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Chapter 8: Use of Technology in Agriculture

Short Answers

CSM 05: Agriculture

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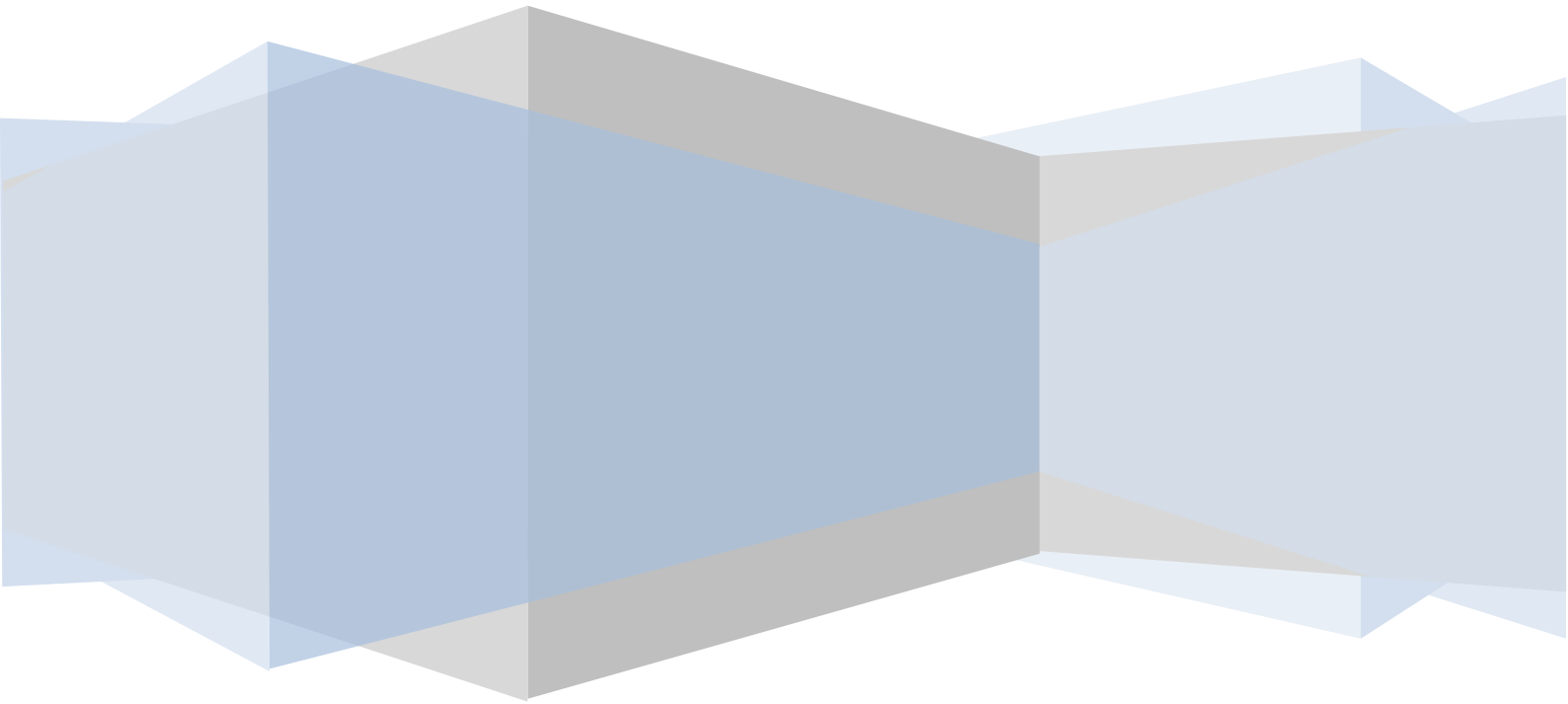

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1. Genetic Engineering for Crop Improvement

As the world's demand for food continues to increase, plant breeders work to breed high yielding crop varieties. The era of scientific crop improvement dates back to around 1900, when the impact of Gregor Mendel's studies on trait inheritance in peas became widely recognized. Since then, a broad range of techniques have been developed to improve crop yields, quality, and resistance to disease, insects, and environmental stresses of different nature. Most of the plant breeding programs rely on manual cross-pollination between genetically distinct plants to create new combinations of genes.

Genetic improvement of crop plants through conventional plant breeding has made impressive contributions to the breakthrough in the global agricultural production. India too has benefitted from the progress in science and technology. It has provided the platform for the Green Revolution, and laid the foundation for social and economic gains over the last 50 years. The nation has, however, hardly used 1-5 per cent of genetic resources available in the country so far. India has rich genetic diversity pool of its own. At the global level too, there still exists vast scope of genetic pool that can be tapped for achieving crop and livestock improvement. Increases in global food production have kept pace with increase in population from 1960 to 2015. In this period, world cereal production doubled and per capita food production increased by 37 per cent. Most of the productivity gains have been due to yield increases, particularly those resulting from the discovery and deployment of dwarfing and other useful genes in wheat and paddy, apart from maize. The progeny plants are intensively evaluated over several generations and the best ones selected for potential release as new varieties. The more advanced techniques involved in breeding new and improved crop varieties include mutagenesis, genetic modification, and marker aided selection (MAS). Genetic modification allows plant breeders to produce a crop variety that could not have been bred using conventional breeding techniques, and is much more precise, in that, it transfers only the desired gene or genes to the recipient plant. It is a technique, that has broken inter-species barriers, opening up a new world of possibilities and be able to surmount the challenges.

Genetically Modified (GM) Crops – Role and Potential

An array of tools and techniques in the field of molecular biology has become available over the last about 35 years for supplementing the conventional genetic approaches. Advances in modern biology, especially bio-technology, offer many advantages over traditional techniques of plant breeding. Genetic transformation and genome editing are powerful methods that can offer solutions to several problems. The most compelling case for bio-technology, and more specifically transgenic crops, is their capability to contribute to: i)

increasing crop productivity, thereby offering support to build global food, feed and fibre security; ii) lowering of production costs; iii) conserving of bio-diversity, as a land-saving technology capable of higher productivity; iv) more efficient use of external inputs, for a more sustainable agriculture and environment; v) increasing stability of production to lessen suffering during droughts/famines arising from abiotic and biotic stresses; and vi) to the improvement of economic and social well-being of the poor.

The term 'genetically modified' (GM) refers to insertion, integration and expression of desired genes of another species or genera in an organism using a series of laboratory techniques collectively called recombinant DNA technology. Other terms used for GM plants or foods derived from them are genetically modified organism (GMO), genetically engineered (GE), bio-engineered, and transgenics, etc. The area of plant bio-technology can be divided into four broad subjects as follows:

i. Plant genetic engineering (gene isolation and transgenic crops) ii. Molecular breeding (marker aided selection) iii. Genomics (genomics, metabolomics and bio-informatics) iv. Genome editing.

Genetically Modified Crops - Global Picture

In a number of countries, transgenic crops are by now produced in more or less a routine manner in both monocotyledons (monocots) and dicotyledons (dicots). Dramatic progress in transformation techniques has widened the genetic base across the species barrier. As per ISAAA, 2017 the global canvas of genetically engineered agricultural crops has seen a vast expansion since its first adoption in 1996 to a record 2.1 billion hectares in 26 countries in 2016. An array of agriculturally important traits has been targeted for modification. The advantages of transgenic technology in improving the major traits are of relevance to Indian agriculture in the current circumstances, characterised by higher aspirations among the farmers and the new challenges, particularly relating to climate change.

Genetically Modified Crops – Status in India

In India, the G.M. technology has been adopted for long. The technologies under use in India have been those developed outside and introduced into the country, as also those developed locally.

In India, cotton is the single most important crop, that has adopted GM variety. Globally, the cotton market is heavily dominated by India and China with regard to both production and consumption. The two countries produced and consumed over 55 per cent of the total cottonseed oil made during the year 2015-16. This dominance is largely attributed to the large amount of cotton cultivation in the region and the high domestic demand for low-priced cooking oil. Thus, in the last fifteen years over 2002 to 2016, cottonseed has become an important source of oilseed in India. This is borne out by the three-fold increase in

production of Bt cotton-based oil from 0.46 million tons in 2002-03 to 1.50 million tons in 2016-17. Remarkably, Bt cottonseed oil accounts for as much as 15 per cent of the total production of ~8 million tons of edible oil from all domestic sources, in the year 2016-17.

