CHIEF EDITOR
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EDITORIAL SUPPORT
NAVEEN JOSHI

JOINT DIRECTOR (PRODUCTION)
VINOD KUMAR MEENA

COVER DESIGN
ASHA SAXENA

EDITORIAL OFFICE
ROOM NO. 653,
Publications Division,
Soochna Bhawan,
C.G.O. Complex, Lodhi Road,
NEW DELHI-110003
Phone : 011-24362859
E-MAIL : kurukshetra.english@gmail.com

FOR SUBSCRIPTION ENQUIRIES,
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INFORMATION
PLEASE CONTACT:

JOURNAL UNIT, PUBLICATIONS DIVISION
MINISTRY OF I & B, ROOM NO. 48-53,
SOOCHNA BHAWAN, CGO COMPLEX,
LODHI ROAD, NEW DELHI-110 003
TELE : 24367453
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Editorial

Technology is a panacea for rural India as it can help improve the quality of life, especially for the poor and disadvantaged. It paves inroads for more and better services and transforms economic scenario. Inputs of technological advancement in agriculture, irrigation, water management, health, communications, biotechnology and GIS hold tremendous promise to transform individuals' lives and enable rural India to progress at an unprecedented speed, hitherto unimaginable.

In a country of India's size and diversity, where more than 68 per cent of the population resides in the rural areas, technological inputs are essential to increase productivity and economic viability. The technologies meant for rural areas should be appropriate for them to fulfil their basic needs and improve their quality of life by taking note of the available skills, financial and natural resources. Some of the technologies appropriate in this context may involve advanced concepts and use very recent scientific developments. Some of the cutting edge areas of science and technology like Space, Biotechnology, Information and Communication Technology (ICT) can be of great relevance for rural development. With telecommunication technology, computers and information processing technology, data and image transfer technology, and interactive technology, there is a qualitative difference in the way we can generate, disseminate and transfer knowledge which in turn promote development. Such technologies have opened new frontiers of knowledge for accelerating rural development efforts. PM Modi has said "I see technology as a means to empower and as a tool that bridges the distance between hope and opportunity" which is so very true for rural development in India.

The focus of the government is to provide solutions through technology which rural people can afford on sustainable basis. One of the areas of focus of the Office of the Principal Scientific Adviser to the Government of India is related to the development and dissemination of technologies for rural development. S&T NGOs, government agencies, district-level administration, and a few initiatives from the industry have been successful in disseminating rural development technologies up to a point. To face the challenge of establishing synergy among all these efforts , RuTAGs (Rural Technology Action Groups) have been conceptualized. As a synergizing mechanism, RuTAG addresses the need based up-gradation of technologies with the help of Indian Institute of Technology (IITs) and local NGOs. RuTAGs activity is helping towards dissemination of refined technologies reaching to rural areas and technology delivery for non-farm/ agriculture sectors. Another such initiative is AKRUTI" programmes under Department of Atomic Energy(DAE) – societal Initiative. Under this framework, `Rural Technology Delivery Centres – RTDCs will be set up jointly by different RuTAGs, BARC and local technically oriented NGO and technologies will be delivered to villages through `AKRUTI-KRUTIK-FORCE' format via RTDCs.

Through such initiatives, Government wants that true development must put the people and their land on the development path so that the people can not only be the beneficiaries, but can also contribute in the rural development on the whole.

SPACE TECHNOLOGY FOR RURAL DEVELOPMENT

Santanu Chowdhury, Dr. K Mruthyunjaya Reddy, E Sivasankar

Affordable mobile telephones embedded with operationally compliant positioning device as well as photography coupled with internet connectivity have added another dimension of digital access to every rural dweller. In such context, it is timely that ISRO has initiated web based geospatial information systems at the behest of Departments dealing with Rural Development in a comprehensive manner. The Geo-spatial solutions contribute to development of rural areas to realize the objective of creating Digital India by minimizing the space between Technology and common man.

The Indian Space programme has the primary objective of developing space technology and application programmes to meet the developmental needs of the country. Space technology, as the powerful enabler, provides a variety of vital inputs for holistic and rapid development of rural areas, and villages in specific. India has been among the world leaders in developing end-to-end capability in both satellite remote sensing and communication.

Recognizing the key needs for rural employment sector, space technology application in the form of Web GIS was initiated in addressing decentralised planning through SIS DP programme and rendering it through BhuvanPanchayat. This has been followed by successful initiatives of Watershed monitoring, geo-tagging of completed assets created under MGNREGA as well as geotagging the agricultural infrastructure created under Rashtriya Krishi Vikas Yojana (RKVY, a national level agriculture extension project) (Fig 1). Three major departments at national level concerning agriculture, land resources and rural employment have adopted the collation of flagship initiatives under PMKSY so as to achieve a linked execution, to benefit the farmer through the cascade of developmental programmes.

Harvesting rainfall and conserving it locally forms the core idea of a national flagship scheme, Pradhan Mantri Krishi Sinchayee Yojana for irrigating rainfed tracts using convergence of rural development programmes aiming to ameliorate rural landscape through soil and water conservation. PMKSY aims to achieve high degree of effective water availability and use for Indian farms especially in water scarce regions. Integrated Watershed Management Programme (IWMP), Mission Water Conservation (MGNREGA), Har Khet Ko Pani (HKKP, Water for Every Farm) and Per Drop More Crop (PDMC) are four major pillars of PMKSY which in turn, are linked by principle of water to be delivered preferably for dry land farming. All four programmes are being monitored by ISRO using integrated web GIS based solutions including smart phone apps. Monitoring IWMP and GeoMGNREGA has substantial relevance for the current perspective since it involves a sizeable investment in plantations of both horticulture and forestry crops as well as additional agriculture achieved due to them.

In view of such an ambitious flagship initiative, application of space technology is being developed at much higher capacity. Villages spread across wide variety of terrain and access

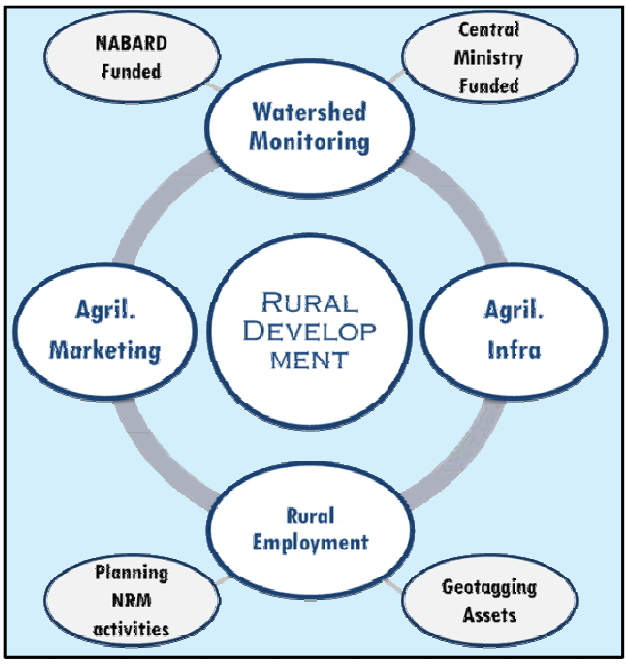

Fig. 1 : Space Applications in Rural Development

are being monitored, assessed and assisted using geospatial technology for achieving best possible development rooted in conservation of soil and water. NRSC / ISRO developed Geo-Spatial solutions for monitoring and evaluation of IWMP, MGNREGA, PMGSY, Assets mapping under RKVY, Waste Land development, Space based Information Support for Decentralised Planning (SIS-DP).

Monitoring Impact of Watershed Management Programmes:

Watershed Development Programme is one of the major initiatives in the country towards conservation of soil and water resources in the rain fed area for enhancing agricultural production, ensuring livelihood security to rural people besides halting the depletion of natural resources. Over the years, space applications have been adapted to respond to integrated development of land and water resources, and assess the improvements of the treated watershed. The developmental plans drawn at micro-watershed level, using thematic maps on resource status viz. land use, cropping area, water bodies and drainage, soils, terrain characteristics, have resulted in various visible impacts on ground viz., improvement in cropping intensity & crop yield, decrease in fallow lands, increase in irrigated crops.

Integrated Watershed Management Programme (IMWP) initiated by MoRD has been implemented across India where in each cluster of micro-watersheds called projects are treated through various bio-physical measures. Watershed Development Component is critical component of PMKSY, where as other components address network of irrigation at farm level (HKKP :Har Khet Ko Pani, Water to Individual Farm) as well as micro irrigation (PDMC – Per Drop More Crop).

IWMP aims to bring in ecological stability through conservative utilization of soil and water resources for all IWMP identified watershed projects. Implementation of IWMP ensures that more micro level water sources are created as well as ground water is replenished by controlling run off.

IWMP projects across the country were monitored initially in 10 states and 50 districts for special projects under PMO focus. Buoyed by the reliability and success, after about 15 months of the initiation of the project, Department of Land Resource allotted all IWMP projects to NRSC for monitoring. Monitoring involves observing 8200 projects (covering about 81000 micro-watershed) every year for five years beginning from 2013-14 period which is about 3.5 – 4 years after the first allocation of IWMP. By virtue of its innovative convergence of high resolution satellite data, vector database from states as well as precise geotags of activities completed on the ground, this project was recognised at highest level of Government as a flagship remote sensing application project addressing operational requirement. The challenge of using satellite data of high resolution to detect changes brought in due to watershed interventions as well as non-treatment reasons across varied agro-climatic contexts makes it unique. Especially the scope of integrating land cover alterations effected due to other projects as inducing changes in surface and subsurface hydrology is far reaching.

Remote sensing technology can play a major role in monitoring such activities. The high resolution satellite data (images) gives large perspective view of the ground situation and it can be monitored at periodic time intervals. A Web based GIS application (Srishti) enabling the monitoring and evaluation of IWMP watersheds was developed using satellite remote sensing and sample field data. A mobile smart phone application (Drishti) has been developed for field data collection.

Field data collection using smart phone is integrated as complementary data. The collected field attributes with photographs information can be overlaid over the satellite data (geotagged) to give a good perspective of activities in the field. Till date, a total of 8.71 lakh geotags have been collected (accepted 7.6 Lakhs) for various activities executed on the ground. Each geotag is coded automatically in Bhuvan server following a specific structure to identify the asset (activity done on the field), which Department of Land Resources uses for official purposes.

National Bank for Agriculture and Rural Development (NABARD) is providing the financial support to the watershed development activities

with an aim to increase incomes through enhanced agricultural production and to improve sustainability of natural resources through better watershed management among the people living in selected micro-watersheds. The web based monitoring and evaluation of 108 watershed projects is implemented in Gujarat (28), Rajasthan (31), Madhya Pradesh (13) and Telangana (36). Project has been upscaled and another 394 projects are taken up for Monitoring &Evaluation in Second Phase of Project across additional 14 states. A Bhuvanportal is developed using satellite data as per the requirements of NABARD (http://bhuvan.nrsc.gov.in/projects/nabard/index.php) and a mobile app for NABARD's requirements for field data collection.

Impact of IWMP:

The impact of water conservation efforts has been clearly evident in bi-temporal Satellite images during the implementation period. Observations and interactions during field visits, confirm the irrigation potential of structures created under IWMP. Since the entire process is available as geospatial database comprehending the results of the watershed management, indicators of sustainability can be derived from the time series satellite imaging even in periods beyond project schedules. Illustration of changes brought about in watersheds due to construction of check dams, farm ponds as well as vegetation establishment (Fig 2) provided herewith demonstrates the potential of web enabled GIS portal for rendering

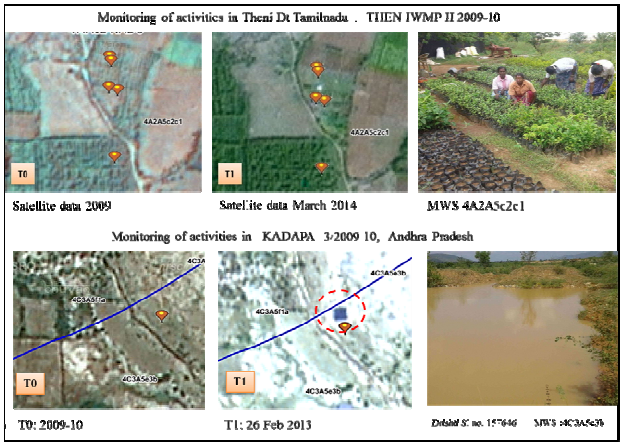

Fig 2 . Monitoring of IWMP Watershed Activites using satellite data for Horticuture sector and construction of structures

the most transparent monitoring of development activity including access to citizens.

GeoMGNREGA : Geospatial Applications for cataloguing, monitoring and planning Rural Employment Generation Activities

GeoMGNREGA which is a space technology based component of MGNREGA of Ministry of Rural Development aims to implement geographic information system for entire range of activities implemented under the scheme. National Remote Sensing Centre (NRSC), ISRO developed and implemented Web portal on Bhuvan integrating smart phone app and GIS. Further to its initial geotagging exercise, MoRD is implementing activities realigned to water conservation based on ridge to valley principles and has made role of remote sensing, GIS and GPS technologies central to their planning, implementing and monitoring.

Geo-MGNREGA, developed by NRSC, is a geo-information enabled web service / portal that assists the planning and management of activities of MGNREGA ranging from support functions to the delivery of work to the end-users. It has been developed through integrating NREGASOFT with the ISRO's BHUVAN portal. Database of completed assets residing on "NREGASoft" is also pushed to Bhuvan, which in turn is served to each data collector under Gram Panchayats through GeoMGNREGA. Collected data is moderated for quality by approved authorities at block level. Thus, Bhuvan facilitates an inclusive geographic information storage, retrieval, analysis and reporting for completed assets, with a high resolution Indian Remote Sensing Satellite in the backdrop for rural development planning. The major application of GeoMGNREGA is primarily in operational monitoring of the assets (Fig. 3).

MGNREGA is monitored through Bhuvan Geoportal involving geotagging of completed assets through smart phone application across the country. Of targeted 2.72 crore assets created under NREGA, 1.57 crore assets were geotagged, with persistent support of Ministry of Rural Development. Bhuvan portal for field level geotagging demonstrates the utilization of Geo-Spatial technologies for governance and enables mutual benefit to all stakeholders involved.

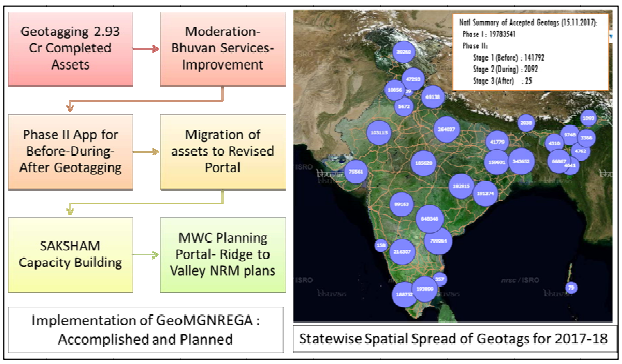

Fig 3. Approach and Status of GeoMGNREGA

Realising the need to orient it through a scientific basis, especially in the context of PMKSY, Department of Rural Development has remodelled the rural employment paradigm on Natural Resource Management (NRM) principles and adapted it as Mission Water Conservation. In this renewed approach, ridge to valley principles will be used for deciding the MGNREGA works under NRM category. NRM category consists of 111 out of 153 activities being carried out under MGNREGA. The approach (Fig.4), would employ remote sensing images, existing information on assets of villages and spatial database on various themes such as rocks, geomorphology, water, land, forest and disaster proneness.

Geospatial Technology for Rashtriya Krishi Vikas Yojana (RKVY):

Department of Agriculture and Cooperation and Farmers Welfare, Ministry of Agriculture, has implemented Rashtriya Krishi Vikas Yojana (RKVY), as a special Additional Central Assistance (ACA) Scheme by DACFW, MAFW. Project started from 2007-2008 covering 5768 projects (Fig. 5) in broad categories of agriculture and allied sectors, viz., horticulture, natural resources management, agricultural mechanization, marketing and post-harvest management , animal husbandry, dairy development, fisheries, extension etc.

A Bhuvan portal has been developed for mapping Assets under RKVY. A smart phone based mobile app was developed by NRSC/ISRO for capturing the assets spread across country. This app is location specific and has features like locating the Asset on Bhuvanmap, capturing the latitude /longitude along with photos, attribute information by field official/enumerator. As of now more than 62000 assets have been geotagged, of which about 12000 have been accepted after verification (Fig 5).

Prime Minister Gram Sadak Yojana (PMGSY):

The conventional data source for rural roads such as cadastral maps, SOI topomaps provide useful information. But this information needs to be updated periodically for effective monitoring and evaluation. In this context, high resolution satellite data will provide reliable information on the status of rural roads as on the date of satellite imagery. For the first time, an attempt was made to create spatial database on rural roads in the year 1999 on a pilot basis for IchodaMandal in Adilabad district, Telangana State wherein it demonstrated the use of IRS 1C

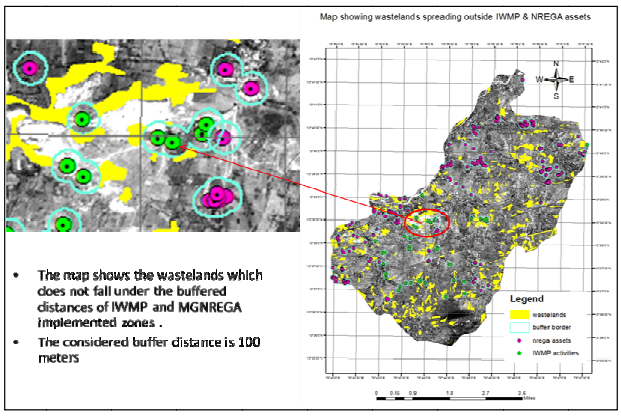

Fig 4. Illustration of a multi-thematic database oriented planning of MGNREGA (MWC) Activities

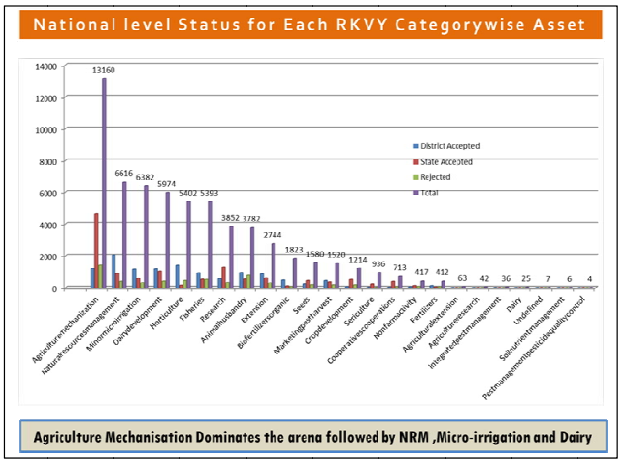

Fig 5. Activity wise Spread of Geotagged Assets under RKVY across country

PAN data. Subsequently, the study was extended to the districts of Jhalawar, Baran and Dhaulpur in Rajasthan on operational basis at the behest of Ministry of Rural Development, Government of India in the year 2001(fig-1). Later in the year 2015, Center for Geo-Informatics Application in Rural Development (CGARD), National Institute of Rural Development &Panchayati Raj (NIRD & PR), Ministry of Rural Development, Govt. of India, executed a pilot project covering 10 districts in 5 states. Further, for three selected blocks of erstwhile Mahabubnagar district, Telangana state, similar studies were undertaken by NRSC. The resultant geospatial information was ported on Bhuvan for visualization.

