Using and Improving Irrigation: Producer Perceptions and Possibilities

by

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A thesis submitted to the Graduate Faculty of
Auburn University
in partial fulfillment of the
requirements for the Degree of
Master of Science

Auburn, Alabama
December 13, 2010

Keywords: Irrigation, Adoption, Diffusion, Innovation, Water, Barriers

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Abstract

Frost, drought, and other sources of crop stress may be reduced through irrigation. A random sample of Alabama crop, tree, and vegetable producers was surveyed about the nature and extent of irrigation practices and problems. The study assesses needs for technical assistance relative to irrigation use and improvement. Results profile farmers' personal characteristics, irrigation practices, equipment, and water sources to identify barriers to adoption of improved irrigation. Findings suggest that being innovative encourages irrigation adoption, improvement, and expansion. Irrigation growth in information-transfer and collective learning may not have reached their potential for the Alabama farmer. Finding ways to support less innovative farmers may be vital to encourage greater irrigation use among those who need it most across Alabama. Financial circumstances influenced farmers' decisions to irrigate in 2008. Cost-sharing and other financial incentives could be key parts of efforts to advance irrigation use in Alabama.

Acknowledgments

I would like to thank the Alabama farmers for their participation, time, and interest in this study. To my professors at Auburn—Dr. Joseph J. Molnar, Dr. Michelle R. Worosz, Dr. Donn A. Rodekohr, and Dr. Conner Bailey: Thank you for your support, time, and all that you have invested in me over the past two years to help me accomplish this project and grow intellectually. Thank you to all of my friends and fellow students for all the memories. I give a special thank you to John and my family for all of their love and support.

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I. INTRODUCTION

Significance of Irrigation for Crop Yields

Irrigation makes agriculture possible in areas previously unsuitable for intensive crop production (EPA 2009). Irrigation transports water to crops to increase yield, keep crops cool under excessive heat conditions, and prevent freezing. Less than 15 percent of U.S. cropland is irrigated, although irrigation is essential for crop production in some of the most productive areas of the nation (EPA 2009). For instance, Arizona is home to some the highest corn yields in the country (208 bushel per acre state average in 2001, compared to 152 for Illinois), but much of the crops are under continuous irrigation from planting until harvest (EPA 2009). The need to irrigate is usually driven by the necessity to meet the water needs of the crop from year to year (some areas of the country simply receive too little rainfall during the growing season to support economical crop growth). In other situations, irrigation is viewed as insurance against occasional drought. Also, agencies across the United States often require irrigation to protect their investment before making crop loans, since accurate irrigation scheduling in cotton can increase yields (Bajwa et al. 2007).

In areas where rainfall is plentiful in most years, irrigation can bring benefits by reducing risk of disease, frost damage, and other crop stressors, which can provide income stability. Other benefits include: improving crop quality (most noticeably for vegetable crops), significantly increasing crop yields, particularly on sandy soils (as in parts of Alabama) which have low moisture-holding capacities, increasing opportunities for double cropping (such as planting soybeans after wheat in the same year), and providing a means for liquid fertilizer application (EPA 2009).

Irrigation consists of surface-water and groundwater withdrawals. Various types of irrigation systems are used for crops, nurseries, sod farms, and golf courses in Alabama. In the short-term, application rates are likely to vary annually according to the amount and timing of precipitation, soil conditions, and crop type. Over the long-term, application rates are influenced by changes in technology, farming practices, and climate (Bai 2008; Britannica 2010; Green et al. 1996; USGS 2010).

An example of the importance and success of irrigation on crops can be seen in California's San Joaquin Valley, which receives approximately five inches of rain per year, virtually none of which falls in the summer (Langcuster 2007). Nevertheless, the valley, which is only 300 miles long and 120 miles wide, raises hundreds of agricultural commodities for the rest of the world. This is largely due to networks of irrigation made possible by a range of social, economic, and technological factors, coupled with wise water-use practices. However, the valley has its share of problems due to its irrigation practices. Dam constructions on the river tributaries, which provide irrigation water, have made the rivers inaccessible to migrating salmon and mostly have ended the salmon run. Also, almost 60 miles of the San Joaquin River is dry due to water diversions. Irrigation runoff water, contaminated with pesticides and fertilizer, causes the river to become heavily polluted. Although the San Joaquin Valley has ecological problems, it also produces an abundance of food in an arid climate; this area has capitalized on its irrigation networks to grow crops with little rainfall.

Agriculture and Irrigation in Alabama

Agriculture is one of the largest economic activities in Alabama (Ghebreslassie 2001; Murphy 1992). In Alabama, farmers depend on rainfall every year to run their farming operations. Warmer and drier weather necessitates more watering, while cooler or wetter weather necessitates less watering. Most watering occurs May through October; any additional watering from November through April is generally to aid in application of fertilizer or herbicides (Bai 2008; Britannica 2010; Green et al. 1996; USGS 2010).

Although Alabama receives ample amounts of rainfall—56.90 inches on average per year (compared to Wyoming which gets about 13.31 inches per year and to New Mexico with 8.91 inches per year), this moisture sometimes is not available when crops need it most (Langcuster 2007). Farmers across Alabama in general suffer from recurrent spells of drought (Monks et al. 2000). For example, the southern half of Alabama suffered a severe drought in 2000 that lasted for many months (Monks et al. 2000). Such climatic fluctuations cause irregularities in the amount of rainfall received each year. Thus, irrigation is vital for the success of the world's food production, including production in the state of Alabama (Langcuster 2007).

Approximately 80 percent of the world's food supply is provided by industrialized agriculture and the remaining 20 percent by subsistence agriculture (Miller 2005). However, small and mid-sized, limited resource farms compromise more than three-fourths of the operations in the Southeastern states of Alabama, Georgia, and Mississippi. This portion of the farm population has disproportionately low levels of adoption of established measures for conserving soil and protecting groundwater (Molnar, Bitto, and Brant 2001). The industrialized agriculture system led to the demise of small and midsize farmers, since they cannot effectively compete with large commercial farms (Pretty 1995; Molnar et al. 2001). Smaller farmers who lack sufficient resources to adopt new technology may be forced to leave agriculture. Thus, concerns regarding the social, environmental, and economic impacts of industrialized agriculture have emerged in recent years.

The farming community's middle sector is rapidly disappearing (Brooks 1991). The disappearing middle of the farm-size distribution is associated with the demise of the family farm (Brooks 1991). One concern is that the dwindling number of mid-sized farms may imply a loss of middle-class independent producers who sustain community institutions, and thus a subsequent decline in community well-being (Brooks 1991).

An agricultural sector that thrives in spite of occasional setbacks associated with prolonged dryness and that capitalizes on irrigation and water stewardship practices to raise a wide variety of crops is one idealized scenario for Alabama agriculture (Langcuster 2007). Langcuster uses cotton as an example of how increased usage of irrigation in Alabama may provide greater yields and profits. Of the 500,000 acres of cotton grown in Alabama, only eight to ten percent is irrigated; irrigating just half of Alabama's currently non-irrigated cotton acres could potentially generate an additional 56 million gross dollars to the state's farm economy (Langcuster 2007).

Environmental Concerns

Environmental concerns related to irrigation include: depletion of water sources (falling water tables, reduced water levels in streams or reservoirs), soil erosion due to over-application, runoff and leaching of chemicals, salinization of the soil (salt-buildup), and minerals and nutrients drain from the irrigated area (Rijsberman 2004). Because of such ecological pitfalls of irrigation, many in the environmental community think that water withdrawn for agriculture should be reduced, not increased (Rijsberman 2004). They maintain that irrigation development impairs the ability of many ecosystems to provide valuable goods and services, such as flood protection, water purification, and provision of food (Rijsberman 2004). Yet others assert that not enough attention is given to alternative, more sustainable means of production (Alcamo et al. 2000, Rijsberman 2004).

Surface irrigation methods typically apply large volumes of water in short periods of time and may have low application frequency (Ayars et al. 2006). There may be poor distribution uniformity unless these systems are well installed and managed. This can result in poor distribution uniformity and excessive deep percolation losses, which can result in water logging, production losses, excess additions to shallow groundwater in some areas, and under-irrigation in others. Improved irrigation management and the use of shallow groundwater can reduce water logging, reduce the volume of deep percolation, and improve crop yields (Ayars et al. 2006).

Corn and other southern crops are primarily surface irrigated (Vories, Tacker, Lancaster, and Glover 2009). Vories et al. (2009) investigated the effects of subsurface drip irrigation (SDI), a water-conserving irrigation method, on corn production over three years. They found that SDI produced the same yields, while using less water than traditional irrigation methods. Subsurface drip irrigation proved to be efficient, effective, and water conserving in this study, although not affordable (average costs and prices considered). The costs of installing and maintaining the system were not paid by the returns from crop sales (Vories et al. 2009). Implementing efficient, new irrigation technology is a costly investment, and this cost may be a potential barrier to adoption.

Excessive groundwater withdrawal for irrigation can result in groundwater depressions and a decline in groundwater level (Bajwa and Vories 2007). For example, Arkansas deals with challenges from a rapidly declining irrigation water supply and a need to improve cotton yield and yield quality. Therefore, accurate irrigation scheduling is important for optimal water use.

Knowing the best irrigation method is not simple, as the Southeast experiences dry periods with irregular rainfall during the growing season and yearly weather varies from dry to wet. Bajwa and Vories' (2007) hypothesized that cotton water stress in humid areas is affected by canopy reflectance or temperature. Field experiments were conducted in 2003 and 2004 with three irrigation treatments to study cotton responses to water stress. The experimental plots were monitored for soil water potential, canopy reflectance, and canopy temperature. Rainfall was plentiful both years. Excessive irrigation in these conditions decreased yield, indicating the need for accurate irrigation scheduling (Bajwa et al. 2007). Such organizational measures may be particularly relevant in a context of inter-state conflict over water during droughts.

Hsaio et al. (2007) mention a number of ways for producers to become more efficient in agricultural water usage, as do organizations such as the World Water Council and the Global Water Partnership (Rijsberman 2004). Irrigation can become more efficient by: involving users more in the management of water, often through the establishment of forms of water-user associations; pricing water and/or making it a trade-able commodity; and establishing river basin authorities that integrate typically fragmented government responsibilities for water into a single authority responsible for the river basin (Rijsberman 2004).

Barriers to Adoption of Irrigation Techniques

As irrigation remains integral to crop production, the trial and adoption of irrigation technologies and innovations is often necessary for successful and abundant crop yields (Bajwa et al. 2007). Though there has been recent abundant rainfall, rain may not always come when needed most (Langcuster 2007). Other sources of crop stress may be reduced through the use of irrigation (Langcuster 2007). Irrigation adoption can increase farmers' yields by minimizing disease and frost damage and by promoting early plant growth. For example, as efficient, sustainable, and water-saving irrigation methods are developed, there are innovative, improved irrigation techniques available for farmers to adopt; the adoption of such technologies may allow farmers to water their crops in more efficient and environmentally friendly ways. This reflects a relatively new emphasis on more innovative water-conserving irrigation techniques in the state of Alabama (Bajwa et al. 2007). Understanding how irrigation technology is communicated is necessary for fully understanding why farmers either adopt or neglect to adopt irrigation practices that may potentially benefit their production rates. Thus, understanding the barriers to the adoption of irrigation techniques is vital for the increasing use of such methods.

In a study of “stone” fruits, such as peaches or plums (fleshy fruits with a single seed), and “pome” fruit, such as apples and pears that grow on trees, researchers found that in most cases, the motivation for growers in Goulburn Valley, Victoria, Australia to change orchard irrigation management practices was not because they needed to save water or to increase water-use efficiency (Kaine et al. 2005). Instead, growers were changing practices in order to save time irrigating, to improve the scope for managerial flexibility in the orchard, or when redeveloping their orchard for a closer planting design. These findings suggest that producers are more likely to respond to an extension program coupled with a broader program of farm changes.

Adoption of a technology new to an operator, such as an irrigation system, is a complex phenomenon and several economic and social factors contribute to farm-level decisions affecting adoption. Kulshreshtha and Brown (1993) estimated the role that attitudes of potential adopters towards irrigation play on subsequent adoption on their farm. The results suggest that adopters' attitudes, particularly with respect to economic and environmental effects of irrigation, were significant determinants of their decision to proceed with adoption of irrigation and affect adoption of irrigation, possibly even more so than the effect of socio-economic characteristics. The results suggest that negative perceptions of the economics of irrigation and detrimental environmental impacts of irrigation may be significant deterrents for irrigation adoption. Thus, this study suggests that those planning future water development projects, especially those involving irrigation, must be cognizant of potential adopters' attitudes (Kulshreshtha et al. 1993).

Rodriguez and colleagues (2008) found that there are a substantial number of Southern farmers who are reluctant to use efficient irrigation techniques, such as sub-surface drip irrigation (SDI). Rodriguez et al. (2008) used a web survey to determine what barriers to adoption of sustainable agriculture practices (SAP) are perceived by change agents working with farmers in the U. S. South. Farmers rarely adopt SAP even when they have support from technical assistance providers. Change agents are often not well prepared to address farmers' needs pertaining to SAP and in specific farming situations. Government programs sometimes fail to encourage adoption due to lack of funding and other incentives. Thus, farmers may find it difficult to acquire accurate information about the benefits of SAP. Strategies to encourage SAP adoption include: improved management of existing information, careful design of economic support programs, and extension efforts to overcome identified barriers (Rodriguez et al. 2008).

For Alabama farmers, challenges to implementing new irrigation techniques (such as building off-stream reservoirs to store water from streams during periods of high rainfall) include money and labor (Langcuster 2007). Franklin County's Extension coordinator Tim Reed claims that irrigation entails great expense and without grants, many farmers may not have the money for it (Langcuster 2007). For example, Reed mentions one Alabama farmer who is already irrigating 400 acres of drought-stressed corn and is paying $600 per day just to cover diesel fuel costs (Langcuster 2007). According to Reed, government-sponsored grants, not just farmer motivation and extension expertise, may be necessary to enable farmers to feasibly implement irrigation practices (Langcuster 2007).

Bai (2008) found that although irrigation plays a positive role on poverty alleviation, it is not the single factor in determining poverty status in a rural region. Rural poverty is jointly affected by various factors other than irrigation and productivity, such as race structure, education, and so forth. However, Bai found that irrigation plays a statistically significant, though moderate, role on income inequality. In other words, even though small, limited resource, and/or minority farmers may reap greater yields and higher sales with an efficient irrigation system installed, other socioeconomic factors such as race and education achievement may perpetuate poverty. Other socioeconomic factors may very well, then, prevent these small and minority farmers from obtaining the financial means needed to equip their farming operations with irrigation technology that would help achieve greater net returns. Thus the cycle continues; while irrigation has the potential to improve crop yields and thus affect income, poor farmers cannot make the initial investment to obtain the necessary equipment to reap the benefits of irrigation (Bai 2008).

Molnar et al. (2001) found that minority farmers are less likely to receive federal assistance for their farm operations, a potential barrier preventing these farmers from irrigating. Minority farm advocates claim that farm program regulations prevent minority and limited-resource farmers from accessing programs that have helped larger, non-minority producers survive the changes in agriculture over the past 50 years (Molnar et al. 2001). Advocates identify institutional insensitivity to the differing needs of minority and limited-resource customers and public agency tendencies to neglect their responsibility to reach out and serve all that need assistance (Molnar et al. 2001). The disparity in participation and treatment of non-minority and minority farmers can be partially accounted for by the smaller average size of minority and female-operated farms, their lower average crop yields, and their greater likelihood not to plant program crops, as well as less sophisticated technology, insufficient collateral, poor cash flow, and poor credit ratings (Molnar et al. 2001). However, representatives of minority and female farm groups point out that previous discrimination in USDA programs has helped produce these very conditions now used to explain disparate treatment (Molnar et al.

2001). Thus, lack of access to water (and therefore lack of irrigation) may be because the cumulative barriers to accessing capital investment and technology have kept minority farmers from building on their investments (Rijsberman 2004).

Bjornlund et al. (2008) argue that the major drivers of irrigation adoption are ensuring security of water supply during drought, increasing quantity and quality of crops, and saving costs. The major impediments are financial constraints and physical farm conditions. Thus, it is evident that considerable financial incentives or cost-sharing will be necessary to encourage a significant increase in adoption. Promotion and education campaigns that encourage new practices involving minimal cash outlays may yield the greatest water savings in the future (Bjornlund et al. 2008).

Objectives of the Study

Though there has been recent abundant rainfall, other sources of crop stress may be reduced through the use of irrigation, such as frost. Without irrigation, the productivity of tree crops and vegetable growth will diminish, as will the livelihood of the farmers that grow these crops. Understanding the barriers to the adoption of irrigation techniques is vital for the increasing use of such methods.

This study profiles Alabama farmer operators' irrigation practices and their equipment and water sources, with the purpose of identifying barriers to adoption of irrigation improvement. The target population is small- and medium-scale row crop (e.g., cotton, soybeans), tree crop (e.g., peaches, grapes), vegetable (e.g., tomatoes, corn), and specialty producers in Alabama. A random sample of such producers was surveyed about the extent of irrigation practices and the problems experienced in the irrigation process.

The aim of this research is to profile Alabama farmer operator's irrigation practices, as well as their equipment and water sources, with the purpose of identifying barriers to the adoption and improvement of irrigation. Specifically, the research aims to identify the barriers to irrigation adoption and to provide information to policy-makers, farmers, and others to provide a greater understanding of how irrigation adoption affects the prosperity of small- and medium-sized farms.

This research examines farmer perceptions of various common constraints to irrigation implementation and development. It specifies the connections between various farm and household characteristics as they affect commitment to the adoption of irrigation technology. The results can provide insights into circumstances that limit the practice of irrigation in Alabama and similar Southeastern states. The results should provide better understanding of farmer perceptions of the practical advantages and disadvantages of irrigation and new irrigation technology. The findings have practical importance since the results can suggest topics where farmers need more technical information, as well as cost-sharing and policy changes that can facilitate the installation and use of irrigation.

II. CONCEPTUAL FRAMEWORK

This chapter addresses theory of technology adoption and diffusion, irrigation as an adopted technology, and how irrigation adoption has been conceptualized. Hypotheses are formulated about factors influencing irrigation adoption. Diffusion of Innovations was chosen as the framework for this study because it accounts for the role of personal characteristics and social networks in the rate of technology adoption.

Adoption and Diffusion of Innovations

Diffusion of Innovations is a theory of how, why, and at what rate new ideas and technology spread through cultures, across space, and among adopters over time (Carr 2009). In the study of diffusion of technology, “adoption” refers to the stage in which technology is selected for use by an individual or an organization; “innovation” refers to a new or “innovative” technology being adopted; and “diffusion” is the stage during which technology spreads to general use (Carr 2009).

Sociological factors play a significant role in the decision to adopt conservation practices. Ryan’s (1943; Griliches 1957) study of the diffusion of hybrid corn in Iowa was the first visibly sustainable contribution to an interest in innovations, which was especially popularized by Everett Rogers' (1962) *Diffusion of Innovations*. Rogers (Rogers and Shoemaker 1971) was one of the first to associate personal characteristics of farmers with the timing of their adoption of an innovation (Clearfield 1986). Rogers defines “diffusion” as the process by which an innovation is communicated over time, through certain channels, and among the members of a social system (Rogers 1962). The key elements in diffusion research are the innovation itself, the types of communication channels, the time or rate of adoption, adopter characteristics, and the social system that frames the innovation-decision process (Rogers 1962).

