Linking Knowledge with Action
in the pursuit of sustainable water resources management

Summary of a Workshop
20-23 February 2006
Tempe, Arizona, USA

Knowledge Systems for Sustainable Development Project

Draft – April 18, 2006
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I. Introduction

The Challenge
The management of water resources for sustainable use, poverty alleviation and economic
development is a technically and politically difficult challenge for societies. The knowledge
systems that support decisions about water resource management and development link basic
research to applications on a broad range of issues, from agricultural efficiency, to water quality
implications of effluent use, to habitat implications of water supply and energy facilities.
Decision support activities are also widely divergent, ranging from economic and social impact
analyses and environmental assessments, to evaluations of alternative management options and
institutional arrangements. Moreover, much of the knowledge in use day-to-day is experience-
based and tacit, even where there are sophisticated systems of monitoring in place. Managers of
dam and weirs, farmers, climate forecasters, local water managers, construction engineers and
irrigation canal operators combine many forms of knowledge, consult through networks and
negotiate in reaching their decisions and taking actions.

Some of the most critical decisions and technologies in sustainable development related to water
are those with implications that may span decades, requiring the ability to respond to long-term
climate, technological and consumption changes. For example, many decisions about major
water infrastructure, like construction of dams, creation of irrigation schemes, and inter-basin
transfers often have multiple, complex, and unanticipated longer-term impacts. Likewise, major
water policies focused on demand management (rather than supply augmentation) may also have
impacts that unfold over decades, for example, by encouraging certain styles of housing and
gardens or investments in agricultural technologies. Some social innovations may even change
the fundamental way water is perceived and “valued” from a virtually inalienable right to just
another marketable commodity.

Our understanding of how best to bring knowledge and action together for the sustainable
management of water resources is rudimentary.

The Workshop

The purpose of this workshop was to bring together a small group of practitioners, researchers
and stakeholders from four different basins to help bring out the key issues involved in the use of
scientific information in strategic planning and management of water resources. By strategic we
mean a focus on long-term planning and management strategies, decisions over large-scale water-
related infrastructure, and major changes to water use rules, regulations and institutions. The four
basins are in Yaqui Valley, Mexico, northeast Brazil, the Mae Nam Ping Basin, Thailand and San Pedro River, Arizona, USA.

The participants presented the four case studies and compared their experiences relating to the use of scientific information in water management decisionmaking. They were then asked to summarize the main themes and questions that emerged; the themes were combined into three central questions that were discussed within subgroups on the second day; the findings of the breakout groups were then presented to the broader group; finally, a series of “insights” or lessons learned relative to their own case studies and more general observations were developed by the group.

Water problems are very complex and require a lot of knowledge, both knowledge about people and knowledge about aquifers and river systems. Water managers have a very tough job, yet a lot of the scientific information is not available to them. The researchers believe they are producing useful information, yet they feel that their information is not being used. There is a mismatch between what researchers believe is needed and what practitioners think is needed.

This set of initial questions was provided to the group prior to the workshop to guide the exploration and comparison of knowledge relations concerned with strategic planning and management of water resources in different basins around the world. Each case description was asked to answer the following questions:

1. **The Players** – What are the main organizations involved in strategic planning and management of water resources? Who works for them? What are the main activities and tasks they perform? What are the goals and mandates? What important resources do they control?

2. **The Issues** - What kinds of knowledge does each of the main players “have”, create or use? What are the most important knowledge-intensive decisions and actions that need to be taken? Whose knowledge is used, and whose is neglected?

3. **The Relations** - How is knowledge shared or contested by key organizations and individuals? Which actors and linkages help produce knowledge potentially useful for sustainable management of water resources? Are there any players with important intermediary roles? What do they do?

4. **Performance.** Have the key organizations been able to respond effectively to challenges requiring application of current, or search for new, knowledge? How is performance of the players or their relationships monitored and evaluated? Are there transferable lessons from this experience?
II. Case Material

Yaqui Valley, Sonora, Mexico

**Location:**
The Yaqui Valley is a highly productive, semi-arid agricultural region in northwestern Mexico (Sonora). Geographically, the Yaqui Valley proper is a 100 km by 60 km wedge of coastal plain between the outlets of the Yaqui and Mayo Rivers, bounded by the Sea of Cortez to the west and the Sierra Madre foothills to the north and east.

**Background:**
With a substantial endowment of surface water from the large Yaqui River basin for irrigation, the Yaqui Valley is part of the ‘bread-basket’ of Mexico—a primarily wheat-based agricultural system with the agricultural legacy as the birthplace for the Green Revolution for irrigated wheat. Irrigable land along the Yaqui River encompasses 228,000 hectares in the Yaqui River Irrigation District, plus an additional 25,000 hectares of Yaqui indigenous reserves. The population in the Valley has climbed continuously during the past 60 years and currently is near 400,000 (INEGI, 2000), mostly concentrated in the growing urban center of Ciudad Obregón.

