# 6. Water Management

In this chapter, we briefly describe water management issues and the technologies and practices associated with irrigation. The Area Studies survey data are described with respect to the use of irrigation practices. The results of simple adoption models for these practices are reported for the combined-areas and single-area models. The human capital, production, agricultural policy, natural resource, and climate factors affecting the adoption of water management practices are discussed.

Agricultural production can require extensive quantities of water, especially in arid regions where evapotranspiration rates are high. The relatively fixed amount of developed water supplies has contributed to increased competition between irrigated agriculture and other water demands, such as for municipal, industrial, and environmental uses. The challenge for the agricultural sector is to maintain productivity with a diminishing supply of water. More efficient irrigation technologies have been developed to conserve water, and such technologies will help producers meet this challenge.

The use of water for irrigation can have implications for the quality of both ground and surface water. Irrigation can accelerate the transport of soils off the fields and contribute to sediment loadings in surface water resources. Chemicals that adhere to soil particles are also transported into the water. Water drainage from irrigated agriculture can contain chemical contaminants that may run off fields directly into waterways or leach into groundwater (NRC, 1989). The National Research Council (1996) reported that in the arid Western States, irrigated cropland accounted for 89 percent of river and 40 percent of lake pollution from sediment and chemical runoff. The soil conditions that enhance the transport of chemicals are often the same that increase the need for water applications. Soils with low water-holding capacity, such as sandy soils, cannot retain water as readily as soils containing large amounts of clay, for example. These highly leachable soils can act like a sieve where water moves easily through soil particles transporting chemicals to water bodies.

Farmers' decisions whether or not to irrigate and the choice of irrigation system depend on many factors. Use of irrigation reduces the risks associated with variable climate and soil conditions, but installation of irrigation equipment often requires large capital investments. The effectiveness of an irrigation system is site specific and depends on the physical characteristics of the land on which it is used (Caswell and Zilberman, 1985; Negri and Brooks, 1990). Farmers will base their decision to invest in irrigation on whether the benefits of adoption outweigh expected costs, compared with their current production system. Whether or not supplemental water applications are needed for crop production depends on climate, crop requirements, and soil conditions. Water inputs in crop production may be necessary for soils that are highly leachable. Adoption decisions will also be based on field topography. The more uniform the contour of the land, the greater the efficiency of water applications (Caswell, 1991).

## Summary of Water Management Practices and Data

The Area Studies survey sample contains a wide distribution of soil types and irrigation adoption rates. The sample design was not targeted to capture a representation of irrigated agriculture, however. Figure 6.1 displays the percent of cropland acres by soil leaching potential (SLP)[1] for each region. The measure of SLP was divided into three categories representing low, moderate, and highly leachable soils.[2] The areas with 40 percent or more cropland acres categorized as highly leachable soils were the Mid-Columbia and Snake River Basins, Southern Georgia Coastal Plains, Albemarle-Pamlico Drainage, Southern High Plains, and Mississippi Embayment.

Figure 6.2 displays the percent of irrigated cropland by highly leachable soils. The Snake River Basin had the largest amount of highly leachable acres under irrigation, almost 90 percent. The Central Nebraska River Basins area was the next highest with 50 percent of highly leachable acres under irrigation. The amount of residual water that transports chemicals to groundwater supplies or to surface water through subsurface flows

[1] Soil leaching potential measures the inherent potential of soil to leach chemicals into groundwater. SLP is described more fully in chapter 2.

[2] For figure 6.1, we also included a category for observations with unknown soil leaching potential.

Figure 6.1
**Soil leaching potential by region**

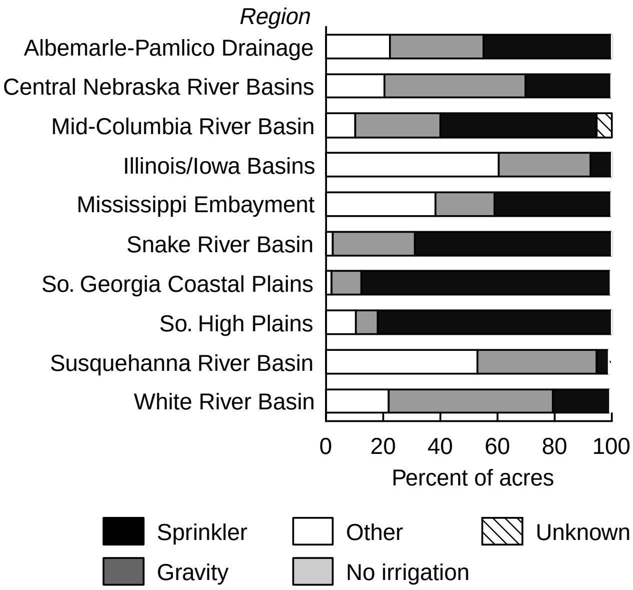
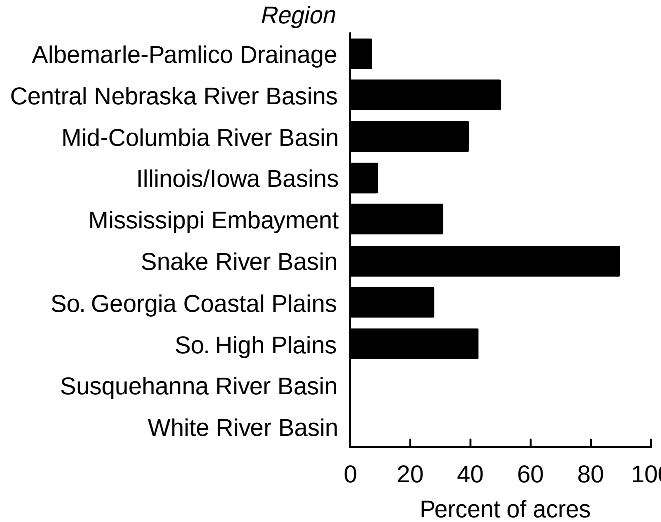