Decision-making occurs through a series of communication channels over a period of time among members of a social system. Thus, Rogers characterizes diffusion of an innovation as a five-step process (Rogers 1962). Rogers originally categorized the five stages as: awareness, interest, evaluation, trial, and adoption. Rogers eventually revised the steps to: knowledge, persuasion, decision, implementation, and confirmation, though the descriptions of the categories remained similar. An individual might reject an innovation at anytime during or after the adoption process (Rogers 1995). [1]

Early Versus Late "Knowers" of Innovations

Rate of adoption is usually measured by the length of time required for a certain percentage of the members of a social system to adopt an innovation (Rogers 1962). The rate of adoption is defined by Rogers' adopter categories. Rogers defines an "adopter category" as a classification of individuals within a social system on the basis of their "innovativeness" (Rogers 1962; Rogers 1995). He suggests (1962) a total of five categories of adopters in order to standardize the use of adopter categories in diffusion research. The rate of adoption follows an "S" curve, based on the cumulative percent adopting over time (Rogers 1962; Rogers 1995). The categories of adopters include: innovators, early adopters, early majority, late majority, and laggards (Rogers 1962). These categories, based on standard deviations from the mean of the normal curve

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[1] For more information about the five stages of adoption, see Rogers 1962; Rogers 1964; Rogers 1965; Brown 1981.

(percent adopting at each period over time), provide a common language for innovation researchers (Rogers 1962; Rogers 1995).

Within the rate of adoption, there is a point at which an innovation reaches "critical mass" (Rogers 1962; Rogers 1995); this is a point in time within the adoption curve that enough individuals have adopted an innovation for it to become self-sustaining (Rogers 1962; Rogers 1995). To describe how an innovation reaches critical mass, Rogers describes several strategies that help an innovation reach this stage. These strategies are: have an innovation adopted by a highly respected individual within a social network; creating an instinctive desire for a specific innovation; inject an innovation into a group of individuals who would readily use an innovation; and provide positive reactions and benefits for early adopters of an innovation. [2]

There are several generalizations that summarize Rogers' (1995) findings regarding adopters' early knowledge about an innovation. Earlier "knowers" of an innovation, for example, often have more formal education than those who gain innovation knowledge later. Those with early innovation knowledge tend to have higher socioeconomic status. Thus, those with greater knowledge are more likely to adopt when they have the finances to do so (Rogers 1995). Also, early adopters frequently have more exposure to mass media channels of communication and more exposure to interpersonal connections. These adopters tend to have greater communication with personal connections and easier access to information through media channels, such as the Internet. Early adopters also have more change-agent contact than their later-adoption counterparts. These early adopters frequently are involved in greater social participation than later "knowers" (Rogers 1995).

Innovators

Innovators are the first individuals to readily adopt an innovation. They typically make up approximately 2.5 percent of any population (Rogers 1962; Rogers 1965; Surry et al. 1996). They are usually willing to take risks, are the youngest in age, have the highest social class, have greater financial acuity, are very social, have close contact to scientific sources, and have regular interaction with other innovators (Rogers 1962; Rogers 1965).

Early Adopters

Early adopters comprise approximately 13.5 percent of the population (Rogers 1962; Rogers 1965; Surry et al. 1996). This is the second fastest category to adopt an innovation (Rogers 1962; Rogers 1965). These individuals have the highest degree of opinion leadership among other adopter categories. Early adopters are typically younger in age with higher social status, have more financial lucidity, have more advanced education, and are more socially forward than late adopters (Rogers 1962, p. 185).

Early Majority

Of the population, the early majority makes up 34 percent (Rogers 1962; Rogers 1965; Surry et al. 1996). Individuals in this category adopt an innovation after a varying degree of time, but time of adoption is significantly longer than that of innovators and early adopters. Over all, Early Majority adopters tend to be slower in the adoption process, but have above average social status, contact with other early adopters, and show some opinion leadership.

[2] For more information regarding adoption strategies, see Rogers 1962; Rogers 1995.

Late Majority

Another 34 percent of the population falls into the late majority group (Rogers 1962; Rogers 1965; Surry et al. 1996). Individuals in this category will adopt an innovation after the average farmer. These individuals approach an innovation with a high degree of skepticism and adopt an innovation after the majority of society. Late Majority members are typically skeptical about the innovation, have below average social status, very little financial lucidity, are in contact with others in late majority and in early majority, and have little opinion leadership.

Laggards

Individuals in the laggard category are the last to adopt an innovation and comprise approximately 16% of the population (Rogers 1962; Rogers 1965; Surry et al. 1996). Unlike most of the previous categories, laggards show little to no opinion leadership. Laggards usually tend to focus on traditions and have an aversion to change-agents. These individuals tend to have lower social status and financial fluidity, are often older than all other adopters, and are in contact only with family and close friends.

Opinion Leaders and Communication Channels

Rogers relied on the ideas of Katz and Lazarsfeld (1955) in developing his ideas on the influence of "opinion leaders" in the diffusion process. Throughout the diffusion process, there is evidence that not all individuals exert an equal amount of influence over other individuals (Rogers et al. 1964; Rogers 1995). Often, some individuals in a given community accumulate considerable social capital and achieve prestige and influence among their peers (Kleiner 2003; Smith 2005; Rogers 1995). Technical agencies often are more attentive to their innovative, wealthy, educated, information-seeking, and "easy to convince" clients (Rogers 1995). These producers' names come up time and again, sometimes because they have authority, but most often because they have attained legitimacy. These individuals thus become "opinion leaders" who are highly trusted as advisers by others for a variety of reasons, such as their expertise, knowledge, and power (Rogers 1995). Opinion leaders are influential in spreading either positive or negative information about an innovation (Rogers et al. 1964; Rogers 1995). These leaders may possess characteristics that set them apart from other individuals. They typically have greater exposure to mass media, are more cosmopolitan, have greater contact with change agents, have more social experience and exposure, have higher socioeconomic status, and tend to be more innovative (Rogers et al. 1964, Rogers 1995).

Theory of innovation suggests a bandwagon process, where an increase in the number of irrigators creates a stronger "bandwagon" pressures. Social pressures can potentially cause increases in the number of irrigation adopters (Abrahamson et al. 1997). Through communication with other local irrigators, producers can develop a social network for information and technical support for each other (Rogers 1995). Influential farmers who irrigate may have the respect, power, success, and influence to encourage other farmers to follow in their footsteps and consider irrigation as part of their farming strategy (Abrahamson et al. 1997). Lack of local support may act as a barrier to implementing and improving irrigation systems. Peers who use irrigation can create a pressure to fulfill a social norm which may influence a producer's perceived behavioral control (Morris et al. 2000).

Socioeconomic Status and Adoption

Individuals' socioeconomic status is related to their degree of change-agent contact (Rogers 1995). Status and change-agent contact are, in turn, highly related to their degree of "innovativeness." More progressive farmers may have the economic means to adopt and can therefore more easily obtain credit if needed. Because such innovative producers often operate larger farms, the direct effect and potential gain from their adoption on total agricultural production is greater, widening the socioeconomic gap and potentially heightening these farmers' influence (Rogers 1995). How new agricultural equipment is marketed has an important influence on whether larger or smaller farmers will purchase it. Larger, more expensive machines will be less affordable for smaller farmers who reap smaller profits for smaller productivity (Rogers 1995). Producers who have sufficient funds to pay for irrigation equipment (higher socioeconomic status) may be able to afford irrigation and bear the risk of miscalculation or error. Irrigation technology may be profitable, but the central reason for its introduction is not profitability enhancement, but feasibility and potential cost.

The Role of Social Networks and Electronic Communication in Diffusion

New ways of doing things do not necessarily take hold all at once. Instead, they often spread gradually through social networks (Young 2003). One classic study by Coleman, Katz, and Menzel (1966) showed that doctors' willingness to prescribe the new antibiotic tetracycline diffused through professional contacts. A similar pattern has been documented in the adoption of family planning methods, new agricultural practices, and a variety of other innovations (Young 2003; Rogers et al. 1971; Rogers et al. 1981; Rogers 1983; Valente 1995). Because adoption is a social process, having physical proximity to other irrigation adopters is positively related to adoption (Hagerstrand 1967).

The theory of innovation explains the rate at which innovations diffuse and the succession in which they are adopted (Abrahamson et al. 1997). Social pressures can cause increases in the number of adopters of irrigation (Abrahamson et al. 1997). To show that this occurs, Abrahamson et al. (1997) investigated the average number of social links of adopters. They found a higher mean number of adopters among farmers with greater numbers of social links, many of which were beyond the core focal strata of the study. Abrahamson and colleagues concluded that a feedback loop occurs, where increases in the number of adopters create stronger bandwagon pressures, and stronger bandwagon pressures, in turn, increase the number of adopters (Abrahamson et al. 1997).

Prior to the introduction of Internet, social networks played a crucial role in diffusion of innovations (Veneris 1994). Widespread adoption of computer networks leads to better diffusion of innovations, greater understanding of possible innovative shortcomings and identification of needed innovations that would not have otherwise occurred (Veneris 1994; Walton et al. 2010; Khaledi et al. 2010). Early adopters tend to have more exposure to media communication channels (Veneris 1994; Rogers 1995).

Clearfield (1986) profiled the prototypical farmer who is most likely to adopt conservation practices. He reviewed previous studies and found that "adopters of conservation practices are likely to be well-educated, full-time farmers, with a high level of organizational participation" (Clearfield 1986:6). Yet, Napier (2001:286) found that:

> Factors such as access to information, farming experience, technical assistance, partial economic subsidies, farm size, personal characteristics of the primary farm operator, debt-to-asset ratio, farm income, participation in government conservation programs, and a host of other variables examined in the studies were not useful for predicting extent of use of conservation production systems."

Previous studies on the adoption of agricultural conservation practices, then, are limited in their ability to explain the adoption process. Contradictory findings make it hard to draw conclusions about what variables most certainly affect adoption rates.

The "Agricultural Treadmill"

During the past half-century, farm profits remained low, although farm size grew significantly and, at the same time, farmers adopted more and more new technology. Cochrane (1958) introduced the concept of the "agricultural treadmill," a notion that farmers are under continuous pressure to adopt technology or risk a decline in profits. According to this theory, no individual small farms that produce the same products as large farms can affect a commodity's price (Cochrane 1958; Gould et al. 2004). Thus, farmers adopt new technology to increase productivity. However, over time, others follow and further increase supply, and as supply increases, the price of commodities tends to fall. Increased efficiency in agricultural production also can drive down commodity prices. The downward pressure on crop price has two direct results: (1) those who have not yet adopted the new technology must do so lest they lose income ("price squeeze") and (2) those who are too old, sick, poor, or indebted to innovate are eventually forced out due to the cost of adoption ("cost squeeze") and the remaining producers who made early profits absorb their resources ("scale enlargement"). In effect, the latter results in concentration of resources and rural income and further exacerbates inequality (Cochrane 1958; Gould et al. 2004). This is theory is relevant because the effects of debt and income level on adoption of irrigation are investigated in this research. In this study, I am interested in how irrigation technology spreads among Alabama row crop, fruit, vegetable, horticulture, and specialty crop farmers over time. Next, I present my hypotheses, followed by the framework of supporting literature.

Hypotheses

Table 1. Hypotheses, Alabama Farm Operators, 2009	
Hypothesis	**Hypothesis Statement**
H1:	Farmers who have a larger farm-size are more likely to irrigate.
H2:	If irrigation is perceived as minimizing risk, the greater the adoption.
H3:	The more innovative the farmer is, the more likely they are to irrigate.
H4:	Farmers with neighbors who irrigate are more likely to implement or improve irrigation systems.
H5:	The younger the farmer, the more likely they are to irrigate.
H6:	Producers with greater education attainment will adopt irrigation more often than those with less education.
H7:	Those with positive relationships with sources of technical information are likely to adopt irrigation.
H8:	The greater the producer's annual income, the more likely they are to irrigate.
H9:	The lower the producer's level of debt, the more likely they are to irrigate.
H10:	The more resources there are for irrigation, the more prone a producer is to adopt irrigation.
H11:	Farmers with access to the Internet are likely to adopt irrigation.
H12:	Ethnic minority-operated farms in Alabama will be less likely to use irrigation than Caucasian-operated farms.
H13:	Female-operated farms in Alabama will be less likely to use irrigation than male-operated farms.
H14:	The independent variables together predict the dependent variables.

Farm Size

H1: *Farmers who own more acreage (have a larger farm-size) are more likely to irrigate.*

Owning a larger area may increase the overall benefits of adoption and beneficial innovations (Pannell et al. 2006; Abadi Ghadim et al. 2005; Whittenbury et al. 2009). On a larger farm, there is more produce to protect than on a small farm and large farm owners may have more resources to invest in irrigation. Having a larger farm, then, may increase the likelihood of adoption. Risk-averse irrigators tend to use more water per unit of land. With larger acreage, there is a greater amount of produce at risk without irrigation (Pannel et al. 2006; Abadi Ghadim et al. 2005; Whittenbury et al. 2009).

Attitude towards Risk

H2: *If irrigation is perceived as minimizing risk, the greater the adoption.*

Adoption of most technologies that alter farm management are similar to investing in high-involvement products (Kaine 2004; Montagu et al. 2006). High-involvement products are generally expensive, rarely purchased, and correlated to self-image and ego (Montagu et al. 2006; Assael 1998). They typically involve some risk, such as financial risk. Where risk is high, a farmer is more likely to devote time and effort to careful consideration of alternatives before making a purchase (Montagu et al. 2006; Assael 1998). Ensuring predictable outcomes from as many sources as possible is important for successful farming and adoption. This ensures that profits are generated at acceptable levels of risk (Montagu et al. 2006). English and Orlob (1978) reported on the significance of risk aversion to irrigation decisions. They found that the most risk-averse manager would prefer an irrigation strategy with a 40 percent lower expected profit than preferred by most risk-tolerant managers.

Also, adopting an innovation may be seen as a way to avert risk. Irrigators may be risk averse and use irrigation as a means to avoid potential drought, disease, and other stressors that irrigation can potentially prevent. Not having irrigation equipment installed may be framed as an economic risk to one's crop yields, and thus irrigators may be very concerned with risk and irrigate to minimize the risk of not irrigating.

Individual Innovativeness

H3: *The more innovative a farmer is, the more likely they are to irrigate*.

Innovators will adopt an innovation earlier on the adoption continuum (Carr 1999). Morris and Venkatesh (2000) found that compared to older workers, younger individuals' technology usage decisions were more strongly influenced by attitude toward using the technology. Older people were more strongly influenced by subjective norms and perceived behavioral control. For instance, the research shows that younger individuals are more innovative and more apt to adopt technological changes (Pannell et al. 2006; Whittenbury et al. 2009).

Social Networking and Influence

H4: *Farmers who have neighbors who irrigate are more likely to implement or improve irrigation systems.*

In the context of technology usage, subjective norms—or perceived social pressure to perform or not perform a behavior—have manifested as peer influence (Ajzen 1991; Morris et al. 2000). Farmers with irrigation can act as social influences, as well as sources of information about implementing and improving irrigation. Through communication with other local irrigators, producers can develop a social network of information and technical support for each other (Abrahamson et al. 1997). Lack of local support may be a barrier to implementing irrigation systems (Brown 1981). Those who use irrigation can create pressures to fulfill a social norm and influence other producers' perceived behavioral control (Morris et al. 2000). If a large proportion of one's peers irrigate, a producer may perceive this technology as easy to use and acceptable. This type of acceptance decision may influence producers' long-term usage decisions.

Age

H5: T*he younger the farmer, the more likely they are to irrigate.*

Morris and Venkatesh (2000) found that compared to older peers, younger individuals' technology usage decisions are more strongly influenced by attitude toward using the technology. Younger individuals appear to be more innovative and apt to adopting technological changes. If a farm is not going to be passed on to a farmer's children and if the benefits of new practices are not expected to be fully reflected in the farm's sale price, then older farmers may have less incentive to invest in something that will be primarily of benefit to the subsequent owner (Pannell et al. 2006; Gasson et al. 1993; Whittenbury et al. 2009).

Education

H6: *Thus, producers who have obtained greater levels of education may adopt irrigation more often than those with less education.*

A landowner's perception of a problem is one of the most important factors related to the adoption of practices (Ervin et al. 1982; Klapproth et al. 2010). Landholders with higher levels of education often adopt beneficial innovations more quickly (Pannell et al. 2006; Rahm et al. 1984; Feder et al. 1985; Goodwin et al. 1994; Kilpatrick 2000, Whittenbury et al. 2009). In the case of a complex technology or a practice that is disadvantageous when all its effects are considered, having a higher education level may reduce or delay adoption because the educated adopter recognizes the limitations of the practice (Pannell et al. 2006; Marsh et al. 2006; Whittenbury et al. 2009). Such limitations may go unrecognized by less educated producers, who may consequently adopt the practice mistakenly (Pannell et al. 2006). On the other hand, educated producers may more easily comprehend complex, technical practices and weigh the costs and benefits more objectively than their less educated counterparts.

Technical Assistance

H7: *Those with positive relationships with sources of technical information are likely to adopt irrigation.*

Using an innovation typically requires a certain set of skills and level of knowledge (Surry et al. 1996). Without the necessary skill set, people may become frustrated and immobilized. Thus, training is usually a vital part of successful innovation adoption. Studies made of forest landowners suggest that those who worked with a professional forester were more likely to regenerate tree stands after harvest than landowners who did not get assistance (Klapproth et al. 2010; Alig et al. 1990). Thus, producers with sufficient training and technical assistance will implement or expand irrigation systems.

Income

H8: *The greater the producer's annual income, the more likely they are to irrigate.*

Hunte (1981) interviewed a random sample of rural Louisiana residents to determine the extent of their educational, occupational, and by extension, their financial motivations for their adoption of agricultural technology. He found that levels of technology adoption were positively correlated for residents with high-income levels, and negatively related for those with lower income levels.

Debt Level

H9: *The lower the producer's level of debt, the more likely they are to irrigate.*

Having a lower level of debt allows producers to focus their resources on investing in production technologies (Hunte 1981). Those who spend less on debts have more financial capital to invest in production, equipment, and technology. On the other hand, we must consider that producer debt may reflect capital investment in irrigation technology.

Availability of Resources

H10: *The more resources there are for irrigation, the more prone a producer is to adopt irrigation.*

Surry and Ely (1996) found several conditions that contribute to innovation implementation. One condition is the availability of vital resources. Resources are the things that are required to make implementation successful; without them, implementation is difficult. The outlines of innovation diffusion patterns are shaped by where innovation resources are available (Brown 1990; Brown 1981). Important components that determine where resources are available and the overall pattern of diffusion include the propagator of the innovation (such as the manufacturer), the diffusion agency that distributes the resources to market (equipment dealerships, e.g.), the diffusion strategy designed to encourage adoption, and location of diffusion agencies where the innovation is made available and that determines pricing, advertising, and population segments targeted by promotional efforts (Brown 1990; Brown 1981).