The coastal Yaqui Valley experiences a semi-arid climate quite similar to Arizona, with annual local rainfall averaging approximately 300mm. Over half of the annual precipitation for both the Yaqui Valley and the entire Yaqui River basin is concentrated in the summer months of June through September. The mean annual flow of the Yaqui River is ~3300 million cubic meters (MCM), though this flow is highly variable and has only averaged ~2000 MCM during the recent drought. Three reservoirs provide storage capacity of nearly twice the mean annual flow of the Yaqui River, of which an average of ~2400 MCM has been extracted for agriculture in the period 1969-2003. Groundwater is also pumped for agriculture and some urban supply in the coastal Valley, historically between 100-400 MCM annually.

Agriculture by far is the largest sector of water use in the Yaqui River basin (~95% of all allocated water), with only minor upstream water use (mining concessions, small municipalities, and small agricultural areas of less than 2000 hectares). Within the Valley, wheat remains the dominant crop in the Yaqui Valley, with significant area in maize, cotton, and oilseeds also part of the mix. Lesser quantities of citrus, vegetables, alfalfa and garbanzo are grown, although poorer farmers grow wheat and maize almost exclusively. With the exception of vegetable crops, all crops are irrigated through gravity-flow methods (furrows or basins). Declining prices and reduced water supply has increased interest in changing to appropriate high-valued crops.

**General Water Issues:**

(1) **Modernization improvements:** Long-term infrastructure improvement is a major issue on the water management agenda in the Yaqui Valley, involving external as well as local/regional actors. Capital outlays for the current plans will be about $700M pesos in the form of loans directly to the Irrigation District (50%) and budgeted from CNA, the Government of Sonora, and other sources (50%). Recent drought has accelerated this planning, which includes canal lining, improved canal structures lining as well as increased groundwater use (Comision Nacional del Agua, 2003).
(2) Increased groundwater development: Due in part to the recent severe drought conditions in the Yaqui Valley, the potential for increased groundwater development has received increased attention in policy and research circles. As part of the Modernization plan, up to 200 additional wells have been planned, increasing maximum bulk extraction rates by 50% (400->600). Both international and local universities are conducting research on the sustainability of such development in the context of the Yaqui Valley’s distinct groundwater systems.

(3) Annual reservoir planning: With drought, annual reservoir planning has become more difficult. Farmers must wait until after the rainy (monsoon) season to know how much water will be allocated in the coming year; this uncertainty impairs farmers’ planning and their capacity to obtain credit.

(4) Coastal issues, instream flow and agricultural drainage: These issues currently receive less attention than “infrastructure” issues but have potential to constrain sustainable development, similar to environmental issues that have arisen in other irrigated agricultural systems (such as the San Joachim Valley of California). Drainage to the Sea of Cortez has been associated with algal blooms. Extensive localized groundwater pumping for municipal use has

1. Please identify the main organizations involved in strategic planning and management of water resources. Who works for them? What are the main activities and tasks they perform? What are the goals and mandates? What important resources do they control?

The main organizations considered by this case study include: the Yaqui River Irrigation District, the National Water Commission, water user associations, and several universities with ongoing research in the Yaqui Valley.

The Yaqui River Irrigation District, jointly accountable to water users and the federal government, oversees the allocation and delivery of water resources and the maintenance of water conveyance infrastructure. The Yaqui River Irrigation District was created in 1992, when the federal government began to decentralize water resource management throughout the country. The operations of the Irrigation District are managed by technical engineers but governed by the water users themselves. The Irrigation District is spatially divided into 42 modules of water users, each electing two representatives onto the District’s governing council. A few members of the District’s technical staff previously managed the Valley’s water resources through the National Water Commission before the transfer took place. The water users are almost entirely farmers, who purchase water delivery services volumetrically from the Irrigation District. Each Irrigation Module represents the farmers who own and operate the area within it. Individual farmers can sell water back to their module or purchase extra water. Such transactions are completed first within each module, while inter-module transactions are aggregated at the module scale.

The National Water Commission (CNA) is a government organization under the direction of the Secretary of the Environment and Natural Resources (SEMARNAT). Its mission is to administrate, operate and preserve hydrological resources within Mexico. In the Yaqui Valley, CNA allocates surface and
groundwater resources to the urban, industrial, and agricultural sectors; oversees the maintenance of reservoirs, dams, and major canals; and supervises the Irrigation District’s activities.

Funding sources for water-related research (primarily universities) in the region include: CONACYT (National Commission for Science and Technology), CNA, the Irrigation District, the World Bank, and some international nongovernmental organizations. The State Water Commission of Sonora (CEA) is a recently-emerging influence on water management in the Yaqui Valley, and funds some studies. OOMAPASC and COAPAES are local and state agencies, respectively, concerned with municipal water supply.

