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Function &Application of GIS in Precision Agriculture at Darjeeling Hill

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***Abstract*—** Being an ancient geographical practice agriculture can be enormously benefited by the application of GIS. For collection of spatially referenced data, to perform spatial analysis, decision making and application of variable rate treatment and specific farming systems may utilize GIS and several related technologies such as global positioning system (GPS), continuous yield sensors, remote sensing (RS) instruments, receivers, etc. These advanced technologies offer numerous advantages to generate & synthesize new information related to agriculture cheaply and quickly; document data source & methods of integration provide diagnostics for error detection and accuracy assessments, prepare maps and tables for proper and various types of cultivation. But due to our lack of knowledge of statistical methods for summarizing spatial patterns, difficulty of moving geographical data and model results between different scales, and cost and difficulty of field validation, we are unable to access the data and maps. This problem can be overcome through the use of GIS and related technologies and this can help us to improve the cultivation or agricultural system in the Darjeeling hills. The main objectives of sustainable agriculture follows: balancing the inherent land resource with crop requirements, optimization of resource use towards achievement of sustained productivity over a long time.

Keywords --Geographic Information System(GIS) , Remote Sensing(RS), Geographical Positioning System(GPS), Precision Farming(PF).

I. INTRODUCTION

In order to map the natural resources at micro and macro level, GIS and remote sensing has evolved as a beneficial tool. The hill regions of Darjeeling which has a highly diversified terrain ranging from low hills to high hills have provided a challenge to enhancing and utilizing the latest technologies in agriculture.

In comparison to flat agricultural lands, in the hills agriculture is more sites specific and therefore, precision farming is very significant in the hilly areas. Managing the agriculture at very small site specific crop areas becomes quite difficult without identifying the location of each field. The small site specific locations can derive the maximum benefit by improving traditional modes of farming through the implementation of the precision agriculture. GIS and remote sensing plays a vital role in the implementation and monitoring of farm practices at these small site specific locations. In order to get a precise and site specific solutions for the hurdles the farmers require actual mapping of the fields which can be done by the use of GPS device which are either inbuilt in the smart phones or can be functional through hand-held gadgets[1]. Relating the spatial content derived through the field mapping by the help of GIS and remote sensing to other web based applications often act as a useful means of monitoring the crop stages, managing of the diseases, estimating the yield mapping, weeds and soil management etc. The wide ranging applications of GIS and remote sensing, like food and security analysis, potential sites identification, Spatial Decision Support System (SDSS), livestock mapping, crop stimulation models, pest management, yield estimation etc. has made its use increasingly popular among the farmers in the hilly area (Darjeeling). Moreover, since today's world is dependent on the saved information over the internet, it is impossible to function on the conventional stand alone appliances. As GIS and RS linked with other web based applications provides a spatial library that can be used by a large number of users, they also become means of accessible data to be used by the policy makers in their improvising of strategies in relation to precision farming [2]. Through the uses of this updated technology oriented agriculture, the farmers of the hills would definitely enjoy huge increase in their yield that would benefit their living standard and all round development in general. So GIS based precision agriculture in Darjeeling hills is proposed here.

Section I contains the introduction of the proposed GIS based precision agriculture in Darjeeling hill. Section II discusses the existing farming practices. Section III presents the importance of precision farming. Section IV gives an idea of GIS. Section V discusses Remote Sensing technique. Section VI presents the integrated application of GIS and RS in precision farming. Section VII shows the spatial decision

support system to help the farmers in precision farming and finally Section VIII is the conclusion in which the importance of precision farming in Darjeeling hills, some limitations of this method and future scope of the proposed technique is discussed.

II. EXISTING FARMING PRACTICES

Farming system of Darjeeling hills stands upon the differences of availability of resources & its use leading mainly to two types of agriculture. One for the mid-hills ***i.e.*** below 1500 meters and another for the high hills *i.e.* between 1500 meter-2750 meters. Villages at the bottom of hills and near the bank of river area have relatively more flat irrigated lands cut into valley side slopes. More flat and large lands are used to grow rice. In these surroundings fewer livestock are seen within the vicinity of households which tend to be tethered and gazed. Further, farmers make compost with animal droppings and forest litter. These fields are used rotationally throughout the year for cultivation of different crops. More or less everywhere "Goth"(huts for livestock) can be seen at places near ponds, rivers & streams. Often some rich farmers have the practice of taking their livestock to low elevation during winters for grazing. During this periods herdsmen live there.