Figure 6.2
**Adoption of any irrigation practice on highly leachable cropland by region**




will depend on the quantity of water applied and the water-use efficiency of the irrigation system.

Irrigation technologies have been developed to provide more efficient management of water and energy resources. The performance of these irrigation technologies greatly depends on crop requirements, and soil and field conditions. Aillery and Gollehon (1997) offer a detailed description of different irrigation technologies and the advantages and disadvantages of each.

There are two broad categories of irrigation technologies, gravity versus pressurized systems. Gravity systems, as the name implies, operate with the use of gravity to transport water along furrows or across the surface of the field (basin). Gravity systems perform best on fields that have a uniform contour and higher quality soils, such as soils with low leaching potential. Pressurized systems, such as sprinklers or drip irrigation, depend on energy to distribute water to the crop. These systems generally distribute water more efficiently to plants than gravity systems do, and have a relative advantage on nonuniform fields with greater slopes and on soils with higher leaching potential. Although pressurized technologies require the use of energy and greater capital investments, there are savings in water use and potentially in labor costs, especially with the use of self-propelled sprinkler or computerized drip systems. In addition, fertilizers and other chemicals can be delivered through these systems with the irrigation water thereby reducing labor costs further. Figure 6.3 shows the distribution of sprinkler and gravity irrigation on highly leachable land. Sprinkler systems are in greater use than gravity systems on highly leachable soils in the surveyed areas. Pressurized technologies have become increasingly popular. Acreage under pressurized systems has increased from 37 percent of total irrigated acreage in 1979 to 50 percent in 1994 (Aillery and Gollehon, 1997).

Figures 6.4 and 6.5 show the percent of acres on which some form of irrigation is used, by crop and region. Several crop dummies (ROWCROP, GRAIN, FRTVEG, CORN, COTTON, POTATOES, HIGHVAL) were used in individual irrigation adoption models to capture the effects of crop choice. The natural resource characteristics included in the analyses were also expanded. The components of the aggregate erosion measure were included separately to reflect sheet and rill erosion (RKLS) and wind erosion (WIND). A variable (SLOPE) was included to reflect differences in irrigation technology effectiveness due to unlevel terrain. In addition, a variable (WATERBODY) was used to indicate whether the field was adjacent to a water body.[3] No ADVICE variable was included because the survey instrument did not ask about sources of information or technical assistance for water management.

The first (binomial) adoption model below focuses on the factors that determine the decision to irrigate, i.e.,

[3] Respondents were asked if the field was beside a stream, river, lake, pond, canal, or ditch.

Figure 6.3
**Adoption of irrigation practices on highly leachable cropland by region**

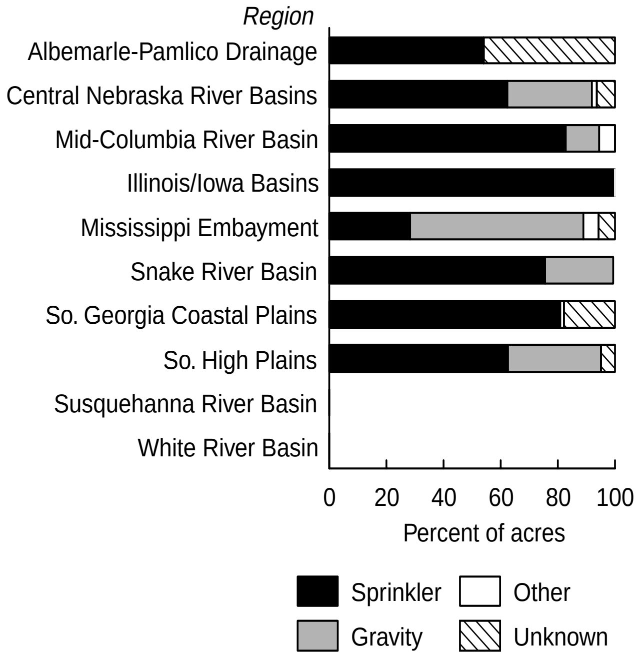
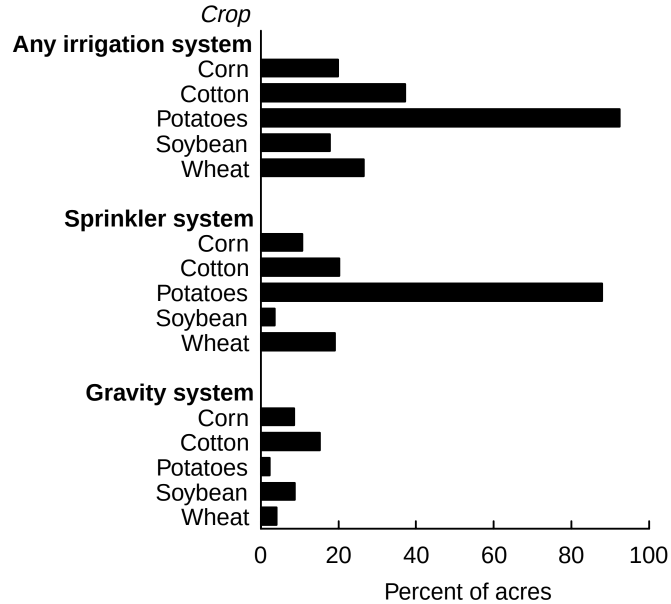