Access to Information

H11: *Farmers with access to the Internet are likely to adopt irrigation.*

Even prior to the introduction of the Internet, social networks played a crucial role in the diffusion of innovation (Veneris 1994; Khaledi et al. 2010). The Internet has also become a means to connect with social networks through email, blogs, social networking pages, and so forth. The widespread adoption of computer networks has lead to better diffusion of innovations, greater understanding of possible innovative shortcomings, and identification of needed innovations (Veneris 1994; Khaledi et al. 2010; Walton et al. 2010). Handheld computers, such as personal digital assistants (PDA) and handheld global positioning services (GPS), for example, have become increasingly important in cotton production (Walton et al. 2010). Walton and colleagues (2010) found that younger farmers who used computers in farm management and had a positive perception of Extension had a greater likelihood of adopting more technological devices, such as GPS and PDAs. With more and more information filtering through the mass media, especially on the Internet, farmers potentially have access to a large quantity of information and media reports regarding crop-water needs, progressive farming technologies, their benefits, and how to use them.

Minority Farmers

H12: *Ethnic minority-operated farms in Alabama will be less likely to use irrigation than Caucasian-operated farms.*

Molnar and colleagues (2001) found that minority farmers have disproportionately low levels of adoption of conservation measures. The number of black-owned farms is declining at a more rapid rate than other farms, and this trend has drawn attention to the treatment that minority farmers, especially African-American farmers, have experienced in receiving federal assistance (Pretty 1995; Molnar et al. 2001). Minority farmers are less likely to receive federal assistance for their farm operations (Molnar et al. 2001); this may be a potential barrier preventing these farmers from irrigating.

Gender

H13: *Female-operated farms in Alabama will be less likely to use irrigation than male-operated farms.*

The disparity in participation and treatment between non-minority and minority farmers may be partially accounted for by the smaller average size of minority and female-operated farms, their lower average crop yields, and their greater likelihood not to plant program crops, as well as less sophisticated technology, insufficient collateral, poor cash flow, and poor credit ratings. However, representatives of female farm groups point out that previous discrimination in USDA programs has helped produce these very conditions now used to explain disparate treatment (Molnar et al. 2001). The lack of access to water (and therefore lack of irrigation) may be because cumulative barriers to accessing capital investment and technology have kept not only ethnic minority farmers from building on their investments, but also female producers (Rijsberman 2004).

Aggregate and Independent Variable Effects

H14: *The independent variables together predict the dependent variables.*

Regression analysis will show the independent effects of the variables on each dependent variable. It also will show the amount of explained variation. The next chapter outlines the procedures used to collect data and test the hypotheses.

III. RESEARCH METHODS

This chapter describes how the hypotheses stated in Chapter II are tested and analyzed. First, the survey is described. Then, the desired sample population and the sampling method are illustrated and the data collection process is explained. The overall response from respondents is briefly described, as well. Lastly, the dependent and independent variables are listed and how the variables were coded is described.

Method, Sample, and Units of Analysis

Survey Instrument

This study uses survey data from a statewide sample of Alabama farm operators to explore the barriers to the adoption of irrigation. Funded by a special grant through the United States Department of Commerce National Oceanic and Atmospheric Administration (NOAA), the survey adapted questions from the 2003 USDA Census of Agriculture Farm and Ranch Irrigation Survey and addressed issues specific to Alabama, such as producer knowledge of State water requirements.

The questionnaire was a twelve-page document, following the Dillman method (2010). Along with a cover page, an informational letter was incorporated into the questionnaire. The questionnaire included 32 questions of primarily Likert-type form. For example, respondents were asked: "How helpful are each of the following sources of information about implementing or improving irrigation (Mark one for each)?" This question was followed by a list of several information sources lettered "A" through "F."

Each information source had its own response scale (1 = "Not helpful," 2 = "Somewhat," 3 = "Very helpful"). An additional page was provided for any open-ended producer comments. The survey distributed by the United States Department of Agriculture National Agricultural Statistics Service (USDA NASS) in Montgomery, AL. Printing of the questionnaire was contracted out and conducted by a regional print mail center in Jackson, Mississippi.

Sample

The target population was all row crop, fruit-tree, vegetable, and horticulture producers across the state of Alabama. The sampling frame for this study is the USDA NASS list of agricultural row crop, vegetable, and fruit-tree crop farmers in Alabama. This list is continually updated by obtaining current information from a variety of local and state sources. A random sample of farmers was surveyed about the extent of their irrigation practices and the problems they experienced in the irrigation process.

Data Collection

Data were collected from July 2009 through September 2009. The initial surveys were distributed in July 2009; On July 23, 2009, the regional mail center delivered 2,339 surveys to the postal service. Each mail packet included only the twelve-page questionnaire and a return envelope. After two weeks, a reminder was sent out to the same list (Dillman 2000; Dillman et al. 2009). On August 5, 12 days after the first mailing, the mail center delivered 2,095 forms to the postal service for a second mailing. The target was the same as the first mailing, with the exception of those who had already returned their form by mail prior to that date. It was sent out again two weeks later, making a total of three rounds to the population (Dillman 2000; Dillman et al. 2009).

Between August 3 and August 6, 2009, the Alabama National Association of State Departments of Agriculture (NASDA) staff phone-called approximately 2,000 respondents to encourage survey participation. They did not collect survey data by phone, as the questionnaire was complex and lengthy and thus prohibited efficient data collection via phone. However, if a respondent noted a change in operating status (e.g., out of business, deceased), this information was collected as a response, but an unusable report. Phone refusals were also considered to be unusable responses. A minimum of two phone-contact attempts were made for most operations. If contact was made with an individual (family member or other representative), encouragement was given on the importance of completing the survey by mail. If an answering machine was the contact, a similar message was left, encouraging survey participation and completion. In both circumstances, the staff identified themselves as calling on behalf of Auburn University and the USDA and noted that the producer should have recently received a mail survey dealing with irrigation practices in Alabama. As mentioned earlier, approximately 2,000 respondents were targeted for contact. Of these, approximately 900 (45 percent) were contacted personally by phone, 800 (40 percent) were left a message on an answering machine, and 300 (15 percent) were unable to be reached. Approximately 30 of the 900 personally contacted indicated that they would not participate in the survey. Approximately 45 others screened out of the survey, as they were no longer engaged in farming. A total of 818 surveys were returned, of which 794 were usable. The net mail response rate from all mailings was 18.4 percent.

Response

The mailed returns deemed unusable represented blank returned forms (implied refusal) or forms on which respondents indicated that they no longer engaged in farming. The net mail response rate from all mailings was 18.4 percent. Questionnaires were divided into those who currently irrigate and those who did not. Of all usable returns, 189 of the 794 total useable returns (approximately 24 percent) indicated that they currently irrigate.

All counties had at least one good report, with the exception of Coosa County. Most counties, where the concentration of agriculture is predominant, had twenty or more usable reports. The highest return was in Baldwin County, with 64 usable reports. Baldwin County is known for specialty crops, such as sod, peanuts, and soybeans, which are high in value. Thus, the high return from this area may be due to a high number of farms. Nine forms were returned with personal identification removed by the respondent; these were counted as unknown counties.

Measures

Dependent Variables

Use of Irrigation Technology

There are five measures of irrigation adoption used in this study. The first measure is a dichotomous variable that contrasts farmers that have irrigation with those that did not, coded 1 = “No,” 2 = “Yes.”

Extent of Irrigation Usage

A second measure of irrigation adoption is the sums of responses to three items. Respondents were asked: what percent of your land is used for the following purposes was irrigated? The items were: (1) row crops, (2) fruit, vegetable, horticulture, or specialty crops, and (3) pasture or hay land. The response framework was: “None” = 1, “Some” = 2 (1-50%), and 3 = “Most” (greater than 50%). This measure, the “irrigation land index,” is the sum of these items.

Secondary Uses for Irrigation

A third measure of irrigation adoption counts the number of secondary uses for the irrigation system beyond providing water for plant growth. Respondents were asked if they used irrigation for a series of five secondary uses: (1) crop cooling to delay early budding, blooming, or to reduce heat stress, (2) to prevent freeze damage, (3) used to apply chemical fertilizers, (4) used to apply pesticides, and (5) other uses such as land disposal of liquid livestock waste, etc. The indicator, described as the “irrigation use index,” used was a count of the “yes” responses to the six items and was not specific to crop type.

Expenditures for Irrigation Equipment

A fourth measure of irrigation adoption reflects the relative amount spent for irrigation equipment repairs in the previous year. Respondents rated their spending on items: (1) building or improving permanent storage and distribution systems (dams, ponds, reservoirs, ditches, etc.), (2) land clearing and leveling for irrigation purposes, (3) new well construction or deepening of existing wells, and (4) purchasing new or replacing irrigation equipment and machinery. The response framework was: 1 =

"None," 2 = "Some," 3 = "Major Outlay". The indicator reflects the sum of the four ratings and is referred to as the "irrigation outlay index."

Extent of Irrigation Improvements

A fifth measure of irrigation adoption counts the number of irrigation improvements made by the respondent. Respondents were asked to check from a list of eight possible irrigation improvements indicators: (1) adding moisture instrumentation, (2) adopting irrigation scheduling as a management practice, (3) changing energy source for pumping, (4) expanding acres covered by irrigation, (5) making irrigation changes that decreased energy costs, (6) making irrigation changes that improved crop yield or quality, (7) making irrigation changes that reduced water requirements, and (8) retrofitting sprinkler system for a low pressure operation. This indicator, the "irrigation improvement index," counts the number of indicated improvements.

Independent Variables

There are 13 predictors of irrigation adoption treated in this study. The independent variables are as follows: land holding/farm size, innovative proneness, willingness to take risks, social networking, age, education, technical assistance helpfulness, annual income, debt level, availability of resources, Internet access, ethnicity, and gender (Bai 2008, Byerlee et al. 1986, Shashidara et al. 2007).

Land-holding/Farm Size

A measure of farm size is the sum of responses to six items. Respondents were asked to summarize their farms' land use in 2008 and indicate the number of acres for six separate items. The six items included: (1) cropland harvested, including all land from which crops were harvested or hay was cut, and all land in orchards, citrus groves, or vineyards, (2) cropland used only for pasture or grazing, including rotation pasture and grazing land that could have been used for crops without additional improvements, (3) other cropland used for cover crops, cropland on which all crops failed, in cultivated summer fallow, and idle cropland, (4) woodland, (5) other pastureland and range-land, (6) and all other land, including land in farmsteads, buildings, livestock facilities, ponds, roads, wasteland, and so forth. The measure is the sum of acres reported.

Attitudes towards Risk

Farmers were asked to rate a selection of possible barriers to implementing an irrigation system or to improving the one already in existence. In order to assess risk attitudes, producers were then asked if they felt that irrigation system operating costs are too risky. They rated this as 1 = "Not a possible barrier," 2 = "Some," or 3 = "Great barrier."

Individual Innovative Proneness

To measure innovative proneness, farmers were asked, in terms of using new farming practices and technologies, how would you describe yourself? They were scored based on the selection they chose: 1 = "An innovator, often trying new approaches before anyone else," 2 = "An Early Adopter of new practices," 3 = "Not the first, but part of the Early Majority of users," 4 = "Part of the Later Majority of users of new ideas," or 5 = "Often one of the Last to try new things." The ordinal measure is scored one to five.

Social Networking and Influence

There are three measures of social networking among producers. One such measure elicits responses to the statement, no other farmers around here irrigate, as a potential barrier to implementing irrigation systems and a measure of social influence on irrigation practices. Producers matched each as 1 = "Not a barrier," 2 = "Some," or 3 = "Great barrier." A second measure had producers rate whether "Having neighbors object to irrigation operation" as 1 = "Not a reason for neglecting to irrigate," 2 = "Some," or 3 = "Major reason for not irrigating." The third measure asked farmers how helpful were other farmers with irrigation? They were rated as 1 = "Not helpful," 2 = "Somewhat helpful," or 3 = "Very helpful."

Age

Producers were asked an open-ended question to measure their age: "What is your age?" They responded by recording their actual age in years.

Education

The measure for education counted the highest level of education respondents completed. They were asked, which category best describes your level of education? Respondents ranked their education: 1 = "Some high school or less," 2 = "Graduated high school," 3 = "Some college/technical school," 4 = "College graduate," 5 = "Some graduate school," and 6 = "Master's degree or more."

Technical Assistance

Producers were asked, how helpful are each of the following sources of information about implementing or improving irrigation? The respondents ranked nine sources of technical assistance as 1 = “Not helpful,” 2 = “Somewhat helpful,” or 3 = “Very helpful.” The sources of information included: the Alabama Office of Water Resources, Auburn University specialists or researchers, county or regional extension agents, specialists from the USDA-Natural Resources Conservation Service, Internet websites, irrigation equipment dealers, media reports or information from the press, other farmers with irrigation, and private irrigation specialists or consultants.

Need for Technical Training

To measure the influence of technical assistance on irrigation adoption, producers rated their level of agreement or disagreement with the statement: “I need more training and technical assistance to implement or expand irrigation on my operation.” They were scored accordingly: 5 = “Strongly Agree,” 4 = “Agree,” 3 = “Undecided,” 2 = “Disagree,” 1 = “Strongly Disagree.”

Annual Household Income

An eighth variable that potentially influences irrigation adoption is annual household income level. A measure of income level reflects the total amount earned per household over the course of a year. Respondents were asked to check from a list of eight possible income brackets: 1 = “Less than $20,000,” 2 = “$20,000 to $29,000,” 3 = “$30,000 to $39,000,” 4 = “$40,000 to $59,000,” 5 = “$60,000 to $99,999,” 6 = “$100,000 or more.”

Level of Farming Operation Debt

To measure current debt level for their farming operations, respondents were asked to check from a list of four possible debt groups: 1= “No debt,” 2 = “Very little debt," 3 = "Moderate debt," 4 = "Heavy debt." The responses indicate the respondents' perception of their debt level, rather than their actual level of debt.

Availability of Resources

The availability of resources may influence the implementation of irrigation adoption. Respondents were asked how hard it is to get replacement parts when needed and rated the difficulty of accessing resources for equipment and parts as: 1 = "Not a barrier," 2 = "Some," or a 3 = "Great barrier" to implementing or improving irrigation.

Access to Information

Another predicted influence on irrigation adoption is farmers' access to media and Internet, or more broadly speaking, to technical information. To measure this, producers were asked: "Do you have Internet access?" They responded by checking either "No" = 1, "Dial-up only" =2, or "Cable or DSL" = 3. The question ascertains whether or not respondents have access to Internet and what quality of Internet is available.

Information Sources

Respondents were asked how helpful a number of information sources were in regards to implementing or improving irrigation. Information resources included the Alabama Office of Water Resources, Auburn University specialists or researchers, county or regional extension agents, specialists from the USDA Natural Resources Conservation Service, Internet websites, irrigation equipment dealers, media reports or information from the press, other farmers with irrigation, and private irrigation specialists or consultants. Respondents checked whether these resources were: 1 = "Not helpful," 2 = "Somewhat helpful," or 3 = "Very helpful." The indicator counts the number of information sources used and/or found helpful.

Ethnicity

To measure ethnicity, respondents were asked: What is your ethnicity? They responded by checking one of six possible options: 1 = “Black or African American,” 2 = “Asian or Pacific,” 3 = “White or Caucasian,” 4 = “American Indian or Alaska Native,” 5 = “Spanish, Hispanic, or Latino Origin,” or 6 = “Other ______________________.”

Gender

To measure gender, respondents were asked: “What is your gender?” Respondents checked either 1 = “Male” or 2 = “Female.”

The next chapter outlines the analysis of the data and the procedures used to test the hypotheses.

IV. RESULTS

This chapter tests the hypotheses developed in Chapter II and describes the irrigation activities and techniques used by farmers across Alabama. First, the demographics of the sample and the irrigation practices and systems used in Alabama are presented. Then, descriptive statistics are provided for the dependent and independent variables in the study. Next, each dependent variable is related to the independent variables to test the hypotheses. Regression analysis is used to assess the partial and cumulative impact of the independent variable on each dependent variable. The analysis relates farmer attributes, farm characteristics, and the use and availability of media and technical resources to irrigation adoption, irrigation usage, and the extent of irrigation used in Alabama.

Demographics and Descriptive Statistics

Sample Demographics

Ninety-five percent of respondents identified themselves as white or Caucasian, as shown in Table 7 on page 53. Only five percent reported being another non-white ethnicity. In fact, only four percent reported being "Black or African American," one percent as "American Indian or Alaska Native," 0.1 percent as "Spanish, Hispanic, or Latino Origin," 0.1 percent as "Asian or Pacific." and 0.7 percent as some "Other" ethnicity. This compares to the US Census data which reports a percentage of 71 whites in Alabama in 2008 (US Census Bureau 2008). Approximately 97 percent are male, while only about three percent female.

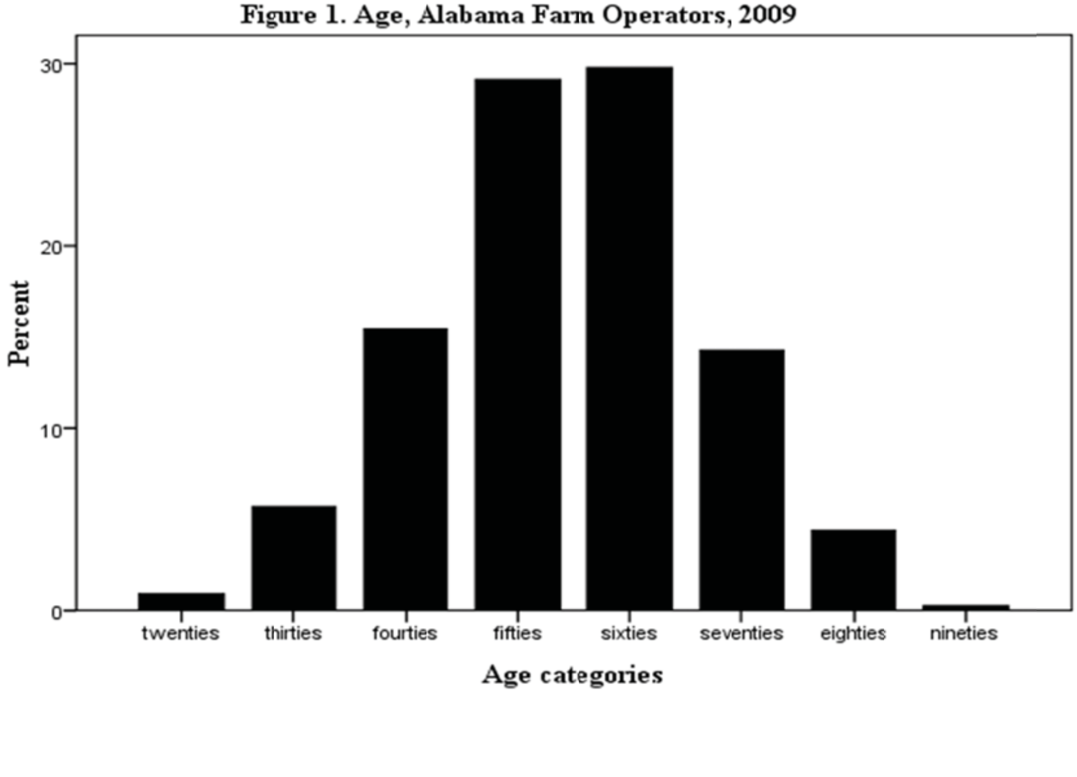
Only five percent reported having not graduated from high school. Thirty percent of respondents graduated from high school, 26 percent graduated college, and almost 12 percent had a Master's degree or more. The U.S. Census data from 2008 reports that 80.4 percent of Alabamians had a high school diploma and 24.4 percent graduated college with a Bachelor's degree or higher. Thus, most respondents had at least some college or technical school education. About 64 percent of respondents had a gross annual household income over $40,000 dollars in 2008. Again, this compares to the 2008 Census data reporting a median household income of 42,586 dollars. About 34 percent reported having a moderate debt level, and another ten percent had a heavy debt level.