Every year farmers grow two crops of maize, wheat, barley, millet and variety of other crops on rain fed land below 2300 meter. There is "pakho"—an agricultural, inclined land (30ft to 35ft along the slope), which is suitable for maize only. Farmers usually plant one crop of potatoes or barley buckwheat in the fields above 2500 meter because of the cooler climate, steeper slope and stonier soils. Compared to lower elevation here agriculture is more marginal. An area above 2500 meter is generally covered by monsoon cloud and has evergreen forest.

III. IMPORTANCE OF PRECISION FARMING

The technological application and principals of managing the spatial and temporal variations in relation with each and every aspect of agricultural productions can be termed as precision farming (PF). The PF is the consequence of the technological revolution that has happened in the last decade[3]. By integrating and utilizing modern technologies, PF can be done on a particular form since it also functions on single site specific technology. The implementation of technology is dependent on the awareness of the farmer along with high speed internet connectivity. PF as an agricultural management based on information and technology, benefits the farmers in improving the efficiency of the productions in a way which is both cost effective and eco-friendly, since it allows lowering the environmental pollution by avoiding the usage of unwanted chemicals and pesticides [4]. The prime objective of PF is to collect information about the condition of both the soil and crop and thereby sequentially capture the crop as well as soil condition at spatial level.

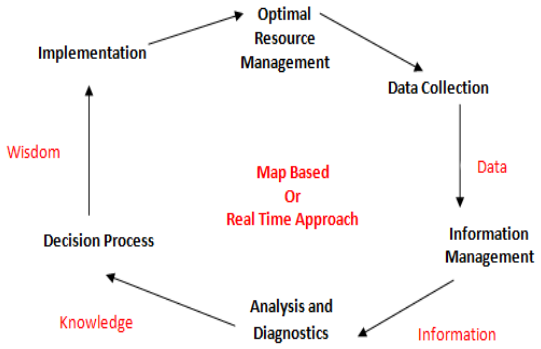
PF as a database for the farmers includes the following:

1. Information about the crop regarding the stages of growth, requirement of nutrients for the better health.
2. The chemical and physical property of the soil along with its texture, status of the nutrients, depth, temperature, potential of productivity, salinity and toxicity.
3. Data regarding the microclimate, (daily and season wise) such as humidity, wind speed and direction.
4. Facilities regarding irrigation, availability of water and future planning of required inputs.
5. The drainage condition of surface and adjacent areas of it.

Fig 1. Precision farming integration of technologies

IV. GEOGRAPHIC INFORMATION SYSTEM (GIS)

GIS helps in fussing hardware, software, capturing and



managing data and displaying all genre of geographically referenced. Actually GIS can redact intricate analytical functions and present maps, tables or graphs before the head to select the best part and conduct it.GIS is assisting the farmers all over the world by increasing agricultural production, managing land and decrementing their cost. For those who are involved with farming industry, GIS has proved to be very helpful. Decision making on the base of particular area geography helps to gain development. To get an idea of an areas social, executive and environmental issue, understand the people's familiarity and geography of the particular location.

GIS is like one technology which helps in encircle geography and to make intellectual judgment [5]. As digital map has a table it helps a rectifier to sum up information of the tangible world. It has the caliber to knot number of data in eternal ways. A GIS program which has many information in it can fuse its information into map project. There are many countries in this world who collect their geographic data for exploration. These data helps the country's government to make their own data-set.

V. REMOTE SENSING (RS)

RS helps in monitoring the spatial changes. From time to time West Bengal sustains variant changes due to infrastructural prosperity and the cutting down of forest for agricultural and grazing ground. Modern technology has wrapped into agricultural and it should be monitored orderly. Remote sensing helps in lowing cost data, high spatial resolution and high temporal resolution [6].

VI. INTEGRATED APPLICATIONS OF GIS & RS IN PRECISION FARMING

GIS is different from other technologies. It excerpts data from variant sources and integrates it to make the model powerful while functioning. If the data of GIS is not complete or accurate it will not perform properly. From topographic maps some data related to the subject is digitized. None the less, these maps are subordinate in nature and does not exhibit the order which we look for. Secondly due to swift variation in the group, topographic maps are old-fangled. RS and GPS can exceed all this obstacles. GPS is a gracious method of collecting authentic data. Satellite image can give current data regarding the areas.

GIS and GPS are substitute to one another and they have their own limitation. To utilize their strength integration is needed. Integration will broaden their scope and can be used at emergency time or early warning. The integration of GPS, RS and GIS in combination with ground monitoring systems has proved effective in every circumstance where used.

