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Role of information and communication technologies for improving input efficiency of horticultural crop production

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Abstract

Indian farming community is passing through a phase of reducing incomes, uncertain and unpredictable markets and weather conditions. They need advance information and intelligence on agricultural commodities and their supply/demand position in the local as well as global markets. They also need advises on the impending climate/weather parameters so as to regulate their choice of crops and farm management and operations. They have to be enabled to face the global competition. For that Information and communication Technologies (ICT) are very use full.

The use of ICT in agriculture in general and rural livelihood security in particular remains restricted in India. Effective utilization of ICT has the potential to make the rural communities in India prosperous. Failure to exploit the benefits of ICT would make them isolated, victims of the vicious cycle of poverty and widen the gap between rich and poor people, thereby affecting social equality and livelihood security. The use of ICT should not be restricted to simply establishing information flow channels, rather we should find a way to integrate it with the various livelihood needs (natural, social, human, physical and financial) of the rural community. The narrow ICT coverage is found to be financially non-viable. Further, no single agency can effectively deliver this critical input. Besides the public sector, the need for a proactive participation by the private sector, NGOs and other civil society organisations is being increasingly felt. For ICT initiatives to be successful and sustainable in the long run, collaborative efforts are indispensable. This digital development in rural areas of India facilitates rural prosperity, rural empowerment, and a warehousing of data for development, increasing input efficiency and productivity, reducing cost of service delivery etc. a step towards digital inclusions to foster rural enterprise in India.

Kew words : *ICT, horticulture, GPS, GIS and precision farming*

Introduction

With the grand success of green revolution in India, agriculture has evolved from subsistence farming into a complex and profit oriented business,which requires accumulation and integration of knowledge and information from diverse sources. An increasing population coupled with mining of natural resources requires application of new technologies to maintain a sustainable food and water supply without environmental degradation. Horticultural crop production is input intensive enterprise. Presently the costs of the planting material/seeds, nutrients, pesticides, water, power and labor are increasing enormously, where as increase in crop productivity is at low pace. Farmers are more concerned about the choice of crops that are appropriate for the changing environmental conditions and more conscious about location-specific crop management so that the input costs are minimal and less risk prone.

It is essential to optimize the various inputs under different edapho-climatic and cropping system. Information and communication technologies (ICT) particularly the Internet, are transforming all human activities dependent on information, including rural development and food security. ICTs play a crucial role in improving the efficiency of inputs as water, nutrient and pesticide use, Ananda Sagar and Vijayanand (2003). Modern tools such as Remote sensing and Geographic Information System (GIS) are helpful to estimate area and production under horticulture and other related crops. Other models such as decision support system, Bio-Informatics, Precision Agriculture, Rural net working etc can be achieved by aligning Information Technology with agriculture. Combining the satellite technology with the tools of ICT farmers in a remote village can demand and get the following information's:

- Land use planning for Horticulture crops for farmers

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fields based on integrated information on soil, water, weather, fertilizer and pest management models.

- How and where to get seeds or good quality nursery plants of horticultural crops
- Interactive exchange of information for planning and day-to day operations by farmers.
- E-procurement

In addition to this farmers can access the information on prevailing prices of farm equipments, agricultural produce, products and series of such set of information, which can lead to high productivity and optimum cost benefit to the farmers.

Information is crucial

The Horticultural sector is facing the challenges of sinking land resources, increasing biotic and abiotic stresses, indications of factor productivity decline, threatened loss of bio-diversity, natural resource shrinkage and degradation, climate change, new IPR regime, intensifying competition (costs and quality) in international trade, widening economic inequality etc., Adiguru and Mruthyunaja (2005). Further, Indian agriculture has come under significant adjustment pressure from market liberalization and globalization.

Recent evidence shows that farmers, including small landholders are gradually shifting their production portfolios in favour of high-value commodities, and are willing to take high risks. But they are confronted with a host of constraints like high transaction costs in acquiring resources, marketing of tiny marketable surplus and inadequate information (Joshi et al. 2003; Ballabh and Sharma, 1989, and Hiremath and Ballabh, 1996). Farmers need reliable and timely information about best practices of production, processing, marketing, input and output prices, financial markets and risk-covering institutions. It is comprehensible that on the one hand Horticulture is becoming highly science driven and knowledge intensive, but on the other hand the existing public extension system, has become outdated and ineffective in spite of the fact that it has been a catalyst in successfully heralding the Green Revolution in the country. This is partly due to an inadequate use of new means of information dissemination and also due to inadequate natural resources, Adhiguru, Mruthyunjaya and Birthal (2003).The public extension system follows a top-down approach and has become less interactive, more time-consuming and costly and fails to meet the expectations of those involved in the agricultural production and other involved in the value chain. Therefore, a new extension system re-oriented to meet the information needs of the farmers should be put in place across the country by using ICT, Adhiguru and Mruthyunjaya (2004).

