Syllabus

1. **Introduction:** Basic terminology, Recent history of adoption of ICT in developing countries, leapfrogging technology – the mobile phone, ICT and its ramifications for rural economies, Introduction to various ICT enabled rural services related to land, education, health, insurance, micro-credit, marketing etc. Village Resource Centre (VRC), Common resource Centre (CRC), Tele- education, community radio etc. Potential impact

2. **ICT for production systems management :** Types of ICT information service, Short-term productivity information services , Crisis management information services , Long-term productivity information services , Risk management information services , Common ICT platforms for information services , Collection and analysis , Delivery , Issues and challenges for ICT information services , Advantages of and opportunities for ICT information services

3. **ICT for market access:** Types of market access ICT service, Pricing services , Virtual trading floors , Holistic trading services, Downstream (and upstream) administration , Issues and challenges for market access ICT services , Advantages of and opportunities for market access ICT services

4. **ICT for financial inclusion:** Types of financial inclusion, ICT services , Transfers and payments , Agricultural credit , Savings for agricultural needs , Insurance , Common ICT platforms for financial inclusion services , Issues and challenges for ICT financial inclusion services , Advantages of and opportunities for ICT financial inclusion services.

5. **Overview of Geographical Information Systems (GIS):** Remote Sensing and Image Processing, GPS, GIS Data Modeling, Geographical Information Systems, Issues and Concerns in Land and Water Management, The GIS Approach. Planning and Implementing a GIS; Case studies on GIS; GIS and Precision farming; GIS Applications in micro resource mapping, principles in micro planning, modeling in resource mapping GIS Technology trend and next generation Systems.

Unit 1: Introduction to ICT

Acronyms

ACDI/VOCA Agricultural Cooperative Development International Volunteers in Overseas Cooperative Assistance

AGRISNET Agriculture Resources Information System Network (India)

ATM automated telling machine

B2B business-to-business

B2P business-to-person

BCNM business correspondent network manager

CARE Cooperative for Assistance and Relief Everywhere

CEPES *Centro Peruano de Estudios Sociale* (Peru)

CGAP Consultative Group to Assist the Poor

EU European Union

FINO Financial Inclusion Network and Operations (India)

G2P government-to-person

GIS Geographic Information System(s)

GPRS General Packet Radio Service

ICRISAT International Crops Research Institute for the Semi-Arid Tropics

ICT information and communications technology

ICT4D information and communication technologies for development

ICTA Information and Communication Technology Agency (Sri Lanka)

IFMR Institute for Financial Management and Research (India)

IIIT International Institute of Information Technology (India)

IVR interactive voice response

KACE Kenya Agricultural Commodity Exchange

KCC Kisan Call Center (India)

MFI microfinance institution

MFS mobile financial service(s)

MIS management information system(s)

MNO mobile network operator

NAMA Northwest Agricultural Marketing Association (Cambodia)

NGO	non-governmental organization
OLPC	One Laptop Per Child
P2B	person-to-business
P2P	person-to-person
PDA	personal digital assistant
PIN	personal identification number
POS	point-of-sale
RANET	Radio and Internet for the Communication of Hydro-Meteorological Information (Zambia)
RFID	radio-frequency identification device
RITS	Relationship Information Tracking System
RML	Reuters Market Light
SMS	short message service
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
USSD	Unstructured Supplementary Service Data
VAS	value-added service(s)
VSAT	very small aperture terminal
VSLA	village savings and loan association
VTF	virtual trading floor

WHAT IS ICT

Definition of ICT is: *an umbrella term that includes any communication device or application, encompassing: radio, television, mobile phones, computers and network hardware and software, satellite systems and so on, as well as the various services and applications associated with them, such as video-conferencing and distance learning*. (Lewis, 2009)

ICT is simply an electronic means of capturing, processing, storing and disseminating information (Duncombe & Heeks)

There are mainly three components of ICT viz, computer technology, communication technology, and information management technology.

In many agriculturally based local economies, the low availability of timely and needed information is skewed in favor of more "networked" individuals or organizations which often force disadvantaged farmers to sell their harvests below fair value. The uneven spread of infrastructure – market, finance, administrative (e.g., government services) and physical (roads, etc.) – is equally problematic in developed and developing nations, leading to significant differences in the ability to leverage individual and regional strengths. Insufficient extension services and poor access to information widen the gap in the adoption of new technologies and can lead to lower long-term productivity.
Most farmers have access to a variety of information sources that they consult for regular agricultural information, even though these may not be the most up-to-date, accurate or beneficial sources. Many farmers do not have a single channel that serves as a comprehensive source for all their information needs. The most common sources are still TV, radio, newspapers, other farmers, government agricultural extension services, traders, input dealers, seed companies and relatives. However, the quality and relevance of the information provided by these sources can be highly variable. Some sources of information may even be biased against the farmer, such as the intermediary/trader who also serves as a moneylender. Most farmers in developing countries therefore lack access to consistent, reliable information for many of their needs and often rely on a combination of these varied but inconsistent sources, plus traditional knowledge, experience and estimates, when making decisions. Another constraint is that even when correct and timely market price information is available, farmers are often unable to exploit any potential pricing benefits that exist between markets because of their inability to transport their produce to the markets with higher prices.

Encouragingly, different information and communications technology (ICT) solutions have emerged – notably low-cost but well-connected mobile phones, which are increasingly available in even the remotest locations – to help overcome these information gaps and improve the business of agriculture proactively. This document outlines many of these solutions to help practitioners consider and devise potential ICT solutions of their own (or improve existing ones) so they in turn can help the value chain players they work with to grow and prosper.

Basic terminology and document structure

- ICT encompasses the use of existing technology: hardware, software and telecommunication options, including the Internet and telephony (mobile and landline) systems.
- ICT solutions for agribusinesses and value chains typically fall under a relatively new topic called information and communication technologies for development (ICT4D), which can also entail other types of development interventions in health and education, for example. This document covers primarily a subset of ICT4D, usually called ICT for agriculture.
- The ICT examples are divided into three main categories based on experience, observations and research. These categories are used to help present the concepts and are not an attempt to create new taxonomies or terminology. Each of the three categories has subtopics that the different examples fall under. Some examples may seem to be misplaced, and there may seem to be missing categories, as there is significant overlap of solutions (ICT solution providers often offer myriad different services that cut across categories):

✓ ***Category 1: ICT for production systems management*** comprises information that is linked to helping farmers improve their productivity, yields and profitability (and minimize their risks) during the course of their normal business of growing agricultural produce. This chapter covers ICT applications for production systems that involve short- and long-term productivity enhancement, minimize the negative effects of crisis events, and improve field-based risk management (Chapter 2).

✓ ***Category 2: ICT for market access services*** comprises any service that facilitates beneficiaries' (especially farmers') access to information on pricing of agricultural products (inputs and outputs), and connections to and knowledge of suppliers, buyers or logistics providers, such as storage facilities and transport companies. These services also include ICT solutions that help the typically larger upstream and downstream firms, such as processors or exporters, to manage their operations and the quality of the produce better (Chapter 3).

✓ ***Category 3: ICT for financial inclusion*** entails ICT solutions that allow formal and semiformal financial institutions and direct value chain players (e.g., those using trade credits) to provide financial services in a more convenient, secure, flexible and low-cost manner (Chapter 4).

Recent history of adoption of ICT in developing countries

The information economy represents not only a current digital divide, but also a digital opportunity for the developing world. Very few communities in the developing world understand the full potential that ICT can offer in the short and medium terms, providing people with opportunities in the information economy, regardless of their class, gender or location. Difference in the pace of ICT adoption is based mainly on:

a) Availability of infrastructure, and hence access to the service;
b) Assessment of value of the service, and hence keenness to adopt it;
c) Disposable income levels and pricing of the service.

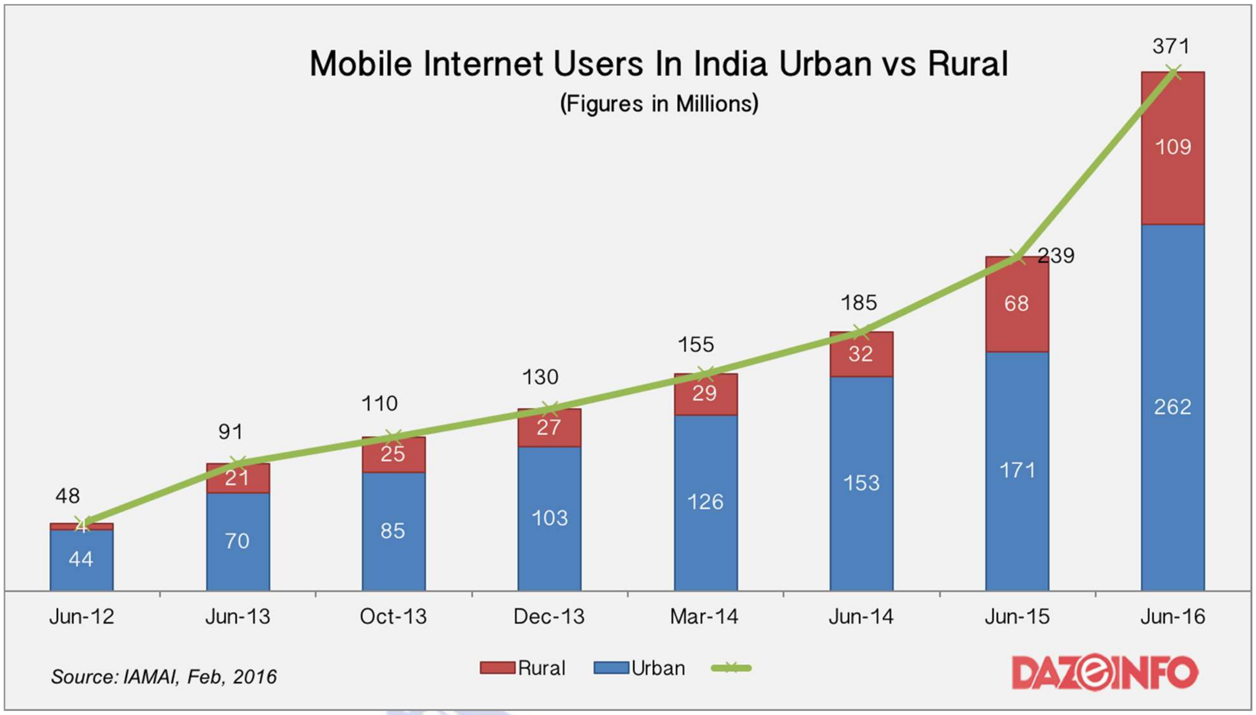
Leapfrogging technology – the mobile phone

Since the late 1990s, the use of Internet, mobile communications and computing power has grown exponentially throughout the world. For example, developing countries and their citizens have been able to skip the step of having landline phones and move straight to mobile phones.

The same is predicted to happen for the Internet in the near future, with the developing world likely to skip the stage of accessing the Web through typical desktop and laptop computing (using Internet service providers such as cable or phone lines) and move straight to access from their mobile phones. The terms "cell phone" and "mobile phone" are used interchangeably throughout this report. The rate of mobile phone adoption has been significant in all parts of the world, especially the developing world, and is making access to information much easier. This is by virtue of the rapidly declining cost of both airtime and handsets, combined with the rapid increase in services made available on handsets and the rapid build-up of mobile phone networks by mobile network operators (MNOs).

The rise of mobile phones is only one of the ICT solutions with significant potential to serve developing markets, especially rural ones. For example, recently, many Internet-provided services have begun to shift away from written language towards the use of audio and video services, lessening the need for consumers to be able to read and write. These services are available from both government agencies and private players.

Depending on the quality and frequency of information available, the services are often paid for by farmers/traders who need information that is not locally available. Box 1 provides another innovative example based on the creation of tablet/laptop computers at prices that are much more affordable in the developing world (US$100 or less). Poverty and inadequate education have not proved to be significant barriers to acceptance of new technologies or services, such as the mobile phone or even, for example, rural Indians' ingenious way of using automated telling machines (ATMs) as an unintended safe remittance system (Pandey and Shukla, 2009). The perceived value of the service is paramount to the adoption rate of a technology/service. Irrespective of education level, people in all countries have adopted technologies that provide a visible direct link to better incomes and better access to important markets, services or opportunities.

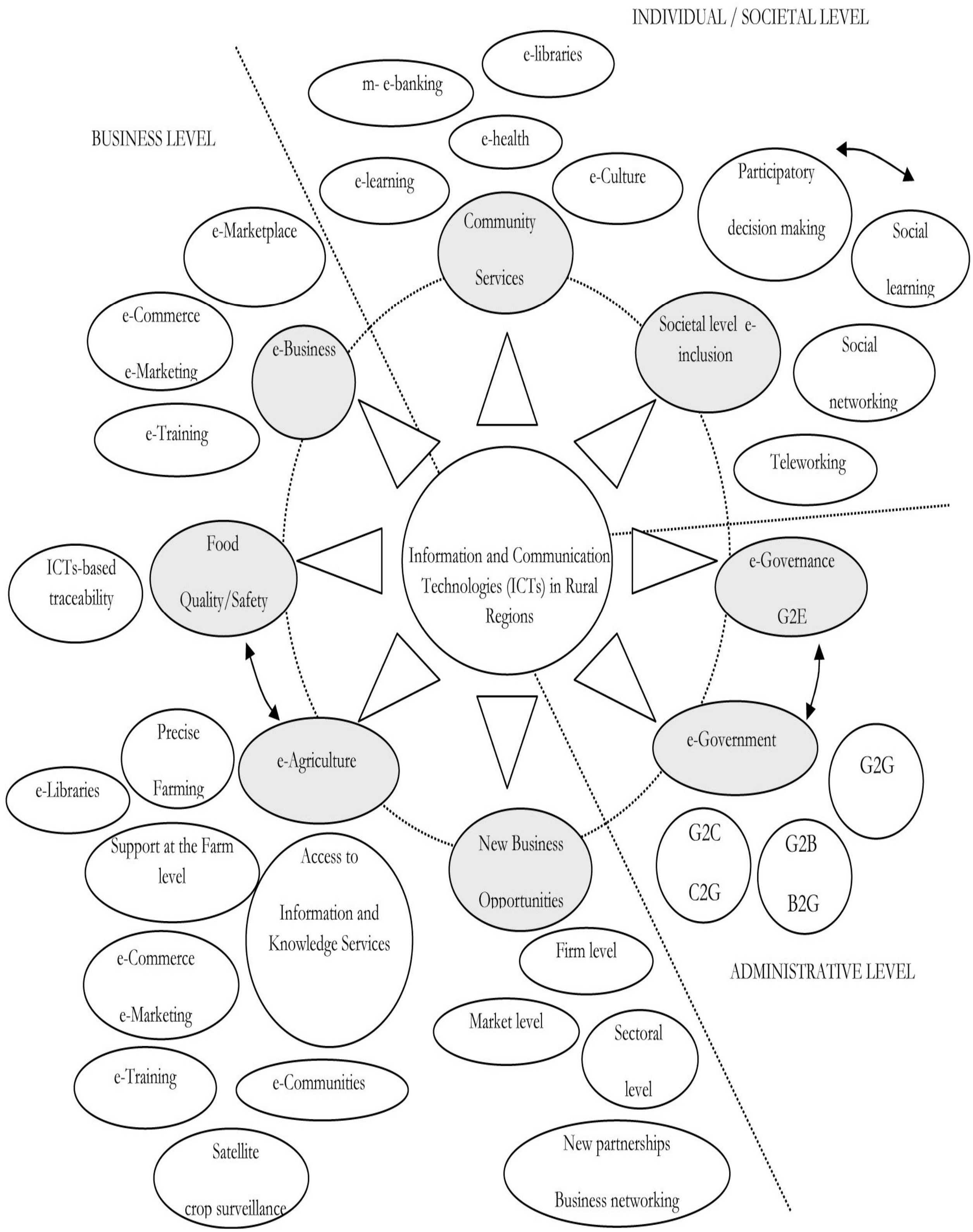


ICT and its ramifications for rural economies

From making a simple call to a contact for information, to gaining access to new markets and buyers, or obtaining expert advice from distant experts, ICT – particularly the mobile phone – has made obtaining the right information on demand achievable for many people, despite their remoteness.

The impact on productivity can be measured in terms of increased returns to farmers, through changes in cropping patterns, yield increases and better prices for inputs and output. Non-price factors, such as information on the availability of inputs, seed quality and the adoption of modern techniques, are also critical to raising productivity.

Prior to the 1990s, ICT in agriculture entailed mainly the use of radio and TV, especially radio in Africa and some parts of Asia, to pass on information to farmers in a static and standard format. Now, however, many countries, including India, Indonesia, Thailand and Viet Nam, have simple short message services (SMS) through cellular telephones for market prices of agricultural commodities. These cater to a range of clients from farmers to market intermediaries. Applications for sharing even more types of timely and relevant information in ways that are tailored to individual needs are only a few steps away, and many new solutions are already being tested – as described in this report. For example, the linkage of radio and TV stations to cellular telephony technology has not yet been fully exploited, and there are many more potential solutions.


INDIVIDUAL / SOCIETAL LEVEL
BUSINESS LEVEL
e-libraries
m- e-banking
e-health
e-learning
e-Culture
Participatory decision making
Social learning
e-Marketplace
Community Services
e-Commerce e-Marketing
e-Business
Societal level e-inclusion
Social networking
e-Training
Teleworking
Food Quality/Safety
ICTs-based traceability
Information and Communication Technologies (ICTs) in Rural Regions
e-Governance G2E
e-Government
G2G
Precise Farming
e-Agriculture
e-Libraries
Support at the Farm level
Access to Information and Knowledge Services
New Business Opportunities
G2C C2G
G2B B2G
e-Commerce e-Marketing
Firm level
ADMINISTRATIVE LEVEL
Market level
Sectoral level
e-Training
e-Communities
Satellite crop surveillance
New partnerships Business networking

ICT Enabled Rural Services

Within the new, society empowering, cross-sectoral, place-based, integrated policy paradigm for rural development, of critical importance is the interaction taking place among the various actors, namely citizens / society, businesses and administrative units, both within a rural region and between the region and the outer world. ICTs can support a two-directional interaction among the main actors in rural societies. The range and potential of ICTs applications that are serving these types of interaction in rural regions, but also add value to personal, business and rural regions' development perspectives are presented in the following, classified as to their contribution to the individual / societal, business and administrative level.

ICTs applications at the individual / societal level

In this section are presented ICTs applications that can apply to the individual / societal level.

Provision of community services

A number of ICTs applications can be identified that allow citizens of rural regions to enjoy access to those basic services that are necessary for the improvement of the quality of their life, decreasing thus inequality in access to services between rural and urban population. As such, can be mentioned:

e-Health services: distant, non-stop medical support of rural population is of importance, especially for the elderly or disabled groups, mainly due to the limited access of rural regions to sufficient health services. ICTs are offering a great potential in this respect and a great progress can be marked in the field of e-health applications. In-house video-phone equipment allows direct communication of rural citizens with properly equipped health centers, where they can send video information and receive care support from specialized staff. This staff can monitor citizens' health via ICTs equipment (e.g. a GIS and a CRM system keeping historical clinic information) and properly intervene in case of critical incidents. Portable devices (e.g. cell phones) can also be used, which enable population to be real-time monitored by specialized health centers. Moreover, e-health applications can also be used for both disease management and prevention.

Table 1: Types of interaction enabled by ICTs among the main actors in rural regions

To From	Individual/Citizen	Business	Administration
Individual / Citizen	*C2C* *Citizen to Citizen* e.g. social networks, e-communities	*C2B* *Citizen to Business* Citizens as clients – access to market-places or businesses Citizens as employees	*C2G* *Citizen to Government* e-government (access of citizens to public services e.g. tax offices)
Business	*B2C* *Business to Citizen* e.g. e-marketing, e-commerce, e-banking	*B2B* *Business to Business* e.g. e-commerce, networking - virtual enterprise	*B2G* *Business to Government* (access of businesses to public services)
Administration	*G2C* *Government to Citizen* e-government – provision of public services	*G2B* *Government to Business* e-government	*G2G* *Government to Government* e-government**1** *G2E* (e-governance2 – government to employee)

e-Learning services based on ICTs: aim at reducing barriers to the access of rural population to education / training services. e-Learning applications are quite useful both at the educational level (school) and the community level. At the educational level they can provide an e-learning platform that supports the teacher's work (e.g. organize and upload pedagogical material, create an on-line library of the courses); the student's work (e.g. on-line access to the library; on-line clarifications and cooperation); the group work e.g. access to remote laboratories for experimental work. Moreover, they increase familiarization of young people and development of skills in ICTs. At the community level, each individual has the possibility to use on-line learning services (e-courses) offered by various providers (companies, universities, private and public institutions, etc.), developing thus new skills and competencies that lead to personal empowerment and increase of skills and knowledge of employees in rural regions, adding value to labour productivity and competitiveness.

e-Libraries: offering access of rural population to knowledge and information sources. Joining networks of libraries enables local population (students, professionals, etc.) to share a larger amount of knowledge resources.

e-Culture: ICTs applications are offering rural population access to museums, cultural events etc. These are interesting applications, especially for young people in remote rural regions, keeping them on-line with exceptional cultural assets and events all over the world.

e-banking: improving access to financial services is vital for rural regions, especially the more remote ones. e-banking and m-banking applications can revolutionize the provision of formal services of the banking sector, offering new cost-effective ways of delivering traditional services, with huge benefits for users.

