Chapter XV

GIS in Agriculture

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Abstract

This chapter introduces the use of geographic information systems (GIS) and global positioning systems (GPS) in agricultural production. Precision agriculture is a catch-all term that describes using GIS and GPS technologies to manage specific areas of fields. Precision agriculture technologies use information from multiple sources to assist farmers in making crop production and management decisions based on the variability of production potential within fields. In this chapter, we describe the technologies used in production agriculture and we review some of the research associated with the use and future trends of these technologies. The purpose of this chapter is to define and explain GIS and GPS technologies used in agriculture and some of the economic benefits, impacts, and challenges of using these technologies.

Introduction

Farmers have long known variation existed within their fields, but did not have the tools to properly quantify, view and manage that variation. Geographic information systems (GIS), along with global positioning system (GPS) enabled technologies, have given farmers the ability to make management decisions with more precision and information...
than ever before. Fields no longer have to be managed on an across-the-board basis, but rather fields can be managed on the production potential of each area of the field. Agricultural crop production can be limited by soil chemical or physical characteristics, topography, crop variety, or a number of other variables. GIS allows farmers to determine where deficiencies exist, search for the cause of the deficiencies, and make management decisions necessary to improve productivity in the problem areas. With GIS and GPS systems, farmers can have access to a tremendous amount of information on yield variation, soil properties, topography, water absorption, plant health during the growing season, and records of chemical use.

The catch-all term, precision agriculture, means to use GIS and GPS technologies that allow farmers to manage specific areas of fields. GIS serves as one component of decision support systems (Grupe, 1990), which lends itself to the working definition of precision agriculture that is published by the National Research Council (National Research Center, 1997) as, “a management strategy that uses information technology to bring data from multiple sources to bear on decisions associated with crop production.” Farmers see that their production is being squeezed with higher input costs and tougher international competition and some have considered adopting precision agriculture as a way to lower production costs, protect the environment, and to manage large farms (Olson, 1998).

Precision agriculture tools are used to monitor crop yields, apply inputs at a variable, rather than constant rate, and to guide equipment. Other tools are used to determine soil electrical conductivity, manage soil on a site-specific basis, and to monitor crop growth and health from satellite or aerial images. All of these tools utilize GIS to acquire, process, analyze, and transform the data collected into information that farmers can use to better manage production and improve profitability. The incorporation of precision agriculture tools began in the mid 1980s (NRC, 1997) and the initial adoption has been slow (Swinton & Lowenberg-DeBoer, 1998). While economic benefit is the deciding factor for sustained use of a precision agriculture technology, other reasons, such as attitudes toward technology, may possibly affect adoption (Cochrane, 1993). Although the research on the economic benefits is mixed, (Malcolm, 1996; Sawyer, 1994, Swinton & Lowenberg-DeBoer, 1998), farmers are primarily investing in them sequentially (Isik, Khanna, & Winter-Nelson, 2000; Dillon, 2002).

The purpose of this chapter is to define and explain the technologies used in precision agriculture, to explain some of the economic benefits, the impacts of producers’ decisions, the challenges of using these technologies, and to review some of the precision agriculture technology research. Benefits of precision agriculture technology include: reduced variable costs, increased yields, increased profits, and reduced environmental effects (Intarapapong, Hite, & Hudson, 2002; Sawyer, 1994). Increased yields result from increasing inputs in more productive areas of managed fields, thereby increasing yields. Sometimes fewer inputs are applied in areas of the field that have lower yield potential, which reduces variable costs (Intarapapong et al., 2002). Fewer environmental effects are possible because of the more precise application of inputs (Kitchen, Hughes, Sudduth, & Birrell, 1995; Intarapapong et al., 2002; Sawyer, 1994). However, farmers cannot vary the input until they have the information that shows how yields or soil properties, such as pH levels, vary across the fields.
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