judicious and timely input use enhancing farm incomes.

Future Extension Strategies Must Draw Strengths

The future extension strategies must draw strengths from international extension models and private sector experiences: learning from Companies, Corporate Sectors, Multi-nationals, Non-government Agencies, Entrepreneurs, Farmer Professionals and Para Professionals & Outreach Programmes of Research Organizations. This would enable extension contents and delivery move on improved & dynamic mode as per need of the local situation.

Refocus Research in Extension

Research in Extension is a crucial area but not attended to adequately to look into the efficacy of different Extension approaches being followed in various states. Strong extension research input is required to strengthen the basic knowledge in extension discipline (NAAS, 2015). MANAGE, SAMETIs, ATARIs and Directorates of Extension of the SAUs would need to have a strong extension research window. They may deliberate & define broader Extension research areas annually as applicable (e.g.: case studies, comparative analysis of extension approaches, media combination for effective extension, training strategies, role combinations of extension service providers, extension priority setting, etc.). The specificities should be left with the local institutions

Revisiting Agricultural Extension Syllabus

Dynamic Demands on Extension Syllabus

Competent extension professionals are the assets of agricultural extension services. Diverse and dynamic agricultural systems, advancing science and technologies, changing socio demographics, increasing globalization and growing competition for resources, demand that agricultural extension professionals be proficient in the technical aspects of their areas of expertise as well as in the processes and delivery of the services. In other words, the need and demand

for extension professionals to demonstrate a higher level of professionalism in their services are growing.

Crucial Recommendations on Revision of Extension Syllabus

Revisiting the existing syllabus of Agricultural Extension Education with the following recommendations is suggested (Sadamate & Padaria, 2018), (i) Orienting the course syllabus to the emerging challenges in agriculture and Agricultural Extension, (ii) Fundamentals of Extension should be continuously enriched with lessons/experiences of contemporary Extension Reforms, (iii) Customization of management principles with suitable cases of extension organizations and approaches, (iv) Ensuring relevance of course content to present and future scenarios in agricultural extension, (v) Extension Education for entrepreneurship, (vi) Enabling ICT mediated extension system, and (vii) Elaborate user consultations involving experts from diverse user groups like academicians, practitioners, industries, business organizations, farmers and change agencies to provide input to ICAR/Deans Committee.

Emphasis upon Skill Building through Suitable Courses and Practicum

(i) Social Skills: • Situation and gap analysis: rural and urban systems, gender and farm youth • Communication skills • Rapport building with multi stakeholders, **(ii) Management Skills:** • Need assessment, • Programme planning, execution, evaluation • Mobilization and group dynamics • Team building • Decision making • Conflict management • Empowerment of farmers and disadvantaged groups • Business management skills and (iii) Technical skills: • Extension methods and interventions • Livelihood analysis and promotion • Entrepreneurship development • ICTs • Data collection, analysis, report writing • Participatory methods • Stakeholder analysis and their interplay • Market assessment and Value chain development • Contemporary issues: gender, climate change, sustainability issues • Risk analysis

In addition to above, specialized skills in following areas should be developed among PG students: **(i) Agro ecosystem analysis** • Project formulation-feasibility, revenue models • Programme planning • Programme execution • Programme evaluation• Impact assessment and **(ii) Social research methodology** • Market led extension • Media, communication, ICTs content development, instructional technologies • Information technology • Policy analysis

Agricultural Extension Services in the Context of SDGS

Two Conferences held recently could be cited in this context: (i) April 22-24, 2017 at Hyderabad, India and (ii) May, 10-12th, 2018 at Kandy, Sri Lanka. Major Stakeholders like National/International Extension Experts, NGOs, Private

Extension Service Providers, Scientists from SAUs and Field Extension Systems, Extension Entrepreneurs, Innovative Farmers/ Farm Women, Extension Academia and Research Scholars participated. The proceedings were guided by Dr. Daniel Gustafson, DDG FAO & Dr.A.K.Singh, DDGE ICAR.

It was revealed that Extension Services were found to be directly influence the following SDGs (Gustafson, 2017) : Poverty Alleviation (SDG-1), Food & Nutritional Security(SDG-2), Education and Learning (SDG-4), Gender Equality & Empowerment of Women (SDG-5), Water and Sanitation Management (SDG-6), Climate Change (SDG-13), Eco-system Sustainability (SDG-15) and Peace & Well being (of Farming Community) (SDG-17)

Doubling Farmer Income (DFI) Committee Report – Observations on Extension

Honourable prime Minister of India Sri Narendra Modi envisioned 7-point strategy to double the farmers' income which laid emphasis upon securing per drop more crop through Pradhan Mantri Krishi Sichayee Yojana; soil health management by ensuring Soil Health Cards to all farmers; promotion of cold chains and value addition; ensuring effective market through National Agriculture Market and e-mandis; streamlining Crop Insurance through *Pradhan Mantri Fasal Beema Yojana*; promotion of ancillary activities like dairy, apiary, fisheries; promotion of organic farming; and strengthening of information system (DD Kisan).

The eminent agricultural scientsist Dr. M.S. Swaminathan observed that doubling income is feasible by bridging the large gap between potential and actual yield per hectare. He has suggested pragmatic strategy which includes enhancing small farm productivity and stability of production through soil health care, water harvesting and management, choice of appropriate technology and inputs, credit and insurance and finally opportunities for remunerative and assured marketing; focusing upon the knowledge, skill, credit and land ownership empowerment of women farmers; inclusion of high value crops, horticulture, animal husbandry, agro-forestry in the farming systems; promotion of commercial use of the whole biomass of the crop; and fixing the procurement price at cost C2 (All costs - cash and kind) incurred on production with rental value of owned land, rent for leased-in land cost and imputed value of family labour and interest on own assets) plus 50 per cent to enable small farmers enough surplus (Farmer Commission Report).

Observations of DFI Committee-2018 Chaired by Dr. Ashok Dalwai

Rationale: Production performance alone is not a sufficient condition for farmers' welfare. The difference between the farm gate prices and prices on the finished/processed products are very high and the farmers share in the

final price is very insignificant, Further, the farmers, specially the small and marginal ones are challenged by vulnerable climatic situations and inadequate risk cover. Size of land holding is getting smaller and smaller and the economic viability of small and marginal farms has not been able to sustain the total family size for productive gain. Farm income of small and marginal farms as compared to the town and urban areas is falling far behind this is resulting into disengagement of farm youths in agriculture and allied areas. Farm youth appears not interested in primary farming but seems to be interested in secondary agriculture. Resultantly, there is a serious, mismatch between production and income realization- hence there is need to make serious efforts to enhance the income of the farmers

Growth Drivers Identified by DFI Committee

(i) Increasing production and productivity across the production systems, (ii) Effective Input Use Efficiency & Programme Delivery, (iii) Reduction of Post-Harvest Losses, (iv) Crop Diversification & Value Addition, (v) Reforms in Agricultural Marketing, (vi) Risk Management and (vii) Focus on Allied Sectors & Non-farm Income

DFI Committee's Relevant Extension Recommendations

Redefined Agricultural Extension: The System of empowering farmers for sharing knowledge, technology, skills and farm management practices, across agricultural production systems and sub sectors, all along the value chain, enabling the farmers to realize the higher net income from their enterprises, on sustainable basis: (i) Providing synergetic role space to Private Extension Services, (ii) Rejuvenating the ATMA, (iii) Strengthening KVKs for effective backstopping ATMAs, (iv) Streamlining Agricultural Extension System, especially interplay between the systems, (v) Strengthening Downstream Institutional Linkages, (vi) Addressing Human Resources Issues in Agricultural Extension, (vii) Enabling ICT driven Extension Services, (viii) Focus on Gender Concerns, (ix) Revisiting Agricultural Extension Curriculum in Agriculture Universities, and making a good mix of Academic & practical, entrepreneurs, start-ups, commercial propositions.

Conclusion

The technology dissemination services, both public and private, across the production sectors, have played crucial role in achieving impressive performance of agriculture and allied sectors. Despite record achievements the agriculture sector as a whole faces formidable challenges. These include: sliding down GDP contribution of farm sector, shrinking land holdings, adverse impact of climate

change, regional imbalances, emergence of farm distress though sporadic, stagnant productivity in some crops/areas, increased production costs, dwindling natural resources, market uncertainties and efficacy of delivery systems.

Agricultural Extension services have travelled through series of programmes like: Grow More Food campaign, National Extension Service, IADP, IAAP, NDS, FTCs, SFDA, KVKs, T&V System, NAEP, ATMAs, KCC, enhanced network of Training Institutions, etc. Parallel, the private sector extension service providers also widened their base over a period and included: NGOs, Input Support Providers, Entrepreneurs, Agribusinesses, Cooperatives, ICT based services, Mass/Social Media interventions, etc. leading to pluralism in extension operations.

Significant learning and lessons emerged focused on much needed extension reforms like: (i) Farmer empowerment through various modes, (ii) Enhancing outreach of extension models in operations, huge task, bringing in agri business and marketing opportunities, (iii) Focus on extension coverage in allied sectors, (iv) Integrating private sector efforts, (v) Strengthening R&D linkages at different levels, (vi) Revisiting training strategies, (vii) Extension planning and prioritizations, (viii) Convergence of extension efforts through block extension plans, (ix) Media management and (x) Revisiting agricultural extension syllabus.

Role of Extension Services has been found to be crucial in addressing the SDGs (Gustafson, 2017) and in Doubling Farmer Income Strategies (Dalwai, 2018)

The Extension Delivery is a very complex system dealing with farm technologies on one hand and the social issues on the other. The basic sciences have laboratory back up to generate the body of knowledge. However, in extension services we have farmer's socio economic background and his/her fields as live laboratories. Thus, social dynamics plays an important role in determining the performance of the extension services.

In a given situation, you may have technologies, may have schemes and programmes and investments too. However, in the absence of streamlined and reformed extension services the programme delivery to the targeted clientele may not go efficiently, the development efforts would still be inadequate to produce desired impacts.

Hence, sincere arguments for (i) strong extension reforms both in public and private systems, (ii) on the lines proposed, for (iii) efficient technology dissemination resulting in (iv) higher adoption, integrating marketing /agri business opportunities and enhancing farmer incomes.

References

1. Adhiguru, P., Birthal, P. S., and Kumar, Ganesh P. (2009), "Strengthening Pluralistic Agricultural Information Delivery Systems in India," Agricultural Economics Research Review, vol. 22, no. 1, pp. 71–9.
2. AESA (2019), Extension and Advisory Services in Scaling up Climate Smart Agriculture in South Asia, Policy Brief.
3. Babu, S. C., Joshi, P. K., Glendenning, C. J., Kwadwo, A. O., & Rasheed, S. V. (2013). The state of agricultural extension reforms in India: strategic priorities and policy options. Agricultural Economics Research Review, 26(347-2016-17086), 159-172.
4. Bowonder, B., Vinay, G., & Amit, S. (2007). Developing a Rural Market e-hub, The case study of eChoupal experience of ITC, Socio-Economic Report Planning Commission Study-ICT4. Retrievedfrom http://planning commission. nic. in/reports/sereport/ser/stdy ict/4 e-choupal, 20.
5. Chander, M. 2016. WhatsApp in Agriculture? Blog/ Global Forum on Agriculture (GFAR) https://blog.gfar.net/2016/07/14/whatsapp-in-agriculture/
6. Chapman, R., & Slaymaker, T. (2002). ICTs and Rural Development: Review of the Literature, Current. London: Overseas Development Institute.
7. DAC&FW (2018-19), Ministry of Agriculture and Farmers Welfare, Annual ReportDAHD&F (2018-19), Ministry of Animal husbandry and Fisheries Annual Report.
8. DARE/ICAR, 2018-19, Annual Report.
9. Davison, R.M., R.W. Harris, S. Qureshi, D.R. Vogel, and G.H. de Vreede, (Eds.). 2005. Information Systems in Developing Countries: Theory and Practice, City University of Hong Kong Press, 289pp.
10. Directorate of Economics and Statistics (2017-2018), Ministry of Agriculture and Farmers Welfare, Agricultural Statistics at a Glance
11. Directorate of Economics and Statistics (2018), Ministry of Agriculture and Farmers Welfare, Horticultural Statistics at a Glance
12. Directorate of Economics and Statistics (2018-19), Ministry of Agriculture and Farmers Welfare, Third Advance Estimates of Production of Food Grains.
13. Doubling Farmers Income Committee (2018), Ministry of Agriculture and Farmers Welfare, Report.

14. Glendenning, J. C., Babu, Suresh, and Asenso-Okyere, K. (2010), "Review of Agricultural Extension in India: Are Farmers Information Needs Being Met?" Discussion Paper 01048, International Food Policy Research Institute (IFPRI), Washington D.C
15. Gustafson, D (2017), Agricultural extension services in the context of SDGs, Advances in agricultural extensions, PRDIS, Hydrabad.
16. IFPRI (2018), Global Hunger Index Report.
17. Kumar, R., Singh, B. P., & Kaswan, S. (2012). Production driven to market driven extension approach. Indian Research Journal of Extension Education, Special Issue, 2.
18. Meera, Shaik N., A. Jhamtani, and D.U.M. Rao. 2004. Information and communication technology in agricultural development: a comparative analysis of three projects from India. AgREN Network Paper No.135, ODI, January 2004.20p.
19. Ministry of Statistics and Programme Implementation (2018-19), Annual Report
20. Murray, E.V. (2008) 'Producer Company Model-Current Status and Future Outlook: Opportunities for Bank Finance', Financing Agriculture, pp18.
21. NABARD (2019-20) Farmer Producers' Organizations (FPOs): Status, Issues & Suggested Policy Reforms.
22. Sadamate, V.V. and RN, Padaria, (2018).Policy reforms in Agricultural Extension Education: Indian Perspective. Proceedings of IAUA Golden Jubilee International Conference on Agricultural Education- Sharing Global Experiences organized during November 23-25, 2018 in New Delhi .
23. Priyadarshni et al (2019), Enhancement of diffusion and adoption of local knowledge through social learning: A case study of white fly management in cotton in Haryana, Indian Journal of Traditional Knowledge vol 18(1), pp 169-177.
24. Sadamate, V.V.(2003), PPPs in Agricultural Extension Management, Fulbright Post Doc Research Study, MSU, USA.
25. Strengthening research in extension, Brainstorming session, NAAS, 2015
26. Sulaiman, R., & van den Ban, A. W. (2003). Funding and delivering agricultural extension in India. Journal of International Agricultural and Extension Education, 10(1), 21-30.
27. Sulaiman, V., & Sadmate, V. V. (2000). Privatising agricultural extension in India, NCAP, Policy Paper.

28. Thakur D. 2016. An Expert-backed WhatsApp group that works for Farmers, Global Forum on Agriculture (GFAR) bloghttps://blog.gfar.net/2016/09/12/an-expert-backedwhatsapp-group-that-works-for-farmers/
29. The Economics Times, 6th March, 2019

•

Applications of Biotechnology in Enhancing Crop Productivity and Farmers' Income

• Dr. M. A. Shankar •

Biotechnology and Crop Genetic Modification

Biotechnology is an application of biological organisms, systems, or processes to learn about the science of life and the improvement of value of materials and organisms such as pharmaceuticals, crops, and livestock [ACS 2012]. Biotechnology is a broad area and the quantum of research and developments happened in the last two decade is highly remarkable especially in food value addition, healthcare and agriculture sector.