In light of the above mentioned efforts on using Geo-informatics in rural road projects, Ministry of Rural Development approached NRSC and CGRAD in coordination with NRRDA to jointly undertake the activity in project mode. Hence, a project is being initiated to monitor the rural road activity under PMGSY.

Development of Waste Lands:

Department of Land Resources under the Ministry of Rural Development (MoRD), requested NRSC/ISRO, to generate spatial information on wastelands, using remote sensing techniques, with respect to their distribution, extent, nature, degree of degradation and temporal behavior to facilitate the planning and implementation of development strategies for reclamation of wastelands. NRSC had prepared wastelands map and atlases since 1986 and monitored them from 2005-06 onwards.

According to National Wastelands Development Board, waste land is defined as “degraded land that can be brought under vegetative cover’ with reasonable effort and which is currently under-utilized and land which is deteriorating due to lack of appropriate water and soil management or on account of natural causes”. NRSC prepared the wasteland maps of all the States and Union Territories on 1 : 1 million scale in the year 1985. An eight fold classification system was adopted for mapping of wastelands in the country. Based on this study, the total area under wastelands in the country was estimated to be 53.3 million hectares or 16.20 per cent of the total geographical area of the country. The maps generated in this exercise provided gross estimation of wastelands and their spatial distribution.

Waste Land mapping was carried out during the period 1986-2000 adopting 13 fold classification system. A final consolidated atlas on wastelands was published in May, 2000. Subsequently, at the request of Department of Land Resources (DoLR), NRSC mapped the waste lands adopting 28 fold classification and updated the earlier Atlas. The extent of wastelands in the country was estimated as 55.27 m. ha. (17.45 % of Total Geographical Area).

To understand the spatial and temporal changes in wastelands, a project on National Wastelands Monitoring was initiated in 2006 with the objective of assessing the status of wastelands and to monitor its changes. The satellite data of three seasons viz kharif, rabi and zaid of 2005-06 has been used to derive information on wastelands. This exercise enabled to improve the delineation of wasteland categories due to use of three season satellite data. An area of 47.22 m. ha (14.91% of TGA) was recorded as wastelands. In the year 2010, DoLR has again requested to undertake wasteland mapping using satellite data of 2008-09 and to bring out changes in wastelands with reference to 2005-06. The wasteland classes of 2005-06 were updated using satellite data of 2008-09 and the change areas were identified. These changes were later confirmed using limited ground checks.

National Wastelands Change Analysis is unique in the entire wastelands mapping since it facilitates objective comparison of wastelands between 2005 - 06 and 2008 - 09. An area of 46.70 m. ha (14.75 %) have been recorded as wastelands. The decrease in wastelands of 3.2 million hectares was observed, spread over 112057 locations, while simultaneously an increase in wastelands of 2.7 million hectares in 42886 locations was observed. Thus, the net result was decrease in wasteland area to the tune of 0.5 million hectares in 2008 - 09 as compared to 2005 - 2006, when aggregated for the entire country. Recently at NRSC/ISRO, Hyderabad Wastelands mapping for entire country was taken

up using ortho-rectified satellite data acquired during 2015-2016 of three seasons (kharif, rabi and zaid). The mapping exercise is in the final stage of completion. Fig.6 shows how wastelands are utilized for the development of solar parks. Waste lands data base is hosted on Bhuvan Web portal of NRSC and also DOLR web site.

Space based Information Support for Decentralized Planning (SIS-DP):

Reliable information on land & water resources and their optimal management is vital for developmental planning at grass root level. Space based Information is being utilized for support decentralized planning by empowering the local bodies (Panchayats) to prepare developmental plans. It encompasses geo-referenced images, state level data repository on natural resources at 1:10000 scale coupled with stakeholder data sets. A geo-portal 'BhuvanPanchayat' has also been deployed for visualization, asset mapping, activity planning and monitoring of the schemes at Panchayat level. Under this initiative, it is planned to carryout mapping of assets in about 2.5 lakh panchayats in the country. BhuvanPanchayat Geoportal will be further augmented to enable preparation of locale specific action plans for developmental planning.

Bhuvan incorporated variety of legacy layers essential for taking up a planning since inception and keeps them updated subject to the availability of appropriate database. Major thematic database serving rural development is Land Use and Land cover database at 1:10000 scale created under ISRO's flagship programme SIS-DP (Space based Information Support for Decentralised Planning) along with drainage and road layers at same scale based on high resolution ortho-rectified multispectral database. Digital elevation model available thereupon also acts a pivotal physical determinant of the planning. Latter aids the terrain perception and clarifies the ridge and valley contexts precisely for planning purpose. Land use land cover database has 27 classes and characterizes landscape for micro level planning.

Space Applications in Agriculture and Water Resources Sectors:

NRSC developed following Geo-Spatial solutions in Agriculture and Water Resources sectors, which contribute to the development of Rural areas in terms of food production, farmer's income, water availability for localized irrigation and aqua culture. These Geo-Spatial solutions have immense value for the sustainable development of Rural India.

- Crop Insurance Decision Support System (CIDSS) – A Web-enabled Integrated package for implementing Pradhan Mantri Fasal Bima Yojana (PMFBY);
- Crop Intensification-Bringing Green Revolution to Eastern India - Satellite-based mapping of post kharif rice fallows (National Food Security Mission);
- Mapping & Evaluation of High Value Crops;
- Agricultural Drought Vulnerability;
- Mapping Horticulture Crops;
- Fibre Crop Information System;
- Water Body Information System.

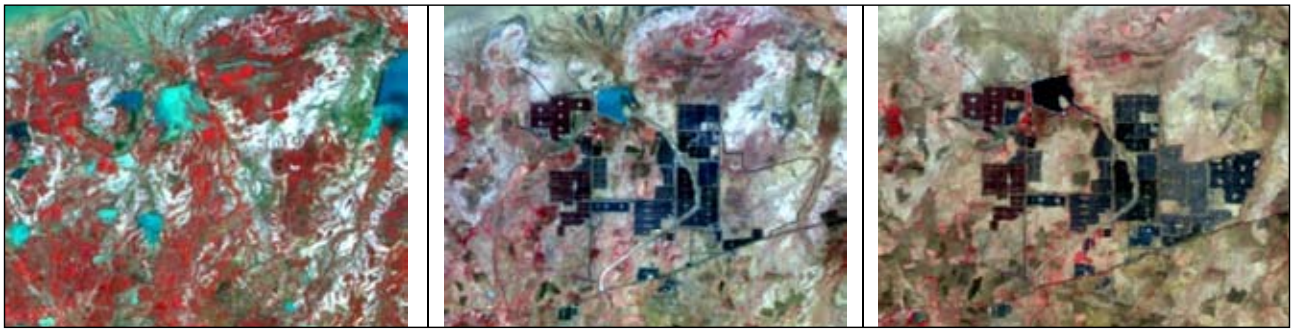

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Fig.6: Wasteland to solar power generation, Charanka solar park Radhanpur, one among 44 such projects in Gujarat State

Benefits of Geo-Spatial Solutions:

- Enhanced ease of governance with improved monitoring and evaluation for integrated development activity.
- This Geo-Spatial solution is transparent and efficient compared to traditional approach with manual surveys in the field.
- Linking management information system to geo-spatial visualization.
- Comprehensive planning and development at local level as it provides an opportunity to spatially analyze the impact of having assets by combining the data from multiple projects.
- It also aids in qualifying the need for having an asset at a particular location and knowing if there is any damage caused to the assets due to human or natural causes.

Bhuvan Geo-Portal:

Bhuvan, an Indian Geo-Platform of ISRO, provides a host of services covering satellite data visualization, free data download, thematic map display, download and analysis, timely information on disaster and project specific GIS applications since August 2009. The thematic Services offered by Bhuvan have the facility to select, browse and query the thematic Datasets consisting of LULC map at 1:10,000 scale and several other themes. It has the options of getting state and district wise statistics, Area of Interest (AOI) based analysis, URL for WMS/WMTS services, view based print and adding external WMS layers thus making it easy for the Scientific and Research community as well the government machineries to use the Geoinformatics inputs for various applications.

Bhuvan currently hosts multi-temporal, multi-sensor and multi-resolution satellite imageries, thematic maps of 12 natural resources, 10 million Point of Interest data, 53 geo-physical products for downloads, 6200+ OGC Services and provides major services including Bhuvan 2D/3D, NRSC Open Data Archive, Thematic services, Disaster Services, Crowd Sourcing applications, Online mapping applications. It provides platform to create, visualize, share and analyze geospatial data and services towards spatial mash-ups. There are around 75 applications developed in collaboration with states, central ministries, NGOs for utilizing Bhuvan as a platform for governance activities like natural resources management, disaster management, monitoring & evaluation.

Since inception of Bhuvan, there had been a rapid growth of Bhuvan services and large number of users from government, academic, private sector are using Bhuvan. Bhuvan has now more than 70,000 registered users spread all over India and also from other countries. Recent years have seen good collaborations with state government and ministries. The applications that are rolled out have various aspects of governance like planning and development, inventory of government assets, program monitoring and evaluation etc.

Conclusion:

Governance of rural areas especially for improving employment potential has received a welcome boost through initiatives which have enabled geo-tagging of all created assets, bringing in unprecedented level of transparency and verification by functionaries and citizens alike. Improving capability of remote sensing and positioning in terms of spatial and temporal resolutions can bring in huge advantage of addressing micro-level concerns fully and satisfactorily. Web enabled GIS applications can serve information to every corner of the country, hence throwing open the technology for use by common man. Affordable mobile telephones embedded with operationally compliant positioning device as well as photography coupled with internet connectivity have added another dimension of digital access to every rural dweller. In such context, it is timely that ISRO has initiated web based geospatial information systems at the behest of Departments dealing with Rural Development in a comprehensive manner. The Geo-spatial solutions contribute to development of rural areas to realize the objective of creating Digital India by minimizing the space between Technology and common man.

(Santanu Chowdhury is Director, National Remote Sensing Centre, ISRO. Dr K Mruthyunjaya Reddy is Group Director, PPEG and Head, RDWMD and Shri E Sivasankar is Head, Project Management Division, PPEG, NRSC, ISRO.)
Email: director@nrsc.gov.in)

TECHNOLOGY INTERVENTIONS IN RURAL AREAS

Dr. Anand B. Rao

RuTAG is a synergizing and catalyzing mechanism. It addresses need based up-gradation of technologies with the help of Indian Institute of Technologies (IITs) and local NGOs. The needs are identified by S&T Institutions, NGOs, Public Sector Undertakings (PSUs) and State and Central Government organizations. The demand-driven interventions could be technology upgradation, delivery, training and demonstration etc. Specific training programmes are also sponsored by RuTAG.

Today India has about 6 lakh villages where more than the two-third of the total population lives, as compared to about 85% at the time of Independence. Apart from the growing rate of urbanization, the ever-increasing share of urban population may be attributed to the large scale migration of rural people to cities and towns in search of employment opportunities and better living conditions. Most of the villages still lack the provision of basic amenities (water, sanitation, electricity, clean cooking energy, roads) and facilities (health, education, communication). The disparity between the rural and the urban areas is driving the unidirectional exodus of rural people looking for better prospects and thus leading to a haphazard growth of the cities.

"Access to technology" is a major differentiator between the urban and rural areas and is often considered as a solution to the development issues faced by the underdeveloped communities. Although many technologies have been developed for the rural areas in India and elsewhere in the world, there are several challenges in taking them to the end users. Typically, the technologies to be used in rural areas may need downsizing, and lose the economy of scale. However, the use of the locally available raw materials, local employment and value addition through processing can provide a boost to the rural economy. It is also important to recognize the externalities of technology. Considering the present situation in rural areas, the technical interventions need to mainly aim at drudgery reduction, efficiency improvement and overall sustainability.

Initiatives by RuTAG IIT Bombay:

The Indian Institutes of Technology i.e. IITs, established in India about 60 years ago, are known for their contribution in nation building through cutting edge technology research and education. How far have they helped the rural masses and the unorganized sectors that are often neglected in the mainstream development process? To address this deficiency, Rural Technology Action Group (RuTAG) was conceived by Dr. R. Chidambaram, the Principal Scientific Advisor to the Government of India. RuTAG was established as a mechanism to enhance rural development through science and technology (S&T) interventions by engaging the expertise available in the IITs. There are RuTAGs set up in 7 IITs (Madras, Kharagpur, Delhi, Roorkee, Guwahati, Kanpur and Bombay) and RuTAG IIT Bombay was established in 2010.

So far, RuTAG IIT Bombay has initiated 20 projects in rural development. Some technologies such as 'Floating fish cages for aquaculture' have been successful and appreciated by the Government. Apart from the project investigators and the project staff, more than 20 faculty

Floating Fish Cage for Inland Aquaculture

members from various departments such as CTARA, Mechanical Engineering, Civil Engineering, Energy science and Engineering, Industrial Design center (IDC), Humanities and social sciences (HSS), and Computer science and Engineering from IIT Bombay are involved in RuTAG projects and activities.

RuTAG IIT Bombay works in close association with the Centre for Technology Alternatives for Rural Areas (CTARA), an independent academic unit within IIT Bombay, where it is housed. CTARA was set up with an objective of catering to the technology needs of rural areas. CTARA's teaching and research is aimed at providing relevant solutions to the rural areas. CTARA believes in demand-driven, participatory approach in identifying and implementing solutions to the problems of the unorganized sectors and under-privileged communities. In order to do this effectively, CTARA has developed linkages with various stakeholders such as NGOs, Government departments and ministries and industry. The faculty members and students of CTARA have been working on some of the RuTAG projects and have made substantial contributions to the activities of RuTAG IIT Bombay.

RuTAG Interventions: The Approach:

RuTAG IIT Bombay operates in the western zone, which includes the states of Maharashtra, Gujarat and Goa. The typical approach that is adopted at RuTAG IIT Bombay in designing technology interventions has been described in this section.

Process for Identification of Projects:

RuTAG projects are 'demand driven', i.e. the problem has to come from the end users. This also helps in getting better engagement from the stakeholders, ensuring success of the intervention. Since the focus is on working for problems in rural areas, initiatives for communication and outreach to target audience are taken.

Voluntary Organizations (NGOs) working in rural areas are relied upon to reach the people and understand their issues. Familiarity and the local context are essential for the better understanding of any situation and problem communication. Over the years, connect with several NGOs has been established. The team members of RuTAG IIT Bombay regularly undertake field visits for networking with NGOs, interacting with stakeholders in rural areas and identifying problems suitable for RuTAG projects. Sometimes, workshops are organized with regional or sectoral focus, that provide a forum for all the stakeholders to brainstorm together and prioritize the problems to be taken up for S&T interventions.

RuTAG IIT Bombay also benefits from the close association with Centre for Technology Alternatives for Rural Areas (CTARA). The CTARA faculty members have an excellent rapport with various NGOs as well as Government officials such as the District Collectors and CEOs. The M.Tech.students undertake a nine weeks field work and in-depth study of a specific rural area under the supervision of a faculty member as a part of their coursework. At the end of nine weeks, the students bring back very rich and valuable data and interesting problems for RuTAG. Apart from them, many faculty members across various other departments are passionate about working on rural interventions and are actively working on RuTAG projects.

Detailed Background Study:

Once the problem is shortlisted, the research engineers interact with local people along with the NGO and confirm that the need for intervention is genuine and also that there is high level of commitment from the stakeholders. The end users are interviewed and detailing of issues is done. The other components of background study include study of current practices along with supply chain and value chain wherever possible. Apart from this, a detailed literature review helps in understanding if some work in target area has already been conducted elsewhere. Horizontal transfer of existing solutions, after the necessary adaptation to the specific local context, has often found to be helpful and efficient.

Design features:

Once the project is taken up, the faculty members associated with the project (Project PI and Co-PI) initiate the project activities. While designing the prototype, care is taken to incorporate the following features:

- **Easy to assemble:** The tools and gadgets usually have simple design and are easy to fabricate or assemble.
- **Low cost:** It is ensured that the machines are low cost and affordable.
- **Engagement of Local Fabricators:** They are usually trained in manufacturing tools so as to build a local ecosystem.
- **Use of locally available material:** As far as possible, an effort is made to use locally available material for fabrication of gadget of tool being designed.

After building a prototype,it is tested for its performance and to identify any potential issues in operation or w.r.t safety. The end users are involved in getting feedback as their suggestions are very valuable. Modifications are made, if required, and the process is iterated. This process continues till we fabricate a machine acceptable and suitable for the end users.

Examples of RuTAG Interventions:

Over the last 7 years, about 20 projects have been completed, mostly aiming at drudgery reduction and livelihood enhancement across various sectors such as the fisheries, animal husbandry, post-harvest processing of NTFPs or agricultural produce and traditional crafts. A few illustrative examples are included here, while further details are available on website (http://www.ctara.iitb.ac.in/en/rutag).