As shown in Table 7 (page 53), gross annual total household income level is another variable that may influence adoption of irrigation. The average annual income on a theoretical range of six categories is 4.3. The actual range is six. The mean total annual household income category is $40,000 to $59,000. On average, respondents earned 54.2 percent of their total annual income from farming during the three years 2006 through 2008. Thirty percent of respondents earned a combined household income of at least $100,000 in the year 2008. A fourth earned $60,000 to $99,999, and 19 percent earned $40,000 to $59,999. Eleven percent earned $30,000 to $39,999, while only six percent earned $20,000 to $29,999. Ten percent of respondents earned a household income of less than $20,000.

Thirty percent of respondents reported having no debt in the year 2008; 27 percent claimed to have very little debt. Approximately one-third faced a self-determined moderate debt level. Only 10 percent reported heavy debt. Debt measurements were not suggested on the questionnaire, so all debt claims made by respondents were completely self-reported.

As shown in Figure 1 below, respondents' age ranged from 24 years to 95 years. Approximately 59 percent are in their fifties and sixties. The average age of respondents was 58.7 years of age, with a standard deviation of 12.4 and a range of 71, as shown in Table 7. The highest reported age was 95 years. Thus, the average respondent reported being middle-aged or older adults. This compares to the most recent Census of Agriculture (2007) that reports the average age of principle farm-operators as 57.6 years old (USDA—NASS 2007).

Figure 1. Age, Alabama Farm Operators, 2009



Irrigation Practices and Systems

Land Irrigated in 2008

Table 2. Land Irrigated on Farm in 2008, Alabama Farm Operators, 2009

	Frequency	Percent
Yes	192	24
No	602	76
Total	794	100

Table 2 shows the percentage of irrigators and of non-irrigators in Alabama during the year of 2008. Only 24 percent of the 794 respondents reported irrigating at any point and any extent in 2008, while 78 percent indicated not irrigating that year.

Sources of Irrigation Water Used in 2008

Table 3. Percentage of Sources of Irrigation Water Used, Alabama Farm Operators, 2009

Sources of Irrigation Water (N = 192)	Some	Main Source
Ground water from well located on farm or another farm	21	30
On-farm flowing surface supply (stream, spring, or river)	22	25
On-farm standing water body surface supply (lake, pond, or reservoir)	20	21
Off-farm water suppliers (commercial company, municipal or community water system	3	7
Did you have to pay for water for irrigation?	16	67

As is shown in Table 3, 30 percent use ground water on or near their farm, which was the highest water source used on or near farm. Sixty-seven percent of respondents reported that they have to pay for most of their irrigation water, and another 16 percent indicated paying for at least some of this water.

Types of Irrigation Used by Alabama Farm Operators in 2008

Table 4. Types of Irrigation Used, Alabama Farm Operators, 2009

Type of Irrigation System (N=192)	Percent Using System
Center Pivot	55
Drip, Low Flow, or Trickle Irrigation	33
Hose Tow	13
Sprinkler Irrigation	12
Gravity Irrigation Down Rows or Furrows	5
Cable Tow	4
Linear and Wheel Move Systems	3
Solid Set and Permanent Systems	3
Hand Move	2
Irrigated Acres That Have Been Laser Leveled	0

As shown in Table 4, various types of irrigation techniques are adopted to provide the necessary amount of water to meet plant needs, which differ in respect to how water is obtained from the sources and how it is distributed. Center pivot irrigation (including high, medium, and low pressures) was the most highly used irrigation technique in 2008, with a total of 57 percent.

Reasons for Not Irrigating

Table 5. Reasons for Not Irrigating, Alabama Farm Operators, 2009

Reasons for Not Irrigating (N = 794)	Some	Major
Cannot afford the investment	15	46
Shortage of surface water	17	20
Irrigation is uneconomical due to high energy costs	24	19
Shortage of ground water (wells or falling water tables)	16	17
Do not own the land that could be irrigated	13	16
Sufficient soil moisture—No irrigation needed	18	8
Plan to quit farming	9	7
Hard to get reliable information on different irrigation methods	12	4
Irrigation equipment failure	7	2
Neighbors object to irrigation operation	3	1
Pollution of water source	3	1

Table 5 lists potential reasons for not irrigating and shows the percentages that farmers reported these reasons to be somewhat of a barrier or a major barrier to irrigating. The main reason reported for not irrigating, reported in Table 5, was that farmers could not afford the investment. The next two major reasons were due to shortage of surface water, which may force farmers to look for water elsewhere and pay for water, and because irrigation is uneconomical due to high energy costs. Thus, finances appear to be a major factor for not irrigating.

Table 6. Dependant Variable Measures, Alabama Farm Operators, 2009

Measures	Dependent Variables	Mean	Standard Deviation	Number	Definition
	a. Last Year	1.24	0.43	794	Practiced irrigation in 2008 (not acres)
	b. Row Crop Use	1.87	0.62	150	Percent of land irrigated for row crops
Land Index	c. Horticulture Use	1.83	0.81	152	Fruit, vegetables, horticulture, or specialty crops
	d. Pasture Use	1.25	0.5	124	Pasture/hay land
	e. Crop Cooling	1.03	0.16	794	Irrigation for crop cooling to delay early budding or reduce heat stress
	f. Freeze Damage	1.02	0.14	794	Irrigation to prevent freeze damage
Use Index	g. Apply Chemicals	1.04	0.19	794	Irrigation used to apply chemical fertilizers
	h. Apply Pesticides	1.01	0.08	794	Irrigated to apply pesticides
	i. Other Uses	1.01	0.09	794	Other uses, i.e. land disposal of liquid livestock waste
	j. Irrigation Distribution	1.27	0.53	151	For building or improving permanent storage and distribution systems
Outlay Index	k. Land Clearing	1.2	0.47	143	For land clearing and leveling for irrigation purposes
	l. Well Construction	1.16	0.47	143	For new well construction or deepening existing wells
	m. Replace Equipment	1.65	0.68	178	Purchased or replace irrigation equipment
	n. Moisture Instruments	1.01	0.09	794	Added moisture instrumentation
	o. Irrigation Scheduling	1.03	0.16	794	Adopted irrigation scheduling as a management practice
	p. Irrigation Pumping	1.02	0.15	794	Changed pumping energy source
Improvement Index	q. Irrigation Acres Expanded	1.08	0.27	794	Expanded irrigated acres
	r. Energy Efficiency	1.05	0.21	794	Made irrigation changes that decreased energy costs
	s. Crop Impact	1.04	0.2	794	Made irrigation changes that improved crop yield or quality
	t. Water Efficiency	1.04	1.05	794	Made irrigation changes that reduced water requirements
	u. Low Pressure	1.05	1.22	794	Retrofitted sprinkler system for low pressure operation
	Composite Measures				
	v. Irrigation Land Index	3.36	0.73	794	Sum of items b, c, d
	w. Irrigation Improvement Index	1.08	0.77	794	Count of items n through u
	x. Irrigation Use Index	0.77	1.52	794	Count of items e through i
	y. Irrigation Outlay Index	4.88	1.17	136	Sum of items j, k, l, m

Dependent Variables

Irrigation Land Index

Figure 2. Irrigation Land Index, Alabama Farm Operators, 2009

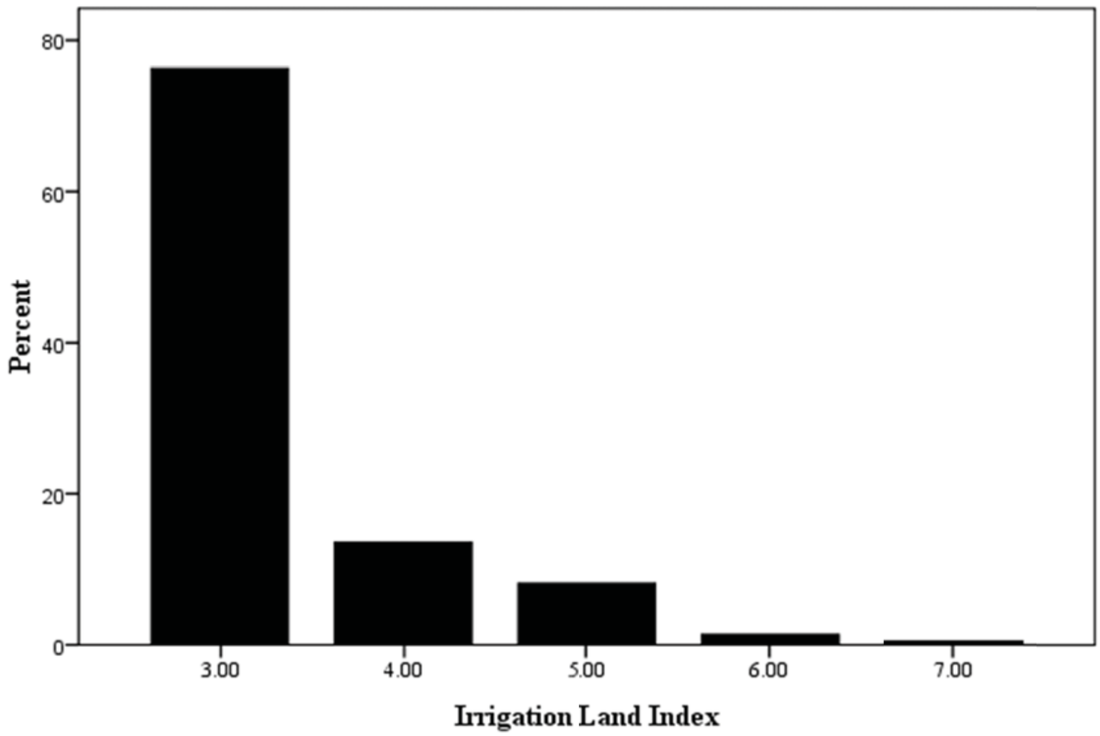
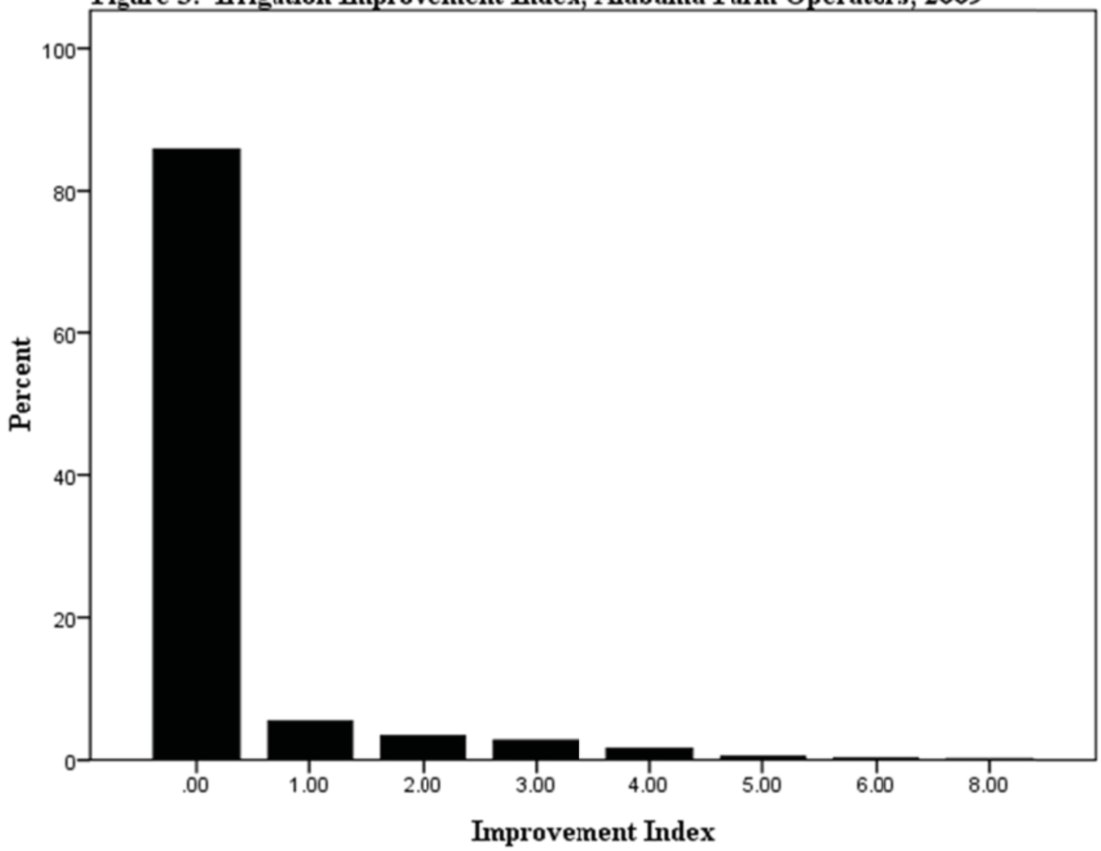


Table 6 on page 47 provides descriptive information describing the dependent variables. The mean score on the irrigation land index was 3.4. The theoretical range is six, from three to nine, three meaning that a respondent did not irrigate any of the three types of crops listed. A score of nine would mean that a respondent irrigated a major portion of all of the types of crops listed (row, horticulture, and pasture crops). However, the index only had a range of four (three to seven); no respondent reported irrigating to the largest extent—irrigating a major outlay of land. Thus, most respondents who irrigated in 2008 did not irrigate to a large extent and likely irrigated only one type of crop. As shown in Figure 2, 76 percent reported not irrigating any fruit, vegetable, horticulture, or specialty; pasture, or hay crops; or row crops during 2008. Only 14 percent reported irrigating between one and 50 percent of only one type of crop. Eight percent irrigated one to 50 percent of two crops. Only two percent reported having irrigated most (greater than 50 percent) of at least one crop.

<u>Irrigation Improvement Index</u>

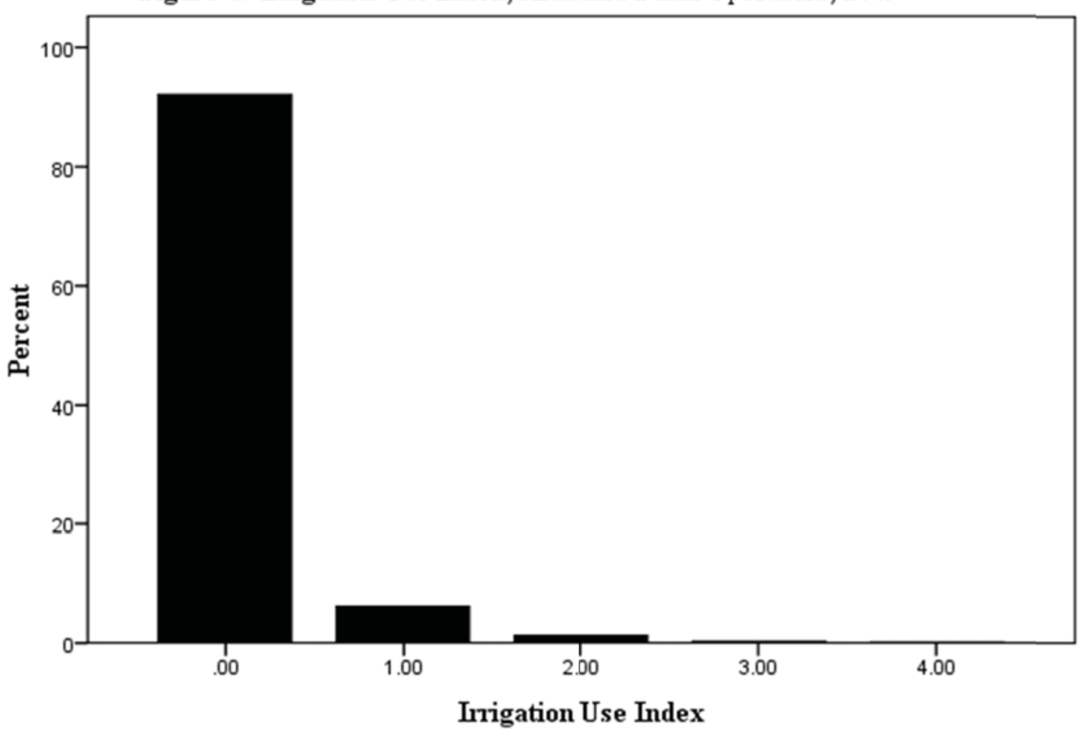
Figure 3. Irrigation Improvement Index, Alabama Farm Operators, 2009



As shown in Table 6, operators averaged 1.08 on the irrigation improvement index. The index ranges from zero to eight, and scoring a zero meaning that a respondent did not make any improvements or irrigation equipment installations. A score of eight would mean that respondents made all improvements and installations mentioned. This means that operators indicated using just one of the irrigation improvements on average. Thus, the mean suggests that irrigators in 2008 made only minimal improvements and additions to their irrigation operations. Eighty-six percent of respondents made no improvements to their irrigation systems and equipment in 2008, as shown in Figure 3. Only six percent reported making one change, three percent made two changes, and three percent made three changes. Two percent reported making four changes, and only one percent reported making five or more changes.

Irrigation Use Index

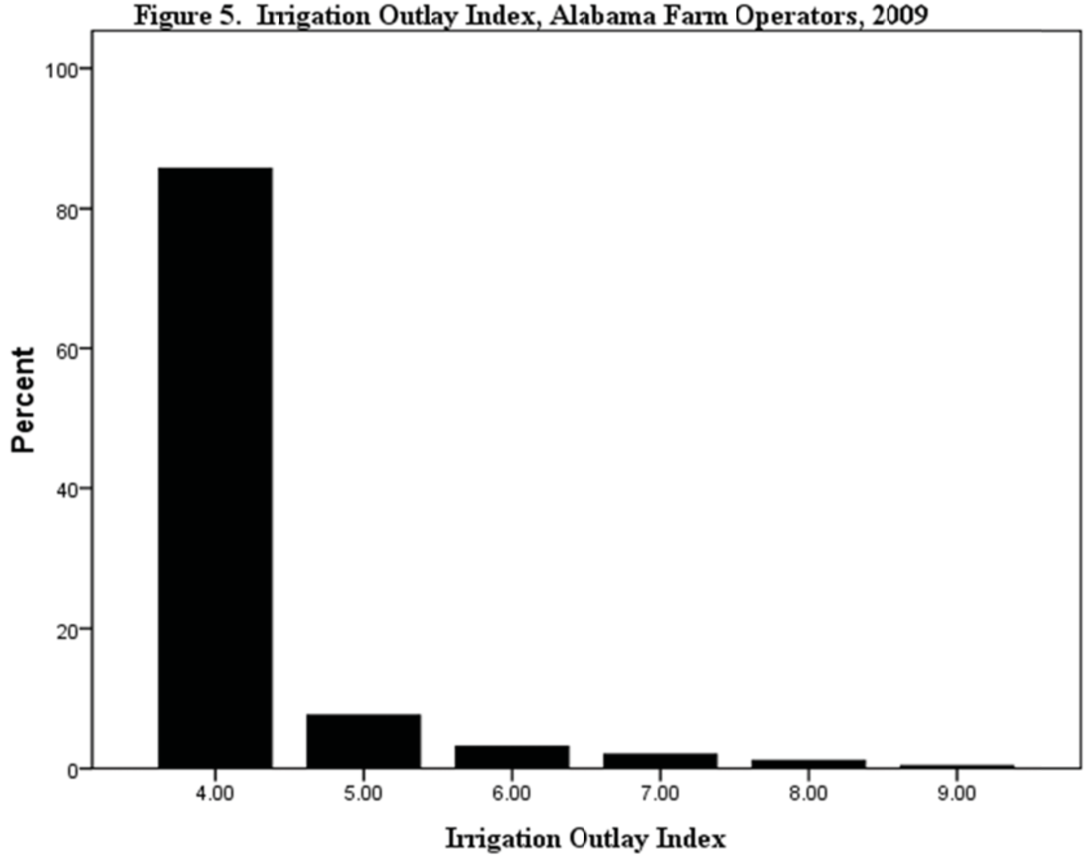
Figure 4. Irrigation Use Index, Alabama Farm Operators, 2009



As shown in Table 6, respondents averaged a score of 0.77 on the irrigation use index. The theoretical range for this index is five, ranging from zero (irrigation was not used for any secondary purposes) to five (irrigation was used for all five listed and possibly more secondary purposes). However, the actual range is four (zero to four), showing that no respondents reported using up to five or more secondary uses for irrigation in 2008. Thus, respondents rarely used irrigation for any secondary purposes, but typically only for the sole purpose of providing water to their crops. Ninety-two percent of respondents used irrigation solely for supplying water when needed to crops. Six percent reported using irrigation for one secondary purpose and one percent for two other purposes. Less than 1 percent reported using irrigation for three extra uses, or for four or more secondary purposes.