Though there is s significant increase in percapita agricultural production, there is still a challenge for the food production due to limited natural resources (such as water and land), climate change and population growth. In this context, the agricultural biotechnology, if properly integrated into the current agricultural practices, can increase the crop productivity.

The modern biotechnology includes Genetic engineering, Genome editing, RNA interference technology, etc. besides the conventional approaches. The global research in biotechnology assisted crop improvement programs have lead to development of many new crop varieties, most of them are genetically engineered which involves engineering plant's genome through molecular biology tools.

Genetically-modified crops are otherwise known as GM crops. In agriculture, GM crops are developed by modifying the crops genetic material by molecular biology tools. The genetic modifications are done in order to create crop varieties with desirable traits, such as tolerance against herbicides, tolerance/ resistance against specific pests, improved nutritional content, etc.

High Adoption of Biotech Crops

Ever since the commercialization of biotech crops for over 23 years, as on 2018, 26 countries grow 191.7 m ha of biotech crops. There is an increase of 1.9 m ha in 2018 compared to 2017 with 189.8 m ha. USA has the highest area (75 m ha) of biotech crop plants followed by Brazil (51.3 m ha), Argentina (23.9 m ha), Canada (12.7 m ha), and India (11.6 m ha Bt. Cotton). Due to immediate approval and commercialization potential of of new biotech crops that target problems related to climate change and the emergence of new pests and diseases, in certain countries viz. USA, Canada, Argentina and Brazil, the percentage adoption of biotech crop is more than 90%.

Diversity of Biotech Crops

The spectrum of biotech crops are widening beyond the major crops such as maize, soybeans, cotton, and canola. This is expected to give more choice to the consumers to select the suitable crop of their economic important and suitable for the Geo-climatic zone. The new biotech crops include alfalfa, sugar beets, papaya, squash, eggplant, potatoes, and apples that are already available in the foreign market.

Biotechnology and Insect Resistant Crop

One of the important applications of biotechnology in developing insect resistant crop is by introducing a gene from *Bacillus thuringiensis* (Bt) that produces a protein toxic to certain insects (of *Lepidoptera*, *Coleoptera* and *Diptera* families). Besides Bt, there are many protein with insecticidal property and their gene have been reported to have potential use in developing insect resistant crops. If right strategy is followed, such insecticidal genes are more safe than the application of insecticides. Introduction of insect resistant crop can cease spending on insecticides and minimizes risk related to health and environment [Krattiger 1997].

Bt Cotton in India

The Genetically Modified Bt Cotton was first commercialized in the US, Argentina, China, Mexico, Canada and Australia in 1996. In India, the Bt Cotton variant BG-I was released for cultivation in 2002. Four years after the release of BG-1, BG-II variety was released. The Bt cotton got wider acceptability as it resists age-old pink bollworm pest issues. The present statistics shows that, more that 95% of India's cotton crop is from the Bt cotton seeds. Bt Cotton has considerably reduced huge amount of pesticides and labour. However, boll-worm getting resistance to Bt cotton in India (Keshav R., 2005) needs to be read in bracket with the fact that, 21 years after the introduction of GM crops in the world, only six countries contribute for more than 90% all GM crop, the US, 40%; Brazil, 23%; Argentina, 14%; India, 6%; Canada, 6%; and China, 2%; and most of the developed countries do not grow it. This fact demands more investments in public sector to study the long term effects of GM Crops. But needless to say that, we need to sustain the research and development in GM crops to face any future catastrophic crop failure.

Biotechnology and Nutritional Security

Asia alone is noted for vitamin A deficiency on over 180 million children and women. Being rice is the staple food of the people of these areas, an improvement in rice was made by introducing several genes. Golden Rice is considered to solve Asia's Vitamin A deficiency problem in an efficient and less expensive manner. Further, Golden Rice has the potential to be integrated into the farming system of Asia [Kryder 2000].

Biotechnology and Biofuel

Biotechnology has a very important role to play in biofuel sector that include technological and operational advances in the production of biofuel and other byproducts. The key focus of biotechnology here is to improve plants and biological conversion systems for production of bio-fuels from biomass or other intermediates from biomass. The Indian biofuel sector is expected to reach INR 50,000 crore by 2022. Diesel fuel blended with 5% biodiesel demands more than 600 crore liters and in case of petrol blending with 10% ethanol demands 450 crore liter bioethanol by the year 2020 [The Hindu Business Line, 2016].

Biotechnology Based Crop Improvement: An Appeal to Increase Farmers Income

In the crop improvement program, biotechnology plays a very important role. Biotechnology has all potential to develop more nutrition crops, biotic and abiotic stress tolerant crops. Such crops can save natural resources, minimize impact on the environment (in terms of pesticide application), and helps protect human health. There are sufficient evidences to prove that the biotech crops can be considered for better income for the poor and insecure farmers. Therefore, the better economic conditions, social health, etc. obtained through the sustainable use of biotech crops need to be highlighted. This knowledge might help the farmers and consumers about the informed choice of the crop for better economic return. The policy makers and regulators need to draft more realistic and liberalized bio-safety guidelines for commercialization and adoption of biotech crops.

References

ACS (2012), Biotechnology Archived.

Krattiger, A., 1997. Insect Resistance in Crops: A Case Study of Bacillus thuringiensis (Bt) and its Transfer to Developing Countries. ISAAA, Ithaca, NY.

Kryder, R. David, Stanley P. Kowalski, and Anatole F. Krattiger. 2000. The Intellectual and Technical Property Components of pro-Vitamin A Rice (Golden Rice TM): A Preliminary Freedom-To-Operate Review. ISAAA Briefs No. 20. ISAAA: Ithaca, NY. 56 p.

https://www.thehindubusinessline.com/economy/by-2022-biofuel-willbecome-a-50000crore-business/article8968034.ecehttps://www.indoasiancommodi ties.com, Posted on October 5, 2016 by admin in Food, Special Feature

Keshav R. Kranthi, Nature Biotechnologyvolume 23, pages1476–1477 (2005)

•

Sustainable Development in Agriculture through Machine Learning

• Dr. Asheesh Shah •

Farming has long been a more technologically-savvy industry than people give it credit for. On many of today's farms, you're likely to find robots grafting plants and drones monitoring vineyards.

Technologies like these are a growing necessity in the agricultural industry, helping farmers of all sizes optimize their operations and increase profitability — even amidst challenges like climate change, over-cultivation, and pollution. But agricultural sustainability doesn't just benefit farmers themselves — it also extends to consumers. Already, the ability to maximize farmers' yields is becoming more important as the demand for food grows. That demand could double worldwide when the global population reaches an expected 10 billion in 2050.

Luckily, as the necessity of agricultural sustainability grows, so does the technology feeding this demand. One critical technology empowering long-term sustainability is machine learning. By rapidly processing the mountains of data produced by IoT sensors, computer vision, and more, machine learning can surface insights for farmers about making impactful changes to everything from planting to harvesting. As machine learning permeates the agricultural industry, it will be a vital tool for ensuring farmers have the answers they need to increase yields — and preserve the food supply of the future.

Machine Learning in Agriculture

Is there a problem area in my field I'm not aware of? Am I using the right amount of fertilizers? These are the kinds of questions farmers are asking on a regular basis. Better monitoring of soil and field conditions is key to answering them — and improving sustainability and crop yields by extension. Precision farming company OneSoil is using data and machine learning to make sure farmers are empowered to do both through the companies platform, available on a web browser or via mobile app. To start using the platform, farmers simply find and select their field from some one million tracked on the OneSoil application all over the world.

Case Study 1: OneSoil

OneSoil has leveraged machine learning at every stage of its growth. In partnership with Amazon Web Services, the company built machine learning

algorithms that can process vast amounts of publicly-available satellite data and then delineate the boundaries of each field and crops that grow there (available for use via the OneSoil application and on the OneSoil Map). The satellite data was made available via the Amazon Public Datasets program that seeks to democratize access to data for high-value, cloud-optimized datasets. OneSoil is currently building out additional algorithms to generate more precise recommendations. The algorithms will eventually offer more detailed insights for farmers, including the level of soil moisture, seeding and harvesting dates, and the phenostages of crops. OneSoil's ultimate goal is to be able to predict yield.

"We want to know what is growing in these fields right now," says OneSoil Data Scientist Christina Butsko. "And we want to know what has been growing on this field in the previous years. We want to know how the borders of the fields changed. We want to know what problems are occurring in the field in terms of nutrient deficiency, and so on."

Important Point

Even as the company is building out these machine learning capabilities, OneSoil is already having a meaningful impact on sustainability in farming. Butsko the scientist of the company says some farmers who use the platform see a 20% improvement in their resource optimization. What's more, helping farmers feel confident about fertilizer and pesticide amounts prevents overuse, reducing their environmental impact. As the company grows, it hopes to continue improving yields and overall sustainability.

Case Study 2: Aquabyte

Aquabyte, is a company using machine learning and computer vision to improve the sustainability of fish farming. "That makes it inherently hard to understand how fish grow and behave."

Data is continuously uploaded to AWS cloud servers for use in refining the company's modeling systems. Farmers can also access a dashboard via AWS to monitor their crop. And the more data Aquabyte collects, the more sophisticated its machine learning applications will become.

Case Study 3: Wefarm

Wefarm is an IT platform using machine language. Demand for Wefarm has grown over the last few years – today, nearly 2 million farmers are signed up to the platform, and approximately 20,000 interactions are sent in by members per day. While the service is free and easy to use for the farmers, it requires really advanced machine learning to provide useful responses to

so many people, in a number of different languages. Wefarm developed a platform built entirely on AWS to automate this processing, with different algorithms to get an accurate response in their native language.

"We're not developing an answer machine, we're using machine learning to leverage the knowledge that's already in the community. The real opportunity for small-scale farming lies in connecting people together, and that's what the Wefarm platform is doing." Ewan clarifies.

Challenges

While the benefits of machine learning and other technologies are clear, many farmers don't have access to these systems today. That's especially true for many of the one billion people working in small-scale farming, which produce an estimated 70% of the world's food. Instead, Wefarm is connecting this community of farmers to the people and resources they need to be more successful — even those farmers without access to the internet, in places like Sub-Saharan Africa, via SMS. Wefarm's platform allows its members to ask questions, like why a cow isn't producing milk, or how to find relevant farming inputs at more affordable prices.

"The member that always stands out for me is a farmer in Kenya called Kepha," says CEO Kenny Ewan. "He kept about 50 chickens. That was his entire livelihood. A disease came into his farm and in the space of a few days, and about half of the chickens died. He reached out to Wefarm, and within minutes, he got really great advice and managed to save the other chickens, eventually rebuilding his flock."

Conclusion

A Sustainable Future for Food and Farming

Machine learning is quickly becoming the sustainable food industry's secret sauce — improving agricultural practices today to feed the growing global population well into the future. By helping farmers improve their yields sustainably, machine learning is feeding a global demand that will only keep increasing.

•

Restructuring Agriculture-New Road Map for 2030

• Dr. Manoshi Baruah Deka •

The transformation of Indian Agriculture has been marvelous, from a food deficient rather food starved country six decades back, we have come to guaranteeing food security for all. In recent years, the Government of India has renewed its focus of decentralized planning in Agriculture and each state has been entrusted with the huge responsibility of utilizing the earmarked funds through various planned investments (in project mode) as per its own plan and priorities. The government is also restructuring and rationalizing centrally sponsored schemes. The budgeting concepts at the state level linked to Sustainable Development Goals (SDG) have been introduced. Having a vision document and work plan based on local priorities with SDG action plan is imperative for line departments within agriculture and allied sectors to augment and ensure appropriate use of resources. Still Agriculture is not very profitable for the farmers with increased costs of production. Conventional agricultural practices depend on expensive modern equipment and machineries and costlier inputs such as fertilizers, chemicals, pesticides, fuel and hybrid seeds. This leads to the thought provoking discussion towards restructuring agriculture and deliberating on the road map during 2030. Needless to say that a lot of thinking, lot of imaginary but related picture drawing exercises is needed to build a future agricultural scenario for the country.

Reasons for Restructuring Agriculture

In this context first and foremost step is to identify and enlist the emerging issues and the technologies for significant positive change which will guide to formulate the strategies. Some of the issues are environmental sustainability as present days farmers are not being able to grow as in the past due to exhausted natural resources, polluted environment, product differentiation as a means to competitive advantage in the context of change in demands, biotechnology, including genomics and gene technologies, globalization, information technologies and more importantly climate change impacts, and changes to rural communities for which the points given hereunder needs to be addressed for sustainability of the road map and more importantly the farming community and the society for meeting the food and nutrition security. Further it has also to ensure that the farmers are economically secure. At the same time we should not forget the majority of farming community are marginal land holders. The average size of the holding declined from 1.33 ha

in 2000-01 to 1.15 in 2010-11. Hence restructuring agriculture and fine tuning of the road map for 2030s the need of the hour.

Major Challenges

Some of the major challenges are:

- The size and trends of agricultural labour
- Looking at agriculture through gender lense/perspective
- Addressing the issues from climate change (not mitigating but evolving coping strategies)
- Issues related to organic farming
- Conservation of ethnicity and biodiversity
- Multi-cropping/integrated farming/crop diversification
- Value chain for agricultural produce
- Intensifying the existing extension system/information delivery system
- Developing market/Creating market linkage - Reforms of wholesale markets
- Restructuring the architecture of agricultural supply chain

– **The Size and Trends of Agricultural Labour:** Employment in agriculture has declined steadily across developing and developed countries which is true for our country too. The number of labours required by an average farmer is becoming scarce due to various reasons such as engagement of the adult members in MGNREGA, disintegration of joint family system, migration for alternative livelihood, unaffordability due to low socio-economic status, mechanization of agriculture, untrained labour.

– **Looking at Agriculture through Gender Lense/Perspective:** Women are central to agriculture and make a strong contribution to food security and nutrition at both the household and community levels. In many developing countries, they make up almost half of the agricultural labour force, but their production is limited by barriers to finance, inputs, and extension services, as well as land ownership and rights. Data on gender difference in formal years of schooling and also in occupation clearly indicates that whatever plan the policy makers make should consider the women folk of the country as direct client/target as women contribute enormously to family labour, the workers are unrecognized and they often being discriminated. The technologies developed so far and the ones which are in the pipe line may be popularised among the practicing farm families to get the optimum output. Some suggestive actions are roof top gardening

or terrace gardening, upscaling of women producer groups to companies, tapping the inherent creativity and capitalizing on location specific produce etc etc.

- **Issues Related to Organic Farming:** Low access to production resources due to low SES, complicated and lengthy procedure for certification which needs to be addressed. Further it would lead to diversification and integration, sustainability by reducing off-farm inputs, enhance soil resource, natural plant nutrition-manage nutrients by managing soil organisms, build the soil, natural pest management and integrity by protecting organic products from contamination and commingling with non-organic products. Hence the production of bio fertilizer, vermi-compost, compost need to intensified through massive awareness campaigns, exposure visits and so on. The women are found to be engaged in production of vermi-compost but due to partial or incomplete knowledge on use and application is limiting the utilization of the product, through it is serving as a secondary source of income. Unavailability of package of practices on organic farming of different crops is also to be addressed.
- **Conservation of Ethnicity and Biodiversity:** For social and economic sustainability of any technology proper recognition is to be given for conservation of ethnicity result in to conservation diversified, valuable and unique bioresources having high medicinal properties and serve as economic storehouse. Ethnic foods also are found to be store house of valuable nutrients and good for health. For example–Rice bear of North-East is attracting tourists from different parts of the globe making it a source of income generation by reinvigorating its bio-economy leveraging specialty agriculture en cashing its competitive advantage to become leader in organic agriculture.
- **Multi-cropping/integrated Farming/Crop Diversification:** The increased marginalisation of holdings - less than 2 hectare holdings account for about 85 % of the operational holdings and 45% area (Agricultural Census, 2010-11). Integrated farming systems for enhancing productivity per unit area through recycling of wastes is the need .Diversification in this option refers to undertaking alternative forms of agricultural production. Given the range of potential enterprises, it is not possible to provide an exhaustive list of the types of enterprises considered as alternative agriculture, but it may include: Minor fruits, Vegetables, Mushroom, Herbs, Horticulture, Bees/ Honey and Biomass. Another opportunity lies in capitalizing potential of livestock and fisheries sub sectors including the small birds, thus achieving sustaining inclusive growth and addressing the rural poverty.

