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An Introduction to Precision Agriculture and Its Role in Sustainable Development of Agriculture

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ABSTRACT

Today, agriculture plays an important role in the world economy. It helps reduce poverty and also boosts sustainable development, especially in developing countries. The need of new technologies for increasing productivity along with reducing ecological pollutions, makes Agriculturalists search for new logical methods. Precision Agriculture is one of these methods and relies on sustainable agriculture and healthy food production. Farms have variable temporal and spatial characteristics, therefore the aim of precision farming is to determine the input, in relation to these variables. Due to this, the use of Variable rate technologies (which are equipment that automatically change the amount of material usage in relation to spatial positions) is getting more common. In Precision Agriculture, sensors and converters are important. Because of them, the evaluation and guidance of equipment is done automatically. One of the important topics of Precision Agriculture is drawing the Yield Map. It helps us recognize the damages and variables on the farm's surface. These plans can be made using GPS with great precision and then by incorporating it with local geographical data in GIS network; we can manage the farm easier. The aim of this article is to define this technology in a simple, yet scientific manner.

KEY WORDS: Precision Agriculture, Global Positioning System (GPS), Sustainable Development, Geographic Information System (GIS), Yield Map.

1. INTRODUCTION

If we think of the environment as an arena with human groups as its inhabitants; and consider development, as the actions made by these groups on this arena for the sole purpose of making it a meaningful and comfortable living place, then we should know that this consideration requires serious and broad cultural endeavors so that the backgrounds required for the unremitting participation of the

People in the processes of decision-making and development policies are obtained. On the other hand, we must always remember that there exists only one earth in this process [12]. And not only the human life, but also the life of all living creatures belongs to this earth. Therefore it is necessary to think about the range and limits of human interference in the environment and the atmosphere in this complex human-environment relation, and try to revise them all [3]. If we believe that a comprehensive social or individual welfare is very important, and then we should search for ways of protecting and sustaining it; and in that matter, the role of agriculture is undeniable.

Problem's Definition:

The history of Agricultural and Environmental Science, proves that advancements in technology and agricultural management requires time, cost, education, cultural and social development, knowledge and proper intellectual, social, political and economic backgrounds. A good example can be the history of tractors in agriculture. It took nearly 30 years for the farmers of advanced countries to properly understand how useful tractors really are [6]. Now precision agriculture is not an exception either; and like any other modern system, it needs new and improved thoughts, skills, talents and tools.

As a matter of fact, precision agriculture is the synchrony between the management and control of natural resources such as soil, water and plant (crop) and the conditions, behaviors, variables and dynamics in the realms of time and space; and also the necessity of monitoring and data processing from one hand and having the required tools to the other. The vision of precision agriculture involves the use of sophisticated tools to assess the farm's conditions and applying chemicals and fertilizers to the farm. Using technologies like the GPS, electronic sensors, monitors and advanced computer software, enables the farmer to create a detailed image of his work (Also managing the small areas inside the field for the purpose of reducing the use of chemicals and improving

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productivity, is one of the aims of precision agriculture) [11]. It's also worth mentioning that precision agriculture may not be economical for all farmers.

Today technology has reached a level that it allows farmers to analyze and manage the changes in the field that were previously known, but were not manageable. Farmers should try to achieve more economic benefits with regards to the environment and economic issues.

In the topic of precision agriculture, spatial variability is very important and it means the changes in the measured properties of crop and soil on the surface and in depth, are related [11]. Variability can be seen on every part of the field. It can even be seen in soil fertility, pest population, moisture, and plant vigor. Of course we should not forget the time parameter. Although many of the properties of the soil are stable and tend to change very little over time (like the soil's texture); however, soil's organic matter and moisture and also features such as Nitrate levels (NO3) can be changed very quickly. Also plant's conditions can change in a matter of hours and all of these factors can influence the decisions of farmers and their reactions [11].

Farmers from all around the world use more than 100 tons of nitrogen fertilizers, phosphorus and potassium every year [4]. This amount can include at least a quarter of all cash costs; and if we add the costs of pesticides and the impacts on the environment to it, then we will reach the decision to make the possibility of managing these inputs, easier. Precision Agriculture technique is applicable to every crop production cycle (from operations before planting to harvesting), and it can be effective in many ways, such as improving the soil, tillage, planting, fertilization, spraying, crop monitoring and harvesting.

MATERIALS AND METHODS

The first step in precision agriculture for the farmer is to make a yield map with a GPS device to control yield, we need a yield map prepared from our own farm. The production and storage of accurate yield maps follow five steps [5]:

1. collecting accurate yield data;
2. data storage;
3. data cleaning – removal of erroneous data points;
4. changing the GPS projection to easting and northing;
5. Interpolating data (producing a smooth map surface).

