

Digital India - Reaching to Small, Marginal & Women Farmers

Dr. Amrit Patel

[Former Deputy General Manager, Bank of Baroda]

Agriculture & Rural Credit Consultant, Ahmedabad, Gujarat, India

ABSTRACT

India has been endowed with substantial resources for sustained agricultural development, viz. land, labor, water, livestock, fisheries, forestry accompanied by congenial climate and adequate solar radiation. India has, also, established extensive and robust network of agricultural research institutions which have been engaged in evolving high-yielding varieties of crops and production technologies. However, studies have revealed that government's agricultural extension agencies are weak to disseminate accurate and authentic information relating to proven farm technologies and related services to small, marginal, tenant and women farmers. It has been reported that only 3% farmers receive agricultural information from the government agencies whereas as high as 94% farmers depend upon "fellow farmers" followed by agricultural input dealers [10%], and TV/Radio [4%]. According to a "Situation Assessment of Indian Farmers", only about 28% of all farmers use any kind of agriculture-related information that is available rather than *what they need*. About 72% of farmers, especially small farmers and other vulnerable groups do not benefit from any source of information delivery system that can help them adopt latest technology. Additionally, farmers are unable to benefit from several institutions, organizations and agencies [credit, insurance, marketing etc.] established to provide support services. This is primarily responsible to farmer's low crop productivity, output and profitability of farming enterprise. This article briefly highlights the imperative need to facilitate small, marginal & women farmers' easy, authentic and accurate access to agricultural information that they need through digital ecosystem for agriculture and initiatives of the government & private sector along with specific areas that need for focused attention in the context of government's policy on digital India.

Keywords: TV/Radio, ICAR, AGRISNET, ICT, KCC, M2M, SEEDNET, DACNET, AGMARKNET, RML, ITC, USAID

I. INTRODUCTION

Low Crop Productivity & Profitability

Despite India has the largest irrigated land and ranks second in terms of arable land the yield of most of the crops is 20%-40% of the world's best levels. As for example, yield of rice in 2011 in India was 3.2 tons per hectare as against 7.5 tons in USA, 6.7 tons in China and average of 4.3 tons for the world. Similarly, yields of coarse cereals were 1.0 ton per hectare in India as compared with 2.7 tons in USA and 2.1 tons in China. Even the most productive States in India fall short of world standards in terms of yields. During 2010-11, Punjab with the highest yield in rice produced 3.8 tons per hectare as against the world average of 4.3 tons. Yield of oilseeds in Tamil Nadu, the highest in India, at 2.1 tons per hectare was lower than 2.7 tons in China and the USA. The ICAR study to assess the size of untapped yield reservoir in different crops and in different agro-

ecological regions at currently available levels of technology showed that the difference between the yield of demonstrations in farmers' fields and the average yield of the area varied by a factor 3 to 6. The ICAR report on the available exploitable production potential showed that, integrating agricultural credit with technology and production inputs, farmers can increase wheat production by 30 million tons or around 40% and double paddy production at current levels of technology. Efficient agricultural extension agency and support service providers can bridge the existing gap between the actual crop yields at field level and the potential yields. The post-harvest losses exceed 25% annually. For marketing, small farmers have to deal with multiple layers of middlemen. For example, farmers sell 85% of wheat and 75% of oil seeds in Uttar Pradesh, 70% of oil seeds and 35% of cotton in Punjab, and 90% of jute in West Bengal in village itself. These middlemen take away about 47% of the price of rice, 52% of groundnut and 60% of potatoes. On an average, Indian farmers realize only 20%

to 25% of the value paid for by consumers as compared to 40% to 45% in developed countries.

