

## SAHRA Activities

Last Updated Saturday, 22 September 2007

SAHRA Scenario Development Team A team of physical and socio-economic scientists formed to focus specifically on developing scenarios for SAHRA models. And we are (clockwise from top left): Steve Stewart (Research scientist, SAHRA), Mohammed Mahmoud (Ph.D. student, SAHRA), Yuqiong Liu (Research scientist, SAHRA), Hoshin Gupta (Professor, University of Arizona, <http://www.hwr.arizona.edu/hoshin/>), Francina Dominguez (Research scientist, SAHRA), Thorsten Wagener (Assistant professor, Penn State University, <http://www.engr.psu.edu/ce/divisions/hydro/wagener/index.html>), Holly Hartmann (Research scientist, SAHRA)

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### SAHRA Integrated Modeling Activities River Basin Focuses

SAHRA frames its science and stakeholder activities in a river basin context, with primary geographical focus on four semi-arid river basins in the southwestern US and the northern Mexico: the Upper San Pedro, the upper Rio Grande, the Salt-Verde, and the Rio Conchos. In these river basins, limited water sources and rapidly growing population have resulted in increasing water stress and strong competition for various beneficial uses. This has led to overdraft of groundwater, resulting in subsidence problems, and disappearance of much of the riparian habitat. Three water-related issues have been deemed to be of particular importance to support sustainable water resource management in these areas:

- An extensive ongoing landscape transition from historical grassland to shrub land.
- A continued loss of riparian habitat and invasion by non-native species such as tamarisk (salt-cedar). The need for mechanisms for effective and efficient allocation of water among competitive uses, while maintaining appropriate checks and balances to prevent lasting and irreversible environmental damage. Three Integrating Science Questions

To address these issues, SAHRA focuses its scientific research and modeling activities on three stakeholder-relevant integrating questions, which are critical for the wise management of water resources in semi-arid regions and can only be addressed by collaborative research operating in center mode through the consistent deployment of integrated, multidisciplinary science.

These three questions are:

- Vegetation Question: What are the impacts of vegetation change on the basin-scale water balances?
- Riparian Question: What are the costs and benefits of riparian preservation and restoration?
- Water Markets Question: Under what conditions are water markets and water banking feasible?

More details are available at <http://www.sahra.arizona.edu/about/questions.html>. Scenario-Based Multi-Disciplinary Integrated Modeling Approach

In developing a strategy to address such questions in support of sustainable water resources management, SAHRA has adopted a scenario-based multi-resolution integrated modeling approach, with each resolution targeted towards different questions. Different models of three overlapping resolutions are loosely integrated in a unified framework, so that feedback among multiple interacting components is inherent in the simulations.

The three model resolutions are: 1) coarse (units being reaches and sub-basins), 2) medium (units being 1-12 km grid cells), and 3) fine (units being grid cells of 100 m or smaller).

- Fine resolution modeling (FRM) provides a scientific computational foundation for water resource decisions by coupling detailed physical models of vegetation, land surface hydrology, and groundwater hydrology.
- Coarse resolution modeling (CRM) implements the best possible high-level representation of the

&ldquo;behavioral&rdquo; (primarily socio-economic) and &ldquo;institutional&rdquo; aspects of the human environment, coupled with a moderately simplified representation of the underlying &ldquo;physical&rdquo; eco-hydrological system and the &ldquo;engineering&rdquo; components that link the natural and anthropogenic worlds.

· Medium resolution modeling (MRM) bridges the gap between the rigor and detail about natural system physics (hydrological & ecological aspects) embedded in FRM and the rigor and detail about human system behavior (institutional and socio-economic aspects) embedded in CRM; at this level, particular attention is given to proper representation of the resource allocation, engineering and land use management aspects of the system, constituting a natural interface between the natural and socio-economic-institutional layers.

The vegetation question is primarily addressed by FRM, while the riparian question and water markets question are collectively addressed by linking together relevant modeling components from MRM and CRM. All these different modeling activities are guided and integrated through developing and assessing a series of regional scenarios that represent a broad range of future natural and socioeconomic conditions in the US southwest. As a way to build synergies between different activities, the scenario development within SAHRA is based on the three integrating questions and takes into account the interactions of different components. On the other hand, these modeling activities are supported by the development of a common underlying conceptual model and a geospatial database that are closely coupled with data collection and process studies. This multi-disciplinary, multi-resolution integrated modeling framework can be used to assess impacts of climate variability and land use change on water resources management in semi-arid river basins around the world.