Some of the main areas where the information technology can work in collaboration with horticulture to increase input efficiency are discussed.

Expert System in Agriculture

An "Expert system" is an intelligent computer program that uses knowledge and inference procedures to solve problems that are difficult enough to require significant human expertise for their solution. These software programs typically suited to the category of decision support tools (Malobika Ghatak, 2002). Decision support programs imitate an expert by involving a client in a problem-solving situation, often providing a recommendation in response to a client's request for help in making a decision. Expert systems help farmers run their business more economically.

Remote sensing

Remote sensing has shown potential for use in horticultural crop management. New companies that provide aircraft-based imagery to meet the resolution and temporal requirements for agricultural management are now emerging in a big way. The promise of commercially available, high-resolution satellite imagery will also provide additional sources of remotely sensed data. Remote sensing imagery can be obtained either through satellite-based sensors. Remote systems vary in spatial resolution, spectral coverage and temporal frequency. The selection of remote systems is dependent on agricultural applications, which are different for different applications. Remote sensing is required to provide with characteristics of low turn around time, low data cost, high spatial temporal and spectral resolutions and delivery of analytical products in simpler formation.

Bioinformatics

Informatics is a very essential component in the biotechnology revolution. Bioinformatics has emerged out of the inputs from several different areas such as biology, biochemistry, biophysics, molecular biology, biostatistics, and computer science. Specially designed algorithms and organized databases is the core of all informatics operations. The requirements for such an activity make heavy and high level demands on both the hardware and software capabilities.

Precision Farming in Horticulture

India has a variety of climates and soils on which nearly 48 fruits and plantation crops, 50 vegetable crops including potato and tuber crops:20 spices ,10 ornamental,70 medicinal and aromatic plants are being grown commercially.

Diversification to horticulture is best option. These crops are adapted to wide range of climates produce higher biomass than field crops per unit area. They have potential for improvement of wasteland through planned strategies. Horticultural crops contribute 28.65% to GDP from merely 8.5% of area and have a high potential for value addition and foreign exchange earnings (Chadha, 2005).

Time bound removal of quantitative curbs on import and other barriers to access to domestic markets under WTO of which India is a signatory, will require Indian horticultural product to be competitive both in domestic and export market. For that Hi-tech and precision Farming technologies are required. Hi-Tech Horticulture as defined are those, which are modern, less-environment dependent, capital intensive and have the capacity to improve the productivity and quality through the use of genetically modified crop varieties, micropropogation, integrated nutrient and water management, integrated pest management, organic farming and hi-tech post-harvest technologies including cold chain

Precision Farming (PF) is one of the most scientific and modern approaches to sustainable Horticulture which has gained popularity in the 21st Century. Precision Farming is defined as the application of the technologies and principles to manage spatial and temporal variability associated with all aspects of agriculture production. Precision Agriculture, which focuses on the positioning of agricultural tools with high degree of accuracy and sophistication for maximizing returns.

It is a comprehensive approach to farm management designed to optimize agriculture production through the use of information technology to bring data from multiple sources to bear decision associated with agriculture production marketing, finance and personnel while taking care of the environment issues. Precision farming has also been termed as Precision Agriculture (PA), Variable Rate Technology (VRT), spatially variable farming (SVF), Global Positioning Systems(GPS) based agriculture, Site Specific Farming (SSF) etc.

Aspects of Precision Farming

In precision Farming the field is broken into "management Zones" also called "grids" based on Soil pH, nutritional status, pest infestation, yield rates and other factors that affect crop production. Management decisions are based on requirements of each zone and PF tools such as Geographical Information System(GIS),GPS etc., Which are used to control inputs.

In contrast, traditional farming methods have used a "whole field" approach where the filed is treated as homogeneous area. Decisions are based on field averages and inputs are applied uniformly across a field.In reality most of the fields are not uniform and there exit a within-field variation in soil characteristics, topography, drainage, microclimate etc, (Shylla; Handa and Sharma, 2004). As such sampling in the traditional system where representative samples of the entire field is used for testing and further recommendations for fertilizer applications are made based on these generalized data may not prove to be very effective, leading to yields below field capacity. But with grid sampling method under precision farming system, it is possible to identify the fertilizer /pesticide requirement of a particular grid and as such necessary applications as per requirements can be made thus reducing the amount of fertilizer/pesticide etc., which may have an impact on the environment leading to ecological degradation.