II. METHODS AND MATERIAL

Rural & Agricultural landscape of India

- **Rural households:** [i] India has 73.5% rural households of which less than 50% are engaged in agriculture; 25 % have no access to irrigation; only 30.1% directly engaged in farming and 51.14% employed as farm or manual laborers [ii] In case of 74.5% of rural households, the highest-earning member earns less than Rs.5000 per month [iii] 36% of the 884 million people are illiterate; of the 64% literate, more than 20% have not even completed primary school, only 5.4% have completed high school and 3.4% have graduated from college; 23.52% rural families have no literate adult above 25 years [iv] 12.24 crore [68.32%] have mobiles which suggests mobile connectivity has become a basic service, helped by cheaper handsets and call rates.
- **Small farmers:** Indian agriculture has been characterized as farms of “small and marginal” size. Small and marginal farmers owning less than two hectares constitute 85.9% of the total. Though small farmers are efficient in production their increasing number and shrinking farm size raises questions about their economic viability, sustainability and producing marketable surplus. Disadvantages they face are economies of scale and inadequate access to technology, production inputs, institutional credit, insurance and marketing services. Agriculture has been crowded with the increasing number of small farmers and facing substantial production, market and climate change risks, thereby forcing them in a vicious cycle of food insecurity and poverty. During the last three decades [1980-81 to 2010-11] [i] numbers of landless labourers and the land owners have doubled from 141 million to 282 million [ii] nearly 50 million holdings were added from about 88 million to 138 million. This resulted in the decline in operated area by about four million hectares and [iii] 91 million landless labourers were added from 53 million to 144 million. The net sown area remained stagnant around 140 million hectares since 1970-71 and consequently the per capita net cultivated land area declined from 0.26 hectare in 1971 to 0.11

hectare in 2011. Also, the land/man ratio declined from 0.90 hectare per agricultural worker in 1972-73 to 0.68 hectare per worker in 2009-10. This shows significant pressure on land creating adverse impact on land and labour productivity. This declining trend makes small farms financially unviable/unsustainable leading to increase in the rate of poverty. Small farmers are concentrated in rain-fed areas and cultivate crops under a high risk environment, mostly confronted by frequent droughts, floods and soil erosion. Their crop-yields are lower than that of irrigated/better endowed areas. Policy and programs to enable them to access technologies; technical education, credit, insurance and marketing services are *sine qua non* for them to produce marketable surplus farm output, minimize costs & risks, and generate more income.

- **Land Degradation:** More than 57% of the total reporting area in India is characterized as degraded land as against 17% at the global level. Nearly 120.72 million hectares of land in India is degraded due to soil erosion and about 8.4 million hectares are affected by soil-salinity and water-logging problems. It is estimated that India is losing every year about 0.8 million tons of nitrogen, 1.8 million tons of phosphorus and 26.3 million tons of potassium depriving soil major essential plant nutrients.

Potential of ICT

Information and Communication Technology (ICT) has the potential to revolutionize Indian farming sector in terms of significantly improving farm productivity, production and profitability at the level of lakhs of small, marginal, tenant and women farmers. Several apps are now available and many more can be developed which can help farmers access authentic, accurate and timely information related to high-yielding variety seeds, production-enhancing & cost-minimizing agronomic practices, efficient use of water including micro-irrigation system, integrated nutrient and pest management, post-harvest management technology, measures to mitigate adverse impact of climate change and marketing of farm produce in domestic and international markets.

Farmers' Needs

Digital ecosystem for agriculture in 21st century assumes indispensable role for disseminating information on all

aspects of developing agriculture including crop cultivation, animal husbandry and fisheries. Farmers, in the context of advanced technologies developed by national, regional and international premiere research institutes, need to be motivated and encouraged to adopt these proven yield-enhancing, cost-efficient and environment-friendly technologies. For this, they should be provided accurate information from authentic sources on various aspects, viz. [i] details of location-specific crop production technology [ii] economics of crop, livestock and fish farming [iii] authorized sources of timely availability of standard quality inputs [seeds, fertilizers, pesticides etc.] farm equipment, sprinklers, drippers, among others, along with costs [iv] post-harvest management technology and facilities including transport, storage, processing, preservation, packaging and marketing [v] commodity prices, weather, measures to minimize impact of drought and climate change [vi] detailed procedure for availing bank credit, crop and livestock insurance cover, government subsidies, land records, schemes of National Bank for Agriculture and Rural Development, etc. [vii] government's programs providing subsidy and other facilities to develop irrigation potential, rainwater harvesting, soil and water conservation measures, soil and water testing, prevention and control of pests and diseases, bio-gas, minimum support prices [viii] contract farming, value chain system, warehouse receipt [ix] reclamation of degraded, saline & alkaline land [x] mechanism to redress grievances. Accordingly, farmers need ICT-enabled portals for following purposes. .