2. List the kinds of knowledge each of the main water management “players” has, creates or uses. What are the most important knowledge-intensive decisions and actions that need to be taken? Whose knowledge is used, and whose is neglected?

Knowledge either created or used by the players in the Yaqui Valley falls into three rough categories. Technically-based system knowledge encompasses what is known generally about the processes and properties of the hydrological system, the biophysical agricultural system, and a professional understanding of how irrigation infrastructure functions. System knowledge is produced both by researchers working independently and on their own initiative (e.g. ITSON, Stanford) and researchers who are contracted by decision-makers at the CNA and Irrigation District (e.g. UNISON, IMTA). Operational knowledge relates to the operation of physical infrastructure and groundwater reserves and the delivery of water resources to users. Technical managers typically acquire operational knowledge through their collective experiences, rather than from complex models. Finally, long-term planning efforts rely ostensibly upon integrated planning knowledge, which combines regional economic development and water resources planning. This knowledge includes engineering feasibility studies and project proposals developed through international finance institutions.

Important knowledge-intensive decisions and actions include (1) infrastructure development and maintenance, (2) groundwater management, (3) annual diversion and pumping planning decisions, including allocation of water between users, and (4) field level investment and water use decisions, (5) institutional design. The CNA applies rules of thumb to annual water diversion and groundwater pumping decisions, although a new set of risk-based guidelines is currently under approval. The Irrigation District relies heavily on its operational experience and auto-generated data to oversee water allocation and delivery. At the farm level, water use is determined by crop, irrigation, and field investment decisions, which are based on technical assistance provided through the organizations that finance them and on their personal experiences. As for infrastructure investments and institutional design, it seems that international finance institutions (i.e. the World Bank Group and the Inter-American Development Bank) have initiated and/or influenced the major decisions, including decentralizing water management institutions, transferring management to water users, modernizing district infrastructure, and expanding groundwater development. Feasibility studies and project proposals, mostly contracted through scientists, are used to justify the initiatives.
3. How is knowledge shared or contested by key organizations and individuals? Which actors and linkages help produce knowledge potentially useful for sustainable management of water resources? Are there any players with important intermediary roles? What do they do?

For short-term management, water-related knowledge is shared between the Irrigation District and CNA under accountability provisions in the Irrigation District charter. Beyond these simple exchanges of data in reports (which included distribution data, water quality (surface and groundwater), and groundwater levels), Irrigation District and CNA representatives also meet as a Hydraulic Council—an intermediary body of sorts which coordinates annual irrigation plans with reservoir management plans. The success of the Hydraulic Council seems to depend on the effectiveness of key individual representatives that have system-level understanding as well as personal trust and networks across organizations. National-level CNA officials give final approval on reservoir management plans, but their rationale (model-based?) for approval is not well known to managers in the Yaqui Valley and has been challenged before.

For longer-term infrastructure and development planning (surface water and groundwater), external consulting expertise is sought, but knowledge gained from that process tends to remain within the CNA-Irrigation District commission on “modernization”. General groundwater-related research is shared between academic researchers throughout Sonora in annual regional conferences and occasionally national-level meetings—knowledge potentially useful for planning purposes. More often groundwater-related knowledge has linked to the Irrigation District directly through consulting relationships. International development banks, involved in the large-scale “modernization” plans for the Valley, also have filled an intermediary role with groundwater, with recent calls for proposals from hydrology researchers in the region. A CNA-mandated Basin Council does exist for the Yaqui and Matape rivers, but it does not seem to be an active forum for knowledge exchange on large-scale issues. One attempt for planning greater economic development was the “Cajeme 2020” forum which featured some participation of water planning agencies, but the role of the Irrigation District and CNA is unclear.

4. Have the key organizations been able to respond effectively to challenges requiring applications of current knowledge or the need for new information? How is performance of the players or their relationships monitored and evaluated? Are there transferable lessons from this experience?

The main challenges for water management recently have been a recent prolonged drought and the need for increased agricultural reliability in the region in the face of both drought and market uncertainty. In the extreme drought conditions of the past eight years, organizations have done reasonably well in the face of unprecedented conditions. Organizations and researchers mobilized to gather some operational knowledge (new surveys to better estimate of reservoir storage, and expanded groundwater measurements, for example). At the same time, mechanisms were not in place to gather and use other types of knowledge (short-lead climate predictions, and risk in reservoir operations, as examples). As an emergency drought response, a hastily-organized but well-coordinated “drought program” was quite integrative, involving crop prioritization, incentives for proper fallowing, and sharing of aquifer water.
For longer-term agricultural reliability, the “modernization” plans of the Irrigation District in coordination with CNA have sought private consulting advice on how they can improve efficiency both in physical works and in institutional practices (designed to streamline water planning and delivery for irrigation).