ICTs applications in rural regions at the individual/societal, business and societal level – e-Inclusion

Social networking: the development of ICTs has largely contributed to the increase of social interaction taking place between individual to individual, individual to group, group to individual and group to group communication. ICTs and the Internet can be characterized as highly e-inclusive technologies, allowing people to establish links with the rest of the community or other communities as well. e-Inclusion is of paramount importance for rural regions, especially for those which are geographically isolated, leading to the creation of social networks. Such networks are vital for the strengthening of social relationships among citizens of rural communities, but also can be considered as important platforms for information dissemination and increase of awareness on various issues of concern at the local level.

Social learning – knowledge-sharing platforms: the unlimited potential for interaction among various partners based on ICTs is marking the growing capacity of multiple-actor networks to develop and perform collective actions, assuring both e-participatory potential and network-run (web-based) technical processes.

Participatory decision making is a promising option provided by ICTs and relates to the most sophisticated level of e-Government, characterized by "networked presence" (Palvia and Sharma, 2007). Rural citizens, in such a context, are deliberatively involved in a two way open dialogue with governmental institutions, and express their views, visions, expectations etc., playing thus an active role in the decision-making process. Various examples of successful implementation of ICTs for participatory decision making are encountered e.g. smart cities.

Teleworking: is an important application of ICTs and a promising one in the rural context. ICTs are key drivers, among others, for the greater flexibility of jobs in time and space. New, location- and time-independent working structures are now offering the potential for decentralization of work through various teleworking schemes. Teleworking, as a powerful tool for "breaking down barriers between people, places, roles and activities" (EC, 1999), can benefit rural regions by rendering them attractive locations for the development of teleworking schemes e.g. televillages, with considerable consequences in terms of new job creation, based on the geographical dispersion of businesses; strong job growth in the service sector; restructuring of socio-economic pattern of rural regions; production and consumption patterns; commercial and social interactions.

ICTs applications at the business level

In this section are presented the range and potential of ICTs applications that can apply to the business level.

e-Agriculture - Farm-specific ICTs applications

"e-Agriculture": an emerging field in the intersection of agricultural informatics

In the 21st century, a new knowledge-based farming system is emerging that, based on farm-specific ICTs applications (e-Agriculture) can support the: profitability at the farm level; production of competitive, market-oriented, qualitative food products; decrease of environmental and climate change impacts; and energy efficiency (FAO, 2005; Downey, 2006). Knowledge and information are key requirements that enable farmers to deal with contemporary challenges, particularly as the new agricultural technologies become more "knowledge-intensive"

ICTs farm-specific applications can be roughly distinguished into: on-farm support services; management and decision making support services; and on-site support services, all delivering appropriate knowledge and information to farmers in rural regions. These are presented as follows:

PDA – Personal Digital Assistance equipment

On-farm support services refer to the provision of on-farm personalized information via mainly wireless communication. Remote rural farmers can get access to special agricultural support services by use of mobile and wireless networking technologies, integrated to the satellite broadband channel (FAO, 2005). By these means, farmers can get: access to on-farm support (consulting services) by directly linking to agriculturalists; and information on specific problems at the farm level. The end users (farmers) can be located in remote areas (e.g. farms or greenhouses) and, by using mobile devices (Tablet PCs and PDA), they are able to raise questions to agriculturalists; transmit digital information in real-time; and get immediate diagnostic feedback. Interaction can be either synchronous e.g. transmit digital photos of infected plants in real-time and wait for immediate diagnostic feedback; and asynchronous e.g. raise an issue, ask questions to agriculturalists or to other farmers, upload high resolution pictures relevant to the issue raised and gather knowledge on the issue at hand.

Moreover, the convergence of different technologies e.g. nano-biotechnology with ICTs, has created effective new technological products that are now available in the market, which claim to resolve various kinds of problems. Examples are nano-sensors embedded in the ground, which, combined with ICTs, can provide valuable information to farmers on the variations in soil quality, the water table and crops on a day-to-day basis

Management and decision-making support services aiming at the enhancement of farmers' knowledge for management and decision-making purposes. As ICTs applications, serving this purpose, can be considered:

- **Precision farming**: advanced e-Agriculture application, where ICTs, computers and satellite technologies are used to better manage farm resources (FAO, 2005), based on the identification, analysis and management of spatial and temporal variability of soil and plants (e.g. through digital field records) that are supporting efficiency and sustainability objectives (rational use of resources, such as water and fertilizers).

- **Access to information and knowledge systems**: supports the acquisition of various kinds of farm-specific information, e.g. weather information for irrigation, seed options, information for field work purposes, but also information on commodity prices, developments in farm machinery, pesticides and chemicals etc. that aim at supporting decisions at the farm level and improve farm management. As various studies show (FAO, 2005), farmers involved in such processes migrate quickly to Web-based transactions.

On-site support services delivering knowledge and information to farmers. As such can be mentioned the following:

- **On-site training services by agriculturalists** - e-Seminars - available either in real time or in recorded video. These provide useful knowledge on various themes of agricultural interest, e.g. new and improved ways of cultivation, sustainable production, management issues, advisory services on new technologies in farming, cost effective techniques, new and upcoming agricultural methods, and agricultural events.

- **e-Marketing –** e-Commerce that allow farmers to directly access either traders or customers in order to: market and sell their products; identify targeted audience; collect and track client/customer information on preferences; provide on-line information on product updates at a minimum effort and cost; etc.

- Access to e-Libraries that helps farmers to acquire specialized knowledge in respect to issues of interest, which enhance local knowledge in agricultural issues e.g. sustainable agricultural practices, organic farming, new production techniques, marketing approaches, agricultural policy framework.

- Access to e-communities via which farmers and other professionals in rural regions can get access to professional networks, crossing geographical boundaries and exchanging information with other members of the community that contributes to the increase of their knowledge and experience or the pursuance of mutual interests (networking) and objectives within the e-community.

Food quality and safety

The increasing concern of consumers as to the quality and safety aspects of food is reflected to their demand for improved traceability of food in the whole chain of production, processing and distribution (from "farm to plate" chain). Traceability is becoming a mainstream commercial requirement and will continue to be a key requirement for exporting agricultural production e.g. to EU and the USA, based on the introduction of the EU General Food Law and the US Bioterrorism Act 2002 that have made traceability a mandatory requirement for market access. Moreover, there is already considerable evidence that the demand for certified safe and traceable food will continue to rise also for domestic production and supply in many countries.

e-Business

ICTs and their applications are offering a platform supporting businesses in rural regions, both in the agricultural and other sectors, towards the: re-engineering of their production, management and organization processes; support of direct on-line interaction with customers; search for new market opportunities etc., enhancing thus their competitive potential in the new economy. The most promising ICTs applications for rural regions in the business sector are:

- **e-Commerce**: ICTs are offering rural businesses the potential to establish an on-line transaction space with their customers and/or other businesses (B2C and B2B interaction).

- **e-Marketing**: rural businesses can, by means of ICTs, market their products by establishing direct links with their customers (firms or individuals), creating thus a dynamic and adaptive two-way communication, increasing their potential towards the identification and adjustment to customers' needs; permeating to new market segments, etc. (B2C and B2B interaction).

- **e-Training** (life-long e-training): businesses can get access to distant training opportunities for their employees, which support the upgrading of their knowledge and skills at an affordable cost.

- **e-Marketplace**: based on ICTs, rural regions can develop e-marketplaces as marketing and transaction platforms that are based on local enterprises/products. Such e-marketplaces can allocate virtual spaces to all local businesses, so that their products are marketed through the network, providing access to a much larger clientele and bypassing traditional trade networks that often manipulate market prices.

New business opportunities

ICTs, in their function to diffuse information irrespectively of time, place and volume/type, are "enabling technologies", supporting new business opportunities. ICTs applications in this respect can:

- At the firm level: support a new, more efficient, intra-organizational structure of firms in rural regions; provide access to operating support, etc.

- At the market level: enable firms in rural regions (farmers, manufacturers, tourist firms, etc.) to reach new market segments by directly accessing their clients (firms and consumers); and enable business networking as a cost-effective approach for generating new business opportunities

- At the sectoral level: enable new business opportunities in various sectors e.g. tourism sector, manufacturing sector, service sector

ICTs applications at the administrative level

In the following are presented ICTs applications that can apply to the administrative level.

e-Governance

ICTs applications are supporting the improvement of the production processes within governmental agencies, by transforming interaction patterns among employees (G2E interaction). As a result, cost-effective public services are produced, based on the more effective management of organizational resources (capital, human, materials and machinery).

e-Government

ICTs applications can effectively support the interaction taking place between governmental agencies on the one hand and citizens, businesses or other bodies of government on the other. In such a context, they consist of a communication platform, along which interaction is taking place in one of the following forms):

- A one way communication, in which governmental agencies are disseminating various types of information, e.g. regulatory services, public hearing schedules, issue briefs, notifications.
- A two-way communication between governmental agencies and citizens, businesses or other governmental agencies. Such an interaction implies that individuals, businesses or other bodies can engage in a dialogue with a certain governmental agency, in which they can communicate problems, post comments, or requests to the agency.
- Conducting of transactions such as lodging tax returns, applying for services etc.

Such a ICTs-enabled communication platform can provide and/or improve governmental services in rural areas by allowing on-line transactions through the development of one-stop e-Government portal (G2C, G2B and G2G interaction). Moreover, it increases efficiency and improves services of governmental agencies in rural regions, assures better accessibility of public to services and improves transparency in decision making and accountability.

Barriers appearing in the adoption and use of ICTs applications in rural areas

The following steps need generally to be undertaken in order to develop ICTs applications in rural areas:

First step: deployment of the necessary network infrastructure, referring to both hardware e.g. fiber optic or wireless public broadband networks, fixed wireless technology (WiFi, WiMax), mobile wireless (m-) reaching directly individual end-users, satellite networks (VSAT) for data transmission, local networks, hubs - terminals for public use (nodes providing access to network services), cable Interactive Digital Television (IDTV), Public Switched Telephone Network (PSTN), etc. and software.

Second step: creation of the ICTs applications and content layer, involving all applications and digital services that are best suited to the needs of each specific rural region, together with the content needed for each application, e.g. establishment of e-Government platforms for the provision of services to the citizens or e-training applications, together with the necessary content layers serving these applications. Various sector-specific applications for rural regions can also be developed in this step (e.g. health-care, tourism, training, food industry, agricultural applications).

Third step: relates to the familiarization of the end-users with ICTs and their applications in order to become active members of digital affairs in the rural community. This step implies the:

- Familiarization of rural population with new technologies through training on the use of ICTs, that will motivate them to joint the 'trip';
- Familiarization of businesses with new technologies and their potential for supporting new business opportunities; and
- Preparation of local authorities and administration as pioneers of the whole effort, in terms of both getting access to the proper equipment (hardware and software) and training public servants.

Based on the above steps, barriers appearing in the effort of rural and remote regions to "log-in" the information and knowledge society can be systematically identified within the following general streams

a) Barriers relating to the *deployment of network infrastructure*: ensuring accessibility of rural regions to network infrastructure is a critical issue in promoting ICTs applications in these regions. Barriers relating to the development of network infrastructure in rural regions are mainly associated with the:

- Costs involved in the deployment of this infrastructure, which, when combined with the lack of sufficient demand, render relative investments financially unsustainable e.g. in the case of remote, sparsely populated, rural areas.
- Diversity of ICTs applications that can serve the needs of rural regions and the respective network infrastructure requirements necessary for serving these applications e.g. e-platforms for community-specific ICTs applications vs m-platforms for personalized farm-specific ICTs applications.
- Lack of continuous and high speed network connections.

b) Barriers relating to the development of specific ICT*s applications and content* in rural regions such as:

- Lack of access of rural regions to proper equipment, both hardware and software, for the development of specific applications as well as costs involved in this respect;
- Lack of knowledge of the range of applications that could be of relevance for each rural region due to the lack of a regionally-focused and demand-driven approach to identify specific needs;
- Lack of skilled personnel to build and run such applications and content;
- Costs involved in content development, where different needs and preferences of different groups call for a region-specific user-oriented content development, with content developed for or adapted to the specific rural context (FAO, 2005; SCAR Foresight, 2007);
- Lack of region-specific knowledge and respective needs of the various rural regions from those engaged to develop applications and content. This may result to a mismatch of applications and content developed in respect to the real needs of rural population;
- Barriers relating to the management of the digital content due to constraints in coherence and inter-operability of data and information sources, from which such information is gathered.

c) Barriers associated with the *adoption and use of technology* by the end-users in rural areas (citizens, businesses and administration), relating to:

- Lack of skilled human resources – limited capacity of human resources as users of ICTs;
- Lack of institutional capacity and capacity of people involved in the information provision in rural areas to ensure the right information in the right formats;
- Limited range of e-government services that use open IT standards, which introduces barriers to the end-users relating to the necessity to use commercial technology / software.
- Low level of entrepreneurship in rural regions;
- Low level of sector-specific applications in rural regions (health-care, tourism, food industry, environmental industries etc.) that impede ICTs adoption rates at the business level;
- Lack of training opportunities / structures that offer the chance to rural population to develop skills and competencies on ICTs and their applications, focused on their specific needs;
- Lack of knowledge on the potential offered by ICTs applications for personal (skill and competence acquirement) and business development (integration into supply networks, knowledge networks, potential for knowledge management)
- Inability to build various kind of local partnerships, which will ensure that information is accessible by all local stakeholders;
- Language skills that bound interaction potential of rural population / businesses and limit the benefits reaped out of this;
- Barriers due to culture and traditions of rural social systems, resulting to a reluctance to shift to a new, less controllable, regime, which impede social anchoring of ICTs in local rural communities. In locally-oriented rural economic systems, such kind of barriers may be stronger, while in open, export-oriented rural economic systems, these may appear weaker;
- Lack of new technology culture, holding especially for the older age groups in rural regions that influence the propensity to adopt and use ICTs and their applications;
- Lack of trust to technology at the local society; and
- Costs involved in getting access to (PCs, mobiles etc.) and use of ICTs for businesses and citizens.

d) Barriers relating to missing or of limited capacity network infrastructure in respect to the type of applications / content that would serve the needs of rural areas. These are mainly due to:

- The lack of region-specific and demand-driven approach to network infrastructure and ICTs applications / content development that can lead to a mismatch of network infrastructure on the one hand and ICTs applications / content on the other; and

- The multiplicity of application-specific network requirements in rural areas e.g. e-platforms for community applications, m-platforms for farmers' personalized applications, satellite technology for farm management purposes.

e) Barriers relating to the *type of network infrastructure* selected for the support of e-applications in each specific rural region. Barriers involved in such a context refer to the:

- Type of network infrastructure technology adopted that should adjust well to local pattern of communication. Deployment of network infrastructure based on technologies that are not building upon already established communication means within each rural community can place barriers to rural population in joining the 'trip', due to lack of familiarity, trust, etc. (FAO, 2005).

- Close to the above issue is the tendency of deploying network infrastructure, which is focusing more on the technological aspects than the communication and networking potential this can create, i.e. there is a domination of a technology-led service provision approach, with no effort devoted on fostering demand

- Lack of establishment of multi-device / multi-channel access, exploiting multiple and diverse communication tools that integrate the full range of existing media in rural regions, enhancing thus accessibility potential that can influence 'log-in' attitude/behavior of local population.

- Costs involved in using the network infrastructure.

- Costs involved in getting access to the necessary equipment to join the network.

f) Barriers relating to the type of applications and relating content that is proper for different types of end-users. Barriers appearing in this context relate to:

- The lack of a user-oriented knowledge development (content) and exchange strategy (medium) that can deliver a wide range of applications relevant to the needs of different end-users (citizens, businesses and administrative units). Matching ICTs applications / content to the specific needs of end-users is a key issue towards the 'log-in' perspective of these users.

- The lack of effective interaction among researchers as developers of ICTs applications and end-users in rural regions that will establish a demand-driven approach to the applications / content development.
- Lack of users' involvement in the design of the various ICTs applications / content
- Lack of simplicity of applications. There is an increasing need for applications which, based on open software and peer-to-peer platforms, can provide low cost and easy to use solutions that fit local needs.
- Lack of a multimodal, multi-channel system of digital communication that integrates all media. This will remove barriers appearing in matching applications offered through a certain technology to the technology disposed by the end-user.
- The over-focus of ICTs applications on technological aspects than the communication and networking potential they enable
- Costs involved in the access (PCs, mobiles etc.) / use of the ICTs applications and content.

Policy recommendations for future rural development ICTs policy

ICTs can contribute to many aspects of rural regions' development such as the improvement of agricultural production and productivity, the production of safer food, the support of businesses and entrepreneurship, the upgrading of skills and competencies of local labor, the strengthening of bonds in the local society, the social equity in 'logging-in' opportunities, the increase of public participation, the more effective and sustainable use of natural resources etc. In this respect, ICTs applications can be strategic tools for the development of rural regions, provided that they take into account the social contexts and offer tailored-made solutions to community needs.

Policy making needs to take into account the peculiarities of rural regions, by addressing more effort on the promotion of those network technologies that are best suited for rural regions and their transformation into products and services, effectively dealing with region-specific needs. 'Network readiness' is of crucial importance in this respect. Based on that, the deployment of case-specific ICTs applications and content for rural inhabitants will increase awareness and take-up of Information Society in rural regions, contributing to their future development.

In order to motivate actors in rural regions to log-in the information society, certain policy directions are critical. Towards this end, policy recommendations for the future rural development ICTs policy may concern:

- The development of *user-oriented knowledge and exchange strategies*, targeted to address current and emerging needs of rural regions in transition.

- The development of *place-based applications* that are adapted to the lack of continuous and high speed connections in many rural areas around the world. Alternative mobile and wireless infrastructure and applications (in particular WLAN technologies, such as microwaves and 802.11 protocol) can be useful in this respect, as well as applications adapted to TV set-top boxes.

- The development of *location-specific applications*, supporting the provision of personalized knowledge and information. In this respect, eGIS (Geographic Information Systems) serving the identification of spatial entities and delivery of location-based services for rural development are important.

- The setting up of effective *communication infrastructure / processes* that are focusing more on the outcome they can create than on the technology it self.

- A focus on building *e-communities*, by addressing research efforts on technologies that support community building and trust, with a particular emphasis on technologies enabling the building of human relationships, acting as a catalyst for knowledge and information diffusion.

- The development of a *multimodal, multi-channel system of digital communication* that integrates all media and adjusts better to the local communication pattern and the varying communication preferences of end-users.

- The development of proper *interfaces* for the take-up of ICTs applications. Challenges include: multilingual, multi-modal and adaptive interfaces, natural language interaction, visualization technologies, etc.

- The strengthening of the efforts devoted to the *upgrading of skills* of human resources as users of ICTs, by establishing proper life-long learning and training structures in rural regions as well as by facilitating knowledge exchange and mutual learning among communities with similar needs.

- Finally, of particular importance seems to be the *role of local administration* as leaders in establishing a ICTs culture in rural regions.

The community radio movement in India

India has been quite a latecomer to this promising channel of people empowerment through community media. Until late 2006, only educational institutions were allowed to set up *campus radio stations* having a transmission range of 10-15km. The scope was only recently expanded to also include non-profit agencies, agricultural research institutes, and schools, to set up *community radio stations* that would involve local communities in the content production process. The progress has been steady since then, although arguably somewhat slow. As of now, there are four stations that are broadcasting, and around six stations that are in advanced stages of their application approvals. I will first briefly describe the historical context of the CR movement in India, then outline certain inefficiencies in the current CR policy, enumerate a few practical problems in establishing and running CR stations in the Indian context, and finally connect the efforts of Gram Vaani and other organizations in addressing these problems.

Historical context

The importance of community media for community empowerment and democratization is well known. And voice based media are especially relevant in the Indian context, given the poor literacy levels in rural areas. However, despite radio being an efficient channel for voice-based community media, communities and independent organizations were forbidden to set up their own radio stations. Pioneering organizations such as Voices and Drishti Media therefore chose a concept called narrow casting to circumvent the policy restrictions. They worked with NGOs Myrada in Bangalore and Kutch Mahila Vikas Sangathan (a women collective) in Gujarat to train rural community reporters to produce audio programs just like it would be done in a radio studio. But the programs were played out over loud-speakers in common community meeting points such as near temples and at Panchayat (village level governing bodies) meetings, or within "listener groups" of women working together in self-help-groups. The audio production was itself done in a small studio where eminent village personalities and local politicians were invited for interviews, local artists were called in for recording folk songs, and school children were invited to recite poems and famous speeches by great personalities. Namma Dhwani (meaning, our voices), the setup at the village of Buddikote near Bangalore, even pioneered a new concept called cable casting where they used the cable TV network in the village for broadcast. This was a daring step in many ways against the repressive government policies — since cable TV was run by local operators, Namma Dhwani could purchase air time cheaply for their own programs even though it could not run its own radio station. The channel of course did not have any video — just a blank blue screen — but given the high penetration of television in the community, it was a fantastic outreach channel.

Both the experimental setups near Bangalore and in Gujarat were extremely successful in empowering communities, making them realize their rights, and lobby for their demands from local authorities. Given ready evidence, enterprising activists from organizations such as Drishti, Voices, Ideosync, Maraa, One World South Asia, and many independent individuals incessantly lobbied for a policy change to get permission for radio broadcast. Their efforts were rewarded in late 2006, but the policy still remains mired with many complications.

Community radio policy

Currently, there are a number of points of dissatisfaction amongst the CR community.