Technology: Production-enhancing proven crop-specific technologies [from pre-sowing to harvesting and post-harvest management] based on soil & water analysis. Separate for dry land & irrigated farming focusing efficient use of seeds, fertilizers, water, pesticides, farm equipment & labour; and reclamation of degraded, saline & alkaline land.

Production inputs & farm equipment: Crop-specific reasonably priced standard quality production inputs [seeds, fertilizers, pesticides, etc.] and farm equipment and machinery along with sources of availability

Post-harvest services: Storage, transport, processing, packaging,

Institutional services: Land records, farm credit, insurance, marketing, weather, farmer-producers' organizations, market yards, procurement centres

Government facilities: Availability of subsidies, assistance available to mitigate effects of climate change, drought, floods, earthquake, cyclones

Institutions: State government's department of agriculture, state agricultural universities, krishi vigyan kendrs, regional research institutes, farmer-producers organizations, corporate/industrial/business houses and multinational companies engaged in manufacturing/production and distribution of farm inputs, farm equipment & machinery, rural financial institutions, insurance companies, among others, have a significant role and added responsibility to contribute their professional knowledge to develop digital ecosystem for agriculture in India.

Mobile penetration in rural areas

India has about 69% rural population. In 2002, the Government constituted a Universal Service Obligation Fund, to encourage private telecom operators to service remote and less lucrative markets. The digital penetration in the Indian hinterland is growing silently but rapidly. Internet penetration is increasing with mobiles playing the major catalytic role. According to the Telecom Regulatory Authority of India, country has around 960 million mobile subscribers as of 31st March 2015 and now service providers for expansion are focusing attention to rural India. By June, 2014, rural India have about 122.4 million [68.32%] households with mobiles and estimated 85 million Internet users exhibiting mobile connectivity has become a basic service in rural areas. Rural mobile subscriber base is growing twice as faster compared to urban subscriber base. As of March 2015, the national teledensity was 79% and rural teledensity 46.5%. The 2012 Telecom Policy aims to increase rural teledensity to 60% by 2017 and 100% by 2020. Study of the IAMAI revealed 80% using it for communications, 67% for online services, 65% for e-commerce and 60% for social networking. In coming years, digital platform will herald a new era by empowering the rural households through a variety of services. Since the Government is committed to provide services through the digital platform in several areas [including improved governance, land records, health, education and agriculture and digitisation of personal and public records] rural India would present unfathomable opportunities to a number of promising entrepreneurs and existing business/corporate houses to service the rural markets as never before.

Mobile phones can be effectively utilized for myriad purposes including generating, processing, transmitting, disseminating, sorting, archiving and retrieving critical information and data relating to agriculture. Mobile phones are omnipresent and cost effective means to revolutionize agriculture in India. Mobile telephony has significant potential to deliver the benefits of information

access and digital empowerment to large number of small, marginal, tenant and women farmers. Farmers' timely access to farm output related minute information right from the selection of seeds for planting to marketing of produce in domestic and international markets is a must. Mobile Vaani is an important platform on which various innovative technologies can be deployed to address the needs of the farmers and the farming community. Gram Vaani technology offers interesting voice-based platform that can be used for Information dissemination and establishing helplines to answer agriculture-specific queries of farmers.

Government's initiatives

- The Government has proposed a National Broadband Network, which will essentially lay out a fibre-optic cable across the country to achieve last mile connectivity. The Government through the network, like roads, will encourage private operations to make services available in those previously untouched areas. For this, the Government has committed about \$4 billion to build the network to connect 250,000 village headquarters.
- The Government has proposed to create a National Agriculture Market. Currently, farmers are restricted to selling their produce at mandis or market committees that charge various taxes on producers. An online platform would be set up wherein farmers will be able to sell and buy fruits, vegetables and other produce from across the country. An agency would be set up to oversee online trading and to ensure that transactions take place smoothly. It will also focus on creating go-downs and facilitating transportation of the farm produce after the online trade. The move is expected to give choice to farmers to sell the farm produce both in physical mandis or online platform. The freer access to sell via online trade is likely to boost their incomes and improve availability moderating price rise.

Use of ICT in Agriculture: : Acknowledging the emphasis of the national policy on farmers to use ICT for disseminating among farmers at village level the required and authentic information and advisories, sustained efforts are being made to improve and harness latest IT techniques which can capture and collate data and add value to it.