It is unclear how “performance” of the organizations (CNA, Irrigation District) is evaluated by other water users. One lesson may be that where responsibility (and liability) is obvious, there is more follow-up given to gathering appropriate knowledge (where the Irrigation District increased data collection on groundwater in the region).
Case Study:

Location: The Upper San Pedro (USP) Basin is located in southeastern Arizona about 50 miles southeast of Tucson. The headwaters of the San Pedro River are in Mexico, and the river flows north across the international border 90 miles to the northern boundary of the study area. Approximately 80% of the Basin municipal demand exists within the Sierra Vista sub-watershed (SVS) and therefore our focus is on this specific segment of the basin.

Background: Management of precious water resources in the USP is one of the foremost political and socio-economic issues in the region and has widespread ramifications on growth, livelihoods, the economy and the environment. Ground water is the primary source of water for the residents of the SVS, and water outflow from the SVS, including water withdrawn by pumping, currently exceeds natural inflow to the regional aquifer. As a result, ground-water levels in parts of the aquifer are declining and ground-water storage is being depleted. The Upper San Pedro Partnership (USPP), a consortium of 21 agencies and organizations, is the primary water management decision maker regarding water resources for the USP Basin. This voluntary but highly structured organization is unique in the United States, as it is a wholly voluntary organization that has been required by Section 321 of the Defense Authorization Act of 2004 to achieve “sustainable yield” by 2011. Considering the complex environmental/ecological, growth, political, and water management issues which intersect in the SVS, this portion of the USP basin provides a complex and relevant case study in participatory management of water resources and sustainability as well as water augmentation in Arizona.

General Water Issues: Semi-arid desert location. The USP River supports a critical ecological corridor which is habitat for over 400 species of animals. The groundwater contribution to baseflow makes the riparian system relatively resistant to drought unless pumping intercepts the groundwater. The area is highly prone to drought and to a lesser extent, floods during summer monsoon season. The Upper San Pedro Partnership (USPP) has received multiple appropriations from Congress to support its activities and has a congressional mandate to meet “sustainable yield” by 2011. Sustainable yield has not been fully defined, but at the outset has been taken to mean that outflow must be less than inflow to take in to account the needs of the river and the riparian habitats. The consequences of not meeting this deadline are not explicit but could eventually include loss of the Ft. Huachuca military base which is the largest employer in southern Arizona and a major local economic driver, loss of congressional support for research and management activities in addition to the environmental consequences. Primary issues are framed around how to reach sustainable yield. Many options are on the table including water augmentation, water conservation, water harvesting, water importation, limits on growth, regulatory measures. Numerous water conservation, treatment and recharge projects have already been implemented, though most are relatively small-scale.
Please identify the main organizations involved in strategic planning and management of water resources. Who works for them? What are the main activities and tasks they perform? What are the goals and mandates? What important resources do they control?

Main organizations: A consortium of 21 agencies is responsible for planning and managing use of water resources.


State Agencies (4): State Land Department, Arizona Department of Water Resources (ADWR), Arizona Department of Environmental Quality (ADEQ), Arizona Association of Conservation Districts

Local Agencies (5): Cochise County, Sierra Vista, Bisbee, Tombstone, Huachuca City


These organizations work collaboratively as the Upper San Pedro Partnership in an attempt to manage water resources and meet the 2011 deadline. While the USPP has no direct regulatory power, many of its members are in positions of political power and government positions and the monies appropriated to the USPP by congress are put towards various scientific studies and water conservation efforts. The USPP has a $46.8 million five-year financial plan with the majority of money coming from the US Congress.

List the kinds of knowledge each of the main players has, creates or uses. What are the most important knowledge-intensive decisions and actions that need to be taken? Whose knowledge is used, and whose is neglected?

Due to the diverse nature of the USPP, various individuals and organizations bring differing forms of knowledge and ideas to the table. The majority of scientific data used by the USPP is provided by organizations within the USPP including USGS, ADWR, BOR, ARS as well as by SAHRA (affiliated with the University of Arizona). In addition, certain studies are contracted out. The results of these scientific studies are brought before the partnership and taken into consideration as part of the decision making process. There is a wealth of information on the Sierra Vista sub-watershed; it is likely among the most studied watersheds in the world. These studies are funded by the USPP and the results are interpreted by the members of the USPP and used accordingly in the decision making process. It is widely agreed that the studies are of an extremely high quality; primary issues relate to how to respond to the information that is available. Currently the most important knowledge-intensive decisions and actions that need to be taken revolve around
implementing high-yield water projects including augmentation and possibly importation in an effort to meet the 2011 deadline. Land use planning mechanisms for connecting water supply and land development are also under consideration. Getting regulatory measures in place is also critical to this effort and ADWR plays a role in this.

