Herdsmen in Africa are using a decision support tool, Waterhole Monitoring for Livestock Early Warning System, to make decisions on where to move their livestock for water. Photo by Dr. Jay Angerer, Texas A&M AgriLife Research.

FROM CENTRAL TEXAS TO AFRICA

Texas A&M AgriLife Research technology is changing natural resource management

In a remote part of southern Ethiopia, a local herdsman checks the Internet using his cell phone to make a decision critical to his family's livelihood: what direction he should move his livestock to find water.

The herdsman locates available water by accessing online maps generated from a computer-modeling tool developed, in part, by researchers at Texas A&M AgriLife Research and Extension Center at Temple, widely known as the Blackland Center.

With funding from NASA, the AgriLife researchers in Temple worked with the U.S. Geological Survey (USGS) to develop the Waterhole Monitoring for Livestock Early Warning System (watermon.tamu.edu) in southern Ethiopia and northern Kenya. Using climate and satellite images from NASA, the system provides near-real-time monitoring and changes in the water levels at waterholes throughout these countries, said Dr. Jay Angerer, assistant professor at the Temple center.

NASA satellite images identify the waterholes and stream networks from imagery, and climate data streams provide relative humidity, temperature, rainfall and wind. A hydrologic water balance model uses this information to estimate daily waterhole depth variations, he said. Field teams collect data from the waterholes to verify the model.

This decision support tool, which was expanded to the western African country of Mali, is proving invaluable to the nomadic communities, providing them with information for planning livestock movements. When the herdsmen start moving their animals to the next destination, "they don't know whether there is water and whether they might get stranded," Angerer said. "Cattle can't go more than about two days without water."

Now the herdsmen can access color-coded maps from the Internet with their smart phones or consult nongovernment organizations that assist herders in planning. The maps show the condition of the waterholes, ranging from green for good conditions to red for near dry conditions.

"A map really communicates if it has the right landmarks in it," he said. "It doesn't have to be in the local language."

The waterhole monitoring program is one of numerous tools based in computer technology that AgriLife Research scientists at Temple have helped develop since the center's establishment in 1910.

Recognized for their expertise in computer modeling, the AgriLife researchers, often working with USDA's Agricultural Research Service (ARS) and Natural Resources Conservation Service (NRCS) scientists, have used computer technology to develop models to simulate agricultural and watershed information, among other projects.

"Our focus is trying to find solutions to problems that affect land and water," said Dr. Tom Gerik, the center's resident director.

The waterhole monitoring program is an outgrowth of another program first created for Africa — the Livestock Early Warning System (LEWS) — which was developed by scientists at Temple and the Texas A&M Ecosystem Science and Management Department (then Department of Range Science) through the Center for Natural Resource Information Technology (CNRIT). AgriLife Research established CNRIT in 1991 for collaborative research among various departments to develop decision support systems for management of natural resources.

After severe droughts in Africa from the late-1980s through the mid-1990s caused famines, the U.S. Agency for International Development (USAID) provided funding to set up an early warning technology program in four African countries — Tanzania, Uganda, Kenya and Ethiopia — which was later expanded to Dijbouti and parts of Somalia. This early warning system provides near-real-time predictions of forage conditions over the landscape in these countries, Angerer said. Knowledge of forage conditions over the wide area is important, ⇨

he said, because most lands are communal. Management of the land cannot be by just one person, he said.

"The goal is to provide trends of forage conditions to see when forage starts declining and to provide this early warning that there may be conditions conducive to drought, and there is a need to start planning for drought," Angerer said.

Using a hydrologically based plant growth model called PHYGROW, which was developed at Texas A&M, the researchers are able to produce maps showing where forage is declining and what areas appear to be moving into drought. PHYGROW estimates the amount of available forage based on the forage preference of the livestock and the known composition of forage on the landscape. Angerer said statistical tools predict what the likely conditions might be in 60 to 90 days.

Without adequate information, herdsmen can end up in severe poverty because they run out of forage and options, Angerer said. "They did not sell the animals when they had an opportunity and the animals died, or they waited too long and the market prices collapsed," he said.