- Only non-profits more than 3 years old can apply for a CR license. Although this clause is present to help ensure accountability, it is restrictive for new organizations that want to venture into community radio in a dedicated manner. The older non-profits that are applying for licenses have been working in different streams such as micro-finance, low cost housing, health, etc, and tend to look upon CR as an outreach channel for their existing programs. However, the vision and mission of CR is substantially broader and a niche domain in itself.
- The license process can take well over a year. It goes through the approvals of almost five different ministries, and if the application is stuck at any point, then there are hardly any avenues to find out. Updates are rarely available on the government websites. The entire process is also very inconvenient for the applicant organizations because they are often asked to supply more details within sudden deadlines, or required to appear in person in New Delhi without any warning. One of the most significant tasks during the application process is also a community survey that is supposed to be filled out by over 1000 respondents. Although surveys are definitely valuable to assess the information needs of the communities, the specific survey mandated by the government is available only in English, and contains a whole host of amusing questions that are completely irrelevant to community radio. Many people behind the CR movement strongly feel that a one-fits-all survey is not suitable in the diverse Indian context, and applicants should be allowed to design their own surveys based upon certain specific guidelines laid down by the government. Fortunately though, the government secretaries are open to suggestions, and the process will smoothen out over time.
- The FM transmitter equipment for the community radio station can be sold by only three authorized vendors. The third vendor, Nomad, designs and manufactures indigenous transmitters, and got approval only last year after a long struggle with the bureaucratic red tape. Prior to Nomad, the transmitter equipment was available at a prohibitively enormous cost from the other vendors. At Gram Vaani, although we know that even lower cost alternatives exist, but given the approval difficulties we have deferred our development efforts on the transmitter front to later, and decided to focus on other components of the CR technology in priority.
- The policy mandates that the CR station should be owned by a non-profit organization. This is very different from policies in Nepal where local communities can pool funds and apply for a license, or in Bolivia where it is mandatory for a CR station to be governed by a council of members elected from the community. This therefore becomes a push-based top-down approach in India, as opposed to a more desirable pull-based bottom-up approach in Nepal and Bolivia. The non-profit organization in India may or may not choose to listen to feedback from the local community, and there have been reports where feedback from certain community individuals was neglected because these people did not participate in the other development programs supported by the non-profit organization. In the same manner, since the community also may not incur any clearly-observable liability from a failure of the CR station, it would effect their levels of engagement with the

radio station. Unfortunately a circular problem, this does outline the complexities of participatory community development programs.

Other challenges for community radio stations

CR stations also face other challenges, the foremost ones being financial sustainability and technology.

- CR stations are permitted 5 minutes of advertising per hour. If well marketed, this could help cover the operational costs to run the CR station and pay salaries to the staff. But it is practically infeasible for resource-crunched CR station operators to acquire business skills and look for advertisers while they also produce good quality radio content. We feel that having a central agency like Gram Vaani look for advertising on their behalf will be very helpful. But it is also important to create other revenue streams for community radio. We have a number of interesting ideas based on coupling radio with telephony services that we will outline in a subsequent post.
- The setup used by most stations is quite basic — just a computer and mic, connected to the FM transmitter via a mixer. Although simplicity is good, the lack of interactive systems such as telephones, field reporting tools, and content sharing, makes it harder to sustain engagement from the community. Even software used to run the radio station can have a significant impact on its success. Most CR stations currently use Winamp to play out radio programs, and have to resort to hacks to do live broadcast, or interleave advertisements between programs. A professional radio automation system is very necessary to scale activities, but currently there is no free and open-source system that provides a one-stop solution to playout, broadcast, telephony, SMS, and Internet content sharing.

The current push behind the Community Radio movement

We are very glad that our Knight funding came at an opportune time to enable us to make a significant impact in the growth of community radio in India. Gram Vaani is among the early players in the area of improving technology for community radio, and building a business model around making CR stations financially sustainable. Please take a look at other included reports on details of the kind of software and hardware systems we are building for community radio.

We will shortly also write about our current thinking on the business model of enabling services through radio and telephony. The Gram Vaani team and other CR activists are also part of the Community Radio Forum, a pan-India collective whose most important mandate is to lobby for legislative changes on the CR policy front. The third annual meeting of the CR Forum was held last month at a small town called Orchha, in the Bundelkhand region of India. Orchha was chosen because the very first community radio station licensed under the new policy was established there by Development Alternatives five months back. It was widely attended by almost all organizations in the community media space in India, including Gram Vaani.

VILLAGE RESOURCE CENTRES

The Village Resource Centres (VRCs) programme launched by ISRO/ DOS disseminates a portfolio of services emanating from space systems directly to the rural communities. The programme is executed in association with NGOs/ Trusts and State/ Central agencies.

MAJOR BENEFITS

- Rural empowerment
- SMART Governance
- Computerised Gram Panchayats
- Distance education
- Remote healthcare services
- Employment opportunities
- Access to products and services available to city dwellers

Present status

- 461 VRCs set-up in 22 States/Union Territories
- Services include Tele-education, Tele-healthcare, Land & Water Resources Management, Interactive advisory services, Tele-Fishery, e-Governance Services, Weather Services and other services based on local needs

- Over 6,500 programmes have been conducted addressing the issues in Agriculture/ Horticulture, Fisheries, Livestock, Water resources development, Tele-healthcare; Awareness programmes; Women empowerment; Supplementary education; Computer literacy; Micro-credit; Micro-finance; Skill development/ vocational training for livelihood support, etc.

Glimpses of Village Resource Centre

Unit 2: ICT for Production System Management

All ICT interventions in agricultural value chains involve the transmission and use of information. For the purposes of this report, however, information services cover information that is tied to helping farmers improve their productivity; yields and profitability during the course of their normal agricultural and animal husbandry production ion systems management are the most prevalent category of ICT service for inclusive agricultural value chains. This report covers information services that involve four categories:

i) short-term productivity, such as weather information to help farmers decide when to plant or harvest;
ii) long-term productivity, such as training on proper fertilizer usage;
iii) minimizing the negative effects of crisis events, such as information on how to protect crops from oncoming freezing weather; and
iv) Improving field-based risk management, such as information on the implementation of crop rotation to preserve the soil. Many of these services are government-sponsored, but there are also privately run services and public–private partnerships, such as the Kisan Call Center.

Types of ICT information service

ICT applications for production systems management can include the provision of data on the following topics. All of these techniques aim to improve data collection, processing and reporting through simple and affordable means that help farmers to make decisions that will improve (or protect) their incomes. As already stated, information services through ICT typically serve four main purposes: productivity enhancement for short- and long-term effects, crisis management in the short term, and field risk management in the long term.

1. Short-term productivity information services

In the context of this document, short-term productivity information services entail providing information mainly to end beneficiaries, such as farmers, to help them improve their crop yields in the near-to-medium term, and are the most common types of information service available. These productivity services provide information that is generally quick and easy to access and use (information "nuggets"), such as current or forecasted weather information, and is frequently pushed out by the information provider to subscribers without much interaction between the provider and the consumer. These services are especially important to farmers who already know and understand a great deal about their crops and farming techniques but who occasionally need timely information to improve their productivity. This kind of information, such as the exact timing of the oncoming monsoon season, is often difficult to access in remote rural areas, and without timely, technical information, farmers are forced to make decisions based on rules of thumb, past experience, local rumors and instinct. The following examples of interventions for helping to improve crop and dairy yields:

f. Crop advice from experts using digital photos: Project e-Sagu of the International Institute of Information Technology (IIIT) in Hyderabad, India enables farmers to receive advice on planting, monitoring and harvesting crops and on pesticide and fertilizer usage based on digital photos taken by the farmers themselves.

ƒ. Ensuring high milk production from dairy cattle: In Sri Lanka, Web and mobile technologies have been introduced to help dairy farmers achieve self-sufficiency in milk production. The e-Dairy project is part of the effort of the country's Information and Communication Technology Agency (ICTA) to improve the livelihoods of the rural community, which accounts for 70 percent of Sri Lanka's population. The government discovered that 53 percent of the country's milking-cows were yielding milk because they were not pregnant. The low pregnancy rates were because timely artificial insemination and breeding services were not available, owing to the lack of communication between farmers and public sector service providers ICTA attempted to bridge these gaps through mobile phone-based SMS messages and touch-button computers installed at the milk collection centres where farmers gather every morning to sell their milk. The system offers a number of "just-in-time" services, including access to artificial insemination agents, to help induce pregnancy. ICTA believes that if cows are artificially inseminated within the required time frame (after the first signs of being on heat), milk production could be increased by 30 percent (ICTA, 2009).

2. **Crisis management information services**

Crisis management information services essentially help prevent losses, rather than raising productivity. These services often serve as an alert system enabling farmers to react quickly before an oncoming event (often weather- or disease-based) reaches them. The following provide examples of interventions around warning farmers about potential weather and pest disasters:

ƒ. Weather and pest information for farmers: In Turkey, the agricultural department established five weather sites to monitor the need for pest control and frost prevention, and now provides this information to farmers via their cell phones. The service gathers information about when pests are likely to be prevalent by placing pest traps and observing temperature levels. Using the information, the farmers have been able to reduce their use of pesticides by 50 percent – lowering expenses and improving crop productivity. The tracking of temperatures also helps farmers to prevent losses from frost by monitoring temperatures hourly and sending text messages to the farmers, who can then take crisis management measures, such as burning dead leaves near their fields (Kumar, 2011).

ƒ. Sea conditions for fish farmers: The Chilean Aquaculture Project provides daily information about the sea surface temperature, the clarity of the seawater and the amount of chlorophyll in the water. Information on chlorophyll content enables fish farmers to take action when harmful algal blooms multiply to a level where they threaten farmed fish.

3. **Long-term productivity information services**

Long-term productivity information services cover topics that take longer to learn, and are often offered with other technologies and channels, such as face-to-face training or one-to-one support from local extension agents. Many such services are delivered in conjunction with long-term training, extension services, demonstrations and field visits. Benefits from these services are generally realized months or even years later. As far back as 1999, researchers found that livestock mortality in villages decreased after extension officers began to provide more timely advice through mobile phones.

These services typically focus on education, often with a distance learning aspect. They can also serve as tools for obtaining follow-up on services provided in the short term, as in the examples described in the following:

f. Training farmers in the use of agricultural information – *the Community Network in Chancay-Huaral, Peru (long-term productivity enhancement)* (Galperin and Mariscal, 2007): The land surrounding the Chancay- Hural River in Peru should provide adequate resources for local farmers to do well: healthy soil, adequate water, and proximity to Lima and the north. However, residents lack access to communications and public services. *Centro eruano de Estudios Sociale* (CEPES)10, a local NGO, believed that there was likely a correlation between the lack of access to services and communication and the fact that farmers often planted the same crops year after year, despite market prices. CEPES also remarked that there was a strong need to improve water management by the local cooperative board. To counter these two main issues, CEPES created an agricultural information and communication system for the region, offering long-term training to improve farmers' decision-making and timely communications among the local water irrigation commissions that manage the water cooperative. To overcome the lack of telecommunications infrastructure, CEPES put in place a Wi-Fi network connecting 12 villages and providing them with Internet access to the outside world.

4. Risk management information services

Risk management information services are also long-term in scope and, as with crisis management services, they help farmers to avoid losses rather than increasing productivity. These types of service differ from crisis management services in that they take longer to absorb and implement, and the benefits are realized much later than with crisis management. The following is an example of an intervention that helps women farmers in India to avert many of the common effects of drought:

. Distance learning to help women in India overcome drought and pests: In 2004, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) created a Virtual Academy that trains local women who then, with the help of remote scientists, provide critical information to farmers in 21 villages. These women meet ICRISAT scientists via audio and video conferences and exchange key information about droughts, planting practices, pest control, soil fertility, etc. For example, Rameswaramma, a 38 year old villager from Nijalapur village underwent computer and agricultural technical training from the Virtual Academy (and won an award for her efforts). She now helps local farmers experiment with drought-resistant crops, such as castor, and shares other agricultural practices, market prices and weather information with the help of the remote scientist experts.

Common ICT platforms for information services Collection and analysis

Data collection can be quite complicated and expensive in the chain of providing information services, especially when collecting comprehensive and timely data on weather, pests, etc. throughout an entire country. Because of this constraint, governments and multilateral agencies such as the United Nations often undertake the data collection and analysis steps. Commonly used platforms include the creation and updating of Geographic Information Systems (GIS), satellite mapping and environmental maps. However, a form of "crowd-sourcing" is under way, often using simple and inexpensive mobile devices, such as mobile phones, through which local extension agents or even beneficiaries report back certain data. GIS in particular is already being used in many developing countries, such as Bangladesh, Cambodia, Colombia and Malawi. GIS helps monitor agriculture-related issues or identify viable new opportunities in agriculture. For example, GIS tools can help monitor changes in crop coverage in agricultural areas, detect and map relevant chemical and mineral substances within soils in a region, and identify appropriate fishing sites (showing the intensity of fishing). "The software is not costly," said José Aguilar- Manjarrez of the Food and Agriculture Organization of the United Nations (FAO). "There are many GIS and remote sensing software packages at low cost, plus the new trend is open source [free] software" (Fog, 2011). However, creating the infrastructure, training personnel, and collecting, processing and maintaining data are expensive activities. For this reason, FAO has developed GISFish, an Internet Web site of GIS-based resources for aquaculture and inland fisheries in developing countries. The mission of the project is to "solve problems in inland fisheries and aquaculture using GIS, remote sensing and mapping". Satellite, airborne, ground and undersea sensors acquire many of the related data, especially on temperature, wave current velocity and height, chlorophyll concentration and land and water use. The data are then analyzed, aggregated, formatted and uploaded for public use on the GISFish website.

Delivery

Since the arrival and proliferation of the mobile phone, the delivery of information services has become much easier and less expensive, and is often provided by private players. The mobile phone's advantages are its simple format (often text-based messages), ubiquitous (or near ubiquitous) ownership and low cost. Many MNOs or mobile application providers provide these services as add-ons to normal mobile services, often called "value-added services" (VAS). Another common delivery platform is the use of landline telephone numbers (which are being phased out, generally by cell phones), often staffed by experts such as veterinarians or scientists who provide advice. Prior to the proliferation of these phone-based systems, radio and even television were (and still are) used to push out information to farmers. The constraint of radio and television is that they can provide only very general and standard information to everyone, whereas phone-based systems can be somewhat tailored to farmers' specific questions. Data provision directly through the Internet is far less used in rural areas of developing countries. The Internet can provide much more data and in a more easily digestible and visual format than a phone can, but many rural areas do not have access to the Internet, which is also often cost-prohibitive.
Information provision over the Internet often uses information centers or kiosks operated by an entrepreneur or service agent who helps farmers to navigate the different sources:

- ***Internet/Web portal:*** The Agriculture Resources Information System Network (AGRISNET) is a project created by the Tamil Nadu Department of Agriculture in southern India and the Government of India to provide a complete Web-based portal for sharing needed information with farmers. Information is gathered and disseminated by 385 local agricultural extension centers, which all have Internet access. AGRISNET provides information on weather forecasts, market trends, quality requirements, policies and eligibility for benefits, among other topics. In the past year, 8 million farmers in Tamil Nadu have used the service – 33 percent of all the farmers in the state (Government of India)
- ***Combined radio and phone:*** In a study carried out in 2010, Freedom Phone used a combination of radio and cell phone platforms (and other back-end technology beyond the scope of this report) to deliver relevant audio files to farmers in rural Ghana. (The files were often of radio broadcasts the farmers had missed.) Radio stations became the focal point for collecting and recording relevant data on audio files that farmers could listen to when they were interested in the topic. Farmers could also leave voicemail messages to provide feedback on the service. While there were issues of take-up owing to the cost and to farmers not grasping the service's value, the farmers who used the service frequently found it a useful source of pricing trends and agricultural information.
- ***Phone-based voice messages:*** The Local Language Speech Technology Initiative's National Farmers' Information Service project provides Kenyan farmers in remote rural areas with information on crops, livestock, market prices, inputs, disease outbreaks, weather reports and which crops are most suitable for a specific area, even though many of the farmers lack access to the Internet or extension services and are illiterate. Essentially, text-based information is converted to audio, in either English or Swahili, and provided over a landline or cell phone. Farmers call with queries, and staff of the service read the relevant information back to them.
- ***Adapted call centers:*** A version of the Web sites that are popular in developed countries, where users ask questions to experts online, Question Box uses simple technology such as phone boxes in remote villages of India and Uganda, which farmers use to contact trained agents with the relevant language skills to answer their questions; staff typically have access to the Internet. In India, the dairy operator Arohana provides its dairy farmers with a connection to veterinary specialists at the local university. The project in Uganda also has a staff member at the origination point, who makes the calls for service users with enquiries.

Issues and challenges for ICT information services *non-tailored service provision:*

Many of these services are "push-based" in that once the service is subscribed to, the service provider sends the information, often by SMS, at times determined by the service provider. Such services are also one-directional in that the recipient cannot receive clarifications or answers to his/her specific queries. This challenge can be overcome by allowing the subscriber to choose which information she/ he wants first, or by providing staffed services, as KCC does – although this can be difficult and expensive.

- ***Illiteracy:*** Illiteracy is a challenge for services based on mobile phone text messages or the Internet. Farmers typically find a "work-around" solution by asking a literate friend or relative to help, but the text-to-speech example described in the previous section, and emerging interactive voice response (IVR) technology will eventually allow users to use only their voices for enquiring and listening.
- ***Sustainability:*** From a more global perspective on these services, the main issues revolve around sustainability and scale. Most, if not all, of the examples mentioned in this and other publications are essentially pilots subsidized by governments or multilateral institutions. While these players may have to continue providing data collection services, private players' move into the delivery of information (e.g., VAS with mobile phones) can encourage sustainability and greater reach. Two common business models are being explored around the globe:
    i) subscription models; and
    ii) Pay-as-you go models based on usage.

    There is still the issue of whether end beneficiaries will pay for such services, as farmers are often highly price-sensitive and prefer carrying out their business as they have always done. Mobile phones present an additional issue as the VAS provider may charge a fee to the user, and the user has to pay for data and/or phone time charges. The poor often use ingenious tactics to minimize their talk-time usage as much as possible, such as by calling and quickly hanging up before being answered, signaling that the person called should call back. Upstream, for-profit firms such as processors and dairies (and even downstream suppliers) may have an incentive to provide these services for free or at a subsidized rate in the long term as the services could help improve the quality and quantity of the end product.
- ***Cost of collection:*** As already mentioned, the cost of collecting the data used for short-term productivity services is typically high because of the implementation and maintenance needs of these services. This requires that a public player provide short-term productivity services, as finding a sustainable pricing model for consuming the data could be difficult (very similar to how highways function in transportation systems). Setting up such a system takes a great deal of political will, resources and time.
- ***Customer adoption:*** No model can be successful if the end users do not grasp real value from the services. Many of these projects have problems with customer adoption because they are not able to convince potential users to try (and use frequently) such services. Kenya's M-PESA (mobile phone money transfers – the most oft-cited, successful ICT-based service for the poor) has been able to evolve

from a small pilot of a large MNO to a successful and viable business, by listening to end users' needs, conveying the fulfilment of these needs in a simple and compelling message ("send money home"), and executing a consistent and easy to understand service. Few other bodies working in financial inclusion or other development services such as value chain development have been able to match this level of success in using ICT services because they have missed at least one (and often all) of the three necessary steps: understand the need, convey a compelling value message, and execute well. Providers should take care to parse out exactly what information is important to farmers and provide it in ways that make it easy to digest and act on, avoiding "data dumps" of information.

- ***Seasonality:*** Another issue affecting the sustainability of short-term productivity ICT services is that farmers request them only at the time of need. As agriculture is inherently seasonal, with several dormant months a year, the question of sustainability for these types of service arises. If they are a small part of a larger portfolio of services, this is less of an issue, such as for an MNO. However, a dedicated service provider would likely need to offer other services (likely for other target markets) to remain viable during the interim periods.

Advantages of and opportunities for ICT information services

- ***Ease of use:*** The most compelling aspect of these services is that they can provide relevant and timely information in a way that can be absorbed and acted on immediately, for example, "I should plant in a week and not today". The services are also generally simple to understand and easy to subscribe to and use, making them a compelling entry point for additional information services, and perhaps also the services addressed in the next chapter, such as education and long-term extension services. ICT information services can also serve as excellent entry points for farmers who have not previously had access to unbiased and timely information. There is also a dimension of creativity in the delivery of these services, to meet the needs of end beneficiaries, such as the use of voice messages and voice boxes in the examples. However, basic text SMS continues to be the most popular method owing to its simplicity and low cost (see next point).

- ***Cost of delivery:*** Data collection may be expensive for short-term productivity services, and typically requires public support (even the United States Government must step in to provide weather data for the National Weather Service and oceanic data for the National Oceanic and Atmospheric Administration, for example). However, the delivery of such services has become much easier and less expensive with the arrival and proliferation of mobile phones, especially in the developing world. Simple software can be embedded in the phone or downloaded, although many providers choose the even easier and less costly route of providing text messages.

- ***Provider sustainability:*** Most short-term productivity services are leveraged on existing infrastructure, such as radio stations or mobile phone networks. As these service providers have already expensed the major cost in their businesses' fixed costs, any additional service entails essentially added value with relatively low incremental costs. The providers therefore have an incentive to add services as long as there is a strong enough demand and willingness to pay. In addition, as most providers are pre-existing businesses, they are not entirely dependent on this one stream of revenue to continue operating (especially in the early periods).

- ***Tailored services:*** Apart from a few of the services mentioned, such as radio, different types of information can easily be added on to or removed from information services especially for phone-based interventions – depending on the demand from users. This can maximize the benefits for farmers of different crops/animals and in different regions.

Unit 3: ICT for market access

TYPES OF MARKET ACCESS ICT SERVICE

Market access ICT services are somewhat simpler, less varied and newer than the production systems management ICT services described in Chapter 2. The following are some of the market access service types provided. The most common services provide current market pricing for relevant agricultural products. As many of these services are new (and in pilot stages), there will likely be much evolution in final service provision and probably new services and ways of delivery:

- pricing services;
- virtual trading floors (VTFs);
- holistic trading services;
- downstream administration/management.