Figure 6.4
**Decision to irrigate by crop**



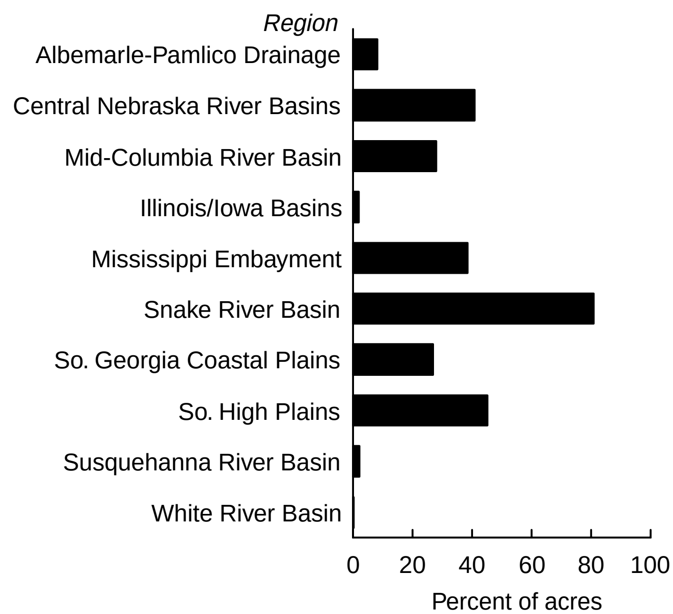

whether any irrigation system is used. The irrigation practices included in this model are center pivot, sprinkler, gravity, drip and trickle, and subirrigation systems. The second (multinomial) adoption model provides estimates on the factors that influence the use of particular irrigation systems. In this model, three categories were created to examine decisions to 1) not irrigate; 2) use a sprinkler system[4]; and 3) use a gravity system. Gravity systems were separated from sprinkler systems since the underlying method for applying water, as well as the efficiency in applying water, differs. See box, pp. 80-81 for a detailed description on the types of irrigation systems covered in the analysis.

## Adoption of Water Management Practices

### *Decision to Irrigate*

The sample means for the combined regional and single-area models are presented in table 6.1. The regions chosen for analysis for the single-area adoption models were the Central Nebraska River Basins, the Mississippi Embayment, the Snake River Basin, the Southern Georgia Coastal Plain, and the Southern High Plains. For the regions investigated, the Snake River Basin had the highest actual irrigation adoption rate, 81 percent. The lowest irrigation adoption rate, 27 percent, was in the Southern Georgia Coastal Plain. The results, along with the significance level, from the irrigation adoption models are displayed in table 6.2. The econometric modeling framework and core set of variables are described in detail in chapter 2.

Figure 6.5
**Decision to irrigate by region**




[4] Since very few producers reported using drip and trickle or subirrigation systems, these were not included as an additional category for analysis.

For the 10 combined areas, 26 percent of producers used irrigation in agricultural production. The predicted probability of adoption for the combined-areas model was 11.8 percent. The percent of correct predictions was 83 percent and the pseudo $R^2$ was 0.53.

Producer characteristics were important determinants of irrigation adoption in the combined-areas model, but the effects in the regional analyses varied. Farmers with at least some college level education (COLLEGE) were more likely to use irrigation practices in the combined areas, but only in the Mississippi Embayment was the likelihood of irrigation adoption significantly greater if the producer had a college education. Years of experience (EXPERIENCE) also had no significant effect on the probability of irrigation adoption in the single-area models, but in the combined sample, farmers with more years of farming experience were less likely to use irrigation. The more days that a farmer worked off of the farm (WORKOFF), the less likely he or she would adopt irrigation in the combined area, the Central Nebraska River Basins, the Southern Georgia Coastal Plain, and the Southern High Plains models. This result may reflect the management or labor intensiveness of irrigation use.

Land ownership (TENURE) was positively and significantly related to use of irrigation. Table 6.4 shows that the percent predicted adoption of irrigation increased from 10.8 to 13.4 percent if producers owned the observed field. Farmers who owned their farm were expected to be more likely than renters to make the large capital investments required for irrigation. Land tenure also had a positive and statistically significant effect on irrigation adoption in the Central Nebraska and Snake River Basins, and in the Southern Georgia Coastal Plain regions. This result was associated with areas where the percent of farmers owning their own land was higher than the average for all regions (see table 6.1).