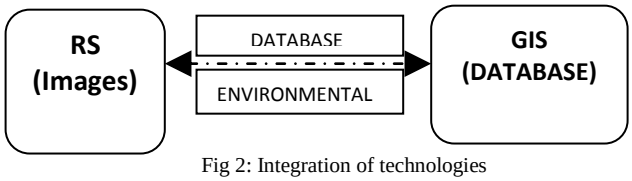


Fig 2: Integration of technologies

VII. SPATIAL DECISION SUPPORT SYSTEM (SDSS):

An intelligent system for assisting the policy framers and farmers for solving complicated spatial problems and controlling of the pests, identifying of hotspots, chemicals, guiding in fertilizer and irrigation facilities, can be structured through an integration of all three technologies. The crop stimulation scenario can be provided through the conventional models such as DSAT, Info crop models etc[7]. For overlaying the entire thematic base line spatial datasets, the conventional DSS needs to be integrated with the spatial aspect that would result in a better intelligent SDSS. In this way, by making minor changes in the inputs like variety selection, timing of irrigation, measuring the dose of fertilizer etc, a high productivity can be ensured through the users identifying of the agro-ecological zone while the other parameters would have been automatically installed into the system. The spatial data input would be provided by the SDSS to the system. This would facilitate in storing complex analytical structures which are exclusive to spatial analysis.

The framework that SDSS provides in order to integrate includes:

1. Crop modeling capabilities.
2. Management system for database.
3. Expert knowledge to serve the policy planners.
4. Outputs based on maps.

A. Crop Growth stages:

The crop growth can be monitored by the help of the 3 technologies as discussed above. Using RS and GIS it is very easy to identify the stages of crop growth such as the period of maturity, weed and paste infestation, crop stresses like water and nutrients stress, diseases etc. integrating the data collected through the different censors using GPS, it is easy to gather and integrate information for field management strategies like application of the chemicals, mode of cultivation and harvest.

B. Weed Insect and Disease infestation:

As a part of post disaster management, hotspots for disease infestation are often mapped after the entire crop gets destroyed. Apart from mapping the incidence of diseases, GIS and RS also assist the experts in understanding the reason behind the crop infestation. Once the spatial integration of the maps of all the occurrences of diseases is made with the agro-ecological zones, it becomes very easy to locate the possible future hotspots of similar infestation. Thus GIS and RS is advantageous in not only for providing the maps but also as tools of signaling early warning of precaution to the farmers regarding possible crop infestations[8].

C. Soil fertility, Micro and Macro nutrients:

As layer based system, GIS and RS provide flexibility to the users in overlaying the different real world layers and find the most suited model of a précised agricultural practice. The various national level project conduct soil sampling and thereby help in the mapping of soil status[9]. At the village level, scale of datasets generated in the national level is made available. The national and state level government also runs mobile units for soil sampling which conduct soil tests and also sample them as coordinates on the GPS. The spatial inventory at the state level maintains these datasets. This further helps in generating data for the type of soil based on the slope, terrain and the other aspects of hilly areas. Once the soil mapping is over, it can be of great use in simulating the yield of the crop with various sets of varieties and other agricultural inputs.

D. Precision conservation:

The hill farmers, apart from the topographic restraints, also suffer from the lack of natural resources needed for irrigation. Despite the competition among the agricultural practitioner to increase the crop yield, they mostly have to make use of the scarce resources and depend almost wholly on the monsoon

for a better harvest. The potential sites of irrigation can be identified through GIS[10]. RS and GIS expert can also helps the farmers in locating the suitable natural slopes which can retain the monsoon water through rain harvesting or water storage tanks. With the intervention of GIS the farmers also can set new channels, linked with the local hilly streams and *jhoras,* for irrigation purpose.

VIII. CONCLUSIONS

The GIS technology collates the data leading to the development of PF. The farm planning becomes easier through precision faming but it requires the farmers to be initiated to the technology. A huge bulk of map data is required to determine the long term planning regarding cropping plants, salinity control, controlling of erosion and assessing tillage system. With the increase of the data the need for data interpretation becomes a taxing task which results often in the risk of flawed interpretation. Farmers adopting precision farming need to work under the guidance of other agricultural professionals and the experts of GIS and computing science. Integrating GPS with GIS and RS is the most significant of all applications which require geo-referenced, precise and real or almost real time data. This integration would facilitate disaster mitigation, mobile mapping and emergency response. Integrating GPS with GIS and RS would become more beneficial in future depending on the enhanced location aware multimedia PDA system. Once the hindrances in integrating the mobile communications are addressed successfully, after there many new application would emerge in due course. The application that would finally be developed, would certainly act as a boon for the hilly farmers in enhancing the production with efficiency, low cost calamity prediction.

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