Pricing services

Simple pricing services generally entail a provider pushing out current market data on one or more agricultural products. Often these data are nation- al or regional in scope, and so may not be entirely relevant for the farmer in the field, depending on his/her proximity to markets. Users (mainly farmers) generally have little interaction with the providers, and must digest the information to find and negotiate with buyers. This service is typically the most common type of market access ICT service provided and simply replaces (or enhances) services that are often provided through print, radio or television. The most common advantages to these services are price transparency and improved negotiating leverage for often-disempowered sellers (farmers). Frontline SMS in particular has helped provide several pricing services to farmersthroughout the world.

Virtual trading floors

VTFs, such as the Farmer Net are electronic market places where buyers and sellers connect over an electronic network (as opposed to providing only static information, as pricing services do). The important difference between VTFs and more traditional trading floors is that the buyers and sellers do not have to be physically in the same location to make an exchange on a VTF.

- Matching services:
  In matching-service VTFs, sellers and buyers connect directly with one another to conduct the exchange of goods available at that moment (the spot market covering today's prices). Sellers register their products and delivery schedules, and buyers register their needs. These records are matched by a machine (or human operators referring to databases), which when requested gives either party a range of options to choose from. There are several matching-service VTFs in various parts of the world although the platform has not taken off as desired.
  In Bangladesh, the e-Purjee system was established jointly by the Prime Minister's Access to Information programme and the United Nations Develop- ment

Programme (UNDP) in December 2010. e-Purjee uses SMS to issue growers with permits and billing information for sales of sugar cane to the 15 State-owned sugar mills. Some 2.5 million growers across the country obtain fair prices and no longer have to depend on potentially corrupt intermediaries to sell their sugar cane to the mills. On 13 January 2012, e-Purjee reported on its Web site that it had facilitated almost 500000 permits for the processing of 826 000 tonnes of sugar cane to produce 47 000 tonnes of sugar.

- Commodity exchanges:
  They act as intermediaries to match buyers and sellers at the right price and quantity without either side of the transaction knowing who the other is. This type of exchange is similar to the commodity exchanges found in the developed world (other than in size and sophistication), such as the Chicago Mercantile Exchange in the United States of America. An advantage of commodity exchanges is that not only is there a spot market of current prices, but the exchange also generally has enough information to estimate future prices and even to provide risk management services through forward contracts or more complex derivatives for buyers and sellers, to mitigate potential losses from price fluctuations in the future (and ideally to smooth out income expectations). However, these types of commodity exchange are generally more difficult and capital-intensive than a matching service, such as the VTFs mentioned in the previous subsection.

Both trading floors and exchanges are difficult to set up because of the capital required. It is also difficult to achieve success because the "network effect" has a significant impact on the numbers of buyers and sellers involved (and the product volumes). With exchanges such as these, the higher the volumes and numbers of players, the better the information and the exchange's value. So it is difficult to achieve break-even in the early years, as players decide whether or not they want to be part of the exchange. Another potential issue for commodity exchanges is that they are a volume business, and small producers may not have large enough product allotments to participate, or may be priced out by high or flat fees.

Although VTFs have had only limited success, they are an important step in using ICT to reduce the distance between the producer and the buyer. In many traditional value chains, it is common to have three to four intermediaries between the producer and the final consumer, making the producers' revenue share in the value chain much lower than is often warranted. Reducing the number of intermediaries by even only one or two through VTFs can boost the producers' return if carried out efficiently.

Holistic trading services –

Holistic trading services essentially provide the same services as do pricing information services and VTFs but they offer additional assistance beyond the simple economics of purchasing and buying agricultural products. This assistance can entail services such as weather information, technical information on agricultural practices, and long-term education. These holistic service pack- ages can link not only suppliers and buyers but also parties involved in logistics, transportation, processing and storage.

Often, holistic ICT providers also offer access to financial services (payments, credit, etc.). These holistic types of service can be advantageous for many rural farmers in developing countries, who often have more than one problem or gap. Rural farmers often have many impediments that prevent them from maximizing their agricultural product yields and incomes, such as low productivity resulting from poor use of fertilizer, and lower income because of not knowing prevailing market rates. Packages of holistic services can serve farmers' critical needs more efficiently and from a trusted source. Holistic services can also put more of a "face" to the service package than can offering a simple pricing service, for example, which sends out only static information. Farmers often have follow-up needs and extensive customer service/extension service needs well beyond simple information.

The drawbacks to these holistic services are essentially the same as those for VTFs:

i) large capital outlays; and
ii) the need for a large network to reach the necessary scale for sustainability – this need is likely to be more pronounced for holistic services than for VTFs. Many of the services added on to pricing and trading also require extensive human interaction with the consumers. As there is an almost infinite number of potential add-on services (or VAS), practitioners should take care in planning how many types of service to offer and which services to roll out in the initial stages. Service providers may want to focus on only a few additional services at a time, to ensure that these are highly needed services and to avoid overwhelming the system and staff. Although relatively successful, the famous e-Choupal kiosk system has run into such issues with its *sanchalak* kiosk entrepreneurs becoming overwhelmed by the product offering.

Downstream (and upstream) administration

In the context of this document, downstream administration essentially entails any ICT solution that helps direct value chain players beyond farmer producers – such as input suppliers, cooperatives, bulk/lead-firm buyers, exporters, processors and transport companies – to manage their businesses more efficiently. There are too many types of solution to list here.

Examples include:

- accounting systems for cooperatives, to improve financial management and reduce fraud and errors;

- systems that monitor the level of moisture or temperature for products stored in a warehouse, to avoid spoilage;
- satellite tracking of trucks moving produce from the cooperative to the processor's plant;
- equipment that tests the quality and fat content of dairy products,
- updating a system for calculating payment amounts;
- databases of input suppliers for farmer customer management, such as Kickstart, Kenya's use of Frontline SMS to reach potential farmer customers
- export traceability solutions that track pro- duce through the entire value chain, from farmer to end consumer.

Traceability systems: Traceability is often but not exclusively applied to export markets and entails a system of record keeping and documentation by value chain players that enables tracking of the movement of a product or ingredient throughout the agricultural value chain. Traceability systems should aim to enhance the continuity of information through the food supply chain, making them eminently suitable users of ICT. By establishing a food traceability system, governments and companies can win the confidence of consumers and address documentation requirements stipulated under export trade agreements.

However, traceability requirements can impose a significant burden on players in the value chain, so the hope is that ICT can make data input more efficient and reliable, thereby lowering the cost of compliance with traceability standards. The additional data should also help value chain players improve their businesses in the long run. To minimize complexity and costs, organizations tend to combine high-technology solutions with low technology, such as the simple segregation of sourced products in different containers, ware-house compartments, etc.

Most developing countries have to start with the basics of traceability and overcome many coordination issues resulting from the frequent fragmentation of players within the value chain; many smallholder farmers, governmental agricultural departments, formal and informal processors, testing laboratories, transport companies, warehousing facilities and exporting companiesare involved. To establish a secure traceability system for the food chain, it is necessary to ensure consistent standards not only *within* individual organizations, but also *between* food business operators along the supply chain, from upstream to downstream. When establishing traceability systems for an entire industry, it is also desirable to ensure consistency *among* food business opera-tors who are at the same stage of the food value chain, such as processors or packers.

Critical parameters to be met for a successful traceability project include:

- systems-orientation, in which no documents are issued without interaction with the software;
- ability to review all the previous steps completed, to track the movement of documentation and products;
- inbuilt checks and balances in the software ensuring that the succeeding step can be carried out only when the preceding steps have been successfully completed.

Examples of traceability systems from around theglobe include the following:

- *The Agricultural Produce Export Development Agency of the Government of India* has installed the integrated monitoring software TraceNet to cover all the produce stake- holders in the supply chain with a centralized database. TraceNet is an Internet-based traceability software system, which goes up to the farm level and includes components for monitoring pesticide residue, achieving product standardization and facilitating product tracing back from retail shelves to the farm, using various techniques of sampling, testing, certification and packing. This solution has been successfully used by grape farmers and there are plans to include pomegranates, mangoes and other key fresh produce.
- *The Livestock Identification Trace-back System project of the Government of Botswana* uses radio-frequency identification devices (RFIDs) to capture data on individual cattle, which are transmitted directly and error-freeto a central database. RFID tags are located in the stomachs of more than 135 000 cattle, which can be individually identified and traced throughout their lives. The database helped Botswana's meat export industry obtain EU certification for exports, and is a critical information source for livestock farmers, State veterinary services and healthauthorities.

COMMON ICT PLATFORMS FOR MARKETACCESS ICT SERVICES

Pricing services: For simple pricing service initiatives, the requisite ICT front-end and back-end infrastructure is minimal. Many initiatives use the existing mobile phone infrastructure to deliver services through a specially developed simple soft- ware application that is housed on a user's phone or through even simpler (and cheaper) SMS messages. However, these services are often delivered in parallel via many low-technology channels, such radio, TV and newspaper.

Virtual trading floors: VTFs also often use mobile phones as a delivery mechanism, but need a more sophisticated back-end infrastructure (which is more expensive to set up and maintain) because of the needs for two-way communication and for safeguards to ensure timeliness and security. These systems often require more human resources to serve the users directly and to trouble-shoot.

To eliminate mistakes, these services have installed robust call-center software and hardware. Although still not perfect or ready for scale- up, some providers are now experimenting with voice-enabled systems or IVR in which the user moves through the service with the help of theICT system (which uses the local language), ratherthan having a human operator. Such systems can also help reduce human error, enable those who are illiterate to use the service, and even offer a higher level of security owing to the uniqueness ofeach individual's voice.

Holistic trading services: Because of the diversity of holistic trading services offered, the ICT needs also vary. However, to support many products and services on one platform, the systems for these services need to be far more robust than those for pricing services and basic trading floors. Some may even need to implement an expensive enterprise resource planning system to ensure coordination and communication across the different platforms used. If data needs are high, connectivity and information delivery are critical in the field, where existing infrastructure (even mobile phones) can- not suffice. The provider may therefore need to create infrastructure, such as ITC has done with its e-Choupal kiosks using VSAT connections. These services also depend on strong relationships with and customer service for their users, which cannot all be automated. Holistic trading services therefore require well-informed and always available human resources.

ISSUES AND CHALLENGES FOR MARKETACCESS ICT SERVICES

Up-front investment: Other than simple pricing services and other mono-focused VAS applications delivered over mobile phones, market access services in general require high levels of investment of capital and human resources. Such services are often non-existent or have no infrastructure to build on, necessitating significant capital outlays for development and for acquiring equipment and software. The volumes required for profitability and the security required for gaining user trust also demand significant capital outlays. Providers can overcome these challenges by partnering existing parallel providers, such as MNOs, and using their networks, especially for delivery.

Scalability and viability: Scale determines the viability of market access services. Very few examples of highly successful and profitable market access ICT services at significant scale were found. Many of the examples in this chapter are at the pilot stage and are still being subsidized to some extent. Even the oft-cited e-Choupal has not realized a clear and proven business model. However, while there is no typical business model for information services, there is one for market access services, which generally facilitate transactions and services that farm- ers already pay for, meaning that customers have a clearer idea of the cost and value of the services.

Farmers and other value chain providers have been using the old, low-technology intermediary system for market access for ages. Convincing them to change will take time and require the establishment of a clear value proposition that can be trusted. The intermediaries will fight back to protect their businesses, and the providers of market access ICT service might want to con- sider developing a transitional solution, such as e-Choupal's use of intermediaries as *samyojaks*.If market access ICT service providers can find a way of securing sufficient numbers of farmer and buyer customers, their incremental revenues should eventually exceed the mainly fixed costs commonly involved in such ICT offerings. Once such a service is set-up, expanding into new regions or new products (such as rice versus wheat) will not require much additional capital, as the main system is already in place.

Trying to be all things: While holistic trading ICT services are an intriguing idea as efficient and valued “one-stop shops”, especially for farmers, there are risks involved in this model. One of the primary issues is that new services tend to take on too many initiatives at once – often adding two or three (or more) new services before the first has yet proved successful and viable. Field agents and call center representatives may also become confused by wide-ranging offerings, or be inadequately trained on them. Another risk area is customers’ perceptions of the overall service (i.e., the brand). Customers may become confused by the variety of services being offered, or prefer specialists for the services that are most critical to them. Many holistic service providers are likely trying to offer several services at once to cover the significant fixed costs of creating an entirely new channel and ICT infrastructure. However, rather than pursuing economies of scope by offering many products before the system and brand are proven, providers may consider focusing on economies of scale by taking on the one or two services that are the most important/critical for the most farmers.

ADVANTAGES OF AND OPPORTUNITIES FORMARKET ACCESS ICT SERVICES

Time and cost efficiencies: One of the clearest advantages of using an ICT solution to provide market access services is the empowerment ofthe poor and their potential gains in income from better sales prices and reduced transaction and transport costs. Such services should also reduce the time it takes for all players to conduct transactions, allowing them to spend more time in more productive or personally preferred activities.

Improving the overall value chain: Not only can market access ICT services help improve cost and time efficiencies throughout the value chain, they can also help realize other less tangible but equally important advantages, such as improving the way business is done. These ICT services can help improve trust among players by providing transparency of prices, transaction histories/ reputations and other information. Knowing the person on the other side of the transaction also helps to reduce defaults on trade credit through proper screening and the desire of each player to continue functioning in the market in the long term. Such gains in trust should also help to improve the overall success of transactions in general – delivery, storage, etc.

Smart technology: One of the more encouraging aspects of the examples profiled in this chapter is the use of smart technology. This term is not used in the same way as it is in “smart phones”, which can do seemingly smart things, instead it refers to the appropriateness of ICT for delivering the needed value chain services. The market access services provided through ICT are rarely entirely new – price information provision and buyer-seller brokerage have always existed. So rather than throwing out the low-technology solutions altogether, many of the examples, such as *Soko Hewani* in Kenya, use ICT to complement and strengthen other channels such as radio and newspapers. Not only does this allow markets to transition more smoothly into technology adoption, it also allows time for the technology to improve and yield reductions in implementation and maintenance costs (early adopters often obtain inferior technology that costs more than it would have done if they had waited for a year or two). The examples have also demonstrated that the technology is not the product or service itself (the “what”), but rather the means for end users to obtain that product or service (the “how”). The ultimate goal is therefore not to purchase the best and most expensive ICT solution, but rather to supply services in the most convenient and cost- effective way, regardless of how.

Unit 4: ICT for Financial Inclusion

ICT applications for improving financial inclusion within agricultural value chains have long been pursued but have been elusive, especially when scaling up their use. Other than limited use of personal digital assistants (PDAs – the pre-cursor to smart phones) in the late 1990s and early 2000s, much of the ICT used for financial inclusion in the past was "back-office", focusing on helping financial institutions manage and track the data created from serving thousands of small customers at once. ICT is now sufficiently evolved (and has become less costly) to be more widely used for direct customer interactions.

Many studies have shown that farmers in the developing world can and do use financial services extensively, such as savings groups or local moneylenders, even if no formal or semiformal financial institutions are available. With the help of ICT, formal (i.e., banks) and semi-formal institutions (such as NGO microfinance institutions [MFIs]) can extend their reach if they provide their services in ways that satisfy the primary needs of the rural poor:

i) convenience, such as short distances, appropriate opening hours and low documentation needs;

ii) security, such as a strong brand, good systems and ethical field staff;

iii) flexibility, such as few withdrawal/deposit restrictions and appropriate products that match agricultural cycles; and iv) of course, low cost.

ICT can help satisfy each of these customer criteria by:

- helping financial service providers extend their reach into remote areas, through eliminating the need for full-service branches, which also reduces costs;
- improving access to financial services, by putting more direct control over how such services are used into the hands of local operators/agents or the customers themselves.

TYPES OF FINANCIAL INCLUSION ICT SERVICE

The primary types of financial services offered through ICT solutions for value chains are:

- transfers and payments;
- credit;
- savings;
- insurance;
- financial derivatives.

1. **Transfers and payments**

- ***Transfers:*** The most recognized and successful solutions in the provision of financial services to rural areas are those offering payments and transfers.
  Example-
- The most widely known example, M-PESA in Kenya, began as a service enabling people living in cities to send money back home (money transfers) to their families in rural villages in an easy, trustworthy and low-cost way. The individuals at each end of these transactions typically use their own mobile phone for processing the transfers and visit the local shop for depositing and withdrawing the cash.
- This service type, such as the two examples from the Philippines, does not help improve agricultural value chains directly but facilitates the provision of supplemental income for when the agricultural cycle does not permit income

generation, and therefore creates a safety net for rural farmers and their families. The service is typically called a direct person-to-person (P2P) service. These types of solution are often offered by MNOs rather than banks, as the service is a simple cash transfer, similar to that offered by Western Union. (However, many banks are catching up or partnering MNOs.)

- In recent years, governments have also begun to make transfer payments – government-to-person (G2P) payments – such as welfare, social security and pension transfers to beneficiaries, through these same electronic platforms. Ideally, this new way of transferring monetary benefits reduces costs, improves efficiency and, most important, reduces graft and waste.

- ***Payments:*** While the P2P and G2P transfers mentioned in the previous subsection have been more widespread and successful as supplemental sources of indirect support to agricultural value chain players, ICT-based payment services provide perhaps an even more compelling way of improving agricultural value chains directly.
  These options entail business-to-person (B2P) and person-to-business (P2B) models, with payments from businesses to people/farmers (B2P) or the reverse, from people/farmers to businesses (P2B).
  B2P ICT payment services typically entail a buyer of agricultural products paying a farmer (or group of farmers) for his/her agricultural products. The buyer does not pay in cash but rather through electronic payments that are typically transferred to either the farmer's bank account or to his/her mobile (phone) money account to be withdrawn at ATMs or cash-in/cash-out points – often local retailers. The advantage of such a service is that the buyer does not have to worry about keeping large amounts of cash on hand of about all the related administrative issues and human resources required. Farmers are typically paid much faster, do not have to travel several miles to be paid, and do not have to carry the entire cash amount for a harvest on their person, risking theft, loss oroverspending.
  P2B ICT payment services involve the farmer paying a business, typically an input provider, for the purchase of inputs such as fertilizers and pesticides. There are often two transactions in this process in which the trade or input supplier extends credit (credit is described in greater detail in the following section) to the farmer to obtain the inputs; at the time of harvest, the farmer repays the input supplier using the income earned from the sale of agricultural products (and perhaps obtained through B2P payments). The agricultural product buyer may even coordinate with the input seller/trader so that the input seller/trader is paid before the remaining amount of the payment is sent to the farmer. Such solutions are often completely cashless, meaning that payments are often sent between the buyer's bank account and the input supplier's bank account, using traditional computer terminals and the Internet to conduct the transaction and monitor the many different sales of inputs and related trade credit (i.e., this type of P2B is often really business-to-business [B2B]). The primary advantage of using ICT for P2B payments is the reduced administrative and human resources costs it requires to track and process such payments, which are often relatively small and numerous. Using B2B payments also reduces the chance of default on trade credit.

2. Agricultural credit

For many decades, the use of agricultural credit has been a common response for facilitating rural development. Large credit programmes through governments have often failed, but in recent decades, there has been a significant increase in access to credit from private credit providers, such as input suppliers, lead buyer firms, specialty lenders, MFIs and banks, which all require at least sustainability if not profitability. This trend has encouraged a search for higher efficiency, improved (credit) risk monitoring, and better delivery to farmer and institutional customers; ICT has played a significant part in achieving all three of these aims.

Efficiency: One of the main reasons that financial institutions do not extend their services to remote rural areas is the issue of cost. Running a branch in a rural area and running one in an urban area require (more or less) the same amount of "bricks and mortar", information technology, security and human resources. Many of these costs are fixed in nature. However, the amount of business that can be generated in a rural branch is significantly less, with fewer customers, who often have much smaller transaction needs. This means that (up to a point) it takes the same amount of resources to service 1000 as 2000 clients, and the same amount of time to underwrite and administer a single loan of US$100 as one of US$1000.
ICT can often serve as a way to reduce the effect of these fixed costs even when there are fewer clients, who have small financial needs. First, ICT can increase the number of customers one staff member can serve in the credit underwriting, disbursement and servicing processes by reducing the required paperwork, eliminating entire (unnecessary) steps altogether (such as the need to talk to more than one staff member), and reducing duplication of data entries (e.g., by only having to provide the customer's name once even when there are several "forms" to be filled in). By increasing staff productivity, this can help increase top-line revenue. Second, ICT can reduce costs. Instead of increasing revenue by having more productive staff, the lender can cut back on the staff needed. Other fixed costs can also be reduced, especially regarding the physical infrastructure required. A simple example is that less space is needed for the processing, filing and storage of documents. The IT infrastructure needed can be sophisticated and expensive, such as banks' proprietary solutions with whole IT staff teams and rooms full of secure servers, or simpler (and cheaper) solutions can be used, such as cloud-computing (data storage on the Web) or "off-the-shelf" software.

Credit risk management: In addition to the efficiencies that ICT can generate for credit, technology can also help to improve financial risk management systems that are already in place. The primary risk that lenders face is credit risk, or the risk of default by borrowers. Technology allows lenders to enter data during the underwriting process, using software that can predict the likelihood of default in a short time (e.g., by checking external credit bureau or using the lender's own credit scoring methodology), while individual humans could not possibly do the same without spending significant analysis and data review time. ICT can also enable lenders to know how exposed they are to sub-industries or regions, helping them to avoid overreliance on one group of customers. By completing the menial analysis, ICT also permits lenders' staff to spend more time on the more value-added due diligence activities that technology cannot do, such as reference checks and visual examination of places of business. Post-disbursement, ICT also allows lenders to aggregate and analyse transaction data for monitoring credit repayment trends for the entire portfolio at once and for identifying any individual credit red-flag issues or clustering red flags, including mass defaults in a certain region or within a certain sub-industry such as dairy farmers. A mass default situation can be mitigated by the speed of data transmission. ICT can assist in this by connecting branches/outlets to the central office in real time/ on the same day, rather than having each branch send in monthly paper-based reports, for example. Such data transmission can be done through sophisticated dedicated line transmission or simpler, less costly transmission over the Internet or through mobile phone networks.