Irrigation Outlay Index

Figure 5. Irrigation Outlay Index, Alabama Farm Operators, 2009



As shown in Table 6 on page 47, the mean score for respondents on the irrigation outlay index was 4.3. The index ranges from four (no spending on any of the four listed improvements) to 12 (major spending on all four improvements). However, the actual range is only five, extending from four to nine. Thus, respondents, on average, made almost no expenditures on improvements or additions to their irrigation equipment in 2008. Eighty-six percent spent no money to make improvements to their irrigation systems and equipment. Eight percent made one improvement, three percent made two improvements, and two percent made three improvements. However, only one percent made four improvements and even fewer spent money to make five or more improvements to their irrigation systems. No respondent indicated making expenditures on the major outlay of all of the possible listed improvements.

Table 7. Independent Variable Measures, Alabama Farm Operators, 2009

Independent Variables	Mean	Standard Deviation	Number	Definition
a. Farm Size	932.61	1211.4	708	Size of farm operation in acres
b. Risk Attitudes	1.91	0.76	597	Farmers felt that implementing/improving irrigation was too risky
c. Innovator Status	3.01	1.2	702	Eagerness to adopt new technology
d. Neighbor Adopter	1.48	0.68	587	Having no other local farmers irrigate was a barrier to irrigating
e. Neighbors Object	1.06	0.28	486	Neighbors object to irrigation operations as a reason to not irrigate
f. Age	59.74	12.37	769	Age of farm operator
g. Education	3.25	1.37	769	Education level
h. Helpful AOWR	1.67	0.66	502	Helpfulness of Alabama Office of Water Resources as a source of information
i. Helpful AU	2.06	1.12	545	Helpfulness of Auburn University specialists/researchers
j. Helpful Extension	1.93	0.71	537	Helpfulness of county or regional extension agents
k. Helpful NRCS	1.92	1.13	520	Helpfulness of the USDA-Natural Resources Conservation Service
l. Helpful Internet	1.74	0.65	504	Helpfulness of Internet websites
m. Helpful Dealers	1.87	0.69	529	Helpfulness of irrigation equipment dealers
n. Helpful Media	1.494	1.08	500	Helpfulness of media reports/ press information
o. Helpful Farmers	2.05	0.7	534	Helpfulness of other farmers with irrigation
p. Helpful Consultants	1.66	0.67	504	Helpfulness of private irrigation specialists/consultants
q. Training Needed	3.28	1.14	563	Need for training and technical assistance to implement/expand irrigation
r. Annual Income	4.31	1.61	690	Annual Income
s. Debt Level	2.24	1.04	741	Operation debt
t. Resource Avaiability	1.33	0.55	576	Difficulty of getting equipment
u. Helpful Sources Index	16.99	4.88	794	Sum of items h through q

Independent Variables

In addition to age, education, gender, ethnicity, income, and debt level noted on pages 41—43, the other independents are: farm size, risk attitudes, innovator status, social networking and influence, the "helpfulness index," technical assistance, and resource availability. These variables are described below and in Table 7 on page 53.

Farm Size

Approximately 25 percent reported farming 174 acres or less. About 26 percent reported farming between 175 and 500 acres, and 24 percent farmed 501 to 1,200 acres in 2008. A fourth farmed 1,201 to 11,500 acres. Thus, there was a great deal of variation in the amount of acreage farmed among respondents. Table 7 on page 53 provides descriptive information describing the independent variables. As shown in Table 7 on page 51, farm size (in acres) averaged 933 acres, with a standard deviation of 1,211 acres. Reported farm size ranges from zero acres to 11,500 acres.[1] Because there is such a large range, the 11,500-acre farm may pull the mean much higher.

Risk Attitudes

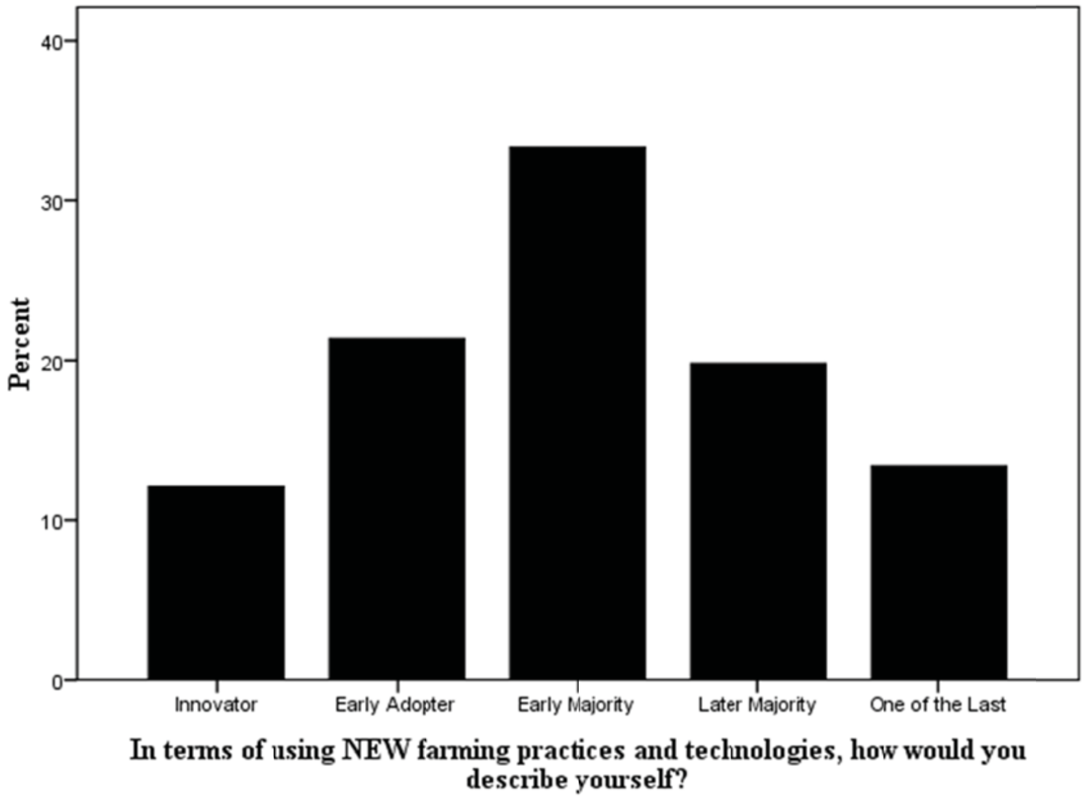
As shown in Table 7, risk attitudes—whether farmers felt that the costs of implementing irrigation was risky—had a mean of 1.9 (SD = 0.8). The range is three; one meaning operators do not feel that irrigation costs are too risky and three meaning that farmers feel that irrigation system operating costs are very risky and thus are a great barrier to implementing an irrigation system (or improving the one already in place to reduce energy and/or conserve water). Approximately one-third reported that they did not feel that irrigation system operating costs are too risky. Forty-two percent, however, felt that the risk of irrigation operation was a barrier to implementing irrigation to some

[1] This extensive range is not a mistake; there was in fact a very large upper tail.

extent. Nineteen percent reported that irrigation operating costs were a great barrier to implementing irrigation on their farms.

Innovator Status

Figure 6. Innovative Proneness, Alabama Farm Operators, 2009



In terms of innovator status, respondents on average scored a 3.0, as shown in Figure 6 above. The theoretical range is five (1 = innovator, 5 = laggard). Twelve percent felt that they are innovators who try new approaches before others. Twenty-one percent reported that they are Early Adopters of new ideas—not the first, but ahead of most of their counterparts. One-third of respondents reported being part of the Early Majority of users. Twenty percent described themselves as part of the Later Majority, and 13 percent as one of the last, or a Laggard. Thus, it appears that respondents typically did not feel that they were often one of the last to try new things (Laggards), but instead tended to be part of the Early Majority of users.

Neighbor Adopters

Table 7 shows that respondents feel that having neighboring farmers who do not irrigate is a not great barrier to implementing or improving irrigation, as the mean is 1.35. The range is three; having no neighbors who irrigate is either 1 = not a barrier, 2 = somewhat, 3 = major barrier as a barrier to the adoption of irrigation. About 73 percent reported that having no other farmers around them irrigating was not a barrier to irrigating on their own farms. Nineteen percent reported that having no neighboring farmers irrigating was somewhat of a barrier to implementing irrigation, and only 8 percent of respondents felt that a lack of irrigating peers was a great barrier to irrigating themselves.

Neighbors Object

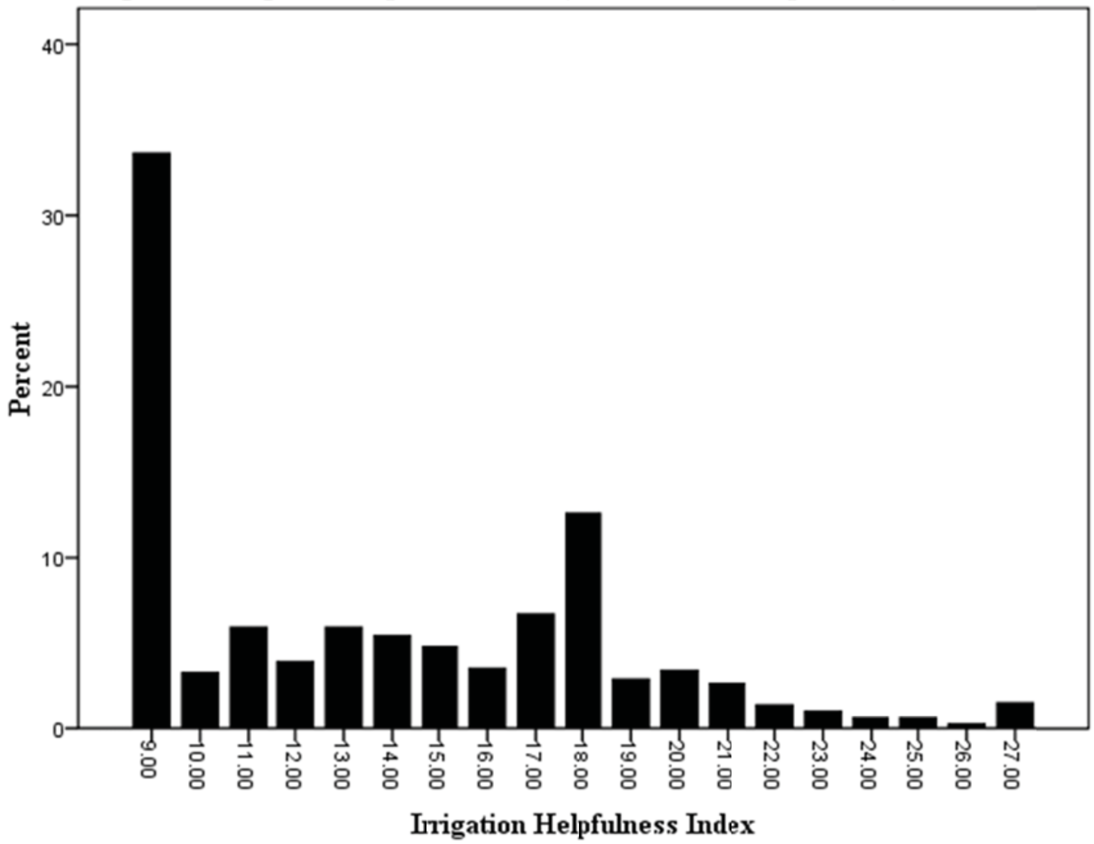
Table 7 shows that "having neighbors object to irrigation operations" as a reason for not irrigating has a mean of 1.1 with a range of three (1 = none, 2 = some, 3 = major reason for not irrigating). About 97 percent reported that having neighbors object to irrigation operations was not a major reason for not irrigating their farms in 2008. 2.6 percent reported that neighbors' objection was part of the reason; while only 0.6 percent felt that their neighbors' opposition was a major reason not to irrigate in 2008. Thus, respondents generally did not feel that objecting neighbors influenced their decision to adopt irrigation or not.

Training Needed

The survey asked respondents if they needed more training and technical assistance to implement or expand irrigation on their operations. Again shown in Table 7 (page 53), the mean for this variable is 3.3 on a scale of five (1 = strongly disagree that more training is needed, 5 = strongly agree that training is needed) and a standard deviation of 1.1. Almost a third of respondents, 32 percent, are undecided as to whether they need more training and technical assistance to implement or expand irrigation. Only eight percent strongly disagreed that they needed more training. Seventeen percent of respondents felt that they did not need more training. Twenty-eight percent agreed that they did, indeed need more training, and 16 percent strongly agreed that greater training and/or technical assistance is necessary to implement or expand existing irrigation on their farms. Thus, many respondents are "undecided," or unsure, whether they need further training and technical assistance to implement irrigation. If farmers do not know there is new technology available, they may not be able to determine whether they are truly technically savvy or not.

Helpfulness Index

Figure 7. Irrigation Helpfulness Index, Alabama Farm Operators, 2009



As shown in Table 7, the theoretical and actual ranges for this index are 18, from nine (none of the resources were helpful) to 27 (all of the resources listed were very helpful). The mean is 13.8, with a standard deviation of 4.7. According to Figure 7, approximately one-third of respondents—34 percent—did not find any of the listed Alabama and public resources helpful for implementing, improving, or expanding irrigation. About 13 percent, however, found half of the resources helpful, but only 1.5 percent found all resources to be helpful. This suggests that there is room for Alabama's information and technical resources to improve upon their communication, accessibility, and helpfulness. However, this requires further investigation, as the type and quality of information being provided to farm operators is unknown.

Replacement Parts

Another independent variable tested is the availability of resources, or the difficulty of getting parts and irrigation equipment. The theoretical range is three (1 = not a barrier, 2 = somewhat, 3 = great barrier). The mean is 1.3, with a standard deviation of 0.6. The majority of respondents, 71 percent of all respondents, do not find it difficult to get replacement parts for irrigation equipment when they are needed. Twenty-five percent found getting replacement parts when needed to be somewhat of a barrier to irrigating their farms in 2008. Four percent found getting irrigation replacement parts when needed to be a great barrier to irrigating their farms in 2008. Thus, respondents did not find it hard to get replacement parts when needed or simply do not find lack of resource availability as a barrier to irrigating their land.

Access to Media Information

Twenty-eight percent of respondents have no Internet access of any type; 18 percent have dial-up Internet only. However, the majority—55 percent—have the more efficient Cable or DSL types of Internet.

Correlations

Dependent Variables

Table 8 (page 60) summarizes the correlations found between the five dependent variable indices. For this study, each of the dependent variable indices were positively and strongly correlated ($p < 0.01$). Thus, the strong correlations show that these variables are sufficient indicators of the extent of irrigation used and the level of irrigation adoption for respondents.

Table 8. Correlations Among Irrigation Adoption Dependent Variables, Alabama Farm Operators, 2009.

	Irrigation Adoption Indictors			
Independent Variable	Last Year	Land Index	Irrigation Use Index	Irrigation Outlay Index
Irrigated Last Year				
Irrigation Land Index	0.873**			
Irrigation Use Index	0.463**	0.466**		
Irrigation Outlay Index	0.610**	0.590**	0.405**	
Improvement Index	0.603**	0.608**	0.365**	0.628**

* p<0.05; ** p<0.01; *** p<0.001 (2-tailed)

Independent Variables

Bivariate correlations were performed to test for relationships between the independent variables and the dependent variable indices. Table 9, shown below, summarizes the correlations found between the dependent variables and the independent variables. Results from Table 9 on page 61 are used to examine the study hypotheses presented in Chapter II.

Table 9. Correlations between Irrigation Adoption and Selected Individual and Farm Characteristics, Alabama Farm Operators, 2009.

	Irrigation Adoption Indictors				
Independent Variable	Irrigated Last Year	Irrigation Land Index	Irrigation Use Index	Irrigation Outlay Index	Irrigation Improvement Index
Farm Size	0.19**	0.12*	-0.04	0.20**	0.21**
Risk Attitudes	-0.34**	-0.16**	-0.11**	-0.16**	-0.16**
Innovative Status	-0.17**	-0.16**	-0.13**	-0.21**	-0.20**
Neighbor Adopter	-0.06*	-0.16**	-0.02	-0.13**	-0.13**
Neighbors Object	-0.06*	-0.04	-0.06	0.01	-0.03
Age	-0.07*	-0.07*	-0.07*	-0.10**	-0.11**
Education	0.07*	0.09**	0.03	0.04	0.08**
Helpfulness Index	0.04	0.03	0.06	0.06*	0.08**
Training Needed	-0.16**	-0.14**	-0.06	-0.08*	-0.5
Annual Income	0.01	-0.01	-0.5	0.07*	0.03
Debt Level	0.11**	0.07*	0.08*	0.12**	0.11**
Resource Availability	-0.06*	-0.04	-0.05	-0.05	-0.03
Ethnicity	0.01	0.02	0.10**	0.01	-0.00
Gender	-0.06*	-0.05	-0.05	-0.66**	-0.07

* $p<0.05$; ** $p<0.01$; *** $p<0.001$ (1-tailed)

Farm Size

H1: *Farmers who own more acreage (have a larger farm-size) are more likely to irrigate.* As shown in Table 9 on page 60, there is a significant positive correlation between farm size and irrigating, $r = 0.19$, $p < 0.01$. Thus, farmers with greater farm acreage are more likely to irrigate (or, in this specific case, to have irrigated in 2008). There was also a positive strong correlation between farm size and the irrigation land index ($r = 0.12$, $p < 0.05$), showing that as farm size increases, the more irrigation is used on more types of crops (including horticulture, row, specialty, pasture, and hay crops). There is a negative correlation between farm size and the irrigation use index ($r = -0.04$, $p > 0.05$), but it is not significant. It is possible that as farm size increases, secondary uses of irrigation are used less. However, this may be due to chance and is not significantly correlated. There are positive, significant correlations between farm size and the irrigation outlay index ($r = 0.20$, $p < 0.01$) and irrigation improvement index ($r = 0.21$, $p < 0.01$). Thus, with greater farm size, there tends to be greater expenditures on irrigation and more improvements made to irrigation equipment.