Floating Fish Cage Structure for Inland Fisheries:

One of the most successful interventionsfrom RuTAG IIT Bombay so far is the 'Designing floating fish cage structure for inland aquaculture'. The intervention was driven by a request from NGO 'Shashwat' from Pune district of Maharashtra. Central Institute of Fisheries Education (CIFE) recommended fisheries for livelihood for the tribals displaced by Dimbhe dam and introduced 'aquaculture' with the help of 'floating fish cages'. The structure of fish cages was developed by Prof. Siddharth Ghosh from the Department of Civil Engineering. Fish cage structures are used for protective aquaculture wherein fingerlings are incubated to small fishes (for better survival rate in the open water thus resulting in higher catch), or even grown to table size. The structure is very strong, safe and stable.The technology has potential to improve the livelihood of inland fishing communities across the country and has been appreciated by the Government of Maharashtra. The salient features of the structure are as follows:

- Robust, Safe, Stable Scalable and can be customized.
- Consists of G.I. pipes, fibre gratings, plastic drums etc., which are typically available at most places.
- Cleaning/Maintenance can be done while the structure is still floating in water.

The installed structure has provided better livelihood option for the locals as well as strengthened and empowered women SHGs whose participation in this activity has substantially increased due to the safe and stable structure. After the successful demonstration of this technology in Dimbhe dam, The Ministry of Tribal Development, Government of Maharashtra, sanctioned a project to NGO Shashwat to install 28 RuTAG fish cage structures in 4 dams with the help of RuTAG IIT Bombay, thus helping in dissemination of this technology.

Old Sari Cutting Machine for Handlooms Operated by Visually Challenged Individuals:

In this project, investigated by Prof. Suhas Joshi (Department of Mechanical Engineering) and Prof. Bakul Rao (CTARA), was taken up at the request of an NGO GrameenShramikPratisthan (GSP), based in Latur, Maharashtra. The visually challenged

Old sari cutting machine

Prototype of cow lift

weavers used to cut the old saris into ribbons by using a blade. This was unsafe, laborious, time consuming and also the ribbons formed were of varying width. The Sari Cutting Machine developed by RuTAG helped to overcome all these problems. Thus, it made the operation safe and efficient. It can be run using electric power (reduced drudgery), and rolls the ribbons on bobbins, thus improving the quality of product (mats) as well.

Cow Lift for a "Downer cow":

The project addresses the need for facilitating a 'downer cow' (a cow unable to stand due to weak leg muscles due to various medical conditions) stand on its feet for medical treatment. The device can be dismantled completely and assembled at the site where animal is located. Wheels provided at the bottom make it portable. The project was investigated by Prof. Tanmay Bhandakkar from the Department of Mechanical Engineering.

Hybrid Solar Food Dryer :

This project, investigated by Prof. Shireesh Kedare and Prof. Manaswita Bose from the Department of Energy Science and Engineering, addresses the issue of drying agricultural produce in a fast and efficient way while keeping the cost as low as possible. The main focus of this project is achieving continuous drying of the agricultural produce. Most of the existing solar dryers lack this feature and the quality of the food product is affected due to the drop in temperature in the evening. Continuous drying is achieved by using PCM (Phase Change Material).

Design of Protective Suit for Wild Honey Bee Harvesters:

The project aims at designing a dress for protecting people who harvest honey from beehives in wild. This will make the dress more convenient to wear and at the same time protect the person. The proposed dress is easy to manufacture and use, is lightweight, durable and washable. The project was investigated by Prof. R. Sandesh from the School of Design (Industrial Design Centre).

Post-Harvest Processing:

Many of the technologies designed by RuTAG IIT Bombay assist the local communities to process either the agricultural produce or the NTFPs (non-timber forest products) collected from jungles for value addition and enhanced earning. Machines have been developed for the processing of medicinal fruits such as Hirda and Behada and nuts such as Chironji which fetch good market price. Thus, we hope that the local communities can benefit from such intervention that helps them move from primary to secondary sector of the economy.

Conclusion:

RuTAG IIT Bombay has come a long way and designed several useful interventions addressing the problems in rural areas. While designing the interventions, care has been taken to ensure that locally available materials are utilized and local people are engaged in the best possible manner.

Solar Food Dryer

Protective Suit for Wild Honey Harvesters

Many of these technologies have a potential for dissemination in multiple locations across the country. The Ministry of DONER (Development of North East Region) has recently funded a project to disseminate 200 'floating fish cages for inland waters' across the various NE states. It is proposed to involve the faculty members and students of local engineering colleges for enhancing the activities of RuTAG. Better coordination with potential stakeholders and collaborating with other platforms (e.g. CSR and various government agencies) can help realizing better impact in the society.

Acknowledgments: The author gratefully thanks all the PIs of RuTAG projects along with the RuTAGproject staff, all NGOs associated with us, CTARA and the Principal Scientific Advisor to the GoI and PSA office for the continued support in this endeavor.

(The author is Associate Professor, Centre for Technology Alternatives for Rural Areas (CTARA), Indian Institute of Technology - Bombay (IITB), Powai, Mumbai.
E mail: a.b.rao@iitb.ac.in)

ICAR promoting New Technologies for Rural Areas

To increase productivity, reduce cost of cultivation, reduce drudgery, improve value addition, conserve resources and provide alternate means for energy generation through improve farm mechanisation during the last 3 years, ICAR has developed 72 new farm equipment/machines/gadgets and 34 new products/process protocols and supplied over 16500 prototypes of agricultural machinery to farmers/ entrepreneurs.

In the area of fisheries, ICAR developed breeding and seed production technology of 9 food fish species; the technology of marine cage farming and its dissemination through 1500 cages (principally in Gujarat, Maharashtra, Karnataka, Kerala, TN and AP); 4 feeds for different life stages of important fish and shrimp species and their commercialization, breeding and seed production technology for 9 ornamental fish.

The research efforts of the Institutes/Centres/AICRPs have also led to the development and release of 748 high yielding, stresses (biotic & abiotic) tolerant varieties/hybrids in different field crops for cultivation under different agro-climatic conditions during 2014-2017. Besides, 130 improved varieties of 54 important horticultural crops and 105 improved crop management technologies, package of practices for horticultural crops were also developed.

To disseminate information about such innovation/technologies to the farmers, the ICAR has established a network of 690 Krishi Vigyan Kendras (KVKs) in the country, mandated for conducting front line demonstration at the farmer's field, technology refinement, training and capacity building. The technologies duly tested and refined are thereafter passed on to line departments for large scale demonstration and transfer among farmers.

Around 2.75 crore farmers are registered on mKisan portal who are continuously receiving crop specific advisories in their local language on their mobile sets. No internet is required for receiving such advisories. Experts from ICAR, IMD, and State Government down to the block level send crop specific advisories to registered farmers. Apart from mKisan, Kisan Suvidha mobile App has also been developed for use of the farmers having smart phones and access to internet. Information about Agro advisory, weather, market price, plant protection etc. are provided to farmers with the click of a button.ICAR is giving focused attention towards development, promotion and propagation of new technologies i.e. high yielding and multi-stress resistant/tolerant varieties/hybrids using conventional and genomic tools in major crops through its 102 institutions comprising of 67 Research Institutes, 6 Bureaus, 14 Directorates and 15 National Research Centres mandated for conducting research in agriculture and allied areas besides 11 Agricultural Technology Application and Research Institutes (ATARIs) and 81 AICRPs/ Network Projects.

NEW TECHNOLOGIES IN IRRIGATION SECTOR

Dr. Bharat Sharma

New initiatives in the irrigation need to be comprehensive so as to cover the modern technologies, practices and policies for all the water resources of surface water and ground water, and rainfall for about 51% of the rainfed farmers; reduce the non-beneficial uses of water and deterioration of water quality and synergise all these benefits to improve the crop yields and economic value and livelihoods based on the water resources.

Irrigation has always been central to life and society in India. With a net irrigated area of 68.1 Mha (2013-14) by canals, tubewells and wells and other sources; and a gross irrigated area of 95.77 Mha, India has the largest irrigated area in the world. Still only about 49 per cent of the gross cropped area is under some degree of assured irrigation and rest of the 51 per cent cropped area is dependent upon the seasonal rainfall. Largest share of irrigated area is concentrated in the north-west India (Punjab, Haryana, and western Uttar Pradesh) and presently, Punjab is the only one state in India which has almost 100 per cent irrigated agriculture. Irrigation coverage in rest of the 28 states varies from a low of 5 per cent to above 90 per cent. Thus, it is not surprising that Punjab also has the highest yield levels of rice and wheat in India. Several studies have shown that irrigation coverage is positively correlated to productivity and prosperity and negatively to rural poverty.

Irrigation Development in India:

Starting with a net irrigated area of about 22.5 Mha in India during 1950-51, the country witnessed a strong emphasis on the development of large multi-purpose surface irrigation projects and a good network of canals, distributaries, minors and field channels along with a number of Canal Area Development Authorities were established (Fig. 1). Massive investments in public major and medium irrigation systems and to a smaller extent in minor irrigation were made through loans and assistance from World Bank and other donor and development agencies (Fig. 2). But there irrigation infrastructure and investments were not sufficient to achieve the much-desired food self-sufficiency in the country. With the advent of Green Revolution in the seventies, there was an urgent demand to provide timely irrigation to moisture-sensitive improved dwarf varieties of rice and wheat which could not be fulfilled only with the slow pace of development of canal irrigation. This additional demand was fulfilled with the rapid development of shallow groundwater tubewells which provided the irrigation on demand and in areas outside the canal command.

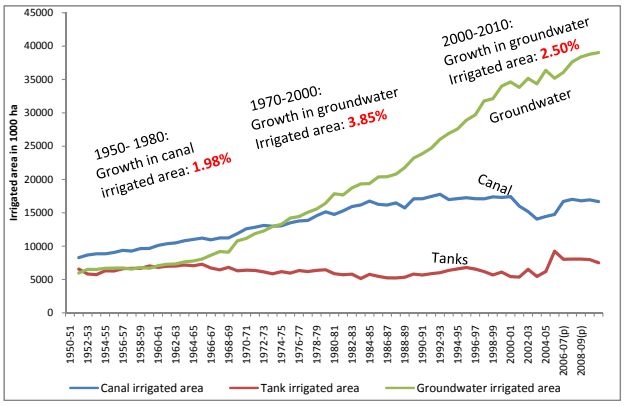

Fig. 1. Source-wise irrigation infrastructure development in India during 1950-2008(CWC)

Groundwater:

India is also now the largest user of groundwater in the world. About 71 % of the tubewells are energised by electricity, and the rest mostly in the eastern region of the country, have to depend upon costly diesel-based irrigation. Further, the distribution of the wells and tubewells is also sparse in the eastern region and intensively concentrated in the north-west and southern regions. Though on one hand the large expansion of groundwater resources has provided stability to irrigation and sustained and expanded the green revolution to other regions, on the other hand, this has caused massive over-exploitation of the groundwater resources and rapid decline of groundwater levels and a rise in 'critical' and 'semi-critical' groundwater blocks in the country (Fig. 3). During the last decade, there has been a

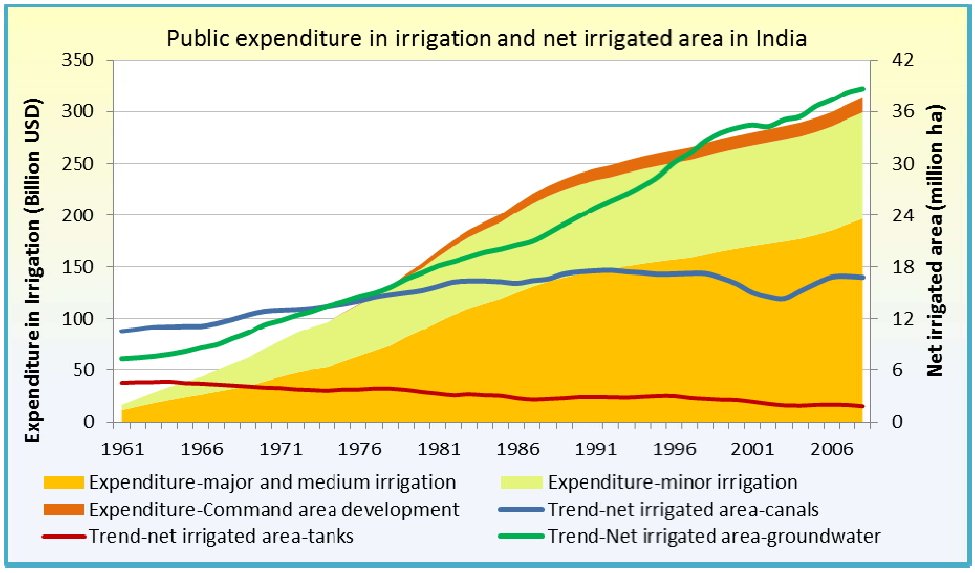

Fig. 2. Public expenditure in irrigation and net irrigated area during 1961-2008 in India (CWC)

drastic increase in the number of deep tubewells from 14.4 lakh to 26.1 lakh. Eleven states of Uttar Pradesh, Maharashtra, Madhya Pradesh, Tamil Nadu, Telangana, Rajasthan, Karnataka, Gujarat, Punjab, Andhra Pradesh and Bihar have almost 90% of the total minor irrigation structures in the country.

The above analysis shows that both surface and groundwater irrigation in India, inspite of being the largest in the world, is under great stress and needs a paradigm shift in the technical designs; efficient conveyance, distribution and application systems; innovative operation & maintenance and pricing, sustainability both in terms of quantity and water quality; inclusive and balanced regional development through policy changes in energisation and resource development and use of modern technology and ICT to reach the millions of irrigators so as to achieve the laudable objectives of *"Har Khet ko Pani- Irrigation to Every Farm" and "More Crop per Drop- Higher productivity and value from each unit of water."*

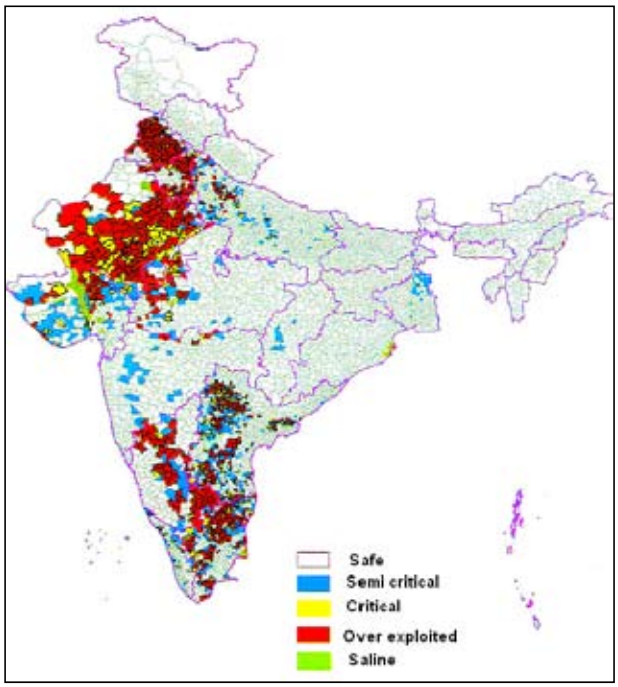

Fig. 3. Categorisation of groundwater structures in the country- groundwater use is highly exploitative in the north-western region and some southern states. (CGWB, Faridabad)

New Initiatives in the Irrigation Sector:

New initiatives in the irrigation need to be comprehensive so as to cover the modern technologies, practices and policies for all the water resources of surface water and ground water, and rainfall for about 51% of the rainfed farmers; reduce the non-beneficial uses of water and deterioration of water quality and synergise all these benefits to improve the crop yields and economic value and livelihoods based on the water resources. The following matrix approach in Fig. 4 is suggested:

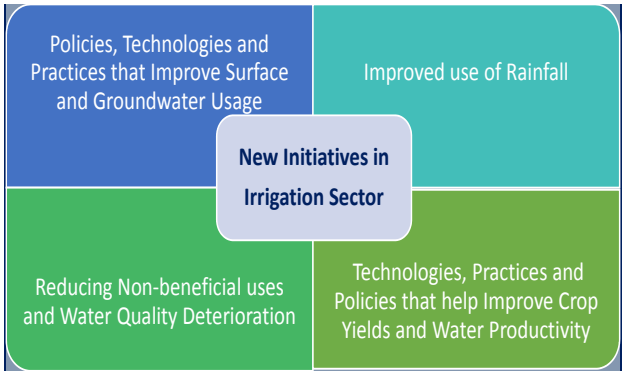

Fig. 4. Comprehensive Matrix Approach for New Initives in the Irrigation Sector in India

A brief description of some of the important initiatives is given below:

i. Improving Conveyance Efficiency of Surface Irrigation:

Freshwater resources are finite and even by allocation of large funds for ambitious programs, the development of new public water resources is happening at a very slow pace. Farmers dependent on rainfall or private sources cannot wait any further. In cases where the development of water resources is not happening any time soon, the states and the centre can at least take steps/ interventions to cover larger areas with the already created irrigation potential. This is possible through improved distribution and conveyance pipes, underground distribution systems, affordable and reliable energy to lift water from shallow depths and innovative and differentiated energy policies both for the 'north-west and south', and more importantly for 'east and the north-east'.