In the year 2016-17, as many as 7.2 million number of cotton farmers adopted Insect Resistant (IR) cotton [Bascillus thuringensis (Bt) cotton] representing 96 per cent of the estimated 11.2 million hectares of cotton area in India. In recent years, farmers have increased the density of cotton planting particularly in irrigated and semi-irrigated conditions, leading to substantial jump in cotton productivity per hectare across the states. The major states growing IR resistant Bt. cotton in 2016 include Maharashtra, Gujarat, Andhra Pradesh and Telangana, Madhya Pradesh, Punjab, Haryana, Rajasthan, Karnataka, Tamil Nadu and Odisha. The high adoption percentage of IR cotton by farmers across different states reflects the importance of controlling the menace of the American bollworm complex, a group of deadly borer insects that were causing heavy damage to cotton crop in the past.

Transgenic Crops and their Adoption in India

The quantum jump in agricultural productivity achieved by the country during its 'green revolution' phase of the 1960s & 1970s has over the last decade been showing signs of fatigue. The yields have plateaued. The journey of crop improvement that began with the domestication of a desirable plant type present within the nature has entered the era of crop bio-technology, wherein, a crop genotype can be tailor-made into a 'designer crop'.

The techniques of new biology or molecular biology have unravelled the genetic basis of yield components; identified genes across the organisms which can impart tolerance against biotic and abiotic stresses; modified nutritional status of the harvest; and even added industrial or pharmaceutical value to the crops to make it a commercial raw material. It has also provided means and ways to transfer the genes into the desirable compartment of the cell and in turn the plant type per se.

The technological developments in understanding the various processes of biology which in the context of crop improvement define the basis of various agronomically desirable traits were particularly hastened, once the techniques of plant transformations, i.e., ability to introduce genes across the barriers of species were discovered. This has paved way for finding solution to the long-standing breeding objectives which were otherwise difficult to accomplish through conventional breeding techniques. The technique of plant transformation since its first demonstration in 1983 by three research groups has been improved phenomenally and now transformation protocols are available for almost all the major crops (Gelvin, 2017).

Adoption of Transgenic Technology in Non-food crops

India has established a comprehensive regulatory system to deal with application GM technology in agriculture as discussed above. Commercialisation of GM based crop release is system based and passes through rigorous protocol. Notwithstanding the rigour of protocol, the doubts around the food crops based on GM technology continue to occupy the minds at various levels.

There has also been widespread resistance from the society at large, particularly in respect of food crops, and hence the progress relating to commercialisation of GM crops has not been proportionate to the potential and promise that GM technology holds. Under the existing regulatory system, so far, five events of cotton with genes MON 531 (cry1AC gene); MON 15985 (cry1AC & cry2Ab); GFM Cry1A (cry1Ab-cry1Ac); JK-1 (cry1Ac) and CICR (cry1Ac) have been approved for commercial use. Further, at least 4 new events of cotton and one event of brinjal EEI and corn each, besides mustard have been under consideration by GEAC.

In case of food crops, use of genome editing which does not suffer from the safety fears associated with other transgenic technologies can be considered. Further, the conventional breeding technology can be continued to be relied upon by using the vastly unused gene pool available in the genetic diversity of the country, as also from imports. There are well established germplasm banks across the world today and can be accessed.

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2. Role of Digital Technologies

In many developed countries, farming has been modernised by a wave of technologies, adopted at farm level. In emerging economies too, agriculture is becoming "Industrialised", and spoken of as a "Value System". Digital technologies are finding increasing use in the agricultural value system, and farmers are increasingly becoming more informed, as various measures are taken to provide them ready access to technology and information. High-tech farming is becoming the standard, thanks to use of sensors, logic controlled systems, data analytics, etc. In India, the increasing availability of energy and internet connectivity to the large rural landscape is further accelerating such changes. This transformation will continue as linkages with international markets also get expanded and get more robust.

The transformation comes from the stark changes that technologies bring about on age old practices and from informational inputs that effect a rethink in the decision making processes. The transformation also causes disruptions as it builds aspirations and competition, which in turn can amplify various errors and omissions. Various examples of changes that technology can bring in the operational environment abound. Some are simple and already a part of history.

When communication systems were analog in nature, the market yards were literally assembly points for farmers to collect and exchange information. The market network was also used by the government as a platform to propagate information and ideas, and to regulate. With the advent of digital communication, the information dissemination progressed onto radio, television, and is now using mobile and internet technologies. The physical assembly of people is not needed and markets should no longer be considered assembly points but as modern platforms where produce can be aggregated in a scientific manner and as initiators of trade that is transparent and offers a choice of markets to the producers. Digitised information systems allow remote access to knowledge, has given rise to group sharing and continue even now to revamp how societal exchanges happen interpersonally, commercially and in the extension services system.

Applying Remote Sensing in Agriculture

One of the pre-requisites for enhanced and stable farm incomes is sustainable and efficient management of agriculture yield and output. Management of diverse crop growth ambience, uncertainties of climate, soil and water regime will require pertinent and timely crop and soil information on temporal and spatial basis. Thus, a farmer needs to be informed well in advance of the probable upcoming problems and outbreaks. The relevant technologies for generating the required information at requisite spatial and temporal scales comprise remote sensing with satellites, drones and localised sensors, and mobile-

based Information Technology (IT) applications. The possible components for modern management of agriculture are:

• Remote sensing • Geographical Information System • Data Analytics • Artificial intelligence & Machine learning • Internet of things

Remote sensing fundamentally made use of visible, near infrared and short-wave infrared sensors to form images of the earth's surface by detecting the solar radiation reflected from targets on the ground. As technology developed further, and resolutions improved, remote sensing has advanced to also detect and identify heat signatures of planted crops and animals. Similarly, moving beyond sonar, ocean temperature maps are used to show upwelling and chlorophyll distribution to identify coastal productive zones, use side-looking airborne radar to detect shoals of surface swimming fish, etc.

ICT based support for Farmers

The Ministry of Agriculture & Farmers' Welfare targets improved awareness and knowledge efficiency of farmers. A comprehensive ICT strategy has, therefore, been developed not only to reach out to farmers in an easy and better way, but also for planning and monitoring of schemes so that policy decisions can be taken at a faster pace and farmers can be benefited quickly. To empower different sections of rural areas, different ICT strategies have been devised and are listed below:

• Those who have access to digital infrastructure can get the information through websites/web portals.

• Those who have smart phones can access the same information through mobile apps.

• Those who have basic phones, can get this information through SMS advisories sent by experts.

• Farmers can also call at the toll free number of Kisan Call Centre – 18001801551.

Agriculture 2.0 (Digital Agriculture)

Under Digital India interventions, the Government has given prominence to ensuring availability of information on various agriculture and allied sectors activities, to improve the agricultural output. Agriculture 2.0 (Digital Agriculture) directly falls under Pillar No. 5 of Digital India, i.e. eKranti – Electronic Delivery of Services and broadly caters to other pillars as well, like e -Governance: Reforming Government through Technology, Information for All and Early Harvest Programmes. (It is worth noting, that, Digital India is architected on 9 pillars in total). Some of the key thrust areas identified under Digital India for Ministry of Agriculture & Farmers' Welfare are incorporation of space technologies, development of mobile apps, GIS Mapping, citizen-centric services for Cooperation, fertilizer testing labs,

cold-chain availability, identification & development of services for specific sectors of horticulture and fisheries, use of crowd sourcing, increasing online transactions, and use of innovative technologies like text to speech, image recognition; as also Big Data Analysis and Data Intelligence, Direct Benefit Transfer etc.

Upcoming Technologies

Developing technologies such as Big Data Analytics, Internet of Things (IoT), Block Chain, Artificial Intelligence, Robotics & Sensors, etc. are inter-related and are used to optimise the decision making process, and the operating procedures of every sphere where they find application. These technologies are practices that are deeply inter-woven with computerised systems, complex digitised interactions and even self-learning models. In contrast, agriculture involves earthy processes such as attending to soil & water management and cultivation, managing the production and supply of goods. However, agriculture, despite being civilization's primary organised production process, continues to be subject to uncertainties across various involved disciplines. Not only has agriculture moved beyond sustenance farming into commercial production, it now touches more lives than the population immediate and local to the producing region. Its circumference of influence is only bound to widen as rural population moves into urban agglomerations, and nations gets globally integrated.