Risk Attitudes

The second hypothesis: *If irrigation is perceived as minimizing risk, farmers are more likely to adopt irrigation to a fuller extent*, was also tested. Farm operators were asked if irrigation system operating costs are too risky. The responses to this question were correlated with each of the five dependent indicators. As shown in Table 9, there is a negative correlation between risk attitudes and having irrigated in 2008, $r = -0.34$, $p < 0.01$. Thus, if farmers do not perceive irrigation operation costs as risky, the more likely they irrigate. Farmers who perceive irrigation as a potential safeguard against risk may be more likely to adopt irrigation techniques. A strong negative correlation was found between risk attitude and the irrigation land index ($r = -0.16$, $p < 0.01$). Thus, the less farmers perceive irrigation operation as a risk, the more likely they are to use irrigation to a fuller extent and on more crops. The correlation between risk attitudes and the irrigation use index is also negative and significant ($r = -0.11$, $p < 0.01$). Farmers who perceive irrigation as not very risky are likely to use irrigation for a greater number of uses other than simply providing water to crops. There are also negative, significant correlations between risk attitudes and the irrigation outlay index ($r = - 0.16$, $p < 0.01$) and the irrigation improvement index ($r = -0.16$, $p < 0.01$). Farmers who do not perceive irrigation costs as risky, then, may make greater expenditures and improvements on irrigation. When crop types (row crops, fruit/horticulture/specialty crops, pasture/hay land) are correlated with risk individually, irrigated row crops ($r = -0.13$, $p < 0.01$) and fruit/horticulture/specialty crops ($r = -0.13$, $p < 0.01$) were both significantly and negatively correlated with risk. Pasture and hay land, however, was not significantly correlated with risk aversion. Farmers who produce row crops, vegetables, fruit, horticulture, and specialty crops are less likely to view irrigation operating costs as risky. Instead, it may be risky for these farmers to not irrigate. For example, there may be a greater risk of freeze damage to a producer's Satsuma crop that makes any risk from irrigation costs minimal.

<u>Innovative Status</u>

My third hypothesis was: *The more innovative the farmer is, the more likely he/she is to irrigate*. There are negative correlations between innovative proneness and all dependent measures. There is a negative correlation between having irrigated in 2008 and innovative status ($r = -0.17$, $p < 0.01$), as shown in Table 9. Innovative proneness is reverse coded; thus, being more innovative may encourage irrigation adoption and usage. Those who are more innovative may also use irrigation to a fuller extent on a greater number and variety of crops ($r = -0.16$, $p < 0.01$), as well as for a number of secondary purposes ($r = -0.13$, $p < 0.01$). Innovative farmers may spend a major outlay on irrigation equipment ($r = -0.21$, $p < 0.01$) and improvements ($r = -0.20$, $p < 0.01$).

<u>Neighbor Adopter</u>

The fourth hypothesis was: *Farmers who have neighbors who irrigate are more likely to implement or improve irrigation systems.* Again, as shown in Table 9, there was a negative correlation between not having neighbors who have adopted irrigation and respondents who irrigated, as well, in 2008. Farmers were asked if "no other farmers around here irrigate," and were scored accordingly (1 = not a barrier, 2 = some, 3 = great barrier). Thus, having neighbors who irrigate may influence other farmers to adopt. Neighbors may provide a social pressure to adopt, as well as provide information and support. Also, there is a strong negative correlation between farmers who do not have neighbors who irrigate and/or adopt new techniques and the irrigation land index ($r = -0.16$, $p < 0.01$), the irrigation outlay index ($r = -0.13$, $p = < 0.01$), and the irrigation improvement index ($r = -0.13$, $p < 0.01$). Thus, farmers who do not view non-irrigating neighbors as an adoption/irrigation barrier or who have irrigating neighbors are more likely to use irrigation to a greater extent, as well as spend more money on improvements and irrigation equipment. However, the correlation between having neighbor adopters and the irrigation use index ($r = -0.02$, $p > 0.05$) was not significant.

Age

The fifth hypothesis states: *The younger the farmer, the more likely they are to irrigate.* There are significant, strong correlations between age and all five dependent variable indicators. There is negative correlation between age and having irrigated in 2008, $r = -0.07$, $p < 0.05$. As age decreases, then, adoption of irrigation increases. The correlation between age and the irrigation land index ($r = -0.08$, $p < 0.05$) is significant. This indicates that as age increases, farm operators use irrigation to a smaller extent. The correlation with the irrigation use index ($r = -0.07$, $p < 0.05$) suggests that as age increases, irrigation is used for fewer purposes. The negative correlation with the irrigation outlay index ($r = -0.10$, $p < 0.01$) and with the irrigation improvement index ($r = -0.03$, $p < 0.01$) show that older farm operators are less likely to invest in irrigation equipment and operation or on irrigation improvements. These correlations support the hypothesis that younger farmers are more likely to irrigate.

Education

The sixth hypothesis states: *Producers who have obtained greater levels of education adopt irrigation more often than those with less education.* There was a positive correlation between education level and irrigating in 2008, as hypothesized. Farmers with greater education achievement, then, are more likely to adopt irrigation than those with lesser education. There is also a significant positive correlation between education and the irrigation land index ($r = 0.09$, $p < 0.01$), as shown in Table 9 on page 60. Thus, those who have attained higher education levels are likely to use irrigation to a fuller extent and on a number of crops. Also, the correlation between education and the irrigation improvement index is positive and significant ($r = 0.08$, $p < 0.01$). Those with greater education, then, are more likely to spend more on irrigation improvements. However, the correlations between education and the irrigation use index ($r = 0.03$, N.S.) and irrigation outlay index ($r = 0.04$, N.S.) are not significant.

Helpfulness Index

I hypothesized that: *Those with positive relationships with sources of technical information are likely to adopt irrigation.* Having created an index to rate and test the helpfulness of local technical information sources, the index was tested with the dependent variables. The correlation between the helpfulness index and having irrigated in 2008 was not significant ($r = 0.04$, N.S.), as shown in Table 9 on page 60. Also, the correlations between the helpfulness index and the irrigation land index ($r = 0.03$, N.S.) and the irrigation use index ($r = 0.06$, N.S.) were not significant. However, the correlations between the helpfulness index and the irrigation outlay index ($r = 0.06$, $p < 0.05$) and the irrigation improvement index ($r = 0.08$, $p < 0.01$) are significantly positive. Thus, those who find information resources available to them quite helpful are more likely to make major investments into irrigation equipment and improvements.

Annual Income

The greater the producer's annual income, the more likely they are to irrigate. There was a positive correlation between annual household income and having irrigated in 2008, but it was not significant ($r = 0.01$, N.S.). Thus, we cannot rule out chance as a cause of this correlation. The correlation between annual income and the irrigation improvement index was also positive and insignificant ($r = 0.03$, N.S.). The correlations between annual income and the irrigation land index ($r = -0.01$, N.S.) and the irrigation use index ($r = -0.50$, N.S.) are both negative, but insignificant. The correlation between annual household income and the irrigation outlay index ($r = 0.07$, $p < 0.05$) is significantly positive. Thus, those with a greater annual income tend to make greater expenditures on irrigation equipment and operation. This is in support of the hypothesis that those who have a greater income are more likely to irrigate. Farm size is significantly positively correlated with annual income ($r = 0.23$, $p < 0.01$); thus, farmers with larger incomes tend to have larger farm acreage. Thus, they may be more inclined to irrigate because they may have a greater amount of crop acreage to protect.

Debt Level

I hypothesized that: *The lower the producer's level of debt, the more likely they are to irrigate.* Table 9 on page 60 shows that there is a positive correlation between debt level and irrigation adoption ($r = 0.11$, $p < 0.01$). Thus, as debt level increases, farmers are more likely to irrigate. There is a significant correlation between debt and the irrigation land index ($r = 0.07$, $p < 0.05$). Debt level is also positively and significantly related with irrigation use index ($r = 0.08$, $p < 0.08$). Debt level is very strongly correlated with the irrigation outlay index ($r = 0.12$, $p < 0.01$) and with the irrigation improvement index ($r = 0.11$, $p < 0.01$). The hypothesis that farmers who have lower debt levels will be more likely to irrigate appears to be incorrect, as all five correlations with the dependent variables were positively and significantly related. Thus, the greater the debt level of a farming operation, the more likely the operator is to irrigate. Producer debt level, then, may reflect capital investment in irrigation.

Availability of Resources

If irrigation resources are available and accessible, then a producer is more likely to irrigate. There is a negative correlation between resource availability and having irrigated last year ($r = -0.06$, $p < 0.05$). Also, there is a negative correlation between resource availability and the irrigation index ($r = -0.04$, N.S.) and a negative correlation between the irrigation use index and resource availability ($r = - 0.05$, N.S.), but neither is significant. There are negative correlations between resource availability and the irrigation outlay index ($r = -0.05$, N.S.) and the irrigation improvement index ($r = -0.03$, N.S.), but these are not significant. Thus, resource availability is strongly, negatively correlated with having irrigated in 2008, but not with the other dependent variables.

<u>Ethnicity</u>

Ethnic minority-operated farms in Alabama will be less likely to use irrigation than Caucasian-operated farms. There is a significant positive correlation between being non-Caucasian and using irrigation for secondary purposes other than watering crops ($r = 0.102$, $p < 0.01$). Ethnicity—being non-Caucasian, specifically—is not significantly correlated with the irrigation land index ($r = 0.02$, N.S.), the irrigation improvement index ($r = -0.00$, N.S.), the irrigation outlay index ($r = 0.01$, N.S.), and having irrigated in 2008 ($r = 0.01$, N.S.). This is not specific to crop type. Thus, ethnicity is significantly and positively correlated with the irrigation use index, but not with any other dependent variable index.

<u>Gender</u>

Female-operated farms in Alabama will be less likely to use irrigation than male-operated farms. There is a significant negative correlation between being female and having irrigated last year ($r = -0.060$, $p < 0.05$), as shown in Table 9 on page 60. There is also a significant negative correlation between being female and the irrigation outlay index ($r = -0.66$, $p < 0.01$). There are negative correlations between being female and the irrigation use index (r = -.050, N.S.), the irrigation improvement index (r = -0.065, N.S.), and the irrigation land index (r = -0.47, N.S.) but none of these correlations are significant. Being female is strongly and negatively correlated with using irrigation in 2008 the irrigation outlay index, but not with the other dependent variables. However, the percentage of female respondents in this study was quite small.

Multivariate Linear Regression

Table 10 on page 70 gives a summary of the multivariate linear regression results for the five measures of irrigation usage as related to producer and farm characteristics. The analysis showed patterns that sustain many of the stated hypotheses.

Table 10. OLS Regression of Irrigation Adoption on Selected Irrigated Farms, Alabama Farm Operators, 2009

	Irrigation Adoption Indicators				
	Irrigated Last Year	Irrigation Land Index	Irrigation Use Index	Irrigation Outlay Index	Irrigation Improvement Index
Independent Variable	Beta (Standard Error)	Beta (Standard Error)	Beta (Standard Error)	Beta (Standard Error)	Beta (Standard Error)
Farm Size	0.02	-0.01	-0.00	0.03	0.07
	(0.02)	(0.03)	(0.02)	(0.03)	(0.04)
Risk Attitudes	-0.18***	-0.25***	-0.10	-0.26***	-0.33***
	(0.03)	(0.05)	(0.03)	(0.06)	(0.7)
Innovative Status	-0.05*	-0.10**	-0.04*	-0.12***	-0.14**
	(0.02)	(0.03)	(0.02)	(0.04)	(0.05)
Neighbor Adopter	-0.10**	-0.19**	-0.01	-0.11	-0.11
	(0.04)	(0.06)	(0.04)	(0.07)	(0.09)
Neighbors Object	-0.10	-0.09	0.00	0.12	-0.10
	(0.08)	(0.14)	(0.08)	(0.15)	(0.19)
Age	0.00	-0.00	-0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Education	0.02	0.04	0.02	0.01	0.07*
	(0.15)	(0.03)	(0.02)	(0.03)	(0.04)
Helpfulness Index	-0.01	-0.14	0.00	-0.01	-0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)
Training Needed	-0.07***	-0.09**	-0.02	-0.08*	-0.06
	(0.02)	(0.03)	(0.02)	(0.04)	(0.04)
Annual Income	-0.02	-0.05	-0.02	0.01	-0.07*
	(0.01)	(0.03)	(0.01	(0.03)	(0.04)
Debt Level	0.05*	0.06	0.04	0.06	0.07
	(0.02)	(0.04)	(0.22	(0.04)	(0.05)
Resource Availability	0.02	0.08	-0.19	0.00	0.07
	(0.04)	(0.07)	(0.04)	(0.08)	(0.10)
Gender	-0.08	-0.16	-0.10	-0.13	-0.24
	(0.12)	(0.22)	(0.12)	(0.24)	(0.30)
Ethnicity	0.14	0.27	0.29***	0.26	0.25
	(0.09)	(0.15)	(0.09)	(0.17)	(0.21)
Adjusted R^2	0.19	0.13	0.06	0.11	0.12
F-ratio	8.30***	5.87***	2.84***	4.68***	5.20***

*p<0.05; **p<0.01; ***p<0.001

Irrigated Last Year

The adjusted R square for the dependent variable "irrigated last year" equals 0.189, and the F value = 8.3, significant at $p < 0.001$. Significant predictor variables are mentioned below.

As shown by regression results in Table 10 on page 69, attitudes towards risk had a significantly negative effect on irrigation use in 2008 (beta = -0.18, $p < 0.001$). Thus, hypothesis 2 is accepted for this dependent variable. Also, producer innovativeness had a significant influence on all five dependent measures, including whether they irrigated their land in 2008 or not (beta = -0.05, $p < 0.05$); those who reported being more innovative tended to have irrigated in 2008. Innovative proneness is reverse coded (5 = innovator, 1 = laggard). Thus, being more innovative is reflected in irrigation adoption and use.

Farmers were asked if "no other farmers around here irrigate," and were scored accordingly (1 = not a barrier, 2 = some, 3 = great barrier). Not having neighbors who have adopted irrigation negatively influenced respondents who irrigated in 2008 (beta - 0.10, $p < 0.01$). Also, there is no significant effect of having neighbors who object to irrigation usage on whether producers irrigated in 2008.

Regression results showed that those who reported using irrigation in 2008 did not feel that they needed more training and technical assistance to implement or expand irrigation; having sufficient technical training and assistance positively influenced whether producers irrigated any of their farmland in 2008 (beta = -0.07, $p < 0.001$).

As shown by regression results, debt level is significantly related to whether Alabama producers irrigated in 2008 or not (beta = 0.05, $p < 0.05$). Thus, irrigating one's crops may be a great expense and cause greater debt.

Irrigation Improvement Index

The adjusted R square for the irrigation improvement index = 0.118, and the F value = 5.2 at the $p < 0.001$ significance level. Significant predictor variables are mentioned below.

Producers' innovative proneness had a significant effect on the irrigation improvement index (beta = -0.138, $p < 0.01$), as shown by Table 10 on page 69. Those who are more innovative, then, were more likely to have made improvements to their irrigation systems in 2008. Also, producers' risk attitudes significantly affected the improvement index (beta = -0.330, $p < 0.001$). Those who did not feel that irrigation operating costs are too risky made greater improvements to their irrigation equipment, as well. However, total combined household income during 2008 (beta = -0.070, $p < 0.05$) had a significant negative effect on this dependent variable; thus, higher income households reported fewer improvements. In contrast, education level had a positive effect on the improvement index (beta = 0.072, $p < 0.05$).

Income had a significantly negative effect on irrigation improvements made in 2008 (beta = -0.07, $p < 0.05$). Regression results showed that producers' level of debt had a significantly positive effect on whether they irrigated in 2008 (beta = 0.05, $p < 0.05$). Farmers with more debt were more likely to irrigate.

Irrigation Land Index

The regression for the irrigation land index produced an adjusted R square value of 0.133 and an F value of 5.87, where $p < 0.001$, as shown in Table 10. Five independent variables influencing this index, which measures the number of different crops that receive irrigation, are described below:

The need for more training and technical assistance to implement or expand irrigation had a negative significant effect on the irrigation land index (beta = -0.10, $p < 0.01$), as did producer innovative proneness (beta = -0.09, $p < 0.01$). Thus, producers who reported not needing further training and technical assistance and being more innovative were more likely to irrigate to a fuller extent in 2008. Also, producers' risk attitudes had a significant negative effect on the land index (beta = -0.25, $p < 0.001$); those who did not feel that irrigation operating costs were too risky used irrigation more widely on a greater amount of land. Having "no other farmers around here that irrigate" negatively affected the land index (beta = -187, $p < 0.01$) as well. Thus, not having neighbor adopters did not appear to affect the extent to which producers irrigate. And lastly, household income level in 2008 negatively and significantly affected the land index (beta = -0.05, $p < 0.05$).

Irrigation Outlay Index

As shown in Table 10, the adjusted R square for the irrigation outlay index = 0.105 and the F value = 4.68. These values are significant at the $p < 0.001$ level. Regression results showed that those who reported using irrigation in 2008 did not feel that they needed more training and technical assistance to implement or expand irrigation; having sufficient technical training and assistance positively and significantly influenced whether producers made significant expenditures on their irrigation systems in 2008 (beta = -0.08, $p < 0.05$). Also, more innovative farmers tended to spend more on their irrigation operations as well (beta = -0.121, $p < 0.001$). Producers with more positive risk attitudes, who did not feel that irrigation system operating costs were too risky, were more likely to spend more on irrigation in 2008 (beta = -0.26, $p < 0.001$). None of the other predictor variables significantly affected the irrigation outlay index.

Irrigation Use Index

The adjusted R square value for the irrigation use index = 0.06 and F = 2.84 ($p < 0.001$). Table 10 shows that innovative proneness had a significant effect on the irrigation use index (beta = -0.04, $p < 0.05$). Thus, those who described themselves as being more innovative reported using irrigation for more secondary purposes than those who reported being less innovative. Risk attitudes also significantly influenced the use of irrigation for secondary uses (beta = -0.10, $p < 0.01$), as did ethnicity (beta = 0.29, $p < 0.001$). Thus, the regression results suggest that more non-white producers use irrigation for secondary purposes other than watering crops. However, the proportion of non-Caucasian ethnicities was quite low, so this particular result should be taken cautiously.

Summary and Conclusions

Table 11. Hypotheses, Alabama Farm Operators, 2009

Hypothesis	Hypothesis Statement
H1:	Farmers who have a larger farm-size are more likely to irrigate.
H2:	If irrigation is perceived as minimizing risk, the greater the adoption.
H3:	The more innovative the farmer is, the more likely they are to irrigate.
H4:	Farmers with neighbors who irrigate are more likely to implement or improve irrigation systems.
H5:	The younger the farmer, the more likely they are to irrigate.
H6:	Producers with greater education attainment will adopt irrigation more often than those with less education.
H7:	Those with positive relationships with sources of technical information are likely to adopt irrigation.
H8:	The greater the producer's annual income, the more likely they are to irrigate.
H9:	The lower the producer's level of debt, the more likely they are to irrigate.
H10:	The more resources there are for irrigation, the more prone a producer is to adopt irrigation.
H11:	Farmers with access to the Internet are likely to adopt irrigation.
H12:	Ethnic minority-operated farms in Alabama will be less likely to use irrigation than Caucasian-operated farms.
H13:	Female-operated farms in Alabama will be less likely to use irrigation than male-operated farms.
H14:	The independent variables together predict the dependent variables.