Setting up piped water facilities to connect dams/ canals and micro-irrigation system can reduce water loss and increase the overall water use efficiency up to 90 per cent. At present, considering the conveyance loss of surface irrigation and application loss due to flood irrigation, only about 40 per cent of irrigation water actually reached the farmer's field from the source dam. Thus the investments need to be made not only to increase creation of irrigation potential, but must be channelized to make them more efficient.

ii. Micro-irrigation for Improving Application Efficiency of Irrigation

Micro-irrigation (drips, sprinklers, micro-sprinklers, tapes, guns) is a suitable option to

Table 1:

Strategies	Technologies, Practices and Policies
Improved Usage of Surface and Groundwater	Laser land levelling of fields, optimum size of basins
	Furrows, raised beds, conveyance pipes, underground distribution system
	Proper canal schedules, irrigation schedules, well-maintained distribution networks
	Use of remote sensing, GIS, sensors, drones and ICT technologies for improved irrigation
	Water user associations, Smart card based community tubewells
	Pricing of water and power to recover their full costs,Solar pumps and allowing excess solar power to be fed back into the grid, focus for the east.
Improved Use of Rainfall	*In-situ*, on-farm and catchment water harvesting for supplemental irrigation
	Synchronising crop planting, transplanting with on-set of monsoons
	Improved water retention through mulches; drainage of excess water, use of rainfall for recharge through Underground Taming of Floods for Irrigation
	Agro-met advisory services, crop insurance; drought and flood management
Reducing non-beneficial Uses and Water Quality Deteriora-tion	Improved canopy architecture through agronomy and plant breeding
	Zero and minimum tillage to reduce evaporation
	Enhanced use of micro-irrigation- drips, micro-sprinklers, sprinklers
	Use of plastic and residue mulches; boundary plantations
	Peri-urban agriculture and safe use of waste water.
Improving Crop Yields and Water Productivity	Improve incentives structures for water efficient crops through price and procurement policies, Direct Input subsidies to all farmers and let farmers decide which crops they want to grow.
	Breeding of superior crop varieties with higher yield, stress and disease tolerance
	Precision irrigation: synchronising water application with crop water demand
	Soil fertility management-rotation, tillage, targeted application of nutrients
	Disease, pest and weed management

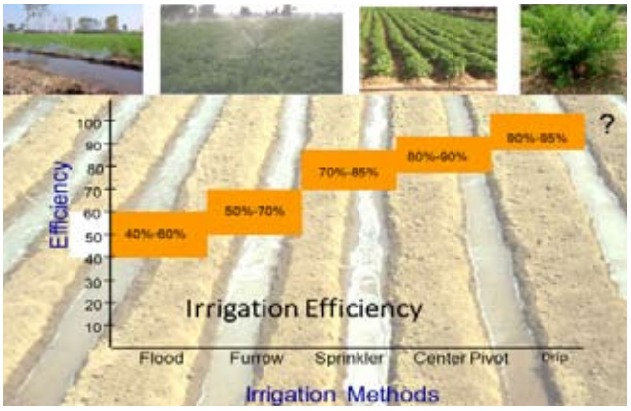

Fig. 5. Irrigation efficiency of different irrigation methods (Courtesy: Rajput, WTC)

enhance the coverage under irrigation, improve land and water productivity and quality of the produce. In case of commonly practiced flood irrigation method, the rate of water application loss is around 35 per cent, while in micro irrigation techniques, the application loss is only 10-15 per cent. Adoption of these techniques (Fig. 5) will help to save water and thereby increase the area under irrigation by diverting the saved water to other non-irrigated fields. Instead of promoting micro irrigation as just a water saving technique, it should be popularised among the farmers as an yield enhancing and input cost saving method, considering the incremental yield and electricity and fertiliser saving associated with the technique.

iii. Solar Irrigation:

Solar irrigation system needs to be further promoted to ensure assured and timely irrigation water availability in electricity deprived interior villages particularly in the eastern region. Solar pumps shall turn out to be a boon promising timely availability of power for lifting groundwater and water from ponds, lakes and depressions for irrigation, helping farmers to get rid of the costly diesel pumps. These can be further coupled with efficient application methods for higher water productivity. The ***Solar Pump Irrigators" Cooperative Enterprise*** (SPICE) in Gujarat is one of the worthwhile models that can be followed and scaled up. Assured grid connection must also be provided to the farmers to encourage them to divert the excess solar power generated in fields to the state grids, thereby ensuring the judicious use of solar power for groundwater extraction. Successful models such as *Solar Power as Second Remunerative Crop* (SPaRC)at Dhundi are working and can be scaled up by NABARD and other agencies. Such projects may be capital intensive at the initial stages and government will have to figure out smarter ways like feed-in-tariff (FIT) to mobilise the funds.

iv. Underground Taming of Floods for Irrigation (UTFI) :

Innovative and economically viable techniques have now been developed to utilise the excess flood water for ground recharge through construction of a battery of vertical shafts in the unused village ponds. Successful models have been developed and demonstrated by International Water Management Institute at Rampur district in Uttar Pradesh and elsewhere (Fig. 6) and successfully included in the District

Fig. 6. An unused village pond retrofitted with UTFI technology for flood water recharge in Rampur, Uttar Pradesh

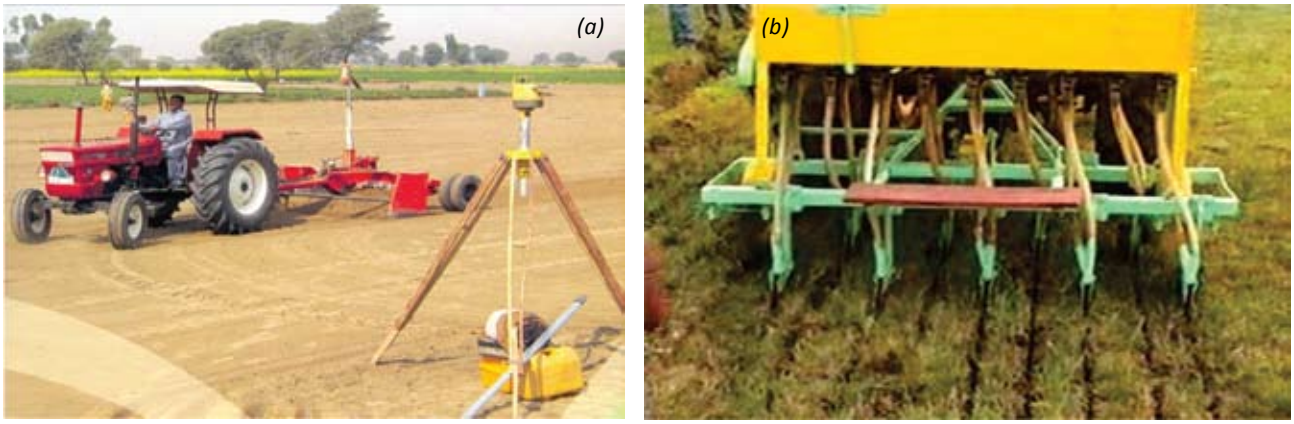

Fig 7. Use of Laser Land Levelling (a) and a Zero-Tillage Machine(b) for Conservation Agriculture

Irrigation Plans. This has sufficiently helped in improvement of water tables, some moderation of the floods and improvement in the local environment. These models need to scaled up under comparable agro-hydrologies in India.

v. Laser Land Levelling, Zero Tillage, Aerobic Rice and System of Rice Intensification for Saving Water and Energy and Improving Yields

These are some of the promising new initiatives adopted by progressive farmers which help in saving irrigation water upto 15-25 per cent, saving of farm energy by upto 20 % and improving the crop yields upto 20-25 per cent. Farmers need to be trained to use these new technologies with the help of improved machinery (Fig. 7) which can be made available through custom-hiring basis or the farm cooperatives.

Table 2. Important Programs and Policies in the Irrigation Sector

Major and Medium Irrigation Projects	Irrigation potential created increased from 9.72 M ha (1950-51) to 47.97 M ha (2011-12)
Accelerated Irrigation Benefits Programme (AIBP)	108.21 M ha irrigational potential created (about 77% of UIP)
Command Area Development and Water Management Programme	About 22 M ha covered since inception upto March, 2011
Repair, Renovation and Restoration (RRR) of Water Bodies	Restoration completed in 1054 water bodies in 15 States
Artificial Recharge to Ground Water through Dug wells	Implemented in 1180 over exploited, critical and semi-critical blocks in 7 States.
National Water Mission	Major goal to improve WUE at least by 20%
National Mission on Micro Irrigation	Promoting enhanced WUE
National Program on Aquifer Mapping & Management	Mapping & characterizing aquifer at 1:50000
Prime Minister Krishi Sinchayee Yojana	Provide water access to each farm field
Regulation for Delayed Transplanting of Paddy to Save Groundwater	Implemented in Punjab and Haryana with real savings in water and energy

vi. New Programs and Policy Initiatives in the Irrigation Sector:

A number of programs and policy initiatives have been developed to improve the irrigation sector in the country. Some of these programs have been on-going for some time and others have been launched recently and still are in nascent stage to show their full benefits (Table 2).

(The author is Scientist Emeritus (Water Resources) International Water Management Institute (IWMI).
Email: B.Sharma@cgiar.org)

REDUCING DRUDGERY THROUGH TECHNOLOGY

Dr. Manish Mohan Gore

Intervention of farm technologies and drudgery reducing equipments has played a pivotal role in the enhanced agricultural productivity under NFSM (National Food Security Mission) for the Twelfth Plan. This comprised of the production of additional 25 million tonnes of food grains, which included 10 million tonnes of rice, 10 million tonnes of wheat, 3 million tonnes of pulses and 2 million tonnes of millet. This data shows that drudgery reducing equipments boost agricultural productivity. Hence, the need of the hour is to empower farmers especially women farmers through technology to reduce drudgery and health problems and to enhance agricultural productivity along with efficiency.

The major source of livelihood of almost 70 per cent population in our country is agriculture. We always talk about the farming, yield, fertilisers, pesticides etc. One grey area is always left out which is the fatigue and drudgery faced by the farmers and farm labours. Women farmers are an integral part of all these farm activities. According to an estimation of the International Labour Organization, women perform one-third of the world's counted labour. We consider agriculture as one of the most labour intensive occupations of unorganized sector. In India, majority of work forces are employed in unorganized sector, where health and stress are worse. Heavy workloads and drudgery are resulted in stress and poor health in agricultural work which usually have been overlooked.

In view of different kinds of agricultural work-load and resultant drudgery of the farmers, and making available simple cost effective technologies would help minimize drudgery, stress and ill health of the farmers. Besides minimizing drudgery, these technologies and equipments should reduce energy, expenditure, time, and in turn enhance efficiency, productivity, quality of produce, income and overall satisfaction of the farmers. Such technologies must also be appropriate and need based. Although a number of technologies have been developed by agricultural research organisations and scientific institutions of the country but end users are not so aware about and their outreach is crucial.

Types of Drudgery for Farmers:

It is seen that farmers, especially women farmers and farm workers are engaged in a number of agriculture and farm operations such as seeding, transplanting, weeding, thinning, harvesting, winnowing etc. All these labour intensive works lead to drudgery or fatigue in the form of physical or mental stress. Researchers have found that due to farming related drudgery, most of the farmers suffer from frequent headache, backache, sleep disorder, abdominal pain, sore throat or running nose with fever. Crucial examples of women farmers have also been noticed facing depression, anaemia, abortion, miscarriage and other gynaecological problems. When we consider women farmers, it is obvious that they face greater amount of total drudgery as they shoulder almost entire workload of household activities and child bearing along with substantial contribution in farming. When women farmers' drudgery combines with the constraints of illiteracy, malnutrition and unemployment, the situation becomes more vulnerable.

Women farmers usually perform agricultural works with the age old traditional tools since gender friendly tools are either not available or those are inappropriate. Some tools and equipments are available but due to lack of awareness their need based utilisation is not happening. On the other hand, farmers are forced to work with hazardous, unhealthy and tedious traditional tools. If farmers be made aware with the available drudgery reducing tools and equipments, these would not only contribute in drudgery reduction; but also increase their capability, productivity and improve efficiency.

Minimizing Drudgery:

It is found that ergonomically designed *cotton picking bags* (Marathwada Agriculture University, Parbhani and CCS, Haryana Agriculture University) have a higher carrying capacity and

ease in tying proved significantly superior over those picking bags having longer picking time with less interruptions. These bags exert 37 per cent less load on heart beats, 18 per cent lower energy expenditure. Similarly, *tubular maize sheller*, *sitting type groundnut decorticator*, *seed treatment drum*, *naveen sickle* and *groundnut stripper* have been introduced in past to reduce farmer's drudgery. The usage results indicate that use of tubular maize sheller reduced hand pain (80%), shoulder pain (70%), backache (73%) and waist pain (72%) caused by stick beating. The use of *sitting type groundnut decorticator* reduced finger pain (73%), hand pain (60%), backache (40%), tooth pain (66%) and cuts in mouth (70%). The use of the *groundnut stripper* also reduced hand pain (80%), shoulder pain (77%) and waist pain (67%). The mixing efficiency of seed treatment drum (98%) was better than the mixing of chemicals with seeds directly by hand (80%) although it took 25 min/qt. which was 5% more than their local practice. It has reduced the itching in hand (63%) and redness and swelling in hand (83%) caused by mixing of seeds by hand. The use of *naveen sickle* has reduced cuts on finger due to rubbing of hand in harvesting ground level crops (80%), pain in waist and hand (70%) and physical tiredness (73%) caused by local sickle. Such technological interventions have help in reducing the time and physical strain of harvesting agricultural produce.

ICAR-CIAE (Central Institute of Agricultural Engineering), Bhopal, Madhya Pradesh is nationally and internationally premier Agricultural Engineering Research and Development Institute devoted to develop and promote appropriate technologies for land development, farm mechanization, irrigation, processing of agro-produce, utilizing renewable, animate and mechanical power sources. Aligned with its mandate, CIAE has developed a number of tools and technologies which assist drudgery reduction to the farmers and farm workers. A few such tools are discussed here.

Seed Drill:

In the traditional method, a furrow is opened by hand hoe in the soil and seeds are placed. These operations are done in bending posture which causes pain in waist and back of the farmers. In traditional practices, placement of seed at proper depth is usually difficult which

gives chance to birds and insects for eating/ damage. Often, time for sowing operation is less; the operation is delayed resulting in lower yields. In order to resolve these discomforts and reduce fatigue, seed drill has been developed by CIAE. It consists of a handle, seed hopper, ground wheel, a fluted roller and a furrow opener with seed tube fixed in it. The metering of seed is done by fluted roller which is operated by the ground wheel by a sprocket and chain mechanism. The seed drill is operated by two farmers; one pulls it and the other pushes and guides the equipment for proper operation. It can be used by small farmers for sowing of seeds like sorghum, pigeon pea, soybean, maize, wheat, Bengal gram etc. Capacity of this innovative tool is 0.04 hectare per hour. The cost of this tool is Rs. 5000. It is suitable for placing seeds in the soil at desired depth and seed sowing can be completed in a shorter time and drudgery is reduced. The crop yield is also increased due to better placement of seeds at proper depth and desired row spacing.

Hand Ridger:

While farming operations, women farmers very often bend or squat and pull the soil towards them to make small ridges and furrows. It puts strain and they suffer pain in the back and shoulders. They often complain of spondylitis. The Hand Ridger is an incredibly simple and useful labour saving improved equipment. Farmers can make ridges and furrows very easily using this equipment. The ridger includes two heart-shaped metallic wings and a pulling beam with T- type handle. It helps to place the soil on either side and make a clean ridge. Two women famers can operate the equipment in the field; one pulls the tool while the other pushes and guides it. The capacity of this equipment is 0.03 hectare per hour and cost is Rs. 700.

Twin Wheel Hoe Weeder:

Traditional manual weeding by hand hoe (Khurpi) is a labour intensive process. Farmers usually bend and keep moving in the field while they take out the weeds and remove unwanted vegetative growth between rows/plants. This causes pain and stiffness in waist, neck and back in the long run due to bending/squatting posture. Women farmers often complain of pelvic pain. The alternate of traditional hand hoe is twin wheel hoe which is a very high capacity equipment suitable for weeding. This tool reduces the drudgery in weeding operation in less time with increased productivity. A simple push and pull action by women using this weeder effectively removes weeds. It consists of two wheels, frame, V-blade, U-clamp, scrapper and a handle. It is a push-pull type weeder that gives high output per worker. The capacity of this tool is 0.015 hectare per hour and cost is Rs 800.

Improved Sickle:

Harvesting cereal crops is usually done manually by women workers using local sickle. The local sickle is heavy weighing about 300 to 350 gram which causes pain in wrist. Often conventional sickle causes bruises and cuts on the edge of the palm and thumb. The edge of the conventional sickle needs to be sharpened almost daily. On the other hand, the improved and serrated sickle requires less cutting force and the cutting edge retains the sharpness for a long time. Its low weight (about 150 to 180g) turns less fatigue on the wrist. Also there is drudgery reduction of about 15% as compared to local sickle. It consists of serrated blade, ferrule and wooden handle. A bend of about two inches near the holder helps to reduce the abrasion to hand of farm women during cutting of crops. The working capacity of this improved sickle is 0.015 hectare per hour and cost is only Rs. 60. Crops with herbaceous and dry stems like paddy, wheat, soybean are suitable for this equipment.

Bhindi Plucker:

Plucking bhindi is a messy job since it lacerates the skin of farmers. The fine rather tough and prickly skin of bhindi causes much irritation in harvesting. CIAE has developed a very innovative tool in the form of Bhindi Plucker which offers effective protection from the sticky chemicals with which the hands come into contact while plucking Bhindi. This is a small sized tool which can be used to pluck Bhindi very easily and that too without causing any itching or discomfort to skin. The working capacity of this plucker is 5-10 Kg per hour and cost is only Rs. 35.

Coconut Dehusker:

Traditionally deshusking of coconut is done by a sharp iron shovel called *Muna* fixed on a wooden log or with the help of a long knife which is dangerous and accident prone. With the use of coconut dehusker, pain in arms, shoulders, and lower back is reduced to a great extent. This tool accounts for about 50% reduction in drudgery. Imaginatively designed with the operating handle upwards, the Coconut Dehusker splits/opens coconut partially at several points thus making dehusking by hands far easier. The capacity of this tool is 200 nuts per hour and cost is Rs. 800.

Government Schemes and Awareness Generation:

About 25 to 50 per cent subsidies are made available to farmers by the Government to ensure

the machinery or drudgery reducing technologies /tools/equipments at a better and affordable price. However, the Government has provided ceiling limits to all categories of farmers for the purchase of various agricultural equipments under various schemes of the Department of Agriculture and Cooperation. A few such schemes are *Macro Management of Agriculture, National Food Security Mission (NFSM), Rashtriya Krishi Vikas Yojana (RKVY), National Horticulture Mission* etc. Under these schemes, Government has distributed nearly 30.16 lakh improved farm machineries including water saving devices and drudgery reducing equipments. In this connection, capacity building of farmers has also been encouraged through arranging 43656 Farmers' Field Schools (FFS) at farm level so far.

Survey reflects that farmers are mostly unaware about drudgery reducing tools and equipments related with agriculture and horticulture. Even those who are aware, they don't know the place of availability and other related information. In this scenario, the role of publicity and awareness about drudgery reducing tools, modus operandi, places of availability and concerned Government Schemes becomes very important and essential. Many of the government and non-government organisations are also extending their support in this direction.

A multimedia compendium on women friendly improved farm tools for agro-drudgery reduction has been brought out by *Vigyan Prasar* (An Autonomous Organization under the Department of Science & Technology, Govt. of India). The DVD containing 37 video clips of women friendly improved tools and equipments for women in agriculture has been developed with the technical guidance from Central Institute of Agricultural Engineering, Bhopal. Vigyan Prasar connected with a significant number of women farmers to understand their specific information and capacity building needs to overcome drudgery related challenges in farming. The multimedia compendium serves the specific purpose of improving preparedness of stakeholders to use alternative tools/equipment/ suitably adapt practices and as a forerunner to training and capacity building.