- Government has already developed and put in operation three portals viz. farmer portal, kisan call centre and mkisan portal to facilitate farmers take informed decisions with more precision for efficient

farming and utilization of post-harvest products due to weather unpredictability. Analytical tools can provide demand forecasts to enable farmers to produce as per the requirement, thus cutting down on wastages. Farmers can reach the nearest buyers directly and sell products easily and thus can avoid post- production storage and transportation cost. Social media help connecting farmers all over the country and connecting buyers with sellers directly removing the middlemen.

- Recently farmers in Maharashtra have formed a group on social media and invite other farmers from across the region to join the group to meet the supply-demand gap.
- **Farmers' portals:** This portal aims at serving as One Stop Shop for all farmers for accessing information on agricultural activities. Besides, giving links to appropriate pages of 80 portals already developed so far, the farmers' portal links the location of the farmer [from his block] with National Agricultural Research Project zone that he belongs to. Therefore, all information related to crops grown in that area along with agronomic practices in that region is then provided to the farmers using a graphical interface. Farmers can get information about package of farm practices, crop/seeds/varieties, common pests; dealer network for seeds, fertilizers, pesticides, machinery & tools, agri-met advisories etc. Data for most states has been entered in one language and the portal will be launched after the data are entered both in English and in vernacular language of the State.
- **Kisan Call Centres:** KCC initiative aims at providing information to farmers through Toll-free telephone line. Farmers can get information in their language through 25 kisan call centres located in different States. During four years in each of the 10th and 11th plan 20.63 lakh and 41.85 calls were received. Kisan Knowledge Management System is developed and KCC agents give instant and appropriate information making use of this user-friendly search engine. Unattended calls automatically get escalated to the next higher level after some time for further response.
- **Machine-to-Machine [M2M]:** M2M helps farmers optimising crop productivity through efficient use of farm resources on real time basis under different agro-climatic conditions.
- Technologies, viz. geographic information system and global positioning system along with a wide range of sensors, monitors and controllers for agricultural equipment enable farmers to use

electronic guidance aids to direct equipment movements more accurately and provide precise positioning for all equipment actions and chemical applications.

- Precision farming helps in mapping and monitoring crop yield as also presence of weeds, salinity, applications of fertilizers and spraying pesticides at variable rates.
- Under the eGovernance program, soil health card software has been standardized and web-based software developed in association with Indian Institute of Soil Science, Bhopal to provide
- integrated nutrient management recommendations using soil test crop response method for eight states.
- **National e-Governance Plan in Agriculture [NeGP-A]:** This mission mode project introduced during XI plan aims at achieving rapid agricultural development by providing agriculture related information to farmers through use of ICT. For providing information on various activities to farmers under agricultural value chain system various IT initiatives are taken up. These initiatives are being integrated to help farmers make proper and timely use of available information. This information will be provided to farmers through multiple channels including Common Service Centres Internet Kiosks and SMSs. Currently, 12 identified clusters of services provide information on [i] weather [ii] soil health [iii] seeds, nutrients, pests [iv] irrigation [v] crops, good agricultural practices, farm machinery[vi] marketing infrastructure [vii] farm commodity prices, arrivals, procurement points, interaction platforms [viii] electronic certification for export & import [ix] drought relief & management [x] livestock, fisheries management[xi] training [xii] monitoring implementation and evaluation of schemes. The first phase of the project is under implementation in seven states, viz. Assam, Himachal Pradesh, Karnataka, Kerala, Jharkhand, Madhya Pradesh and Maharashtra.
- **Strengthening/promoting Agricultural Informatics System:** To promote e-Governance in agriculture at the level of central government & to provide support to states for implementing the central sector schemes with components viz. [i] IT Apparatus for central Government, field offices & directorates [ii] development of agriculture informatics & communication [iii] strengthening of IT Apparatus in states [AGRISNET] [iv] Kisan Call Centres. IT Apparatus for central government and its field offices/directorates: Under the DACNET project, the directorates and field offices are provided basic infrastructure to help achieve e-readiness.

