Geographic Information System in Agriculture and Precision Farming

Pongpichaya Limpisathian

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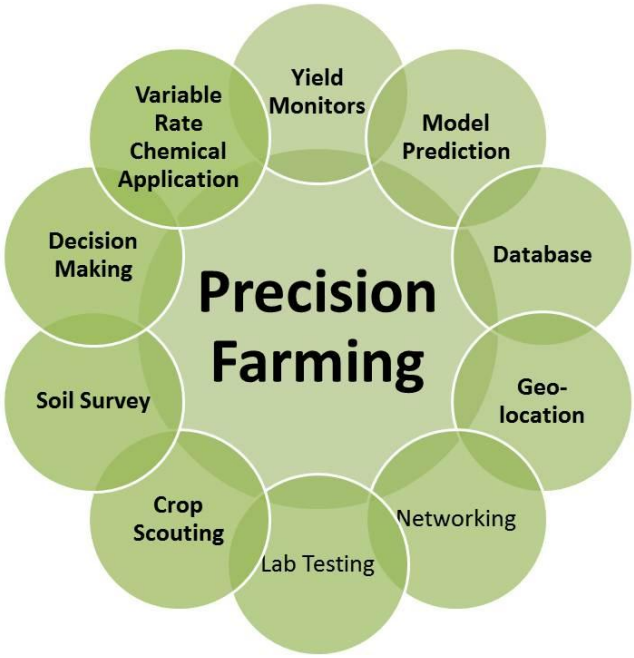
At present, GIS is being utilized by an extensive range of modern day industries; such as logistics, criminology, disease control and many others. However, there is one particular field of use that is rapidly growing which is the field of agriculture. This is due to the fact that more and more farmers are realizing the value of GIS and how it can benefit them. Today there are multiple usages of GIS in agriculture, the most prominent of which is precision farming.

Precision farming, or precision agriculture, is the farming concept that integrates geographical data obtained from technology such as GIS and GPS and helps optimize the yield and lower the cost of agriculture (Goddard, Kryzanowski, Cannon, Izaurralde, & Martin, n.d.). Furthermore, precision farming is not just beneficial to the farmers, it is also beneficial to nature and the environment as it helps reduce the unnecessary impact of man and traditional farming techniques on the environment (Goddard, Kryzanowski, Cannon, Izaurralde, & Martin, n.d.). With GIS and precision farming, farmers are able to determine the areas that need what in term of nutrients, pest control and conditioning ("GIS and precision," n.d.). This consequently reduces the need and cost of pesticides, fertilizers and other agro-chemicals because farmers can now estimate the quantity of agro-chemical is actually required. This process is also known as “site-specific” agriculture which refers to handling the smallest area of land as an independent element (Pfister, 1998). Therefore, precision farming using GIS along with other geographical technology essentially improves farming overall by giving famers more specific information as to how to treat or farm their crops in order to achieve maximum yield while reducing upkeep costs.

Precision farming consists of many different elements working together in synchronicity with the help of GIS (Fig 1.). These multiple elements range from collecting and maintaining soil nutrient data before and during farming to yield monitoring during harvesting to see whether the

optimized "site-specific" precision farming is effective (Pfister, 1998). The process for this farming technique is a year-round process that starts from before the planning process all the way to the harvesting process. After the harvest the famers still have to go through the data collected, analyze it and prepare a plan for the next round of crops.



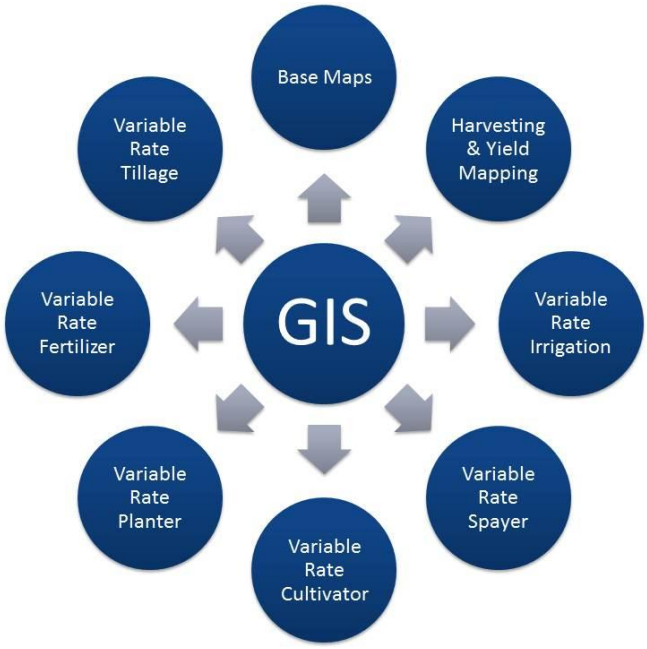
The multiple components of precision farming, most of which is greatly enhance by GIS
Fig 1. (Credit: Indian Space Research Organization, n.d.)