Collecting accurate yield data:

When dealing with specific and detailed management systems, behavior of soil parameters should be considered as a key components and because of this, we need to estimate the behavior of the soil in our farm, to do so we use the soil test, in the soil test phase when we are sampling the soil in order to measure soil nutrients, we use GPS to detect and record the sampling location. Later this information is used to provide a yield map and soil map.

In the soil test, information such as soil texture and the amount of organic matter in the soil should be calculated as the output, so yield units of the soil can be considered as precision agriculture management units [6]. The effect of this action is apparent in the followings:

1. Tillage: changing the depth of tillage and crop residue remaining on the soil surface by using GPS technology and soil sensors is possible. In this method the problem of soil congestion on marked locations can be resolved with tillage and so soil moisture and temperature makes for optimum plant growth.
2. Cultivation (planting): changing the amount of seeds a farmer plants in a specific area enables him to plant more seeds in soils that can tolerate more crop congestion. Also with the help of moisture sensors, we can plant the seeds in the optimum depth for germination.
3. Fertilization: distribution of fertilizer and lime (material) on the field based on the level of nutrients in the soil according to the results of soil testing can be analyzed and then changed so that each part of the field receives the exact amount of fertilizer it needs.
4. Spraying (pesticide): with sprayer's automatic control function, farmers can alter the amount of toxins released while driving around in their farm or even realize how much pesticide or herbicide they should use in various parts of their farms.
5. Harvest: the most developed part of this technology is the crop's performance in the farm. Sensors installed on the combine can determine the crop's performance at the time of harvest. This technology along with help from GPS allows farmers to record the crop's performance based on location. All of this leads to improvements in the modifications made within each field [11].

Data storage:

Before starting to process the data, we must make sure that all of the previously collected data is correct and reliable. Then we should make a back-up copy of all the raw data files onto a CD. Following a common naming procedure will come in handy when relocating files in the future. File names should contain paddock name, crop type (e.g. wheat, canola), the year it was collected and data type (e.g. raw, trimmed, and interpolated) [7].

Data cleaning – removal of erroneous data points:

Not every data point is appropriate for mapping; some may be misplaced due to GPS signal error, others are low or even zero readings at the start and end of rows when the comb is not at full capacity or abnormally high when the harvester slows, or when there is a blockage in the system. All of these erroneous data points need to be removed. Firstly, yield monitor calibration accuracy should be checked. This can be done by comparing total deliveries (do not forget stored or grain kept for seed) with the total yield recorded on the yield monitor [7].

Changing the GPS projection to easting and northing:

GPS data is generally gathered based on longitude and latitude on decimal degrees using the WGS84 American standard. However, mapping software requires it to be in eastings and northings with units of meters. To make this change the software will require your Universal Transverse Mercator (UTM) zone.

ArcGIS program is example for these programs.

Interpolating data (producing a smooth map surface):

To turn all the data points and spaces between them into a yield surface, first the data needs to be interpolated.

Finally, by using all the previous data along with help from ArcGIS software and aerial maps of the farm and GPS information, we can plot the yield map and process all the data and needs of the farm

Now we have the yield plan of our farm along with real numbers that represent the changes in performance; and that's about enough reasons for us to start using this technology. The use of yield maps can create relations between performance changes and differences in soil type or issues considering weed control, fertilization, drainage, soil congestion, improper use of equipment and so on [11]. Now, according to data obtained from the yield map, we must equip the combine with monitors, grain flow measurement systems and different kinds of sensors such as grain moisture sensor, speed sensor, yield sensor and etc.

Due to the researches made by the Agriculture and Natural Resources Research Center of Khorasan Razavi[1] on the combine harvester belonging to class Dominator s-68 (which is widely used in Iran), it shows that all the gadgets above are completely compatible with this kind of combine harvester [8].