Intervention of farm technologies and drudgery reducing equipments has played a pivotal role in the enhanced agricultural productivity under NFSM (National Food Security Mission) for the Twelfth Plan. This comprised of the production of additional 25 million tonnes of food grains, which included 10 million tonnes of rice, 10 million tonnes of wheat, 3 million tonnes of pulses and 2 million tonnes of millet. This data shows that drudgery reducing equipments boost agricultural productivity. Hence, the need of the hour is to empower farmers especially women farmers through technology to reduce drudgery and health problems and to enhance agricultural productivity along with efficiency.

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(The author is Scientist, and writes regularly for Vigyan Prasar, Department of Science & Technology.
Email: mmgore@vigyanprasar.gov.in)

FINANCIAL INCLUSION THROUGH TECHNOLOGY

Dr. Manjula Wadhwa

RBI has been actively involved in harnessing technology for bringing more and more people in the ambit of formal banking sector of commercial banks. As far as rural India is concerned, the task has been assigned to the apex agriculture and rural development bank (NABARD), which has been working towards bringing the excluded population into the formal banking system by addressing both demand and supply side constraints, appropriately realising the fact that instead of opening bank branches in rural areas, new players such as Business Correspondents, Business Facilitators, Mobile Operators and fintech companies need to be roped in.

Nowadays, in 'State Level Bankers' Committee' (SLBC)meeting of all states, the regular agenda item has been fixing and achieving targets for bringing financial Inclusion and financial literacy among Indian masses, through a targeted approach in a time bound manner and ofcourse, through latest modes of technology. So the most important concepts to deliberate upon here are **Financial Inclusion, Financial literacy and the role of technology** in it. Financial inclusion is the process of ensuring access to appropriate financial products and services needed by all sections of society in general and vulnerable groups such as weaker sections and low income groups in particular at an affordable cost in a fair and transparent manner by mainstream institutional players. Actually, it is one of the critical determinants of national inclusive growth and it's significance increases manifold in a country like India, where, despite the passage of 70 years of Independence, the unbanked population is approximately 19 per cent of the total. There are few, if any, instances of an economy transiting from an agrarian system to a post-industrial modern society without broad-based financial inclusion.

Let us look at the ground reality in our nation -of the underprivileged sections of the rural India –approx. 51.4% of farmer households are financially excluded. Of the total farmer households, only 27% access formal sources of credit. One third of this group also borrow from non-formal sources. 73% of farmer households have no access to formal sources of credit. Apart from the fact that exclusion itself is large, it also varies widely across regions, social groups and assets holdings. The poorer the group, the greater is the exclusion. There is clear evidence that farm debts are increasing much faster than farm incomes, leading to the most drastic step of commiting suicides by farmers in all parts of the country. In comparison, while casting a glance at very small countries like Kenya, we observe that nearly two-thirds of all adults are active customers of a mobile phone-based money transfer and payments service, and 50 per cent of mobile phone owners in Tanzania actively use mobile money systems.

Virtually, one of the biggest components of financial inclusion is **financial literacy**. No matter how many banks our government opens and how many boots are there on the ground, if a person does not know about the financial options that are open to him, policies/schemes and financial instruments will mean little. So it is more than obvious that apart from other measures, **technology** can be strongly leveraged to achieve the objective of financial inclusion and literacy.

Financial literacy has to be based on three principles:

- Effective use of mediums like computer, mobile and internet to enable people to have

the skills, knowledge or information about financial instruments.

- We must ensure, people have the ability to critically understand the content they have received through digital means.
- They should apply it to the best of their knowledge and capacity.

Delving deep into the issue, RBI realised that for achieving the gigantic objective of financial inclusion and financial literacy, the conventional banking modes are not feasible, especially for low ticket size of transactions, deposits, loans, etc.,in semi-urban and rural areas. And so, the Central Bank of our country has been actively involved in harnessing technology for bringing more and more people in the ambit of formal banking sector of commercial banks. As far as, rural India is concerned, the task has been assigned to the apex agriculture and rural development bank (NABARD), which has been working towards bringing the excluded population into the formal banking system by addressing both demand and supply side constraints, appropriately realising the fact that instead of opening bank branches in rural areas, new players such as Business Correspondents, Business Facilitators, Mobile Operators and fintech companies need to be roped in.

As an effective alternative credit delivery mechanism, **SHG-bank Linkage programme,** run country-wide by two major organisations/ departments, has proved to be the biggest mile-stone for achieving financial inclusion. In line with Hon'ble Prime Minister's mission to **"transform India into digitally-empowered society and knowledge-economy" digitization of SHGs project** is running in 100 districts of the country, Under this project,first the mapping of the existing SHGs in each district (bank wise, branch wise) is done, then the volunteers are trained to collect SHG wise/member-wise data. The data is fed through a customized software in central server. After this, the data is hosted on the web under a dedicated website and also updated regularly. Thus finally, MIS is generated for various users.

As far as it's implementation is concerned, there are many challenges ahead of us like sourcing of information from poor database and records, large scale capacity building needs, cooperation from banks, GPRS connectivity and ofcourse funding requirements for scaling this pilot from the present level to 86 lakh SHGs across the country.

Then in 2014 came, **PMJDY**- a National Mission on Financial Inclusion encompassing an integrated approach to bring about comprehensive financial inclusion of all the households in the country in two phases, with clear understanding that **this deep penetration at an affordable cost is possible only with effective use of technology**, by way of Every Bank A/c to be on-line with RuPay Card & Mobile Banking Facility, use of e-KYC to ease the account opening process, use of Aadhaar Enabled Payment System (AEPS) for interoperability, support for setting up FLCs, support for demonstrating banking technology (Mobile Van fitted with ATM), on-line Monitoring through system generated MIS and facility of Call Centre & Toll free number. The 6 pillars of financial inclusion under PMJDY, as per Hon'ble PM's vision are as under:-

Towards achieving this goal, no doubt, we are facing many challenges like Telecom connectivity,

Keeping a/c live, success, reach and effectiveness of Bank Mitr, OD repayments, Direct Benefit Transfer cost, Coverage of difficult areas ,like HP, NE, J&K, Uttarakhand, LwE distts.

As a part of its financial inclusion plan, RBI started the **Business Correspondent model** in 2006. Business Correspondents (BCs) are representatives appointed by banks to act as their agents, who provide banking services in remote locations, where the bank may not have presence, at the doorsteps of the poorest. The two major technological components involved are the hand-held offline device through which financial services are offered to the customers and the smart card (32k/64k memory chip) provided to each customer for recording of transactions. Along with these, the BC uses an Account Opening Form (AOF) and a laptop for feeding customer data, a digital/web camera for capturing customer's photograph and a biometric device for recording his fingerprints. No doubt, the BCs and BFs are providing banking services in far-flung places but they can not be expected to provide their services for free. Especially in NER, given the lower number of transactions, BC model viability has been a major issue. In order to circumvent the problem, a part of the monthly commission subject to a cap of Rs.3000/- per BC per month is reimbursed from the fund in case of RRBs.

Undoubtedly, Financial Inclusion has been high on the Govt. as well as RBI agenda during the last decade and is likely to remain even in the next decade. Now let us look at the various initiatives, the Govt. of India has progressively launched over the last several years.**The Digital India initiative,** coupled with a payment infrastructure, is laying the cornerstone for a digital economy, keeping in mind the increasing willingness of people to use the internet and the rising data traffic in the country, an investment of $18.4 billion has been made to provide last mile internet connectivity, better access to government services, and development of IT skills, provision of broadband internet access to 250,000 village-clusters by 2019 at a cost of about $5.9 billion.

In addition, all the **cooperative banks and Regional Rural Banks have been brought on CBS**

platform for providing anytime and anywhere banking to the rural populace. **RuPAY Kisan Cards** have been providing impetus to cashless transactions among the farming community. NABARD has extended support to Coop. banks and RRBs in procuring EMV chip-based RuPAY Kisan Cards. The impetus to Financial Inclusion given by Pradhan Mantri Jan-Dhan Yojana (PMJDY) has made it possible to flood the hinterlands with Ru-PAY cards. However, with hardly any of the 1.50 million POS terminals deployed beyond Tier 1 and Tier 2 centres, these PMJDY–related RuPAY cards were generally used for cash withdrawals. Given the prevailing situation where we are moving towards digital payments, it was necessary to create an ecosystem in rural India where the populace could use its cards to carry out digital transactions and not just use it on cash-dispensing machines. Hence, the apex Agri and rural Development Bank has extended support for deployment of 2 lakh POS terminals in 1 lakh villages in Tier 5 and Tier 6 centres.

The technology-levered Aadhaar programme is likely to be the biggest disruptor in financial inclusion delivery, as innovations leveraging the Aadhaar card are expected to assist in broad-basing the access and acceptance by financially excluded segments. In order to provide impetus to Aadhaar based biometric transactions, it was decided to extend support for incentivizing these transactions. The support is 0.5% of transaction value with a cap of Rs.10/- per Aadhaar enabled Point of Sale (POS) based transaction (for transactions upto Rs.2000/-)

Direct Benefits Transfer scheme was initiated to facilitate disbursements of government entitlements such as those under the social security pension scheme, handicapped old age pension

scheme, etc., of any central or state government bodies, using Aadhaar and authentication thereof, as supported by UIDAI.

Payments banks are a new model of banks conceptualised by RBI. The main objective of payments bank is to widen the spread of payment and financial services to small business, low-income households, migrant labour workforce in secured technology-driven environment in remote areas of the country.

Today, more than 70 per cent of our population owns **mobile phone**, hence, leveraging it's penetration to rural areas, with it's advantages over traditional banking methods because of breaking down geographical constraints alongwith immediacy, security and efficiency, it offers an innovative low-cost channel to expand the reach of banking and payment services especially to the large section of rural mobile subscribers.

Since connectivity and power issues can badly affect banking services and more in remote areas, all coop. banks in the NER and A&N Islands, have been made eligible for **support for solar powered V-SATs** from '**Financial Inclusion Fund'.** V-SAT connectivity support is also extended to all banks for new branches being opened in identified **LWE districts,** restricted to 7 branches per district.

To promote digital transactions for personal consumption expenditure, two schemes viz. **Lucky Grahak Yojana** and **Digi-Dhan Vyapar Yojana** was funded through Financial Inclusion for consumers and merchants respectively. National Payments Corporation of India (NPCI) determines the winners for cash rewards by choosing them through an electronic draw of lots from amongst the digital transaction IDs generated from 8 Nov. 2016, during the course of such transactions. Apart from this, the **Financial Literacy Awareness Programmes were recast as d-FLAP,** with an objective of transition from a cash-based economy to less-cash one. The digital modes of transactions like mobile apps, USSD-based transaction are also explained/demonstrated in dFLAPs held across the country.

The Way Forward:

What is to be emphasized here, is the need for banks to move beyond simply opening bank A/c, to ensuring that the poor customers are confident and comfortable enough to use them. We need a frugal, trustworthy, and effective Indian model of technology for financial inclusion. Let us wait for the forthcoming recommendations of the Dr. Nachiket Mor Committee, Dr. Sambamurthy Committee which will guide us how to expand mobile banking in India through encrypted SMS based funds transfer in any type of handset. So in sum, while several challenges do present themselves they carry within them the core of opportunities which will spur development impulses and lead to growth with equity.

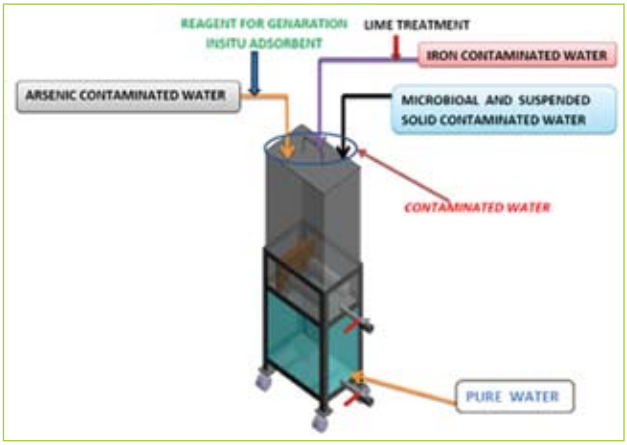
(The author is Asstt. General Manager, NABARD, Chandigarh.
Email:].jaipur@gmail.com)

AKRUTI TECHNOLOGY PACKAGE FOR RURAL ENTREPRENEURS

S. Mule

Considering the wealth of technology and innovative capability generated in BARC & DAE units as an off-shoot of R&D in Nuclear Energy and its applications in power and non-power areas, Department of Atomic Energy has launched DAE – Societal Initiative for utilization of Non-Power Applications (NPAs) and Spinoff technologies (Spinoffs) in the area of water, land, agriculture, food processing and urban-rural waste management. Within this framework of societal initiative, structured programme called "AKRUTI - KRUTIK - FORCE" has been formulated and is being implemented by BARC for techno-economic growth of the rural sector.

Over the past 50 years, a large indigenous Science & Technology (S&T) know-how has been generated in various national laboratories and in parallel, several technologies have been imported. Urban sector has received the highest attention by way of deployment of large number of these technologies and know-how in urban areas resulting in rapid urban development leading to urban rural divide in terms of prosperity and opportunities. Further, India's young population is expected to be the largest in the world in decades ahead, over 500 millions. Creating gainful and productive work for them is the greatest challenge. Technical know-how generated in national laboratories related to basic needs such as water, food, energy and environment has been underutilized. Deployment and adaptation of this know-how to the rural needs could provide a creative opportunity for expected 500 million youths in rural and urban India to contribute to the national wealth with prosperity for everybody including villages.



Nanocomposite Ultrafiltration Membrane Device For Domestic Drinking Water Purification W.R.T. Arsenic, Iron And Microbial Contaminations

In a country of the vast size such as ours, technology innovations and adaptation has to be evolved in a greater measure particularly since such technology has to fit with varied local conditions and need to be applied quickly to enhance the quality of life of larger population. Considering the wealth of technology and innovative capability generated in BARC & DAE units as an off-shoot of R&D in Nuclear Energy and its applications in power and non-power areas, Department has launched DAE – Societal Initiative for utilization of Non-Power Applications (NPAs) and Spinoff technologies (Spinoffs) in the area of water, land, agriculture, food processing and urban-rural waste management. Within this framework of societal initiative, structured programme called "AKRUTI - KRUTIK - FORCE" has been formulated and is being implemented by BARC for techno-economic growth of the rural sector, as one of the many schemes for large-scale deployment of BARC technologies - 4th Key Driver of Major programmes of Department of Atomic Energy (DAE) and Vision of NITI Ayog for social outreach and awareness.

Since the initiation of this programme, it is popularly known as AKRUTI programme. AKRUTI is an acronym for Advanced Knowledge and RUral Technology Implementation initiative. Under this programme, several AKRUTI MoUs were signed. Three AKRUTI nodes were set up in Maharashtra state and made operational with funding by GoM and as a follow up, some more nodes were set up in self-financed mode by other NGOs in other states. AKRUTI nodes through NGOs have demonstrated the usefulness of BARC technologies for rural sector leading to societal benefit. Further, it has demonstrated that technically oriented HR in rural sector is capable to deploy technologies for their use under the guidance of BARC scientists

and engineers. This programme has potential to encourage village techno-preneurship based on BARC technologies.

Akruti Tech Pack for Techno-Economic Activity:

'Akruti Tech Pack' (ATP) for Exclusive Rural Deployment on chargeable basis is a technology package introduced in the year 2009 for desirous technically oriented individuals including women / entrepreneurs / industry / companies in villages and cities, to promote techno-economic activity in rural sector through AKRUTI programme at an affordable price. Now the scope is expanded by adding more technologies, better training facilities and new schemes of technology deployment under XII plan project and flexibility is increased by adding more user friendly terms and conditions to ATP as given below:

ATP Technologies:

Akruti Tech Pack is made of twelve *(12) technologies as given below:

Akruti Tech Pack at Affordable Cost:

To enable and encourage techno-entrepreneurship in the villages, all those who desire to start activity in villages can avail these technologies at an affordable cost. To quick start the activity, some of the products can be purchased by them either from operational AKRUTIs or from industries as they find suitable and deploy them in the region. Based on the experience gained, they can spread the activities in surrounding villages by deploying them in rural sector through local techno-preneurship with the technical know-how and training support provided under this programme for deployment.

Under DAE-Societal Initiative, to encourage potential techno-preneurs in rural sector and to promote large scale deployment of BARC technologies, these technologies are provided for deployment in the rural area with concessional License Fee to locals from rural areas and also urban entrepreneurs to start this activity in rural sector at an affordable price. All the technologies mentioned

S.No.	Technology
1	Nisargruna - Biogas plant based on biodegradable waste
2	Soil Organic Carbon Detection & Testing Kit (SOCDTK)
3	Vibro Thermal Disinfestor (VTD)
4	Foldable Solar Dryer (FSD)
5	Process for retaining Pericarp Colour and extending shelf life of Litchi, novel process, wherein the fruits after treatment can be stored at low temperature upto 45 days.
6	Domestic Water Purifier (DWP)- a technology to get bacteria free clean drinking water without use of electricity
7	Solar Energy driven Portable Domestic Brackish Water Reverse Osmosis (BWRO) technology- technology based on solar photovoltaic (PV) system. It has capacity of 10 litres/hr (lph) which can desalinate contaminated water of salinity 1000–3000 ppm (mg/lit) to provide drinking water of 50 - 300 ppm. The product water will be devoid of toxic elements, pathogens & turbidity too. It is best suited for remote/ rural areas where electricity is not available or the voltage is not stable.
8	Dip N Drink (DND) Membrane Pouch, technology to convert the biologically contaminated water into sterile solution for oral consumption, useful during flood, cyclones, tsunami, earthquakes, etc. in remote areas/villages.
9	Banana Tissue Culture (BTC) Technology for mass-production of commercially important banana varieties. This technology can also be used for conservation & multiplication to the desired scale, of several other locally important, elite, endangered and ornamental banana varieties.
10	Mass multiplication medium of Biofungicide Trichoderma spp.
11	Microfine Neem Biopesticide
12	Nanocomposite Ultrafiltration Membrane Device For Domestic Drinking Water Purification W.R.T. Arsenic, Iron And Microbial Contaminations

Control Samples *Irradiated samples*

Fig: Preservation of Food & Agricultural Commodities by Radiation Technology

above are offered under AKRUTI Tech Pack. Applicant is free to choose any one or combination of technologies for deployment in the rural sector as per need of the region and his financial capacity. On successfully deploying the taken technologies in the rural sector, the ATP holder can request for following free consultancy suitable to his region on trial basis.