Whether or not a producer had crop insurance (INSURE) did not influence farmers' use of irrigation in any of the models. The effect of farm size (ACRES) on irrigation adoption differed greatly by region. While, in most regions, the larger the number of acres operated, the less likely were producers to irrigate, the opposite result was found in the Southern Georgia Coastal Plain. Producers in the Southern Georgia Coastal Plain had lower farm sizes on average and lower irrigation adoption than the other regions.

**Table 6.1—Sample means from irrigation adoption models**

| Variables | Combined areas | Central Nebraska | Mississippi Embayment | Snake River Basin | Southern Georgia Coastal Plains | Southern High Plains |
|---|---|---|---|---|---|---|
| DECISION TO IRRIGATE | .26 | .41 | .39 | .81 | .27 | .45 |
| COLLEGE | .44 | .38 | .47 | .60 | .39 | .55 |
| EXPERIENCE | 24 | 24 | 23 | 21 | 25 | 23 |
| WORKOFF | 32 | 31 | 21 | 35 | 41 | 23 |
| TENURE | .38 | .43 | .30 | .62 | .46 | .36 |
| ACRES | 1701 | 1610 | 2331 | 2550 | 1495 | 1967 |
| ROTATION | .54 | .42 | .27 | .66 | .71 | .19 |
| ROWCROP | .30[1] | .50[1] | .88 | .13[2] | .15[3] | .75 |
| GRAIN | .21 | .25 | .11 | .72 | .17 | .27 |
| FRTVEG | .01 | 0 | .10[4] | 0 | .08 | .64[5] |
| PROGRAM | .80 | .75 | .87 | .47 | .80 | .92 |
| INSURE | .40 | .43 | .14 | .27 | .32 | .70 |
| WATERBODY | .43 | .27 | .77 | .34 | .40 | .07 |
| SLP | 119 | 125 | 116 | 150 | 148 | 151 |
| PISOIL | .80 | .85 | .80 | .82 | .37 | .69 |
| SLOPE | 2.6 | 3.8 | 1.0 | 3.0 | 2.6 | 0.9 |
| RKLS | 21 | 27 | 19 | 8 | 16 | 5 |
| WIND | 11 | 19 | 0 | 29 | 0 | 66 |
| RAIN | 3.1 | 2.1 | 4.3 | 1.2 | 4.2 | 1.6 |
| TEMP | 55 | 49 | 61 | 44 | 65 | 58 |
| Number of observations | 6543 | 701 | 820 | 537 | 507 | 507 |

1 Corn only
2 Potatoes only
3 Cotton only
4 Fruit, vegetables or rice only
5 High-value crops only

Regions with very large farms may have experienced some irrigation adoption inefficiencies due to their large size. Although the number of acres operated in the combined-area model was a statistically significant determinant of irrigation adoption, table 6.4 indicates that predicted adoption levels decreased by only 1 percentage point for farmers that operated 5,000 acres compared with 500 acres.

Crop rotations (ROTATION) increased the likelihood that a farmer would use irrigation except in the Central Nebraska and Snake River Basins. In the Central Nebraska River Basins, crop rotations were negatively correlated with irrigation adoption. The type of crop grown greatly influenced the likelihood of irrigation adoption in each region. The crops that increased the probability of irrigation included corn in the Central Nebraska River Basins; fruits, vegetables and other high-valued crops in the combined areas, Mississippi Embayment, Southern Georgia Coastal Plain, and the Southern High Plains; potatoes in the Snake River Basin; and cotton in Southern Georgia Coastal Plain. Producers who grew corn (ROWCROP) also were more likely to adopt any irrigation practice in the combined, the Central Nebraska, and Snake River Basins areas. The strong effect revealed in the Central Nebraska River Basins area likely drove the result in the combined area.

Participation in a Federal commodity program or CRP (PROGRAM) positively affected the use of irrigation