- **Value Chain for Agricultural Produce:** Gender inclusive value chains plays an important role in improving women participation and income generation. For example, rice based products fetch more income than common rice packets and after harvesting the straw instead leaving in the field can be used for preparation of mats, rugs, carpets and also used for mushroom cultivation and vermi-compost production besides using as fodder. Extraction of Bhindi (okra), Banana fibre for different end uses such as yarn, non-woven fabric utility and decorative items and in paper industry, composite boards. Thus, waste can be converted to wealth through value chain.
- **Intensifying the Existing Extension System/Information Delivery System:** Planning and percolation of information using ICT based tools to the producer groups by extension personnels attached to Krishi Vigyan Kendras and NGOs by way of rejuvenating the extension machinery with enriched knowledge and motivation would result in receiving the information on time by the clientele. The deliverables targeting the women and marginal farmers needs to be revisited in terms of inputs and doses to achieve the adoption and transformation. Extension in public-private partnership ,market led extension would also intensify the existing extension system with limited manpower in a country like India with diversified ethnicity, culture and farming system
- **Developing Market/Creating Market Linkage - Reforms of Wholesale Markets:** The results of marketing of major crops show that when the role of the Food Corporation is limited to only procurement for the buffer stock, there are considerable welfare improvements and both farmers and consumers benefit more when the marketing system becomes more competitive. Producer organisations of smallholders is widely seen as an antidote to smallholders' problems of dealing with buyer-driven chains. The farmers and entrepreneurs of rural world are a globally competitive minority comprised of the family farmers. Therefore, proper marketing facilities needs to be created at local levels where the producers can directly sell their product not waiting for FCI to collect or resulting to suicide of the farmers for not getting the right price at the right time. State support for building small producers' capacity, strengthening the farmer's voice in the process of setting standards and codes of conduct, including those for sustainability, should be undertaken as a partnership with producers rather than enforced from a distance. Provisioning of overnight stay in Mandies and whole sale markets will facilitate the marginal producers by cutting down the transportation cost. Online trading has to be popularized for achieving multiple platforms. Mahila e-haats may be increased. Competition

policies that protect markets are as important to sustainable development as policies that protect land and water. Improvement in public services under market mechanism is also needed.

– **Restructuring the Architecture of Agricultural Supply Chain:** The agricultural supply chain is relooked at and its architecture is restructured by changing the flow. After restructuring, the agricultural supply chain starts from the farmer who can self sustain by adapting to alternative or low input sustainable farming methods such as zero budget natural farming, bio-dynamic farming, effective micro-organisms. Various hypotheses are proposed related to problems of increased physical capital investments by farmers in the agricultural supply chain, how alternative sustainable farming methods can possibly be used to reduce the physical capital investments and the barriers for farmers in adopting the alternative sustainable farming methods are to be seen.

The visionary road map should be able to address the scenario like should the agriculture sector turn grave how to still produce more food, how to preposition to respond effectively to the challenges and produce surplus food grains and trade internationally with market intelligence based planning.

•

Water Savings Technologies in Agriculture

• P. P. Donga •

Gujarat is one of the water deficit States in India and water savings in agriculture is of paramount importance in the State. Realizing this fact the State and Central Governments are encouraging the farmers to adopt water savings technologies in agriculture through financial assistance mainly for the adoption of Micro Irrigation.

Gujarat has adopted a unique model for implementation, by establishing a Separate Special Purpose Vehicle (SPV), Gujarat Green Revolution Company Limited (GGRC). GGRC exclusively works as nodal agency for implementing the State supported "Micro Irrigation Scheme" and "Per Drop More Crop (Micro Irrigation) component of *Pradhan Mantri Krushi Sinchai Yojana* (PMKSY)" in an integrated manner popularizing the concept of Micro Irrigation among the farmers. This model of implementation has been very successful and popular among farmers.

The Scheme is being implemented within the framework of issued Government Resolutions/orders in an integrated manner with uniform financial norms of assistance while adhering to the Operational Guidelines of Per Drop More Crop (Micro Irrigation) component of *Pradhan Mantri Krushi Sinchai Yojana* (PMKSY), a Central Government Scheme. GGRC put all efforts into an integrated approach to achieve sustainable natural management regime in agricultural sector in Gujarat State. The dovetailing of the Central assistance with State resources facilitates a higher coverage of beneficiary farmers adopting Micro Irrigation Technology.

GGRC has developed a unique model for implementation of the Scheme and processing of beneficiary farmer's applications and transfer of assets (Micro Irrigation System) and disbursement of subsidy to farmers using the state-of-art information technology. The applications are processed centrally through a dedicated software which is web-based and user friendly. Applicants are enabled to track the status of application through "Farmer Portal".

GGRC operates the Scheme with a distinct philosophy, wherein the farmer is treated as a customer and not as a beneficiary and the subsidy provided to the farmer, is considered as an investment on the part of the Government. The modality of implementation of the Scheme by GGRC is based on corporate systems and processes. The Scheme implementation is flexible and beneficiary friendly, wherein the beneficiary farmer has the discretion to choose the extent

of area to be covered under the micro irrigation technology, the kind of Micro Irrigation (MI) system to be installed, system design compatible with his cropping pattern and also the MI system supplier who would install the system on his/her farm. All Micro Irrigation components of the system are uniformly priced under the Scheme, which ensures that the MI system suppliers adhere to uniform quality standards and system costs.

As a result of consistent efforts in a right direction, within 14 years (From May-2005 to August-2019), 18.35 lakh hectares area covered under Micro Irrigation benefiting more than 11 lakh farmers of the State. The annual average adoption of Micro Irrigation is around 1.28 lakh hectares. The State ranks number one among all States in terms of achievement in bringing area under Micro Irrigation.

Challenges Faced by the State Before Establishment of GGRC as Implementing Agency

- Multiple implementing entities (line departments) with varying subsidy norms and ambiguous policies
- Very low level of awareness among farmers regarding use of Micro Irrigation technology and government scheme benefits.
- High level of reluctance among farmers to adopt and to switch over to modern method of irrigation i.e. Micro Irrigation from traditional flood irrigation.
- The resource poor farmers to bear his/her share.

Ways & Means for Overcoming Challenges through GGRC

1. GGRC – SPV - integrated approach for implementation – single window for applicant farmers
2. Uniform subsidy norms
3. Continuous & round the year extension and promotion activities
4. Awareness & on field farmers trainings
5. Institutional linkages with banks/NGO/Corporate bodies for credit channelization/additional incentives to farmers and handholding of farmers.

Pre-Post GGRC establishment outcome scenario

Period	**Before GGRC**	**After GGRC**
	1991 to 2005 (14 years)	**2005 to 2019 (14 years)**
Total area covered(ha)	2.26 lakhs	18.13 lakhs
No. of beneficiary farmers	1.41 Lakhs	11.20 lakhs

Implementation of Business Module

The Scheme is being implemented roping in registered Micro Irrigation System (MIS) manufacturers/suppliers appointed by GGRC. For authentication of applicant farmer and registration of application, MIS Suppliers (57 at present) take biometrics data viz., photograph, digital signature and left/right hand thumb impression of the applicant and register the application, undertake Geo Positioning System (GPS) based survey of the field and prepare design, supply and install the selected MI Systems on the farmers' field. After installing the system, the MIS Supplier(s) are made responsible for rendering maintenance services for a period of five years. A provision has been made under the scheme for insuring the Micro Irrigation system as well as life of a farmer for a period of one year. To ensure strict adherence to quality standards in the use of MIS components, GGRC has made it mandatory for MIS suppliers to use only those components which conform to BI Standards. Third party inspections are conducted periodically by technical agencies such as Central Institute of Plastics Engineering and Technology (CIPET), and Gujarat Industrial Research and Development Agency (GIRDA) at the factory site of the registered MIS Supplier(s). Furthermore, GGRC has also put in place a regimen of third party inspections wherein Third Party Inspection Agencies (TPIAs) have been appointed to conduct inspections of installed Micro Irrigation System on farmers field to verify and ensure that material is supplied as per bill of quantity and Micro Irrigation System is commissioned as per the design and operational on farmers field. TPIA Inspectors are equipped with android based QR Coded "E-Capture Solutions" which enables the Inspection agencies to capture and upload photographs of the MIS installation at site along with GPS coordinates through mobile phone for subsequent monitoring of the site on Bhuvan Map/Google map.

High level of transparency is a forte of the Scheme. To achieve the status, GGRC has established systems and developed processes in a corporate mode for processing MIS applications with the use of state-of-art information technology. The applications are processed centrally through a dedicated software which is web-based and user friendly. A state-of-art IT infrastructure has been put in place for implementation of the Micro Irrigation Scheme with an in house data centre.

Innovative Aspects of Implementation of the Scheme

A. Transferred Governance from Government mode to corporate mode. It is a unique corporate model of governance in place of traditional governmental departmental governance model for implementing centrally sponsored

flagship scheme wherein a corporate body is established and entrusted to implement the scheme

B. The applicant farmer has freedom to select Micro Irrigation Supplier, type of Micro Irrigation system and extent of the area of adoption of Micro Irrigation

C. Simple and flexible approach of implementation

D. Single window for implementation

E. Uniform prices of the Micro Irrigation system components in the entire State

F. Precise and fast track disbursement of subsidy

G. Higher autonomy in functioning and decision making

H. Dedicated "Farmer Portal" which enables beneficiary farmers to track the status of application and details of subsidy amount

I. Multi stage monitoring and control and efficient vigilance mechanism at place

J. Highest transparency

K. State-of-art IT application software to process Micro Irrigation application, ensure asset transfer and subsidy disbursement to farmers

Present Subsidy Norms

1. General Farmer- (Land holders of 2 hectares and more) :- Up to 70% of MIS Unit Cost or Rs. 70,000/- per hectares, whichever is less
2. General Farmer- **Non Dark Zone area:** Small and Marginal farmer (Landholders of less than 2 hectares) :- Up to 70% of MIS Unit Cost or Rs. 80,000/- per hectares, whichever is less
3. General Farmer- **Dark Zone area:** Small and Marginal farmer (Landholders of less than 2 hectares) Up to 80% of MIS Unit Cost or Rs. 80,000/- per hectares, whichever is less
4. SC/ST Farmers- **Non Dark Zone area:** Up to 85% of MIS Unit Cost or Rs. 1,00,000/- per hectares, whichever is less
5. SC/ST Farmers- **Dark Zone area:** Up to 90% of MIS Unit Cost or Rs. 1,00,000/- per hectares, whichever is less

Socio Economic Impact of the Micro Irrigation Scheme

Results of the study conducted by CIIE-Indian Institute of Management (IIM), Ahmedabad on MI scheme implemented by GGRC are as follow:

1. Saving of Water: 33-50%

2. Saving in Labour Cost: 35-40%
3. Saving in Fertilizers: 21-25%
4. Increase in Crop Yield: 25-30%
5. Saving in Energy: 937 kWhr/Hectare
6. Increase in net income/hectare: Rs. 15,487/-

As above details indicate that over and above saving of water, fertilizers, energy, labour cost and increase in crop yield, the increase in net income per hectare to the beneficiary farmer is Rs. 15,487/-.

Moreover, because of adoption of micro irrigation, many farmers have changed their cropping pattern and diversified to high value horticultural crop like fruit and vegetables which resulted in doubling their income.

In addition to above mentioned reported benefits, Micro Irrigation technology also offers advantages of irrigating undulating land, prevent soil erosion, reduce incidents of crop diseases and pest, uniform distribution of water in the crop root zone and improvement in quality of crop produce.

Presented in National Round Table Meet on "doubling of farmers income" organised by National Council for Climate Change, Sustainable Development and Public Leadership (NCCSD) held on 21-9-19 at Ahmedabad.

•

The Role of Institutions, Markets and Policy-Making

• Dr. Hitesh V. Bhatt •

This note has been prepared by a group of IRMA faculty members and researchers who have devoted considerable time and energy in recent years in understanding and in strengthening the varied dimensions of rural India and underlying development processes. The note highlights the following actionable points for MoRD's consideration along with associated explanations.

1. Extend the Make-in-India to Agriculture-based RURAL ENTERPRISES

The COVID-19 presents a unique opportunity to extend the mandate of Make-in-India to the agricultural sector. While traditional agri-food producers of the world (USA, Germany, France, and Italy) have suffered severely, the Make-in-India paradigm can be tweaked to enable Indian Agriculture-based Rural Enterprises to become global producers, generate high levels of local employment opportunities, and household income. Provisioning for the following infrastructure using public fund may be taken up:

1.1 Modern warehousing facilities for better humidity control in cereals and pulses

1.2 Cold storage and cold chain facilities for humidity and temperature control for perishable items like horticultural produce, dairy, poultry, fishery, etc.

1.3 Upgradation of technology for meeting the global standards

2. Agribusiness and Food Processing Industries: Farmer Producer Organizations (FPOs) could be a Significant Player

2.1 Strengthen Agri-input supplies through consortium formation at national level between key seed/fertiliser/pesticides/farm equipment players (both Public and Private) along with support institutions (KVKs and Agriculture Universities for Agricultur Extension and support/Cooperative Banks/Post Offices/Private sector Banks and MFIs for financial support).

2.2 FPO's should be funded to develop commercial projects and once infrastructure like cold chain, warehousing facility, input marketing outlets, etc. are created, they should be supported to tie up with private sector companies for arranging inputs or sale/value addition of their produce.

2.3 The institutional platform of DAY-NRLM can be harnessed to create farmers producers organisations (FPOs).

2.4 Provide support to private players/start-ups in Agricultural technology space through reduced interest loans on capital costs and working capital support.

2.5 Providing tax incentives and working capital relief to primary and secondary processed food products firms procuring local farm produce to reduce transaction costs, promote local food, enhance incomes of farmers and availability to consumers as well as reducing supply chain concentration between producers to consumers

2.6 Create a National FPO portal connecting all registered FPOs under NABARD and SFAC towards pooling demand for Agri-inputs, registering for crop insurance and selling produce B2B through the support of appropriate IT and financial infrastructure.

2.7 Incentivise horticultural exports through special incentive schemes from APEDA and increasing horticultural and animal origin produces storage spaces in all the Cargo Areas.

2.8 A one-stop export model like the POSSEC of Thailand for fresh produce agricultural exports can also be explored.

2.9 Non-farm sectors like handlooms, handicrafts, etc. could also unlock the potential of employment and income generation.