1. Preservation of agri-produce through Irradiation :

Radiation technology can be effectively used in preserving agriculture produce, improving food safety and enhancing international trade by overcoming trade barriers caused by the presence of quarantine insect pests and microbes in agricultural commodities. Major technological benefits that can be achieved are disinfestations of insect pests, inhibition of sprouting, delay in ripening and destruction of microbes creating food spoilage. This leads to increase of storage life, hygiene and safety. It is desired to increase the awareness of these benefits in urban as well as rural sector.

In order to promote this awareness in rural sector, radiation processing consultancy service will be provided to the holders of AKRUTI Tech Pack for carrying free trial sample irradiations of products available in their regions on separate request.

2. BARC New Seed Varieties:

For increasing the awareness and spread of new crop varieties developed by BARC, sample seeds shall be made available to sow in their region to ATP holder on separate request. Women Entrepreneurs (WEs) are further encouraged by providing additional 10% concession on AKRUTI Tech Pack license fee with other conditions remaining same.

Eligibility Criteria:

- Person desirous to deploy these technologies should have working place/site/farm in a village with technical inclination or background.
- Villagers with farm activities having scope to expand or willing to augment the activities with self-financial support/ can arrange finance is preferred.
- City resident desirous to start activities in villages based on AKRUTI Tech Pack will be also considered provided, place / site / farm is available to him/her in a village as a working place.

Products under drying in Foldable Solar Dryer (FSD) : above left and some of the products dried in FSD

- AKRUTI Tech Pack is offered for rural deployment on a non-exclusive basis.

All these technologies have been transferred to industry on non-exclusive basis under Technology Transfer Agreement.

Conditions For Deployment Of Akruti Tech Pack:

- Strictly in rural sector with rural manpower.
- Place of activity must be in rural sector providing opportunities of employment and entrepreneurship to villagers.
- Working place / facility must be set up in rural sector except NISARGRUNA with precondition as given below.
- NISARGRUNA can be set up in villages as well as urban sector. Urban sector activity of NISARGRUNA can be initiated only after setting first (1st) plant in the rural sector.
- Products made in villages can be marketed in urban areas along with meeting the village needs.
- The individual/entrepreneur/industry/company taking AKRUITI Tech Pack can deploy technologies in other villages through suitable format of "AKRUTI-KRUTIK-FORCE" or NGOs operating in those villages with above conditions.

Training Facility:

DAE-Out Reach Centre (DAE-ORC) co-located in Higher Education Campus in collaboration with Shri Vithal Education & Research Institutre, Pandharpur, Maharashtra, Rajiv Gandhi S&T Commission, GoM and NIC, New Delhi for societal applications has also been set up. One of the units called Rural Human & Resource Development Facility at DAE ORC provides training with affordable charges to interested entrepreneurs on some AKRUTI Tech Pack technologies.

For growth and wide spread of AKRUTI Programme, training centers have been set up in different parts of the country. BARC has signed MoU with following institutes for setting up DAE Technologies Display & Dissemination Facility under XII plan project:

- SLBS Engineering College, Jodhpur, Rajasthan
- SJC Institute of Technology (SJCIT),Chickballapur, Karnataka
- Anu Bose Institute of Technology, Paloncha, Khammam Dist, Telangana
- NIT, Tiruchirappalli (Trichy), Tamil Nadu
- Raipur Institute of Technology, Raipur
- School of Agricultural Sciences and Rural Development (SASRD), Nagaland University, Medziphema Campus, Medziphema, Nagaland
- Manipur Science & Technology Council, (MASTEC), Imphal, Manipur
- HNB Garhwal University, Uttarakhand
- GITAM University, Visakhapatnam, Andhra Pradesh (Technology Display & Dissemination Centre in R&R Colony, Dibbapalem)
- Utkal University, Bhubaneshwar, Odisha (DAE Outreach Centre at Vanivihar Campus)

Conclusion:

The basic need of opportunities for innovation, work and entrepreneurship for the rural areas can be accomplished by canalising modern indigenous know-how and technologies through this structured program "AKRUTI-KRUTIK-FORCE" with the existing financial support in the initial stage. This will enable the villagers to deploy and make use of the technologies with local adaptation for themselves, which itself will generate village entrepreneurship and make this activity self-sustaining and wide spread. In-turn, it will create a strong, wide spread network for embedded innovative S&T culture in rural areas. AKRUTI-KRUTIK-FORCE can work like a catalyst to speed up deployment, use and spread of NPAs & spin-offs. Thus, BARC-DAE technologies in AKRUTI node, deployed by KRUTIK through villagers amongst FORCE groups will create `People Centred Research & Extension for Assured Livelihood of the rural sector'. Livelihood security of the rural sector will ensure the food security of the nation.

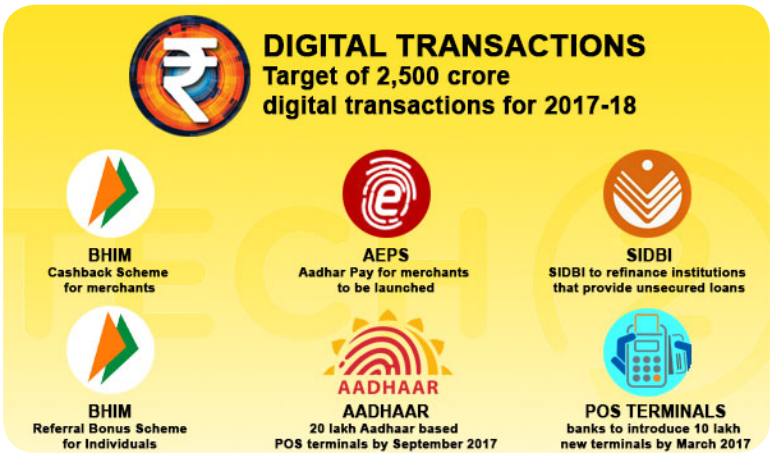
(The author is Principal AKRUTI Coordinator, Technology Transfer & Collaboration Division, Bhabha Atomic Research Centre Trombay, Mumbai.
Email: smule@barc.gov.in)

ROLE OF ICTS IN RURAL DEVELOPMENT

Dr. Anshu Parashar

ICTs can play vital role in management of rural development programmes and schemes. Availability of the real time information of various projects help the central/state government agencies to effectively plan, implement and monitor execution of their schemes at ground level. Web/mobile based applications can be deployed to keep track on fund flow and disbursement of benefits/wages to beneficiaries. The applications can be effectively utilized to increase awareness of rural masses, to keep track of physical/financial progress of a project. Further, Geographic Information System (GIS) should be used to manage and analyze geographic data of the underline project including natural resource maps, planning maps, satellite images.

Rural areas in India still face challenges like sustainable employment in agriculture/ allied sectors; quality education; marketing infrastructure, over exploitation of natural resources; inadequate electricity, transport, communication, health, food and storage facilities etc. It has however been recognized that Information and Communication Technology (ICT) can play a vital role in management of rural development programmes to ensure that benefits reach to actual beneficiaries in time. ICT has the potential to capture real-time status & progress of programmes/ schemes, fund utilization/parking, timely disbursement of wages/subsidies, awareness & capacity building, geo-tagging of house/ toilet/infrastructure constructed under various schemes etc. The integration of ICT and welfare schemes has resulted into latest buzz word called as "New India" or "Digital India".



Integration of Communication and Information Technologies as ICTs:

Information Technology and Communication Technology are two different streams, but integrated together as ICT (Information and Communication Technology) in order to achieve desired solutions of real life problems. ICTs mean a whole range of technologies (hardware and software) concerned with management and exchange of information. The integration of communication and information technology enables us to share the knowledge/ information effectively. The effectiveness of ICTs has increased phenomenally due to advancements in the fields of information technology. Use of ICT in real time is attributed to the emergence of advance processors, memory devices, internet, multimedia and information highways (e.g. fiber optics/wireless). Latest technologies like Remote Sensing (RS), Geographic Information System (GIS), and Global Positioning System (GPS) strengthen the software applications to capture and manage massive Geospatial/Geographical data. These advanced ICTs help to deploy applications for better land use, management of wastelands, village planning, water exploration, environmental conservation, ecosystem studies, disaster management etc.

Digital Divide:

It is a known fact that ICTs is making a considerable impact on the rural and urban communities due to its universal applications and great appeal. Now, it is possible to communicate with greater ease and speed in this new era of-The Information Age. While people in urban areas have seen positive contributions of ICTs in their lives but

same is not the case in rural areas. There is a Digital-Divide between the have's (Urban) and have-nots (Rural). The existing marked differences in the access and ownership of various ICT aids/facilities between urban and rural areas indicate towards the Digital-Divide. The penetration of ICT softwares and devices in rural areas is still limited but shows an upward trend. In this era of digitization, cashless economy, web/mobile applications etc., we have to bridge the gap of digital divide and need to place ICTs infrastructure in rural areas.

Digital India:

Digital India is ICTs based initiative of the Government to integrate the government departments and the people of India. It aims to ensure that government services are made available to citizens electronically thereby reducing paperwork. It includes planning to connect rural areas with high-speed internet. Digital India mainly has three core components, a) creation of digital infrastructure; b) delivering services digitally and c) digital literacy. Under Digital India and National e-Governance Plan, central and state governments are undertaking various Mission Mode Projects (MMPs) on cashless economy, agriculture, e-district, land records, gram panchayats, health, education etc.

ICTs for Rural Development:

Through use of ICTs, Government can disseminate welfare policies fast and also reach target beneficiaries quickly. It has become possible due to penetration of computers and mobile devices in rural areas. Also, now a days telephone, broadband, Internet Service Providers (ISPs) companies are expanding their network in rural areas .Due to emergence of smart phones, Wi-Fi, broadband, ICTs gadgets (e.g. PoS, MicroATM etc,) and mobile/web applications, nowadays, villages or Panchayats are transforming to Digital-Villages or e-Panchayatas. Not limited to SMS, rural people are becoming more familiar with social media like WhatsApp, Facebook etc. They are also downloading and playing Audio/Video clips for entertainment as well as educational purposes. These things are becoming possible due to increasing availability and accessibility of ICTs infrastructure in rural areas.

Moreover, ICTs hold tremendous potential to be used as a tool by the Government for reaching out to the rural masses and provide benefits of rural development schemes and other basic G2C services to the rural people. Some of the potential roles and applications of ICTs for rural development are listed below:

- **ICTs for Management of Rural Development Programmes**

ICTs can play vital role in Management of rural development programmes/schemes. Availability of the real time information of various projects help the central/state government agencies to effectively plan, implement and monitor execution of their schemes at ground level. Web/mobile based applications can be deployed to keep track on fund flow, disbursement of benefits/wages to beneficiaries, to mobilize/aware rural masses, to keep track on physical/financial progress etc. Further, Geographic Information System (GIS) should be used to manage and analyze geographic data of the underline project including natural resource maps, planning maps, satellite images etc.

- **ICTs for e-Governance (including Services Delivery System)**

ICTs can transform Governance into e-Governance. Through ICTs, all Government services can be accessible to common man in his locality, through common service delivery outlets. By using web/mobile applications along with latest communication devices, Government can ensure efficiency, transparency and reliability of such services at affordable costs. Various services under G2B, G2G, G2C models of e-governance can be delivered effectively as compared to the physical application/file/noting system. ICTs can help to provide common services like land registration, birth/death/caste certificates, pension & insurance, ration card, railway ticketing, utility bill payments, election services, grievance tracking, Aadhar enrolment etc. under one roof.

- **ICTs for Agricultural Extension Services and Marketing**

ICTs can help in extending research from lab to the field. Especially, FM, community radio, mobile

telephony, soil sensors and testing devices are most compelling for making Smart Farmers. Various ICTs based systems including touch screen kiosks, online agri-clinics, mass/social media, Kisan Call Centres, TV channels etc. can deliver useful information to farmers regarding crop care and animal husbandry, fertilizer and feedstock, drought mitigation, pest control, irrigation, weather forecasting, seed sources and market prices. ICTs based applications can also facilitate electronic trading like where-to-buy/sell, when-to-buy/sell and how-to-buy/sell etc.

- **ICTs for Climate Change and Natural Resource Management**

Using ICTs, climatology and agronomics, latest information on weather/climate change can be given to farmers. ICTs can handle massive data produced at different spatio-temporal scales by various sensors observing earth/environment in order to extract useful climate change information and patterns. Further, for natural resources, ICTs like RS, GIS etc. can be applied for scientific planning, management and monitoring.

- **ICTs for Rural Health Care Services**

ICTs can contribute to improve the coverage of national health services in rural areas. ICTs can offer specialized applications for rural areas including doctor database, visualization of medical reports, geographical disease pattern, hospital MIS and disease data analysis etc. Telemedicine services can enable access to professional doctors (through web camera, VSAT etc.) irrespective of geographical location. Further, mobile/web applications on health care can help health workers to maintain mother/child database, communicate easily with district/regional health centers for prompt delivery of health services in rural areas. Moreover, mobile/web applications can help to broadcast health messages on hand-washing, prenatal and delivery care, immunization and nutrition, family planning etc.

- **ICTs for Disaster Management in Rural Areas**

The advent of high resolution geographical data, RS, and GIS can offer greater capabilities for ICTs based disaster management applications during earthquakes, floods, oil spills, landslides, fires, tsunami like situations etc. in rural areas especially for remote locations.

- **ICTs for Rural Connectivity**

Development of rural roads requires appropriate planning, identification and prioritization. ICTs especially, Geographical Information System (GIS) is useful tool for processing spatial and non-spatial data of routes/links as well as village boundaries. ICTs based system help to maintain database of rural road network, project proposals, sanctioned projects, contractor's details, physical and financial progress, quality monitoring etc.

- **ICTs for Education**

ICT is an effective mechanism to make tremendous change and advancement in traditional education scenario. Nowadays, students are attracted more towards e-contents in the form of multimedia presentations and animations. With the launch of online courses and availability on e-study material of most of the education boards and universities, rural people can also have opportunity to avail best educational facilities regardless of geographical distance and limited financial resources. Availability and accessibility to computers/laptops/tablets (loaded with e-contents/books) with internet facility within the village itself (in school library, computer lab, Gram Sachivalya etc.) can help rural youth to fulfill their educational needs and enhance their ability to compete with outside world. Moreover, concept of smart class rooms (equipped with smart board, EDUSET etc,) should be introduced in the schools. A dedicated TV channel for educational program also facilitates the rural youth to get guidance from the eminent subject experts.

- **ICTs for Social Justice and Empowerment**

Direct Benefit Transfer (DBT) (with or without Aadhar) should be implemented in all the schemes/

programmes in order to ensure transparency, reduce the duplicate/fake beneficiaries and eliminate leakages. Through ICTs, Government agencies can transfer the pension (old aged, widows, handicapped etc.), subsidy, scholarship and wages directly in the bank account of the beneficiary/citizen to fulfill the mandate of social justice and empowerment. ICTs based system help in fund tracking and also result in saving of Government fund.

- **ICTs for Public Distribution System**

The Public Distribution System (PDS) in the country facilitates the supply of food grains and distribution of essential commodities to a large number of poor people through a network of Fair Price Shops (FPS) at a subsidized price on recurring basis. ICTs facilitate to implement the Electronic Public Distribution System (ePDS) in more transparent and effective manner.

- **ICTs for Rural Tourism**

ICTs, if effectively and smartly utilized, can assist in promoting rural tourism. Promotion of tourist places within the village or nearby locations can be done in better and cheaper ways by making web sites/portals that provide information about remote tourist locations, photos of key features, location map, etc. It will help to reach out to the masses, seek attention of the possible tourists and ultimately uplift the livelihood opportunities and economy in those places.

Some of the important ICTs based Center/State initiatives concerned with the rural development under various sectors e.g. wage employment, rural housing, watershed management, panchayati raj, education, health etc. are listed below:

MIS for MGNREGA: Management Information System (MIS) for planning, implementing and monitoring of MGNREGA programme is named as NREGASoft. NREGASoft provides interface for all the stake holders (officials, workers, citizens etc.) to capture and explore all the activities under MGNREGs. NREGASoft has been integrated with PFMS for fund management and it also facilitates social audit, grievances management, deployment of Barefoot Technicians (BFTs) etc. Further, integration of GEOMGNREGA and SECURE with NREGASoft enhanced its capability and also promotes transparency and accountability. GEOMGNREGA web/ mobile application facilitates capturing, publishing and viewing of geospatial data (Geo tagged) of the assets created under MGNREGs using the BHUVAN. Furthermore, SECURE (Software for Estimate Calculation Using Rural rates for Employment) is ICT based solution for estimate preparation and online approval process of Administrative/Technical Sanctions (TS & AS) for Mahatma Gandhi NREGA works.

MIS for Pradhan Mantri Awaas Yojana (PMAY)-Gramin: AWAASSoft is an ICT based solution for PMAY-G. AWAASSoft has different modules mainly for target setting, beneficiary management, inspection/verification of houses, fund management, preparation of audit reports, utilization certificates, staff management, progress monitoring, grievance redressal system etc. This empowered the masses especially, beneficiaries by providing interface for checking the beneficiary selection, transfer of fund to beneficiary bank account, complaint lodging etc. Further, Awaas Mobile App provides basic modules for logging inspection process, beneficiary information, FTO tracking, uploading of geo-tagged photographs of completion status of houses constructed under PMAY-G.

MIS for Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) erstwhile IWMP: IWMP- MIS is a web based system which can be accessed by all stake holders to enter the data related to IWMP projects. Project Implementing Agency (PIA) feeds the data related to Gram Panchayat and Watershed Committee. All the reports related to IWMP projects are in the public domain and can be accessed by anyone.

Panchayat Enterprise Suite (PES): The Ministry of Panchayati Raj (MoPR) has undertaken e-Panchayat, a Mission Mode Projects (MMP) under Digital India Programme that seeks to completely transform the functioning of Panchayati Raj Institutions (PRIs), making them more transparent, accountable and effective. PES comprises a set of applications to provide ICTs based solution to the Panchayats for planning, budgeting, implementation, accounting, monitoring, social audit and delivery of citizen services, etc. Some core applications under PES are:

- **Local Government Directory (LGD):** LGD provides all details of local government entities e.g. Panchayats. This facilitates to create and update the directory with newly formed panchayats/

local bodies, re-organization in Panchayats, conversion from Rural to Urban area etc and provide the same information in public domain.

