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RESEARCH ARTICLE :

Development of a geographic information system based farmer advisory system: Case of Randheja Village, Gandhinagar

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SUMMARY : GIS and remote sensing techniques have been operationally used in many countries to provide basic information on crops, soils, water resources and the impact of drought and flood on agriculture. The main users of crop maps and yield forecasts are the government officials, agribusiness, extension personnel and farmers who have considerable interest to assess the demand, anticipate prices and plan the use of resources. The study has been conducted with a view to understand the present situation of the cropping area, the prospects and problems of Randheja village, Gandhinagar Gujarat and develop a GIS map to help the extension worker and farmer get the crop information on a single mouse click over the map.

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KEY WORDS :
GIS, Agriculture advisory system, Farmer, Information technology

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BACKGROUND AND OBJECTIVES

We being in the present generation of modernization and information technology have a sense of responsibility and realization regarding sectors such as agriculture and allied sciences which are purely based on traditional system of production and management. Agriculture in India is considered as the major occupation of the masses, providing sources of livelihood and income, but there is a need for the improvement in the technology to have healthier production and income. To keep up with the demands of the ever increasing population it is necessary to develop technologies which can retrieve, process and disseminate information in an effective and reliable manner at the fastest pace possible. The rapid development of the information and communication technologies will play a very vital role in the development and progress of any organization or nation.

Earth functions as a complex system and existing infrastructure and methodologies are inadequate for the community to address the problems of the system. It requires an integrated and innovative approach to analyse, model and develop extensive and diverse data sets. Currently there is a chaotic distribution

of available data sets, lack of documentation and methodologies, lack of easy to access tools, computer modelling etc. Geo informatics is a rapidly developing science which encompasses all modern tools and techniques like remote sensing, GIS, GPS, photogrammetry along with computer modelling to systematic data storage, analysis and retrieval for research as well as for documentation to bring out relevant information and advancements in various fields. Geographical, earth sciences and agricultural sciences rely increasingly on digital spatial data acquired from remotely sensed images, analyzed by GIS and visualized on the computer screen or paper. Significant technical advances have been made in measuring and displaying variation in crop yields across a field, but it is not always clear how to determine the best management practice for each part of a field in order to achieve a particular goal. Several ways are being explored in which crop models can be used to determine relationships between yields and levels of inputs. The farmers may use the various crop simulation models for the selection of the cultivar/soil type combination, planting date, row spacing, irrigation scheduling harvest timing and yield prediction.

Review of applications of GIS in Agriculture and allied sectors :

Bhatia *et al.* (1994) and Bhatia and Prasad (2003) have used the spatial statistics in studying the large field variability in hilly and salt affected regions.

Ahmed *et al.* (2003) have developed a suitability index for potential agro-forestry areas in Yamunanagar district of Haryana using the "Spatial Analytical Hierarchical Process (Spatial AHP)".

Singh and Elamaithi (2003) have generated the fertility and yield contour maps using ARC INFO under the project entitled *Development of Site Specific Management through PF Technologies in Rice Wheat Cropping System* at Allahabad Agricultural Institute, Allahabad.

Dixit *et al.* (2004) carried out an exercise to find the soil suitability criterion for coffee plantation (variety *Coffee Arabica*) in Paderu Mandal of Vishakapatnam District of Andhra Pradesh. For the present study "ERDAS Imagine" version 8.4 was used to process the satellite data and apply GIS techniques.

Cluster analysis can be usefully employed in classification of field plots into different categories based on data on several characteristics. Nigam *et al.* (2004) have used cluster analysis in the preparation of fertility contour maps using the uniformity trial data. The fertility maps and yield contour maps were generated using "Smart" yield mapping software, ARC GIS etc.

Objectives :

The objectives of the study are :

– To study the various cultivation patterns of the crops in the village and underline their requirements.
– To develop a system that contains all the necessary information about the crop growth and yield in the form of a geo database where in the data is displayed in a tabulated format at the point of a single click.
– To provide consultancy services based on specific needs of the farmer regarding agricultural activities.