3. Strengthening MGNREGA

MGNREGA can certainly reduce some of the distress caused by COVID-19. It needs to be utilized to the fullest extent so that money reaches in the hands of people. This will increase the rural demand and expenditure and that may kick start the revival of the economy. We have the following suggestions:

3.1 On Number of Days of Work

a) It needs to increase. In the year 2020 considering from May mid, we are left with 230 days. Of these 230 days, 150 days of work needs be provided.

b) If the pandemic situation continues to remain in 2021 number of workdays needs to be increased to 200 days per year (currently, it is 120 days).

3.2 Who should be Considered Eligible

a) Apart from the regular job cardholders, the scheme needs to be extended to all the migrant labourers who have returned to the village.

b) The scope of the scheme can be extended to all the labourers stranded in urban areas without a job.

c) Anybody in a rural or urban area who is not able to carry out his regular

livelihood activity due to the pandemic and volunteered to do work under MGNREGA

3.3 Wages and Budget

a) The wage rate may be increased to Rs. 360/- (currently it is announced at Rs. 202/-) to have equivalence with a wage rate of unskilled agricultural workers. This makes Rs. 6000/- per month for a household

b) Both online (preferable) and cash in hand options need to be worked out.

c) For those households in the red zone and unable to work because of lockdown, wage equivalent to 120 minimum days of work (monthly 3000/-) can be provided.

d) The budget for MGNREGA at this health crisis situation needs to be kept open-ended.

e) Part of the National and State relief funds, including PM CARES can be utilized towards this.

3.4 Enhancing Scope of Work (Creation of New Infrastructure): Besides construction of check dams (could be under the guidance of local Water Users Associations), field channels, drainage system, soak pits, internal roads, culverts, afforestation etc a variety of innovative works can come under MGNREGA. There are: schools, ICDS centres, and most importantly, primary health infrastructure, which is not upto the mark in most parts of central and northern India. Since skilled migrant labourers are back in the village they can provide skill training to unskilled in the village under the scheme.

3.5 Workplace Safety Measures

All precautionary items (like masks and soaps) need to be provided at the worksite. In the green zones work MGNREGA work can start taking the precautions. In the orange zone, work can start in areas away from the restricted zone observing the guidelines issued by the state and central government.

4. Containment of the Reversal of In-Migration

4.1 Create a reliable database of migrant workers, their location, contact details and skillsets.

4.2 Migrant workers should be linked with reliable banking/other fintech services for remittances. This database can also become useful for the government for direct cash transfer to them and to help those in dire need of financial support.

4.3 Their home states must take the remittances from migrant workers seriously

and make efforts to impart better skills to them in order to improve their earning capacity and occupational growth. MGNREGA programme in their home states can have a component for skill-up gradation of migrant workers and reputed skill providers can be engaged on an outcome basis.

4.4 Migrants working from the construction sector can be financially supported to become local contractors. The government can provide them initial support in executing 3-4 small civil works like construction of school rooms, sub-centres of PHC, Anganwadi centres, weaker section housing, etc.

Suggestions on Other Dimensions

5. Strengthen the Panchayats to cooperate, coordinate, manage information, and mobilize resources while dealing with the pandemic. Also, strengthen their synergies with NRLM promoted SHGs in the village.

5.1 We propose that state governments be incentivized to use Gram Panchayats to deal with the spread of Covid-19 as well as devise strategies to help in economic development in the post-Covid situation. Panchayats are in an ideal position to track and promote the economic welfare of rural households. The Panchayat should be asked to enlist such workers (along with the skills they possess) who have lost their jobs. The Labour Department can be asked to then connect them with the industries and map the labour requirements. Since labourers have left the job and left their workplace, industries are also suffering from lack of labour force. People, based on their skills, who lost their jobs can be placed in such industries within the same (or neighbouring) districts. This arrangement can ensure employment to people in their own district, and industries can get the labour force to restart their production/manufacturing.

5.2 Panchayats and SHG movement can be directed to align their functioning and overall objectives. SHGs have been successful in dealing with rigid social structures and in empowering women, while Panchayats have the constitutional mandate to improve the political participation of women. COVID has given rise to the opportunity where the functioning of Panchayats and SHGs can be merged optimally so as to enable women to become the marketing agent of their home produce. There is some research that shows that households with better decision-making by women are more likely to face such covariate shocks as COVID.

5.3 Farmers have their harvest-ready but are not able to sell even though the Government is trying hard to attract them to Mandis. Panchayat can list the farmers who want to sell their produce, and the same can be procured from the village itself, instead forcing farmers to bring the produce to

Mandis. After procuring the produce, the money can be transferred to their accounts.

6. Possible use of CSR Funds:

6.1 For the next two years, companies under a special advisory could be asked to use CSR funds for the restoration and creation of livelihood opportunities in the rural areas, urban slums, and 'C'-type towns. The CSR funds could be spent in two main areas – agriculture & its allied activities and entrepreneurial activities, which can be linked to creating 10 million low-income jobs.

•

Importance of Weather Forecasting for Climate Smart Agriculture

• Dr. Kirit Shelat, Dr. Shovik Jha •

Abstract

Agriculture is one of those prime sectors that impacted heavily due to Climate Change. India is a large country with diverse climate, seasons, crops and farming systems. Rainfall, temperature and radiation are having direct impact on agriculture systems and productivity. Wet and dry spells as well as extreme events cause enormous impacts on the agriculture sector.

It finds that even at just 1° C of warming, a negative impact for major crops like wheat, rice and corn would be seen. For India and China, the prediction is that the stress on staple wheat crop would increase negatively, affecting the overall food security of the continent.

Despite change in climate and its adverse impact on crops/animals, income to farmers should not decrease. It is essential to provide opportunities to farmers to have multiple source of income from agriculture, animal husbandry, fisheries-milch cattle and poultry. So when one fails, other supports. All this can be achieved through Climate Smart Agriculture.

Keywords: Climate Change, Agriculture, Rainfall, Weather, Crop, Productivity

Introduction

Climate change has created the most difficult challenge in new millennium one to its unpredictability increasing frequency and intensity of its impact on agriculture and livestock management. This gets magnified for rural areas where majority depend on agriculture as direct or indirect source of income. Entire world and specially India is passing through unpredictable changes whether it is cyclone or high temperature, heavy rain or drought or extra ordinary cool wind. There is main threat to food security and food for hungry millions.

We have also seen main climate change related drivers are temperature, precipitation, sea level rise atmospheric carbon dioxide content and incidence of extreme event – may affect the agriculture sector in many way like reduction in agriculture production and productivity, limitation of water resources exacerbation of drought period reduction in soil health, pest and disease outbreak etc. result in reduction in agriculture and production. Under this

climate change situation if we want to increase or if we want to maintain agricultural and dairy production and productivity we have to develop our farmers, awareness regarding climate change issue, and develop our farmers knowledge, skill, understanding and favourable attitude towards climate change and its recommended improved practices of farming through proper training.

It is the farmer alone who can increase the production and productivity. We can say that perception of climate change issue, and recommended modern scientific agriculture knowledge can reach to the door of farm family only through intensive farmers' training programme.

Key Findings of IPCC's Fifth Assessment Report

- Climate change impacts are projected to raise global average surface temperature 2.6–4.8° C by 2100.
- Climate related impacts are already reducing crop yields in some parts of the world, a trend that is projected to continue as temperatures rise further.
- Major impacts are projected on water availability and supply, food security, and agricultural incomes, including shifts in production areas of food and non-food crops.
- Combined with increasing food demand, global temperature increases of 4° C or more would pose large risks to food security globally and regionally.
- Greenhouse gas (GHG) emissions from agriculture comprised about 10–12% of man-made GHG emissions in 2010.
- If temperatures increase by 3° C or more, agricultural adaptive capacity is projected to be exceeded in regions closest to the equator.
- The agricultural sector has significant potential to make cuts in GHG emissions.
- Farmers can adapt to some changes, but there is a limit to what can be managed.
- Climate change is projected to:
  - Increase price volatility for agricultural commodities
  - Reduce food quality
- Overall, climate change is projected to cause food production to fall, with lower yields from major crops.
- These projected impacts will occur in the context of simultaneously rising crop demand.
- The agricultural industry's own interests are best served by ambitious approaches to adaptation and to cutting emissions.

National Mission on Sustainable Agriculture

India has prepared and submitted National Action Plan for Climate Change which includes eight missions which focuses on various mitigation and adaptation strategies to tackle climate change. One of the important missions out of eight is National Mission for Sustainable Agriculture. It has been formulated for enhancing agricultural productivity especially in rain fed areas focusing on integrated farming, water use efficiency, soil health management and synergizing resource conservation.

For Risk management priority areas as indicated in NAPCC includes

- Strengthening existing agricultural and weather insurance mechanisms.
- Development and validation of weather derivative models by insurance providers. Ensure access to archival and current weather data for this purpose.
- Creation of web-enabled, regional language based services for facilitation of weather based insurance.

For Access to information priority areas includes development of regional database of soil, weather, genotypes, land-use patterns and water resources.

For Action points under Rainfed Agriculture includes Model codes on "Droughts, Floods and Good Weather" be prepared bringing out short term and long term mitigation measures, such as ensuring availability of quality seeds, planning for crops/varieties resistant to heat, floods, etc.

For Action points under Risk Management includes Weather insurance products will be developed further strengthened and used as potent instrument for managing risks. The compensation is expected to be more realistic and prompt to meet the needs of farmers.

Provisions in the proposed model codes of Droughts, Floods and good weather" would be implemented to minimize the risk.

For Action points under Data Access includes m-powering extension workers farmers, researchers, decision makers to understand the impact of climatic changes and provide timely forecast of weather agriculture situations well in advance.

The strategies and programme of actions (POA) outlined in the Mission Document, that was accorded 'in principle' approval by Prime Minister's Council on Climate Change (PMCCC) on 23.09.2010, aim at promoting sustainable agriculture through a series of adaptation measures focusing on ten key dimensions encompassing Indian agriculture namely; 'Improved Crop Seeds, Livestock and Fish Cultures', 'Water Use Efficiency', 'Pest Management', 'Improved Farm Practices', 'Nutrient Management', 'Agricultural Insurance',

'Credit Support', 'Markets', 'Access to Information' and 'Livelihood Diversification'.

This is nothing but Climate Smart Agriculture.

Climate Smart Agriculture (CSA) - Need of The Time

It provides opportunity to young members of family to acquire multiple skills, support for setting up microenterprise locally, based on demand and supply situation or set up protected agriculture, farmers with use of greenhouse technology. It provides safety net at the time of natural calamities – by way of crop insurance – for crops & animal husbandry. It provides employment in community projects during lean season or at time of drought or whenever needed.

Meaning of Climate Smart Agriculture

It contributes to achievement of sustainable development goals and integrates social, economic and environmental development to meet challenge of providing sustainable (a) livelihood to farmers (b) food security to hungry millions, and (c) eradication of poverty.

It is composed of four pillars:

1. Sustainably increasing agriculture productivity and income
2. Adapting and building resilience to climate change
3. Reducing and/or removing greenhouse gas emission wherever possible
4. Uses agriculture as a major tool for mitigation of GHG – CO_2 by laying emphasis on its unique capacity to absorb CO_2 and release Oxygen through photosynthesis process.

It envisages achieving this through (a) increased cropping by reducing rain fed areas through integrated water and river basin management (b) expansion of agriculture on wasteland, wetland, degraded fallow areas and urban agriculture.

Climate Smart Agriculture prepares farmers to develop agriculture smart enough to survive onslaught impact on climate change on a permanent basis and not as a temporary solution. Therefore, the real challenge before Agriculture Administration which includes Agricultural Scientists, Extension teams and Agricultural organizations both Public and Private as well as Public leadership is to make this happen. It is an approach for addressing the development efforts towards the technical policy and investment condition by mainstreaming agriculture in overall development strategy.

Climate smart agriculture involves crop pattern based on soil health & moisture analysis of an individual piece of land to support crops which can

be sustained by its soil. It also includes Weather advisory at a local level including long term – medium term – short term inputs to take precautionary action directly by farmer. After unexpected weather changes immediate Agro – advisory is made available for timely corrective actions that prevent crop loss. Nutritional and preventive vaccination is considered for cattle and poultry. All these can be achieved by direct communication to farmer at his doorstep. By using all available scientific technology agriculture can become more productive, less costly and linked with value added market mechanism.

There are three kinds of impact of change in climate

1. Unexpected change in weather pattern during monsoon season like delayed rain, long intervals for rain or heavy rain
2. Major calamity like floods, cyclone/tornado, and cloud burst etc
3. Change in soil moisture and its productivity and same about livestock

Considering these impacts Agriculture Administration should focus on Water Cycle, Soil and Moisture Management, Livestock Management, Energy saving in farming, Value chain for Agro produce – enhancing value, Multiple source of Income to farmers as well as Bridging gaps in productivity.

1. Water Cycle

Element of Water Cycle	**Climate Change Impact**
Annual precipitation	Expected to increase globally during the 21st Century, with potentially great spatial variations
Inter annual variations in precipitations	Expected to increase everywhere
Seasonal variability of rainfall	• Expected to increase everywhere • Delayed monsoon • Interim delay with in season
Soil moisture stress (droughts)	Moisture stress to generally increase as a result of increasing variability of rainfall distribution (longer periods without rain) and increasing temperatures and deplete soil moisture faster than natural vegetation
Floods	Increased as a result of increasing frequency and intensity of extreme rainfall events flood intensity can affect standing crops, washing away of upper fertile crust of soil & cause soil erosion (Navsari District)

River discharge (Kutch District)	Increased variability as a result of changes in rainfall patterns. Changes in annual runoff expected to vary from region to region
Groundwater	Varies as a function of changes in rainfall volumes and distribution. Impact is complex, with floods contributing to increasing recharge and droughts leading to increased pumping
Evapo transpiration	Increases as a function of temperature increases
Water quality (in rivers, lakes & aquifers)	Moderate impact through temperature increase
Salinity in rivers and aquifers	Potentially high impact where sea water level rise combines with reduced runoff and increased withdrawal

2. Soil and Moisture Management

Soil with moisture and sunlight makes agriculture production possible. With inputs and combination of soil health and moisture, productivity increases, declines or remains stable.

The challenge is to that, in the changing weather parameters, stability in productivity is maintained and wherever possible, increased. We have to make this happen by farmers providing not only scientific inputs but demonstrating its success.

This includes Bio-diversity, Integrated Soil Fertility Management System (ISFM), Conservation of agriculture system, Organic and In-organic inputs, Agro-forestry , Perennial crops, Crop selection, crops which can be sustained in such conditions, Resource Conserving Technologies (RCTS) and Soil health and moisture analysis card for each farmer with details of (a) crop that can be sustained (b) nutrient that are needed.

3. Livestock Management

Selection of breed, Shelter Design, Feeding practices and Mixing Ration are important aspects for the protection of milk animals against Climatic Change. Drinking water requirement, Breeding practices, Rearing Practices, Vaccination and deceases prevention and Milking care before & after are important to be considered during extreme heat and drought, during monsoon and flood as well as during winter.

Need of Weather Forecasting

It is a known fact that variable weather plays a dominant role in year-

to-year fluctuation in crop production; both in rain fed or irrigated agriculture. Though complete avoidance of farm losses due to weather is not possible, however, losses can be minimized to a considerable extent by making adjustments, through timely agricultural operation and accurate weather forecasts. Weather forecasts are of four types, viz., now casting (4 to 5hrs), short range forecast(valid for 48 hours), medium range(valid for 5 days to a week) and long-range or seasonal forecast (valid for month to season). All these four types of weather forecasts are prepared by weather forecasting agencies in most of the countries of the world, including India.

