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Mapping of agriculture farms using GPS and GIS technique for precision farming

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■ **ABSTRACT :** Over the past several years, an increasing number of large-scale agriculture corporations have expressed the requirement for logging their farming operations at a low cost. Hence, in precession agriculture this system as alternative to the field verification to recording and collecting farming data. The technical and economic feasibility of applying GPS equipped with GIS technology to the system was ascertained. In farm land record approach the use of GPS in Agriculture is limited but it is fair to expect wide spread use of GPS in future. One of the primary challenges that farmers have is the lack of knowledge on what crop to plant, as well as where to plant for guaranteed maximum yield. However, modern farming has benefited two fold –it is mechanized and uses great technologies such as the spatial technologies. Evidently, the use of GIS and GPS technologies at your farm is highly beneficial. With such technologies in place, it not only makes it easy to manage the farm, but also guarantees high yields and profits. Therefore, this record keeping farm management system needs to be adoptes these technologies so far, helps in farm management and the creation of new opportunities that are necessary in increasing your profit margins. The field mapping of PSB Agricultural Farm at Sriniketan, West Bengal was carried out using handheld GPS receiver and collecting secondary study area maps and crop practice information. The digitization and mapping was carried out in Arc View software environment is masking out the crop area from other landuses. The various cropping pattern was also recorded and a database was developed for record keeping and making better production decision.

■ **KEY WORDS :** Precision agriculture, GPS, GIS, Field mapping, Record keeping

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Agriculture is the backbone of our country and economy, which accounts for almost 30 per cent of GDP and employs 70 per cent of the population. Though this is a rosy picture of our agriculture, how long will it meet the growing demands of the ever-increasing population? This is a difficult question to be answered, if we depend only on traditional farming. For developing countries, such as: India and China have huge food grain requirement of 480 million tonnes (Mt) by the year 2050 (Bisoyi, 2006), with the increasing challenge of biotic and abiotic stresses experienced by crops, introduction and adoption of modern technology in Indian agriculture is inevitable. Geographic positioning system (GPS) and Geographic Information system (GIS) have emerged as an effective tool for the macro and micro level mapping of natural resources. Such methods are

known as spatially variable crop production, GPS and GIS based agriculture, site-specific and precision farming (PF) for mapping of agriculture farms. Precision farming (PF) is a bridge that connects sustainability with enhanced productivity, where natural resource productivity is effectively and efficiently maintained. The primary aims of PF are to increase efficiency, improve environmental performance which eventually leads to increase profitability. PF is a management philosophy or approach to the farm and is not a definable prescriptive system (Dawson, 1997; Brisco *et al.*, 1998 and Carr *et al.*, 1991). Thus, it provides base for making appropriate decisions in the field of agriculture (Tayari *et al.*, 2015). Precision farming is designed to increase whole farm production efficiency with low cast effect while avoiding the unwanted effects of chemical loading to the environment.

PF utilizes all modern technologies such as GPS, RS and VRT (Mondal and Basu, 2009). Good land record keeping is essential to successful agricultural farm management. The GAP-CROP provides guidelines on local sustainable production of safe, healthy vegetables and fruits. Farmers may voluntarily follow this COP, identify potential problems in their farms, take appropriate control/mitigation measures and monitor the effectiveness of such measures (AFCD, 2017). Easy to use and essential farm a management software maintenance records, tank mix calculator and GPS field mapping when and where you need it (Farmlogic, 2017). However, even with the increased ability to capture and retrieve more detailed farm information, empirical economic evidence of higher farm profitability is limited (Norvell, 2003). A good farmer needs to keep accurate and organized records by forming a functional system of record keeping. GPS technologies are making explicit information that was once recorded only in the minds of farmers. This is making historically implicit data explicit, thereby improving communication between individuals involved in management of the farming.