Agriculture no longer drives other economic and social activities, as in the past, but is subject to and is expected to reflect the demand from the wider population. Though the agricultural system, directly impacts on quality of life of all individuals, evens those in non-agricultural activities, it in turn, is expected to be led by the demands from its end-consumers. A physically inter-connected world has made agriculture a highly competitive production and marketing system. Nevertheless, agriculture still has a certain fuzzy logic built into its operations, as the factors that affect the system, have various degrees in how they manifest. The widening scope of agricultural activities, its continued subjectivity to uncontrollable environs, the large quantity of data it generates from dispersed locations, and the increasing need to have focused & specific deployment of agricultural sciences has made the agricultural system an important domain for use of aforesaid new technologies.

Digitalised technologies in Farming

All current and upcoming technologies hold the potential of catalysing innovations in organisation that would leads to improvement of agricultural models. By adopting Data Science and an analytical approach, various solutions can be found to erstwhile insurmountable challenges, to minimise risk and maximise profit of the farmers. Smart systems have been brought into use in India's Dairy Sector by private sector organisations, for improving agrisupply chain parameters, including milk production, milk procurement, cold-chain, animal insurance and farmer payments. The introduction of smart technology

into farming practices provides a new way for farmers to manage natural resources and hence, the economic profitability of the farm. Smart Farming uses modern automation and IT (Information Technology) to increase the productivity and efficiency of modern farming in a sustainable way with minimal impact on the environment. The current array of technologies would include the integrating of Internet of Things (IoTs), Satellite Monitoring, Mobile devices, Soil / Plant Sensors, Smart Zone Seeding, Autonomous Robotics, Weather Modelling, Fertilizer Modelling, and Smart Micro-Irrigation. The systems would require to be standardised and inter-compatibility ensured, so as to be most relevant.

Business models are changing and are trying to develop software platforms that will act as farm-management systems, which will collect data from individual farms and process them, allowing for the farm's history, the known behaviour of individual crop strains and the local weather forecast, and then make recommendations to the farmer. Information, when combined with geo-mapped land, creates a yield map that shows which bits of land are more or less productive, and thus in turn be fed into the following season's planting pattern. Farming solutions are facilitated by using technologies such as, Big Data (e.g. Agriculture Statistical System - Scientific Disease Monitoring and solutions), for subsequent analysis and use in Artificial Intelligence applications. The solutions they lead to can be such as, remotely controlled irrigation water management, site-specific farming (variable rate) for adaptation of the cultivation to the heterogeneity within the field (soil testing, landscape, microclimate), maximise yield potential and improve crop quality, reduce amount of inputs and environmental impact, etc. The technology and applications are suggestive of the scope and scale possible. The impact on analytics in rationalising priorities and expediting the policy making process is yet to be fully realised.

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3. Digitalisation across the Agri-Value System

Strategic Use of Technologies in the Agricultural Life Cycle

The use of a hi-tech machine or a computer aided technology can make a particular farmer more efficient in operations and decision making, and actually up the value added by the farmer by his cultivation activities. Similarly, the use of warehouse management and inventory management software will augment the value added by that individual warehouse. The use of digital way bill and GPS vehicle tracking, electronic warehousing receipts, sensor controlled irrigation, digitised finance, use of ICT in extension services, etc. are other bits of examples that can make an individual enterprise more competitive in their sphere of operations.

The use of multiple quality or market standards, makes the market system ineffectual and non-transparent. In governance matters, non-standard data disallows development of harmonised dashboards for monitoring and decision making. Lack of harmonisation in knowledge management and dissemination also adds to confusion and conflicting conclusions. The standardisation and digitalisation in the chain of agricultural and linked activities will support focused and targeted implementation, a greater convergence in efforts, improved monitoring of implementation and equitable development of this primary sector.

Existing Status and Concerns

Various digital technologies are being developed for use in agriculture, both by the public and private sector. The public sector plays the major role in the satellite and observatory based weather forecasting system, geo-spatial crop forecasting and insurance monitoring system, and digitalisation of land records, market price monitoring and other large scale, high cost functions, which have a wider socio-economic impact across areas. The public sector also has many institutions and agencies that develop and implement solutions that are specific to crops, regions or a set of activities, for subsequent sharing of the solution. The public service envisioned is implemented at a low or zero cost to end-user, or through passing on the technology to partnering private sector agencies.

The private sector predominantly focuses in developing solutions and products that target problems, that are more specific to a prospective range of end-users. The data used by private sector solutions can be independently gathered, or sourced from data generated by government services. For example, the data provided by government on crop production, yield, weather, market prices, etc., is freely used by the private sector for analytics and developing solutions.

Major ICT interventions of Agriculture Ministry

The three departments under the Union Ministry of Agriculture and Farmers' Welfare have developed several ICT based technologies. These have also evolved over the years into robust windows. Some of these are discussed below:

Websites/Portals:

In order to meet the information needs of the farmer, Ministry of Agriculture and Farmers' Welfare has developed different websites and web portals that allow farmers to access the information using Internet. Information on Market Price, Soil Health Card, Crop Insurance, Government schemes etc. is available to farmers through these websites. These websites also aim at enhancing communication between the research institutions and the farmers. They have also helped improve communication and knowledge sharing between researchers and subject-matter experts. Farmers' Portal, Agmarknet, Soil Health Card Portal, eNam, Crop Insurance etc. are some of the examples of web portals developed for farmers.

Use of Mobile Apps:

Diffusing agricultural related information to farmers spread across the vast geography is made easier by proliferation of mobile phones. Today, mobile apps and services are being designed and released in different parts of the world. Mobile apps help to fulfil the larger objective of farmers' empowerment and facilitate in extension services which can address global food security, agriculture growth and farmers' welfare.

Use of basic mobile telephony:

Mobile telephony has transformed the tenor of peoples' lives. In India, increased penetration of mobile handsets, large number of potential users, increased spread of communication, and low cost of usage are leading to growth of large number of mobile based information delivery models for the agricultural sector. A few of the modes used to meet the information needs of the farmer are SMS, IVRS, OBD, USSD etc. In mkisan (mkisan.gov.in), around 2 crore (20 million) farmers are registered (2016-17) and experts/scientists of different departments like Indian Metrological Department (IMD), Indian Council of Agricultural Research (ICAR), State Government, State Agriculture Universities send information to farmers.

Personalized Information through Call Centres:

Kisan Call Centres (KCCs) were launched by the Ministry of Agriculture and Farmers' Welfare in 2004 to bridge the gap between farmers and the technology assessment. This initiative was aimed at answering farmer's queries on a telephone call in their own language / dialect.

At present, the KCC services are managed from fourteen locations. All KCC locations are accessible by dialling a single nation-wide toll free number 1800-180-1551 through landline as well as mobile numbers of all telecom networks from 6.00 A.M to 10.00 P.M. on all 7 days a week including holidays. KCC enables farmers to engage in direct discussions with the subject matter experts who are able to analyse the problem effectively and provide the solution directly. For every KCC location, Level-II experts are also identified from State Agriculture Universities, KVKs etc. In case, Farm Tele Advisor (FTA) is unable to provide answer to the query of farmer, call is transferred to Level II expert. Around 25,000 calls are received daily in KCC.s

Use of Technology for Data Collection & Monitoring:

Use of mobile apps to collect data from the field is indeed a revolutionary change. It can definitely avoids human error and increase productivity.

CCE Agri is a mobile app used for data collection and data monitoring in rural areas. Data of crop cutting experiments (CCEs) is digitized using this mobile app which definitely removes chances of human error and reduces the time in data collation. This app significantly improves data speed (from harvesting to insurance loss estimation) and biggest gain is data quality. Geotagging ensures field visit, photos mitigate the manipulation risk and data transfer greatly improves data consolidation/analysis which eventually results in quick claim settlement. In rural areas, there are challenges on account of absence of or poor connectivity. Hence, this (CCE Agri) app has been designed in such a way, that data can be collected without internet connection and as and when internet is available, data can be pushed to the server.