**Table 6.2—Change in percent predicted decision to irrigate**

| Variables | Combined areas | Central Nebraska | Mississippi Embayment | Snake River Basin | Southern Georgia Coastal Plains | Southern High Plains |
|---|---|---|---|---|---|---|
| CONSTANT | -1.6926** | -0.1848 | -2.9419** | 0.2640** | -1.8044** | 2.7589** |
| COLLEGE | 0.0406** | 0.0190 | 0.1292** | -0.0086 | 0.0781* | 0.0579 |
| EXPERIENCE | -0.0167** | -0.0860* | 0.0139 | 0.0077 | -0.0673* | 0.0113 |
| WORKOFF | -0.0074** | -0.0298** | -0.0092 | -0.0020 | -0.0341** | -0.0206** |
| TENURE | 0.0245** | 0.1154** | -0.0578 | 0.0284** | 0.1285** | -0.0206 |
| ACRES | -0.0041** | -0.0375* | -0.0017 | -0.0267** | 0.0629** | -0.1610** |
| ROTATION | 0.0684** | -0.1486** | 0.3209** | 0.0180 | 0.0960** | 0.4655** |
| ROWCROP | 0.0841**[1] | 0.3488**[1] | — | 0.1350**[2] | — | — |
| FRTVEG | 0.2321** | — | 0.8378**[3] | — | 0.2475**[4] | 0.1848**[4] |
| PROGRAM | 0.0545** | 0.1723** | 0.2324** | -0.0150 | -0.0268 | 0.0619 |
| INSURE | 0.0137 | 0.1126** | -0.0479 | -0.0040 | -0.1707** | -0.0196 |
| WATERBODY | 0.0205** | 0.0985* | 0.0241 | 0.0100 | 0.1791** | -0.3268** |
| SLP | 0.0356** | 0.3193** | 0.1020 | 0.0239 | 0.0585 | -0.8991** |
| PISOIL | 0.0155 | 0.4850** | 0.0144 | -0.0104 | 0.1652* | 0.1357 |
| SLOPE | -0.0570** | -0.0962** | -0.2003** | -0.0344** | -0.0244 | -0.0543 |
| RKLS | 0.0064 | — | — | — | — | — |
| WIND | 0.0070** | 0.1271** | — | 0.0651** | — | 0.1138* |
| RAIN | -1.0072** | -0.9930** | — | -0.0676** | 0.5564* | -1.1992** |
| TEMP | 2.1025** | — | 2.4663** | — | — | — |
| Number of observations | 6543 | 701 | 820 | 537 | 507 | 507 |
| % predicted adoption: | 11.8 | 37.2 | 31.7 | 97.3 | 20.4 | 44.4 |
| % correct predictions: | 83 | 77 | 76 | 91 | 77 | 72 |
| Pseudo $R^2$:[5] | .53 | .46 | .49 | .76 | .37 | .37 |

— Variable not included in the adoption model.
** Significant at the 5-percent level.
* Significant at the 10-percent level.
[1] Corn only.
[2] Potatoes only.
[3] Fruit, vegetables, or rice only.
[4] High-value crops only.
[5] Veall and Zimmerman's pseudo $R^2$.

Note: For the table, the coefficients estimated from the limited dependent model have been converted into change in percent predicted adoption. For continuous variables (EXPERIENCE, WORKOFF, ACRES, SLP, PISOIL, EROTON, RKLS, WIND, RAIN AND TEMP), the reported value is the change in the percent predicted adoption given a 1-percent change in the variable mean. For binomial variables that have a value of either 0 (no) or 1 (yes), the reported value indicates the change in the percent predicted adoption with a unit change of 0.01 from the variable mean. See Appendixes 2-A and 2-B for further details.

for the combined, the Central Nebraska River Basins, and the Mississippi Embayment areas.

Natural resource endowments of the field can determine the effectiveness and feasibility of irrigation. The only natural resource characteristics that appeared to play no role in irrigation adoption decisions were soil productivity (PISOIL) and soil erosion due to rainfall (RKLS). Producers who had fields adjacent to a water body (WATERBODY) were more likely to irrigate. One reason could be that the water body served as a water source for irrigation, but the data do not allow us to check whether that was the case.

In the combined-areas model, soil leaching potential (SLP) also had a significant and positive influence on use of irrigation. However, in the separate regions this was not the case, except in the Central Nebraska River Basins. In fact, soil leaching potential had the opposite effect in the Southern High Plains region. High SLP values usually signify the presence of sandy soils. The water retention capabilities of these soils are often limited, and crop production may require irrigation. The soil conditions that promote water applications are often the same conditions that convey chemicals into waterways, however. When making an irrigation decision, a producer considers the water-holding capacity of the soil and not necessarily whether chemicals will be transported. Therefore, a more direct measure of water-holding capacity may be better for assessing the impact of field characteristics on the adoption decision (*production impact*). The soil index, SLP, could be used to assess the potential fate and transport of water and chemicals associated with a particular adoption choice (*environmental impact*).

**Table 6.3—Change in percent predicted adoption by irrigation type: Central Nebraska River Basins, Mississippi Embayment, Snake River Basin, and Southern High Plains Regions**

| Variables | Variable means | Non-irrigators | Sprinkler system | Gravity system |
|---|---|---|---|---|
| CONSTANT | — | 3.7348** | -1.4592** | -2.2756** |
| COLLEGE | .47 | -0.1036** | 0.0654** | 0.0383** |
| EXPERIENCE | 23 | -0.0111 | -0.0038 | -0.0073 |
| WORKOFF | 25 | 0.0115** | -0.0104** | -0.0010 |
| TENURE | .36 | -0.0282 | 0.0485** | -0.0203 |
| ACRES | 2084 | 0.0133* | 0.0006 | -0.0138** |
| ROTATION | .31 | -0.1293** | 0.0720** | 0.0573** |
| CORN | .18 | -0.3103** | 0.2322** | 0.0781** |
| COTTON | .27 | -0.1153** | 0.1834** | -0.0681** |
| POTATOES | .01 | -0.5333 | 0.5839** | -0.0506 |
| HIGHVAL[1] | .02 | -0.3883** | 0.3653** | 0.0230 |
| PROGRAM | .81 | -0.1126** | 0.0383 | 0.0743** |
| INSURE | .34 | -0.0404 | -0.0008 | 0.0412** |
| WATERBODY | .47 | -0.0056 | -0.0126 | 0.0182 |
| SLP | 129 | -0.1151** | 0.1417** | -0.0265 |
| PISOIL | .79 | -0.1310** | -0.0736 | 0.2046** |
| SLOPE | 1.9 | 0.1268** | -0.0009 | -0.1259** |
| WIND | 20 | 0.0005 | 0.0252** | -0.0257** |
| RAIN | 3.0 | 2.4738** | -1.0430** | -1.4307** |
| TEMP | 56 | -5.4925** | 2.0744** | 3.4182** |
| Mean of dependent variable | | .59 | .20 | .21 |
| Number of observations | | | 2493 | |
| % predicted adoption: | | 70.0 | 19.7 | 10.3 |
| % correct predictions: | | | 69 | |
| Pseudo $R^2$: [2] | | | .53 | |