- **Area Profiler:** Area Profiler captures geographic, demographic, infrastructural, socio-economic, political and natural resource profile of a village/panchayats.
- **Plan Plus:** PlanPlus (planning tool) helps in the preparation of participatory Gram Panchayat Development Plan (GPDP). This application facilitates to capture wish-list, resources, activities, plan and approval. Further, the approved plan is ported to the AcionSoft application.
- **Action Soft:** Action Soft provides interface for the Financial and Physical progress reporting of all the works carried out from approved plan.
- **PRIA Soft:** PRIASoft is basically accounting software to capture receipt/expenditure details through voucher entries and automatically generates cash book, registers and other useful reports.
- **National Panchayat Portal (NPP):** NPP provides a dynamic web site for each local body e.g. Panchayat to share information in public domain.
- **Service Plus:** ServicePlus is a portal to provide electronic delivery of basic services to the citizens.
- **Trainings Management Portal (TMP):** TMP addresses training needs of stakeholders including elected representatives, officials, and citizens. It captures all training related data and mainly Center/State recognized training institutes mange their trainings through TMP.

mKisan and eNAM: mKisan Portal for farmers enables all Central and State government organizations in agriculture and allied sectors to give information/services/advisories to farmers by SMS/ IVRS in their language, preference of agricultural practices and location. For agriculture marketing presently, eNational Agriculture Market (eNAM) is a pan-India electronic trading portal which networks the existing APMC mandis to create a unified national market for agricultural commodities. This includes commodity arrivals & prices, buy & sell trade offers, provision to respond to trade offers, among other services.

ePathshala: The ePathshala educational portal, a joint initiative of MHRD and NCERT has been deployed for providing all educational e-resources including textbooks, audio, video, periodicals, and a variety of other digital resources to the students. Further, ePathshala Mobile app is also available to provide quality and inclusive education.

Common Service Centre (CSC): **CSCs** are providing the citizen centric services including issue of various certificates (e.g. birth and death etc.), driving license, vehicle registration, etc. It is ICTs based service delivery system under a single roof helping citizens to get time bound service delivery along with elimination of corruption and middlemen

Aadhaar enabled Public Distribution System (AePDS): Haryana state is implementing AePDS for online ration cards, supply chain management, ration distribution through PoS devices at FPS using Aadhaar based authentication.

Online Grievances Redressal System: CM Window is a best example of grievances redressal and monitoring system implemented by the Haryana state. Citizen can register, track and find reply on his/ her grievance.

eUpchar and Hospital Management System: Through eUpchar patients get a unique identification number to store their health records and that can be

referred online at any hospital of Haryana with the help of Hospital Management Information Systems (HMIS).

HARIS and HALRIS: ICTs based property registration and land records management are also implemented by the Haryana state named as HARIS (Haryana Registration Information System) and HALRIS (Haryana Land Records Information System).

Challenges of ICTs in Rural Development:

Rural areas are still underserved in terms of ICTs infrastructure and capacity building. As a result, ICTs have not been able to play their expected role in the development of rural areas. Some of the challenges are:

- **Continuous Supply of Electricity:** The limited supply of electricity restrains rural areas to fully utilize ICTs applications especially at village level. Further, unavailability of quality UPS and Generator Set as well as their maintenance at village level is also a major issue.
- **Low level of Digital Literacy:** Literacy rate is considerably low in rural areas as compare to urban areas. The condition is more unsatisfactory when we talk about the Digital Literacy.
- **Shortage of ICTs Personnel:** At village level, few digitally literate professional are available. If villagers (especially farmers, youth, and beneficiaries) are willing to utilize ICTs based applications then who will regularly train them to acquire the desired knowledge and skills is a major concern.
- **Lack of Access of Telecommunications and Internet Services:** The ICTs based applications need uninterrupted services of telecommunication and internet. Presently, there are some patches in rural areas where reach of mobile telephony along with internet is still not upto the mark.
- **Unavailability of Web Content in Local Language:** The content part plays a dominant role as far as rural area is concerned especially rural farmers, artisans and poor beneficiaries. The content creation (in local language) needs to be addressed altogether in different manner to have the balance between rural and urban context.
- **Acceptance in Rural People:** Apart from other factors, user acceptance for the ICTs applications in the rural areas is a major challenge. It is often taken for granted that any technology transfer to the rural areas would be accepted but we have to consider their own established cultural and traditional ways of doing things.
- **Unethical Use of ICTs:** In the era of digital world, personal privacy, data security, copyright infringement, computer crimes, cyber crime etc are also coming in front as major concerns. Further, unethical use of social media is also posing problems.

Conclusion:

The country should recognize the potential ICT has for their communities residing in rural areas. The policies, schemes etc. should be equipped with the ICTs enabled plan to avail the benefits of latest technologies. To formulize the concept of Digital India for rural sector, we should have a clear cut e-plan or e-policy that guides the government priorities to adopt ICTs for rural development. It demands proper understanding of the social and development priorities of the rural areas. It also requires a vision and leadership of highest levels of the government along with political will. It requires rationalizing how every ICT objective needs to be carried out both in terms of responsibilities assigned to government agencies as well as the continuous financial support. Today, Societies are transforming to information-societies by adopting cashless economy, social network and other communication mechanism. Recognizing the present needs of promoting ICTs applications and cashless economy, rural people should be empowered by capacity building programmes. The premier institutes like National Institute of Rural Development and Panchayati Raj (NIRD&PR) and all State Institute of Rural Development (SIRDs) should play vital role to meet out the capacity building needs of the rural people. Although, India is on the right direction in terms of ICTs implementation for rural development but the significance of ICT revolution lies in the fact that it should surely help in delivering basic services in the rural areas in more innovative ways to uplift the quality of life in rural areas.

(The author is Assistant Professor (IT), Haryana Institute of Rural Development, Nilokheri, Haryana.
Email: parashar.hird@gmail.com)

GENERATING CLEAN ENERGY FROM WASTE

Dr. J.S. Samra

Some of the first generation technologies of animals dung (gobar) gas, ethanol from sugars and starch, bio-diesel production and power generation are not competitive due to market forces and availability of better alternative technologies. Latest Anaerobic Digestion technologies for crop residues have made Bio CNG cheaper than Fossil CNG. Anaerobic digestion of mixed feed stocks of paddy straw with cattle dung; industrial wastes and activated sewage sludge has further raised the productivity of CNG. CNG being neat and clean fuel with zero foot prints of green house gases have been suggested by National Green Tribunal and other honorable courts.

In India, about 234 million tonnes of surplus biomass with a potential of Rs. One lakh crores fossil fuel import replacement has been estimated .However, burning of crop residues, cow dung cakes, exhaust of vehicles, tractors, untreated sewage, residues of milk, meat, vegetable and fruit processing and methane liberation from cattle dung heaps pollute air and pollute environment. Some of the first generation technologies of animals dung (gobar) gas, ethanol from sugars and starch, bio-diesel production and power generation are not competitive due to market forces and availability of better alternative technologies. Mulching and incorporation of crop residues into soil, with heavy machinery liberates green house gases and is not being adopted by farmers in spite of heavy fines as it leads to a higher cost of cultivation. Controlled burning of biomass into steam boilers for electricity generation also liberates air polluting gases and farmers lose very valuable organic manures which ultimately deteriorates soil health. Tariff rates of generated electricity of Rs. 7.50 to 8.1 per unit is unviable as compared to Rs. 2.44 per unit of solar and wind power. Latest Anaerobic Digestion technologies for crop residues have made Bio CNG cheaper than Fossil CNG. Anaerobic digestion of mixed feed stocks of paddy straw with cattle dung; industrial wastes and activated sewage sludge has further raised the productivity of CNG. One ton of rice straw generates 115 kg of CNG worth Rs.4600 @ Rs.40 per kg with a total potential of Rs. 8300 crores and market of the paddy straw. By-products of organic manures or slurry maintains soil health, its fertility, productivity and profitability of the distressed farmers. It has a total potential of Rs. 25,000 crores of market sales annually. Oil marketing companies have become stakeholders in the production and marketing of bio-CNG with private investments of Rs. 10,000 crores. It will also create employment in primary and secondary activities and additional income of the farmers. CNG being neat and clean fuel with zero foot prints of green house gases have been suggested by National Green Tribunal and other honorable courts.

Waste to electricity plant

As per the report of Steering Committee on Air Pollution and Health Related Issues of the MoH&FW (2015), air pollution and food are the top most health risks. India is a polluted country with 1.6 million pre-mature deaths and 49 million disability adjusted life years due to household and ambient air pollution. Burning of crops residues,

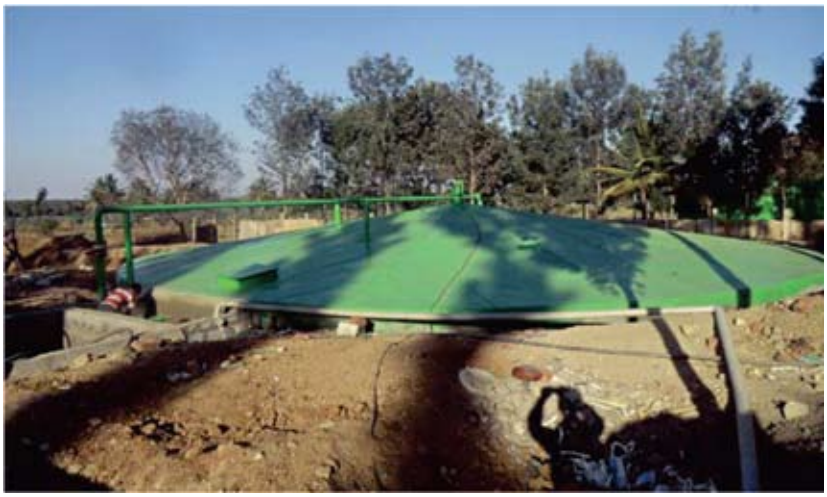
animal dung cakes, fossil fuels, solid wastes, untreated sewage, dust particles etc. are the major sources of pollution. Co-digestion or co-management of crops residues and other biomasses with animal dung, wastes of milk, meat, vegetable, fruit, sugarcanes processing and activated sewage sludge etc. can generate bio-fuels, compost for maintaining soil health, reduce import bill etc. Crops residues, industrial and other wastes have vast potentials of creating market for the wastes, provide rural employment, enhance income of the farmers and reduce pollution. Budget 2018-19 envisages incentives for **"Waste to Wealth"** including **GOBAR-dhan** scheme for realizing Rs. One Lakh Crore economy focused on bio-CNG generation. This year's budget has also announced an incentive of Rs. 7000 crores for the public sector Oil Marketing companies including GAIL to set up CNG purchase and sale infrastructure. Indian Oil Company has also signed an MoU of Rs. 5000 cores with Punjab state and investors to planning to set up 400 plants in the rural sector. Punjab Government has also transferred *Panchayat* land to Petroleum Ministry for investing Rs. 600 crores for setting up Bio Refinery in Bathinda with feed stock of paddy and other crop residues.

Biogas Plant

First Generation Technologies: Khadi and Village Industries Commission is promoting bio gas production from animal dung for many decades but could not scale up to the competitive marketing. Similarly, coal production from biomass has been banned now under the Pollution Control Act. Bio-diesel plantations of *Jatropha, Jojoba*, Olive oil and other oil bearing trees especially on waste lands could not end up into success stories. Ethanol production also led to competition for the so vital food and nutrition securities under declining per capita availability of land, water and other resources. Technologies of solar and window energy with tariff rates around Rs.2.44 per unit has made some of the first generation bio fuel and other technologies irrelevant. Still more efficient photo voltaic technologies are in the pipeline and electricity tariffs are going to fall further making some of other bio-fuel technologies non-competitive.

Green Revolution Technologies: Investments into technologies generation, inputs, extension, efficient marketing and mechanization have increased food production from 52 million tons in 1951-52 to 277.5 million tons in 2017-18 i.e. 5.3 times increase in 66 years. About 234 Mt of biomass of crops, sugarcanes, horticulture and others is surplus for producing bio-energy worth Rs one lakh crores. Now profitability of the farmers has declined due to technology fatigue, market distortions, over-exploitation of soil and ground water resources etc. and has led to indebtedness and distress in rural sector. It called upon diversification and utilizing bio mass raw material for doubling income of the farmers. High productivity and cropping intensity of mono rice-wheat system has created environmental problems of burning the crops residues. Various technologies have been evolved to manage residues of crops, industrial wastes, municipal and sewage wastes. Shredding and mulching of crop stubbles for quick seeding of next crop with Happy Seeders (Happy Seeder is one of the unique technique which is used for sowing wheat without any burning of rice residue) requires a higher investment and subsidy of Rs.1151 crores for Punjab, Haryana, UP and Delhi for heavy machinery has been provided in the current budget. However, the farmers are apprehensive of the high cost of cultivation and are not adopting it in spite of imposing fines by the state governments as per the directions of National Green Tribunals and other honorable courts. It will also release green house gases during decomposition process. Diversification into production and processing of perishable

commodities of milk, meat, vegetable, fruits etc. also requires management of their wastes. Accordingly, incentives for **"Waste to wealth"** have been announced in the 2018-19 Budget to augment income, employment, clean and green environment in the rural sector by harnessing second generation (2G) advanced technologies of bio-fuels.



Bio gas Digestor

Second Generation (2G) Bio Fuel Technologies: First generation technologies focused primarily on sugar, starch, plantations etc. and competed for limited land and other resources, environmental, food and nutritional security. 2G technologies aim at cost effective, import substitution and pollution free bio fuels production.

Crop residues as Fuel: Traditionally, a part of crop residue as cotton sticks etc. are used for cooking food. However, there are vast quantities of paddy and other straw but they have low calorific values. Most of them are loose bulky material, which require densification and bricketing for fueling the steam boilers for power generation. High alkalinity, silicon and low melting point of rice straw ash corrodes, klinkers, slags and fouls the boilers. Special grating and travelling type Franklin boilers are now available and are being used in Punjab for electricity generation. As compared to uncontrolled and incomplete burning by farmers in the field, there is a complete combustion in the boilers with relatively lesser air pollution potentials. It still releases green house gases except black smoke particles in the open burning. Moreover, tariff rates work out to be between Rs.7.5 to 8 /unit as compared to Rs.2.44 per unit in solar and wind power. It requires considerable subsidy for wheeling the electricity generated. This technology also does not produce any organic manure to maintain health of soil, its fertility, productivity and farmers profitability.

Bio-Refineries: Punjab state has already transferred *Panchayat* land in Bathinda to The Ministry of Petroleum for setting up Rs. 600 crores plant for producing ethanol from paddy and other biomasses. However, this process generates 37% less energy as compared to Bio CNG.

Anaerobic Digestion Technology: This resolves many limitations of thermal power generation. In fact, the first anaerobic digester for human excreta in the world was demonstrated in India in 1859 near Mumbai for lighting up a lepers colony set away from the city. However, anaerobic digestion of rice straw is more difficult as compared to excreta of animal and human beings. Rice straw is hollow, coated with a hard layer of lignin with relatively higher contents of carbon, celluloses and hemi-celluloses as compared to sugars, starches etc. used for ethanol production in the first generation technologies. The 2G technologies focus on Bio CNG generation ordered by the Supreme Court of India for public and other transport for improving air quality and pollution reduction. Patented and verified technology of anaerobic digestion of IITs, DBT, others and related policies are now available. After producing bio gas, the remaining residue (digestate) is a very good manure free from seeds of weeds and other harmful elements. One ton of paddy straw will give 250 cu.m. of bio gas or 115 kg of CNG worth about Rs.4600 @ Rs.40 per kg. Production of Bio CNG gas from 18 million tonnes of paddy straw alone being burnt amounts to sales of Rs.8300 cores and more than that of compost and liquid manure with a total business of Rs. 20,000 crores annually with almost zero pollution of air in Punjab state alone. It will also create primary and secondary level employment both for the skilled as well as unskilled persons. Indian Oil Corporation has already signed an MoU

in June 2017 for Rs.5000 crores with Punjab Govt. for setting up biogas and bio CNG gas plants. It will generate about 400 jobs around each plant. Indian Oil Corporation has further signed up with companies to set up 400 plants over next 3-4 years, all over the rural areas of Punjab. It will bring in private investment of Rs.10,000 crores in the rural sector.

Advanced Technology: Bio-gas needs further purification by removing carbon dioxide and Hydrogen sulphide for arriving at BIS standards compressed CNG for vehicular and other purposes. Advanced technologies are in the pipe line even to convert carbon dioxide to methane which has a relatively high calorific value and is better in quality in terms of environmental externalities as compared to imported fossil CNG. It will be cheaper than imported CNG by Rs.10-15 per kg and will survive even in competitive marketing.

Convergence, coordination, co-generation and co-placement: Rice straw with high carbon content is a difficult feed stock and mixing it with low carbon and relatively high nitrogen animal dung, food wastes, spoiled potatoes, activated sewage sludge, wastes of milk, meat, vegetables and fruit processing plants increases the overall productivity of both bio and methane gas. Mixing of rice straw and cattle dung in 80:20 ratio produces 70 per cent more as compared to rice straw alone. Some of the companies are purchasing fresh cow dung at Rs.500 per trolley at the bio-digester site, poultry dropping at Rs.40 per kg and spoiled potatoes at Rs.50 per quintal as feed stocks for bio CNG production. All stinking dung heaps in the villages need to be replaced with digesters. It requires coordination of various departments of agriculture, horticulture, animal husbandry, dairy, sewage treatment and rural development to optimize complementarities and suplementarities. It will lead to sustainably benign healthy India and generate employment, income, goods, services and pollution free environment.

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(The author is Ex-CEO, National Rainfed Area Authority.
Email: jssamra2001@yahoo.com)

Mahila Kisan Shashaktikaran Pariyojana and Value Chain Initiatives

In order to promote agro-ecological practices that increase women farmers' income and reduce their input costs and risks, the Deendayal Antodaya Yojana – National Rural Livelihoods Mission (DAY-NRLM) has been implementing Mahila Kisan Shashaktikaran Pariyojana (MKSP). As of March 2018, more than 33 lakh women farmers were being supported under this scheme. Further, about 8 lakh Mahila Kisans have been mobilized into 86,000 Producer Groups (PGs) which are federated into 126 Producer Companies (PCs). These value chain development initiatives have contributed significantly to the farmers' income from agriculture, horticulture, dairying, fisheries and Non-Timber Forest Produce (NTFP) related activities. Small and marginal farmers producing Maize, Mango, Floriculture, Dairy, Goatery etc., have benefited significantly through the value chain interventions across different states. As on February 2018, more than 1.05 lakh SHG members have been covered under these interventions. In order to enhance agricultural productivity, the Mission promoted 4,150 Custom Hiring Centre/ Community Managed Tool Banks across multiple States. These hiring centers enable small and marginal famers to hire farm equipment and services such as soil testing, cold chain management etc., at nominal rates.