Location of the study :

The study was conducted purposively in Randheja village under Gandhinagar tehsil, Gujarat during January – May, 2009. The study mainly focused on providing a database to the farmers regarding the crop situation, the necessary steps to be taken, and preventive measures to be followed over a seasonal period.

Data collection :

Secondary data on parameters like crops grown, soil structure, weed and pest management, disease management, rainfall, temperature and the over-all crop growth were collected from BISAG (*Bhaskaracharya Institute for Space Applications and Geo-Informatics)* and primary data on the most frequently asked questions about cropping were asked from the farmers using a structured questionnaire. A geo database and GIS maps were generated for the village which provides information on the spatial location of the village (latitude and longitude), crops grown, varieties, grown, soil status, weed management, pest and disease management, time of harvest and yield on a single mouse click.

RESOURCES AND METHODS

Requirement analysis for database development :

A requirement analysis was carried out involving experts in agriculture and database management. A review of the existing databases, identification of data needs of the farmers and the extension personnel, identification of data sources, data availability and storage level were made. Thematic maps to be generated using

Table A : Data structure of crop production and management in agricultural crops

Item	Parameter	Data fields	Data type
General information of the crop			
Name of the crop	General information	Crop_Sc_Name	Text
		Crop_Origin	Text
		Crop_Genus	Text
		Crop_Family	Text
		Crop_Order	Text
		Crop_Species	Text
		Crop_Image	Image
		Crop_Description	Text
		Gen_Sutability	Text
		Season	Text
		Imp_Varieties	Text
		Other_Info	Text
Information on varieties			
Name of the crop	Varietal details	Var_Code	Number
		Var_Name	Text
		Var_Duration	Text
		Var_Description	Text
		Var_Image	Image
	Soil requirements	Soil_Reqt_Code	Number
		Soil_Reqt_Name	Text
	Climate	Climate_code	Number
		Climate_Name	Text
	Season	Season_code	Number
		Season_name	Text
	Other details	Pest_resistance	Text
		Disease_Resistance	Text

Table B : Data dictionary report of crop production and management

Field name	Data type	Size	Description
Crop_Code	Integer	10	Crop_Code
Crop_Sc_Name	Text	50	Crop_Sc_Name
Crop_Origin	Text	100	Crop_Origin
Crop_Genus	Text	20	Crop_Genus
Crop_Family	Text	20	Crop_Family
Crop_Order	Text	20	Crop_Order
Crop_Species	Text	20	Crop_Species
Crop_Image	Image	20	Crop_Image
Crop_Description	Text	255	Crop_Description
Gen_Sutability	Text	50	Gen_Sutability
Season	Text	15	Season
Imp_Varieties	Text	50	Imp_Varieties
Other_Info	Text	100	Other_Info

Table C : Crop details

Crop	Variety	Seed rate (kg/ha)	Soil type	Soil Nutrient (N,P,K) kg/ha			Water requirement (mm-ha)	Temperature (degree Celsius)
Paddy	Jaya Guj 17	80	Saline and alkaline soils	100-150	30-60	25-27	1190-2650	20-35
Cotton	Cotton HJ 6,8,9	5	deep alluvial soils	59	18	60	900-1200	21-27
Chillies	Guj 1	1	Sandy loam soils	24	16	24	850-1200	20-25
Bajra	MH 169	4-5	Loamy soils	60	40	90	400-750	28-32
Wheat	GW 496-503, 173	100-125	Alfisols, vertisols	120	60	40	250-1800	16-25
Mustard	Guj 1		light loam soils	131	26	133	250-400	20-35
Castor	GCH 2,4	5-6	shallow sandy loams	50	20	16	600-700	20-26