** Significant at the 5-percent level.
* Significant at the 10-percent level.
[1] High-value crops other than cotton.
[2] Veall and Zimmerman's pseudo $R^2$.

Note: For the table, the coefficients estimated from the limited dependent model have been converted into change in percent predicted adoption. For continuous variables (EXPERIENCE, WORKOFF, ACRES, SLP, PISOIL, EROTON, RKLS, WIND, RAIN AND TEMP), the reported value is the change in the percent predicted adoption given a one-percent change in the variable mean. For binomial variables that have a value of either 0 (no) or 1 (yes), the reported value indicates the change in the percent predicted adoption with a unit change of 0.01 from the variable mean. See Appendixes 2-A and 2-B for further details.

**Table 6.4—Percent predicted adoption: Combined areas**

| | Multinomial logit model | | | |
|---|---|---|---|---|
| Variables | Decision to irrigate | Non-irrigators | Pivot/sprinkler system | Gravity system |
| Probabilities at means | 11.8 | 70.0 | 19.7 | 10.3 |
| ***Land tenure*** | ** | | ** | |
| Yes | 13.4 | 68.0 | 23.0 | 9.0 |
| No | 10.8 | 70.9 | 18.0 | 11.1 |
| ***Land operated*** | ** | | | ** |
| 500 acres | 12.0 | 68.9 | 19.7 | 11.4 |
| 5000 acres | 11.0 | 71.7 | 19.8 | 8.5 |
| ***Soil leaching potential*** | ** | ** | ** | |
| 100 | 11.2 | 72.4 | 16.7 | 10.9 |
| 150 | 12.7 | 68.0 | 22.2 | 9.9 |
| ***Soil productivity*** | | ** | | ** |
| .50 | 11.2 | 73.1 | 22.1 | 4.8 |
| .95 | 12.0 | 66.7 | 18.1 | 15.1 |
| ***Slope*** | ** | ** | | ** |
| 1.00 | 15.7 | 62.9 | 19.3 | 17.8 |
| 2.50 | — | 73.7 | 19.5 | 6.8 |
| 4.00 | 9.0 | — | — | — |

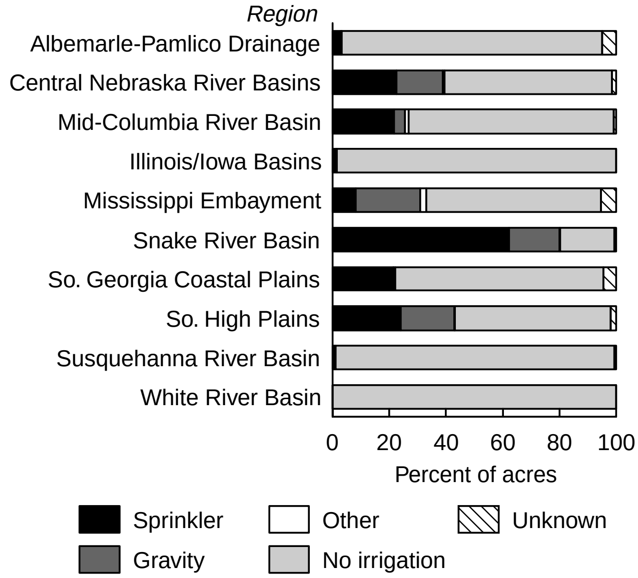
** Significant at the 5-percent level.
* Significant at the 10-percent level.

The probability that a producer would adopt irrigation was negatively influenced by land slope (SLOPE). The larger the degree of the slope, the less likely a producer would irrigate in the combined areas, the Central Nebraska River Basins, Mississippi Embayment, and Snake River Basin regions. Table 6.4 illustrates that a decrease in slope by 1 percent raised the percent predicted adoption to 15.7 compared with 11.8 percent when the percent slope is at its mean of 2.6 for the combined-areas sample.

Although soil erosion from rainfall did not affect farmers' use of irrigation, soil erosion due to wind did influence adoption as predicted. The greater the severity of the wind erosion problem, the more likely a producer would use irrigation. Wind erosion is mostly a problem in arid areas, and producers may wet the soil as a method for controlling wind erosion (WIND) in addition to providing water to crops.