GOBAR-DHAN: RE-EMPHASIZING INDIA'S TRADITIONAL PRACTICES

Dr. Kaushik Chandrasekhar and Dr. Suneel Pandey

Considering the increased rural electrification increasing deployment of solar power and discounted power prices for farmers, there is definitely an underlying call for an incentive to promote Gobar gas. The government must streamline and fast track implementation and disbursement of eligible subsidy either under National Biogas and Manure Management Programme or GOBAR-DHAN yojana to ensure sustainable replicability. Technical support and capacity building to address aging or ailing plants are the other key factors aiding growth of biogas based models in the country. With appropriate measures to address issues, the sector could be given the much needed thrust. With a rejuvenated intension, GOBAR-DHAN could be that one substantial step in that direction.

With government's increased impetus on tapping energy from waste, traditional methods of resource management are beginning to resurface albeit with better visibility. The Galvanizing Organic Bio Agro Resources Dhan (GOBAR-DHAN) scheme was announced by the Finance Minister Arun Jaitley during the budget speech on February 1, 2018. The scheme according to the Finance Minister would contribute towards management and conversion of cattle dung and solid waste in farms to compost ,fertilizer, bio-gas and bio-CNG.

India today boasts of a cattle population of over 300 million according to the 19th Livestock Census in 2012. The huge population depicts an enormous potential for biogas, considering a dung production of roughly 10kg per capita and that 25kg of dung produces 1 m^3 of biogas as a rule of thumb. Biogas could be used for sundry purposes which include cooking, lighting and electricity generation to name a few. Most commonly, 1.5-2.4 m^3 of gas would be required by a family of five for 2 meals in day. The use of biogas could also help further to reduce our dependence on other fuels also assuming a tag of environmental friendly clean fuel owing to its minimal emissions.

What is GOBAR DHAN?

In his monthly address to the nation "Mann Ki Baat", Prime Minister expressed that the GOBAR- DHAN scheme would be aimed at ensuring cleanliness in villages and generating wealth and energy by converting cattle dung and solid agricultural waste into Compost and Bio Gas. He further expressed that the sale of compost and biogas would augment the income of the farmers whilst improving levels of sanitation in villages and increasing farm yields. The yojana would pilot under the Swachh Bharat Mission- Gramin.

Evolution of Biogas Technology in India:

The footprint of the technology was established as early as 1942 when the first biogas plant was designed at India Agricultural Research Institute by N.V Joshi. However, the early plants were expensive, were prone to explosions and lacked output efficiency to be commercially viable. The following years saw the development of floating dome model by Jashbai Patel and its promotion by Khadi and Village Industry Commission in the name of KVIC model. Research on various technologies of anaerobic digestion continued with the development of the Janata Model (fixed dome plant) by the Planning Research and Action Division (PRAD) based in Uttar Pradesh. The Janata model was known to be 30% cheaper

Name of Fuel	Kerosene	Fire wood	Cow Dung cakes	Charcoal	Soft Coke	Butane	Furnace Oil	Coal Gas	Electricity
Equivalence of 1m3 biogas	0.620 Kg	3.474 Kg	12.29 Kg	1.458 Kg	1.605 Kg	0.433 Kg	0.4171 Kg	1.177 m3	4.698 KWh

than the KVIC model with added advantages such as no moving parts which made the possibility of local maintenance easier. However, the accumulation and cleaning of sludge was still a cause of concern. Towards the end of 1975-81, the biogas programme was inducted into the twenty point programme designed by Government of India. This was followed by the launch of a development programme called National Programme for Biogas development (NPBD) by Ministry of Agriculture, Government of India. NPBD was then taken over by Department of Non-Conventional Energy Sources (DNES) created under Ministry of Power. In 1984, a new design called Deenbandhu biogas plant was introduced. Although the model was a developed version of the Janata model, it was considered to reduce installation costs further. This popular design was soon a breakthrough in India and saw the implementation of multiple plants around the country. This however, led to a newer phase of non-operational or malfunctioning plants requiring further dispersed attention. The implementation of NPBD was characterized by reforms which encouraged autonomous bodies and entrepreneurs to take part in the implementation. By 1996, there were seven biogas plant designs available in the market which included Janata, Deenbandhu and Flexi design. However, problems relating to implementation remained ranging from improper sizing of plants, technical failures, lack of regular dung availability, to lack of technical expertise for process maintenance. Subsidies and free electricity to farmers could have contributed as disincentives to adoption unless subsidy for biogas was available. One other factor was the inertia behind changing traditional practices of burning wood or crop residue and adopting waste based cooking for preparing staple food such as Roti's could also have acted as dampeners for adaptation.

The Way Forward:

While clearly biogas could easily be a solution to wet waste management and a substitute in the form of a cleaner fuel, it's imperative that we learn and evolve from constraints faced historically. Implementation of a self-sustainable business model is key. We may take cue from success stories such as the Gobar Bank model in Surat or metered cooking gas initiative by Cooperative Service Society in Punjab. Efficient Supply chain management of cattle dung to plants is required to avoid low feeding of plants leading to disruption in output. With advances in technology, raw material aggregation may be one very important aspect to be addressed. Considering the increased rural electrification increasing deployment of solar power and discounted power prices for farmers, there is definitely an underlying call for an incentive to promote Gobar gas. The government must streamline and fast track implementation and disbursement of eligible subsidy either under National Biogas and Manure Management Programme or GOBAR-DHAN yojana to ensure sustainable replicability. Technical support and capacity building to address aging or ailing plants are the other key factors aiding growth of biogas based models in the country. With appropriate measures to address issues, the sector could be given the much needed thrust. With a rejuvenated intension, GOBAR-DHAN could be that one substantial step in that direction.

Footnote

1 http://web.iitd.ac.in/~vkvijay/Biogas_%20A%20fit%20Option%20for%20Rural%20Energy.pdf

(Suneel Pandey is Director, Environment and Waste Management Division, The Energy and Resources Institute (TERI), New Delhi. Kaushik Chandrasekhar is Associate Fellow at TERI, Bengaluru.
Email: spandey@teri.res.in)

COMBATING DROUGHT THROUGH FARM POND TECHNOLOGY

Dr. A.V. Ramanjaneyulu, K. Indudhar Reddy, M. Venkata Ramana, and V. Ramulu

Farm ponds are considered as one of the best mechanisms to mitigate drought in rainfed rural areas. Government is also encouraging this viable technology and supporting the farmers through subsidies. But the main hindrance for implementation is loss of 5-10% of farm land. Hence, farmers in rural areas should be motivated to adopt this technology by conducting farmers awareness programmes, field days and training programmes, for enhancing the dryland productivity and improve the economic status.

Crop production in rainfed areas depends primarily on rainfall. On one hand, failure of monsoon leads to drought which in turn, causes decline in Agricultural production and productivity. On the other hand, floods and water logging following heavy or incessant rainfall causes destruction of crops, life and property. Further, late onset of monsoon, prolonged dry spells of more than 10 days during July and August and terminal dry spell during September are not uncommon in rainfed areas. Hence, productivity in rainfed ecosystem in India is not exceeding 1.0 t per ha as compared to 2.5 t per ha under irrigated ecosystem. Rainwater harvesting through several location specific methods is an old age practice and in vogue across many parts of the world. However, farm ponds are widely accepted water harvesting structures as they occupy less area thus less evaporation besides better benefits to local people or individual farmers and ease of management by individuals.

Farm ponds:

Farm pond is a dug out structure with definite shape and size having proper inlet and outlet structures for collecting surface runoff flowing from catchment area. It is a ex-situ method of water conservation. It is also called as on farm reservoir. They are constructed to collect excess water after the rainwater is conserved through different in-situ measures. Construction of farm ponds need large catchment area with a minimum slope of >1-2%. It should be free from septic tanks/house drains and should have a safe spill way preferably a vegetative one.

Small farm ponds of size 100-300 m^3 can be dug for storing runoff water. Farm ponds having a capacity of 250-300 m^3 for each hectare of catchment area is ideal to collect the run-off. For a four-hectare farm, the size of farm pond may be 20mx20mx3m in clay soils. However, the size of the farm pond depends on rainfall events, slope of

the soil and catchment area. The side slope of 1.5:1 is considered sufficient. But, it varies with soil type. For eg. 1-2:1 in clay soils; 1.5-2:1 clay loam soils, 2.0-2.5:1 in sandy loam soils and 3:1 in sandy soils. A depth of 2.5-3.5 m for farm pond is considered as ideal. Though farm ponds can be constructed in different shapes, trapezium and square shapes are the best due to ease of operation and maintenance besides cost effectiveness.

Alfisols have a high runoff generating potential than vertisols with deep cracks at the commencement of the monsoons. On alfisols even with contour bunds, there is at least 20 to 30 per cent runoff. Simple treatment of the land such as shaping, removing obstructions etc. enhance the harvesting efficiency of runoff water. There are two situations where farm ponds are generally filled viz., high intensity rainfall (>2 inches/hr) and cyclonic rainfall.

Seepage and evaporation are the main two problems associated with farm ponds. In unlined farm ponds in Alfisols, water loss through seepage is substantial, while, it is very less in Vertisols. The loss of water from unlined pond can be reduced by lining walls.

The different types of lining materials are used depending on the availability, cost and soil type viz., soil-cement, red and black soils, cement-concrete, bricks, kadapa slabs, stone pitching, polythene sheet etc., HDPE geomembranes sheets with 500 µ thickness and Silpauline sheet with GSM 300-350 are best and long lasting. Evaporation losses can be reduced in farm ponds especially in arid regions by rubber or plastic floats. Spraying neem oil (5 ml per litre) or kaolin (50 g per litre) powder reduces the evaporation considerably from the farm pond.

Benefits of Farm Ponds:

- Farm pond can provide water for a part or full of the year depending on its size. It can also control loss of soil and nutrients from the farmers fields.
- If the farm pond is filled in summer and there is a late onset of monsoon in June, harvested water can be utilized for sowing and establishment of rainfed crops like cotton, maize and Jowar etc., which need to be planted in June itself (Ramanjaneyulu and Venkata Ramana, 2017).
- If the farm pond is filled before or during monsoon season, this water can be used for life saving/supplemental irrigation to rainfed crops to break the early/mid/terminal dryspell. In the Indian rainfed agriculture context, supplemental irrigation holds promise. Provision of irrigation at critical stages during cropping season has the potential to improve the yield by 29-114 per cent for different crops. The AICRRPDA has shown that one cm of irrigation in rainfed areas at critical stages leads to about 200 kg additional yield in cereals and 100 kg additional yields in pulses and oilseeds (Venkateswarlu, 2010). Scientific studies have reported that, India has about 114 billion cubic meters of harvestable surplus rainfall water, which can be collected from more promising rainfed areas of about 28.5 Mha, can be partly utilized as harvestable water for crop husbandry. In this way, crop production can be enhanced by 28-36 million tonnes from an area of 20-25 Mha during drought and normal monsoon periods, which accounts for 12 per cent increase over the present production from dry land areas. As both irrigation and fertilizer application are inclusive, top dressing of fertilizers depending on the stage of the crop has to be done for efficient utilization of nutrients thus high productivity and profitability.
- If it is filled at the end of monsoon season and there is no terminal dry spell for long duration crops, the water can be used for meeting part of water irrigation requirement of short duration field or vegetable crops in rabi season. The water can also be utilized for horticultural plantations. Thus, this technology provides regional water and food security by enhancing the crop productivity. Osman (2009) has reported that a farm pond of 900 m^3 capacity dug in vertisols of Garkampet village, Gudihatnoor mandal of Adilabad district in Telangana state, got filled during the first week of August 2008 and water was retained till February 2009 even after use. The farmers have grown tomato in 0.5 acres land with farm pond water. The farmer accrued net returns of Rs. 72,350 after meeting the cost of cultivation of tomato and recovery cost of farm pond. Thus, they got benefit:cost ratio of 5.53 based on cost of cultivation of tomato and

2.23 based on cost of cultivation of tomato + recovery cost of farm pond.

- Helps to increase cropping intensity. Atmaram Mishra (2009) reported that due to excess rainfall in the years 2001 and 2003 and deficit rainfall in the year 2003 at Sadeiberini village of Dhenkanal district of Orissa, the farmers were encouraged to grow second crop of rice with farm pond water which has resulted in increasing cropping intensity from 100% to 131%, 176% and 200% in the first and third year, respectively. Due to water availability in farm ponds in 2001 and 2003, Pisciculture was also followed which resulted in an additional income to the farmer.
- Cultivation of vegetables/indigo on bunds is possible for additional income.
- Provides water for spraying purpose in dry lands and drinking water for cattle.
- Improves groundwater recharge in case of unlined farm ponds.

Our experience at RARS, Palem

The Regional Agricultural Research Station (RARS) located at Palem, Nagarkurnool district under Professor Jayashankar Telangana State Agricultural University (PJTSAU), Hyderabad, Telangana state is the lead center for developing farming-situation-specific technologies in dryland agriculture with a view to enhance rainfed crop productivity. Cotton, maize, pigeonpea, maize and castor are the rainfed crops grown predominantly in the zone during kharif season. While, in rabi, groundnut in Alfisols and Bengalgram in vertisols are widely grown. The center receives a mean decadal annual rainfall of 791 mm of which 71% (565.2 mm) is received during June to September. The crop production in the zone faces problems like delayed onset of monsoon leading to delayed sowing, prolonged mid season breaks in rainfall leading to stunted growth and terminal dry spell leading to effect on flowering or grain filling. Sometimes, high intensity rainfall or incessant rainfall due to cyclone leading to runoff and erosion.

We have constructed a farm pond of 1250 m^3 size lined with 500 µ HDPE sheet. This was filled to an extent of 80-100% of its' capacity in 2011 and 2012 before kharif season, 50% at the starting as well as 100% after kharif season in 2013, 50% at the starting and 50% after kharif season in 2014, 40% only after kharif season in 2015 and 100% at the end of kharif season in 2016. It will be more beneficial for the farmer if the farm pond is filled before or during kharif season, so that harvested can be utilised for life saving or supplemental irrigation to the rainfed crops in the event of dry spell. If it is filled at the end or after kharif season, the harvested water can be utilized for meeting a part or full requirement of winter field crops or short duration vegetable crops. If water is present in farm pond for more than 6 months, pisciculture can be taken for additional income.

Life saving Irrigation to Rainfed crops:

Sometimes, farm ponds are filled to an extent of 40-50% their capacity due to limited run-off. So, it allows only life saving/supplemental irrigation to mitigate dry spells especially during critical stages of most rainfed crops. Hence, different methods viz., check basin, sprinkler and drip irrigation were tried in various crops. Adoption of microirrigation methods for scheduling life saving at critical stages to rainfed crops helped efficient utilization of limited but precious farm pond water, thus, increase irrigated area and water use efficiency besides yield and economic advantage over other methods (Ramanjaneyulu et al., 2012). Life saving irrigation through drip @ 40 mm gave 39% higher kapas yield over sprinkler/check basin irrigation and 81% over rainfed crop. Likewise, in castor, life saving irrigation through drip system @ 30 mm at primary spike development and secondary spike formation stages resulted in 32% yield advantage over check basin and 43% over sprinkler and 61% over rainfed crop. Drip irrigation to maize @ 35 mm at knee high and silking stages gave 13-15% higher higher seed yield over that of sprinkler and check basin irrigations and 67% over rainfed crop. In millet crops like, Pearlmillet, Fox tail millet and Finger millet, one life saving irrigation resulted in 25-33% yield advantage over rainfed crops. Thus, farm ponds can help provide life saving irrigation with yield can be improved substantially in rainfed crops.

Rain Water Harvesting in High Rainfall Areas :

Some of the states/areas in India receive high rainfall in a short span of four months, these areas

also face water shortage during summer season. Thus, even in high rainfall regions too, agriculture is not sustainable in the absence of proper water storage structures. Adilabad district and north east part of the Telangana state receive 1000-1100 mm annual rainfall. The farmers of the region allocate 5% of farm holding to dig farm ponds for rainwater harvesting. Tribal farmers mostly depend on rainfall to grow rainfed rice and cotton during monsoon season. They provide life saving irrigation from harvested water at critical stages to the crops in case of dry spell. Otherwise, the harvested and stored rainwater will be used for growing vegetables in post monsoon season (Venkateswarlu, 2010). Likewise, run-off water from excess rainfall can be collected and stored in farm ponds in North eastern states and Kerala/Goa for its utilization to grow paddy and plantation crops, respectively

Government Support:

The following government institutions/ agencies are extending support for the construction and renovation of farm ponds and other water storage structures

- National Horticultural Board (NHB) through Horticultural Department
- Mahatma Gandhi National Rural Employment Guarantee Programme (MGNREGA)
- National Bank for Agricultural and Rural Development (NABARD-WDF)
- Hill Area Development Project (HADP)
- Tribal Area Development Project (TADP)
- MGNREGA, Backward Regions Grant Fund (BRGF), Member of Parliament
- Local Area Development (MPLAD) and Integrated Watershed Management Programme (IWMP) provide ample opportunities for periodic desilting and renovation of village ponds, tanks and other storage structures

Conclusion:

Farm ponds are considered as a one of the best mechanisms to mitigate drought in rainfed rural areas. Government is also encouraging this viable technology and supporting the farmers through subsidies. But the main hindrance for implementation is loss of 5-10% of farm land. Hence, farmers in rural areas should be motivated to adopt this technology by conducting farmers awareness programmes, field days and training programmes, for enhancing the dryland productivity and improve the economic status.

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(A.V. Ramanjaneyulu is Sr. Scientist (Agro); K. Indudhar Reddy is Scientist (Agro); M. Venkata Raman is Associate Director of Research, Regional Agricultural Research Station Palem; V. Ramulu is Principal Scientist (Agro), Water Technology Center, JTSA University, Rajendranagar, Hyderabad. Email: avr_agron@rediffmail.com)