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4. Digitalisation of Villages

Sustainable Development of Village – Ongoing Efforts

The demand of rural India today is sustainable growth and development. Expanded reach of the Government – both spatial and demographic – is the corner stone of e-Governance. In 1990s, when digital technologies for village level development were rolled out, it only had database technology and computer technology that merely facilitated management information system (MIS) reports.

India needs an economic movement that starts in villages, and not one that tends to bypass them. There had been many efforts to establish "Village level Database" for micro level planning and decision support, and "Village level Knowledge Management System" for checking farmers' distress (e.g. Information Village Project of IDRC/MSSRF Chennai, Village Resources Centre of ISRO, Village Knowledge Centre of CAPART, Village Knowledge Centre of Union Bank of India etc).

Village Knowledge Centres (VKCs) were envisaged as information dissemination centres providing the farmers instant access to latest information/ knowledge available in the field of agriculture, starting from crop production to marketing. "Mission 2007: every village a knowledge centre", was proposed in August 2007, so as to facilitate convergence and synergy among the numerous on-going as well as emerging programmes. While the green revolution technology has helped improve the productivity and production of rice, wheat, and few other crops, the knowledge revolution would help to enhance human productivity and entrepreneurship.

The National Alliance for Mission 2007 Initiative had received support from the United Nations Development Programme (UNDP), the International Development Research Centre (IDRC) and the Canadian International Development Agency (CIDA), the Swiss Agency for Development and Cooperation (SDC), the United Kingdom's Department for International Development, the World Bank, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the United Nations Educational, Scientific and Cultural Organisation (UNESCO), the World Health Organisation (WHO), the Food and Agriculture Organisation (FAO), the World Food Programme (WFP), the International Fund for Agricultural Development (IFAD), the McArthur Foundation, the Jhai Foundation, and the Global Knowledge Partnership.

This National Alliance, then, included 22 government organisations including the Ministry of Information Technology, the Ministry of Panchayati Raj, the Telecom Regulatory Authority of India (TRAI), and Bharat Sanchar Nigam Limited (BSNL); 94 civil society organisations; and 34 private sector information and communication technology (ICT) leaders such as

NASSCOM, TCS, HCL, and Microsoft. Besides, 18 academic institutions such as the Indian Institutes of Technology, and the Indira Gandhi National Open University; and 10 financial institutions such as the National Bank for Agriculture and Rural Development (NABARD) and the State Bank of India (SBI).

Last Mile Connectivity

Last-Mile technology represents a major challenge due to high cost of providing high-speed and high-bandwidth services to individual subscribers in remote areas. Laying of wire and fibre optic cables is an expensive undertaking that can be environmentally demanding and requires high maintenance. Broadband wireless / wired networks viz., BharatNet, Cable TV Networks, RailTel, Electricity Lines, LoRaWAN, TV White Space Technology etc., will eventually be required to provide the solution to achieve "last mile connectivity" of Digital India Programme.

The on-going Digital Network for Farmers (DNF) over the Broadband Wireless/ Wired Network with APP such as KRISHAK MITHRA Software (KMS) will establish the "last mile connectivity" to have farmers "digitally included" for ushering in "Digital Agriculture India" effectively.

Digital Village Project

DIGITAL VILLAGE Project, among others, aims at the usage of Information & Communication Technologies (ICTs) for development and empowerment of communities (mostly disadvantaged communities). The initiative aims to empower communities (that have limited or no telecommunications access) through the use of mobile technologies, which will help contribute to long-term sustainable and economic development, through Supply-Chain modules. The model will work around the human resources at the village level as an individual, family and society; working out the linkages, identification of the right stake holders, analysis of the services, working out the methodology, digital enablement with digital connectivity with the right stake holders and necessary infrastructure at the village level. The Project proposes to realize this, through the following:

- Introduce & promote Information and Communication Technologies that are cost effective and appropriate for use in rural areas, to enable rural villages digitally to access and benefit variety of services at the last-mile

- Develop and implement a Service Model wherein the villagers, NGOs and the Government work as a cohesive unit in building, maintaining and delivering the information and knowledge base to facilitate development and empowerment of the community

- Operationalise BOM (Build, Operate and Maintain) Model for incubation/deriving best practices for 2 (two) years and thereafter, a realistic sustainable ROT (Remodel, Operate and

Transfer) Model wherein all the failure entities and processes are removed, new innovation, technology updates, process optimization are introduced for 5 years

- Explore and strengthen avenues to make the service model self–sustainable at village level

- Delivery of goods and services right from the request / registration at the village level to delivery at the doorsteps, through the use of agile methods for refining the processes every time in the Service –Delivery-Life-Cycle (SDLC).

Digital Village Development Plan

In the Sansad Adarsh Gram Yojana (SAGY) (Members of Parliament Model Village Plan) Guidelines 2014, the preparation of a Village Development Plan (VDP), through a 2-Stage Participatory Planning (PP) Process is suggested for every identified Gram Panchayat (GP) with special focus on enabling every poor household to come out of poverty. This 2-Stage PP Process includes (a) Undertaking situation analysis, (b) Conducting a base-line survey, (c) Mapping of financial resources available through various programmes / schemes, (d) Mapping of natural & physical resources, and (e) preparation of Needs matrix. The SAGY 2014 programme suggests a National Level Web based Monitoring System with the specialty to upload photos of physical status of project activities.

Agricultural Resources Management

The geographical area of the country presents a large number of complex agro-climatic situations. Several attempts have been made to delineate major agro-ecological regions in respect of soils, climate, physiographic and natural vegetation for macro-level planning on a more scientific basis. They are as follows.

- Agro-Climatic Regions (ACRs)-15- by the erstwhile Planning Commission (now NITI Aayog)

- Agro-Climatic Zones (ACZs)-127- under National Agricultural Research Project (NARP) of ICAR

- Agro-Ecological Regions (AERs)-60-by the National Bureau of Soil Survey & Land Use Planning (NBSS & LUP) of ICAR;

The major focus areas, among others, will be:

- e-governance: Information on entitlements and on methods of accessing the entitlements (e.g. bank credit, inputs, etc)

- e-education: Literacy and technical skills; Digital Learning etc

- e-health: Disease prevention, detection and cure; nutrition with particular reference to maternal and infant (0-2 years) nutrition

- e-agriculture: Crops, Livestock, Fisheries (inland and marine), Agro-forestry, Forestry (Minor Forest Produce), Water and Agriculture in areas dominated by tribal communities.

- e-livelihoods: Opportunities for on-farm and non-farm employment, microenterprises supported by micro-credit, new skills and training in agro-processing and agri-business

- e-commerce: Producer-oriented marketing, quality management, matching production with demand

- e-environment: Conservation and enhancement of natural resources, with specific attention to land care, water conservation and sustainable use, conservation of flora and fauna and management of common property resources

- e-disaster management: Methods to secure investments, cope with disaster and survival in case of floods, cyclones and rare events

- e-judiciary (knowledge of legal systems and processes)

- e-traditional knowledge and practices

- e-Supply Chain platform

The Shyama Prasad Mukherjee National Rurban Mission (SPMNRM) has 14 mandatory components and other essential components as follow:

i. Cluster based skill development
ii. Digital literacy
iii. Skill training linked to employment
iv. Inter village road connectivity
v. Mobile health units
vi. Infrastructure development
vii. LPG gas connections
viii. E-gram connectivity
ix. Electronic delivery of citizen centric services
x. Public transport
xi. Warehousing
xii. Agriculture services
xiii. Agro-processing
xiv. Storage
xv. Water supply provisions through pipes
xvi. Sanitation
xvii. Waste management – solid and liquid
xviii. Education facilities upgradation

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5. Road Map for Modernising Agriculture

Technology Development – Support Framework

Technological innovations and applications, once assessed as a solution for an immediate primary problem, need to be holistically evaluated for other side effects, beneficial or otherwise. New technologies, even if technically feasible, are not necessarily economically viable at the first instance. Such viability comes from building a large consumer or user base, which requires certain financial backing. The private sector provides such funding as venture capital, after assessing the risk-reward ratio. Venture Capital (VC) funding is provided upfront by government agencies, though in a format which somewhat limits the selection, and it is largely treated as a grant.