The climate variables were the most important factors in determining the use of irrigation practices in the combined-areas model. Generally, producers in regions with low average rainfall (RAIN) and high

Figure 6.6
**Adoption of irrigation practices by region**




## Glossary of Irrigation Practices

### *Sprinkler Systems*

*Center-Pivot System* is a self-propelled electronic or hydraulic continuous move sprinkler or spray nozzle system that travels around a center pivot point. The pattern irrigated is essentially a circle. The unit can be end-towed from one field to another. The system is generally low pressure.

*Hand-Move System* consists of a portable aluminum pipe which must be moved one or more times per day to meet crop irrigation requirements.

*Solid-Set* consists of a portable aluminum pipe system that is placed in the field at the start of the irrigation season and left in place throughout the season.

*Permanent Sprinkler System* is a buried pipe system with only the risers and sprinklers above ground.

*Lateral Move System* is a self-propelled continuous move side-roll system on towers. It is designed to be used on square fields (1,320 ft. sq.) and on crops up to 9 ft. high. Water is supplied to the unit by a flexible rubber hose. The unit can be end-towed from one field to another.

*Side Roll/Wheel Move System* is a wheel-move lateral line, designed to be used on rectangular or square fields and on low-growing crops 4 feet high or less. The unit is moved by a small gasoline engine. The unit must be disassembled to move it from one field to another.

*Side Roll/Wheel Move with Tow Lines System* is a wheel-move lateral line with tow lines trailing behind the main lateral line, with one to three sprinklers per tow line. The unit is moved by a small gasoline engine. It can be used for crops up to 9 feet in length.

*End-Tow System* consists of an aluminum pipe sprinkler laterally mounted on dolly wheels or skids. The unit is end-towed through the field from one position to another by a tractor. It is designed to be used on hay and pasture crops, but can be used on some row and tree crops.

*Carousel Sprinkler-Traveler* is a system with a rotating boom that sprinkles or sprays water as it is propelled forward across a field. Its water supply comes from either a well or supply ditch. Most systems are self-propelled with a mounted gas or diesel engine.

*Self-Propelled Gun Traveler System* is self-propelled by a separate engine, or hydraulic continuous move. It consists of a single large gun mounted on a four wheel trailer. Water is supplied through a flexible rubber hose.

*Reel-Type Hose Pull System* uses a non-collapsible (hard) hose on a reel. The gun type sprinkler attaches to the hose and is stationed at one end of the field and the hose reel at average temperatures (TEMP) were more likely to irrigate. Small changes in rainfall and temperature had a dramatic effect on adoption rates. In the Southern Georgia Coastal Plain, however, higher rainfall encouraged greater irrigation adoption. This result could indicate that climate variability may be more important in Georgia than actual average monthly rainfall. If rainfall is highly variable in this region, producers may be relying on irrigation to reduce risks associated with this variability. In this case, irrigation may be a risk management tool rather than a production necessity.

### Choice of Irrigation Practices

In the multinomial model, three categories of irrigation practices were created for examining the adoption decisions of producers who 1) do not irrigate, 2) use a sprinkler system, or 3) use a gravity system. Gravity systems can be considered as a traditional irrigation system, and sprinkler represents more modern technology (Aillery and Gollehon, 1997). Figure 6.6 shows the percent of acreage on which each system is used in each region. The Central Nebraska River Basins, the Mississippi Embayment, the Snake River Basin and the Southern High Plains were the regions selected for a combined analysis of farmers' use of irrigation practices. These regions were chosen because they had a sufficient number of observations in each irrigation category. Table 6.3 presents the sample means and results along with the percent predicted adoption, percent correct predictions, and the pseudo $R^2$ for the model.

The results of the multinomial model for the "do not irrigate" choice generally are the same as for the binomial model, so will not be discussed further.

When a farmer worked off-farm much of the time, the probability of the farmer's using a sprinkler system was significantly lowered. However, off-farm work did not affect farmers' use of gravity systems. Sprinkler systems often require more labor and management than gravity systems. Therefore, that producers who worked more days off-farm may be more likely to invest in irrigation systems that have lower labor demands. Farmers who had crop insurance were more likely to adopt a gravity system.

### Glossary (continued)

the other. As the water passes through the hose it activates a turbine drive system that rolls the hose onto the reel and pulls the sprinkler gun and carriage across the field, ready for the next move.

*Reel-Type Cable Pull System* is similar to the hose pull systems except the sprinkler gun and carriage are pulled by a cable as the hose is dragged in a loop across the field. These systems often require a grassed strip to operate on.

#### Gravity Systems

*Gated Pipe System* is a pipe, usually plastic (PVC) or aluminum, that is fitted with spaced closeable gates or holes that permit the water to flow into furrows or basins. For flood irrigation, the regulating gates are usually controlled manually but can be automated. This system usually requires a powered pumping system but can flow with gravity from a reservoir or diversion dam.

*Gated Pipe with Surge Control* is a modified gated pipe system in which a surge control valve alternates water delivery through two sets of gated pipe to provide water to the furrows in timed surges.