Objectives of Weather Forecasting

Weather information for agricultural operations shall be a tailored product that can be effectively used in crop planning and its management. A comprehensive weather based farm advisory is an interpretation of how the weather parameters, in future and present will affect crops, livestock and farm operations and, suggests actions to be taken. The Advisory Services will be more effective if they are given in simple and local language that farmers can understand it. In order to make the Agro-Met Advisory Services more successful and continuous process, it is to be supported with: (a) agro meteorological database, (b) crop conditions, (c) real time weather, research results on crop-weather relationships, and (d) skilled manpower in multi- disciplinary resources and users interface.

Dr A. K. Singh, Formerly, Deputy Director General of Indian Council of Agriculture Research has analysed the overall Indian scenario.

Indian Scenario: Current Status

- No significant change in monsoon rainfall at All India level, some regional variations are noticed
- Increase in rainfall in west coast, north AP and NW India, decreasing trend in east M.P. and adjoining areas
- Increase in surface air temperature by 0.51^{o} C during 1901-2007, accelerated warming during 1971-2009
- Mean temperature rise by 0.2^{o} C per decade during 1971-2009, greater rise in minimum temperature than maximum
- One day extreme rainfall events are increasing
- Cyclonic storms in Bay of Bengal showed declining trend of 2 cyclones/ decade during 1891-2008
- Deglaciation in the Himalayas
- Sea level rise in Indian Ocean 1.63 mm/year during 1993-2009

Indian Scenario: Future Projection

- Change in rainfall pattern by the end of the 21st century
- Increase in temperature by 2 to 4^{o} C
- Warming will be more pronounced over most of the land areas
- Maximum increase over northern India
- Relatively greater warming in winter and post monsoon seasons
- Frequency of cyclones during post monsoon seasons (2071 to 2100) is projected to much higher than baseline scenario (1961-1990)

Role of Weather Forecasting in Agriculture

Basic philosophy and primary requirement in *Gramin Krishi Mausam Sewa* is to know the farming systems & their potential. It is important to

- Be culturally sensitive & win trust of farmers
- Develop alternatives / options / choices
- Demonstrate how climate / weather info helps make good decisions
- Use seasonal calendar to identify farm activities
- Use matrix to identify critical decisions and relevant climate parameters
- Hands-on learning – role plays to illustrate long-term rainfall
- Advisories based on weather/climate & cropping information
- Climate predictions and meteorological forecasts with added value for agriculture.
- Monitoring and early warning services connected to climate
- Products of agro climatologically characterization
- Development & validation of adaptation strategies

Accuracy: The information should seek to address or solve an issue or problem based on sound science.

Robustness: The method or product should be versatile to operate under a variety of conditions.

Clarity and be Meaningful: The information should be easily understandable by the user.

Timeliness: The information can be created and provided in a reasonable time frame.

Environmental Soundness: The information encourages environmentally friendly procedures.

Economic Viability: The information can be economically justified.

Information about State-wise district level AAS Bulletin -608 Bulletins are as under:

State Name	Total	State Name	Total
Andaman and Nicobar	3	Madhya Pradesh	50
Andhra Pradesh	22	Maharashtra	32
Arunachal Pradesh	14	Manipur	9
Assam	26	Meghalaya	7
Bihar	38	Mizoram	8
Chhattisgarh	25	Nagaland	11
Delhi	1	Orissa	21
Gujarat	26	Punjab	21
Haryana	21	Rajasthan	33
Himachal Pradesh	12	Tamil Nadu & Puducherry	34
Jammu and Kashmir	21	Tripura	8
Jharkhand	24	Uttar Pradesh	67
Karnataka	30	Uttarakhand	11
Kerala	14	West Bengal	18

Recent Climate - Aberrant and Extreme Events

Year	All India SWM Rainfall Departure (%)	Remark
2000	-8	-
2001	-15	-
2002	-19	Drought, extreme cold winters in 2002-03
2003	+2	20 day heat wave during May '03 in AP
2004	-13	Abnormal temp. during Mar '04, Drought like situation in July '04
2005	-1	Abnormal temp. during Jan '05, Floods
2006	-1	Cold wave 2005-06; Floods in arid Rajasthan & AP and Drought in NE regions in 2006
2007	+5	Abnormal temperatures during 3rd week of Jan '07 to 1st week of Feb '07

2008	-2	-
2009	-23	All India severe drought
2010	+2	One of warmest years
2011	+1	Failure of September rains in AP
2012	-8	Early season drought
2014	-12	43% deficiency in June
10 of 14 years experienced deficient rainfall (72%)		

What do we mean by guidance it has to be crop advice –for Example? CROP = SORGHUM

1. Crop cycle length: 120 days
2. Do not plant before 1 June
3. Between 1 and 10 June if there is acumulative 10 - day rainfall of 40 mm;
4. Between 11 and 20 June if there is a cumulative 10 – day rainfall of 20 mm;
5. Between 21 and 30 June if there is a cumulative 10 – day rainfall of 10 mm
6. Between 1 and 10 July even if dry, but preferably after rain; plant 7 after this period, it is recommended to plant a variety with a shorter cycle.

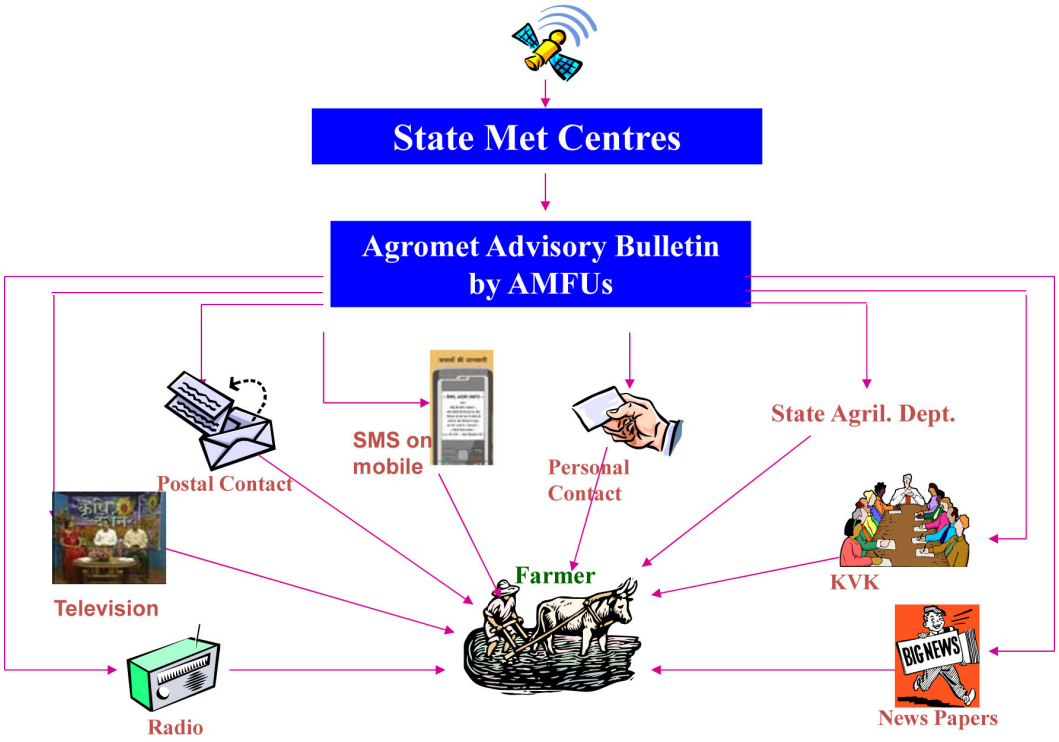
Agricultural/water resource systems operate on many time scales – links to key climate drivers = opportunities for preparedness (Meinke and Stone, 2005).

Decision type (eg. only)	**Frequency (year)**
Logistics (eg. scheduling of planting/ harvest operations)	Intra seasonal (>0.2) (MJO)
Tactical crop management (eg. fertiliser/ pesticide use)	Intra seasonal (0.2-0.5)
Crop type (eg. wheat or chickpeas); irrigation planning; irrigation scheduling	Seasonal (0.5-1.0) (ENSO)
Crop sequence (eg. long or short fallows)	Inter annual (0.5-2.0)
Crop rotation (eg. winter or summer crop)	Annual/biennial (1-2) (QBO)
Crop industry (eg. grain or cotton, phase farming)	Decadal (~10) (STR)
Agricultural industry (eg. crop or pasture)	Inter decadal (10-20)
Land use (eg. agriculture or natural system)	Multi decadal (20+)
Land use and adaptation of current systems	Climate Change

Dissemination of AgroMet Advisory are as under:

- SMS / IVRS to relatively much larger number of farmers.
- Modernize Agrimet website to make interactive
- Multi-platform backend: Web based and frontend.
- Multi Linkages among Agri Experts, Knowledge Institutions, Services Providers, etc.
- ICT based agricultural information dissemination models.
- Media Lab Asia : An Interactive Information Dissemination System (IIDS)
- Agrimet Domain linked to websites of other Ministries viz: Rural, Panchayati Raj etc.

Operational Communication to End-users (Farmers)



Source:

Initiative in India – Weather Forecasting

Reuter's market light– an NGO is implementing agriculture related programme and advising farmers by using ICT solution. It has more than 200 professionals including agriculture experts. It has taken up a project to monitor regularities of Agromet bulletin and analyse the quality of weather bulletins and ensuring relevant and actionable information dissemination to farmers. They have implemented this propgramme in five states i.e. Maharashtra, Rajasthan, Punjab, Tamilnadu and West Bengal for Rabi 2013-14 covering 20,000 farmers and Kharif 2014-15 covering 30,000 farmers.

Their analysis based on survey states that farmers rate weather alerts and agromet advisory significantly high where Punjab, West Bengal and Maharashtra farmers rating it above 90%, West Bengal being on top of the list with 95%. Rajasthan and Tamil Nadu consumer's value messages important and useful where every 3 out of 4 farmers rate it beneficiary to them. Perceived value of weather alerts and agromet advisory is very high, nearly 90% of consumers rate it useful. Timely availability of agro meteorological information and services could facilitate both strategic and tactical decisions in increasing and sustaining agricultural production.

Case Study of Farmers

Sr. No.	Personal Details	Details on Achievement
1	Name of Farmer: Mr. Keshavan State - Tamil Nadu; Village: Ilayanarkuppam; Taluka: Thirukazhukundram District: Kaanchepuram	He got information from RML to delay sowing one week due to possibility of rain. He then spoke with RML farm solution experts who confirmed after reviewing the IMD forecast. Farmer shared this information with his fellow farmers, too. As per forecast, heavy rain did occur causing heavy loss of seeds and newly germinated plants. But Keshavan, due to timely RML-IMD information, saved seeds worth Rs. 75,000. His friends too saved seeds and sowing cost. Overall, he and his friends saved Rs. 3-4 lakh and other expenses like labour cost, fertilizer costs, etc.
2	Name of Farmer: Mr. Kailas Rambhau Adhav State: Maharashtra; Taluka: Ambegaon;	Mr. Kailas Adhav shared his experience regarding weather forecast message received during harvesting stage of Rabi onion. He said he was receiving regular messages of Agro-advisories

	District: Pune	and weather alert of IMD since last 1 year through RML. He got benefit from message received during harvesting stage of onion as there was a possibility of rainfall during that period. When he got message, he transferred his harvested onion in safe place and was able to save crop produce. His loss due to unseasonal rainfall was effectively minimized/zeroed due to such messages. IMD information helped him to increase his crop production as compare with last year.
3.	Name of Farmer: Mr. Santosh State: Rajasthan; District: Bharatpur	Mr. Santosh shared his views regarding the messages of Agromet and weather alerts of IMD. He has been RML consumer from last year. He had received information of IMD for aphid control in mustard from RML. He could save input cost which is most profitable for him. After he received RML Messages on possibility of attack of aphid in next 5-6 days, he sprayed the given pesticide as per the SMS and saved his crop along with minimizing input costs.
4.	Name of Farmer: Mr. Bisupati Barman State: West Bengal; District: Coachbihar	He is a member of Rabindranath Farmers Club of Mathabhanga, Coachbihar. He got weather update of IMD through RML. He claims it was very good content and effective too. The weather content which he got totally matched with the weather of his area. It helped him to take decision when to spray pesticide on the crop. He said if he would get such type of content more, it would help him to take proper decision for management of his crops.
5	Name of Farmer: Shri Narayan Bhai Chawda (KrishiPandit), State: Madhya Pradesh; Village: Gomchi; District: Raipur	Since 1992, I have been getting these weather based agro advisories regularly on the evening of every Tuesday and Friday. Although, we have been involved in agriculture since last 30 to 35 years, these agro-advisories are certainly playing very important role in planning our agriculture activities. Vegetables and the cereals are the major crops grown in my agriculture farm.

6	Name of Farmer: Shri Jayant Bhai Taunk, State: Madhya Pradesh; Village: Doma, District: Raipur	Weather forecasts and agro-advisories issued by the university are definitely playing an important role and I am very much dependent on AAS bulletins for scheduling different agricultural operations like fertilizer application, spraying of weedicides and pesticides, drip irrigation etc. I am very much interested in satellite pictures. It would be better if these pictures appear in local Newspapers every day.

Mahindra Agri business implemented a partnership project on Agro-met advisory in five district of Maharashtra. Basically their analysis is on use of son's advisory to farmers. Their conclusions are:

1. SMS service module is working effectively in delivering SMS to customer base. 90% of the customers receive weather advisory through SMS.
2. Farmers are receiving SMS advisory. Most of the farmers are receiving advisory SMS twice a week.
3. 47% farmers requires customized communication 53% find the messages to be relevant to the crops grown.
4. In answer to "weather communication is useful?"- more than 85% farmers find the message to be useful for them and only 3% feel that the message is totally out of context for them while rest felt that climatic condition are not specified. It is a very generic message and message is incomplete.

NCCSD Approach for Climate Smart Agriculture (CSA)

The top-down approach starts from global climate information and moves down to national & state levels for local projections and its impact analysis.

The bottom-up approach, on the other hand, considers the present as the point of reference and focuses on social and economic areas of vulnerability or potential impact as a basis for considering future vulnerability at local level. The emphasis is on community-based participatory assessment and action involving stakeholders – understand how they are managing situation? What do they know and what new measures they need to take to have sustainable livelihood.

The NCCSD approach is mix above both. First based on available data experts identify local impact and solutions. This is followed by farmer's interaction with experts. In this, first experts present overall picture and advise what is to be done. This is followed by listening to farmers to understand:

I. What do they know about the climate change?

II. What measures they are taking based on their own knowledge?

III. What they have understood from extension network and followed?

IV. What are their needs – problems?

This is further followed by action research to identify the real gap and possible solution. All these are converted into simple guidelines which are placed before Expert Committee for vetting it. The final step is to develop guidelines based on local input, available practices at international and national level and come out with basic framework of guidelines which farmers can follow generally. These guidelines are also for other stakeholders – the district level agricultural team, Krishi Vigyan Kendras (KVKs), ATMA, Extension Education Team of State Agricultural Universities (SAUs) and local level leaders – Sarpanches, Cooperatives, Self-Help Groups (SHGs), APMC and even input dealers.

