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The Role of GIS and Remote Sensing in Agriculture

For years there has been a severe disconnect between where and how our food is produced. However, with rising concerns about the environment and how our food is produced more and more people are becoming involved in the agricultural industry. There are many issues that arise in agriculture that can have widespread effects on the people and the environment. Pollution of groundwater, nitrogen leaching, soil erosion and depletion, plant and animal diseases, irrigation are just a few. The farmers also have their own unique problems that present themselves such as knowing how much fertilizer to use, how much water is needed, the type and amounts of herbicide/pesticide and how much to harvest and when. The field of GIS and remote sensing within the past ten to fifteen years has made significant strides in being able to help farmers and governments answer some of these very questions. GIS and remote sensing programs are laying the ground work for the next generation of farming as well. In our lifetimes instead of teams of workers collecting crops it could be teams of autonomous vehicles and machines that are out in the fields.

Only two decades ago remote sensing programs were only able to effectively map very large scale areas on the ground. These systems were good enough to monitor the soil erosion and large areas of landscape that are constantly changing. These satellites also started to use multi-spectral lenses in order to help determine different types of landscapes such as forests and farmland and natural fields from each other (Sommer). Today remote sensing satellites and aerial photography can identify different species of plants based on their IR spectrum. Multi-spectral imaging can be used to help farmers know how much yield they will have from a crop by the color of it on the IR images. This type of yield estimation system is readily available for commercial crops of grains and cotton. Another example of thermal imaging that has also been used in estimating yield is by determining the amount of fruit that are in an orchard because the temperature of the fruit will differ from its surroundings (Lee). Another application for remote sensing is to locate outbreaks of disease or invasive weeds into crops. Healthy plants will show up as a bright red on a NIR image while dead or unhealthy plants will not appear to be as bold. Different plants, trees and grasses reflect different light so each species can be determined based on their reflectance. The future of using remote sensing is wide open in terms of what can be accomplished. The more sensitive cameras get and the more affordable the technology becomes the more it will be implemented into agriculture.

GIS, remote sensing and GPS technologies can be beneficial to the agricultural industry in many other ways as well. The idea of a fully integrated and automated farm seems like it could come from science fiction yet that reality is not far off. GPS can allow farmers to plot courses for tractors and harvesting equipment and it can allow them to mark areas that may need more or less fertilization because of the soil content. The term precision farming has been coined when these information systems are combined with agriculture. “Precision farming is a way of farming which takes into account the in-field variability, a technology where the application-seeding, nutrient replacement, spraying etc. has taken place to act on the local circumstances of a given field (Nemenyi)” In a precision farming situation the farmer would be
far from replaced. The technology would still be reliant on the farmer’s expertise and personal experiences in order to function effectively and then operators would have to coordinate the machines in order to harvest the crops (Earl). The best information and technology is only useful if it is used correctly, precision farming would place more of the crop production into the hands of skilled technicians instead of unskilled laborers. The removal of the human element from the harvesting of crops would also help reduce the risk of diseases such as Salmonella from entering the food supply.

Another way in which GIS system can help protect us and the environment is through its application in simulating environmental conditions. In Spain nitrogen leaching was posing a serious risk to a population over one million people. This was caused by farmers in the area not adhering to nitrogen recommendations for their crops. Using data about nitrogen uptake from the crops in the area researchers were able to determine that the local farmers could use 50% less fertilizer and their crops would still take up the same amount of N and leaching was reduced by over 60%. It is unfortunate that it took government action and the risk of people becoming sick to realize how much money the farmers were wasting and how much they were unnecessarily polluting (de Paz). However, before every farm in the world has a functioning GIS or remote sensing program there are many hurdles to overcome.

In all of the papers there was one fact that was the same throughout, currently these systems are too expensive of the average farmer to be able to purchase. The camera equipment alone costs in the thousands when dealing with high resolution near-IR and digital cameras. Then compounded with that is the cost of the GIS system and the operator of the system, the man hours needed to interpret the data, the aircraft, satellite or vehicle needed to take the images. Other issues that are hindering GIS in agriculture is the durability of the equipment and also the lack of compatibility between systems. One system that seemed to be the most useful to the average farmer was AgroMap Basic which can use GPS mapping or the user can draw in boundaries. This would allow the user to have one field and to break it up into multiple sections based on any number of variables (Nemenyi). Despite these shortcomings the potential for this technology is astounding. In development now are olfactory sensors that can detect when a crop is ready to be harvested along with many other new innovations that have yet to be seen. One possibility which was overlooked was the potential for fully automated hydroponics or urban gardens. The idea of a large greenhouse where temperature, moisture and other environmental conditions can be monitored and maintained would make farming a much more efficient process and help deal with feeding the growing population of people on this planet.

