Spatial Analysis Software Tools for Community Decision Support

Chris Fulcher*, Yan Barnett** and Chris Barnett***
Center for Agricultural, Resource and Environmental Systems (CARES)
Community Informatics Resource Center (CIRC)
University of Missouri-Columbia

Local governments are increasingly faced with making decisions that were once delegated to the Federal government. However, with this devolution of power, local governments often lack the resources or information to make effective decisions that impact their communities. To further exacerbate this issue, rural communities in the United States are typically resource-poor compared to their more affluent urban counterparts. Specifically, rural communities typically lack the expertise and infrastructure (i.e., access to information, equipment, computer hardware and software) required to make more informed decisions. At the same time, local governments are increasingly employing Participatory Action Research (PAR) methods to address local issues. Participatory Action Research increases the need for accessible, user-friendly, interactive decision support tools to evaluate socio-economic and environmental impacts of group decision making at the local level.

Information science, coupled with emerging information and communications technology (ICT) including geographic information systems (GIS), remote sensing, and data visualization, are increasingly being used to address policy options at the local level. However, there are several drawbacks to using these technologies: (1) limited access – the tools are often developed on stand-alone computers (i.e., not Internet-based); (2) expensive - the cost of the required hardware and software may preclude less affluent communities from using the tools; and (3) resource poor communities may lack the expertise to use the tools and interpret the results. Rural access to the Internet is not considered a limitation in the long run as ICTs continue to evolve (e.g., satellite connectivity to the Internet).

This paper will highlight the spatial decision support tools developed at CARES and CIRC at the University of Missouri-Columbia. These Internet-based tools overcome the shortcomings of traditional decision support tools by increasing access via the Internet, reducing costs and minimizing the expertise required to use the tools; thereby leveling the playing field between primarily resource rich urban and less affluent rural communities in the United States.

There are several advantages to using an Internet-based GIS: (1) Cost effective: The Internet is an efficient and affordable way to distribute information; (2) No GIS software is required: Users only need a browser such as Netscape or Internet Explorer to interact with the Internet-based GIS; (3) No data distribution required: All data and GIS functionality is updated via a centralized server, thus avoiding significant data management and distribution issues; (4) Effective Participatory Action Research tool for engaging stakeholders in their communities; (5) Effective research collaboration tool for engaging scientists in distributed data collection, synthesis, analysis and dissemination.

The Center for Agricultural, Resource and Environmental Systems (CARES) is an intercollegiate research and education center within the College of Agriculture, Food and Natural Resources at the University of Missouri – Columbia. CARES was established in 1992 with the purpose of helping people better understand and address agricultural, natural resource and environmental issues using knowledge and information technologies. The Rural Policy Research Institute (RUPRI) and CARES recently established the Community Informatics Resource Center (CIRC), which is housed in CARES. This new center builds on the Missouri state-level applications offered by CARES and applies the concepts and Interactive Mapping tools to the national level.

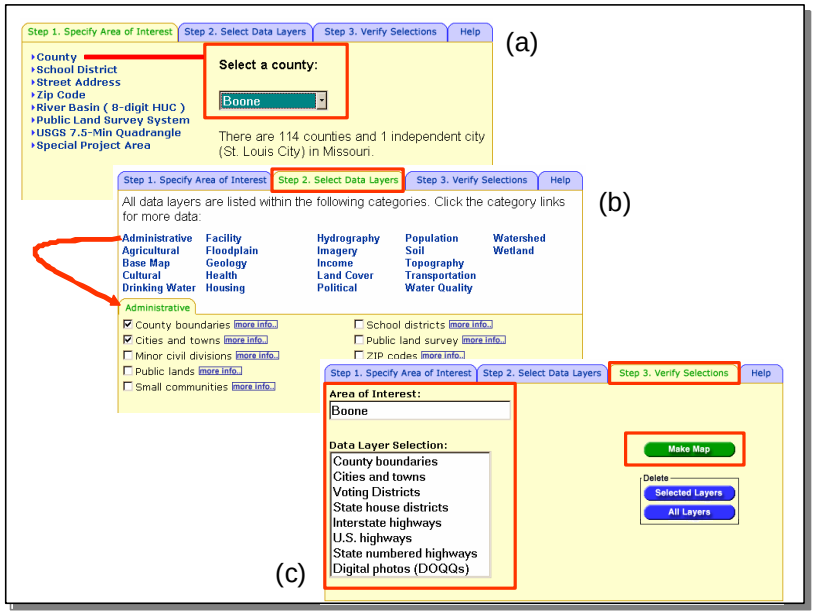
A Holistic Framework for Decision Support