*Open Ditch System* is a method of irrigation where the water supply runs across the upper end of the field. The ditch gates transfer water from the ditch into the furrow.

*Siphon Tubes* are short tubes usually made of aluminum or plastic which are used to "siphon" water from a ditch into a furrow or field.

*Cablegation* is a modified gated pipe system which uses a moving plug attached by a cable inside the pipe to deliver water sequentially to furrows.

#### Other Irrigation Systems

*Drip or Trickle* is an irrigation method that requires maintenance of an adequate portion of the root zone of the plant at, or close to, full soil moisture capacity during the growing or productive cycle. Water is supplied through emitters attached to a supply pipe or porous tubing. The system is designed to be operated daily or at rather frequent intervals.

*Subirrigation* involves maintenance of the water table at some predetermined depth below the surface through the use of ditches, sub-surface drainage tubing or mole drains and water control structures. Conditions for use of this system are limited. The subirrigation system also serves as a drainage system. A good water supply is needed to supply irrigation water needs rapidly.

Source: U.S. Department of Agriculture, Economic Research Service and National Agricultural Statistics Service, Area Studies Interviewer's Manual.

Land tenure had a positive and significant effect on the adoption of sprinkler systems only. Table 6.4 shows that percent predicted adoption of sprinkler technologies increased from 18 to 23 percent for producers who owned the observed field. This outcome may reflect the greater capital investments often required for sprinkler irrigation technologies. Producers who own their farmland may be more likely than renters to make long-term investments.

While the number of acres operated did not have an effect on the use of sprinkler systems, producers with larger farms were less likely to use a gravity system. However, table 6.4 indicates that percent predicted adoption of gravity irrigation decreased by about 3 percentage points for farmers who operated 5,000 acres instead of 500 acres.

Cropping practices and the type of crop grown greatly influenced the use of irrigation practices. Crop rotations significantly increased farmers' use of both sprinkler and gravity systems. Producers growing corn, potatoes, cotton, or high-value crops were more likely to adopt sprinkler systems than if they grew grains or other field crops. Farmers who participated in commodity programs were more likely to adopt a gravity system than those who did not.

Soil and field conditions were important factors affecting the selection of irrigation practices. Table 6.4 shows how percent predicted adoption changes with changes in soil leaching potential, soil productivity, and field slope. Center pivot or other sprinkler systems were more likely to be used on soils with higher leaching potential, whereas gravity systems were more likely to be used on highly productive soils, which generally have higher water retention capabilities. The probability of using gravity systems increases for fields with a higher slope. Fields with higher wind erosion levels were more likely to be irrigated with a sprinkler system and less likely to be irrigated using a gravity system.

Climate played a major role in irrigation adoption. Low average rainfall and high temperatures increased the probability of adoption of both sprinkler and gravity systems.

## Summary

Overall, the most significant factors that influenced the adoption of irrigation as well as irrigation technology choice were human capital, land tenure, the type of crop grown, and climate conditions. Farm size and natural resource characteristics were important in determining adoption in the combined and single regions that were analyzed.

Producers with a college education and those who owned the field were more likely than others to invest in irrigation technology. Conversely, the more days the producer worked off the farm, the greater the probability the producer chose not to irrigate. The probability of irrigation increases for producers growing cotton, potatoes, or other high-value crops. Percent predicted adoption also increased if a producer was growing corn. The prevalence of irrigated corn in the Central Nebraska Basin may have overshadowed the effects in other regions in the aggregate analysis.

The effect of farm size on irrigation use was mixed. Larger farms were less likely to use irrigation in the Snake River Basin, the Southern High Plains and in all 10 areas combined. Farm size had no effect on use of irrigation in the other regions. The results seem to suggest that larger farms may often be less able to adopt irrigation as efficiently as smaller farms. Furthermore, larger farms were less likely to adopt gravity systems. This could reflect the higher land preparation, energy, and water costs associated with gravity systems.

Of the resource characteristics, the slope of the field had a significant effect on irrigation adoption decisions. The greater the slope of the field, the less likely a producer would irrigate. However, in the multinomial choice model, field slope had no effect on the adoption of sprinkler systems, but was significant in deterring the use of gravity systems. Gravity systems are less adapted to nonuniform fields than sprinkler systems. Wind erosion also influenced irrigation adoption. Producers with fields subject to wind erosion were more likely to apply water, possibly reflecting efforts to control damages from soil erosion due to wind. Producers with fields that had higher soil erosion levels from wind were more likely to use sprinkler systems and less likely to use a gravity system. Soil leaching potential also had a significant effect on the choice of irrigation systems.

Finally, as expected, weather conditions played the greatest role in determining irrigation adoption decisions. In almost all regions, producers in hot and dry areas had a higher probability of applying water. The only region that had an inconsistent result was the Southern Georgia Coastal Plain, where producers were more likely to irrigate despite their high rainfall. This could indicate that producers may be using irrigation to control for climate variability, which our weather data do not reflect.

These results show that the strength of an Area Studies-type survey is in the analysis of region- and technology-specific characteristics affecting adoption. Generic indices may mask important factors. For the study of irrigation, the use of slope and wind erosion potential measures may be more illuminating than the composite erosion index used for the other studies.

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