

**Spatial Thinking to Address Complex Social Issues in Agricultural Teaching, Research,  
and Extension**

Carrie N. Baker  
University of Florida  
310 Rolfs Hall  
Gainesville, FL 32611  
(309) 368-2279  
baker.carrie@ufl.edu

Sarah A. Bush  
University of Florida  
117C Bryant Space Science Center  
Gainesville, FL 32611  
(352) 273-2613  
sab5271@ufl.edu

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A Geographic Information System (GIS) is a web-based system that integrates location data with descriptive data to share information, perform robust analyses, and construct maps for sophisticated data visualization (Esri, n.d.; U.S. Geological Survey, n.d.). Within the natural sciences, GIS applications are commonly used for assessing soil and water quality, pest management, crop trends, environmental impacts, land use, flood hazards, and other susceptibilities (Mathenge et al., 2022). GIS can also provide actionable evidence to support decision-making in addressing place-based, complex social challenges (Harder & Brown, 2017), supporting work in agricultural extension. Yet, a recent keyword search for “GIS” in our discipline journals produced limited results. While not a completely new concept, recent applications in our discipline are lacking—which likely results from deficits in awareness, training, and support. Using a variety of statistical analysis methods, educators, social scientists, and practitioners can apply spatial thinking to explore issues in geographic contexts, identify relationships, and address social science questions. We propose that by developing our capacity to use GIS tools, such as ArcGIS Pro, or collaborating with GIS experts, we can foster more innovative solutions for addressing complex challenges in our discipline.

### **How it Works**

Recently, we participated in the University of Florida's Institute of Food and Agricultural Sciences (UF/IFAS) Geographic Information Systems (GIS) Introductory Training Course to develop basic skills for employing case-based problem-solving using ArcGIS Pro. Through that course, we recognized the value GIS holds for enhancing teaching, research, and extension in our field. There are three main steps to begin using GIS and spatial thinking to solve problems:

**Define the problem:** Much like any research project, we first need to clearly identify the problem and research question, and explicitly state the geographic element of the question(s). For example: *What is the relationship between agricultural loss from hurricanes and county-level food insecurity in Florida from 2017-2023?*

**Locate and review data:** After identifying the key question(s), researchers or educators should consider what data might be needed and where to source it. ArcGIS Pro is compatible with many data types, such as Excel and text files (descriptive data), shapefiles, raster datasets (aerial cameras, satellite sensors), and geodatabase data. A robust open-access infrastructure exists for social science datasets online. In the ArcGIS Hub, data are provided by federal and state agencies like the U.S. Department of Agriculture (USDA) and Federal Emergency Management Agency (FEMA) and other credible contributors like National Center for Education Statistics. Outside of ArcGIS, a web search of “GIS data” with relevant keywords elicits many open data portals with additional data. For our example question, we might need state and county-level maps with attributes, longitudinal food insecurity rates from Florida Department of Health, hurricane data from the National Hurricane Center, and county agricultural losses from the federal or state departments of agriculture. Prior to creating maps or conducting analyses, characteristics of the map layers should be reviewed and validated with a GIS professional.

**Apply Geo-processing methods:** There are many opportunities for quantitative and qualitative analysis within ArcGIS Pro (Esri Social Science Collaborative, n.d.), including: extract or overlay features; determine proximity; analyze attribute data; and perform network, image, and spatial analysis. Researchers can also develop and run models for advanced analysis and prediction. In our example, we might use the proximity tool to measure the distance between landfall and areas with high agricultural loss; or the spatial analysis tool to establish correlations between hurricane routes, agricultural losses, and food insecurity rates. We could also take this a step further and measure the distance from hurricane impact to areas with varying food insecurity rates. Depending on available data, we might create a layer using network analysis to understand the county-level extension response to help identify gaps where future resources or support might be needed, especially in more vulnerable or food insecure areas.

### **Implications**

GIS applications can be used for data analysis, visualization, and dissemination. In our field, GIS can aid in addressing problems like education inequity; food insecurity; community and land use planning; natural disaster preparedness and response; and health monitoring (Kenu et al., 2022). Researchers can use GIS to analyze location-based data and create information products, like static or interactive maps and StoryMaps, which are science communication tools for meaningful data visualization and dissemination. Depending on their expertise area, extension professionals can use ArcGIS for research collaborations; addressing community issues (e.g., resource access, climate change impacts, traceability of disease and outbreaks, etc.); tracking initiatives and programs; understanding local needs and setting priorities; and sharing information with stakeholders. It can also be used to pinpoint study areas for research or identify phenomenon to examine. In light of the recent focus on big data, artificial intelligence, and smart agriculture, GIS also has immense utility in agricultural education. Educators can use GIS case studies to teach complex problem solving, systems thinking, research methodologies, mapping, and data visualization.

### **Future Plans and Advice to Others**

We plan to use ArcGIS Pro in upcoming research projects, such as one examining health inequity impacting agricultural workers in Florida, using support from colleagues and our previous training. The 3-day training was invaluable for learning about ways to ask and address questions using ArcGIS Pro. We highly recommend those interested in GIS-based research and outreach collaborate with experts using ArcGIS in related fields, seek out hands-on application opportunities, and invest in continued education through their institutions or online. Resources, trainings, and official certification opportunities are offered through Esri Academy on [esri.com](https://www.esri.com/academy).

### **Costs and Resources Needed**

Through University of Florida, students and instructors can access ArcGIS Online at no cost for education or non-commercial research purposes. For grant-funded research, faculty and staff receive a discounted rate. We recommend exploring institutional support prior to investing in subscriptions. For students or individuals without access, ArcGIS is available for \$100 per year. Depending on need and role, advanced packages range from \$550-\$4,150—though it is unlikely users in our field would need such capacity. ArcGIS products are compatible with Windows and configured Mac systems. Free online maps and datasets are already available for analysis; however, some data may require additional funds to collect and/or purchase.

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