How is knowledge shared or contested by key organizations and individuals? Which actors and linkages help produce knowledge potentially useful for sustainable management of water resources? Are there any players with important intermediary roles? What do they do?

Knowledge in the case of the Upper San Pedro is primarily scientific and emanates from the many studies that have been conducted on the SVS. This knowledge is shared and discussed in an open forum at USPP meetings. Debates regarding knowledge may occur within the USPP when individuals interpret knowledge differently or have differing opinions on how the knowledge should be used in the decision making process. As stated above, knowledge is generally produced by respected agencies involved with the USPP. Dr. Holly Richter of the Nature Conservancy is a key player who holds an intermediary role within the USPP. She heads the Technical Advisory Committee (TAC) which is one of many advisory committees within the USPP. An integral part of her job is to take the scientific information from the studies and to put together strategies, proposals, and projects incorporating this knowledge and then present this to the Political Advisory Commission (PAC) which generally adopts the proposals. The USPP also has a public outreach committee to act as an intermediary between the USPP and the public. In general with the committee system used by the USPP there are various intermediaries who act with and between different groups.

Have the key organizations been able to respond effectively to challenges requiring applications of current knowledge or the need for new information? How is performance of the players or their relationships monitored and evaluated? Are there transferable lessons from this experience?

The gathering of data and information has been quite extensive due to the collaboration of agencies involved in the USPP.

Most everyone agrees that the USPP has been extremely effective in acquiring knowledge and new information of the highest quality through the many scientific studies they have commissioned. When evaluating their effectiveness in meeting the 2011 “sustainable-yield” mandate, opinions diverge greatly and the true results will only be known over a longer period of time based on the health of the Upper San Pedro River and the sustainability of the water supply, the environment, and the social and economic activities that characterize the area and comprise the livelihoods. Monitoring and evaluation of the players is somewhat ambiguous. Public officials involved with the USPP are directly accountable to the public and the success of the USPP is tied to congressional appropriations, however there is not a systematic and progressive on-going method of evaluation in place.
What questions about the use of scientific information in water management would you like to see answered at the workshop? Even where rigorous scientific information exists, there are regulatory and political limits to implementing better water management strategies based on the data, perhaps this could be further examined.
Ceará, Brazil

Case Study:

Location: Ceará is an economically stressed, primarily semi-arid state of nearly 8 million people in an area about 148,000 km² on the northeastern coast of Brazil. The rainfall in the vast interior of the state, called the sertão, is highly variable both temporarily and spatially. Annual precipitation averages around 700 mm and occurs during the February to May “rainy season;” however, rainfall varies widely throughout the state, and severe drought, sometimes associated with ENSO, is a regular phenomenon. Due to a large rural population dependent on rain fed agriculture and rural communities with precarious drinking water supply systems, drought is a major concern for policy-makers. The selection of Ceará as a case study is based on its semi-arid environment and highly vulnerable population, a well-defined institutional infrastructure addressing water management, strong predictability of the local climate system and related water supply based on El Niño forecasts, strong political will at the state governmental level, and identifiable partnerships between local technical and resource management agencies.

Background: Ceará has no naturally occurring permanent rivers or lakes, but stores surface runoff in large networks of reservoirs. Nearly 90% of the state water supply comes from this source. There are 11 large water reservoirs and 126 small reservoirs in the state, with a combined total capacity of 17.8 billion cubic meters. There are also 210 km of canals and some 300 km of aqueducts and distribution networks. The management of dams and reservoirs has allowed three major rivers, once only seasonal, to run year-round, and this water is used for both agriculture and human consumption. Ceará has long suffered from rainfall deficits, but the management of surface waters as part of an integrated system was only institutionalized in 1987 with the creation of the State Secretariat for Water Resources (SRH). In 1992 a State Water Resources Plan was put in place, and in 1993 the Water Resources Management Company (COGERH) was established to manage water resources in Ceará. In 1996, COGERH began charging for bulk water and in 2001 a system of participatory Water Basin Committees was implemented in eight of the principal watersheds.

Please identify the main organizations involved in strategic planning and management of water resources. Who works for them? What are the main activities and tasks they perform? What are the goals and mandates? What important resources do they control?

Federal Agencies (3):

National Water Agency (ANA): The Brazilian National Water Agency, ANA, was created in July 2000 with the mandate to enforce the National Policy on Water Resources. ANA is an executive branch from the Ministry of Environment. It is managed by a Board of Directors and it has administrative and financial autonomy to regulate the multiple water uses. Funded by the federal government.
National Department of Works to Overcome Drought (DNOCS): Part of the Secretariat of Water Infrastructure, Ministry of Integration, DNOCS was first created in 1909 to solve the problem of drought. Although a federal agency, its headquarters are located in Fortaleza, the capital of Ceará. DNOCS has been responsible for the construction and management of federal dams and reservoirs, including large irrigation districts.