Farm record keeping software such as: Farmer Basic is an easy-to-use desktop mapping, field record keeping and cash accounting system for the beginner. Farmer Pro and Farmer Pro Plus subscription bundles serve as a total farm solution that includes desktop, online and mobile solutions. Records can help you improve your farm by showing you how to make changes to make things better in the future. Farmers need accurate and thorough records so they can best know how to manage the farm. These records will highlight inefficiencies in the business so that the manager can make effective changes and see progress (Precision Agriculture, 2017). However, the commercial software still out of reach of the farmers of developed country as well as developing countries like India. Still with little knowledge and skill of GPS software environment and GPS readings, suitable farm records can be maintained with regular update and safe keeping.

While a GIS can enhance farm record keeping, GIS data is not, by itself, necessarily useful or profitable in farm management. The development of primary data in the GIS is just the initial step and much of agriculture is in this early phase (Westervelt and Reetz, 2000). The organization of a GIS can affect the types of analyses that may be done with the data set. The process of creating a farm GIS involves a series of steps. Clearly the first is to obtain the GPS referenced data. Otuka and Sugawara (2003) have developed a labour management application by using a handheld computer. These mobile terminals may be applicable for collecting the farming data of the sugarcane-producing agricultural corporations. The GPS and GIS technologies make it possible to determine and record the position of fields (Nemenyi *et al.*, 2004).

GPS receiver :

The Navigation Satellite Timing And Range Global Positioning System, or NAVSTAR GPS, is a satellite based radio-navigation system that is capable of providing extremely accurate worldwide, 24 hour, 3-dimensional location data (latitude, longitude and elevation). GPS equipment manufacturers have developed several tools to help farmers and agribusinesses become more productive and efficient in their precision farming activities. GPS provides continuous position information in real time, while in motion. GPS receivers, either carried to the field or mounted on implements allow users to return to specific locations to sample or treat those areas (Qian and Zheng, 2006). GPS receiver is linked to a note book computer displaying appropriate, pre loaded information layers, and a software package then combines incoming GPS signals with the displayed data to allow the user to see where they are with respect to the map components. The various layers of information can be easily edited and modified in the field and new

data can be added as point or polygon layers and attribute tables (Mc Govern *et al.,* 1999). In addition, the accuracy, which is the important factor in PF, demands for DGPS; but, in India, we do not find any DGPS service providers.

GIS software :

GIS is a useful tool for the assessment and management of agricultural resources (Iverson and Risser, 1987). GIS is a computer hardware and software system that uses feature attributes and location data to produce maps. An important function of an agricultural GIS is to store layers of information, such as yields, yield maps, soil survey maps, remotely sensed data, crop scouting reports and soil nutrient levels. A farming GIS database can give information on filed topography, soil types, surface drainage, subsurface drainage, soil testing, irrigation, chemical application rates and crop yield. Once analysed, this information is used to understand the relationships between the various elements affecting a crop on a specific site (Trimble, 2005 and 2017).

Mapping of agriculture farms :

Map generation for crop and soil characteristics is the most and the first important step in precision agriculture. These maps provide the base of spatial variability control. Data collection was performed both before and during production and can be implemented by means of GPS coordinates (Mandal and Ghsoh, 2000). GPS allows precise mapping of the farms and together with appropriate software informs the farmer about status of his crop and which part of the farm requires inputs like water, fertilizer and pesticide etc. Mapping in PF is a process where a large field is divided into a finite number of sub-fields, allowing variation of inputs in accordance with the data gathered. Ideally this will allow maximization of return on investment, whilst minimizing the associated risks and environmental damage (Profi, 1998).

It is time to do away with guesswork farming and use technologies that assure you better agricultural production, effective management of land, and reduced cost of production and optimum yields and high profits. Furthermore, by adopting record keeping database technology in this system, large quantities of data of the farmland that are scattered over a wide zone could be handled efficiently.