Support by the government for start-ups that target agriculture can be structured in two ways. The first can be an unencumbered and time limited support to strategically selected technologies, such support being in the form of incubation fees, advisory and seed fund to develop and test prototypes. Such support can also be at school and college levels, and promotes innovation, at partial cost to the government, and be the first step in motivating the eco-system. After the prototypes or pilots are tested, a second level selection, for scalability of technology or of the outcome, can determine a second stage support mechanism.

At this stage, a spearheading fund can be assigned to each project for rolling out commercial or non-commercial use, for a fixed time window. The projects so supported at this stage, can allot a share of the equity. It can be expected that some projects will succeed and such equity can be exited to close the support cycle. In fact, a two stage support mechanism can be utilised for non-technology start-ups too, provided a suitable set of outcome parameters, that are modelled on equitable growth, income sharing, farmers as stakeholders, etc. are formulated. The DFI Committee proposes restructuring the Division of RKVY-RAFTAR in the DACFW to manage Agricultural Investments & Enterprise promotion. Similarly, it has suggested creation of such a Division in the Ministry's sister departments, namely, DAHDF and DARE.

Modernising agriculture is dependent on digitalising large quantity of information, integration of the data, its analytics, and its application in agricultural activities and various practices. Farmers, cooperatives, FPOs, distributors and consumers - the entire agricultural value system comprising a myriad of actors - can be facilitated through digital technologies to work together to establish a culture of inter-dependence, inter-connectivity and traceability.

Strategic Recommendations

Digitalisation of farming system is emerging as a very important "progressive and positive" step towards achieving sustainable agricultural productivity and minimising Farmers' Distress. India requires Strategic ICT & e-Governance in Farming System Life Cycle, and the following seven disciplines need urgent consideration in the Farming Sector:

(i) Digitalised Agriculture: Digital Technology and Innovation in Agriculture: Digital India, Make in India, Skill India and Start-Up India Programmes for Transformational Reforms in Agricultural Sector (SMART Irrigated Farming, SMART Rainfed Farming and SMART Tribal Farming)

(ii) Digitalised Agro-Met Advisories & Agricultural Risk Management Solution

(iii) Digitalised Agricultural Resources Information System and Micro-Level Planning for achieving SMART VILLAGE & SMART FARMING

(iv) Digitalise the Supply Chain for about 400 agricultural Commodities

(v) Digitalised Access to Inputs, Technology, Knowledge, Skill, Agricultural Finance, Credit, Marketing and Agribusiness Management, to Farmers

(vi) Digitalised Integrated Land and Water Management System – Per Drop More Crop as also 'Per Resource Unit More Output

(vii) Digitalised Farm Health Management for reduction of Farmers' Losses

The objective to usher in an Income Revolution in agriculture by 2022-23 is possible through strategic intervention at various levels with mission mode commitments through the following measures:

i. Promote Digital India Programme in Agricultural Sector as 'Farmers' Charter'

ii. Operationalise and strengthen 'Digital Informatics Network for Farmers (DNF)' – AGMARKNET, AGRISNET, FISHNET, APHNET, NADRS, PPIN, VISTARNET, AgRIS, FERTNET, CoopNet, etc.

iii. Develop Digital Agricultural Services based on "Digitalisation and Online Internet technologies" model: Facebook, Alibaba and Uber etc.

iv. Utilise growing FDI in agricultural sector for digitalisation of agriculture to establish a robust ICT ecosystem for farming sector

v. Promote Digitalised Agriculture (Future Farming) based on GRIN Technology (Genomics, Robotics, Informatics and Nano-Technology)- Informatics include IOTs, Big Data Analytics, Geo-Informatics, Cloud Computing, Space Technology, Mobile Computing, Language Computing and SMART Farming Technologies; Create Digitalisation of Agriculture framework, as a strong foundation as the GSTN/Aadhaar framework; Adopt Open Source Platform for lowering upfront cost

vi. Operationalise Digitalised Geo-spatial Agricultural Planning & Management Database: Integrated Agricultural Resources Information System Project of NNRMS (DOS), NRDMS of DST and Sansad Adarsh Gram Yojana (SAGY), to facilitate undertaking Farm Level Plan, Village level Plan, Block level sub-sectoral

plan, District Agricultural Plan, Agro-Climatic Zonal Plan, Agro-Ecological Plan etc., so as to achieve highest level ROI (Return on Investment)

vii. Establish Digitalised Agricultural Risk Intelligence Framework for assessing risk and risk profiling at farm level, regional level as well as at national level including appropriate advisories for risk mitigation, through installation of about 20,000 Automatic Weather Stations (AWSs) for collating real-time weather data from Panchayat level, assuming that a weather station can be representative in about 5 km radius. Also ICT enabled process to realize Agricultural Crop Insurance entitlements to farmers

viii. Set up Digitalised Farm Health Management Information System integrating plant health, soil health, water health and fishery health – One Health/Eco Health – at farm level

ix. Establishment of Centre of Excellence (COEs): National Centre for IT in Agriculture (NCITA), State Centre for IT in Agriculture (SCITA), District Centre for IT in Agriculture (DCITA), to undertake transformational technological interventions for digitalisation of Farming, and Block Centre for IT in Agriculture (BCITA); COE on Data Analytics & Modelling to achieve Big Data Analytics of Agricultural Things (BDA-AoT) and Mission Critical Big Data in Agriculture and also to monitor agricultural production and trade (domestic and international); Agri-clinics and Agri Business Centres, to provide Knowledge, Technology, Inputs and Marketing, as Agri-entrepreneurs and link them to Centre of Excellence (COE) as visualised

x. Bridge the development gaps in Human Resources Development for Digital India in Agriculture– Agricultural Informatics Professional – through M. Tech / B. Tech in Agricultural Informatics Courses in Rural India

xi. Introduce Big Data Analytics in the Directorate of Economics and Statistics (DES) of the Ministry to build DSSs facilitating Analytical, Transformative and Discovery Path to agricultural policy making; and also extend the land use statistics data, under nine fold classifications, to village / panchayat level

xii. Undertake Capacity Building and Competency Development on Digital Technology of Farming Community, through Pradhan Mantri Gramin Digital Saksharta Abhiyan (PMGDISHA)

xiii. Develop Agricultural Constellation of Satellites to provide data in high resolution, with 1-2 day frequencies, in different domains: optical, thermal and microwave

xiv. Formulate, finalise Agricultural Drone Policy for collecting high resolution imageries for agricultural risk management and mitigation, of UAVs by public and private sector providers to support precision agriculture in India, by incorporating appropriate clause in the Draft National Geo-Spatial Policy (May) 2016; and also to facilitate Start-Ups to build high resolution imageries based advisory services

xv. Develop a national programme for Integrated Use of Space Technology in all domains of agriculture

xvi. Replicate model projects such as Farm Beats of Microsoft, Digital Drip Irrigation System Tool Box of Israel, ICRISAT Framework for Digital Agriculture (Agricultural Value System and On-Farm Management) for Small and Marginal Farmers; Netherlands Model of Farm Data Analytics; Ramthal Project of Jain Irrigation Systems; New Zealand Model of "Digital tracking, reporting and monitoring: Future of Our Fisheries", suitable modifications may be effected

xvii. Establish Digitalised Access to agricultural credit and financial services, logistics and warehousing

xviii. Build up Digitalised Agricultural Value Systems for 400 agricultural commodities involving farming community (including one for kiwi fruit of Arunachal Pradesh)

xix. Establish Digitalised Agro-Marine Clusters and Agro-processing Clusters based Value-Chain at Block level, under the PM Kisan Samapada Yojana (PMKSY)

xx. Undertake seamless integration of e-NAM with AGMARKNET Portal to enhance transparency and reduce the Market Information Asymmetry in the Agricultural Marketing System, and above all, to help in containing price volatility and undertaking appropriate policy decisions

xxi. Upgrade 2G and 3G Networks to 5G Network in Rural India to operationalise Digitalised Farming and its associated Workflow Process with IoT and Drones; 5G Bandwidth is very important for IoT Applications

xxii. Introduce Private-Public-Partnership (PPP) initiatives to Operationalise "technologies for agriculture" which are being developed in a fragmented manner, and are at various stages of development

xxiii. Create All India Coordinated Research Project (AICRP) in ICT in Agriculture in ICAR, in which Engineering Colleges (4500 Engineering Colleges, NITs and IIITs who teach Computer Science and Information Technology etc) may also be included to undertake focussed research projects in the area of IoT, Big Data Analytics AI, Space & geospatial Technology and Cloud Computing in the area of Agriculture and Food Sciences - Sensor based Decision Support System for Soil Micro Nutrients, IoT framework design, specialised sensor development, data acquisition models, Algorithm design, Knowledge generation and site specific decision support etc.