- **Development of informatics & communication:** Government has developed 80 portals, applications and websites, in association with NIC, covering both the central /state governments, and field units. Portals include SEEDNET, DACNET, AGMARKNET [prices &, arrivals in mandis], RKVY, ATMA, NHM, NFSM & APY [acreages, productivity & yield]. This facilitates the central government to get online data right from district level and generate reports.
- **Strengthening IT Apparatus in States/UTs [AGRISNET]:** Under the scheme funds are provided to states for providing computers up to the Block level in 26 states, state-specific software packages have been developed to disseminate information to farmers Availability of required hardware and locally suitable software package has resulted in quick retrieval of data, dissemination of information to farmers and provision of farmer-centric services. States include, Andhra Pradesh, Madhya Pradesh, Tamil Nadu, West Bengal, Uttar Pradesh, Gujarat, Karnataka, Uttrakhand, Himachal Pradesh, Meghalaya, Nagaland, Sikkim, Maharashtra, Punjab, Odisha, Mizoram, Kerala, Haryana, Rajasthan, Chhatisgarh, Puduchery, Arunachal Pradesh, Goa, Bihar and Manipur.
- **Activities in NER:** Under the IT Apparatus at field offices/directorates offices covered are [i] directorate of marketing & inspection, Guwahati & Shillong[ii] central integrated pest management centres at Guwahati, Aizwal, Dimapur, Gangtok [iii] regional bio-fertilizer development centre, Imphal [iv] NER farm machinery training & testing centre at Sonitpur, Assam [v] support under AGRISNET extended to various States of NER.

Private sector initiatives

Private sector, NGOs and social groups have also been using ICT in agriculture to supplement the efforts of the Government for efficient delivery of a variety of services to farmers. Following two, among others, are briefly described which have unique methodologies and content to enable farmers to access a plethora of services for agricultural development.

e-Choupal: It is a business initiative by ITC that provides Internet access to farmers. e-Choupal is an innovative market-led business model designed to enhance the competitiveness of Indian agriculture. e-Choupal leverages the power of Information and digital technology and the internet to empower small and marginal farmers

with a host of services related to agricultural knowhow and best practices, timely weather information, order supplies of inputs throughout the region, transparent discovery of farm prices, questions & answers section which enables interaction with ITC's agricultural experts.. ITC is, also, partnering with banks to offer farmers access to credit, insurance and other services. Portal, also, enables farmers to manage risks, such as soil contamination or salinity, through access to technical information.

ITC has established "ITC Kiosk" with computer and internet facility in villages managed by a computer-trained farmer [sanchalak] in his house and is linked to the Internet via phone lines or by a very-small aperture terminal [VSAT] connection. e-Choupal builds on three elements, an internet-enabled computer located at a "focal point farmer," an internet connection via phone lines or VSAT and dedicated services through the echoupal.com portal. Each internet connection serves 10 villages in a 5km radius, reaching 600 farmers on average. This creates a direct marketing channel for farmers, reducing their transaction costs and improving logistics. Finally, it provides the link to Choupal Saagars, integrated rural service centres serving 40 e-Choupals each, where farmers can bring their farm produce to sell and buy seeds, fertilizer and consumer goods. The sanchalak bears some operating cost but in return earns a service fee for the e-transactions done through his e-Choupal. The warehouse hub is managed by the same traditional middle-men [samyojaks] but with no exploitation due to streamlined services. These middlemen fulfil critical jobs like cash disbursement, quantity aggregation and transportation

e-Choupals not only connect farmers with markets but also allow for a virtual integration of the supply chain and create significant efficiencies in the traditional system. Its aim is to inform and empower farmers which can improve farm productivity and quality of agricultural products. Farmers' higher profit margin is because they are no longer forced to sell through a middleman. ITC benefits because its simplified and intensified supply chain system increases business and profits. ITC has 6500 e-Choupals computer stations in 40,000 villages serving 4 million farmers of 10 States in India.

RML Information Services Pvt. Ltd: Following nearly 18 months of market research prototyping and market trials, RML was launched in Maharashtra in 2007 and in Punjab in 2008. RML delivers customized, localized and personalized agricultural information to farmers from pre-

sowing to post-harvest stages including weather, crop prices through SMS on mobile phones in local language. About 1.4 million farmers from about 50,000 villages have been using this service across 18 states. Following are RML's key ICT products:

- » **RMLdirect**- SMS based personalized agricultural information service on crops from pre-sowing to harvest and selling of crops
- » **Krishidoot** -Connecting farming communities and marketplace for agricultural value chain system
- » **R-Edge** Market Information
- » **RMLpro** -Analytical and communication tool providing data, insights and intelligence on farmers' organizations, farmer groups, commodity prices
- » **myRML** -Comprehensive agriculture information application for farmers

RML has empowered farmers with actionable information which enables them to take informed decisions and reduces their production and marketing risks, thereby directly improving their livelihood. According to ICRIER study [2009], RML users had 5% to 25% increase in their income. The World Bank study [2010] revealed 8% increase in price realization to farmers selling directly to traders. The USAID study [2011] observed that farmers accessing RML services realized Rupees six to eight more per kg on their crop.. Around 80% farmer-users improved alignment of farm output to market demands, ensuring improved productivity and better quality of produce.

