8.2 ESTIMATING COTTON-IRRIGATION IN GEORGIA USING GEOSTATISTICS AND GIS

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1. INTRODUCTION

Cotton is one of the most important crops in Georgia with a harvested area of about 1.4 million acres per year. Irrigated acreage for cotton accounts for about 40 percent of the total irrigated acreage for cash crops, grains, vegetables, and orchards (United States Department of Agriculture, 1999). Hence, the estimation of irrigation usage by cotton (i.e., the volume of water discharged to cotton fields) is critical to the overall estimation of water usage for the state of Georgia.

Why is there a need to estimate water usage in Georgia? There are two major reasons. First, water is becoming an increasingly limited resource due to continuous drought conditions in Georgia and other southeastern states (Hoogenboom, 2001; Thomas et al., 2000); planning for water conservation requires estimation of water usage. Second, three states (Alabama, Florida, and Georgia) dispute apportioning of water from major rivers that flow through these states; the apportioning requires an estimation of water usage for each sector in a state. With the above background, the College of Agricultural and Environmental Sciences initiated a project called Agricultural Water Pumping (AWP; www.AgWaterPumping.net) in 1999 to monitor irrigation usage by different crops (Thomas et. al, 1999). Approximately 2% (nearly 400 sites) of the total permitted water withdrawal sites were selected for this project. The objective of this study was to estimate irrigation usage for cotton using geostatistics and a geographic information system.

2. STUDY AREA

The cotton-producing counties identified from the cotton-acreage data collected from the Georgia Agricultural Statistics Service (www.nass.usda.gov/ga) for the year 2000 are shown in Figure 1 These counties are distributed across three water zones i.e., Flint, Central and Coastal zones. There is a total of seven water zones in Georgia but the above three zones represent most of the agricultural land.

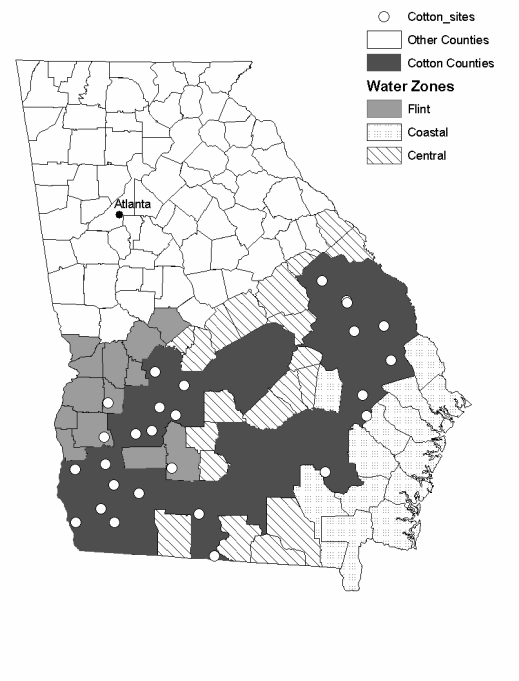

Fig. 1. Cotton producing counties and the cotton monitoring sites in Georgia for the year 2000

3. METHODOLOGY

We employed three geostatistical techniques to estimate irrigation usage: i) Inverse Distance Weighting (IDW), ii) Ordinary Kriging (OK), and iii) Universal Kriging (UK). These techniques are available in the 'Geostatistical Analyst' module of the ARC-GIS v8.2 software (Environmental System Research Institute, Redland, California). Input data Data that were analyzed were the seasonal irrigation

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usage (cm) for cotton fields (point locations). Each site shown in Figure 1 represents a county with irrigation usage averaged from multiple sites monitored within that county. The seasonal irrigation was computed using monthly data on pump discharge and its duration recorded by hour-meters installed at each AWP site.

The IDW technique assumes that each measured point has a local influence that diminishes with distance; we selected a nearest neighbor method (5 nearest points, minimum 2) to apply this technique. The OK and UK techniques fit the following model to the point measurements (Cressie, 1993; Bailey and Gatrell, 1995):

$$Z(s) = \mu(s) + e(s) \quad (1)$$

where Z (s) is the estimated value at site *s*; μ is a constant in the case of the OK technique while a function in the case of the UK technique; and e is an error at site *s*. The OK and UK techniques use semi-variogram, a dissimilarity function, to fit an appropriate model. Application of each of the above techniques resulted in a grid (606 x 541 cells) across the study area. The techniques estimated irrigation usage for each cell and compared the estimates with measured values (i.e., the input data). The UK technique gave the best estimates with minimum error.

4. RESULTS

Using the 'zonal statistics' option in the 'Spatial Analyst' module of the ARC-GIS software, we averaged the cell estimates (by the UK technique) within cotton counties. We then averaged county-estimates of irrigation for each of three zones under study and obtained 23.6 cm for the Flint, 17.7 cm for the Central, and 18.3 cm for the Coastal water zones for the year 2000. By multiplying these estimates with the planted acreage of cotton for the respective zones, the total volume of the irrigation usage can be determined. We are currently conducting a quality control exercise on the AWP database and are studying crop models (Heinemann et al. 2002) to improve the reliability of our preliminary results.

5. CONCLUSIONS

We found the Universal Kriging technique to be more accurate than the Ordinary Kriging and the Inverse Distance Weighting techniques and estimated cotton irrigation of 23.6 cm for the Flint, 17.7 cm for the Central, and 18.3 cm for Coastal water zones of Georgia. Our analysis was based only on interpolation using geostatistical techniques and a geographic information system. We are examining relationships between climatic factors and spatial variation in crop irrigation to develop more reliable models for regional estimation of crop irrigation in Georgia.

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