State Agencies (6):

State Secretariat of Hydrological Resources (SRH): SRH is the agency of the state government that establishes the state water policy supervises the management of water resources, primarily through the semi-public water management company, COGERH.

State Water Resources Management Company (COGERH): COGERH manages the entire water supply of the state, including water basins, reservoirs, canals, and pumping stations. The company sets the fees for bulk water and operates a system of fee collection. COGERH coordinates with the Water Basin Committees, and makes annual allocation decisions on the supply of water. It also monitors water quality.

State Foundation of Meteorology and Hydrological Resources (FUNCEME): FUNCEME is a major source of knowledge that guides water management decisions. It collects local and regional meteorological data from over 100 computerized stations and monitors local stream flow data. FUNCEME has a sophisticated forecasting capacity and annually issues a set of forecasts on the upcoming rainy season. It provides technical support to COGERH for management of water.

State Superintendency of Hydrological Works (SOHIDRA): Responsible for building and maintaining the state's water resources infrastructure.

State Water and Sewage Company (CAGESE): CAGESE is the semi-public company that treats and sells drinking water to consumers, mostly in urban centers and cities. In Fortaleza, it also runs the metropolitan sewage and sanitation system.

Secretariat of the Environment (SEMACE): SEMACE is the environmental protection agency for Ceará and is responsible for assuring water quality and appropriate sanitation.
Local Agencies:

Basin Management Councils and Reservoir User Committees: They play a role in producing the Basin operation plans and mediate water usage conflicts. COGERH serves as Secretariat for these, responsible for convening and supporting their activities.

a) Management Councils: Include water users, civil society, and representatives of key institutions. The councils basically decide the annual operation rules for the major reservoirs through negotiations among its members about water allocation, and under the leadership and guidance of COGERH. No systematic funding.

b) Reservoir User Committees: The reservoir commissions include users and other stakeholders interested in or affected by water allocations in the area of hydrological influence of each "isolated strategic reservoir". Informal institutions created by the state (COGERH)

List the kinds of knowledge each of the main players has, creates or uses. What are the most important knowledge-intensive decisions and actions that need to be taken? Whose knowledge is used, and whose is neglected?

Types of knowledge vary from physical climate (FUNCEME) and hydrological information (ANA, FUNCEME, COGERH) to engineering (DNOCS) and social and economic information (CAGESE, Basin Management Councils and User Committees). Over the short run, the critical decisions to be made by the main players focus on the supply and demand of water for a given year. The knowledge that informs these decisions is derived from rainfall forecasts and precipitation (FUNCEME), from stream flow and storage data (FUNCEME, COGERH), from the situation of urban water distribution systems (CAGECE, Basin Committees), the needs of irrigated agriculture (DNOCS, Basin Committees), and the needs of industry. More long term decisions, regarding for example projections of water supply and demand, rely upon estimates of structural (sectoral) economic change, population growth, land use, hydrology, and climate.

How is knowledge shared or contested by key organizations and individuals? Which actors and linkages help produce knowledge potentially useful for sustainable management of water resources? Are there any players with important intermediary roles? What do they do?

There is a dynamic between the policy-makers, the managers, and the main consumers groups, each represented by key actors or organizations. SRH, together with the governor of the state, sets water policy, including long-term investment policy. Now, the government is deeply engaged in political negotiations over a trans-boundary transfer of water from the large San Francisco River into the state of Ceará in order to assure water supplies through extended drought periods. The national ANA and the Ministry of Integration are involved in generating the knowledge that will support political decisions (e.g., how much water can be spared, etc.). Water management decisions are made by COGERH, implementing the water policy. The major decision is the annual allocation of
water and the sustainability of the water supply. The state maintains its own capacity to generate the knowledge that guides these decisions, although the federal university and DNOCS are also participants. FUNCEME monitors many aspects of the semi-arid environment, including vegetation, stream flow, rainfall, etc. This information is made accessible to all sectors of the state government. COGERH maintains a technical department that monitors storage capacity, water use, water sales, etc. DNOCS directs water to irrigation projects throughout the state. CAGECE purchases bulk water for its water treatment plants in urban centers. The system is highly integrated and information is widely shared. The major policy concerns are to create a low-risk, sustainable water supply that meets the new demands caused by rapid urbanization, expanding industry, and intensive, high-value agriculture.
Have the key organizations been able to respond effectively to challenges requiring applications of current knowledge or the need for new information? How is performance of the players or their relationships monitored and evaluated? Are there transferable lessons from this experience?

The construction of the new Integration Canal from the major now-perennial river basin in the south of the state to the capital city and the newly-implanted industrial complex provides an effective example of applying knowledge to create an infrastructure consistent with a state-wide water policy. The use of climate forecasts has directly supported the management of the water supply and annual allocation decisions. The major lessons from this case study include: a coherent and consistent state water policy has improved the efficiency of decision-making; clear paths of knowledge production with open access vastly increase the use and value of the knowledge; and the attempt to bring all classes of water users into the management process, including the provisioning of knowledge, has reduced potential conflict among different users.