Study area :

The study area is situated in Birbhum district between 23° 32' 30" (right above the tropic of cancer) and 24° 35' 0" north latitude and 87° 5' 25" and 88° 1' 40" east longitudes (Fig. A). This district is triangular in shape surrounded by, River Ajay in the southern base and the apex of the North triangle points, Murshidabad district is in the east and the state of Jharkhand in the west (Mondal, 2006). Geographically, this area lies at the North eastern end of the Chota Nagpur Plateau, as it slopes down and merges with the alluvial plains of the Ganges. The climate is generally dry in nature. During summer, the temperature can shoot well above 40^0C and in winters it can drop to around 10^0C. The annual average rainfall in Sriniketan area is around 1,400 millimetres (Mukhopadhyay, 2006). The district is a continuation of the rice plain of West Bengal, and the vegetation is characteristics of rice fields in Bengal generally, species of Aponogeton, Utricularia, Drosera, Dopatrium, Ilysanthes, Hydrolea, Sphenoclea and similar aquatic or palustrine genera being abundant. Trees like mango, palm, bamboo are frequently found (Birbhum: Geography-2009).

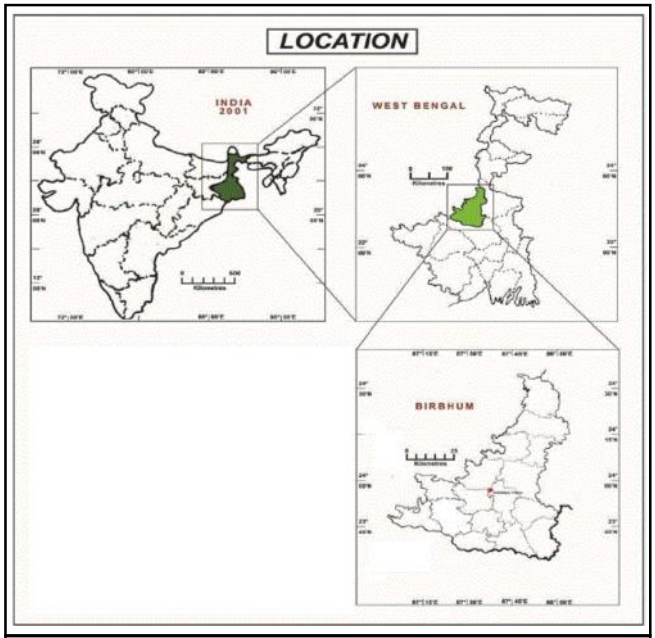

Fig. A : Location of the study area

METHODOLOGY

Available base map was used to locate the study area in Birbhum district. Open series map developed by

Survey of India, 2011 was used for masking the base map of PSB Agricultural Farm, Sriniketan, Birbhum, West Bengal. The scale of the Map was 1:50,000.

Around nine ground control points (GCPs) were collected using eTrex 20 GPS Receiver (Garmin Ltd., Olathe, Kansas, USA) for image registration of the study area. The detail information of each plot comprises its address, the latitude and longitude of the corners of the field, and the field identifying number (IDs). The base map was created by digitizing the mentioned topographical map in Arc GIS 10.1 (ESRI, Redlands, California USA) software environment using the supplied eight GCPs. The digitized map of all the fields managed by the agricultural production corporation was created in the shape file format from the paper maps in ArcView Environment of Arc GIS 10.1.

The features, such as: study area boundary, canal network, ponds, farm house, museum plot, Thresing floor and Vermicompost pit etc. were mapped. The total study area is around 12 hectares. Most of the cropping area is under canal irrigation system.

Crop area mapping :

The crop information for each plot were also collected during the survey work. GPS co-ordinates defining all the corners of the parcel plots were recorded. In addition, the extent of the parcel was "tracked" using a Handheld GPS unit to compute the area as well as to provide the spatial extent of the parcel. The following information was collected, area under rice bean, maize, ground nut and fodder crop (Mixed or Intercropped). A unique identifier was assigned to each parcel. In addition to the information collected with the aid of a handheld GPS, the area under rice bean, maize, ground nut (Mixed or Intercropped) was mapped and a polygon feature captured with the aid of the GPS receiver. This was coupled with the computation of the individual areas under different types of cropping systems (Mixed or Intercropped). Using the data collected from the GPS, a database was developed to store this information. The attribute information was used to prepare farm landuse map. Then the GPS receiver is linked to a notebook computer for displaying preloaded information layers, and the software "Arcview GIS 10.1" package combines incoming GPS signals with the displayed data to allow the users to see where they are with respect to the map components. The various layers of information can be easily edited and modified in the field and new data can be added as point or polygon layers and attribute tables. Some modifications were also carried out in the map, such as: adding plot number, plot area, cultivated crops along with their variety, yield of each crop of the recent year and previous year. If there is two different crops in a same plot then this plot is divided into two parts. Depending on the landuse in the farm, the total area was mapped for agricultural farms, mango orchards, farm building, vermicompost unit etc.