ICICI Bank in Akodara

The ICICI Bank, India's largest private sector commercial Bank, recognized the hard reality that with a nearly saturated urban market and intense competition over a reducing pie, rural India is where the future of banks lies. And it has demonstrated through its branch in Akodara village [Sabarkantha district of Gujarat] that the key to bank's growth is technology, as it is only through mobile phones, the Internet, and tablet banking that banks can bring down operational costs and boost rural consumption and rural economic growth.. Akodara's real symbolic appeal for Indian corporate entities lies in something beyond what ICICI has done. Young generation in this village regularly buy things from Flipkart and Snapdeal. For them to buy most things online is common. They do not worry about getting inferior product because they know that they can return the same if there is a problem. This signifies that commercial banks can replicate the

experiment of technology-savvy branches profitably in thousands of unbanked villages across the country.

III. RESULTS AND DISCUSSION

Digital India

Government of India's "Digital India" envisions empowering citizens with e-access to government and related livelihood services. The project has three core components, viz. digital infrastructure, digital services and digital literacy. Mobile phone is the preferred delivery medium under digital India with focus on mGovernance and mServices. The mAgriculture and mGramBazar out of the seven components covered under mServices directly impact agricultural extension services. The recently launched innovative concept of dedicated Payment Banks, supported by digital platform and mobile operators who have millions of customer- access points across the country, would enable customers load cash onto mobile wallets and send payments across the country. All the components of the policy and programs embodied in the Prime Minister Narendra Modi's address on Wednesday, the 1st July 2015 while inaugurating the "Digital India Week" are most relevant to agriculture and rural livelihood as it would empowers the people and extend services better with the use of information technology and its tools. The digital India has the potential to create a transformational change in various sections of the society with rural India poised for being the biggest beneficiary of this change. The plan to provide universal phone connectivity and access to broadband in 2.5 lakh villages by 2019 is the clarion call for corporates and entrepreneurs to seize the opportunity to develop new solutions for rural markets.

The digital India policy has several aspects to benefit rural India, viz. [i] seeks to transform India into a digitally-empowered, knowledge economy [ii] will facilitate efficiency in governance through programs that include digital literacy and electronic delivery of services [iii] seeks to develop online on-demand digital signature and every Indian will have a digital identity and a mobile connection linked to it [iv] re-engineering of software and systems to help store, share online certificates that will bring convenience and eliminate paperwork[v] at least one person in every family would be digitally empowered, The government expects to make 10 million people digitally literate in five years while aiming to train one million individuals by the end of 2015-16. [vi] covers nine programs that include broadband highways, 100% mobile density, electronic manufacturing and

eKranti or electronic delivery of services by 2018 [vii] aims to bridge the digital divide existing in the country [viii] among other things, it will boost e-governance in several state services, which will cut delivery costs and increase transparency[viii] focus on spreading the broadband connectivity across all local government bodies by 2017 to reach out to underprivileged masses and bring them into the mainstream of society[ix] government has envisioned the 'National Digital Literacy Mission' to educate over 1 million people by 2019.

Focused Attention: "Digital India" policy for agricultural development offers the potential to add annually 0.5% growth rate in agriculture [3% in 5 years] and generate annually 30,000 to 40,000 employments for rural youths trained in agriculture & computer technology by state agricultural universities. For this, following areas need focused attention.