Pearson correlations showed farm size to be significantly and positively related to irrigation use in 2008, the irrigation land index, irrigation outlay index, and irrigation improvement index, though not significantly correlated with the irrigation use index. The multivariate linear regression found no correlations between farm size and the dependent variables, however. However, there are significant correlations between farm size and innovative proneness, age, gender, debt level, household income, internet access, race, and the helpfulness index. Thus, when all of the independent variables are considered, farm size does not have a great deal of significance on all five of the irrigation adoption measures. Therefore, hypothesis 1—farmers who have a larger farm size are more likely to irrigate—is rejected.

Findings for the Pearson correlation showed risk attitude to be negatively related to all five irrigation adoption indicators. Those who do not feel that irrigation operating costs are very risky are more likely to implement and improve irrigation systems. The second hypothesis states that producers are more likely to adopt irrigation if irrigation is perceived as minimizing risk. Regression results supported the significant negative correlations between all five dependent variables. Therefore, the second hypothesis risk is accepted.

The Pearson correlation found significant negative correlations between innovative producers and all five dependent measures of irrigation adoption and usage. The linear regression found innovativeness to be negatively related to all five dependent irrigation measures, as well. Hypothesis 3, "the more innovative the farmer is, the more likely they are to irrigate," is accepted for irrigation use in 2008, the irrigation land index, irrigation outlay index, irrigation improvement index, and the irrigation use index.

Significant negative correlations were found between not having neighbors who use irrigation and four of the dependent variables: irrigated in 2008, the irrigation land index, the irrigation outlay index, and the irrigation improvement index. The linear regression showed that lacking neighbor irrigation users negatively influenced whether or not producers irrigated in 2008, as well as influenced the irrigation land index. However, the variable "No other farmers around here irrigate" has significant positive correlations with innovativeness, resource availability, ethnicity, risk attitudes, as well as income level in 2008. Thus, considering multicollinearity, having neighbor adopters does not significantly influence the other three dependent measures. Therefore, hypothesis 4 (farmers who have neighbors who irrigate are more likely to implement or improve irrigation systems) is supported only for having irrigated in 2008 and the irrigation land index.

There are significant, negative correlations between age and all five dependent variable indicators. However, regression results did not show age to have any significant influence on the dependent irrigation measures. Yet, age is highly correlated with technical assistance, availability of resources, debt level, income level, Internet access, the helpfulness index, innovative proneness, and risk attitudes. Thus, when all of the independent variables are taken into consideration, age is not a significant factor for irrigation adoption. Therefore, hypothesis 5, which states that younger producers are more likely to irrigate, is rejected.

The Pearson correlations showed significant correlations between education achievement and irrigating in 2008, the irrigation land index, and the irrigation improvement index, though not with the irrigation outlay index or the irrigation use index. Regression results showed that the irrigation improvement index was the only irrigation measure significantly influenced by education. Regression shows that when all of the independent variables were considered, educational achievement did not have a significant relationship with irrigation use in 2008, the irrigation land index, the irrigation outlay index, or the irrigation use index. Hypothesis 6—producers with greater levels of educational achievement adopt irrigation more often than those with less education—is accepted for the irrigation improvement index only.

The Pearson correlations showed significant positive associations between the helpfulness index and the irrigation outlay and irrigation improvement indices. However, the regression found no significant affects of the helpfulness index on whether producers irrigated in 2008 or the four irrigation indices. The helpfulness index is highly correlated with many of the other independent variables, including having neighbors who object to irrigation, technical assistance, innovativeness, resource availability, Internet access, age, farm size, and risk attitudes. When all of these independent variables are taken into consideration, the helpfulness index does not affect adoption or improvement of irrigation practices. The hypothesis that those with positive relationships with sources of technical information are likely to adopt irrigation (H7), then, is rejected.

Annual household income for the year 2008 was only significantly correlated with the irrigation outlay index. The linear regression found that income had a significantly negative effect on irrigation improvements made in 2008, but not with the four other irrigation indices. Thus, considering the high correlations of income with other independent variables including innovativeness, neighbor adopters, age, ethnicity, Internet access, education attainment, and farm size, household income does not affect four of the dependent irrigation measures. Thus, Hypothesis 8 (the greater the producer's annual income, the more likely they are to irrigate) is rejected.

The Pearson correlations showed significant positive correlations between debt level and all five dependent measures. However, the linear regression found that producers' level of debt only had a significantly positive effect on whether they irrigated in 2008. The regression shows that when all of the independent variables were considered, debt level did not have a significant relationship with the irrigation land index, the irrigation outlay index, the irrigation improvement index, or the irrigation use index. Thus, hypothesis 9—the lower the producer's level of debt, the more likely they are to irrigate—is accepted only for having irrigated in 2008, not with the four irrigation indices.

A positive correlation exists between the availability of resources and having irrigated in 2008. Linear regression results showed no significant effects for the availability of resources. Access to resources and irrigation replacement parts does not play a role in a farmer's decision to adopt irrigation or to make improvements to irrigation systems already installed when all other independent variables are considered. Hypothesis 10 is rejected. Availability of resources, or the difficulty of finding irrigation parts and equipment, has no effect on a farmer's decision to irrigate or improve currently used irrigation.

Pearson correlation findings showed significant positive correlations between having Internet access and having irrigated in 2008, the irrigation improvement index, the irrigation land index, and the irrigation outlay index. The linear regression results showed no significant effect on irrigation usage, improvements, or expenditures on irrigation. Internet access does not play a significant role in a farmer's decision to adopt or improve irrigation when the other independent variables are considered. Hypothesis 11, then, is rejected; Internet access or a lack there of, has no effect on a farmer's decision to adopt or improve irrigation.

Hypothesis 12 states that ethnic minority-operated farms in Alabama are less likely to irrigate than Caucasian-operated farms. There is a significant positive correlation between being non-Caucasian and using irrigation for secondary purposes (the irrigation use index). However, there are no significant associations between ethnicity and the four other irrigation measures. The linear regression found non-Caucasian farmers to be positively related to the irrigation use index. Thus, ethnic minorities may be more likely to use irrigation for more secondary purposes than Caucasian producers. There are significant correlations between ethnicity, technical assistance, resource availability, neighbor adopters, debt level, income, and Internet. When taking these other independent variables into consideration, ethnicity does not affect the other four dependent irrigation measures. Thus, hypothesis 12 is accepted for the irrigation land index.

Gender, or specifically being female, was positively correlated only with having irrigated in 2008 and the irrigation outlay index. Regression results show no significant influence of gender on having irrigated in 2008 or on any of the irrigation indices when other independent variables are considered. Thus, hypothesis 13 is rejected; female-operated farms in Alabama do not appear to be less likely to irrigate than male-operated farms. However, the small number of female respondents should be considered.

All of the F-ration values are significant for each of the four dependent variable measures. Hypothesis 14 states that the independent variables together predict the dependent variables. This hypothesis is fully accepted.

V. CONCLUSIONS

Irrigation transports water to crops to keep crops cool under excessive heat conditions. In areas where rainfall is plentiful in most years, irrigation can bring benefits by reducing risk of disease, frost damage, and other crop stressors, which can provide income stability. Other benefits include: improving crop quality (most noticeably for vegetable crops), significantly increase crop yields, particularly on sandy soils (as in parts of Alabama) that have low moisture-holding capacities, increasing opportunities for double cropping (such as planting soybeans after wheat in the same year), and providing a means for liquid fertilizer application (EPA 2009). Without irrigation, the productivity of tree crops and vegetable growth will diminish in years over time (especially in years of drought), as will the livelihood of the farmers that grow these crops. This chapter presents theoretical implications, implications for research, and practical implications, including suggestions for technical assistance and support, for the future improvement and usage of irrigation in Alabama.

Implications

Theoretical Implications

This study found that the variables that propel farmers to implement irrigation practices and improve and expand irrigation systems have not changed much in relation to past studies. Irrigation is still relatively underutilized among Alabama farmers. This may indicate that growth in information transfer and collective learning, such as extension education and the Internet, has not yet reached its potential for the Alabama farmer.

Innovative proneness significantly affected all five irrigation indices and is thus related to both irrigation usage and improvement. This finding suggests that being more innovative encourages irrigation practice adoption, improvement, and expansion. According to Rogers (1962; 1965), the early majority makes up 34 percent of the population; 33 percent of the sample in this study reported being part of the Early Majority. Approximately two-thirds of all respondents reported being either an Innovator, an Early Adopter, or part of the Early Majority, while one-third identified themselves as part of the Late Majority or a Laggard. However, this last third of the sample is still a considerable percentage. These producers should not be ignored; instead, their needs should be identified so that those who wish to irrigate may be more inclined to adopt irrigation.

Producers' attitudes towards risk significantly influenced all five dependent irrigation variables. This finding suggests that being less concerned with risk allows producers to more easily adopt, improve, and expand irrigation systems on their property. Irrigated row crops and fruit/horticulture/specialty crops were both significantly and negatively correlated with risk aversion, unlike pasture and hay land. Farmers who produce vegetables, fruit, horticulture, and specialty crops are less likely to view irrigation operating costs as risky. Instead, it may be risky for these farmers to not irrigate. For example, there may be a greater risk of freeze damage to a producer's citrus crop that makes any risk from the cost of irrigation minimal; irrigation costs may be a worthwhile investment in the protection against potential risk and crop stressors. This is consistent with what Kulshreshtha and Brown (1993) concluded. Their study, as does this one, suggests that adopters' attitudes were significant determinants of their decision to proceed with adoption of irrigation, possibly even more so than the effect of socio-economic characteristics (Kulshreshtha et al. 1993).

Neighbor adopters, or producers' local social networks, had a significant effect on irrigation in 2008 and the extent of irrigation used (the irrigation land index). Though respondents were not affected by having no nearby irrigators, having neighbors who irrigate can encourage producers to irrigate and use irrigation on a larger portion of their crops; Rogers' theory of innovation, for example, suggests a bandwagon process where an increase in the number of irrigators creates stronger "bandwagon" pressures. Social pressures can cause increases in the number of actual adopters of irrigation. Through communication with other local irrigators, producers can develop a social network for information and technical support for one another (Morris et al. 2000; Rogers 1995).

Those with greater levels of education made larger numbers of improvements to their irrigation equipment. Thus, education may be a key factor in encouraging farmers to improve their irrigation systems and make them more efficient. Growing pressures to conserve water and reduce costs while continuing to sustain yields and reduce risk require farmers to use the most efficient irrigation techniques; this requires farmers to be aware of and understand how to use new efficient technology. Therefore, finding more ways to educate farmers outside of the traditional educational system and for educators/researchers to collaborate with producers is a possibility for future research.

Those who reported a greater debt level also tended to report having irrigated in 2008. Irrigation is a capital investment for those producers who choose to irrigate and may contribute to their debt level. This is a classic example of Cochrane's (1958) treadmill of production; farmers who adopt new technology and therefore increase productivity gain significant benefits, such as greater yield. Over time, others follow and increase supply; as supply increases, commodity's price tends to fall, which can increase debt as producers continue to irrigate and make expenditures on irrigation equipment and improvements. Increased efficiency in agricultural production, such as increased irrigation also can drive down commodity prices. This downward pressure on crop price results in "price-squeeze" and "cost-squeeze,"[1] which in effect can increase debt level as well (Cochrane 1958).

Finding a way to make irrigation more affordable to implement and maintain may be a necessary step to encourage more Alabama producers to irrigate in the future. Sixty-seven percent of respondents reported having to pay for the majority of their irrigation water and another 16 percent reported paying for at least some of it; this cost may be a reason for not irrigating. Also, the main reason for not irrigating, as shown in Table 5, was that farmers could not afford the investment. Cost-sharing, subsidized loans and other incentives could be key parts of efforts to advance irrigation use in Alabama. Making irrigation water more accessible, making irrigation technology more efficient, educating farmers about efficient techniques and making water more affordable are necessary changes for irrigation to be a smaller financial burden to Alabama's producers.

[1] For more information, see Chapter II, page 21, and Cochrane 1958.

By doing so, a larger percentage of Alabama's farmers may be more inclined to irrigate, expand their currently installed irrigation operations, or continue irrigation in the future.

Farm size and age had no significant direct effect on irrigation adoption, and education, income and debt level were not significant in the regression analysis, but they were correlated with other dependent variables. Rogers (1962; Rogers 1965; Surry et al. 1996) found that "Innovators" are usually willing to take risks, are the youngest in age of all adopter categories, have great financial acuity, are very social, have close contact to scientific sources, and have great interaction with other innovators. With this taken into account, the observed correlations are largely consistent with Rogers' assertions. Respondents who were more innovative were younger, more educated, were better connected with their peers and the scientific community (the helpfulness index), and have greater financial stability, as Rogers found. Thus, these independent variables may not directly significantly affect irrigation use and improvement because they are already accounted for by the innovativeness variable, implying multicollinearity.

Implications for Research

A great deal of research has been conducted on classifying the "innovative farmer" and often the results are similar. Yet overall, there has been a lack of attention to the position of small, limited-resource, minority and female farmers. There was also a large disparity between white and non-white farmers in this particular study. Molnar et al. (2001) found that minority farmers are less likely to receive federal assistance, which may prevent them from irrigating. Such farmers may find it difficult to afford irrigation equipment and maintenance, much less irrigation expansion and improvement. Thus, there is a need to understand the preferences for technical assistance necessary to help minority farms irrigate in Alabama. More research is needed to find methods of getting information and resources to these groups of farmers, so that they may irrigate more easily. Finding ways to support small, limited-resource, and minority farmers in search of irrigation information could facilitate diversification of the "innovative farmer."

Future research should also investigate the needs of female-operated farms in Alabama, although the data had insufficient cases to make meaningful comparisons. Women are under-represented in much of the research on farm operator decision-making, and they are in this particular study, as well (Feldstein et al. 1989; Tallant 2006). Past studies have often focused on women involved in sustainable agriculture, but not usually those in the more conventional, commercial areas. More information is needed to understand the adoption possibilities and barriers experienced by conventional farm women.

The Internet is a relatively new form of social networking; however, having Internet access did not prove to significantly affect irrigation usage or improvement in 2008. Veneris (1994) found that the widespread adoption of computer networks comprised of individuals can lead to better diffusion of innovations, greater understanding of possible innovative shortcomings, and identification of needed innovations that would not otherwise occur. Also, Veneris found that early adopters frequently have more exposure to mass media channels of communication and more exposure to interpersonal channels, such as having Internet access.

A better understanding of the types of information that Alabama farmers prefer and to which they respond could help in the transfer of irrigation information (Veneris 1994; Walton et al. 2010). Thus, research focused on Alabama farmers' preferred information transfer-systems is recommended. Past studies show that farmers prefer printed media, but what about today's farmers? What sort of information transfer mediums are they most comfortable with? If a farmer is not comfortable with the way information is provided, producers may not use it at all (Veneris 1994; Khaledi et al. 2010). Handheld computers, such as personal digital assistants (PDA) and handheld global positioning services (GPS), for example, have become increasingly important in cotton production (Walton et al. 2010). Walton and colleagues (2010) found that younger farmers who used computers in farm management and had a positive perception of Extension had a greater likelihood of adopting more technological devices, such as GPS and PDAs. Rogers' Diffusion of Innovations theory was developed in the 1960's, before the boom of Internet. DiMaggio et al. (2001) have shown that there are delays in providing high-speed Internet access to rural areas, as well as higher costs which discourage use. Rural areas need Internet access in order for many farmers to consider Internet as a possible and legitimate information source. In the future, broadband Internet could be readily accessible in rural areas, making it possible for better, easier, and quicker information transfer (Tallant 2006).

Alabama farmers are very divers in relation to operation size. The data shows that the standard deviation for acreage is 1211, making it hard to classify what type of farmer we are working with. Farm size did not prove to have a significant effect on irrigation adoption in this study. Yet different communication strategies may be needed for such a diverse group. More needs to be learned about how to motivate adoption in relation to operation size. Operation size may also be related to the type of crop produced, making this an area for further research.

Practical Implications

Social networking did not appear to be a major barrier to irrigation adoption in this study. While this particular survey asked farmers what type of Internet they had, it did not ask if these producers used the Internet, what types of sites they visited, and what resources, tools, and information it provides for them. It is clear from the irrigation helpfulness index responses that Internet websites were not extremely helpful as sources of information; farmers may not know all that the Internet has to offer. Training in Internet use could facilitate more use and higher effective rates of irrigation adoption. An online community of farmers committed to understanding how to make irrigation "work" for them could be a good start for many. Being able to find large quantities of agricultural information from numerous agencies and irrigation specialists in one specific place may prove to be extremely beneficial for increasing irrigation adoption rates.

Traditional information-source agencies need to promote irrigation adoption, as well. Outreach and information could be directed specifically toward smaller, limited-resource, and minority farmers and their particular needs. To do so, these agencies could collaborate to provide easy access to information from different agencies in one location, such as a well-publicized website or pamphlet.

Rogers (1995) discussed the role of opinion leaders as guiding the diffusion process. Some individuals in a community accumulate capital, prestige, and knowledge, which give them influence over their peers (Kleiner 2003; Smith 2005; Rogers 1995). Experts such as extension services, Auburn University researchers, and irrigation specialists can provide a wealth of irrigation knowledge to local Alabama farmers. The findings suggest that information sources, such as the Alabama Office of Water Resources, Auburn University specialists and researchers, county and regional extension agents, Internet websites, and private irrigation specialists and consultants, could be more helpful in providing irrigation information and assistance to Alabama's producers. Expert information sources and agencies should carefully distribute their economic resources, targeting farmers and change agents who are truly interested in irrigation, who need the economic help, and who can maximize the impact of available resources.

Promotion of grassroots associations defined by common irrigation interests and problems, such as farmer clubs and discussion groups focused on irrigation, could provide a basis of support for producers to support each other and share experiences and information. Extension agencies could act as facilitators of communication and organization of groups at the local level. Extension could unite these local groups in their shared interests and problems at even regional, state, and national levels. This type of networking could provide a wealth of information for the local Alabama producer who wishes to irrigate but may simply lack the know-how and the means to do so.

Conclusions

In order to understand the potential benefits for information transfer and irrigation adoption, a closer look at the diffusion process is needed. Crucial elements in the diffusion process include: the innovation, which is communicated through certain channels, over time, among the members of a social system. Rogers and Burdge (1972) emphasize the importance of communication throughout the process of diffusion and it is an important element of social change. Understanding who is most important in the communication process specifically in Alabama is important for future research. Time is a central aspect of the diffusion process:

> The time dimension is involved in the innovation-decision process by which an individual passes from first knowledge of the innovation through its adoption or rejection; in the innovativeness of the individual, that is the relative earliness/lateness with which an individual adopts an innovation when compared with other members of his social system; and in the innovation's rate of adoption in the social system, usually measured as the number of members of the system that adopt in a given period" (Rogers and Burdge 1972:355).