xxiv. Create 3D Printing facilities in KVKs to enable agricultural mechanization in a big way in small and marginal farm holdings

xxv. Establish High Performance Computing (HPC) in selected Central and State Institutes for manipulation of very large data sets, particularly related to agricultural genomics, proteomics, geo-informatics and climate change, in collaboration with Ministry of Electronics and Information Technology (MeitY)

xxvi. Undertake collaborative ICT4Ag Projects in the Hub-Spokes Model involving ICAR-NARS, Academic and Research Institutions (IITs, NITs, IIITs, Universities, Deemed Universities, Engineering Colleges and other Institutions of Higher Education etc.), Industry-Institutions and End Users; and also Establish a Clearing House Agency (e.g. MANAGE, NAARM or proposed NCITA) to be the Arbitrator

for ensuring success of Hub and Spokes Model and adopt ICT enabled Extension Services

xxvii. Generate site specific land resources inventory(LRI) and suitability using GIS and remote-sensing techniques for enabling the developmental departments in scientific land use planning (planning, implementing, monitoring, reviewing and evaluating all the land based agricultural developmental projects) at the level of a watershed or a river basin

xxviii. Formulate a Satellite Imagery Strategy for Agriculture by ISRO, in collaboration with Indian Council of Agricultural Research (ICAR), State Agricultural Universities and other Development Stakeholders, to enable accurate and timely Spatial Application Information Utility Tools, in convergence mode, for direct benefits of farmers especially Small and Marginal operational holders who are more than 85 % of the farming community in India

xxix. Undertake Geo-tagging of Agricultural Assets - ponds, markets, cold storages, marketing structures, crop area, watersheds, warehouses, laboratories etc., for their real-time monitoring and effective utilisation and impactful advisories.

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6. Structural Reforms for Higher Efficiency

Shifting the Production and Income Curves

The strategy essentially advocates transforming agriculture into agri-business, which means that the outcome of agriculture should preferably be measured in terms of income returns per unit of asset (land/waterbody/livestock/bird etc.) as against measuring it in terms of production per unit of asset. The strategy then argues for improving productivity, reducing cost of cultivation/production and realising remunerative prices on the produce, for net positive returns at the farmer's level. While various interventions suggested in the pre-production, production and post-production stages will bring in greater efficiency and result in higher returns to the farmer, the inherent bottlenecks that plague the agricultural structure in India today, do not permit the factors of production to play up fully and contribute at their optimal level. The operational efficiency realised even under best circumstances of implementation is likely to be linear and hence incremental in impact.

Operational efficiency in agriculture can be defined as the ratio between an output gained from an agricultural activity and an input used to run this activity. When improving an activity's operational efficiency, the output to input ratio improves and should drive agricultural policy.

Inputs would typically include water / fertilizer, etc., money, man-power (measured as headcount or as the number of full-time equivalents) and time / effort. Outputs would refer to the harvested grain, fruit, vegetable, milk, meat, fish, fibre, by-products and other material. Both require to be computed in terms of value and not only in quantity. It is possible to shift the production curve, as also the income curve to the next higher level by identifying and addressing the systemic constraints.

There exist certain structural weaknesses, which when appropriately addressed will mean the enhancement of the genetic potential of the factors of production; and expansion of the space for these factors to express more wholesomely. Thus, the same intensity of operational interventions will bring more visible results in the following ways:

- efforts made to achieve higher productivity will shift the productivity curve;
- initiatives undertaken to achieve resource use efficiency will result in greater resource saving and cost saving; and
- measures taken to improve marketing efficiency will yield higher returns on output.

Basic Constraints Facing Agriculture Sector

Land, labour and capital have for long been recognised as the principal factors of production. These also constitute the factors of production in industry. However, what differentiates these two sectors, making agriculture much more complex is its biological nature. While in case of a production system based on mechanical processes, the variables can be controlled, and hence, there exists the scope for manoeuvring the demand and supply, agriculture sector suffers from lack of this opportunity.

Being biologically dependent, the variables like climate & weather and their ramifications (temperature, humidity, rainfall, etc.) which are external to the management system are not manoeuvrable. The downside of this is, that the investments made in the factors of production by a farmer are irrecoverable and the outcome is more a matter of chance. The statistical probability of success is at best 50:50, and in reality is worse-off, most of the time.

Important Structural Weaknesses

The target of doubling farmers' income by 2022-23 is only a first radical step, engendering a fundamental shift, to the way agriculture has so far been perceived and practiced in India. If the agriculture sector is to respond suitably to the redefined mandate (DFI Volume-VIII), it will require continuous transformation, so that it acquires the characteristic of agri-enterprise, whereby farmers take to agriculture as a chosen option, and are able to earn their livelihood as entrepreneurs and simultaneously cater to the country's strategic requirement of food security.

It is in this context, that some basic structural issues are identified, so that appropriate reforms can be effected. These are:

i. Land divisions and fragmentation.
ii. Definition of a farmer - many exclusions.
iii. Uncontrolled variables - production risks and market unpredictability.
iv. Controlled regime – difficulty in doing agri-business.
v. Agricultural policies – holding back income growth.
vi. Infrastructure constraints – limiting the market and income growth.
vii. Climate change – complicating the agriculture.

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7. Structure of Land Holding

Changing Agrarian Structure

Today, Indian agriculture is dominated by small and marginal farmers, who account for more than 86 per cent of the total number of landholdings, that counted to 11.88 crore as per 2011 census. The net arable land measures 141 million hectares. The number of land holdings have been steadily increasing since 1951, when they were 6.99 crore in number. In the year 1995- 96, number of holdings were 11.55 crore and the average size of holding was 1.41 ha. and by 2010-11, the average size declined to 1.15 ha. The country's population has been increasing steadily since independence and the dependence on agricultural output has only increased.

While the population dependent on agriculture for livelihood has come down from more than 70 per cent in 1951 to 48 per cent by 2011, in absolute terms, the number of families and the number of holdings have only increased. The NSSO's Situation Assessment Survey (SAS), during the agricultural year July 2012 – June 2013 shows that, of the estimated 15.61 crore number of rural households, the number of agricultural households stood at 9.02 crore, accounting for 57.8 per cent of the former.

Further, of the 86 per cent of the small and marginal land holdings, the majority are marginal (equal to less than 1 ha. in size). The small size of land holdings is a challenge by itself, which is rendered more complex by its fragmentation. While land division is linked to law of inheritance, fragmentation is associated with the practice of dividing and sharing every piece of land among the inheritors.

Most farms in India are thus family farms, sometimes referred to as 'handkerchief size' holdings. It is important to note, that land size has a bearing on production, input costs and final income. The income from operational efficiency is influenced by the size of land holding. It is difficult operationally to individually harvest the scales of economy at both production and post-production stages, and this adversely impacts the costs of production and transaction.

Land Size and Income

As per NSSO's 70th Round, the average annual income of an agricultural household came from four (4) sources, namely, cultivation, livestock, non-farm business, and wages & salaries. The average annual income was Rs. 77,976 in 2012-13. The average ratio of farm to non-farm income as a proportion of the farmers' income was 60.20: 39.80 (60:40 approx). It is relevant to observe, that the ratio of farm income was directly correlated with the size of the landholding (categorised as marginal + small, medium + semimedium, large) as presented below:

- The income ratio from cultivation increased from 36.5 per cent (marginal + small) to 70.8 per cent (medium + semi-medium) to 85.5 per cent (large).

- The income ratio from livestock declined from 14.8 per cent (marginal + small) to 11.5 per cent (medium + semi-medium) to 6.9 per cent (large).

- The income ratio from wages and salaries declined from 37.5 per cent (marginal + small) to 13.0 per cent (medium + semi-medium) to 3.2 per cent (large).

- The income ratio from non-farm business declined from 7.2 per cent (marginal + small) to 4.8 per cent (medium + semi-medium) to 4.4 per cent (large).

It is obvious, that size of the landholding impacts the percentage of income that accrues to the farmer. It therefore, has a say on the viability of farming and the status of farmers' income.