"They can use the early warning information as a decision tool to say: 'Do I need to move my animals? Do I need to sell the animals? Do I need to buy feed? Do I need to wait?'" he said.

As the researchers and their collaborators considered these situations, they realized the herdsmen lacked information on the market prices for livestock in different areas and on the locations of available water. Such information could complement the forage monitoring and make a better decision tool.

For the market prices, Angerer said, the project developed a market information system that has people at different markets collect data on prices and send it by cell phone text messaging to servers. The system extracts the information and puts it into a database. Herdsmen can send a query to the system with a text message to get information on prices for their local market.

"It makes the price information more timely and transparent in the sense that the herdsmen know the same numbers that the livestock traders know," he said. "They now have the power to negotiate."

More than 12 nongovernment organizations, or NGOs, have been involved in the LEWS project with hundreds of herdsmen associated with each organization. The LEWS is also used in Mali, Mongolia and Afghanistan.

Not only are the LEWS and waterhole monitoring projects allowing the herdsmen to better maintain their herds but by using the technology, conflicts between neighbors are being reduced, Angerer said.

"The information has been useful for assisting NGOs and local agencies in providing herders with information to reduce risk and the potential for conflict over water and forage resources," he said.

Becoming the modeling hub of AgriLife

Gerik said Temple's research focus on land and water that later translated to computer modeling started in 1929 when the USDA's Soil Conservation Service (now NRCS) moved to Temple to try to solve soil erosion problems, mainly with cotton.

In 1937 the USDA established the USDA ARS Experimental Watershed at Riesel, an 840-acre research site northeast of Temple. Hydrologists began collecting hydrologic data such as rainfall, evaporation, runoff and soil erosion.

Once the center had access to mainframe computers in the late-1960s and early-1970s, hydrologic models were developed to predict where water runoff from agricultural fields was going and how much erosion and nutrients were lost through the runoff, Gerik said.

"Those hydrologic models were the genesis of our modeling programs here," Gerik said.

In the early-1980s, the USDA wanted to determine the impact of soil erosion on crop productivity and that started agricultural system modeling at Temple, Gerik said. "That is when we took the hydrologic models and married them with the plant and agronomic models and started looking at these agricultural systems," he said.

Through the years, AgriLife, ARS and NRCS researchers have added models and components of models to simulate different ecosystems in Texas, the United States and around the world.

Today, Gerik said, most of Temple's projects center on the computer models. "It's what we do," he said.

"We use these models to answer questions that we can't answer directly experimentally. It would take years and years and years to do experimental studies and then they would only be confined to relatively small windows of weather, time, etc.," he said. "With models we can change different scenarios and can look at them not for just short periods of time but over decades and hundreds of years," he said. "That is the beauty of the models."

Using these models to quantify the environmental benefits of conservation practices associated with agricultural lands throughout the United States is what AgriLife Research's involvement in the NRCS's Conservation Effects Assessment Project (CEAP) is all about.

(left photo) AgriLife researchers along with ARS and NRCS scientists assessed the impact of cropland conservation practices on the soil and water quality of cultivated croplands as well as watersheds across the United States. Photo by Lucas Gregory, Texas Water Resources Institute.

(right photo) A market information system that collects data on livestock prices at different markets enables herdsmen to send a query to the system with a text message to get prices for their local market. Photo by Dr. Jay Angerer, Texas A&M AgriLife Research.

Gerik said AgriLife researchers along with ARS and NRCS scientists have just finished assessing the impact of cropland conservation practices, such as the use of terraces, grassed waterways and conservation tillage, on the soil and water quality of cultivated croplands as well as watersheds across the United States.

Using the farm-scale model Agricultural Policy/Environmental eXtender (APEX) and the watershed-scale model Soil and Water Assessment Tool (SWAT), both developed largely at Temple, they simulated the current cropping practices and conservation practices, Gerik said.

"We took the APEX model, and we looked at just the impacts of these practices on the fields, then we took output from the field data generated by APEX and incorporated that into the SWAT model, which looked at the whole watershed," Gerik said. "So we could determine the effects of cropland conservation practices on the whole watershed."