Delivery: Efficiency gains and risk management improvements benefit primarily the lending organization, but the end customers can also benefit from their lender's use of ICT. The primary benefit is access to credit that many farmers may not otherwise have, or access to better credit terms from a well-reputed institution (versus depending solely on local moneylenders or potentially exploitive trader credit). Farmers can also benefit from the use of ICT through improvements in delivery, such as door-step delivery (versus having to visit the bank branch) and reduced transaction times (meaning more time in the fields). Farmers can have more control over their finances through ICT such as mobile phones, by being able to check their credit balances and confirming that lenders' staff have registered their repayments.

3. **Savings for agricultural needs**

For farmers, savings can serve two purposes in supporting the agricultural value chain. The first is that accumulated savings can help the farmer to purchase larger ticket items, such as a year's worth of fertilizer or an ox for ploughing. Savings are often insufficient to cover the entire price of the expensive item, but they reduce the need for taking on credit. The second main purpose is as a safety net – a type of self-insurance – for emergencies, such as a sick family member or livestock or floods that wipe out an entire crop and home-stead. Savings are often either set aside when the annual harvest payment is received or generated from supplemental income-generating activities that often take place during the off-season for the main agricultural crop, such as daily labour, vegetable/fruit gardening, dairy milking or even small retail activities.

As described in the introduction of this chapter, the rural poor need financial services to be convenient, flexible and secure. These three key needs are even more pronounced when it comes to the rural poor's own money (and not someone else's money obtained through credit).

The most common ways that rural farmers save – **informal ways** such as in-kind savings and through savings groups – generally meet the first two criteria very well: convenience, through providing the service at or near the home; and flexibility, such as by allowing small and frequent amounts of deposits/ withdrawals. However, the third point, security, is a major constraint in informal mechanisms: money guards may run away with the money; in-kind savings, such as stored rice, may spoil or diminish in value; and money left under the mat- tress may be lost in a house fire.

By either making informal methods more secure, or improving formal financial institutions' convenience and flexibility, ICT can help solve the savings puzzle for rural farmers. In Ghana, for example, traditional *susu* (savings) collectors visit their clients in urban and rural areas daily to collect small savings amounts, returning at the end of the month to hand the entire saved amount back to the client (less one day's savings as the collector's fee). The collectors go directly to the customers, and the customers can choose to save any amount they want (in general). However, customers often do not keep track of how much they have saved and do not have formal proof (or recourse) of the saved amounts. As *susu* collectors are not tied to institutions (or regulations generally), they can easily disappear with the money or lose the savings through robbery.

Example:

- In 2006, Barclay's Bank in Ghana (a bank based in the United Kingdom of Great Britain and Northern Ireland) pioneered connecting susu collectors to the formal banking system; local financial institutions, Fidelity Bank and First Capital Plus (a non-banking financial institution) have reported plans to do the same, while enhancing such interventions by arming the *susu* collectors with mobile phones connected to the financial institutions' MIS for better tracking of funds and transactions and lowered risk of fraud and mismanagement. The *susu* customers will also be able to check their balances on their mobile phones.
- The Cooperative for Assistance and Relief Everywhere (CARE) in East Africa is experimenting with connecting its village savings and loans associations (VSLAs) to the formal banking system. Each VSLA will have a single group account tied to a bank, which can be tracked and managed via mobile phone. Individual VSLA members will be able to send in their savings transaction through a phone. The advantages of these links and use of ICT are that they provide access to additional products from the bank, while the bank aggregates small customers rather than dealing with each individual; reduce the likelihood of theft or loss of savings, which were previously kept in a lock-box; and improve the management and accounting of the VSLA's finances, while reducing the potential for fraud and error.

Instead of making the informal sector more secure, the other option is for formal banks to create their own channels for reaching more of the rural poor in remote areas to provide savings options and other products. This is often called "down-scaling", and can include other products such as credit. The most typical solution is for the bank to use a local person, such as a shopkeeper or post office worker, to act as its legal representative for customer acquisition and service and for conducting transactions that generally involve either cash-in or cash-out from customers' bank accounts. The key to success is often in minimizing the paperwork and the time that the agent must spend going to and from the local bank branch (to deposit or withdraw money).

To do this, most banks employ simple technology, such as point-of-sale (POS) terminals or mobile phones, so that transactions are either instantaneously updated in the bank's core banking system (or a special, parallel system) or uploaded in batches at the end of the day. Transactions are often initiated through the customer's own phone and completed with the agent's phone. This allows the customer to have more control and oversight over his/her account. It also minimizes accounting errors and any temptation the agent may have to use the money she/he has in hand until he/she visits a bank branch. The two most prominent

agent-based bank-led models are in Brazil and India, with many other developing countries, such as Mexico, Pakistan and South Africa, experimenting in such down-scaling activities.
The Brazil correspondent banking model, probably one of the oldest agent banking models in existence, and its use of technology to reach remote areas in the Amazon.

4. **Insurance**

Within financial inclusion, insurance, especially agriculture-based, is significantly underrepresent-ed. This is because of multiple issues that are common to offering insurance in the developing world: frequent and severe weather-related events; lack of reliable historical data; low customer understanding, adoption and renewal; fraudulent claims; and high cost of delivery in remote locations. ICT can help solve many of these issues, especially those of delivery costs, using simple mobile phones and local labour, and customer renewal, through SMS reminders for example. While the timing and magnitude of the risk events cannot usually be reduced, ICT can assist insurance companies in collecting reliable data to help the pricing of policies and monitoring of typical risk events (usually weather- or disease-related), which at least minimizes damage.

ICT use in agricultural insurance (often called microinsurance, depending on the size of the beneficiary) can be importantin two areas:
i) data collection for actuarial and claim verification needs; and
2) delivery of initial and subsequent enrolments, claims processing and other communications with customers, typically covering crop yields, weather, and livestock healthinsurance.

ICT applications can also help the reduction of basis risk, i.e., the risk that the index proxy used to calculate pay-out events and outcomes is not adequately linked to the actual field outcomes. Often, weather indices of average regional rainfall data are used, instead of more precise microclimate data, for example. Some farmers may incur losses and not be paid (discouraging farmer adoption), while others may not incur losses but be paid (discouraging insurance companies from taking on such products).
For data collection, insurance companies need historical data both to help underwrite and correctly price insurance policies for agricultural needs and to monitor current patterns such as rainfall, disease, etc. to prepare for or mitigate a risk event in certain regions. Data are often collected through satellite monitoring or local weather stations, typically run by local governments, which are linked via the Internet or mobile phone networks to pass information back to a central database. Insurance companies monitor and use these data for underwriting and processing claims. ICT can also be used in other innovative ways, such as for improving access to livestock (health) insurance by reducing the costs and risk of fraud through regular visits and data collection.
The advantages of ICT's ubiquity (especially mobile phones) and relative improvements in efficiencies and costs are being used to improve access to insurance and make premiums more affordable. In such examples, the servicing of the customer can often be done at

his/her doorstep (i.e., there is no need to travel to an agent's distant office), and the processing of enrolments and claims can be reduced to a fraction of the time usually taken by insurance companies. Mobile phones often reduce (but do not eliminate) the need for an agent, especially in the claims process, as customers can make the necessary enquiries and post the required information themselves. The use of technology enhances the information available to the insurance companies (reducing risk), helps pool many small customers together to improve the overall risk pool profile (and reduce costs), and reduces human resource needs. Each of these improvements for the insurance companies can translate into price reductions passed on to the end customers, making insurance more affordable. Technology can also help tackle one of the most pervasive problems of insurance in rural areas: renewal of policies. Technology allows the insurance company to stay in touch with the customer throughout the insurance period (often a year) and remind her/him when the time for policy renewal approaches. More important, ICT can facilitate the payment of policy renewals by using accessible technology, such as mobile phones, through a payment system or banking platform, rather than requiring farmers to visit an office and pay in cash. It is necessary to be creative with insurance products and features, as well as for their adoption.

5. **Financial derivatives for financial riskmanagement**

Financial institutions and commodity markets have the capacity to provide more than just the simpler form of one-to-one forward contracts. These players can provide derivative-type products, such as futures, options and swaps, to reduce the risk entailed in price fluctuations (or even weather fluctuations), and do not have to be directly involved in the agricultural value chain. No physical products have to be exchanged at the end of the derivative's time period, whereas forward contracts typically involve the buyers and sellers of products and the actual delivery of products at the end. Farmers could benefit from access to such instruments (with much caution however, as described later in this section) through improved price transparency, a more liquid market (i.e., more buyers) and typically better pricing than what a forward contract can offer. Derivatives also permit flexibility in terms of amount, timing, etc.

For example, a farmer does not have to hedge her/his entire crop, but often perhaps only 40 percent of it. The largest agricultural commodity exchanges are based in the United States of America and China, but many developing countries now have growing and substantial exchanges, such as Brazil, Kenya, India and Indonesia. Many of these exchanges have shifted to an entirely computerized operation with little human intermediation.

Derivatives trading is a prime example of the need for using ICT, as the exchanges are typically based hundreds or thousands of miles from most rural areas and maintain a trading volume that requires the ability to conduct significantly large transactions within fractions of seconds with an almost zero margin of error.

As with insurance, providing such complicated and expensive solutions could be achieved through the use of ICT for value chain development. How- ever, these solutions would be difficult to implement because of their complexity and the need for infrastructure, as well as sufficient size and number of direct transactions involving smallholder farmers. Derivatives can also be extremely dangerous when not fully explained to the users or when used as a way to “beat” the market instead of for risk management. A compelling solution might be to bundle needs through cooperatives, single financial institutions or large lead buyer organizations, creating larger, aggregated transactions, and to use seasoned derivative providers on existing exchanges/platforms rather than creating new platforms.

MCX, the sixth largest commodity exchange in the world, has done something similar for large and small farmers in India (*Economic Times of India*, 2010). Through its *Gramin Suvidha Kendra* programme, MCX provides information for farmers at more than 500 (and growing) post office locations in five states, and provides SMS messages directly to inform farmers and traders ofcommodity spot and futures price movements.

Some of these locations install self-service Internet kiosks to provide the information, and at most locations the local post office worker posts daily prices on a simple black-board (some prices are posted on the electronic notice boards at train stations as well). Farmers benefit from better price information and increased access to finance (using product as collateral) and risk management techniques such as locking in prices on the futuresmarket.

COMMON ICT PLATFORMS FOR FINANCIALINCLUSION SERVICES

ATMs: The most widely known type of customer-facing technology is the ATM. ATMs have long been tested and used throughout the world, including in developing countries. However, most ATMs are concentrated in urban areas as there are common issues with installing ATMs in rural areas in developing countries:

1. although ATMs are less costly than branches, the low volume of business often does not warrant the cost of purchase, installation and maintenance;
2. it is difficult to send people to repair and replenish the ATMs;
3. many ATMs in rural areas are vulnerable to theft and damage; and
4. ATMs require a high level of dedicated, strong connectivity to the ATM network, which many rural areas cannot offer. Encouraging innovations include requiring customers to use only a PIN or their mobile phones to access the ATM, such as Nedbank and M-PESA in South Africa, which avoids the need for a card or even a bank account for remittances/loan disbursements;

Making ATMs smaller, and hence less costly, such as the mini-ATM launched by Financial Inclusion Network and Operations (FINO) and NCR in India (Artha Platform, 2010); and using a hybrid machine-and-human model in which the administrative side of the transaction takes place at the ATM machine and the cash disbursement/deposit takes place at the counter of the shop where the ATM is housed, which diminishes the need for cash management in the machine and makes it less expensive. The potential problem with smaller ATMs is that they can be easier targets for theft. Putting ATMs into retail shops could increase customer volumes for shopkeepers but also make them a more vis- ible target for robbery. ATMs will likely always be part of the solution for improving financial inclusion in rural areas (they also add a physical branding presence), but ultimately they will not be able to replace human interaction needs for customer service.

Computers (desktops, laptops, netbooks and tablets): Computers are often used to extend financialreach into rural areas as they have higher functionality and data retrieval than POS or mobile phones and have generally become less and less expensive over time. Contracted agents often use computers connected to peripheral devices, such as printers and card readers. Computers alsoallow agents to offer other services, such as bill payments and ticket purchases (bus, train, etc.), as the connection is often through the Internet. Banks have been testing mini-branches or "one- person" branches with a small, one-room office or kiosk available for conducting transactions using computers. Laptops and netbooks are portable, which can allow agents to visit customers at their homes or places of business. The primary issue with computers is that they generally need to be connected through phone lines or traditional Internet providers, which many rural areas do nothave. Although prices have diminished over time, computers can still be expensive, especially for agents. Computers also do not allow significant customer interaction.

Point-of-sale (or point-of-transaction) devices: POS devices are among the most commonly used devices for agent banking across the developing world, as the technology for credit and debit card transactions has been implemented in a stable manner for many years. POS devices are also generally much cheaper than ATMs and computers. Most POS devices

allow the keying in of basic alpha-numeric data and the swiping of an ATM or smart card for customer authentication. POS devices are also more flexible in their connections to the financial institution's central system, which can be through the Internet, phone lines, cable, VSAT and, more important, mobile phone net-
works (which are more ubiquitous, often through GPRS). Many POS terminals are very portable and allow agents to roam if needed. However, functionality can be limited by the small screen size. Peripheral devices such as biometric authenticators and printers can be connected to the POS with cables or through wireless Bluetooth/near field communication functionality.

Mobile phones: Mobile phones are increasingly becoming the device of choice for improving financial access in remote areas because of the almost ubiquitous mobile phone networks, even in developing countries, and the low cost of mobile phone devices (many of which can be bought for less than US$30). Mobile phones allow customers more direct control over and interaction with the financial service offered and a way of monitoring their balances and activity outside normal visits to agent locations. Often, even when the customer does not have her/his own phone, he/she will have access to a phone within the household. Mobile phones also allow financial institutions to use agents who may not be able to afford the US$100–200 needed to purchase a POS device.

The major constraints to mobile phone use are limited functionality and user interface, as a mobile phone can display (and store) only so much data. To date, the need has been for solutions that can be provided through low-cost devices (i.e., not smart phones) that do not need to be connected to the Internet to download large data files and applications. This need has led to a higher use of SMS text messaging and Unstructured Supplementary Service Data (USSD) technology, which allows an actual connection between two parties. In general, these methods work because many rural individuals are used to texting, loading phone minutes and using other basic phone capabilities. However, USSD can be somewhat problematic for customers (many of whom are illiterate), who often have to memorize menu choices and/or strings.

A promising technology for overcoming both security issues (remote customer authentication) and illiteracy issues is the use of IVR. IVR can allow any customer to speak (and listen) in her/his language of choice and to
move easily through the choices and the transaction process through voice prompts and verbal menus (even if he/she is illiterate). The system typically requires registration of the person who will access the services, and the user's accent and diction are recorded. Thereafter, when the user accesses the system, user identification is based on speech alone and no PIN numbers are required. In fact, IVR decouples the need for customers to own a phone altogether, as they can use any phone with little risk of divulging too much information or losing security features. IVR is a potentially scalable model as once the infrastructure is in place, updates occur at only the central server, with no significant hardware requirements in the field (not even for peripheral devices) and no software to download. IVR is not yet completely free of issues, as it can have problems dealing with ambient noise, often misunderstands accents and certain words, and cannot resolve unusual customer service needs. It also requires significant investment at the beginning to implement and tai-lor the service and language needs. However, it is a compelling idea that should be closely watched.

ISSUES AND CHALLENGES FOR ICTFINANCIAL INCLUSION SERVICES

Overemphasis on technology: The technology is not the financial product; it merely providesaccess to the needed financial services. In recent years, innovations in finance and access to finance through technology have caused quite a stir. However, publicizing the technology often over- shadows the real purpose, which is just to offer what has always been available in a better way – more convenient, more flexible and more secure.There is a risk in overemphasizing the technology, which can create a bubble effect of too many players focusing on seemingly "easy" routes, suchas remittances through mobile phones. While M-PESA has made great strides in improving rural Kenyans' situations and in innovative financialinclusion in general, it has in some ways done adisservice to the rest of the world. Many playersnow want simply to replicate the same solution.However, the most common issues in improvingaccess to finance in rural areas have very littleto do with technology. Mobile financial services technology has been around for well over a decade.The key solutions are more to do with solvingcustomers' real needs and executing the services both of which are more human-related than ICT-related. First, many institutions now tryingto implement technology solutions for finance in rural areas do not really understand what customers need or where their problem areas are in trying to use financial services. For example, mobile financial services are currently receiving significant attention for extending access to finance in rural areas. While mobile phone availability, cost and connectivity have improved greatly over the years, the use of mobile phones is still often a very expensive proposition for rural inhabitants who use their mobile phones sparingly for important needs. (Often they use a "dropped call" technique to have the other person call them back rather than use even one minute of their talk-time.) Therefore, solutions that require the customer to call in for several minutes, send data files over the network, surf the Internet or download feature-rich applications will simply not be appropriate in many rural settings.

The other human issue relates to execution, which typically has to do with the customer-facingstaff member or agent of the financial institution. These staff members or agents are often too poorly trained, too undercompensated and too short of central office support to be able to serve customers adequately. A focus on customer value and execution would therefore increase the success rate far more rapidly than would worrying about whether the most robust, most secure (e.g., the current overemphasis of biometrics) and up- to-date software is in place.

Lack of scale: As mentioned previously, technologygenerally involves high fixed costs at the beginningwith relatively low maintenance costs thereafter. To serve rural areas with customers whose transactions are for small amounts, the primary way to achieve sustainability is through scale, i.e., having many customers or – ideally – many customers who use the service frequently.

Expensive implementation: Despite improvements in technology and the falling costs, implementing the solutions is still an expensive endeavor.

When financial institutions implement the latest, most robust ICT solutions available they incur two risks:

i) not generating enough revenue to cover the more expensive costs of implementation; and
ii) depending on technology that is not 100 per- cent reliable – new technology is often unreliable and must be constantly modified.

Financial institutions operating in rural areas would still likely do better by focusing on inexpensive, simple ICT solutions that have proved to be reliable.

ADVANTAGES OF AND OPPORTUNITIES FORICT FINANCIAL INCLUSION SERVICES

Lower-cost technology: For the past few decades, technology for financial institutions as a whole has improved dramatically and dropped in cost significantly. Even small Western banks and credit unions can easily operate robust customer data systems, ATM network connectivity, etc. at very low relative cost. With the rise of new technology, such as the Internet and mobile phones, this trend has improved, pushing these innovations within the grasp of not only commercial banks in the developing world but also semi-informal institutions, such as credit unions and MFIs.

Efficiency and innovation gains through higher productivity and lower costs: The benefits of technology for financial institutions include true efficiency gains, particularly for financial institutions operating in rural areas. With the spread of mobile phone networks and other communication infrastructure (e.g., satellites), many financial institutions can communicate with and provide operations in very remote areas. Technology also allows financial institutions to avoid having to place expensive fixed-cost infrastructure – for example, by using connected agents – in rural areas where the potential transaction and custom- er volumes cannot cover high infrastructure and human resource costs. Financial institutions are now able to monitor rural operations effectively to reduce risks, and can also increasingly use the same data to help create new products and tailor old ones to rural needs. Another compelling feature for rural finance is that financial institutions do not necessarily have to provide their services to only one segment of the community, but can serve all community members, regardless of whether or not they are involved in the agricultural value chain. This provides financial institutions with an opportunity to achieve a break-even point and higher revenues more quickly.

Increasing flexibility and control for the customer: Technology in rural financial services has certainly helped the end customers greatly, simply by improving access (e.g., convincing banks to engage even without a branch presence). Equally important, technology has reduced major costs for the end customers, such as by requiring less time for travelling, waiting in lines and processing unnecessary paperwork and by reducing the risky holding of too much cash on hand. However, financial institutions could improve the customer experience by looking beyond lowering costs towards improving access; making solutions more flexible to customers' needs, such as by allowing small, frequent transaction amounts and using an easy-to-use customer interface; and placing more control in the hands of customers. For example, M-PESA did not become an instant success. Early on, most transactions were balance enquiries because customers did not yet trust the system. Once M-PESA had proved that customers' money was safe, the level of enquiries declined, and customers began to use the service more for its intended purpose. This provision of control to customers helped M-PESA gain customers' trust and ultimate adoption.

Unit 5: Overview of Geographical Information Systems (GIS)

What is Remote Sensing?

Remote Sensing is a technology to gather information and analyzing an object or phenomenon without making any physical contact. This technology is used in numerous fields like geography, hydrology, ecology, oceanography, glaciology, geology.