As per the same NSSO 70th Round (July 2012 – June 2013), while the average monthly income of a farm household in 2012-13 was Rs. 6,426, the average monthly consumption expenditure was Rs. 6,223, leaving a paltry surplus of Rs. 203. That, farmers owning upto 1 ha. of land are not able to balance their farm budget is also clear from the same survey.

Among various sources from which the agricultural households derived at least some income during 365 days prior to the date of survey, the source that yielded the maximum income was taken as the principal source of income. As clear from figure 2.1 below, agricultural households were mainly dependent on cultivation followed by wage / salaried employment for their livelihood, as about 63.5 per cent of the agricultural households reported cultivation, and 22 per cent reported wage / salaried employment as their principal source of income.

Land Pooling and Improving Land Use Efficiency

Since independence, agriculture has been recognised as a primary activity that supports majority of the Indian population. In the absence of the ability of non-farm sector to absorb surplus manpower that is now engaged in agriculture, the primary sector has continued to be the principle livelihood provider to a vast majority. It is only since 2005-06, that a small shift of people from agriculture to non-agriculture sector has been noticed. In result, the number of cultivators has decreased from 12.73 per cent in 2001 to 11.88 crore in 2011.

Further, both the society at large and successive governments in particular have treated land as the primary asset, and that, as many families as possible should have access to it. The country's constitutional commitment to socialism has meant that land, the primary asset should be equitably distributed. It is this philosophy that has inspired the states to adopt progressive Land Revenue Acts, that:

- lay down the maximum land ceiling beyond which a citizen cannot own agricultural land;
- tiller shall be the owner of the land;
- a person with non-farm income beyond a certain threshold is barred from purchasing agricultural land; and
- a person not already owning a piece of agricultural land is barred from purchasing one.

These provisions have, in the past, helped the landless as also the tenants, sharecroppers and lessees to gain ownership and unhindered access to land, thereby incentivising them to invest in agriculture, adopt new technologies and farm management practices, and produce more. Amongst other adoptions (high yielding variety and hybrid seed, fertilizer, water and procurement of the produce at MSP) that constituted a positive policy framework ushering in green revolution in the country, pro-people land reforms too provided a strong platform for India's celebrated agricultural revolution.

However, the contemporary antidote to the non-viability of farming, arising from continuing land division & fragmentation, seems to be the facilitation of land pooling. The very laws that had earlier driven a positive change in the socio-economic status of large number of cultivating class, by enabling a more robust production system, are in some ways now seen to be becoming an impediment to sustaining the pace of that progress.

Land Pooling via Farmers Mobilisation

Indian socio-economic ethos and constitutional spirit do not admit of reverse exchange of land ownership, however forceful its need or appropriateness may be. No argument for it can hold water, given the large majority of people dependent on cultivable land and related agricultural activities; and the inability of the non-agricultural sector to absorb surplus manpower of high magnitude. Against this backdrop, there exists a strong case for designing alternate ways of land pooling, without breaching the spirit of equitability of asset ownership at the societal level, and without compromising the deed of right, title and ownership at individual level. This would aid in enhancing operational scales and resultant efficiency.

Other Land related Issue

Land Management has continued to be challenging and the owners are never at ease on account of a plethora of issues. There is need for resolving all these and given the power of technology - IT, ICT, geo-spatial technology etc., it is much easier today to surmount the long standing land related challenges.

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8. Farmer for Inclusiveness

Agricultural workers

Agricultural Statistics defines agricultural workers to include cultivators and agricultural labourers. In the year 1951, the total numbers of agricultural workers were 97.2 million (cultivators 69.9 million + agricultural labourers 27.3 million). There was a steady increase in respect of both the cultivators and the agricultural labourers from census to census conducted decadally till 2001, when the total number of agricultural workers rose to 234.1 million, comprising 127.3 million cultivators and 106.8 million agricultural labourers. As per 2011 census, while the total number of agricultural workers rose to 263.1 million, the number of cultivators declined for the first time to 118.8 million and agricultural labourers increased to 144.3 million. It is indicative of the shift of cultivators between 2001 and 2011 to nonagricultural activities. It is also possible that some cultivators may have joined the ranks of the landless labourer.

The nomenclature of 'agricultural worker' for a cultivator may not be appropriate. It needs to be appreciated, that a cultivator is an entrepreneur, who manages his land or livestock like an industrial entrepreneur. To a cultivator, management of his asset involves decisions relating to input and output, and negotiating several risks associated with largely a biological activity that agriculture is. The cultivator or a livestock keeper, therefore, needs to be recognised as an agricultural entrepreneur. The National Commission on Farmers (NCF), 2007 in its Report considered both land owning cultivators and landless agricultural workers as farmers. However, no specific recommendations were made to improve the welfare of the landless agricultural labourers.

As regards cultivators per se, not all cultivators are currently recognised as farmers in reality. A farmer is largely perceived to be the one who owns cultivable land, whether he is cultivating it himself or not; or even directly managing it himself or not. While majority of the cultivators are land owners too, a substantive number of cultivators are not land owners. And therein arises the problem of exclusion of many an actual cultivator by the currently recognised definition of a 'farmer'.

To all intents and purposes, a farmer is one who owns land and possesses a revenue record that establishes his right, title and ownership. This record of right (RoR) is the 'certificate' that offers him a right to access all benefits – material or otherwise, that the government provides through large number of its schemes, programmes and missions. The institutional credit – both short term crop loans and long term investment loans are also available based on RoR. The tenants or lessees or sharecroppers are not considered as eligible to avail of institutional credit. The only exception though, is when the farmer becomes a member of a Joint Liability Group (JLG), a group of 10 members. Promoted by NABARD, there are about 1

lakh JLGs in the country, which means a marginal coverage of farmers and cultivated area in the country. Similarly, the relief measures under the Relief Act are also accessible only against RoR.

The vision of the Government is to double the income of the farmers. The DFI Committee focuses on strategy to improve farm incomes, and therefore, does not directly address the issues relating to the welfare of the landless agriculture labourers, who constitute a large section of the rural society. It may not mean much just by including them (144.3 million, census 2011) under the class of 'farmers', as they will need to be addressed separately, since their livelihood issues, while linked to agriculture differ in many ways and are unique to them as a class. However, the strategy recommended by DFI Committee is expected to generate additional job opportunities for the landless labourers too in multiple agricultural activities and contribute to their welfare. Further, the farmers earning higher net incomes can also be expected to pay the agricultural labour at a higher level.

Various benefits like seed kit, fertilizers, pesticides, farm machinery, micro-irrigation, land development, etc. are given to the one who can prove land ownership. As a consequence, the actual cultivator like the lessee, share cropper, tenant, etc. who are in reality substantive in number stand to be excluded from the system of benefits and entitlements. The outcome is, that the objectives of the government intervention, which are all meant to improve the status of agriculture in the country may not be equitable and inclusive.

Purely from the perspective of developing agriculture and ameliorating the condition of the farmers, the actual cultivator also must be recognised as a farmer and rendered eligible to all the benefits under various schemes / programmes / missions, as also institutional credit and relief measures. Under the provisions of Land Reforms, the tiller is considered as owner, precisely to promote agricultural development, for it is believed, that the owner of the land will demonstrate greater commitment to professional management. However, a situation has arisen now, where more than 65 per cent of the landholdings are less than 1 (one) ha. in size. Most in India still perceive land as a valuable asset and the owners may not be willing to give up ownership and tend to cling on to it. Probably, a sense of security and emotional attachment blend together, to enhance the land-centric sentiment among most Indians. It may only be much later in the future, when those whose principle source of income is not from farms and are earning enough from their salaries or business / service, that they may want to dispose off their small pieces of land, helping land consolidation as a sequel.

For the present therefore, it would be practical to liberalise the definition of farmer by including both the land owner, and the one not owning but cultivating it as a lessee or sharecropper or in any other way, under the definition of a farmer.

Norms based Definition of Farmer

In the above context, it is suggested that certain norms be identified to define a farmer, rendering him/her eligible for all agriculture related benefits. Further, the list of farmers can be dynamic, which means that there can be both entry and exit options, based on the actual status of ownership and / or cultivation. Some of the norms suggested are:

i. Ownership of land and/or actual cultivation.
ii. Agreement with the land owner to the effect that he/she is a lessee / sharecropper, etc.
iii. Eligibility for the period of agreement of lease, etc. with the land owner.
iv. Gender of farmer.