Table D : Crop protection measures

Crop	Herbicides	Pests	Pesticides	Diseases	Fungicides
Paddy	Butachlor (1.5kg a.i/ha), Pentilachlor (0.6kg a.i/ha)	Brown plant hopper	thiomexiam, carbaryl 3gm/l	Blast	thiram/captan 2.5gm/lit
		Hispa	phosalone 2ml/l	brown spot	mancozeb 2-3gm/kg seed
		Stem Borer	Cartap hydrochloride 50%SP	sheath blight	Propioconazole 1ml/lit, Hexaconazole 2ml/lit
Cotton	Fluchloralin (1kg a.i/ha), Pendimethalin (1kg a.i/ha)	Pink Bollworm	Indoxacarb	alternaria leaf spot	Carbendazim, Mancozeb 2.5gm, Copper Oxychloride 3gm in one litre
		Jassids	Carbofuran granules (1kg a.i/ha)	bacterial blight	Paushamycin/ Plantomycin 100mg+3gms of Copper Oxychloride/lit
Chillies	Trifluralin 0.75 kg/ha and Nitralin 3kg/ha	Aphids	0.1% Dimethoate or Methyl demeton (2 ml in one litre of water)	damping off	captan 2g/kg of seed 24 hours before sowing.
		Mites	Wettable sulphur 3g/litre of water or Dicofal 5ml/lit of water.	leaf spot	mancozeb 2gm/lit
		Thrips	spraying with 0.05% endosulfan		
Bajra	Atrazine 0.5kg a.i/ha	Shootfly	Spray malathion 5% dust (25kg/ha)	Downy mildew	Dithane z 78(0.2%)
		Whit grub	Mix carbofuran at 12kg/ha with bajra seeds at the time of sowing	Ergot	Spray ziram (0.2%)
		Grey weevil	Quinolphos 1.5%, methyl parathion 2%,fenvelerate 0.4% at 25kg/ha	Smut	Lantavax or vitavax 0.25%
Wheat	2,4-D (0.3-0.4 kg a.i/ha in 700-800 lit water, Isoprotutron 1-1.5kg a.i/ha, Methabenthiazuron 1.5kg a.i/ha	Termites	Spray 5% dust of aldrin or 10% dust of hch at 20-25kg/ha	Rust	Spraying zineb 0.2% dithane m- 45 0.2%, sandovit 0.1%
		Gujhja weevils	Spray 5% dust of aldrin or 10% dust of hch at 20-25kg/ha	Loose smut	Treat seed with vitavax 2.5g/kg seed
		Army worms	Dusting 10% bhc at 25kg/ha or carbaryl 2.5kg/ha in 800l of water	Bunt	Ceresan or agrosan 2.5g/kg
Mustard	Fluchlorallin (1.25kg/ha or 0.73 kg/ha), Isoprotutron (0.75 kg/ha), Bifenoc, Nitrofen	Mustard sawfly	Spray 2% methyl parathion dust(20-25kg/ha) or 0.05% malatti ec	Alternaria blight	Spray iprodione or mnacozeb 75wp(2kg in 1000l water/ha)
		Mustard aphid	Spray 0.07% endosulfan 35 ec or 0.05% malathion 50 ec	Downy mildew	Treat seed with apron 35 sd (6g/kg seed) before sowing
		Bihar hairy caterpillar	Spray 2% methyl parathion at 20kg/ha	White blister	Spray 0.2% ridomil
Castor	Spray fluchlorallin at 1kg a.i/ha, alachlor 1.75kg/ha or CDAA 6kg/ha, pendimethallin at 1.25kg a.i/ha	Castor semilooper	Spray Monocrotophos or Quinolphos or Dimethoate at 0.05%	Seedling blight	Seed treatment with Captan or Thiram 3g/kg seed
		Red hairy caterpillar	Spray monocrotophos 1.6ml or fenvalerate(0.02%)	Rust	Spray Mancozeb 2.5g/l or Carbendazim 1g/l
		Tobacco caterpillar	Spray neem seed kernel extract 4% or Chlorpyrifos 2.5ml/litre water	Powdery mildew	Spray Hexaconazole (1ml) or Dinocap(2ml)/litre water