Precision Agriculture System

Precision farming is combination of several technologies. It involves integration of information technologies with agronomic knowledge hence this is called technology enabled information based and decision focused (Chadha, 2005).

The components to consider in the development of a Precision Agriculture system are discussed.

Computers and Network

Computer has been used in agriculture to organize and manage data more effectively. It helps in acquisition, management, analysis and output of large amounts of spatial and temporal variability information's. Advent of the networking of computers brings together the information provider and ultimate user.

Global positioning Systems (GPS)

The satellite positioning through Global Positioning System (GPS) is a burgeoning technology, which provides unequalled accuracy, and flexibility of positioning for navigation, surveying and GIS data capture. It has tremendous amount of application in GIS data collection, surveying and mapping. It uses satellite and computers to compute positions anywhere on earth. As a result, numerous observations and measurements can be taken at specific position and GIS can be used to create field maps based on GPS data to record and assesses the impact of farm management decisions.

The technology is a set of 24 satellites in high attitude orbit above the earth developed for pinpointing objects on the surface of the earth. The satellites continuously transmit radio signals that are picked up and deciphered by special receivers. A GPS receiver requires at least four satellites to determine its position on earth. However the GPS signal is not sufficiency accurate to determine position and is needed to provide the necessary accuracy, which can come from a land-based reference signal or another satellite. GPS are used in agriculture for yield mapping and variable rate applications. It has capability of providing location accuracy of less than 1m distance. GPS enables field operation in night hours also.

Sensors

Sensors are devices that transmit an impulse in response to physical stimulus such as heat, light, magnetism, motion, pressure and sound. They have been developed to measure and monitor soil properties, crop

stress, growth conditions, yields, influent ions factors that effecting yield, atmospheric properties, water etc in horticultural crops. These are also used to monitor Pest and disease dispersal along with crop growth indicators such as water stress using aerial or satellite photography in conjunction with crop scouting. They provide the precision farmer with instant information that can be used to adjust or control operational inputs. They can be used to measure soil and crop properties as the tractor passes over the field, as scout goes over the field on foot or as an airplane or satellite photographs the field from the sky.

Remote Sensing (RS)

Remote sensing is the science and art of acquiring information (spectral, spatial, temporal) about material objects, areas, or phenomena through the analysis of data acquired by a device from measurements made at a distance without coming into contact with the objects area, or phenomena under investigation. Initially the data are collected by manually sampling the field along regular grid and by interpolating the analyzed results using geo-statistical techniques, but this is time consuming and expensive. The solution to this lies in the use of remote sensing technology to obtain spatial and temporal variable information almost instantly.

Geographic Information System (GIS)

Geographic Information System (GIS) is defined as an information system that is used to input, store, retrieve, manipulate, analyze and output geographically referenced data or geospatial data, in order to support decision making for planning and management of land use, natural resources, environment, transportation, urban facilities, and other administrative records in horticultural crops.

The key components of GIS are a computer system, geospatial data and users, A computer system for GIS consists of hardware, software and procedures designed to support the data capture, processing, analysis, modeling and display of geospatial data. The sources of geospatial data are digitized maps, aerial photographs, satellite images, statistical tables and other related documents.

GIS for Decision Support

GIS can be a very important tool in decision making for sustainable development in horticulture, because GIS can provide decision makers with useful information by means of analysis and assessment of spatial database. Decision support combine traditional management skills with PF tools to help precision farmers make the best management choices for their crop production system. GIS are used in precision farming as database functions for farm record keeping and for comparing management decisions for yield estimate, pest activity, water quality and other concerns related to past and current agricultural practices. GIS can be used for linking and integrating data of soil, crop etc. with simulation or spatially distributed process models as the basis for subsequent decisions.

Steps in Precision Farming

Management of Variability

The basic steps in precision farming are assessing and managing variation and then evaluation. The available technologies enable in understanding the variability and site specific agronomic recommendations can manage the variability that make precision farming viable (Nawab Ali and Chadha, 2005). And finally evaluation must be integral part of precision farming system. Assessing variability is the critical step in precision farming.

Geo-referencing

The relationship among data based on their geographic locations is referred as georeferencing. Georeferencing gives farmers the option to map and visually display farm operations in horticulture. This gives insights into both production variability as well as inefficiencies in crop production and farm operations.