The time from the moment of first knowledge to the decision to adopt or reject can be substantially reduced. Waiting for information from irrigation specialists and extension agents or traveling to the Alabama Office of Water Resources or the nearest Auburn University Research Station may slow diffusion and be less effective than other communication methods. Information from farmers who have already gone through the adoption process could make decisions easier for those who have yet to adopt irrigation on their farms.

Diffusion time is also related to the findings of Röling (1988), who found that a shift towards more sustainable agriculture is not a question of availability of these techniques, because the diffusion of new and improved agriculture requires a slow learning process and a change in farmers' mentality. Grounded in the field of extension and practice adoption, Röling argues that communication is the main instrument necessary for inducing change, and this limits the ability to induce voluntary change or adoption (Röling 1988). In order to induce adoption, some form of technological communication must persuade a farm operator to adopt a practice or program, such as irrigation. This can be difficult, as one communication strategy that encourages one farmer to adopt may not work for another. While the concept of diffusion of innovations may help explain strategies for the diffusion of irrigation adoption, finding a method of information transfer that works for a large variety of groups is not particularly easy. The possibility of finding a method that works for all Alabama farmers seems unlikely (Röling 1988). A better understanding of the types of information that Alabama farm operators prefer and respond to could help in the transfer of irrigation information. Past studies (Veneris 1994) show that farmers prefer printed media, but what about today's farmers?

Many respondents in this study reported high debt levels, which may either hinder irrigation adoption or stem from irrigation investment. Bjornlund et al. (2008) also found that financial costs influenced irrigation adoption. They found that the major drivers of adoption were ensuring security of water supply during drought, increasing quantity and quality of crops, and saving costs. The major impediments were financial constraints, along with physical farm conditions. Also, respondents who felt that irrigation operating costs were too risky were less likely to have irrigated in 2008 and are unlikely to do so in the future. Adopter attitudes, particularly regarding risk and finances, are significant determinants of their decision to proceed with the adoption of irrigation. Thus, it is evident that considerable financial incentives or cost-sharing will be necessary to encourage a significant increase in adoption. Promotion and education campaigns that encourage new practices involving only minimal cash outlays may yield the irrigation adoption and greatest water savings in the future.

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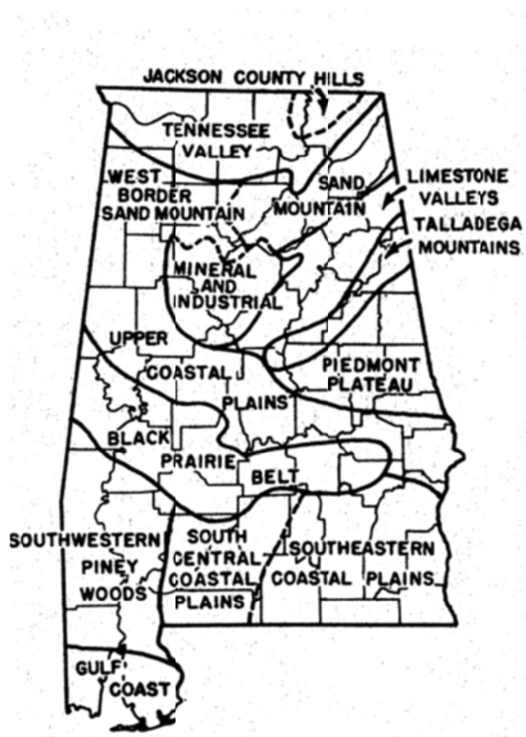
APPENDIX

Survey Instrument

Using and Improving Irrigation in Alabama:

What are your Possibilities?

A Survey of Actual and Potential Irrigators



Agricultural Experiment Station
College of Agriculture
Auburn University

Auburn University

College of Agriculture, Alabama Agricultural Experiment Station
Auburn, Alabama 36849-5406

Dear Alabama Farmer Operator:

Droughts seem to be more frequent in recent years. Reducing the risk of crop failure and protecting yields are becoming a central theme in production agriculture. I am writing to ask for your help in a study of irrigation in Alabama and how active producers such as yourself use these tools and how they might be improved.

Our study is contacting a random sample of commercial farmers in Alabama to ask about irrigation practices, experiences, and concerns. **Even if you do not have irrigation, please fill out this form.**

Results from the survey will be used to help farmers, and the agencies that serve them, expand and improve the use of irrigation systems. Your participation will ensure that the study results truly represent the needs and experiences of those who use this type of information in their farm businesses.

Your answers are completely confidential and will be released only as summaries in which no individual answers can be identified. When you return your completed questionnaire your name will be deleted from the mailing list and not connected to your answers in any way.

This survey is voluntary. However, you can help us very much by taking a few minutes to share your experiences and opinions. If for some reason you choose not to respond, please let us know by envelope. returning the blank questionnaire in the enclosed postage paid

A copy of the results will be sent as soon as they are available.

If you have any questions, I invite you to call me at 334.844.5615 or send email to jmolnar@acesag.auburn.edu. I will be happy to answer promptly.

Thank you very much for helping us with this important study.

Sincerely,

Joseph J. Molnar, Project Director

1. **Was any land on the farm(s) you operated irrigated at any time in 2008?**

❑ NO→ **Skip to question 11, page 5.**

❑ YES→ **CONTINUE**

2. **What percent of your lands used for the following purposes were irrigated?** (*Mark one for each*)

a.	**Row crops** such as corn, cotton soybeans, etc.	❑ None ***0 %***	❑ Some ***1 to 50 %***	❑ Most ***> 50%***
b.	**Fruit, vegetables, horticulture,** or **specialty crops**	❑ None ***0 %***	❑ Some ***1 to 50 %***	❑ Most ***> 50%***
c.	**Pasture** or **hay** land	❑ None ***0 %***	❑ Some ***1 to 50 %***	❑ Most ***> 50%***

3. **What were your actual SOURCES OF IRRIGATION WATER?** --*Check whether each item provided none, some, or was the main source of your irrigation water*

Source(s) of Irrigation Water			
a. Ground water from a well or wells located on this farm or another farm	❑ None	❑ Some	❑ Main source
b. On farm standing water body surface supply (lake, pond or reservoir)	❑ None	❑ Some	❑ Main source
c. On farm flowing surface supply (stream, spring, or river)	❑ None	❑ Some	❑ Main source
d. Off-farm water suppliers (commercial company or municipal or community water system)	❑ None	❑ Some	❑ Main source
e. Did you have to pay for water for irrigation?	❑ No	❑ Yes	

4. What was the **METHOD OF WATER DISTRIBUTION IN 2008?**—*Check the kinds of irrigation you use and indicate the number of acres for each*

❑ Drip, low flow, or trickle irrigation	ACRES
❑ Sprinkler irrigation	ACRES
❑ Center pivot High pressure (60+ PSI)	ACRES
❑ Center pivot Medium pressure (30 to 59 PSI)	ACRES
❑ Center pivot Low pressure (< 30 PSI)	ACRES
❑ Linear and wheel move systems	ACRES
❑ Hand move	ACRES
❑ Hose tow	ACRES
❑ Cable tow	ACRES
❑ Solid set and permanent systems (except for low-flow micro sprinklers)	ACRES
❑ Gravity irrigation down rows or furrows	ACRES
❑ Irrigated acres that have been laser leveled	ACRES

5. What were the **SOURCES OF ENERGY FOR PUMPING?**—*(Check all that apply)*

- ❑ Electricity – regular farm rates
- ❑ Electricity – special farm irrigation rates
- ❑ Diesel
- ❑ Gasoline
- ❑ Water pressure from water system
- ❑ Wind or other natural source ______________________________

6. Was irrigation used for any of the following SECONDARY PURPOSES?—*(Check all that apply)*

- ❑ Crop cooling to delay early budding, blooming, or to reduce heat stress
- ❑ Prevent freeze damage
- ❑ Used to apply chemical fertilizers
- ❑ Used to apply pesticides
- ❑ Other—land disposal of liquid livestock waste, etc. ______________________________
- ❑ **NO other uses**

7. Did you make expenditures in 2008 for your irrigation equipment or system? *(Check whether you spent nothing, some expense, or made a major outlay on the item)*

Expenditure	Level of Spending		
a. Building or improving permanent storage and distribution systems (dams, ponds, reservoirs, ditches, etc.).	❑ None	❑ Some	❑ Major outlay
b. Land clearing and leveling for irrigation purposes.	❑ None	❑ Some	❑ Major outlay
c. New well construction or deepening of existing wells	❑ None	❑ Some	❑ Major outlay
d. Purchase of new or replacement irrigation equipment and machinery	❑ None	❑ Some	❑ Major outlay

8. How did you decide when to apply water in 2008? – *(Check all that apply)*

- ❑ Computer simulation models
- ❑ Condition of crop (observation)
- ❑ Feel of the soil
- ❑ Media reports on crop-water needs (newspapers, radio, and TV)
- ❑ Use of commercial scheduling service
- ❑ Use of soil moisture sensing devices such as moisture blocks or tensiometers
- ❑ Other—Specify____________________

9. **Did you have to discontinue irrigation during 2008 long enough to AFFECT crop yields?**

- ❑ NO, irrigation was not disrupted (Go to Question 10)
- ❑ YES, irrigation was disrupted (If yes, check all that apply below)
- ❑ Cost of water
- ❑ Irrigation equipment failure
- ❑ Loss of water rights
- ❑ Poor water quality
- ❑ Problems with hired labor
- ❑ Pumping cost
- ❑ Shortage of ground water (lowering water level of wells or depletion of ground water)
- ❑ Shortage of surface water (water from reservoirs, lakes, streams, water supply organizations, etc.)

10. **Have you implemented improvements for your irrigation system since 2000?** *(Check all that apply)*

- ❑ NO CHANGES since 2000
- ❑ Added moisture instrumentation
- ❑ Adopted irrigation scheduling as a management practice
- ❑ Changed energy source for pumping
- ❑ Expanded acres covered by irrigation
- ❑ Made irrigation changes that decreased energy costs
- ❑ Made irrigation changes that improved crop yield or quality
- ❑ Made irrigation changes that reduced water requirements
- ❑ Retrofitted sprinkler system for low pressure operation

11. **Reasons for *not irrigating* in 2008 on any or all of your land—(***check whether each was not a reason, some of the reason, or a major reason for* ***not irrigating*** *last year)*

a.	Sufficient soil moisture —no irrigation needed	❑ None	❑ Some	❑ Major reason
b.	Cannot afford the investment	❑ None	❑ Some	❑ Major reason
c.	Plan to quit farming	❑ None	❑ Some	❑ Major reason
d.	Shortage of surface water (from reservoirs, lakes, streams, etc.)	❑ None	❑ Some	❑ Major reason
e.	Shortage of ground water (wells or falling water tables)	❑ None	❑ Some	❑ Major reason
f.	Irrigation is uneconomical due to high energy costs	❑ None	❑ Some	❑ Major reason
g.	Irrigation equipment failure	❑ None	❑ Some	❑ Major reason
h.	Hard to get reliable information on different irrigation methods	❑ None	❑ Some	❑ Major reason
i.	Neighbors object to irrigation operation	❑ None	❑ Some	❑ Major reason
j.	Pollution of water source	❑ None	❑ Some	❑ Major reason
k.	Do not own the land that could be irrigated	❑ None	❑ Some	❑ Major reason
l.	Profit margins are too small to invest in irrigation equipment	❑ None	❑ Some	❑ Major reason

12. **How helpful are each of the following sources of information about implementing or improving irrigation?** *(Mark one for each)*

Source of Information			
a. Alabama Office of Water Resources	❑ Not helpful	❑ Somewhat	❑ Very helpful
b. Auburn University specialists or researchers	❑ Not helpful	❑ Somewhat	❑ Very helpful
c. County or regional extension agents	❑ Not helpful	❑ Somewhat	❑ Very helpful
d. Specialists from the USDA- Natural Resources Conservation Service	❑ Not helpful	❑ Somewhat	❑ Very helpful
e. Internet web sites	❑ Not helpful	❑ Somewhat	❑ Very helpful
f. Irrigation equipment dealers	❑ Not helpful	❑ Somewhat	❑ Very helpful
g. Media reports or information from the press	❑ Not helpful	❑ Somewhat	❑ Very helpful
h. Other farmers with irrigation	❑ Not helpful	❑ Somewhat	❑ Very helpful
i. Private irrigation specialists or consultants	❑ Not helpful	❑ Somewhat	❑ Very helpful

13. **There is a need for subsidized loans to implement or expand irrigation on my operation.** *(Mark one)*

❑ Strongly agree	❑ Agree	❑ Undecided	❑ Disagree	❑ Strongly Disagree

14. **Do you plan to increase or decrease the amount of land you irrigate in the coming year?** *(Mark one)*

❑ Increase a lot	❑ Increase	❑ Same amount	❑ Decrease	❑ Decrease a lot

15. **I plan to change the equipment I use for irrigation to improve efficiency of water use.** *(Mark one)*

❑ Strongly agree	❑ Agree	❑ Undecided	❑ Disagree	❑ Strongly Disagree

16. **I need more training and technical assistance to implement or expand irrigation on my operation.** *(Mark one)*

❑ Strongly agree	❑ Agree	❑ Undecided	❑ Disagree	❑ Strongly Disagree

17. **I am familiar with the State of Alabama requirements that irrigation systems using more than 100,000 gallons per year must be registered with the Office of Water Resources.** *(Mark one)*

❑ Strongly agree	❑ Agree	❑ Undecided	❑ Disagree	❑ Strongly Disagree

18. **Alabama farmers need a cost-share program to implement or improve irrigation systems.** *(Mark one)*

❑ Strongly agree	❑ Agree	❑ Undecided	❑ Disagree	❑ Strongly Disagree

19. In terms of using <u>new</u> farming practices and technologies, how would you describe yourself? *(Mark one)*

- ❑ An Innovator often trying new approaches before anyone else
- ❑ An Early Adopter of new practices
- ❑ Not the first, but part of the Early Majority of users
- ❑ Part of the Later Majority of users of new ideas
- ❑ Often One of the Last to try new things

20. Please rate the following possible barriers to implementing an irrigation system (or improving the one you have to reduce energy and/or conserve water) – *(Mark one answer for each item)*

Barriers			
a. Cannot finance the improvements, even if they reduce costs	❑ Not	❑ Some	❑ Great barrier
b. Cannot get good advice on how to make irrigation pay	❑ Not	❑ Some	❑ Great barrier
c. Do not need irrigation for the way I farm	❑ Not	❑ Some	❑ Great barrier
d. Energy costs are too high	❑ Not	❑ Some	❑ Great barrier
e. Hard to get replacement parts when I need them	❑ Not	❑ Some	❑ Great barrier
f. Improvement(s) will reduce costs, but not enough to cover the installation costs	❑ Not	❑ Some	❑ Great barrier
g. Improvements that conserve water have no economic benefit	❑ Not	❑ Some	❑ Great barrier
h. Installation cost	❑ Not	❑ Some	❑ Great barrier
i. Irrigation system operating costs are too risky	❑ Not	❑ Some	❑ Great barrier
j. Landlord(s) will not share in cost of improvements	❑ Not	❑ Some	❑ Great barrier
k. No other farmers around here irrigate	❑ Not	❑ Some	❑ Great barrier
l. No reliable source of water on my place	❑ Not	❑ Some	❑ Great barrier
m. Not worth the trouble to keep it going	❑ Not	❑ Some	❑ Great barrier
n. Takes too much time to organize and manage	❑ Not	❑ Some	❑ Great barrier

21. Please summarize your farm's LAND USE IN 2008. *(Indicate the number of acres for each)*

a. Cropland harvested—Include all land from which crops were harvested or hay was cut, and all land in orchards, citrus groves, or vineyards.	ACRES
b. Cropland used only for pasture or grazing—Include rotation pasture and grazing land that could have been used for crops without additional improvements	ACRES
c. Other cropland—used for cover crops, cropland on which all crops failed, in cultivated summer fallow, and idle cropland	ACRES
d. Woodland	ACRES
e. Other pastureland and rangeland	ACRES
f. All other land – include land in farmsteads, buildings, livestock facilities, ponds, roads, wasteland, etc..	ACRES
g. TOTAL ACRES	ACRES

22. What portion of your 2008 annual farm sales came from the following commodity groups? *(Mark one for each)*

a. **Row crops** such as corn, cotton soybeans, etc.	☐ None ***0 %***	☐ Some ***1 to 50 %***	☐ Most ***> 50%***
b. **Livestock** such as cattle, hogs, sheep, etc.	☐ None ***0 %***	☐ Some ***1 to 50 %***	☐ Most ***> 50%***
c. **Poultry**, including contract broilers, eggs, etc.	☐ None ***0 %***	☐ Some ***1 to 50 %***	☐ Most ***> 50%***
d. **Fruit, vegetables, horticulture,** or **specialty crops**	☐ None ***0 %***	☐ Some ***1 to 50 %***	☐ Most ***> 50%***
e. **Government agricultural payments**	☐ None ***0 %***	☐ Some ***1 to 50 %***	☐ Most ***> 50%***

23. What best describes the current debt level for your farming operation? *(Mark one)*

☐ No debt	☐ Very little debt	☐ Moderate debt	☐ Heavy debt

24. Which category best describes your total combined household income during 2008? *(Mark one)*

☐ Less than $20,000	☐ $20,000 to $29,999
☐ $30,000 to $39,999	☐ $40,000 to $59,999
☐ $60,000 to $99,999	☐ $100,000 or more

25. Over the past three years, what proportion of your total annual farm income came from your irrigated land?

☐ None or _______ PERCENT

26. Over the past three years, what proportion of your total annual income was from farming?

☐ None or _______ PERCENT

27. Do you have Internet access? *(Mark one)*

❑ No	❑ Dial-up only	❑ Cable or DSL

28. What is your gender? *(Mark one)*

❑ Male	❑ Female

29. What is your age?

❑ ____________Years

30. What is your ethnicity? *(Mark one)*

❑ Black or African American	❑ White or Caucasian
❑ Asian or Pacific	❑ American Indian or Alaska Native
❑ Other______________	❑ Spanish, Hispanic or Latino Origin

31. Which category best describes your level of education? *(Mark one)*

❑ Some high school or less	❑ Graduated high school
❑ Some college/technical school	❑ College graduate
❑ Some graduate school	❑ Masters degree or more

32. Which Auburn Research Station listed below is closest to your farming operation? *(Mark one)*

❑ Black Belt Research and Extension Center, Marion Junction (Dallas County)	❑ North Alabama Horticulture Research Center, Cullman (Cullman County)
❑ Brewton Agricultural Research Unit, Brewton (Escambia County)	❑ Prattville Agricultural Research Unit, Prattville (Autauga County)
❑ Chilton Research and Extension Center, Clanton (Chilton County)	❑ Sand Mountain Research and Extension Center, Crossville (Dekalb County)
❑ E.V. Smith Research Center, Shorter (Macon County)	❑ Tennessee Valley Research and Extension Center, Belle Mina (Limestone County)
❑ Gulf Coast Research and Extension Center, Fairhope (Baldwin County)	❑ Wiregrass Research and Extension Center, Headland (Houston County)

- **Thank you for taking the time to complete this questionnaire. Your cooperation is greatly appreciated.**

Results of the survey will be sent as soon as they are available and will also be published online at http://www.ag.auburn.edu/oia/results

Please feel free to write any comments in the space below.