The major parts of precision farming can mainly be broken up into three steps; pre-planting, post-planting and during the growth, and lastly, during harvest (Pfister, 1998). The pre-planting stage consists of gathering data required for planning. This includes, but is not limited to, gathering soil nutrient data from the farming area, gathering and evaluating data such as ground water level, potential pest and weed and also determining the areas, if any, affected by disease which may affect crop yields (Goddard, Kryzanowski, Cannon, Izaurralde, & Martin, n.d.). After planting and during the growth period, farmers have to use the data and information obtained during the pre-planting stage, through GIS, to manage different areas of the crops specifically depending on their needs. This may include dealing with weeds, diseases, pests and

other problem affecting the crop (Pfister, 1998). The last stage is during harvesting, which the famers use a technique called "yield monitor" which analyzes the data of the yield from the crow to see whether the overall plan is working and to prepare for the next farming period (Pfister, 1998). Data collected by the farmer is then fed into GIS software for analysis providing the farmer with the desired information and maps. It might even be said that GIS is the central component of precision farming. Without it, all the farmer would have is just a list of coordinates and random data. It is only after the data is analyzed using GIS software that it becomes useful information. Still, when looking at it from an overview perspective, the requirements and necessary steps in precision farming may seem daunting. Nonetheless, its effects and benefits seem to outweigh the necessary dedication on the part of the farmers which is clearly visible both from the level of adoption and the initial data being advertised.

Aside from yield monitoring, farmers rely on other related techniques. These include "variable planting," "crop scouting," "variable rate chemical application" and others less predominate techniques displayed in Fig 2. "Variable planting" is basically using the data collected from previous crop cycles to help determine what should be planted where and how much of it should be planted. This can be automated by using seeding machines with yield monitoring data from previous crop seasons (Pfister, 1998). "Crop scouting" is the collection and track data on the growing crop, and the identification of any problems that may arise and the determination of what action should be taken to stop or eliminate the problem. "Variable rate chemical application" is related to automated sprayer systems in which the farmer can use the data previously collected for determining which areas, if any, need chemical intervention and if so how much is needed (Pfister, 1998). They do this by inserting the data into the machine responsible and it will take care of the rest (variable planting also uses similar methods). One

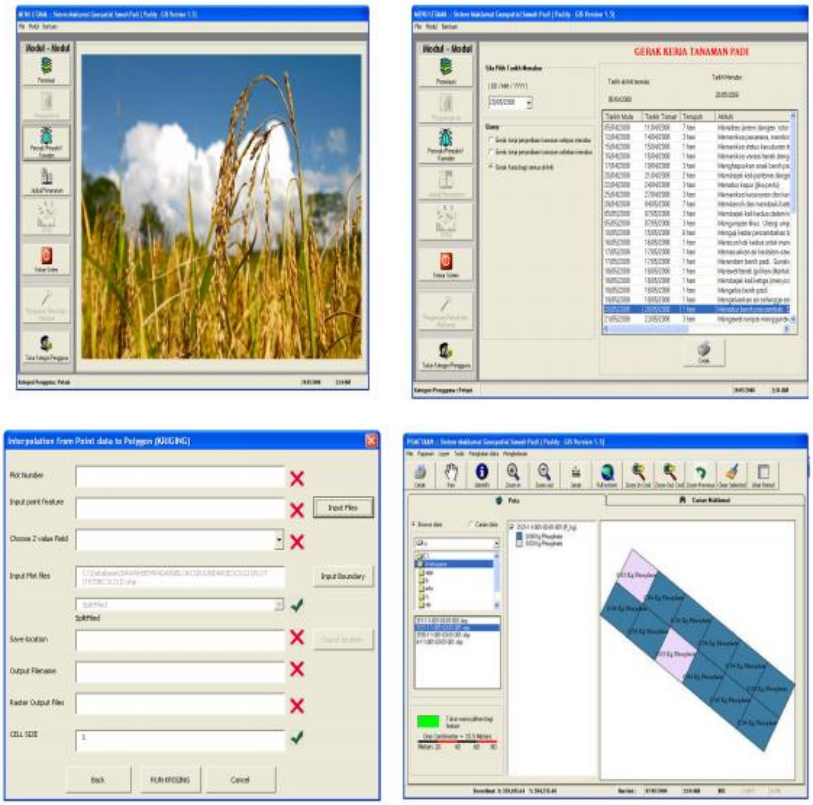
other thing that farmers rely on for precision farming, that is not essentially a specific technique, is lab testing which is used for soil testing to determine information and data relating to "site-specific" farming (Pfister, 1998).