An agency-based framework for disseminating data is not a desirable structure for local governments and citizen groups concerned with issues, such as land use, since they require GIS layers and other data from several agencies. For example, if a citizen steering committee appointed by county commissioners is addressing a land use issue in their county, several layers would be needed, including: land cover satellite imagery which may be obtained from the Missouri Department of Conservation, road networks from the Missouri Department of Transportation, socio-economic and demographic data from the U.S. Census Bureau, soils from the U.S. Natural Resources Conservation

* Assistant Professor, Truman School of Public Affairs, Co-Director, CARES, Director, CIRC; ** Research Associate and *** Associate Director, CARES

Service, and stream networks from the U. S. Environmental Protection Agency or the Missouri Department of Natural Resources. This steering committee, most local governments, and citizen groups will likely not have the resources to readily integrate data from Agency-based Internet Mapping websites and other clearinghouses of GIS data into a meaningful decision support system.

Therefore, CARES coordinated with state and federal agencies to integrate agency-based Internet Mapping websites into a holistic framework for decision support. "Holistic" is often defined as an approach that emphasizes the importance of the whole and the interdependence of its parts. In other words, the "whole" reflects the decision support framework, while the parts are the agency-based data that contribute to the whole.



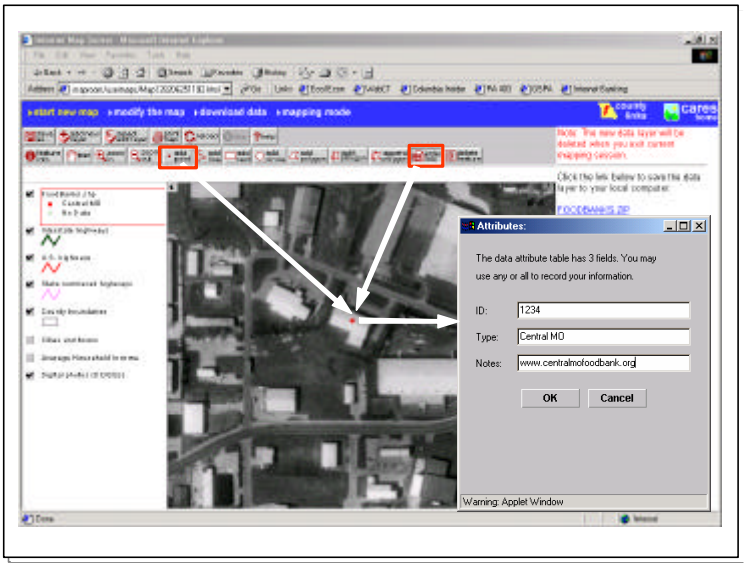
CARES proceeded to develop an Internet Mapping website using focus groups that had no background in GIS or Internet Mapping. These focus groups provided feedback on menu interface development, navigation around the website, and improving the functionality of the mapping tools. Based on focus group input, a three step process was developed for accessing the Internet Mapping website (see figure to right).

Development and Implementation of a Digitizing Tool for Adding Local Knowledge

Engaging citizens and the local government in a Participatory Action Research process is quite valuable in that they provided information, due to their extensive knowledge of the area that may otherwise be missing from agency databases. CARES therefore developed a suite of tools that allows users to digitize (create) their own GIS layers through the Internet. These unique tools enable researchers to engage communities in a participatory research framework by creating "living maps" through the Internet.

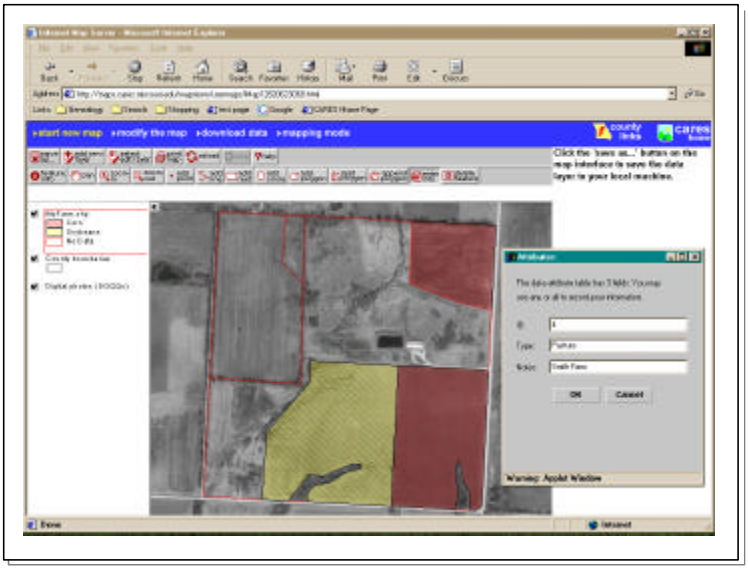
Specifically, the digitizing tools were created to enter in real-time spatial data, including attribute information, via the Internet or a secured Intranet. Using a standard web browser, a user can zoom in on any given location in the Missouri and add or edit geographic features such as points (e.g., households, well locations), lines (e.g., roads, streams), and polygons (e.g., fields or jurisdictional boundaries). 1-meter imagery or other detailed maps often serves as a reference layer to digitize these geographic features.