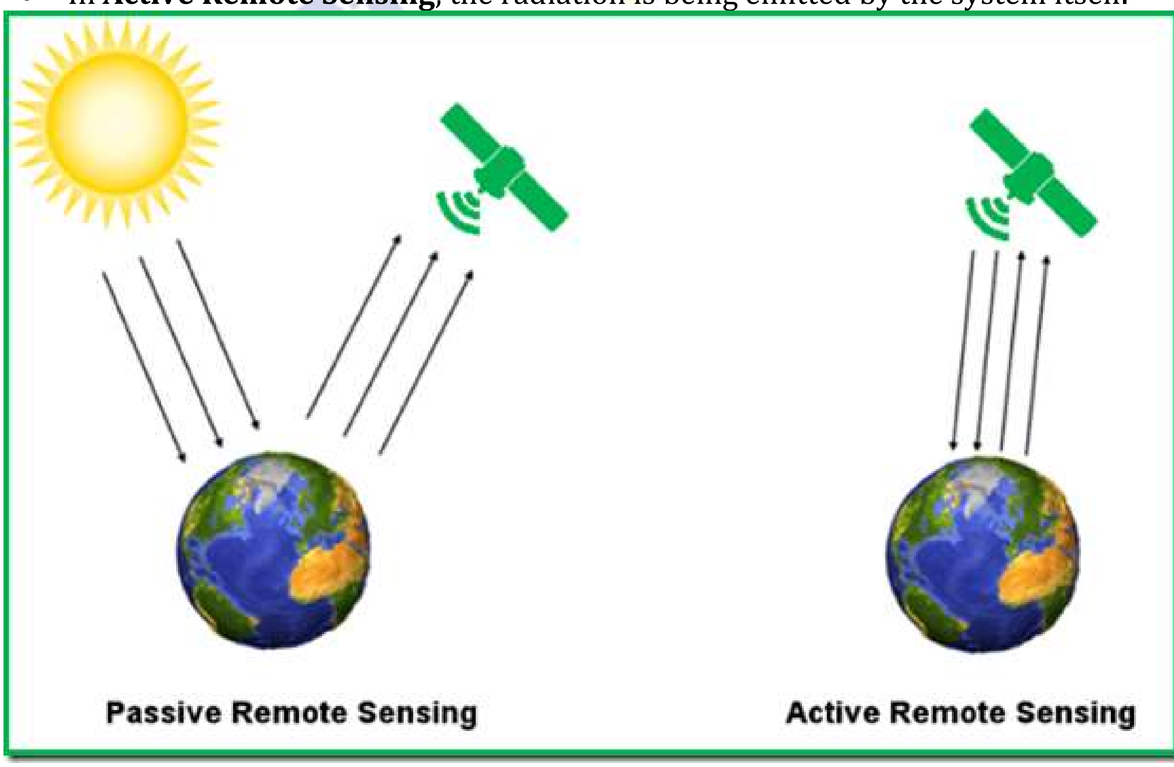
The technical term "remote sensing" was first used in the United States in the 1960's, and encompassed photogrammetry, photo-interpretation, photo-geology etc. Since Landsat-1, the first earth observation satellite was launched in 1972, remote sensing has become widely used.

Essential Elements/ Concepts of Remote Sensing

1. **A target or object**

2. **Electro-magnetic radiation** which is reflected or emitted from an object is the usual source of remote sensing data. However, any media such as gravity or magnetic fields can be utilized in remote sensing.

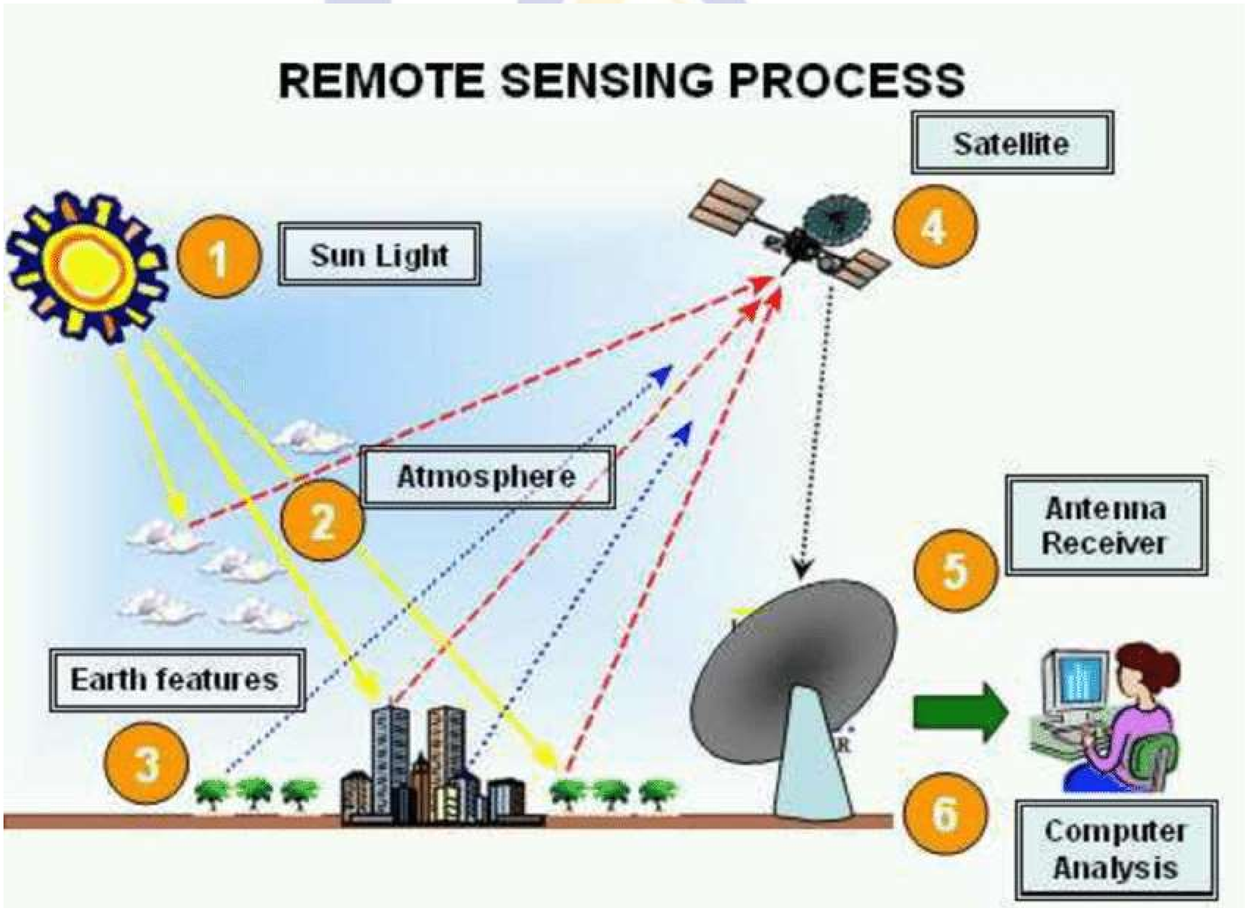
- Usually, electro-magnetic radiation (EMR) is being used as medium.
- In **Passive Remote Sensing**, the radiation emitted by some other source is being used (Commonly Sun is source of EMR)
- In **Active Remote Sensing**, the radiation is being emitted by the system itself.



3. **Remote Sensor/ Sensor:** A device to detect the electro-magnetic radiation reflected or emitted from an object is called a "remote sensor" or "**sensor**". Cameras or scanners are examples of remote sensors.

4. **Platform:** A vehicle to carry the sensor is called a "**platform**". Aircraft or satellites are used as platforms.
   - **Ground level remote sensing**- Ground level remote sensors are very close to the ground. They are basically used to develop and calibrate sensors for different features on the Earth 's surface.
   - **Aerial remote sensing** - Low altitude aerial remote sensing - High altitude aerial remote sensing.
   - **Space borne remote sensing** - Space shuttles, Polar orbiting satellites, Geo-stationary satellites

The characteristics of an object can be determined, using reflected or emitted electro-magnetic radiation, from the object. That is, "each object has a unique and different characteristic of reflection or emission if the type of deject or the environmental condition is different." Remote sensing is a technology to identify and understand the object or the environmental condition through the uniqueness of the reflection or emission.



Why Remote Sensing?

- To recognize macro-patterns which may not be visible from ground
- To gain an OVERVIEW of an area
- To gather information on large areas in short time
- To gather information cost-effectively
- To gather information on inaccessible places
- To replace conventional sources of information (topo sheets, census data etc.)

Advantages of Remote Sensing

- Data can be gathered from a large area of the Earth's surface or atmosphere in short space of time.
- In situ measurements are time consuming and costly over large areas. Remote Sensing is considered as cost effective.
- No sampling bias - consistent coverage of the entire area
- Response of objects collected in different wavelengths
- It has many applications in wide of areas.

Limitations of Remote Sensing

- It is often oversold. It is not a panacea that can be used to collect all types of information for all natural, physical and cultural studies.
- It provides information only about the spectral properties of objects on the earth's surface (and their variation in time and space). We hope that the spectral properties are proxies for the property we are interested in.
- Noise – atmospheric effects, topographic effects, soil/vegetation cover (depending on the application)
- It is often considered an end in itself (the pretty picture syndrome!) Remote sensing should enhance scientific understanding of the system under study.

Applications of Remote Sensing

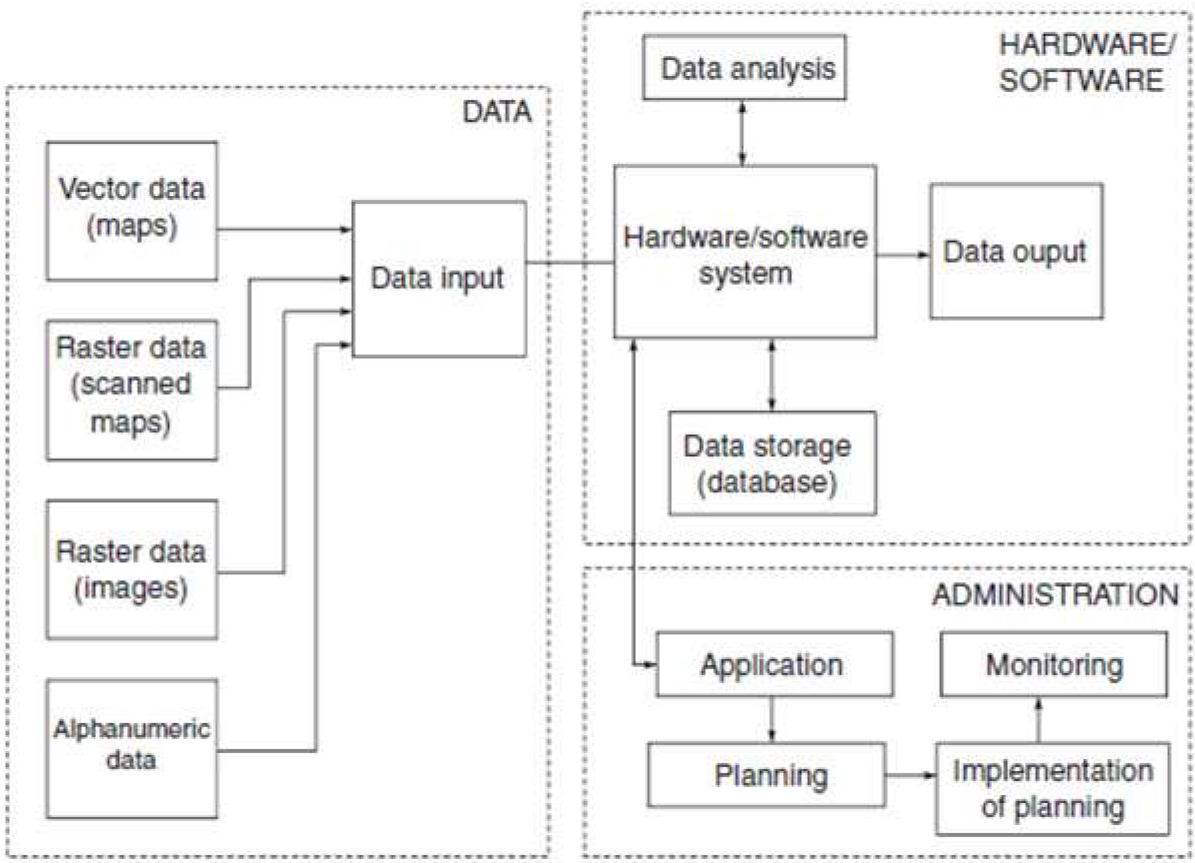
- Military Reconnaissance ν Atmosphere (temperature, precipitation, clouds, wind velocities, concentration of gases such as water vapor, Co2, ozone, etc.)
- Land (tectonics, topography, temperature, soil moisture content.
- Land cover (nature of cover characterizing the type of vegetation, state of its health, mapping man made features such roads, buildings, etc.)
- Ocean (temperature, topography, wind velocity, wave energy spectra and color)
- Cryosphere (snow and ice)

Geographic Information System (GIS)

A **Geographic Information System (GIS)** is a tool that is used for mapping and analyzing feature events on Earth. It is a system designed to capture, evaluate, manipulate, handle, and view all forms of geographical & spatial information and data.

- It helps you to conduct spatial analysis and manage large data and view the data in maps or graphical form for presentation and analysis
- The remote sensing and GIS technology combine major database operations like statistical analysis and query, with maps.
- The GIS manages information on locations and provides tools for analysis and display of different statistics that include population, economic development, characteristics, and vegetation.
- It also allows linking databases to make dynamic displays. These abilities make GIS different from other systems and make it a wide range of private and public remote sensing applications for planning and predicting outcomes from remote sensing satellites.

Concept:



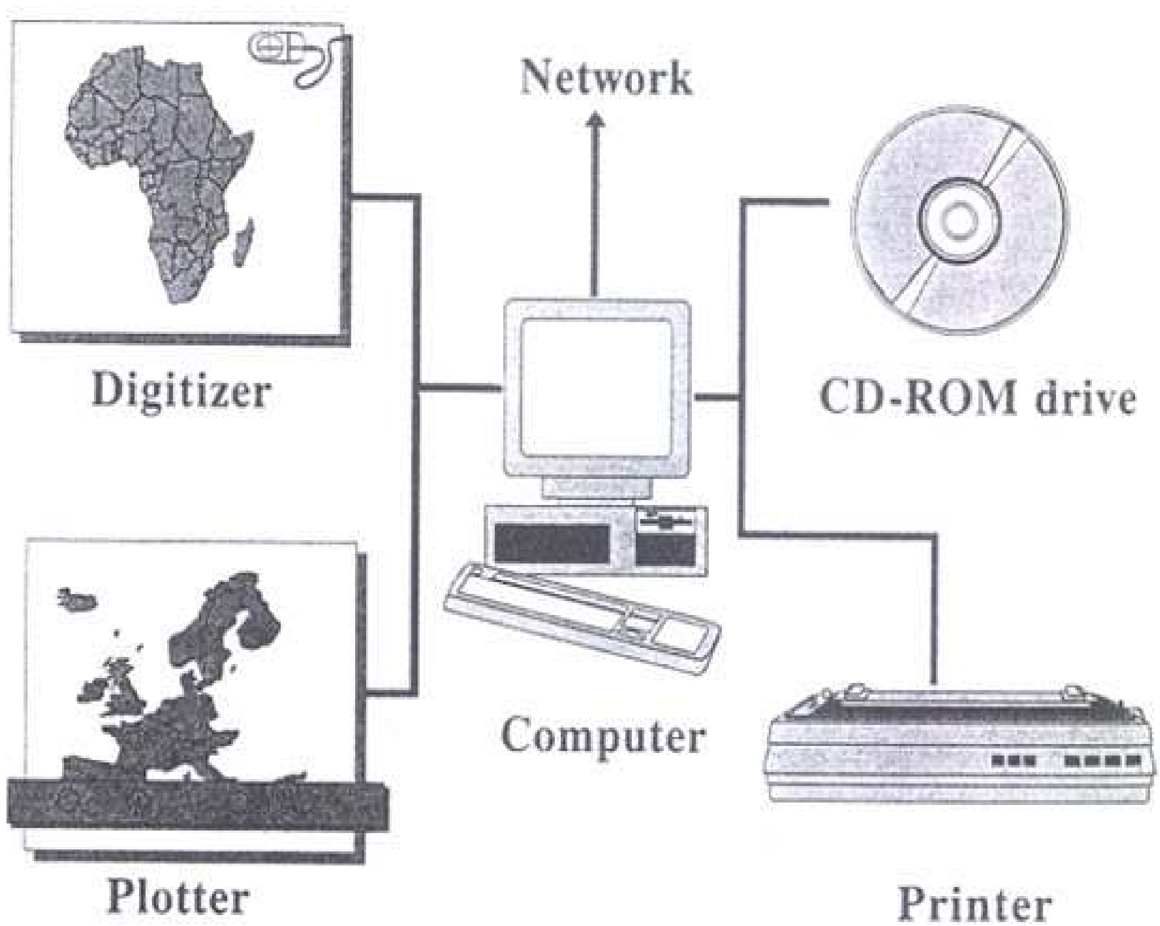
Component:

There are four main components of a true GIS system (Marble 1990). These are:

1. **Data input system**: collects and/or processes spatial data from existing sources such as maps, remote sensing data, images, etc. Data can be "collected" through digitizing, scanning, interactive entry, etc.
2. **Data storage and retrieval**: organizes spatial data and allows for quick retrieval and updates (i.e., editing).
3. **Data analysis and manipulation**: allows for changing form of data, simulation modeling, spatial-temporal comparison, etc.
4. **Output**: displays spatial database and analysis in graphic (i.e., map) or tabular form.

GIS component can also be divided by in this manner:

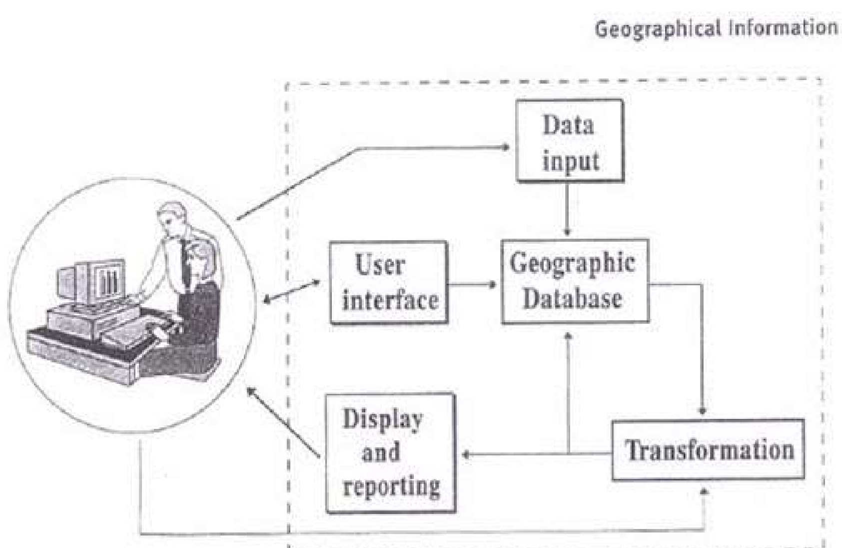
1. **Computer hardware.**



Item	Usage
Hard disk drive	Storing data and programs
Digital tape cassettes, optical CD-ROM's etc.	Storage of data
Digitizer or Scanner	Converts maps and documents into digital form
Plotter, Printer or any other display device	Gives the output of data processing
Local & Global electronic network with either of the following: - Optical fiber data lines - Telephone lines with 'modem'	Provides Inter-Computer communication
Computer screen, Keyboard & mouse or another pointing device	To control the computer and the peripherals such as the digitizer, plotter, printer etc. which are linked to the computer

2. **Sets of application software modules.**
   The software modules can be grouped as follow-

- Data input and verification
- Data storage and database management
- Data output and presentation
- Data transformation
- Interaction with the user



3. **Skilled people to manage it.**

4. **Data**

- **Spatial Data**
  Location or extent of geographic features are stored as spatial data.
  E.g. Location of Taj Mahal, Road Network, Administrative boundaries of States.
  Point (No length No width) Location of Hospital, School
  Line (Length but No width) State highway, National Highway
  Polygon (Length and width) Village, District, State, Nation
- **Non- Spatial Data**
  Attribute data or tabular data.
  E.g. Year of construction of Taj Mahal, length of the Road Network, population of States.

GIS Functional Flow:

Because of the different origins these systems have, it's important to understand each of the functional components of a GIS. Each of the various GIS software packages emphasizes certain aspects of spatial data handling and deemphasizes or omits others. The degree of emphasis placed on development of certain features depends on the marketplace a vendor is targeting. None of the current GIS software packages place their emphasis on the defense community; therefore, an understanding of the basic components of a GIS is needed. Understanding these underlying concepts will help users in their research of the technology and also in the development of applications for the defense community.

1. **Data capture and input processing**

   The first GIS component is Data Capture and Input Processing. In order to successfully implement a GIS, one must have data available for the study area. This includes the acquisition of the data, its digitization, and the appropriate tagging of attributes. Sources may include hard copy maps, existing digital data, imaginary and tabular data. The format, coordinate system, and geographic projection of the data must be known before input into a GIS. One must also be able to generalize the data and select only the amount of data are necessary for a particular project. Digital data take up a huge amount of storage space on computer systems; therefore, the thinning and proper selection of this data is important. Most of the GIS software packages have algorithms and methods to aid in. this process. One must also be aware of the amount of error that exists in the data being used and fully understand its limits and implications in project accuracy. Inherent data errors have been a traditional bottleneck in the development of GIS technology. Research is currently being done to help quantify this error.

   Digital data formats

   "All data that can be mapped have both a location (x,y) and nonlocational (i.e., attribute) characteristics.. These attributes can be both qualitative (e.g., the land use at a location) and quantitative (e.g. the elevation at the same location). In addition, the attributes data location can be monitored through time. These three components location, attribute and time - represent the content of most GIS. This information has to be somehow represented inside the GIS. Map data in this particular format are called digital data, and the process of getting the data into this format is called digitization. Digital data are represented in the computer as large sets of numbers, not as analog images. Two different data structures are commonly used to represent map data inside the GIS: raster and vector representations. Four fundamental types of geographic data have to be stored within a GIS: point lines, polygons, and surfaces. T Raster and vector data representations use different techniques to store points, lines, polygons, and surfaces. These techniques will be discussed because they provide a basis for comparison of the two different types of digital data representations.