GIS were also identified. Two important components of the database were identified as Crop Production and Management and Crop Statistics. Crop Production and Management included complete information on production and management of crops like general information, variety details, and climatic requirements, production and protection details were included. Crop Statistics included information in the area, production and productivity of the crops. A basic data structure and data dictionary was developed based on the components of the database regarding the data fields, type, size and description. Table A presents the data structure for the crop production and management and Table B presents the data dictionary. For illustration only a part of the data structure is presented.

The data to be entered in the geo database as per the components given in the above table has been formulated and presented in detail in Table C and Table D.

A list of the frequently asked questions by the farmers has been developed by randomly interviewing the farmers using semi-structured schedule.

List of FAQs

- What is the suitable soil for the crop to be grown?
- What is the proper time of sowing the crop?
- Any prior seed treatment required or not?
- What is the seed rate and spacing recommended for the crop?
- What is the level of weed infestation in the field?
- What are the crop specific weeds which considerably reduce the yield of the crop?
- What is the critical period for weeding and at what intervals?
- Which herbicides should be sprayed for weed-control?
- How much irrigation should be given to the crop?
- At what stages irrigation is given and at what time intervals?
- What is the most appropriate method of irrigation recommended for the crop?
- What is the level or dosage of N,P,K given to the crop?
- At what crop-stage N,P,K should be given and mode of application?
- What are the factors favorable for pest and disease incidence?
- What are the most common pests seen on the crop?
- At what stage of the crop is pest attack more?
- Which economic part of the plant is most affected?
- Specific chemical control measures for pests
- What is the dosage and method of application of the pesticides?
- What are the common diseases that infest the crop?
- Which stage of the crop is highly affected?
- Time of incidence and symptoms on the plant
- What are the cultural methods of control of the disease?
- Specific chemical control for diseases
- What is the dosage and method of application of the fungicides?
- Recommend pest and disease resistant varieties.
- Use of bio-fertilizers or organic manures for better crop growth
- What is the time for harvesting?

OBSERVATIONS AND ANALYSIS

The software used for the digitization of the data surveyed is ILWIS (Integrated Land and Water Information System) which is a remote sensing and GIS software with features like integration of images, vector and thematic data in a single platform. It is embedded with other features such as digitizing, editing, visualization, raster operations, image processing and table operations. The images are transformed into raster and vector images using common reference points both on the photo and the map. For integrating maps with the data, firstly one should know the latitude and longitude of the area under study. This spatial data helps in giving exact location of the place. The latitude and longitude of Randheja Village is Latitude - 23.2971663^0 East, Longitude - 72.6339251^0 North. Fig. 1 shows the satellite map of Gandhinagar district with Randheja village.

First we should get the satellite image of the area. When we get it we need to import it through the IMPORT option in FILE and specify the location in the drive. ILWIS accepts files with extension Tiff (Tagged Image File Format) while other formats wouldn't be displayed. When the map appears in the catalogue, we can make the necessary changes or update the table details. We can give the pixel information in which the coordinate system of the particular location on mouse click would appear. Similarly attributes can be created for the maps. A raster map is developed using the ILWIS software which is depicted in Fig 2.