The agricultural farms used for growing the crops were masked from other landuse of the farm area. Depending on the location and shape, the farm area was divided into four blocks. Each block is further divided into small plots. The cropping pattern and crop practice information were collected, observed and recorded. The collected information supplied to the GIS software environment for necessary mapping.

■ RESULTS AND DISCUSSION

The PSB agricultural farm was digitized by using handheld GPS reading for nine ground control points (Table 1) in GIS software environment. The agricultural farm is situated between $23^0$40'02" to $23^0$40'15" North latitude and $87^0$39'24" to $87^0$39'40" East longitude.

Table 1 : Ground control points for digitization

Sr. No.	Latitude (degree)	Longitude (degree)
1.	23.66983	87.65895
2.	23.66962	87.65822
3.	23.66939	87.65895
4.	23.66874	87.65894
5.	23.66985	87.65794
6.	23.66957	87.65814
7.	23.66877	87.65816
8.	23.66797	87.65983
9.	23.66981	87.65974

All the landuse/land cover of the farm, such as: crop area, mango orchard, two ponds, One museum plot, One threshing floor, a vermicompost unit, a farm house etc. were mapped (Fig. 1). The agricultural cropping area is around 5.61 ha and the mango orchard was around 1.47 ha (Table 2). There is two ponds of area around 2.47ha have been used for supplying water for irrigation purpose.

Mapping the cropping area :

The agricultural cropping area was masked from

Table 2: Land use distribution of the agricultural farm

Sr. No.	Land use description	Area (ha)	% Area
1.	Crop area	5.61	57.38
2.	Pond area	2.47	25.22
3.	Housing area	2.23	2.28
4.	Mango orchard	1.47	15.01
5.	Vermicompost pit	0.011	0.12