What questions about the use of scientific information in water management would you like to see answered at the workshop?

What is the role of informal relationships in the transfer of knowledge between actors?
Upper Ping River Basin, Thailand

**Case Study:**

Please describe the location, background and general water issues faced in your case study area (no more than one-half page).

**Location:** Upper Ping River Basin

**Background:** Upper Ping River about 450 Kilometers long. Its basin covers an area of 25.3 thousands square Kilometers. About 2.5million people live in this basin. Most of the households are food secured with income tattering comfortably over the national poverty line. In the upland area, ethnicity groups are diverse and often collectively referred to as the hilltribes. In recent history (1970 to 1990), development literatures about the area were mostly on finding agricultural alternatives for opium crop control. At present, Opium is no longer a major concern. Much of the attention now is focus on conserving forests while ensuring a level of welfare for communities living in them.

The river passes through Chiang Mai, the biggest city in Northern Thailand and Chiang Mai sister city, Lamphoon. Chiang Mai is fast growing and currently in the national blueprint, it aspires to be the gate way to trade in the entire Mekong region where the biggest economy is China. An industrial estate producing mostly electronic parts is one of the most important sources of income and employment for Lamphoon.

The topography of this basin is mountainous with numerous small valleys. Natural vegetation pattern is mosaic; with patches of both ever green and deciduous forests that has a long history of human interaction throughout the basin. About 78% of the basin is considered forestland; 16 % agricultural land; 3% residential land; and remainders are waterways, reservoirs (1%), and other land uses (2%)\(^1\). Ping river agriculture is mostly rice, cash crops and fruit tress such as Logan and Lichee.

The basin is in monsoon weather system. The climate is strongly seasonal with an annual rainfall of 1,100 to 1,500 mm of which over 80% falls between May and October in the rainy season. November to February is relatively cool and dry with average daily minimum of just over 10 Celsius. March to April is the warmest dry month with temperature of about 42 Celsius in a hot afternoon.

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General Water Issues:

Floods
Water insufficiency in driven by increase demand intersecting with recurred dry season low flows
Water Quality (Sediments, debris, and pollution)
Please identify the main organizations involved in strategic planning and management of water resources. Who works for them? What are the main activities and tasks they perform? What are the goals and mandates? What important resources do they control?

Thailand’s National Water Resource Committee (NWRC) was established in 1992 as the steering committee overseeing the implementation of integrated water resources management (IWRM) process. Department of Water Resources (DWR), established in 2002, is the secretariat office of the NWRC.

NWRC consist of 35 representatives and is headed by the Prime Minister. Most of the representatives are head of government departments with water related mandates: from offices to do with economic and land use planning, natural resources conservation, in addition to organizations that historically played to most important role in Thai water management the Royal Irrigation Department, and the Electricity Generation Authority of Thailand (EGAT).

The board also includes user group representatives, non-government organizations, academic, and local representative selected from river basin organizations and local governments- selected by the head of the board, the Prime Minister.

Upper Ping River Basin Organization (Ping RBO) is one of 29 river basin organizations coordinated and supported by DWR. It connects with its local administrative groups through planning, information, and public relations working groups (see diagram - from DWR manual B.E. 2548)
List the kinds of knowledge each of the main players has, creates or uses. What are the most important knowledge-intensive decisions and actions that need to be taken? Whose knowledge is used, and whose is neglected?

Ping RBO, very much like other RBOs, knowledge intensive decisions and actions, are about building water related infrastructure such as water supplies for towns and villages as well as building irrigation systems to support agriculture activities. Most of the data is gathered by line agencies represented at the national water board; more importantly hydrological data is generated by Royal Irrigation Department.

A frame work is currently developed for data gathering by local administration at sub-district level (Tambon Administrative Organizations consisting of about 15-20 villages). It is expected that bottom-up knowledge contributions will play a greater role in water management decisions in the future.

Main process framework of RBO is IWRM, there are 4 principles (see www.gwpforum.org), supported by UN, ADB, WB, and NARBO.
How is knowledge shared or contested by key organizations and individuals? Which actors and linkages help produce knowledge potentially useful for sustainable management of water resources? Are there any players with important intermediary roles? What do they do?

Upper Ping RBO is the arena where knowledge is shared. It is also the actor with important intermediary roles connecting local networks, user representatives, to government planning agencies and implementers (see diagram- David Thomas 2005). Head of the planning committee, for example, is from the Royal Irrigation Department, hydrological science unit for the region. The overarching challenge is to link local needs to national development agendas and resources. Through the agency internal echelons, head of RID is also represented in the national board.