- Immediate need is to conduct a nation-wide[separately for each agro-ecological region] evaluation study to assess the impact of digital ecosystem for agriculture already developed and put in place by the government and private sector in respect of [i] number of farmers regularly receiving & using mobile-enabled agricultural information services [ii] feedback from users about content, timeliness, utility, satisfaction, changes required, their grievances [iii] increase in productivity, output and income of benefitted farmers [iv] increase in price realization in farm commodities sold, direct selling without dependence on middlemen [v] reduction in costs of transactions[vi] mechanism to redress grievances.
- The study of the Asia-Pacific Research Centre of the Stanford University on ICT Initiatives under the project "Agriculture & Rural Livelihood" in India concluded that the *usage of ICT* was sparse compared to its significant potential and substantially constrained by factors viz. illiteracy, inadequate infrastructure [particularly connectivity], low level of awareness of usage, availability of very few digital programs, central site location, and government regulations. This suggests the greater need now than before to make coordinated and concerted efforts to create a national agricultural knowledge repository in digital form which is nurtured daily through feeding, weeding, pruning and enriched and disseminated among farmers.
- For developing farmer-friendly digital ecosystem for agriculture & better suited to different agro-ecological regions, factors which need to be considered include viz.[i] Indian agriculture is characterized by innumerable fragmented small farms and very weak

infrastructure [ii] most farmers have to heavily depend upon middlemen and a patchy network of *ad hoc* information sources such as local shop keepers leverage the information asymmetry in the system to make higher profits at the cost of the individual farmers [iii] agriculture is among the most complex commercial systems which requires inputs from a plethora of sources in relation to soil, water, environment, goods, asset and labour markets[iv] apart from the availability of new agricultural technology, a significant amount of useful knowledge generated remains at local level as unstructured information or tacit knowledge[v] timely creation, dissemination and enhancement of appropriate and relevant content for farmers should be the prime focus of digital ecosystem for agriculture [vi] the diffusion and use of ICT can be made self-sustaining and self-enabling by improving the level of general literacy and computer skill[vii] an ideal knowledge ecosystem for agriculture should be able to capture all intricacies and build a large knowledge sharing data base to ensure that the implicit knowledge or experience of one farmer is shared with many others without necessitating the re-invention of the wheel over geographically or temporally separated regions[viii] highly specific local needs and existence of the great diversity in local conditions [ix]poor literacy rate, low use of textual information in daily life and high reliance on verbal communication for knowledge transfer[x]remote village locations [xi] content availability in vernacular languages[xii]any technology solution aimed at benefiting large number of small farmers must be affordable and low-cost so that the perceived economic benefits of such an endeavour are much more than the cost of switching over to a different technological solution.

- For successful designing digital ecosystem for agriculture, the system design should have all desired features of *higher user satisfaction*, viz. [i] ease of access [ii] updated content [iii] layout, design, consistent themes [iv] easy navigation [v] higher interactivity [vi] access through multiple media (particularly voice) [vii]higher use of non-textual information [viii]language options[ix]lower cost of transaction.
- Setting up manufacturing facility to produce large scale low cost devices, the shared use of mobile devices by families in rural markets, sharing cost of infrastructure by mobile service providers and government subsidizing the roll out cost of mobile services would benefit farmers and boost rural growth.

- A professionally managed ICT platform in public private partnership mode can bring various pieces of agricultural value chain system together and design solutions with ‘mobile-first’ approach to maximize on-ground adoption and create visible impact.
- Regulatory & Development Authority need to be in place to ensure [i] increase in farmers’ easy, timely and reliable access to agricultural information system [as per farmers’ needs] throughout the country in a systematic & planned manner [ii] development of need-based appropriate digital models for agriculture under public & private sector which conform BIS & available at affordable cost[iii] improving general and digital literacy and computer skill and digital infrastructure in rural India in line with digital India vision and [iv] prevention of fake models and fraudulent practices.

IV.CONCLUSION

A digital ecosystem for agriculture offers farmers from less developed and remote areas opportunities to participate in the global economy, resulting in knowledge sharing and cooperation among farmers of India and the world to foster local agricultural & economic growth. Development and management of digital contents would result in access to the right kind of information at the right time, resulting in inclusive growth as well as competitive agriculture. It would facilitates two way interactions among all stakeholders, viz. farmers, agricultural scientists, input dealers, marketing agencies, food processors, credit & insurance agencies which are critical for further technological progress in agriculture. In any developing economy, the success of any social development initiative depends on the commitment and ability of the policy makers to seek full participation of the users and the active involvement of the private sector. The unlocking of the potential for agricultural and rural transformation on the strength of digital platform calls for continued innovations and pragmatic approach for determined implementation.

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