The figure to the right illustrates the process of entering in a point on top of a house using 1-meter DOQQ imagery and attributing, or adding intelligence to that point using a "proof of concept" menu interface. Assume a user wishes to create a new GIS layer for community foodbanks to show locations of where food is distributed to hungry people. One purpose of adding foodbank locations may be to determine whether they are in optimal locations based on changing demographics (i.e., proximity to areas in poverty based on income census data). The figure shows the process of first creating a



new layer called “foodbanks”; second, clicking on the “add point” button and then clicking on top of the house to generate a point. The user then clicks on the “enter info” button to add attributes to that point. Attributes may include volume of food distributed in pounds, website address, phone number, etc.

In another example, the same digitizing procedure can be used by a farmer to enter data related to crop management practices. The farmer can use the digitizing tool to first delineate field boundaries using the “add polygon” tool, then attribute those fields with information about what crops will be planted the following year (see figure to the right).



The tools served as a foundation for developing a national-level Internet Mapping tool for the 4-H National Technology Conference, which was held at the University of Maryland, College Park from July 8-12, 2000. The objective of the mapping tool was to enable 4-H youth from around the U.S. to zoom from a national map of the U.S. down to their community. The user can then put a “pin” on the map by clicking on their neighborhood with a mouse. A “Community Technology Self-Assessment” survey then appears on the screen and prompts the user to answer questions about their level of Internet access and other technology related questions. The 4-H mapping prototype served to illustrate the potential of providing agencies with a means for distributed data entry of GIS layers and attributes via the Internet. This national website, in turn, served as a prototype for the establishing CIRC.

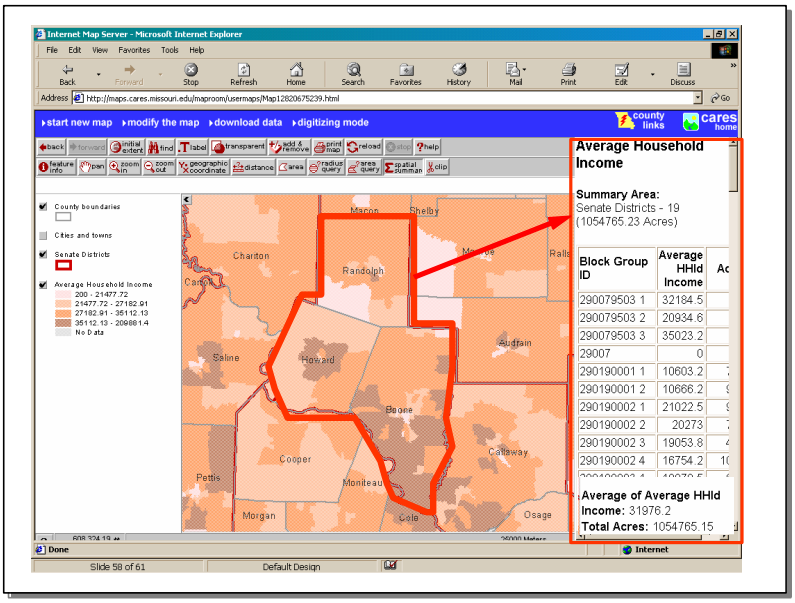
Spatial Summary Tool

A Spatial Summary Tool allows the user to summarize spatial data (e.g., land use) by any geographic feature (e.g., watershed boundary). Essentially, the Spatial Summary Tool serves as a cookie cutter that summarizes data by a specified geographic boundary (county, zip code, school district, congressional district, etc.).

Assume a State Senator wants to summarize “Average Household Income” by senate district, based on the 1990 census data. “Average Household Income” is aggregated to the senate district level by following this three step process:

- Step 1. Click on the “Spatial Summary” icon above the map and then click inside a given senate district boundary on the map.
- Step 2. Select a data layer to summarize: A popup menu opens up for selecting the data layer to summarize; in this case, “Average Household Income”.
- Step 3. Select a data layer to summarize by: A popup menu opens up for selecting the data layer to summarize by; in this case, Senate Districts.