By using these models, Gerik said, they can see what current conditions would be "if we didn't have those practices, and we can look into the future to see if we changed the way we managed the land, what the benefits would be."

The CEAP program is also linking the benefits of the conservation practices to financial benefits.

Gerik said that Congress and the USDA initiated CEAP in 2004 to determine whether the money spent on conservation programs was money well spent. "The OMB (Office of Management and Budget) has seen the value of using models to look at the benefit of government programs," he said.

NRCS has seen the benefit of using APEX as one of its planning tools. The tool can comprehensively design management practices that are the most effective in respect to natural resources conservation and cost on the landscape on a particular farm, Gerik said.

"What we learned is that the existing conservation practices are doing a really, really good job in controlling erosion, reducing nutrient losses and runoff and increasing soil organic matter," Gerik said. "But there are still areas where problems with nutrients and erosion exist, so NRCS is working to focus their resources and energy on those areas and issues."

Finding new uses for technology

Uniquely combining several technologies initially developed for different purposes, an AgriLife research team at Temple is using bathymetry mapping, which merges GPS, GIS and sonar technologies, to calculate a reservoir's water capacity and track deposits of sediment in the reservoir. By using these readily available technologies and a boat, the team can calculate the reservoir's depth and sediment quickly and easily, said Dr. William Fox, assistant professor at the Temple center.

The team recently surveyed a 17,000-acre lake in Oklahoma. "We generated over a million data points, of which 600,000 data points were used to develop a model of the reservoir," Fox said.

The team also has used bathymetry mapping to evaluate the flood control structures at Fort Hood and in the Lampasas River watershed to determine ⇨

the capacities and projected longevity of these structures. Thousands of sedimentation-flood control earthen dams were built during the 1950s to 1970s in rural areas to protect agricultural lands and property, rural roads and small towns from flood damage.

If sedimentation is found to be a problem, then the focus will need to be upstream, working to identify and implement conservation practices to slow the process, Fox said.

Gerik said ultimately this information may get into the hands of policy makers where it can be used by local, state and federal officials in developing and maintaining their water quality and flood control plans.

"With bathymetry mapping we are taking advantage of readily available technologies and applying them to the agricultural and natural resource fields," Fox said. "The technology is very accurate, quick and capable of getting a good understanding of what is out there."

Direct measurements gained from the mapping can also help validate and improve models for future use.

"Reservoirs are the archives of what has happened in the watershed," Fox said. By using bathymetry mapping, "we can see how much sediment is in the reservoir and where the likely contributing areas of runoff, erosion and ultimately sedimentation are in the watershed. We hope to tie that information back to how land management in the past has influenced the possibility of this phenomenon taking place."

For example, Fox believes that this mapping can be used in future conservation programs. "Through the CEAP program, NRCS is able to look at the effects of past conservation practices. I would say another question to ask is: How could we more efficiently target our conservation practices within the watershed? To do that you have to understand where in the watershed sedimentation is taking place."

Future developments

"What is very satisfying and rewarding for our group," Gerik said, "is the impact that the models and the collective research being done by the AgriLife, USDA ARS and USDA NRCS team in Temple is having in this country and around the world."

The SWAT model is being used worldwide, and an international SWAT conference is held annually, attracting more than 400 researchers each year.

With the cropland CEAP finished, Gerik said the team is moving on to tackle grazing land and aquatic wildlife CEAP projects. "With the wildlife CEAP, we are tying our models in with aquatic wildlife models," he said. "So instead of just looking at how we are affecting water quality, we are also looking at simulating the impact that conservation practices and water quality are having on fish populations.

"We are very much engaged to continue to develop the tools and the application of these tools," Gerik said. "It never ends."

For more information, visit *txH2O* online at twri.tamu.edu/txH2O/.

NRCS and Texas A&M AgriLife Research scientists prepare to perform bathymetry mapping on a reservoir in Central Texas. Photo courtesy of AgriLife Research.