2. **Data storage and data management**

   The second functional component of a GIS is the role of data storage and the management of these data. Once the data encoded in their proper digital format, they must be stored in the GIS. Most of the GISs use a database mode to store these data. Today's Geographic Information Systems can use either a hierarchical network or a relational database model to achieve this component. The geographic information is arranged in files of related information, each file being called a layer. Each of these layers can be combined or overlaid upon each other to form new layers. These newly created layers form the basis for geographical analysis and can be queried to answer questions of interest to the user. Each of the attributes associated with this geographic data is stored in the database alongside its data structure and is quarriable.

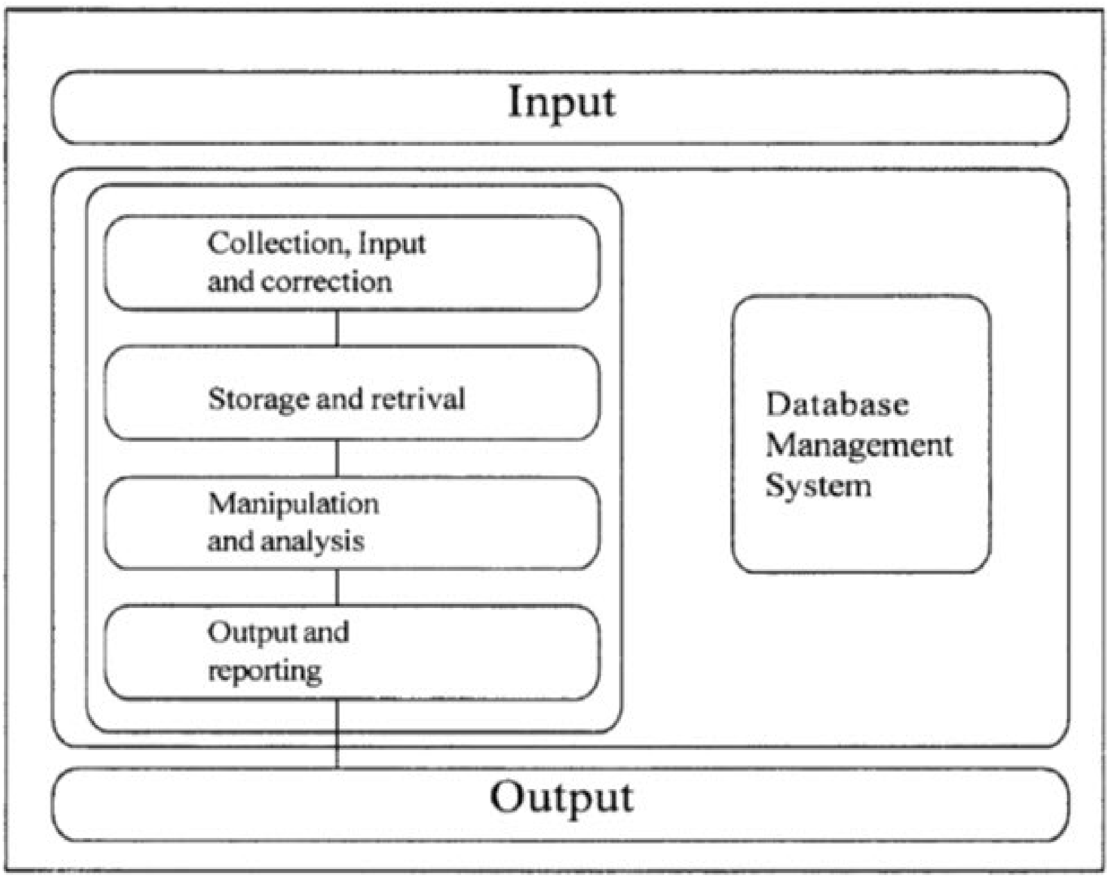
   Since the amount of data needed is usually large, it's recommended that someone interested in setting up a GIS obtain the proper amount of disk storage. With the price of disk space decreasing and the storage capability on each hard disk drive increasing, the space requirements needed for these databases are becoming obtainable. One must always pay attention to the storage capacity demands of both the GIS package itself and the digital data being used for the project.

3. **Data manipulation**

   The third functional component of a GIS is the role of data manipulation. To extract meaningful information from a GIS. database, one must be able to query it and ask logical questions. The leading database model used in GIS technology is the relational database. Relational databases have the ability to join different attribute tables to create new relationships among the data. This concept is important to the GIS in that the geographic data are stored in the database along with its attribute tables, which enhance the geographic data. This relationship helps make all features within a GIS quarriable. When layers of data are combined, the attribute information for this material is carried along and also becomes quarriable. As new information is added to the database and geographic layers are combined among themselves, the newly created geographic and spatial queries aid in performing actual analysis on the data. For example, a typical query could be to find all features of a defined type within a certain area. Another is to find all features that are adjacent to a specified feature. A third is to find all features that are a certain distance from another defined feature. A point and click type query could also be implemented (e.g., point to a road and tell me the attributes that are associated with that road).

4. **Data display and output**

The fourth and final functional component of a GIS is the role of data display and output. All GIBs should include software for this capability and they should provide means for both soft- and hardcopy output. The ability to interface with output peripherals such as wax thermal printers and plotters to be able to produce a map depicting the results of analysis is important to say the least. Report generation and business graphic generation are necessary for some applications. Geographic Information Systems have been found to be lacking in this arena. Tabular data could be imported into desktop publishing packages or spreadsheet packages with little trouble to compensate for this deficiency. Spreadsheet packages could be used to produce graphical output displays such as histograms and time/frequency plots. One should also understand the types of maps he wants to produce when evaluating GIS software packages. Consider this list of maps when deciding what type of output capability, a package has: polygon/choropleth maps, contour/isarithm maps, three-dimension/perspective map and grid-cell maps.

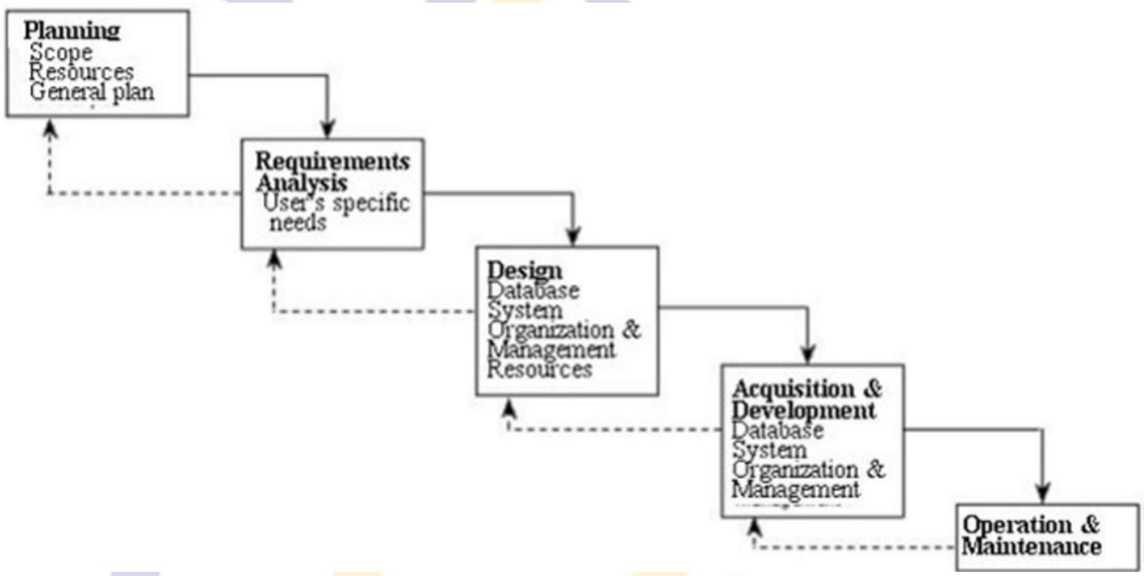


GIS Planning and Implementation Process

GISs can differ greatly, most effective systems are planned and implemented following a structured process that ensures that the GIS ultimately meets the users' and the organization's needs. The GIS planning and implementation process comprises five basic phases:

The process is illustrated in Figure 1. Each component of the GIS is further defined and developed in each successive step. In addition, the process includes feedback loops from each step indicating that information obtained or developed in one step may require backtracking to a previous step to re-examine assumptions or requirements. For example, while performing the cost–benefit analysis in step three it may become apparent that users need to scale back their expectations (step two) or that an larger budget must be established (step one).

Figure 1



1. Planning:

Planning is an important step for any type of GIS. It provides a firm foundation for GIS implementation and operation, and helps avoid costly mistakes. Planning establishes the direction for the GIS. The major aspects that are addressed during the planning phase include:

- **Scope**: The basic nature of the GIS and its role in the organization are defined. This includes recognition of the GIS as a one-time project or ongoing program, the types of applications and users that will be included, how much (if any) integration with other systems and databases will be required, and how the GIS will affect the way the organization does business. The scope, nature, and role of the GIS indicate directions for further planning and implementation activities.

- **Participants**: The scope of the GIS determines who should be involved in its design and implementation. Participants may include users and stakeholders, management and policy makers, the task team that will plan and implement the GIS, and a designated project manager. Also, to ensure that the identified participants can participate effectively in the subsequent implementation steps, adequate GIS background and education is provided, based on individuals' needs.
- **Resources**: Although detailed analysis has not yet been done at this step, the scope of the GIS provides an indicator of the amount and type of resources required. Resources include money, time (in terms of a schedule), labor force, and skill sets. In addition, the scope of the GIS indicates the general types of benefits that can be expected, so it is possible to do a general comparison of benefits to costs. Estimates made at this early stage in GIS planning are necessarily very rough estimates, but help establish basic planning resources and goals.
- **Approach:** Finally, a general plan is developed at this point. Again, the scope of the GIS is the major determinant. It indicates the type of planning and implementation approach that is required. For a small or simple GIS project, the decisions may be obvious and easily made. For larger and/or more complex GISs, more complex planning methods are needed. For example, a simple, single-purpose GIS project that will map resource sites may necessitate only a simple implementation process that is carried out by the end-user. The data and system needs may be straightforward. A multipurpose, enterprise-wide GIS program for a local government, on the other hand, would require a complex planning and implementation process that would aid decision making, and choices from among myriad options. It would also require the involvement of many participants, and often outside assistance.

2. Requirements analysis:

The requirements analysis provides the detailed information necessary for GIS implementation. In this task the future uses of the GIS and the current geospatial data handling situation are examined in analytical detail. Each work process is examined in terms of its purpose or goal, the process steps, the inputs and outputs, the data involved, and the functions performed.

As part of this task, the current geospatial data handling environment and resources are addressed. This includes analysis of the current forms and sources of geospatial data: maps, files, systems, and other sources. The IT environment of the organization, if applicable, is also addressed in terms of how the GIS would fit in. The requirements analysis results in a clear, documented specification of users' detailed GIS needs as well as the organizational support factors. The working products produced include:

- A description and/or diagram of each future GIS work process; including specific data needs and functionality requirements.

- The expected benefits to be derived from each GIS application.

- Any constraints, opportunities, or problems associated with individual work processes.

For a simple GIS project, this analysis may involve only one or two applications. For a large GIS, this process may involve examining dozens of work processes to be performed by hundreds of users.

3. Design:

GIS design is the culmination of the requirements analysis, and often included as the last part of that step. It involves putting all of the requirements together, and designing the GIS components that will support all the users' needs. This task is preparatory to obtaining GIS software and data. In the design task, the key components of the GIS are specified, including:

• **Database**. Data are the most important component of a GIS. Case studies and industry experience indicate that organizations spend the largest portion (as much as 80 percent) of their GIS budgets on data. Database design includes identifying all the data that must be in the GIS, the characteristics of those data, and how they are to be structured and organized in order to meet the users' and the organization's needs. Data modeling is an important component of database design (see also Conceptual Modeling of Geographic Applications).

• **System.** The system components include GIS-specific software and applications, as well as database support, hardware, supporting systems software, and systems integration. Small GIS projects may require only a self contained system, using simple geospatial databases and software. Larger, multipurpose GISs usually involve complex database systems, a suite of GIS software products, specially developed applications, and systems integration. Furthermore, organizations developing multi-participant GISs usually attempt to minimize the number of different GIS software packages that they use in order to minimize redundancy and simplify support. Increasingly, web access to GIS data and applications is becoming an important component of GIS programs.

• **Organization and management.** In addition to the technical database and system components, the GIS design also specifies the management components that will support them. Management aspects include organizational components such as GIS support staff, the GIS labor force for tasks such as data creation, and training. Important management components include data management, system management, and project management for GIS implementation.

• **Resources.** The resources involved in the GIS, as designed, are also detailed at this point. This includes a detailed cost/benefit analysis based on the detailed GIS design, budget, and funding sources, and implementation plans for resource utilization and system implementation

Again, for a simple GIS, the design task may be straightforward. For a large, multipurpose GIS, on the other hand, the design task can be very complex and technically demanding.

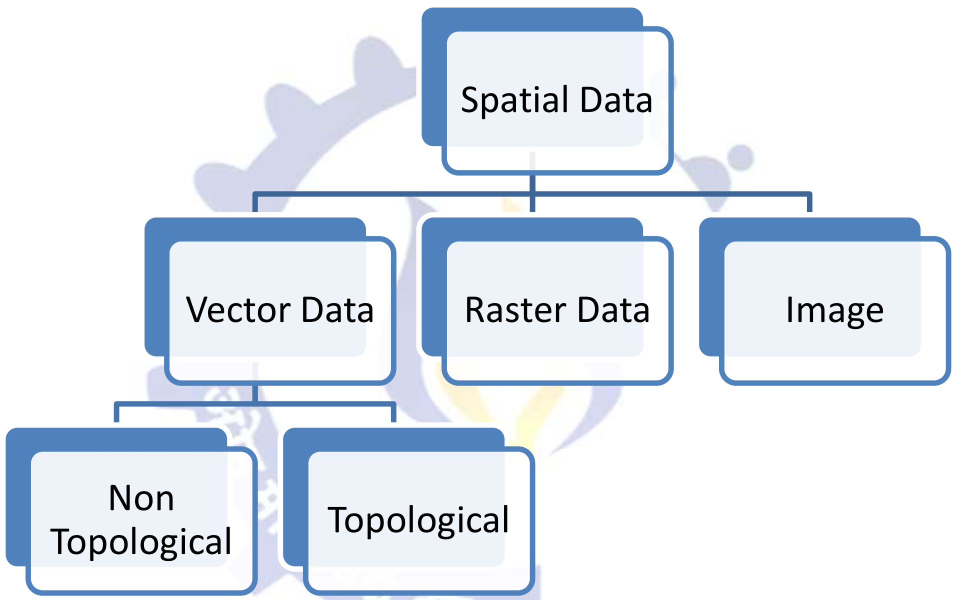
4. Acquisition and development: acquiring system components and putting them together to create a unique system; and

5. Operations and maintenance: putting the system into operation and maintaining the data and the system.

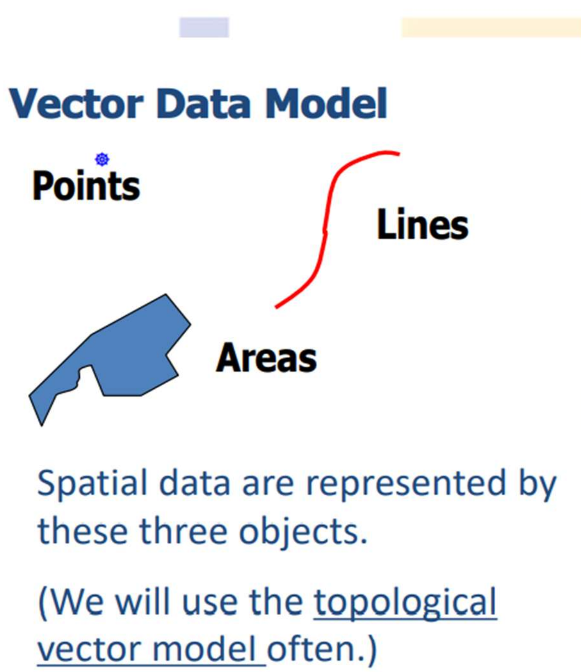
GIS Data Models

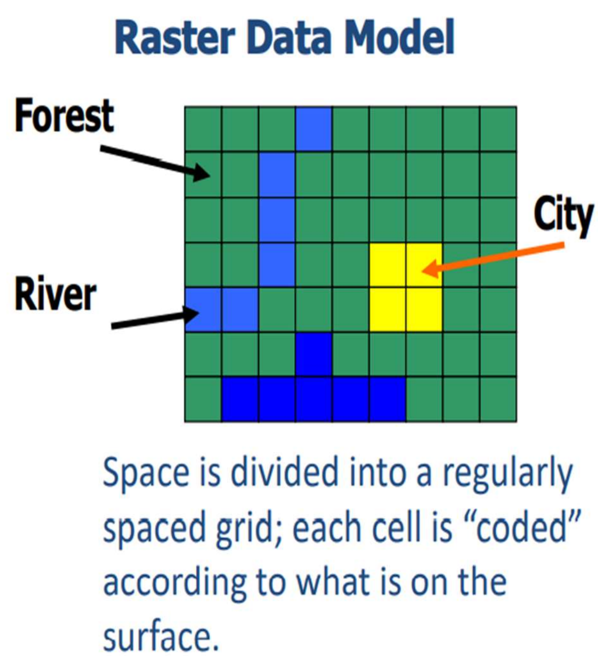
Spatial Data Models

Traditionally spatial data has been stored and presented in the form of a map. Three basic types of spatial data models have evolved for storing geographic data digitally. These are referred to as:



- **Vector**
- **Raster**





• **Image**

Vector Data Formats

All spatial data models are approaches for storing the spatial location of geographic features in a database. Vector storage implies the use of vectors (directional lines) to represent a geographic feature. Vector data is characterized by the use of sequential points or vertices to define a linear segment. Each vertex consists of an X coordinate and a Y coordinate.

Vector lines are often referred to as arcs and consist of a string of vertices terminated by a node. A node is defined as a vertex that starts or ends an arc segment. Point features are defined by one coordinate pair, a vertex. Polygonal features are defined by a set of closed coordinate pairs.

In vector representation, the storage of the vertices for each feature is important, as well as the connectivity between features, e.g. the sharing of common vertices where features connect.

- **Point representations**
  Points are defined as single coordinate pairs (x, y) when we work in 2D or coordinate triplets (x, y, z) when we work in 3D. Points are used to represent objects that are best described as shape- and sizeless, single-locality features. Whether this is the case really depends on the purposes of the spatial application and also on the spatial extent of the objects compared to the scale applied in the application. For a tourist city map,

parks will not usually be considered as point features, but perhaps museums will be, and certainly public phone booths could be represented as point features.
Besides the geo-reference, usually extra data is stored for each point object. This so-called administrative or thematic data, can capture anything that is considered relevant about the object. For phone booth objects, this may include the owning telephone company, the phone number, the data last serviced et cetera.

- **Line representations**

Line data are used to represent one-dimensional objects such as roads, railroads, canals, rivers and power lines. Again, there is an issue of relevance for the application and the scale that the application requires. For the example application of mapping tourist information, bus, subway and streetcar routes are likely to be relevant line features. Some cadastral systems, on the other hand, may consider roads to be two-dimensional features, i.e., having a width as well.
The two end nodes and zero or more internal nodes define a line. Another word for internal node is vertex (plural: vertices); another phrase for line that is used in some GISs is polyline, arc or edge. A node or vertex is like a point (as discussed above) but it only serves to define the line; it has no special meaning to the application other than that.
The vertices of a line help to shape it, and to obtain a better approximation of the actual feature. The straight parts of a line between two consecutive vertices or end nodes are called line segments. Many GISs store a line as a simple sequence of coordinates of its end nodes and vertices, assuming that all its segments are straight. This is usually good enough, as cases in which a single straight line segment is considered an unsatisfactory representation can be dealt with by using multiple (smaller) line segments instead of only one.
Still, there are cases in which we would like to have the opportunity to use arbitrary curvilinear features as representation of real-world phenomena. Think of garden design with perfect circular or elliptical lawns, or of detailed topographic maps representing roundabouts and the annex sidewalks. All of this can be had in GIS in principle, but many systems do not at present accommodate such shapes. If a GIS supports some of these curvilinear features, it does so using parameterized mathematical descriptions. Collections of (connected) lines may represent phenomena that are best viewed as networks. With networks, specific type of interesting questions arise, that have to do with connectivity and network capacity. Such issues come up in traffic monitoring, watershed management and other application domains. With network elements—i.e., the lines that make up the network—extra values are commonly associated like distance, quality of the link, or carrying capacity.

- **Area representations**

  When area objects are stored using a vector approach, the usual technique is to apply a boundary model. This means that each area feature is represented by some arc/node structure that determines a polygon as the area's boundary. Common sense dictates that area features of the same kind are best stored in a single data layer, represented by mutually non-overlapping polygons. In essence, what we then get is an application-determined (i.e., adaptive) partition of space, similar to, but not quite like an irregular tessellation of the raster approach.

  Observe that a polygon representation for an area object is yet another example of a finite approximation of a phenomenon that inherently may have a curvilinear boundary. In the case that the object can be perceived as having a fuzzy boundary, a polygon is an even worse approximation, though potentially the only one possible.