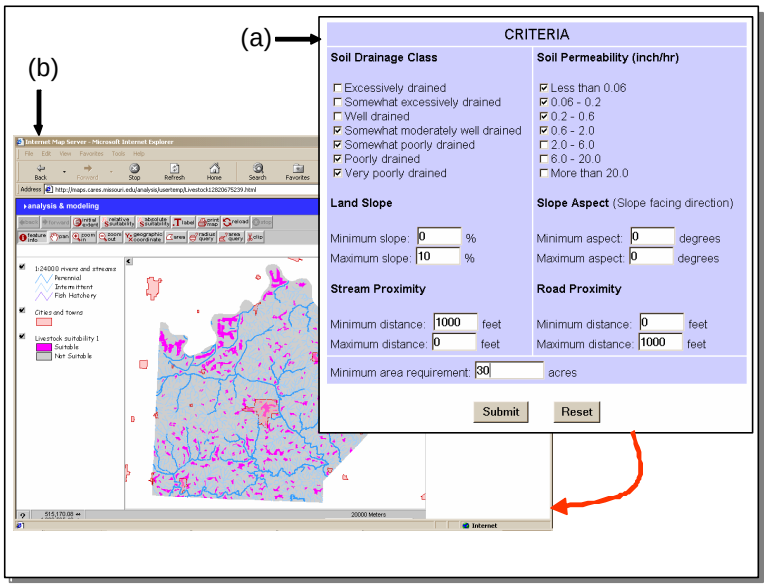
The Internet-based GIS calculates average household income In Senate District 19 to be $31,976 Based on the 1990 Census (see figure to right).



Internet-based Livestock Site Selection Tool

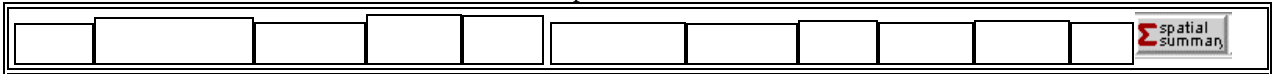
The impact of citizen participation in the local decision making process using Internet Mapping tools is highlighted by a study recently completed for Saline County, Missouri. County commissioners in Saline County approached the University of Missouri-Columbia for assistance in addressing the economic and environmental impacts of Confined Animal Feeding Operations (CAFOs) and their potential expansion in the county. This volatile issue was charged with emotion rather than sound information. Therefore, the University Outreach and Extension put together a team of researchers and Saline County extension staff to work with a citizen steering committee that reflected the varied interests in the county.

As stated earlier, the CAFO issue was volatile; however the site selection tool forced all members of the steering committee to focus on the list of criteria rather than relying on their emotions to drive the process. The first "what if" scenario was based on suitable livestock locations being: somewhat to very poorly drained soil; low in soil permeability; on land less than 10% slope; no closer than 1,000 feet from a stream; no farther than 1,000 feet from a road; and a minimum area of 30 acres (see figure to right).



After selecting values for each criterion, the "Submit" button was clicked to generate a livestock site suitability map for Saline County. The steering committee immediately saw that the City of Marshall was designated as a suitable location for a livestock operation. Both pro- and anti-CAFO steering committee members requested that CARES modify its list of criteria to include an urban setback option whereby a user can enter a minimum distance from an urban area. Other suggestions for adding to the criteria list included providing setbacks for tourist areas, state parks, and rural residences.

For brevity's sake the table below provides illustrations and definitions of additional tools developed at CARES that are located in the menu bar above the interactive map on the CARES Website.



- **Label:** Label features on the map.
- **Transparent:** Make the selected polygon data layer see-through. A popup menu opens for selecting the transparent data layer and level.
- **Add & Remove:** Add or remove data layers from the map.
- **Print Map:** Generate a map for printing out or saving to disk. Opens a separate browser window and displays a page with the current map display, a title, and the legend.
- **Help:** Open this help page.
- **Geographic Coordinate:** Click on a location to display the latitude / longitude and UTM coordinates.
- **Distance:** Draw a line to measure distance. Double click to end the line.
- **Area:** Used to draw a polygon to measure area and perimeter. Double click to end the polygon (planimeter).
- **Radius Query:** Click on a location to get information about features within a radius. A popup menu opens up for selecting the query data layer and entering radius.
- **Area Query:** Draw a polygon to get information about features within an area. A popup menu opens for selecting the query data layer.
- **Clip:** Draw a polygon to cut out features of data layers. Opens a popup menu for selecting the data layers to clip. The clipped data layers are listed as hyperlinks for download.
- **Spatial Summary:** Allows the user to summarize spatial data (i.e., census data) by any geographic feature.

CARES Website: www.cares.missouri.edu; CIRC Website: www.rupri.org/circ; e-mail: FulcherC@missouri.edu