A portal may be developed to enable the owner and lessee, etc. to post their status, accompanied by relevant document(s). A database can be maintained by the local Revenue Officer or Gram Panchayat or the local Agriculture Officer. An annually authenticated village-wise database can be made accessible to the officers of the departments of Agriculture, Horticulture, Animal Husbandry, Fisheries, Banks, Cooperatives, Relief, etc. who are then free to offer eligible benefits to newly defined farmers.

A web enabled application will enable the interested parties to update their status from time to time by using their mobiles or laptops / desktops or when they do not own one, can do so from citizen service centres (CSC) or Gram Panchayats and the like.

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9. Uncontrolled Variables - Production & Market

Agricultural and Industrial Production

The process of agricultural activities across crop production, livestock & dairy, poultry, fishery etc. are all nature-bound and hence, influenced by variables external, that matter to the cultivator in respect of production, productivity, pest and disease management, resource use etc., and are difficult to be regulated unlike in the industrial sector. The latter, which is a mechanically driven process, also depends on various factors of production for the manufacture of its output, these nevertheless, to a greater extent, are amenable to control and change.

Wherever the factors of production and related variables are manipulable, there exists scope to regulate the supply in consonance with the expected demand. This is a big advantage that a manufacturing sector enjoys vis-à-vis a biologically driven activity like that of agriculture. Regulation of supply implies that the production can either be increased by enhancing the capacity utilisation to meet the expected increase in the market demand or it can be reduced if the demand is likely to be subdued.

In contrast, in agriculture which is more an open activity, bound by seasonality, there is a fixed time (limited window) to begin the production operations and once this operation is rolled out it cannot be held back. Seasonal nature is characterised by binary system of 'Yes' or 'No'. When it is time to sow / plant / harvest, the farmers either does it or does not and miss the opportunity. Hence, the farmer is always dragged down by an Hobson's choice. Inability to regulate the supply in accordance with the dynamic changes in the market negatively impinges on the ability of the farmer to monetize his produce appropriately.

Not only is the process of production irrevocable once it is rolled out with the first activity of sowing / planting, but also the crop is subject to multiple vulnerabilities like variations in temperature, rainfall, humidity, etc. Every crop has its own critical stages in production, at each of which water the critical input is highly necessary. If the monsoon fails at this critical stage of crop growth and there is no dependable source of water to meet the obligatory demand, then the crop is bound to suffer in terms of vegetative growth as also its final yield. The weather pattern also influences the probability of infestation by pests and diseases. As seen thus, all kinds of cropping programmes face uncertainty. Likewise other agricultural activities like dairying and livestock, poultry, fisheries etc. are also vulnerable to external weather patterns.

Multiple forms of Natural Calamities

Nature wears multiple facets of natural calamities, adversely impacting all types of agricultural activities. These include drought, flood, hailstorm, whirlwind etc. Some areas in India are more prone than others to natural calamities and in result face greater uncertainty of realising a normal yield.

Negative Impact of Production Risks

Any kind of risk deters a farmer from making recommended investments necessary to realise optimal yields. A situation of greater certainty always bears a positive impact on any agrientrepreneur. The losses that a farmer meets from a natural calamity are huge.

Already in the low income bracket, the farmer is pushed to the precipice. His savings if any, melt soon and the farmer is left with no capacity to meet the subsequent season production investments. The probability of his indebtedness increases.

Negotiating Market Unpredictability

The supply in agriculture system is relatively fixed, and is therefore, not amenable to regulation in harmony with the changing market dynamics. However, it is possible to make certain interventions post-the-harvest to regulate the release of commodity into the market based on price situation.

One of the major problems that farmers face today is distress sale on account of their weak capacity to withhold their stock, pressed as they are to dispose-off their produce immediately to meet debt and consumption expenses. Even when some farmers are capable of withholding their stock from immediate sale, they may still not be able to do so due to perishable nature of certain agri-commodities (particularly fruits, vegetables, milk, etc.) and absence of appropriate logistics systems in close proximity.

In order to help the farmers to hold back their produce and decide on its time, place and form of sale, enabling systems, technology and infrastructure should be put in place. Some suggestions in this direction are as follows:

(i) Enhance availability of post-harvest loans at concessional rates, so that the farmers can avail of pledge loans for a certain period. The pledge loan system warrants a strong network of accredited warehouses in close proximity to the farm gate so that the farmers can transport and store at minimal costs.

(ii) Strengthen agri-logistics in terms of pack-houses, dry and cold storages, dry and cold multi-modal transportation network. This will help the farmers to precondition, transport and store their commodities, of their own volition, in a safe and secure manner in right time and to places where they can fetch better prices for their produce. The logistics components, identified to be of critical

importance, may be given special capital interest subvention to motivate investment and offset shortfall. There will then arise a strong system of connect between production and consumption centres.

(iii) Processing facilities, both small and large scale, can further help the farmers in realising better value on the surpluses that cannot be consumed in fresh form in both near and far markets. It is, therefore, necessary to strengthen food and non-food processing facilities. Such industries, typically hold and stock nventories for their processing needs, and can be developed as a channel to facilitate post-harvest loans to farmers.

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10. Trade Regime and Export Promotion

Among various factors, farmers' welfare is also hinged to their earning optimal and positive net returns from agriculture. This necessitates realisation of remunerative prices on the produce. Given that an ideal market situation, particularly in the agricultural sector, is difficult to achieve, non-market interventions in support of the farmers become inevitable.

Given production growth and the untapped opportunity from enhancing productivity, marketing opportunity for the produce have to be expanded beyond the domestic frontiers. Higher production will require that the export potential be harvested. Indian agriculture under the WTO regime is already integrated with the global market. Agreed upon market access protocols and Trade Agreements with other countries also ensure the scope for import and export of agricultural commodities.

Trade Policy used to Control Domestic Prices

A cursory look at the 'Agricultural Trade Policy' and tariff changes over the last decade, will show that there have been frequent and short term adjustments. More currently, they can be called as knee jerk reactions. Some examples are provided in chapter 5 of Volume-IV of the DFI Report. The examples demonstrate that, both on the import and export sides, the policies are changed frequently, interrupting the trade windows and trading relations. Long term market relations are put at risk when trade policy is varied in the short term and is unstructured in nature.

The trade policy for agriculture is approached as a price support and price stabilisation tool, but its use is mainly tilted to favour consumers. On various occasions, a sudden reduction in import tariffs due to an increase in consumer prices is evidenced, and they harm the immediate interests of farmers, since the cheaper imports tend to offset the economic welfare of farmers by causing a dip in market prices.

Similarly in case of exports, trade policy is used as an internal price control mechanism, to adjust tariffs to curtail any increase in consumer prices. The Minimum Export Price (MEP) is used as a tool to restrict or ban the export of a commodity in reaction to rising prices in the domestic market to protect consumer interests once again. In either case, the agenda is to control the supply of an agricultural commodity to the domestic market, to adjust temporary demand-supply imbalances.

The frequent changes in export and import policies are often triggered by concerns of consumers' unease over domestic prices. The effect is a short term shift in supply and market value, but this in turn, causes disruptions in the production plans of farmers. Such disruption can have long term implications, as they tend to affect next season's cropping plans, resulting in an unhealthy cobweb of production, price and trade.

The agricultural trade policy is not seen to promote agricultural trade, but is mainly used to control prices in the domestic market, in reaction to short term circumstances

There may be certain benefits in achieving this, but there is need to have an Agricultural Trade Policy that supports and promotes linking Indian farmers with the global market. The agricultural trade policy should be guided by balancing the interest of both the producers and the consumers, in addition to long term food and nutritional security concerns of the country.

Agricultural Trade Policy to Promote Trade

There is no long term approach to Agricultural Trade Policy in the country, unlike the Foreign Trade Policy announced by the Department of Commerce which usually takes a long term view (3 years at present). As a supply control mechanism, short term adjustments in tariff and export windows tend to disrupt any planning, or relationship building in international trade. Agriculture is already unpredictable, subject to vagaries of nature on the domestic front and markets uncertainties. A short term view of trade policy only adds to the existing risks and uncertainties.

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