This is followed by actual Capacity Building Programmes at Block Level. Farmers are also provided learning material in form of "Guidebook" – known as "Badlata Havamanma Kushal Kheti". Finally, at the end of the season, the participating farmers are contacted on sample basis, to know what actual benefit they received and what continue to be remain as problem for which they want solution. Simultaneously based on information gathered and needs identified the block level and district administration are sensitized for issues related to programme implementation while the State Government and Central Government are advised about suggestions for strengthening policies and schemes.

NCCSD's Case Study at State Level

Objective

1. To bring awareness among the farmers regarding the issues of Climate Smart Agriculture
2. To develop understanding regarding how this issue arises and what are the effect of climate change in agriculture and livestock
3. To impart knowledge of improve recommended agriculture practices varieties and contingent plan which are more suitable and appropriate in climate change situation.

Methodology

- The study was designed to collect data from two broad categories of farmers those who were trained and those who were not trained.
- These two groups of respondents were compared for their level of image, comparison for their level of knowledge and comparison for their level of modern farm technology they had adopted.

- This was supported to give a comprehensive picture of the image and impact of capacity building training programme for the farmers.
- The study was conducted in three selected districts (Anand, Navsari & Kutch). 12 taluka and 20 villages were selected. From 20 villages 200 trained and 200 untrained farmers were selected.
- The data were collected by using an interview schedule constructed for this purpose. Some of the valid scales designed by earlier research workers were also used. The data collected from the farmer respondents were tabulated.
- The data had been analyzed and described in terms of percentages. The statistical method employed for analyzing the data were average percentage '+' test, X2 test.

Table – I: Distribution of Trained and Untrained Farmers According to their Age, Education, Size of Land Holding and Type of Family

Socio-Economic and Psychological Characteristics	Trained Farmers		Untrained Farmers	
	No.	%	No.	%
A. Age				
Young Age (Below 30 Year)	14	7.00	21	10.50
Middle Age (31 to 50 Year)	106	53.00	103	51.50
Old Age (above 50 Year)	80	40.00	76	38.00
	200	100.00	200	100.00
B. Education				
Primary	40	20.00	48	24.00
Secondary	142	71.00	140	70.00
College	18	9.00	12	06.00
	200	100.00	200	100.00
C. Size of Land Holding				
Small Land Holder (0 to 1 ha)	36	18.00	38	19.00
Medium land Holder (1.1 to 3.00 ha)	120	60.00	128	64.00
Large Land Holder (3.1 & above)	44	22.00	34	17.00
	200	100.00	200	100.00
D. Type of Family				
Joint Family	32	16.00	42	21.00
Nuclear Family	168	84.00	158	79.00
	200	100.00	200	100.00

Table – II: Level of Image of Trained and Untrained Framers about Training Programme for Farmers on Climate Smart Agriculture

Level of Image	Trained Farmers		Untrained Farmers	
	No.	%	No.	%
Incorrect Image (0.00 to 4.00 Score)	08	4.00	176	88.00
Correct Image (4.1 to 8.00 Score)	192	96.00	24	12.00

Table – III: Comparison between Trained and Untrained Farmers in respect of their Image regarding Training Programme for Farmers on Climate Smart Agriculture

Farmers	No.	Mean Score of Image	Sampling Variance (S^2)	'+' Value
Trained Farmers	200	6.5	1778.71	30.65532
Untrained Farmers	200	2.6	316.57	-

Table – IV: Level of Knowledge of Trained and Untrained Farmers regarding Improved Recommended Technology under Climate Smart Agriculture

Level of Image	Trained Farmers		Untrained Farmers	
	No.	%	No.	%
Low Level of Knowledge (0 to 10 Score)	4	2.00	154	77.00
Medium Level of Knowledge (11 to 25 Score)	12	6.00	38	19.00
High Level of Knowledge (26 to 38 Score)	184	92.00	08	4.00
	200	100.00	200	100.00

Table – V: Comparison between Trained and Untrained Farmers in Respect to their Knowledge regarding Recommended Technology under Climate Smart Agriculture

Farmers	No.	Mean Score	Variance	'+' Test Value
Trained Farmers	200	36.15	3098.35	15.775 (*)
Untrained Farmers	200	26.4	983.00	-

Table – VI: Level of Adoption of New Recommended Technology under Climate Change Situation by Trained and Untrained Farmers

Level of Image	Trained Farmers		Untrained Farmers	
	No.	%	No.	%
Low Level of Adoption (0 to 1 Score)	0	00.00	181	90.50
Medium Level of Adoption (2 to 3 Score)	10	05.00	113	6.50
High Level of Adoption (4 to 5 Score)	190	95.00	6	3.00
	200	100.00	200	100.00

Table – VII: Comparison between Trained and Untrained Farmers in Respect of their Adoption of New Recommended Technology under Climate Change Situation

Farmers	No.	Mean Score	Variance	'+' Value
Trained Farmers	200	4.635	3505.6	30.48097 (*)
Untrained Farmers	200	2.503	2364.4	

Table – VIII: Suggestions of Trained and Untrained Farmers about Training Programme for Farmers on Climate Smart Agriculture

Sr. No.	Suggestion	Trained Farmers		Untrained Farmers	
		No.	%	No.	%
1.	Cluster wise Special Training Programme for Farmers	156	78.00	129	64.50
2.	Group wise Organization of Farmers Shibir	104	52.00	23	11.50
3.	Provision of Stripand	74	37.00	118	59.00
4.	Providing the literature of climate change and its effect of trained and untrained farmers	172	86.00	134	67.00
5.	Providing vehicle facilities to participant farmers	138	69.00	182	76.00

Summary of findings: Socio Economic Characteristics of Trained and Untrained Farmers.

1. Age, Education and Size of Land Holding

A middle age farmer having educational qualification of secondary or higher secondary school certificate had come for Capacity Building Training Programme for taking training. Same way a medium size land holders who had nuclear family were found to be in majority among the trained and untrained farmers.

2. Image of Training Programme

About 96.00% of trained farmers had correct image regarding Capacity Building Training Programme on Climate Smart Agriculture

3. Knowledge of Trained and Untrained Farmers

About 92.00% of trained farmers had high level of knowledge of improved recommended agricultural practices. It was observed that trained farmers had significantly higher knowledge than untrained farmers.

4. Adoption of New Recommended Cultivation Practices

Out of 200 trained farmers 190 trained (95%) had new agricultural practices - while 90.50% of untrained farmers had adopted low level of adoption. It was observed that trained farmers had significantly higher adoption level than untrained farmers.

Also it is important to realize that erratic weather changes have already brought huge adverse impacts on the entire Agriculture Sector, Crops – Horticulture, Livestock and Poultry – Birds and Fisheries. But this can be mitigated by (a) advance information and warnings by meteorological department though FM Radio & TV (b) Agro-Advisory on information of impending weather forecast and un-usual pattern provided by Krishi Vigyan Kendras (KVKs) which interlinked with India Meteorological Department (IMD) on internet. In the Farmers Interaction Meet with Experts during National Conference organized by NCCSD at Anand Agricultural University (AAU) – March, 2013, it was revealed that only 10% of farmers have access to weather forecasting.

Conclusion

Farmers appreciate the weather/rainfall advisory service very much but it should be

- **Crop Specific Advisory:** Farmers further demand crop specific SMS. Management of crop specific data is a challenge due to change in cropping patterns.

- **Mobile Compatibility:** Decoding SMS in a regional language is an issue with few farmers
- **Feedback Mechanism:** There is no close loop in the information advisory. Contact mechanism has to be designed
- **On Demand Advisory:** Farmers look for a on-demand advisory through ICT route. Follow up for an SMS received by them

Apart from this it is important to consider

1. Estimation of Soil Moisture Based on Satellite Data

- Technology developed by ICRS, Jodhpur is being operationalized in Agrimet Division, IMD, Pune for estimation of soil moisture for the states Gujarat, Madhya Pradesh and Uttar Pradesh.
- Maps have been generated on experimental mode in near real time using satellite data viz. soil moisture and brightness temperature data received from SMOS, NDVI values from MODIS and LST values from SSMIS sensors

2. Remote Sensing and GIS in AAS

Remote sensing based products can assist in selecting sowing/harvesting time, scheduling irrigation, nutrient management, pests and diseases management, intercultural operations, besides defining the initial condition of the atmosphere for Numerical Weather Prediction models.

The areas where Remote Sensing products will be useful are the following:

- o Soil (moisture, temperature, nutrient, erosion)
- o Crop (coverage, vigor, yield assessment)
- o Crop Sowing/Harvesting Time
- o Forest Status Monitoring & Forest Fire
- o Biotic & Abiotic Stresses On Crops
- o Pest Disease Surveillance
- o Analysis of agro meteorological information using GIS is useful to find
- o Potentiality of the area for a particular crop
- o Expected crop yield
- o Estimation of crop suitability, integrating factors affecting them under GIS environment
- o Evaluate risks and suggest alternative crops or cropping system for an area.

Tools used and the products emanating from them, must be supported by a physical and computing infrastructure that allows for software development and use, and an accessible web platform. These must also be managed by competent IT personnel.

3. Engage Farmers in Developing Advisories

a) Use farmer developed decision trees with weather forecast info as triggers;

b) Discuss what added value they need as well as T & rain;

c) Add this info with the choices to weather forecasts;

d) Use crop model outputs to give gradients and range of coping strategies according to different conditions e.g. (i) Cultivar choice (ii) Planting dates (iii) Plant population and (iv) Fertilizer amounts & application timing

e) Brainstorm & discuss options for presentation & dissemination methods;

f) Meet other farmer groups to test various interventions -engage in discussion & questioning.

Farmer's want accurate information of local and block level weather forecasting

Numbers of training programs are conducted for farmers by Government organizations like ATMA, KVKs, River Board and NABARD as well as by Non-Government organizations like NGOs, Civil Society Organization & Corporate through their CSR. But there is lack of integration of importance of weather forecasting in to their training module. So there is an urgent need to develop a common module which focuses on weather forecasting in relation to climate change to facilitate farmers so that they can mitigate the impacts to maintain their productivity.

Capacity building programmes should be organized for SAUs, KVK, ATMA, Local level leaders, Local extension team, Farmers, Input dealers, Marketing chains and APMC retail marketing as well as wholesalers.

Training should be organized on:

- Climatologically analyses particularly of rainfall and temperature
- Weather forecasting and services specific to agriculture
- Micro-meteorology
- Crop water use and irrigation management
- Crop simulation modelling
- Role of Meteorology in crop protection, including pests and diseases modelling
- Weather, Climate and Livestock, poultry and fish production
- Climate Change and Agriculture
- Geographic Information Systems and Remote Sensing in Agro meteorology.

Training for Extension Officers

- Agriculture Extension Officers have been providing important advice and support for farmers.
- However, it was found that most of these officers are ill-equipped to provide important advice with respect to weather and climate issues.
- In an era of changing climate and increased weather and climate risks, advice on these issues is becoming increasingly important.
- Extension Officers must therefore be made better equipped through training in relevant aspects of agro meteorology.
- Also critical is that the awareness training continue for farmers in the interpretation of weather and climate information, as this would boost decision-making at the level of the unit of production.

It is important consider weather forecasting from planning perspective by keeping in mind.

User Requirements

- The types of economic decision which require agro meteorological products can be categorized according to three time scales:
- Long-term planning for agricultural development (rational allocation of land, choice of crops, selection of species and varieties).
- Medium-term planning for the next season (choice of farming area, crop varieties, etc.);
- Short-term decisions regarding imminent farming operations (choice of optimal sowing and harvest dates, dates and quantities for fertilization, dates and quantities for irrigation, etc.).

Service Requirements

- To establish the worthiness of the service: Economic impact has to be carried out in order to know its potential benefits.
- Service credibility: Credibility is always closely linked to forecast verification. Hence economic impact studies need to be carried out to establish credibility in the eyes of the potential users if optimum benefits are to be derived from the marketing of the service.
- Service accountability or justification: Assessment of the service helps justifying the costs and the ongoing need and existence of such a service.

References

Anupama Mahato (2014), Climate Change and its impact on Agriculture, International Journal of Scientific and Research Publications Comparative analysis of Turral et al., 2011; Comprehensive Assessment, 2007

Dr. D. P. Dubey, Scientist, Indian Meteorological Department, Presentation on Weather, Climate& Water services,

Dr. Gurpreet Singh, RMLISPL, Presentation on Development of Feedback Mechanism & Assessment of Agro-met Advisories of 39 AMFUs in India

Dr. N. Chattopadhyay Deputy Director General of Meteorology (Agrimet), Agricultural Meteorology Division, IMD, Presentation on Gramin Krishi Mausam Sewa: Achievements and Future Plan Fifth Assessment Report, Intergovernmental Panel on Climate Change

Kumar and Gautam (2014), Climate Change and its Impact on Agricultural Productivity in India, Journal of Climatology &Weather Forecasting

Mahindra ????

National Mission on Sustainable Agriculture, Ministry of Agriculture, Government of India

VUM Rao, PC Agronet, Impacts of Climate Change on Indian Agriculture

•

Doubling of Income of Farmers - Role of Stakeholder

• Dr. R. S. Sodhi •

Doubling of Income of Farmers - Role of Stakeholder

Almost a century ago, Mahatma Gandhi said, "The soul of India lives in its villages". More than 70 years later, with 70% of our citizens residing in rural India, this statement still stands true and agriculture remains the backbone of the Indian economy. Currently, our economy is pegged at the USD 2.9 lakh crore mark and expected to achieve USD 5 lakh crore by the year 2025-26.

The Indian economy has been developing continuously over the past seven decades and has achieved an extremely positive and vibrant growth in agriculture, manufacturing and the services sector. Green revolution has helped us in achieving food grain sufficiency. However, in spite of huge growth in grain production, the contribution of agriculture to national GDP is continuously declining. India had a GDP of about USD 20 billion during Independence (nominal, at market price) and a population of 36 crores, 75% of which depended on agriculture for its livelihood and accounted for around 70% to National GDP[1]. In the year 2018, the India's GDP was of USD 2.9 lakh crore (USD 2.9 trillion), at a population 135 crores, out of which 58% were dependent on agriculture for its livelihood and accounted for around 17.5%[2] of the GDP. Also the growth in output did not necessarily translate into the growth of farmer's income.

The net result remained that the farmers' income did not increase substantially. Thus, the current reality of India is that half of its population dependent on agriculture gets 1/7 of its income. The per capita income disparity is 6:1 between those outside agriculture and those depending it, at USD 3,100 Vs USD 500 (as against near parity at Independence).

The consequence of this outrageous rural – urban income gap is urban migration, which has ultimately led to the shift of labour from agriculture and allied activities to the industries. Thus we are in a situation where we have more mouths to feed and fewer hands to produce.