Once the cost, complexity and compatibility issues are addressed the impact that precision farming will have in agriculture will redefine farming. Precision farming will help farming become more efficient by reducing waste and excess fertilizer from our environment. GIS and remote sensing will also give farmers the ability to act faster if a disease does break out and a sensor in the field picks it up before it would be visible to the naked eye. Only time will tell the extent to which precision farming will influence the world but more likely than not we will reap its benefits.
Annotated Bibliography


In the region of Valencia Spain there is a high amount of nitrate leaching and contamination do to many of the farmers in the area ignoring nitrogen recommendations for their fertilizers. It took an EU directive and action on the part of the local government to formulate a nitrogen recommendation for the farmers to use. The researchers involved used data on the nitrogen uptake from potatoes and citrus to formulate and program which could simulate varying nitrogen levels of the soil, the levels of uptake and the level of leaching that would result. The researchers found that by reducing the nitrogen content of the fertilizers by 50% it reduced nitrogen leaching by 65% and crop uptake was only reduced by 3%. This single study will not only help the environment, protect ground water and the population that lives in Valencia but it will also save the farmers in the region thousands of dollars in fertilizers. This article is a prime example of how even though some people have been farming a certain way for decades if not centuries that it may not always be the best for us or the plants and animals being produced.


The topic of this paper examines the possibility of using GIS programs in precision farming and for its future role in automated farming. This paper provides several examples of how GIS programs would be beneficial in an agricultural situation. With a GIS program monitoring crops you can have accurate and up to date information on anything from soil quality to crop yield to moisture content of the crops. The idea of autonomous or semi-automated farming equipment is very intriguing. Automated equipment with the right sensors could detect diseases, pests and weeds that are in with the crops that may not be easily identified by workers. The employment of such equipment would lower costs because you can target the specific areas that need nutrients or pesticides and it would have a decrease on the impact these chemicals would have on the environment.


This article contained the most comprehensive look at all of the GIS and remote sensing technology available and in development for use in agriculture. The paper is broken into several sections that address crop yield mapping, weed detection, crop water status, sensor networks, crop biomass detection, soil characteristics, foliar disease detection, radio-frequency identification and machine olfaction systems. The article not only described multiple types of systems in each section but also looked at the pros and cons of using such technology and what lies in the future for the technology. One of the most important sections was on foliar disease detection which has applications in crops used for food, textiles and for ornamental plants as well. Crop yield is also a very important area where GIS can be implemented because a higher crop yield results in higher profits and it can give a farmer early warning if they are not growing at a correct rate. The main drawback to most of these technologies, as stated in other papers, is
the cost. Right now the cost, complexity and lack of compatibility are what hold back GIS programs from revolutionizing the agricultural industry.


This paper’s focus was to compare two different GIS systems in order to see what the best system was to use in the future for research on precision farming. The idea is that in each field of crops there can be significant variability in the irrigation, drainage and in type of soil that they are planted in. By pinpointing areas that need additional nutrients or water and areas that do not need excess you can save money and help prevent runoff into the environment. This paper also addressed some of the issues that incorporating GIS into agriculture can present. First, is the complexity of many of the programs is difficult for your average consumer to tackle without expert guidance. The second issue is the cost involved with having all the data recorded for a single field placed into a GIS program. Finally, the fact that some of the programs used are not compatible with each other causes significant challenges. Overall they found that the ArgoMap Basic was the best choice for the users of these products.

**Sommer, S. , J. Hill, J. Mégier. 1998. The potential of remote sensing for monitoring rural land use changes and their effects on soil conditions. Agriculture, Ecosystems & Environment 67: 197-209.**

Although an older paper it provides a point from which the newer papers can be compared with. Twelve years ago the technology that was used has no been replaced by remote sensing satellites that have a much higher resolution and can give much more detailed data. This article gives the groundwork for how remote sensing and GIS programs can be used to map soil erosion and changes in vegetation in terms of type and health. While this paper focuses more on large areas of land with the new technology available to us the same principles can be implemented on farms with hundreds of acres instead of entire countries.


The author’s of this paper addressed the issue of the high cost of NIR images and aerial photography. By combining the two different types of images it created a lower costing way to have multi-spectral images. Earlier videography had resulted in blurry images but new digital technology along with the photos reduced the blur significantly. Although the equipment is cheaper you still are in need of a small aircraft and the costs involved with fixing distortion and combining the images into a mosaic are still significant. Overall some costs were reduced and the fact that consumer technology is a point where it can be used for scientific research should not be discounted, it is a definite step in the right direction.