Crop, Soil and Climate Monitoring

These variables are measured using sensors. The output given by sensors is being utilized for crop production. Such sensors include Yield sensors, biomass and crop response sensors, and radio-networked weather stations.

Attribute Mapping

The data generated by crop, soil and climate sensors are often large and intensive. It needs to be managed, cleaned and interpolated in a database to permit analysis. The precision farming technology involved in generation of data sets for the use and variable rate applications. That makes new challenges for mapping. The use of GIS made tremendous improvement in mapping and displaying of data.

Decision Support System (DSS)

Decision support system use agronomic and environmental data combined with information in possible management techniques, to determine optimum management strategy for production. Some of the DSS have been developed such as WHEATMAN,COTTONLOGIC or APSIM to site-specific situations. There is need to develop a DSS that is able to site-specifically model plant environment interaction in terms of yield quality of crop by incorporating sensor gathered data.

Application Areas of Precision Farming

Precision farming is useful in Rice, wheat sugar beet, onion, potato and cotton among field crops and apple, grape, tea, coffee and oil palm among horticultural crops.

Nutrient Management

Precision farming can help Indian farmers in Nutrient management. Most cultivated soils in India are acidic and spatial variation in pH is high. Detecting nutrient stress using remote sensing and combining data in GIS can help in site-specific application of fertilizers and soil amendments such as lime, manure, compost, gypsum and sulphur (Singh, 2005). This in turn would increase fertilizer-use efficiency and reduce nutrient losses. In semi-arid and arid tropics, precision technologies can help growers in scheduling irrigation more profitably by varying the timing, amounts and placement of water.

Pest and Disease Management

Pest and diseases cause huge losses to Indian crops. Remote Sensing can help in detecting small problem areas caused by pathogens, timing of applications of fungicides. Recent studies in Japan show that pre-visual crop stress or incipient crop damage can be detected using radio-controlled aircraft and near infrared narrow-band sensors. Likewise air-borne video data and GIS have been shown to effectively detect and map black fly infestations in citrus orchards, making it possible to achieve in pest control.

Strategy and Action plan for Precision Farming

India is only beginning now to embark up to this potentially powerful technology. We need to move forward holistically in terms of capacity building human resource development and R & D programmes with participation of all relevant disciplines before approaching the farmers for adoption of this technology. The pilot demonstration projects need to be implemented at various growers' locations by involving farmers at all stages of the project (Wiebold; Sudduth; Davis; Shannon and Kitchen, 1998). The pilot projects must attempt to answer the growers needs and emphasize the operational implementation of technology and complete analysis of costs and savings involved. Documentation of pilot projects would help in examining the operational weaknesses and identification of remedial measures. The projects can be used to train innovative farmers and early adopters.

The action plan for implementing precision farming in Indian agriculture could be in phases. The short-term plan may be the development of sensors and processes for precision farming related parameters for fixed and variable rate precision applicators for seeds, fertilizers, water and chemicals. The medium-term plan may include development of databases, expert systems and decision support systems for their use in precision farming applications. The long-term plan, then could include application of precision farming technologies on minimum manageable zone made for selected cropping systems, involving GIS,GPS and RS systems.

Suggested strategies for effective utilisation of ICT

Multi-pronged strategy in deploying ICT is required if it is to make a real dent in the upliftment of the poor. Some points are enumerated below.

1.Content development: Generic and indigenous knowledge, success stories in local language to meet local needs. 2.Unified dissemination: Research and development institutes to develop synergy in content development and delivery (e.g. interlinking of websites). 3.Capacity development programmes: Regional/intermediary institutions may identify emerging training needs and impart training for various stakeholders. 4.Every village a knowledge centre: Improve connectivity by using wireless. low-cost technologies, low-power alternatives. 5. Enable intermediary organisations: Better e-linkage among rural institutions, extension agents, local NGOs, and producer associations to improve their delivery efficiency. 6.Emphasis on gender equity: Providing women-oriented content, easy access, capacity building, and involvement in indigenous knowledge acquisition and management. 7.Strengthen monitoring and feedback: Deploy ICT in community knowledge gathering and eliciting people's feedback for research/development projects and democratic governance. 8. Low-cost training institutes: Schools and panchayat offices can impart ICT trainings. Students can be effective 'no cost trainers'. 9.Location specific knowledge bank: Document the most common sets of questions, and create a library of responses, as well as provide a mechanism to identify key issues that smallholders-friendly agricultural research agenda should address.

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