Conclusion

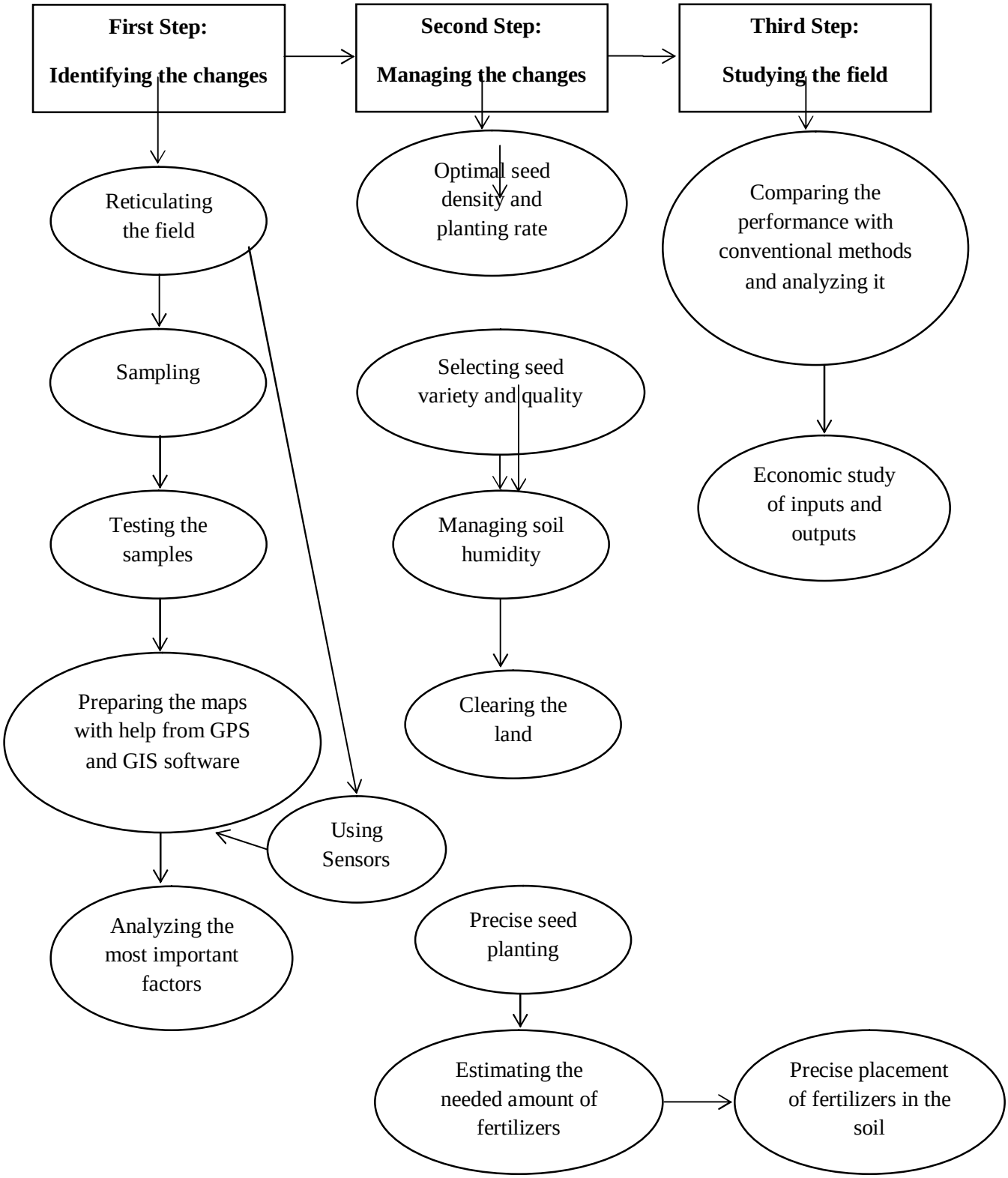
We must not forget that persistence on updating the data about the agricultural land is really important and Remote Sensing (RS) as a potential management tool for precise agriculture has lately drawn a lot of attention to itself. Satellite and aerial images allow the farmer to quickly view and examine his farm and decide which parts need more precise management, even without leaving house. An example of Remote Sensing can be weather maps that display various meteorological features across a particular area at a particular point in time such as rainfall or cloud density.

Finally the use of this technology in agriculture causes fertilizers and pesticides to be used only in the required parts of the field and up to the amount needed. Also diseases and nutrient deficiencies that effect the growth and quality of the crops will not hide from the machine's vision systems even when the leaves change color, and they can be recognized quickly and more accurately. It can even help us act smarter on issues such as drainage, irrigation and the humidity of the farm.

And in the end we can make out a correct pattern to exactly when to harvest and when to plant the crops. All of this enables the farmer to experience an economical and sustainable agriculture.

[1] .Razavi Khorasan : A province located in northeastern of Iran

Figure 1. Essential steps in precision agriculture



Suggestions

1. The profitability of precision agriculture for farmer cannot be ignored but because profitability in this technology is not immediate and requires several consecutive years of usage, there is a strong need for education and training in using this technology.
2. We should avoid focusing too much on scientific and technological aspects of this topic because it usually causes confusion and leaves us with only an isolated scientific development.
3. Allocated funds from the government for the purpose of doing more research projects along with holding incentive plans to encourage farmers in using new technologies can be very helpful and effective.

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