A detail overview of some of the components related to GIS in precision farming.
Fig 2. (Credit: Indian Space Research Organization, n.d.)

Right now, precision farming is being used by numerous countries around the world. In developing countries such as Malaysia, an adapted model of precision farming using GIS has and is being tested (Fig 3.). The adapted model that has been tested in Malaysia is for paddy-based crops and grain such as rice (Aziz, Shariff, Soom, Rahim, Cha'Ya, & Jahanshiri, n.d.). What the model shows is that there is no reason why precision farming using GIS cannot be applied to other types of crops, thus demonstrating that the concept of precision farming using GIS is globally feasible. Even in the cold region of Alaska farmers are also using GIS-based precision farming (Brown, n.d.). What these models and research show is that, generally, GIS-based precision farming is beneficial, if not right away then after the first few crop cycles. Basically, it is giving the farmer more knowledge using information technologies and systems to better

manage his own crops. Whether it proves to be successful or not will rely largely on the farmer's ability to manage his crops from the data he collected through the process and GIS programs.



Sample of GIS software adapted for paddy-based crop called "Paddy GIS."
Fig 3. (Credit: Centre for Agricultural Bioscience International, 2008)

The benefits of precision farming using GIS are equally felt by all sectors related to it, from the farmers themselves to the consumers and even the environment itself. Aside from maximizing the yield while minimizing cost for farmers, precision farming using GIS is also beneficial in that it enables the farmer to make better decisions and to be more knowledgeable about their crops. It is beneficial to the consumer in that the yield product of the crops that have been grown using the precision farming is higher quality since farmers were able to tend to it specifically instead of treating the entire farmland as a whole (Pfister, 1998). It is beneficial to the environment because it reduces the amount of agro-chemicals needed for farming by

identifying the areas that do need the chemical and at what level is sufficient and thus reducing the overall farming footprint (Nemenyi, Mesterhazi, Pecze, & Stepan, 2003).

However there are also some negatives and drawbacks regarding precision farming. For one, because it requires the farmer to invest in technologies that enable the ability to monitor their crops all before actually planting anything, (example of which can be found in Fig. 4) thus increasing the required farming cost in the short term (Lowenberg-DeBoer, 1996). Studies have also shown that long term profitability is not always achieved and some crops tend to be more profitable than others, mainly, high value crops such as vegetable and seeds as opposed to bulk crops such as corn (Lowenberg-DeBoer, 1996). Another drawback of precision farming is the fact that it requires investment and dedication on the part of the farmer right away but it usually takes time to effectively show up and achieve probability (Lowenberg-DeBoer, 1996). However, even with the information that is meant to help farmers make better, well thought-out decisions, the decision of how to treat their crops still ultimately falls to the farmer and if they lacks experience and decision-making skills or the how-to regarding the various tools and components that is needed, the outcome of it may be undesirable. Furthermore, even the slightest miscalculation may prove to be quite costly for the farmer. Lastly, let us not forget about the cost relating to the equipment and components used in precision farming. This cost depends on the usable lifetime of the equipment and components being used and may vary from average to moderate to expensive and costly (Lowenberg-DeBoer, 1996).

GPS/GIS Equipment installed in a farming tractor to collect data.
Fig 4. (Credit: University of Alaska Fairbanks, 2010)

In summation, precision farming looks to be a promising agriculture concept that seems to be overall beneficial to all involved; from the farmers themselves to the consumers like us. It looks to improve the efficiency of agriculture while also saving the environment. But ultimately, there are still some possible limitations of the concept. Due to the fact that it relies so much on the farmers and since the GIS software can only interpret the data that the farmer gives it, if the data that the farmer fed it is incorrect the resulting calculation will therefore be incorrect. In addition, while the concept helps improve the overall agricultural system, studies have shown that it is not an all-encompassing concept that is applicable to all. While some crops require some alteration for it to work, the method has proven to be ineffective for others, mainly bulk crops. So farmers should take this concept with a grain of salt, for the method may prove to be successful for some, it may also easily go the other way for others.

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* Cover page picture courtesy of NASA, n.d.