As per NSSO 2013-14 report, the approximate monthly income of a farmer is Rs. 6426. Despite having the maximum contribution in the income structure,

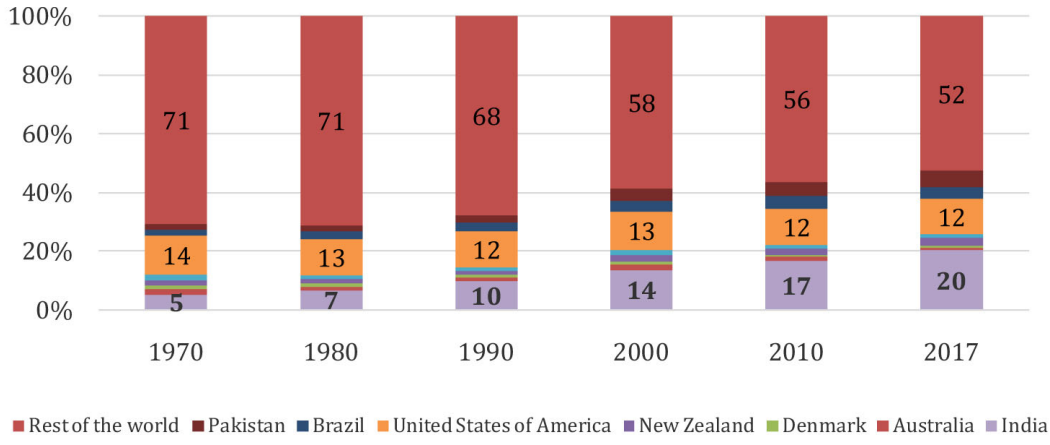
1. Eighth Manu Shroff Memorial lecture by Dr. Shreekant Sambrani
2. Ministry of Statistics and Programme Implementation

the cultivation segment had a Compounded Annual Growth Rate (CAGR) of only 3.7% while Livestock segment grew at a CAGR of 14.3% during the year 2003 to 2013. In the current scenario a growth rate of 10.4% is required to achieve the goal of doubling farmers' income by 2022. Therefore, it is evident that dairying and animal husbandry is one of the better alternatives of livelihood to bring a significant rise in the farmers' income.

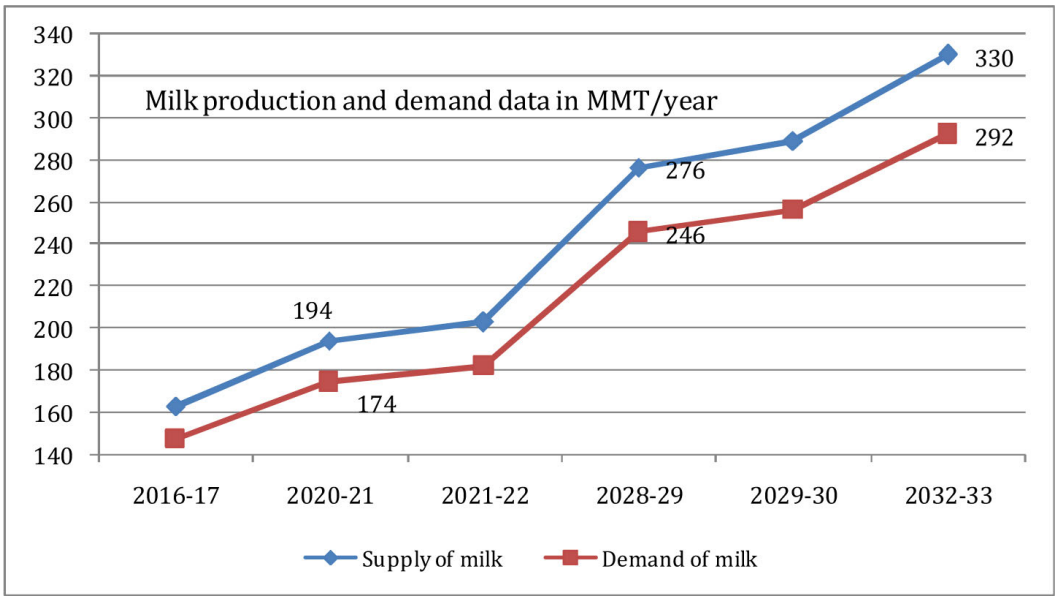
Table-1: Farmers' income contributing factor

Particulars	Amount (Rs/Month)	% of Income	% CAGR Growth in Come from Various Sources During 2003 to 2013
Cultivation	3078	48	3.7
Livestock	765	12	14.3
Wages/Salary	2069	32	1.4
Non-Farm Business	514	8	-0.1
Total Farmers Income	6426	100	3.4

After Operation Flood, the Indian dairy and animal husbandry sector which currently contributes to around 4.2% of National GDP, emerged as a primary source of income for about 10 crore rural households—most of them are either landless, small or marginal farmers. India has been the largest milk producer country of the world for the last 21 years. The current milk production of India stands at around 176 MMT[3] (Million Metric Tonne) per year (48 crore liters per day) which is around 20% of the world's total milk production compared to around 5% during 1970's. Milk production in India has been growing at



3. National Dairy Development Board, Anand



a CAGR of 4.5% for the past 20 years, compared to a global CAGR of less than 2%. The total value of milk production in India is around INR 7 lakh crores (USD 100 billion) which is more than the total value of all pulses and grain put together.

It is also estimated that India shall produce around 330 MMT (91 crore liters per day) of milk during the year 2033-34 and around 30% of total world milk production[4].

Indian milk producer shall produce desired quantity of milk as Indian dairy cooperatives are paying around 71%-75% of consumers Rupee to milk producer members compared to 27%, 30% and 40% by Australia, European Union and New Zealand respectively.

India is not only the largest milk producer of the world but also the largest consumer of milk globally. It is also one of the fastest growing markets for branded dairy products. India's per capita milk availability is around 375 gm/ day/person which is higher than the global average of less than 300 gm/ day/ person[5].

The dairy sector is laden with opportunities due to the growing consumption of milk and milk products. Increasing population, increasing purchasing power of customers and the changing food habits are the main drivers of demand

4. NITI Aayog's Working Group Report (Feb 2018) on Demand and Supply Projections towards 2033 for Crops, Livestock, Fisheries and Agricultural Inputs

5. National Dairy Development Board, Anand

in the dairy sector. Current organized dairy industry is around Rs. 1.7 lakh crores. The industry is expected to grow around 14% CAGR till the year 2030 and expected to reach around 9 lakh crores.

Expected increased of population from current 135 crores to 170 crores during the year 2050-51 and urbanization from 30% to 50% shall definitely increase demand of milk and milk products. To fulfil the demand of milk and milk products in India, an increase milk processing capacity will be required from current level of 9 crore liter per day to 30 crore liter per day and which has the potential to generate employment for around 130 lakhs individuals.

Realizing the importance of dairying and animal husbandry for doubling farmers' income Government of India has created separated ministry for better monitoring and resource allocation. Government of India had also allocated INR 3000 crores for animal husbandry and dairying activities for the year 2019-20.

In spite growing at much faster than agriculture, Dairying and Animal Husbandry sector does face a few challenges which are as follows:-

1. **Dairy Industry is not Considered as Priority Sector:** The Reserve Bank of India (RBI) focuses on the "priority sector" for its lending but when it comes for disbursement of short term and long term loans, dairy cooperatives are not treated as "priority sector" category of direct finance to agriculture.
2. **Analogue Products:** Companies are selling various products by replacing animal fat by cheap vegetable oil and pass off the various analogue products to butter, cheese, paneer, powder, ice cream, khoa etc. as dairy products. Such analogue products are not cheating the consumer but indirectly reducing the payout to milk producer members.
3. **Free Trade Agreement:** All countries are protecting their farmers' interest. Government of India should also protect the interest of milk producer members by not allowing import of dairy products. Dairying should be excluded from all Regional Comprehensive Economic Partnership (RCEP)
4. **Income Tax and GST on Dairy Industry:** To increase payout of milk producer members, there is a need to reduce tax on various milk products. Reduction of tax not only increase farmers' income but also increases the milk consumption among urban consumer.
5. **Milk Productivity:** During last 20 years, milk productivity of bovine population has increased from 740 Kg/animal/year to 1400 kg/animal/year[6]. Though productivity has increased by around 90% during last 20 years, it is still lower than other dairy developed country. To increase the

6. International Farm Comparative Network 2018

milk production and productivity, Artificial Insemination (AI) which is around 30% should increase. Expansion of AI network, strengthening of semen station, selection of superior quality of germplasm and continuous training and monitoring of AI worker is the key to get the desired results.

6. **Feed and Fodder:** Feeding is contributing around 70–75% of total milk production cost. To improve milk producer members' income, there is a need to reduce cost of production. Appropriate technology like convert low nutritive value roughages to high nutritive value roughages, silage making, area specific mineral mixture, cattle feed based on animal physiology need to provide to milk producer members at reasonable cost.

Apart from this, sector faces a challenges like incentive required for expansion and modernization of milk processing plant, expansion of cost effective supply chain, development and training of quality manpower, continues training of milk producer members etc. Effective convergence among all the stakeholders to route all the benefits to the producer are some of the initiatives that can translate into doubling of farmers' income through dairying. There exists a popular misconception in the society that bovine population is responsible for greenhouse gas emission however there is no concrete evidence or research to prove this claim. In fact, the technology is available where animal dung can converts into Methane gas by establishing biogas plant.

Dairying in India has been a source of sustainable income, tool for poverty alleviation by creating livelihood opportunities, insurance for livelihood security and an instrument of bringing about a social change in the lives of 10 crores rural household. Dairying is not only a major economic activity but also an integral part of our social and cultural heritage. Its uniqueness lies in its unifying power, in the fact that there is no other industry that touches the lives of millions of farmers. The dairying and animal husbandry activity is also insulating farmers from draught like situation by providing ensure income.

Doubling of farmers' income by 2022 is quite challenging but it is need of the hour and can be achieved with focused interventions and strategies. Dairying has vast potential to support in increasing farmers income with interventions in the sector for increasing milk production, improving milk productivity of animals, infrastructure development and appropriate reforms at policy level. This will surely place dairying on a growth path, which will ultimately lead to achieve the Hon'ble Prime Minister's mission of doubling of farmers' income by 2022.

Gujarat Cooperative Milk Marketing Federation Ltd., (AMUL) which is India's largest food products organization with annual brand turnover of Rs.

45,000 crores (USD 6.5 billion) during 2018-19 has successfully increased milk producers' income by almost 5 times in just 9 years. During the year GCMMF had procured 91 lakhs liters per day of milk which increased to 230 lakhs liter per day during the year 2018-19 which shows growth of 153% in milk procurement. During the same period, price paid milk producer member is also increased from Rs. 337 per Kg fat to Rs. 690 per Kg fat thus showing the growth of 105%.

Today, Amul is procuring around 230 lakhs liters of milk from 36 lakhs milk producer members of more than 18,600 villages of Gujarat, India. In terms of milk procurement, Amul is 9th largest dairy organization of the world. Amul is supplying milk and milk products to billion of Indian consumer through its 10 lakhs retailers.

Amul is continuously arranging training programmes for milk producer members so to improve milk production and milk productivity. To improve the health and productivity of milch animal is prime concern of Amul. During 2018-19, around 50 lakhs animals treated by 1,000 veterinarian and similar number of semen doses used for Artificial Insemination purpose by Amul. Further, Amul is also producing around 9,000 MT of cattle feed per day and supply the same at farmers' doorstep with "No profit No loss basis"

Dairying is not only a major economic activity but also an integral part of our social and cultural heritage. Its uniqueness lies in its unifying power, in the fact that there is no other industry that touches the lives of millions of farmers.

"Man power without unity is not a strength unless it is harmonised and united properly—then it becomes spiritual power." - Sardar Vallabhbhai Patel.

•

The Income and Livelihood of Small and Marginal Farmers in Gujarat

• Dr. R. V. Vyas •

These are the challenging times, and during this how the agriculture in the state of Gujarat shall respond to the crisis and how do the government measures can positively affect lives of farmers, especially the small and marginal farm households across the state? We assess the immediate challenges that COVID-19 has posed to the farm sector, and suggest mitigation measures to ensure a sustainable food systems in the post-crisis period. Also we suggest the measures that will help in enhancing the incomes thereby uplifting the status of livelihoods of farmers, especially the marginal and small ones.

It is to mention that the state grows cereals, pulses, oilseeds especially cotton and groundnut, and is also among the major growers of horticultural commodities like potato, mango, sapota, pomegranate, cauliflower, cabbage, chilli, capsicum, etc. During the lockdown measures that followed in order to arrest the spread of COVID-19, it has been observed that the supply chain disruptions caused the farmers to suffer and lose their incomes. The disease appeared at a time when the crops were standing in the field for harvest and procurement operations were to start. Following social distancing guidelines, and due to the panic the disease triggered, markets also suffered disruptions in initial stages (during first lockdown).

Looking at the situation that emerged in the fight against pandemic COVID-19, it calls for a set of quick reforms that result in upgrading the livelihood and enhance incomes of the farmers. We shall enable a mechanism through such reforms where farmers need not to go to the market to sell the produce but the produce shall automatically be sold. And to facilitate this, the quality certification, grading etc. shall be done at the farmers' doorstep using the infrastructure available. If there is no infrastructure, it shall be developed. Following reforms are the need of the hour in these testing times of pandemic to strengthen the farmers in the state. These are especially targeted for uplifting the status of the marginal and small farmers. Most of these reforms are needed in the marketing and distribution aspects of the supply chain. Furthermore, these measures emphasize to move agriculture to agribusiness enterprise and adopt holistic approach. These measures can be best summarized under broad categories as follows:

1. **Strengthening of Logistics and Infrastructure:** Poor infrastructure leads to fragmented supply chains and ultimately results in poor returns to the farmers and other stakeholders as well. The supply chain linkages can be created through appropriate intervention through logistics and infrastructure development. The state government must make sure that the cold chain infrastructure is appropriate for the storage and movement of perishables so that their shelf life is not compromised until they reach the consumers. This in turn would generate better returns for the farmers. The private sector investment or private public partnership model can be attracted in the state to develop suitable infrastructure for movement of perishables. If this is not addressed, it may force farmers to shift to move away from perishables causing supply disruptions, and price instability in both perishables and non- perishables. The appropriate incentives shall be given to the farmers under current scenario, so that they are not discouraged from producing perishables. Much on this is already proposed in the state budget. This shall be expedited. The price crash in perishables need to be prevented via suitable services.
2. **Promotion of Quality Testing, Grading and Standardization at Farmers' End:** The state shall have a very strong quality testing, grading and standardization program driven by consumer preferences viz. retail consumer preferences, industrial consumer preferences, and also other consumer preferences like the one coming from livestock, poultry etc. The FSSAI, BIS, AGMARK standards shall be followed. But grading and sorting at farm level shall be encouraged as this enhances the bargaining capacity of the farmers. Today the farmers face trouble as these systems are not in place. Once such infrastructure is established, the logistics will automatically be a cakewalk, leading to achieving the cost efficiencies, remunerative price of the product further leading to production efficiencies.
3. **Setting up of Warehouses and Promotion of Warehouse Receipt Financing:** There is a greater need to develop warehousing in the identified clusters (according to the crops and the requirements), and push warehouse receipt financing more aggressively as explained above. This will help: a) prevent losses, b) release product as per demand avoiding price crash, c) prevent income loss to farmers, d) maintaining the quality of the produce. So the bulk buyers can directly buy from the warehouses. In other words, the pledging of warehouse receipts shall enable farmers to wait for a better price. He can get a loan from the bank for next crop or marketing operations, and later shall be able to pay the money electronically to the bank to release the pledge and then sell the receipt on the same platform. In case of default

by the farmer, the bank is enabled to sell the receipt on the same platform.

Mukhya Mantri Pak Sangrah Yojana, under which in the current budget a provision is made that the farmers will be provided subvention of Rs. 30,000 per unit for construction of small godowns in the farm, to prevent crop losses on farm, shall be implemented on a fast track mode. It could directly be linked to the post harvest management and is expected to influence Farmers' income.