Source : Google Maps https://www.google.com/maps/place/Randheja,+Gujarat,+India/@23.2911033,72.6340826,2940m/data=!3m1!1e3!4m5!3m4!1s0x395c2c483030d709:0xad93c2426e98ad43!8m2!3d23.292206!4d72.6417265?hl=en

Fig. 1 : Satellite map of Randheja Village, Gandhinagar district

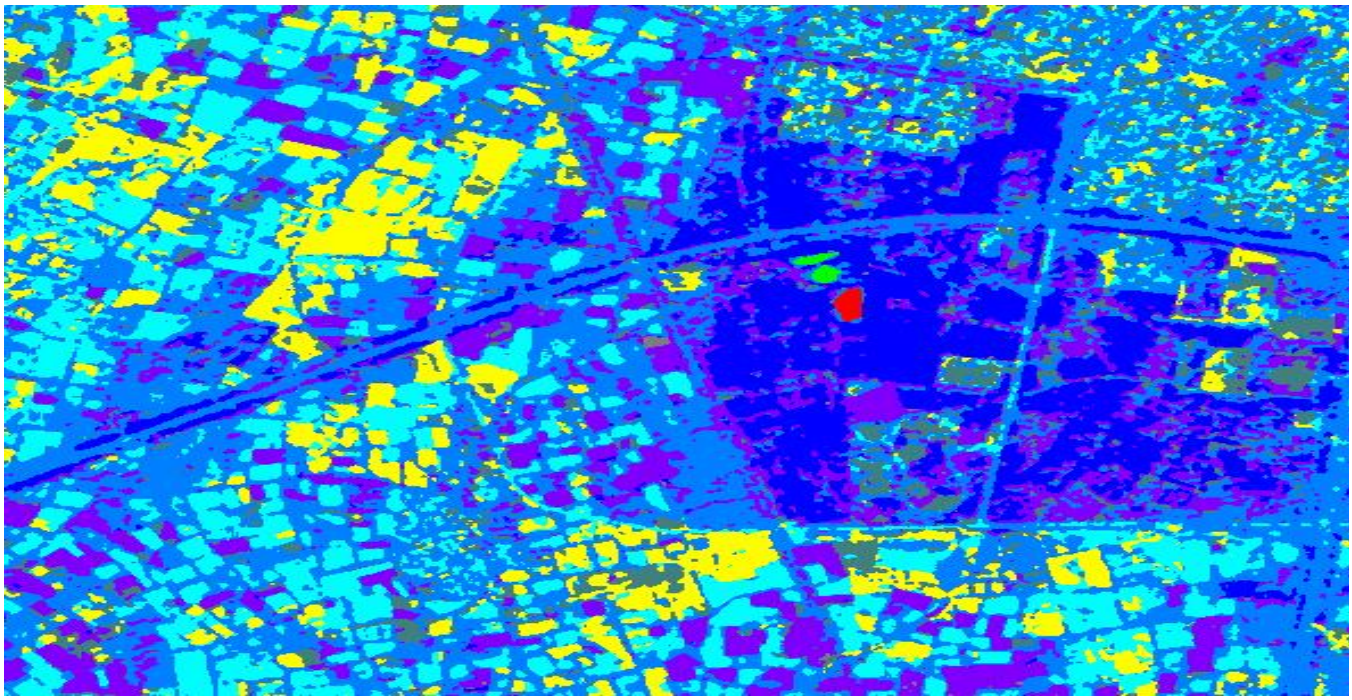

Fig. 2 : Raster map of randheja village

The raster map will be opened in the ILWIS window (Fig 3) and the map coordinates will be displayed as shown in Fig 4.