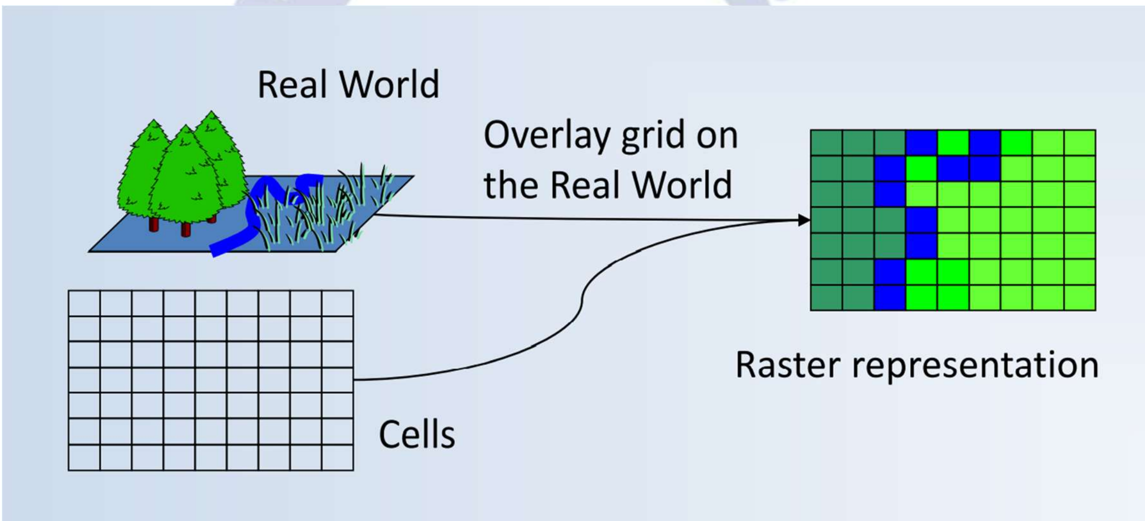
  A simple but naive representation of area features would be to list for each polygon simply the list of lines that describes its boundary. Each line in the list would, as before, be a sequence that starts with a node and ends with one, possibly with vertices in between. But this is far from optimal.

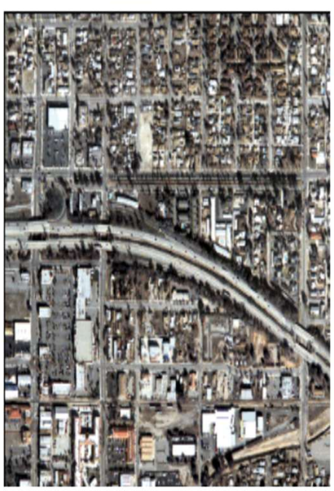
Raster Data Formats

Raster data models incorporate the use of a grid-cell data structure where the geographic area is divided into cells identified by row and column. This data structure is commonly called raster. While the term raster implies a regularly spaced grid other tessellated data structures do exist in grid-based GIS systems.

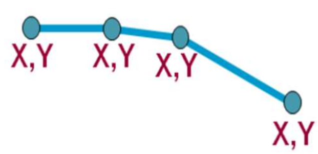
The size of cells in a tessellated data structure is selected on the basis of the data accuracy and the resolution needed by the user. There is no explicit coding of geographic coordinates required since that is implicit in the layout of the cells. A raster data structure is in fact a matrix where any coordinate can be quickly calculated if the origin point is known, and the size of the grid cells is known. Since grid cells can be handled as two-dimensional arrays in computer encoding many analytical operations are easy to program. This makes tessellated data structures a popular choice for many GIS software. Topology is not a relevant concept with tessellated structures since adjacency and connectivity are implicit in the location of a particular cell in the data matrix.

Most raster based GIS software requires that the raster cell contain only a single discrete value. Accordingly, a data layer, e.g. forest inventory stands, may be broken down into a series of raster maps, each representing an attribute type, e.g. a species map, a height map, a density map, etc. These are often referred to as one attribute maps. This is in contrast to most conventional vector data models that maintain data as multiple attribute maps, e.g. forest inventory polygons linked to a database table containing all attributes as columns. This basic distinction of raster data storage provides the foundation for quantitative analysis techniques. This is often referred to as raster or map algebra. The use of raster data structures allow for sophisticated mathematical modelling processes while vector based systems are often constrained by the capabilities and language of a relational DBMS.

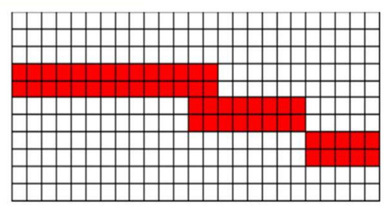




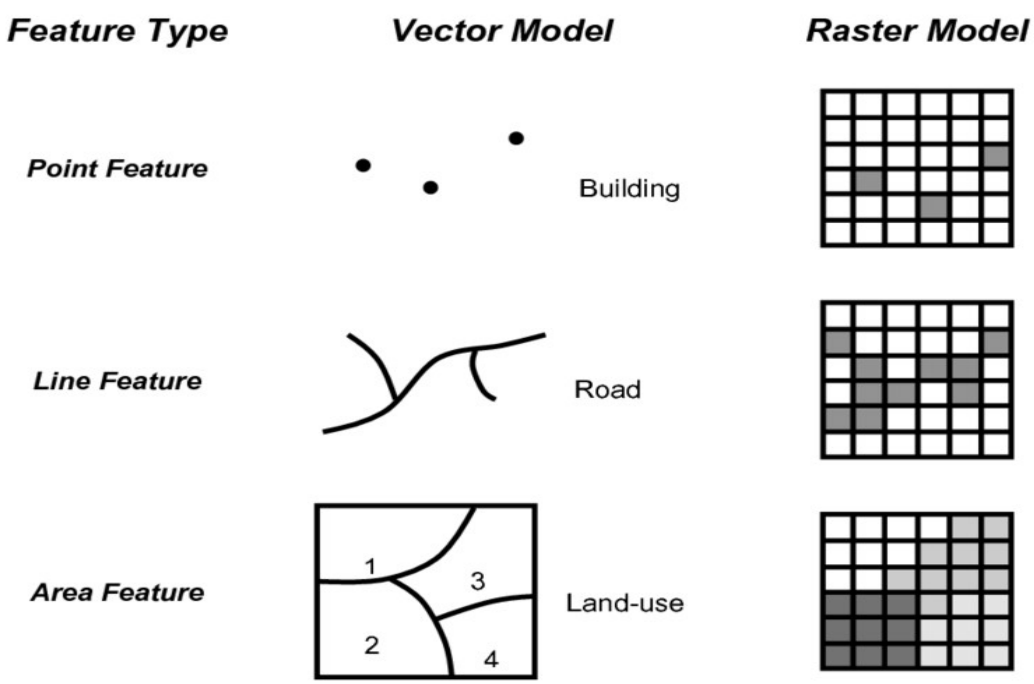
Real world road

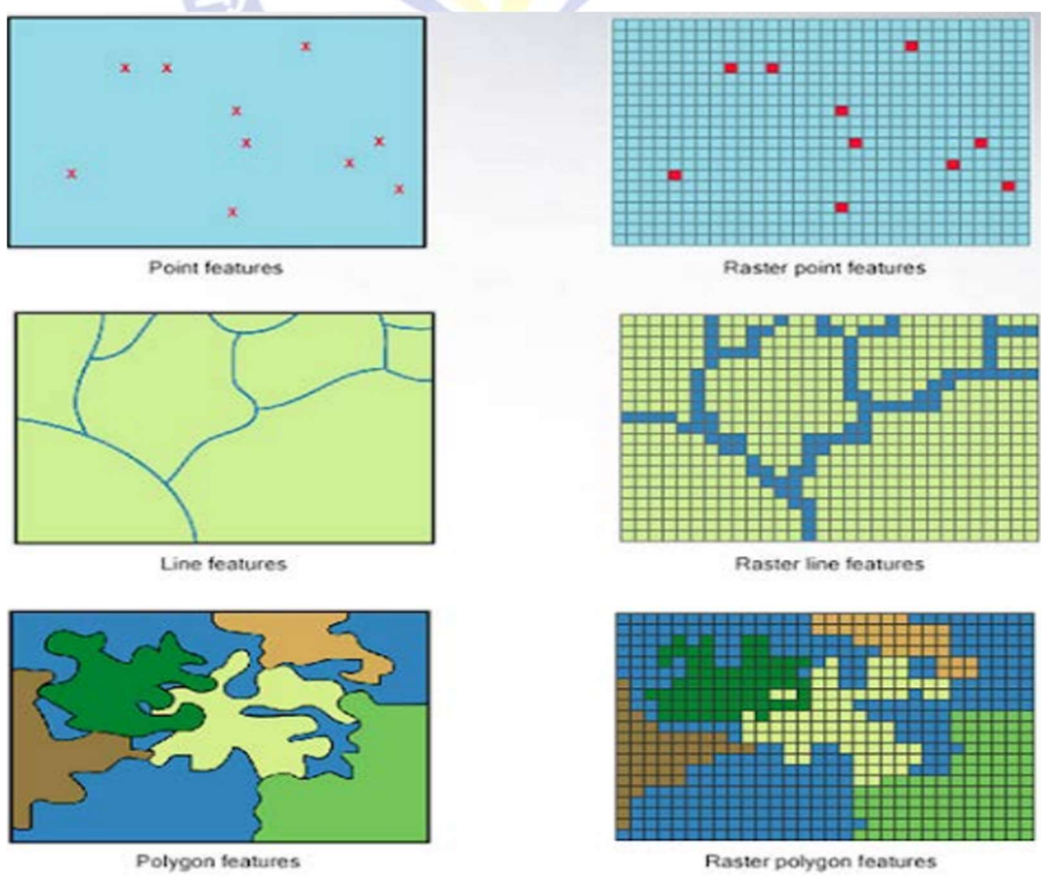


Vector Representation as Line



Raster Representation


Feature Type
Vector Model
Raster Model
Point Feature
Building
Line Feature
Road
Area Feature
1
3
2
4
Land-use


Point features
Raster point features
Line features
Raster line features
Polygon features
Raster polygon features

Integrated applications of GIS and Remote Sensing in Precision Farming

GIS distinguishes itself from the other two technologies in that it enables data from diverse sources to be integrated, analyzed, and even modeled owing to its powerful analytical functionality. These functions, however, cannot be fully realized if the GIS database is incomplete, inaccurate, or obsolete. By their nature, the data contained in a GIS database are either spatial (e.g., administrative boundaries and boundaries of land-cover parcel) or thematic (e.g., types of land cover). Traditionally, spatial data and some thematic data associated with them are digitized from existing topographic or land-use maps. Nevertheless, these maps are secondary in nature. They may not show all desired features because of map generalization. Second, topographic or land-use maps may be obsolete due to rapid changes on the ground. These limitations can be overcome with the use of remote sensing and/or GPS. Aerial photographs and satellite images are original and are able to offer more current areal-based data than do topographic and thematic maps, while GPS is an efficient method of collecting data in a timely fashion.

GIS and GPS are intrinsically complementary to one another in their primary functions. Each of the technologies has its limitations. Only through integration can their strengths be fully utilized. Integration will not only ease their applications in resource management and environmental monitoring (e.g ,pest incidences, hot spots), but also broaden the scope to which they are applicable (e.g., real-time emergency disease response and early warning mechanism). As a matter of fact, the integration of GPS, remote sensing, and GIS in combination with ground monitoring systems has proved to be an efficient method of managing, analyzing, and outputting spatial data for regional water resources management. Such integration is indispensable in devising an effective approach for selectively applying pesticides and fertilizers to improve farming efficiency and reduce environmental hazards.

Spatial Decision support system (SDSS):

An integrated system with the three technologies leads to an intelligent system which is designed to help policy planners, farmers to solve complex spatial problems and to make decision concerning the pest management, hotspots identification, niche areas identification for disease outbreaks, irrigation, fertilization and other chemical usage. The traditional DSS models like DSAT, Info crop models provide the crop simulation scenarios. These models help the policy makers to finalise the farm practices. Just for instance varying the fertilizer dose, irrigation schedule and time of sowing, the scenario can be simulated and the best variety can be opted for better yields. The marginal yield response can be obtained by describing the yield response to the level of particular input. Integrating the Spatial aspect to the traditional DSS leads to much more intelligent SDSS which can now overlay all the thematic base line spatial datasets. Here user can identify the agro ecological zonation and the parameters can be automatically fed into the system which now only requires minor modification in the inputs like fertilizer dose, irrigation timing, variety selection etc. and high yield scenarios can be simulated. The SDSS provide the spatial data input to teh system. It allows the storage of complex analytical structures that are unique to spatial analysis.
SDSS provides a framework for integrating:

1. Crop modelling capabilities
2. Database management system
3. Policy makers expert knowledge
4. Map based outputs.

Crop Growth stages:

The three technologies discussed above can be used to monitor the crop growth. The maturity period, crop stresses such as nutrient and water stress, disease, pest and weed infestation can be identified by using Remote Sensing and GIS. Information gathered via different sensors and referenced using GPS can be integrated to create field management strategies for chemical application, cultivation and harvest.

Weed Insect and Disease infestation: Mapping of hotspots for disease infestations is something like a post disaster management which is carried out when crop is almost destroyed. GIS and Remote Sensing in integrated form provide a solution where mapping for the disease incidences can be carried out. Once mapped the experts can actually understand the causes which led to the crop infestations. Mapping the disease occurrences areas it can be spatially integrated with the agro ecological zones which can help in making simulating the other hotspots for similar infestation in future. This is the one of the major advantages of the GIS and Remote sensing it not only provides maps but its analytical tools can be used to simulate and provide the farmers with the early warning system.

Soil fertility, Micro and Macro nutrients:

GIS and Remote Sensing are layer based systems. This system provides the user with the flexibility of overlaying the various real world layers and finding the best model for précising the agriculture practices. The mapping of soil status as evident from the latest on-going National level projects where the soil sampling have been carried out. A national level datasets is being generated at village level scale. Mobile soil sampling units being run by National and State level Govt. not only conduct the soil test but also take sampling coordinated on the GPS . These datasets are then maintained at state level spatial inventory. An interpolated surface can be generated for soil type keeping in view the terrain, slope and aspect in hilly areas. Soil mapping once done can be used for simulating crop yield with different sets of varieties and other agriculture inputs.

Precision conservation:

The agricultural practices in hill terrain not only face the topographic limitations, but also the scarcity of natural resources available for irrigation. Since most of the area in Himachal is totally rain-fed and there is very sources for irrigation in the form of rivers, or natural wells. In order to improve the crop yield , there is always a competition between the farmers. The stake holders always have to manage in the limited resources which ever are available and most of the farmers relies on the monsoon for better cultivation. GIS plays a very important role in identifying the potential sites for irrigation. Using the GIS and remote sensing technology experts can provide the location where the farmers can make use of natural slopes and use the same for retaining water in the form of water storage tanks or rain harvesting tank. With the help of the of GIS intervention farmers can set up new channels for irrigation. The steep gradient in the terrain need such technology for identifying potential sites for trapping ground water as well as run-off water during rainy season.

Climate suitability and crop suitability:

New RS multispectral and hyperspectral sensors are swiftly generating vast amounts of data in a cost effective manner and at higher spatial and spectral resolutions. Hyperspectral and multispectral images, consisting of reflectance from the visible, near infrared and mid-infrared regions of the electromagnetic spectrum, can be interpreted in terms of physical parameters (such as crop cover, crop health and soil moisture) and are useful for operations such as stress mapping, fertilization and pesticide application and irrigation management

Global Positioning System

GPS is a Satellite Navigation System. It stands for Global Positioning System. GPS is funded by and controlled by the U. S. Department of Defense (DOD). While there are many thousands of civil users of GPS world-wide, the system was designed for and is operated by the U. S. military. GPS provides specially coded satellite signals that can be processed in a GPS receiver, enabling the receiver to compute position, velocity and time. Four GPS satellite signals are used to compute positions in three dimensions and the time offset in the receiver clock.

Here we will mostly focus on the NAVSTAR, the mostly available and used system. GPS consists of mainly three segments, these are

- **Space segment (the satellites)**

  The space segment (SS) is composed of the orbiting GPS satellites, or Space Vehicles (SV). It consists of 24 satellites (21 active plus 3 operating spares), eight each in three circular orbital planes. The satellites are manufactured by Rockwell International, which are launched into space by rockets, from Cape Canaveral, Florida. They are about the size of a car, and weigh about 19,000lbs. This was modified to six planes with four satellites each. The orbital planes are centered on the Earth. The six planes have approximately 55° inclination and are separated by 60° right ascension of the ascending node. This constellation ensures that there will always be at least 4 satellites above the horizon at any location on the surface of the globe.

- **Control segment (the ground stations)**

  The control segment is composed of

  1. A master control station (MCS),
  2. An alternate master control station,
  3. Four dedicated ground antennas and
  4. Six dedicated monitor stations

- **User segment (user and their GPS receiver)**
  The user segment just consists of the user and his GPS receiver. It is composed of hundreds of thousands of U.S. and allied military users of the secure GPS Precise Positioning Service, and tens of millions of civil, commercial and scientific users of the Standard Positioning Service. In general, GPS receivers are composed of an antenna (Internal or external), tuned to the frequencies transmitted by the satellites, receiver-processors, and a highly stable clock (often a crystal oscillator). Generally, they also include a display for providing location and speed information to the user. A receiver is often described by its No. of channels: this signifies signals' from how many satellites it can process simultaneously. Originally limited to 4 or 5, this has progressively increased over the years so that, as of year 2007, receivers typically have between 12 and 20 channels.

How GPS Works

Calculating Location
The basis of GPS is 'triangulation' from satellites also called trilateration. To 'triangulate', a GPS receiver measures distance using the travel time of radio signals. To measure travel time, GPS needs very accurate timing, which is achieved through some tricks. Along with distance, we need to know exactly where the satellites are in space.

Trilateration
Trilateration is a process that uses distance from at least three known locations to determine position. GPS receivers calculate the position of objects in two dimensional or three dimensional spaces using a mathematical process called trilaterlation. Trilateration can be either two dimensional or three dimensional. Let us examine how 2-D and 3-D trilateration work.

- **2-D Trilateration**
  The concept of trilateration is easy to understand through an example. Imagine that you are driving through an unfamiliar country and that you are lost. A road sign indicates that you are 500 km from city A. But this is not of much help, as you could be anywhere in a circle of 500 km radius from the city A. A person you stop by to ask for directions then volunteers that you are 450 km from city B. Now you are in a better position to locate yourself- you are at one of the two intersecting points of the two circles surrounding city A and city B. Now if you could also get your distance from another place say city C, you can locate yourself very precisely, as these three circles can intersect each other at just one point. This is the principle behind 2D trilateration.

- **3-D Trilateration**
  The fundamental principles are the same for 2D and 3D trilateration, but in 3D trilateration we are dealing with spheres instead of circles. It is a little tricky to visualize. Here, we have to imagine the radii from the previous example going in all directions, that is in three-dimensional space, thus forming spheres around the predefined points. Therefore, the location of an object has to be defined with reference to the intersecting point of three spheres.

GPS use clocks and trilateration to determine position. The satellite vehicles (SV) and receiving units both contain highly accurate clocks. Part of the information that the SV transmits is a time stamp. When a GPS unit receives the transmission, it compares the time stamp from the satellite to the time it reached the receiver. The difference between the two is multiplied by the speed of the transmission signal p the distance that the signal traveled.

Micro Planning

- Micro planning is essentially participative, people – centered (target groups) based on informed judgment.
- Micro-planning, in this sense, goes down further than the grass grass-root formal structures to involvement of community groups / affected people / target groups / interest groups etc.
- Micro Planning may be taken up for an area, a community, a group, an individual or for a specific scheme.

Participatory planning

- Participatory planning refers to planning where all stakeholders – beneficiaries, technical staff, donors and policy makers – come together to discuss and agree on an action or strategy.
- Participatory planning is a set of processes through which diverse groups and interests engage together in reaching for a consensus on a plan and its implementation.

Objectives of Micro Planning

- To mobilize the local community to prepare village level plans
- To provide support system to the project so that the project becomes feasible
- To ensure that all affected households are taken care off
- The major objective of micro planning is not on issues pertaining to allocation of resources but on issues pertaining to better use of resources, which are already allocated to community / settlement / village

Some Important Features of Micro Planning

- Micro planning is not a one shot exercise. It is a continuous process and it unfolds itself in the process of implementing the micro plan. It should, therefore, be flexible
- The object and subject of micro planning is local people. Micro planning, therefore, has to be taken up by along with local people
- Micro planning requires less of technical skills but more of social skills. How to interact with the community for a common cause? How do we deal with the existing social hierarchy in a given areas and how do we pool them together

Who is involved in Participatory Planning

- Effective participation calls for the involvement of all stakeholders including Communities, Local Panchayati Raj institutions
- Civil Society Organisations (CSOs) including Non-Governmental Organisations (NGOs) -Community Based Organisations (CBOs) and – members of the Private Sector.

Principles of Micro Planning

- Increase the involvement of local people (target groups affected people etc.)
- Learning from and sharing with the common people using local classification and terminologies
- Adopting informal approach, that is flexible, amenable to change / alterations / amendment to suit changing circumstance or as we progress along
- Be sensitive to local customs / traditions / conventions practices
- Consider whole range of possibilities and select the one that is considered best by people

Some useful participatory Methods for Micro Planning

- Problem Analysis
- Stakeholder analysis
- Objective analysis

Assignments:

- Issues and Concerns in Land and Water Management, The GIS Approach.
- GIS Applications in micro resource mapping,
- modeling in resource mapping
- GIS Technology trend and next generation Systems.