4. **Promotion of Farmer Producer Organizations (FPOs):** FPOs play a bigger role in aggregating. FPO model gives the strength of various other activities like input provision, agri-mechanization etc. Farmer Producer Companies (FPC's) shall be promoted and due support shall be given to them through the experts to prepare a sustainable business plan for them. This will help in creating the forward and backward linkages by linking the product to the market. Also, it will enhance the bargaining power. FPCs shall be more promoted in the case of perishables. The Government shall provide consultation services to the FPCs. This can be done with the appropriate intervention from NABARD, SAUs, incubator centers etc. The proposed FPO based infrastructure cluster development for Banaskantha, Jamnagar and Kutch districts shall be enrolled for entire state. As proposed, in future these clusters will integrate with e-NAM in such a way that local farmers will be able to sell their produce directly in State and in International market as well. However, this is the right time that this activity is picked up-with right institutional intervention.

5. **Contract Farming and Direct Marketing:** The state has modified APMC Act allowing contract farming and direct marketing. Contract farming, which is being seen as vital for farmers, particularly for small and marginal farmers, can be successful to realize its actual potential.

   For making contract farming successful, the state government should direct the APMCs in an effective manner. The fear of losing income from the APMCs, if contract farming system succeeds, needs to be removed from the mind of staff and department concerned.

6. **Demand Based Production:** It is expected that the food demand may take a sea change with more emphasis on nutrition so that the immunity can be enhanced. This aspect of changing consumerism needs to be amalgamated in the production systems. It is thus desirable to switch over to a suitable model with a far stronger nutrition focus where diets are more diverse. A post-COVID-19 situation offers that unique opportunity to repurpose the existing food and agriculture policies for a healthier population. All

consumers including farmers need to be healthier and therefore the model in consultation with the experts shall be prepared and Good Agricultural Practices for a suitable crop plan shall be followed. When the production is demand based or satisfies the need of the consumers- industrial and households, the product gets remunerative price. Marketing is need based exercise. Market demand shall be assessed thoroughly and shall be communicated to the farmers with respect to the crop variety grown and good agricultural practices. This is called market intelligence.

7. **Strengthening of Market Intelligence:** There is high need for agricultural market intelligence system in the state for all crops including fruits and vegetables. It thus comprises both demand estimation and price discovery. Price discovery is basically finding the equilibrium market price of a commodity as a result of the factors affecting its demand and supply. It is rather a central function in any marketplace whether a commodity exchange or a farmers' market. The marketplace brings several potential buyers and sellers together, having specific reasons to trade. By allowing all of them to come and interact together to make the trade deal happen (at an agreed price between the buyer and seller) for a commodity with specific quality, grade and standards, the market actually allows all the participants to interact and in this process establish a consensus price. Enhancing income and livelihoods is not possible unless market intelligence is strengthened. Extension services and field staff shall work more closely as a linkage between the farmers and the Agricultural University Research systems.
8. **Smooth Mandi Operations:** The model APMC Act shall be effectively implemented. The Government must gear up its machineries for smooth procurement operations of farmers' marketable surpluses at MSP (minimum support price) or through other price support schemes. The farmers shall be promoted to sell the product freely to the mandis across nation (with the new central trade act coming up). It will ease the burden on farmers. Besides, health care facilities in APMC yards shall be created and mandatory health guidelines for farming and related operations shall be prepared and implemented.
9. **Promoting e-NAM and Direct Marketing:** e-NAM shall be effectively implemented. In these crisis time with appropriate infrastructure, e-NAM could have played a crucial role. Immediate attention is required to use this platform effectively as it has huge potential. Direct marketing shall be promoted. Efforts shall be made to connect the markets effectively with other markets in the nation. Cluster approach shall be adopted in the

production and marketing. Innovative models in markets shall be adopted. The farmer bodies in consultation with Agril. Universities and industry may devise a suitable model for marketing of perishables.

10. **State Specific Agri Export Policy on Ground of National Agri Export Policy shall be Devised to Promote Exports from the State:** World over food and vegetable supply chain is broken and there is a tremendous opportunities for Indian farmers with support of Government policies and APEDA farmers can earned better and compensate losses due to lockdown.
11. **Strengthening e-Commerce:** e-Commerce and delivery companies and start-ups need to be encouraged with suitable policies and incentives.
12. **Farmers Export Consortium and Organic Farm Market at APMC:** In order to facilitate export of agricultural commodities, trade related procedures and documentation required must be directly routed to the farmers through setting up of Farmers Export Consortium at APMCs. This will help farmers understand global market along with necessary compliance of quality norms in the world market. Also, sharply growing market of organic farming globally and locally and Gujarat being the only state having set up the country's only university focusing on organic farming requires special attention on Organic Farm Market to harness the potential benefit in this area.
13. **MSP and Market Incentive Scheme:** MSP is only in selected crops. It should cover all food grains. For fruits and vegetables market incentive scheme should be made effective so that farmers could be assured of no loss during unfavorable market condition. *Bhaventar Yojana* (price difference scheme) of Government of Madhya Pradesh can also be helpful in reducing the market risk if implemented in letter and spirit.
14. **Crops and Livestock Insurance:** Crops and livestock insurance has not attracted the farmers sufficiently. Lack of awareness and complexity involved are the major problems which need to be addressed effectively. Hundred percent subsidy in case of small and marginal farmers, encouraging PPP mode and adopting the system similar to human insurance where in commission agents play a vital role, can go a long way in making crop and livestock insurance effective.
15. **Agro Service Centers and Input Dealers:** Agro Service centres and input dealers play an important role in providing agri inputs, services and advisories to the farmers. Involvement of input dealers and agro service centres in extension activities is vital for making agriculture attractive and paying proposition to the farmers. They are more close to the farmers in

addressing their agriculture related problems as well as others. They need to be incentivized for their services to the farmers through appropriate policy. Capacity building of the owners of agro service centres and input dealers is also very helpful in this context.

16. **Promoting Custom Hiring Centers:** To obviate the immediate concerns of scarcity of farm labour, policies must facilitate easy availability of machinery through state entities, Farmer Producer Organizations (FPOs) or custom hiring centers (CHCs) with suitable incentives. It is also suggested to explore leveraging MGNREGS funds to pay part of the farm labour (with farmers paying the balance wage amount) to lessen the monetary burden on the farmer, while ensuring wage employment to the landless labour and workers.
17. **Agri-preneurship:** Students should be provided collateral free institutional loans at low rate of interest up to Rs. one crore for starting agri-business against bankable projects. This will not only help agri-preneurship in agriculture and allied activities, which is need of the hour and focused area of the Government policy, but will also transform agriculture into agribusiness and attract the youths who are losing interest in agriculture. Preference should also be given to the students having their project work in the broad area of crops grown and other livelihood activities done by tribal people.
18. **Strengthening Farm Advisory System:** To answer queries relating to the announced measures of Government and addressing grievances of farmers, besides providing advisories on farm operations; availability of agri-inputs, dedicated toll-free helplines/call centers (in local/vernacular languages) must be established in good numbers by the Government. Set up Agri clinics for real time information on prices and markets and also for the effective use of inputs and resources.
19. **Primary Processing Shall be Promoted to Avoid Post Harvest Losses Due to Unavailable Market:** Urgent establishment of Cluster based post-harvest handling cum primary processing centers equipped with required modern facilities is the need of the hour. Processing at village level shall be encouraged along with the branding, labelling and packaging. Mini Oil mill, pulse mill, rice mill shall be encouraged at village level. The farmers shall be encouraged and supported to develop and adopt post- harvest technologies at village level. The state budget has already proposed two schemes, (i) Agro Processing Cluster and (ii) Food Processing and Preservation Capacities. These need a quick implementation. Value addition shall be encouraged at farm level.

20. **Encourage Diversification:** Farmers shall be encouraged for practicing diversification as per the Prime Minister of India declaration of doubling the farmers income. The state shall devise a suitable policy for sericulture, bee keeping, fisheries, poultry, along with dairy husbandry and enterprise for financial security and higher economic returns. There should be concrete crop diversification plan/alternate cropping patterns for every season which shall be implemented in adverse situations, and can be customized as per soil health card at farm level.

21. **General Points:**

a. Information and Communication Technology plays a crucial role. It shall be strengthened at all stages of supply chain. Availability of smart phones to farmers and their technical knowledge shall be imparted.

b. Awareness shall be created that poultry products are not the carriers of COVID-19, through media and mass coverage. This will help poultry farmers, who have made huge losses in the times of this pandemic.

c. Banking network shall be strengthened and institutional credit shall be expanded more. Financial support through crop loan *(PM Fasal Bima Yojana)*, and Kisan Credit Cards should be expedited.

d. Agriculture shall strongly be promoted on the lines of agribusiness.

e. Effective management of soil health through soil health card and use of bio fertilizers, bio-pesticides, Integrated Pest Management and Integrated Nutrient Management shall be promoted.

f. Rainwater harvesting shall be made mandatory and appropriate training shall be provided.

g. MIS coverage shall be extended. Community ponds (well maintained) on wasteland shall be promoted.

h. Encourage solar power embedded farming systems, including solar irrigation, solar gas, etc.

i. Establishment of fodder banks at Taluka level and development of pasture land.

•

National Council for Climate Change Sustainable Development and Public Leadership (NCCSD)

Building Self Reliant and ATMANIRBHAR- Climate Smart Farmers

In new millennium the world is facing challenge of climate change with increasingly unpredictable weather events and its intense adverse impact on habitat. The cause of climate change is global warming – increased Green House Gasses. Although global warming is international phenomena – its adverse impacts are at local level. The severely affected are villages- the farm land and the farmers. The increased floods, cyclones, delayed rains, droughts, heavy rains on one day, un-seasonal hot & cold waves, frost – all these lead to crop-failures – or low productivity-even the livestock & fisheries- also suffer from low productivity & mortality. This also causes challenge of food security.

It was in this context that Dr. Kirit Shelat initiated a dialogue by organizing an International Conference on "Global Warming, Agriculture, Sustainable Development & Public Leadership" at Gujarat Vidhyapith – Ahmedabad in March 2010. The outcome of conference was twofold. The Adviser to Planning Commission of India Dr. Sadamatev set up of a special sub group in Planning Commission on "Enhancing Preparedness for Climate Change" headed by Dr. Kirit Shelat and simultaneously Justice B.P. Singh, formally Judge of Supreme Court of India – thought of setting up a special purpose -NGO with focus on Agriculture – "National Council Climate Change Sustainable Development & Public Leadership-NCCSD at Ahmedabad.

Dr. M.S. Swaminathan, the vateran agriculture scientist – the leader of Green Revolution, Shri Purushottam Rupala, Dr Y.S Rajan & Shri Kantisen Shroff gave their blessing and support. The organization was rolled in September 2010 with Dr. Kirit Shelat as Executive Chairman and Justice B.P. Singh as its President

NCCSD initiated its mission by organizing think tank meets for policy formulation and capacity building training programme for farmers & youth. The focus was to prepare administration & farmers to meet challenges of Climate Change. This was followed by series of initiatives for *Atmanirbhar* Farmers:

- NCCSD participated in "Conference of Parties"- meets of countries organized by UNFCCC to meet the challenges of climate change. It was realized that 'Agriculture & Farmers' do not figure in COP discussions. The role of

agriculture as nature's tool for mitigation – was not recognized – NCCSD participated & organized side events & exhibition & also met senior leaders of International organization & explained how agriculture can mitigate the adverse impacts. By the process of photosynthesis proven which absorb CO_2 from atmosphere. Now by expansion of agriculture on wasteland, degraded lands can provide employment and additional food generation-while absorbing CO_2.

- NCCSD successfully prioritized agriculture in COP. The Paris Agreement accepted importance of food security, food productivity, technology transfer & capacity building.
- FAO also liked idea it created a special purpose organization called GACSA- "Global Alliance for Climate Smart Agriculture".
- At National level NICRA – National Institution for Climate Resilient Agriculture was initiated by ICAR. NCCSD took up 'Capacity Building' as part of it and developed Guide book for farmers for developing Climate Resilient Agriculture.
- NCCSD organized an International Conference on 'Climate Justice' in 2014. The Chief Justice of India inaugurated this. The issues related to farmers got focused & outcome was a liberal Crop Insurance Policy to cover even non-banker farmers and new APMC market reforms.
- In 2014 NCCSD initiated for technology transfer with Florida A&M University (FAMU), USA for Building Climate Smart Farmers. USAID helped FAMU to send US-scientists to train our farmers. Vivekanand Research & Training Institute- VRTI – Mandvi-Kutch- setup a Farmers Education Center. 26 Scientists from USA visited and trained farmers & trainers in this campus over a period of last two years. This is joint FAMU, NCCSD and VRTI project-with soil health lab, Weather forecasting centre ,demonstration farm and a farmer clinic.
- NCCSD has brought out book for farmers on "Building Climate Smart Farmers – A Guide Book for Doubling Income of Farmers in Arena of Climate Change". This book is authored by Dr. Kirit N. Shelat and co authored by Dr. Odemari Mbuiya from Florida Agriculture and Mechanical University – FAMU, USA. This is an outcome of India – USA collaboration. This book is in response to call given by Hon'ble Prime Minister for doubling income of farmers. This is part of its effort to make available learning material to formers. Its publication are in three language – Gujarati, Hindi and English.

- The Gujarat government made available this guidebook to all villages of State as a part of '*Krishi Mahotsav* – 2018'. The Hindi & English version are made available at National level & to all States to use for their farmers.

NCCSD is currently working on '*Atmanirbhar* – Self Reliant & Climate Smart Farmers'. This is in response to call given by Hon'ble Prime Minister for "*Atmanirbhar Bharat*". The current book is part of that initiative. It has already brought out guide book for Farmers and Stakeholders – "*Atmanirbhar Krishi* – Self Reliant Agriculture and Farmers: Role of Stakeholders". It is organizing a series of seminars – how to make Farmers, Fishermen, Animal holders, Rural Youth – self reliant and to do farming, cattle rearing, fishing by following "Good Practices" in Arena of Covid-19 and Climate Change.

The contact person of NCCSD is Ms. Nisha Shah – CEO.

Web-link - http://www.nccsdindia.org

•

Atharvaveda Hymn LXVII

१. पश्येम शरदः शतम् ॥

1. May we see for hundred years. (4960)

२. जीवेम शरदः शतम् ॥

2. May we live for hundred years. (4961)

३. बुध्येम शरदः शतम् ॥

3. May we acquire knowledge for hundred years. (4962)

४. रोहेम शरदः शतम् ॥

4. May we go on prospering and progressing for hundred years. (4963)

५. पूषेम शरदः शतम् ॥

5. May we go on being nourished for hundred years. (4964)

६. भवेम शरदः शतम् ॥

6. May we remain strong and sturdy for hundred years. (4965)

७. भयेम शरदः शतम् ॥

7. May we retain our prestige and influence for hundred years. (4966)

८. भूयसीः शरदः शतात् ॥

8. May we retain all these powers of sight etc., for greater numbers of years than hundred. (4967)

– Dr. R. S. Rajan
Distinguished Scientist - ISRO
Council Mamber of NCCSD

ॐ

#**AatmaNirbharBharat**Abhiyan

Message from Hon'ble Prime Minister

- Move with confidence towards self-reliance
- Time to become vocal about local products & make them global
- Economy, Infrastructure, Technology Driven Systems, Vibrant Demography & Demand are 5 Pillars of *Atma Nirbhar Bharat*
- Bold Reforms across sectors
- Comprehensive package of Rs 20 lakh crores equivalent to 10% of India's GDP for cottage industry, MSMEs, labourers, middle class, industries