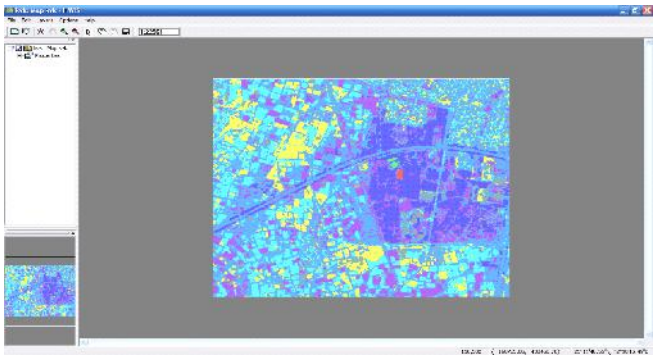

Fig. 3 : Raster map in ILWIS window

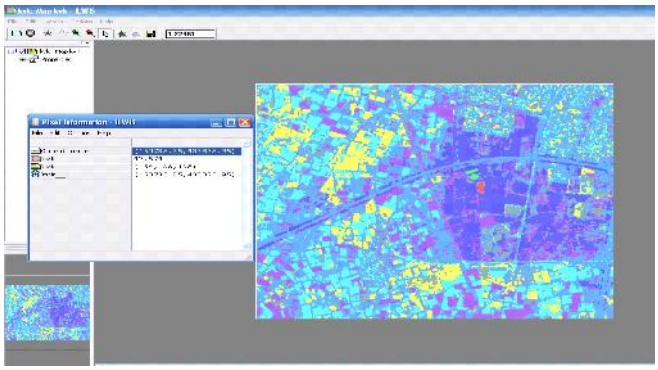

Fig. 4 : Display of map co-ordinates

The next step in the process is to add layers of text and images from the database on to the raster map. We can prepare maps of different parameters such as soil map, crop map, weed map, pest map and disease map. All these maps can be added as layers on a single map and all the details of the crop or the particular area can be viewed at a single click.

Once the layers are added to the map, we get a merged map with all the layers as displayed below. (Fig 5).

As compared with the original satellite image, we can observe some changes in the colours of the image. When two layers are merged or a layer is added on to the other then the colour composition changes and a new image is displayed. Similarly in this manner all the crop data can be displayed on the map. This enables the user to view the crop details on a single mouse click at the specific location required. This system would ensure proper timely decisions to be taken by the farmer.

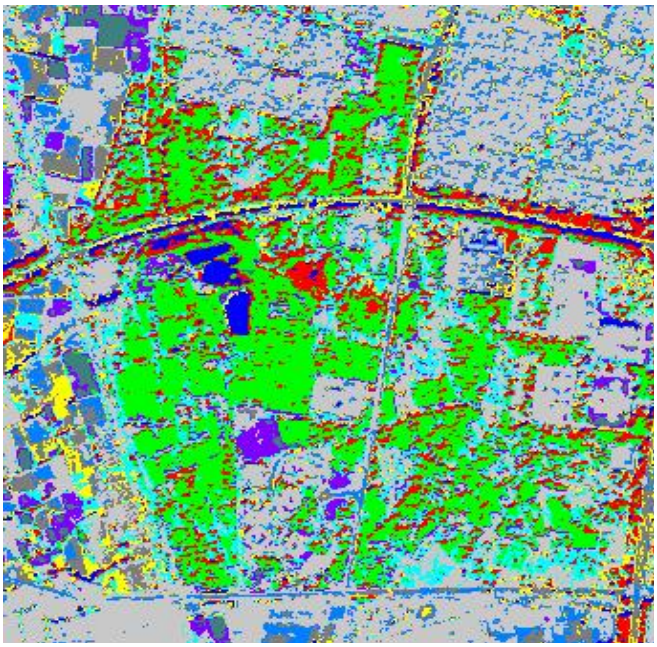

Fig. 5 : Merged map will all the layers

Conclusion :

Agriculture has been mostly confined to developed countries. The main reasons for the limitations regarding the implementation of technology in developing countries like India are small land holdings, heterogeneous cropping systems and market restrictions, lack of technology and knowledge, high cost, GPS readings cannot be taken frequently by the farmers because of its high cost and technology involved. Farmers are not acquainted with the latest technology as well the extension workers as it is a conventional practice of maintaining the results on records and no further updating on par with the changes happening. Hence the use of ICT cannot play effective role in improving agriculture production. The study is taken up primarily to relate the unorganized data with the resources available and integrate them there by producing a unique product on a single platform. This system/model can act as a reference for duplication in other fields enabling the designers and users easy accessibility. Also, the use of ILWIS has provided much additional inbuilt functionality which would otherwise had to be done separately.

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