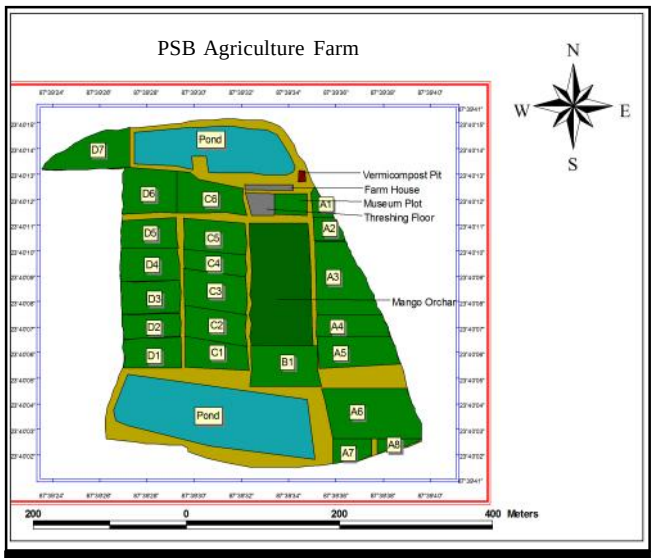

Fig. 1 : Landuse/land cover map of the study area

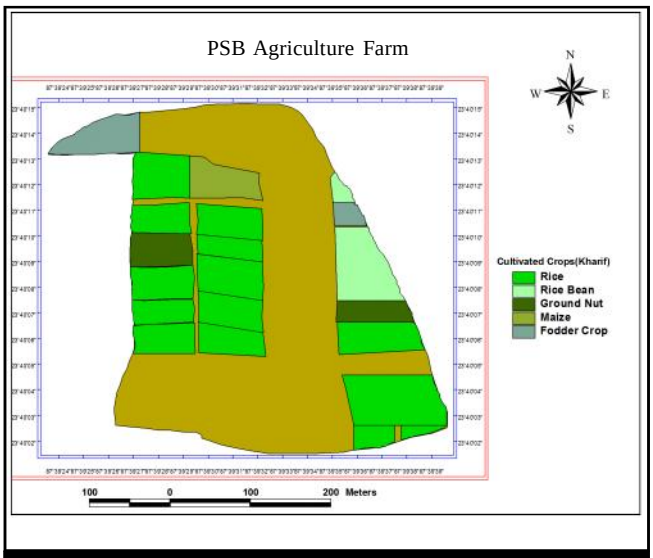

Fig. 2 : Crop distribution map in the study area

other landuse/land covers. For growing crops in the farm, the cropping area is divided into four blocks, such as: A, B, C and D blocks, as per their location and orientation. For convenience of growing different crops simultaneously, each blocks are further divided into no. of plots as follows:

- A-block into 8 plots
- B-block into 2 plots
- C-block into 6 plots
- D-block into 7 plots

For mapping the cropping status, crop practice information were collected from each plots (Table 3). The information were fed into GIS software environment for better mapping. Now after completion of the map, when a user will click on a plot then he will instantly sees the information about the plot on the display screen. Mostly rice crop was grown in the experimental farm, as it is located in the major rice growing region in West Bengal (Fig. 2).

The record keeping database technique allows us to store a large quantity of data and accumulate the user-defined data according to the regional conditions. The

Table 3 : Crop distribution in the agricultural farm

Sr. No.	Crop name	Plot (ID)	Area (ha)	Percentage
1.	Rice bean	A1,A3,	0.58	10.27
2.	Fodder Crops	A2,D7	0.44	7.91
3.	Ground Nut	A4,D4	0.49	8.74
4.	Rice (MTU 1010)	A5,A6,C1,	1.22	21.84
5.	Rice	A7,A8,C5,C3, C2,D5,D3,D2	1.78	31.76
6.	Maize	C6	0.32	5.70
7.	Rice (CR 1010)	C4	0.18	3.27
8.	Rice (MTU 7029)	D6,D1	0.59	10.51

data structure of our databases, such as field database, field map and items to be considered during the farming operation, is applicable to the production of other crops, for example, rice, bean, maize, groundnut, fodder crop and mango orchard. With the trend of an increase adoption of this land record keeping technology as Precession agriculture, so there is a strong possibility that this system can be applied by common farmers and decision maker to compile information during taking production decision. Land record keeping data obtained using Handheld GPS device and yield monitor etc. will be utilized in the next generation and verification of an optimum farming plan. It can also help in selecting best suited cropping pattern for a particular land. We can easily avoid the unsuitable crops or crop varieties for a specific land ensuring better profit margin to the farmers. We can also protect crop from systematic weeds, pest infestation and crop damages. Implementation precision farming techniques and variable rate technologies will be highly benefited from proper maintaining land records.

The small agricultural farm mostly used for experimental purposes will also be benefited in selecting a particular experiment for a farm plot using land record keeping. The unusual behaviour of some of the experiments can be traced out from history of cropping pattern in that particular farm.

Conclusion :

The technical and economic feasibility of applying GPS equipped with GIS technology to the system was as certained. In farm land record approach the use of GPS in Agriculture is limited but it is fair to expect wide spread use of GPS in future. One of the primary challenges that farmers have is the lack of knowledge on what crop to plant, as well as where to plant for guaranteed maximum yield. However, modern farming has benefited twofold –it is mechanized and uses great technologies such as the spatial technologies. Evidently, the use of GIS and GPS technologies at your farm is highly beneficial. With such technologies in place, not only make it easy to manage the farm, but also guaranteed of high yields and profits.

The field mapping of PSB Agricultural Farm at Sriniketan, West Bengal was carried out using handheld GPS receiver and collecting secondary study area maps and crop practice information. The digitization and mapping was carried out in Arc View software environment to masking out the crop area from other landuses. Nearly, 60 per cent area was used for growing different crops in the Agricultural Farm and remaining 40 per cent for supporting activities. The various cropping pattern was also recorded and a database was developed for record keeping and making better production decision. Most of cropping area (around 65% area) has been utilized for growing rice crop, as the study area is located in the major rice production belt of West Bengal.

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