A list of SAHRA Integrated Modeling projects and their details are available at <http://www.sahra.arizona.edu/research/IM/index.html>.

### Objectives and Relevance Goals of SAHRA Scenario Development

SAHRA is developing a series of integrated models that describe multiple components of a river basin system. They are being (or will be) used to develop scenarios that are useful for addressing water management questions. For example, could water banking institutions effectively enable stakeholders to share risks in water supply availability? What types of riparian management options can lead to desired environmental and economic conditions, even in the face of extended drought or increasing water demands? The primary goal of the scenario development project within SAHRA is to define a set of scenarios for SAHRA researchers that: inform stakeholder-relevant decisions; hold up to scrutiny of the scientific community; are consistent with the three SAHRA integrating science questions and across SAHRA projects; and represent a broad range of future natural resource conditions, management institutions and socioeconomic conditions that are feasible in the future. While there are lots of resources available about scenario development in business and information sciences, very few of similar resources are specific to the unique problems of developing scenarios for natural resource and environmental modeling. As a secondary goal of SAHRA scenario development efforts, we hope to provide services and guidance to the environmental and water resources community in scenario development, by sharing and exchanging information and resources, and by fostering a multi-disciplinary community of scenario developers.

Importance of Scenario-based Planning for SAHRA

SAHRA undertakes basin-focused multi-disciplinary research aimed at addressing stakeholder-driven issues relevant to sustainable water resources management practices within river basins. The future, however, is not a static continuation of the past, and multiple potential future alternatives should be analyzed to characterize key uncertainties and learn how to address risks in decision making processes. Scenarios can provide a dynamic view of the future by exploring various trajectories of change that lead to a number of possible alternative futures. SAHRA will ultimately be judged on the quality of the answers to the scientific and policy questions it addresses and the degree to which SAHRA research is applicable to questions that will arise in the future. A concentrated scenario development effort will likely broaden the applicability of SAHRA research by increasing the linkages between models, lead to a broader range of conditions under which individual SAHRA investigator research is applicable, and forge more robust linkages between research projects within SAHRA.

### SAHRA Scenario Development Activities

The mission of SAHRA is to promote sustainable management of semiarid and arid water resources with goal of maintaining this critical natural resource on a long-term basis without causing unacceptable environmental, economic, or social consequences. In this sense, scenarios for SAHRA research should be anticipatory and policy-responsive in nature. On the other hand, since SAHRA conducts multi-disciplinary integrated research to investigate the environmental, engineering, and social-economic dimensions of modern water resources management problems, SAHRA scenarios fall under a mixture of climate, environmental, social-economic, and water resources scenario categories. The scenario development effort within SAHRA focuses on the five key phases (i.e., scenario definition, scenario construction, scenario analysis, scenario assessment, and risk management) and started with reviews of previous scenario studies and standard practices for scenario assessment used by decision makers in the Southwest. Integration of local, regional, and global scenarios for different SAHRA projects across the three science questions is essential. SAHRA researchers and stakeholders in Southwest are working together to define a series of scenarios that will have broad applicability. The

goal is to define regional scenarios that reflect large-scale processes, such as those leading to moderate sustained drought encompassing the entire Southwest (such as that experienced in the 1950's). For specific locations within the Southwest, additional scenarios, driven by stakeholder concerns, will be defined, constructed, analyzed and assessed. At this point, we have arrived at the end of the scenario definition phase, with 8 regional scenarios defined based on three major themes (climate change, population distribution, and monitoring resource availability) identified conjunctively by SAHRA researchers and relevant stakeholders. Currently, we are working on connecting our scenario narratives to SAHRA models by driving from the scenarios key forcings (spatially and temporally distributed) to the models. This moves us into the scenario construction phase which is expected to continue for the next one and a half years or so.

Publications Related To SAHRA Scenario Development

Here is a list of publications / products that have resulted from or are expected to come out from the scenario development effort within SAHRA:

SAHRA scenario development fact sheet

White paper from the scenario development workshop hosted by SAHRA at 2006 IEMSS Conference

Book chapter based on the workshop white paper

Journal article to EMS based on a revised version of the book chapter

IAHS Redbook chapter

Journal article to WRR based on IAHS redbook chapter

AGU-style monograph on scenario development