Upper Ping RBO consists of 37 representatives (line agencies, user groups, civil society, headed by Provincial governor of Chiang Mai) and is connected to 15 tributary committees. At the provincial level, 2 provinces and 29 Districts, 236 Sub-districts. There are about 2400 villages in the basin.

Have the key organizations been able to respond effectively to challenges requiring applications of current knowledge or the need for new information? How is performance of the players or their relationships monitored and evaluated? Are there transferable lessons from this experience?

Information is often limited, but it is unclear how more information could improve performance. Monitoring & evaluation, with respect to knowledge production and sharing, may be limited.

National Water Resource Committee ultimately needs to be able to respond effectively to challenges requiring applications of currently knowledge or new information. From the bottom, sub-district organizations (TAOs) and other decentralization agencies also need additional capacity to effectively respond and to create knowledge from up to date data and information.

What questions about the use of scientific information in water management would you like to see answered at the workshop?

What scientific information could be use to foster effective institutions arrangement and to design policy instruments in river basin managements and how?

Should there be formal procedures of assessment introduced? If so, how should they be designed?
III. Key Themes and Questions

Theme 1: Changing goals

On the second day of the workshop, the group was divided into three breakout sessions, with members of each case study team in each of the three breakouts. This summary combines the input of the three breakout groups on each of the three themes, as reported back to the group in plenary session.

All four case study areas have been experiencing changes in the way goals are set and implemented relative to water management. In Brazil there has been a shift in power from the federal government to state government, and a similar shift in Yaqui. In San Pedro there are shifts also, originally the decision-makers were focused on technical/information needs, now have a more stakeholder based approach. In Thailand, there has been a shift in authority to river basin committees from central authority.

The World Bank is playing a role in most of the cases (all but San Pedro). Shifts in the goals of funders affect the projects they fund. The Bank demands a shift in goals and institutional policies in exchange for the investment. The goals of the World Bank have changed, as they are responding to changing conditions. Water markets (pricing mechanisms) were critical to the Bank in the first agreement with Brazil. In the second, there was a more limited requirement for market based approaches. Then in the third agreement the Bank required participatory water decision making. Accountability is another pillar of the Bank, privatization is getting less important. Lessons: countries should have their own policies, not just be subject to bank policy.

The issue of funding is quite important for what decisions get made. When it is self-funded it has different characteristics, meets the requirements of the water users better. In the San Pedro, they get to make decisions on how the Federal money gets spent, even though they are a local group. This is an unusual situation, the normal Federal system does not provide funding to voluntary partnerships for resource management.

Management objectives are generally controlled by central government. Water is managed for multiple purposes: energy, agriculture and municipal use; the benefits of managing water don’t all accrue locally, so it is not clear that self financing is a good thing. A relationship between costs and benefits is a good thing. Water rights are required for private investment; then when trading starts the actors change into more private interests. However, managing water as a commodity brings its own agenda. Water markets aren’t possible without a strong water rights system. There are very few systems that give entitlements to each of the users.

There is a general concept of sustainability as a goal in each case, but sustainability is not an “official” goal except for the San Pedro Partnership (this is a relatively recent development, as a result of federal legislation that requires that they achieve sustainability by 2011). The concept of sustainability is evolving in that case as well.
Shifts in goals come from leadership, crisis and opportunity in these case studies. Water reform in Mexico is an old idea, but management changes required specific opportunity (a combination of physical and social factors). Avoidance of crisis may have been more of a driver in San Pedro and in Thailand. Resolving water allocation decisions was the number one demand of society; creation of CNA and agricultural reform caused the shift in Mexico. Fiscal crisis was part of the change, but it was not the key driver.

Real institutional change takes time, as well as economic incentives. Drought definitely changes water users’ thinking about efficiency and sustainability in the Yaqui Valley. This is an external force in the system. The new thinking in Ceara is not fighting drought, it is how to live with drought. Approaching water management with an acknowledgement of limits is a critical change in the system. This is the major change in goals and perspective and is a much more sustainable approach than the previous infrastructure-based solution.

The crisis of the workers canal in Ceara is an example of the infrastructure-based approach to dealing with drought. 2 million people in Fortaleza would otherwise have been without drinking water. In general, the infrastructure improvements have been a response to drought crises. However, the changes in management are generally not crisis driven. Now they are management and conflict resolution focused. The concept of water committees is focused on negotiation, not more investment.

Theme 2: Contested knowledge

Contested knowledge in the Ping Valley relates to changes in water law, charging for water, and how upstream activities impact downstream users. In the Yaqui Valley, the hydrologic facts were characterized by the national water commission and paid consultants, ie should groundwater be managed as part of the total water availability? In Ceara there is a conflict between users dependent on surface water reservoirs (such as fishermen) vs downstream users; different interests have different views on releases. In the San Pedro, contested knowledge is focused on whether or not there is enough groundwater to sustain the river spatially (at all stretches) and over the long term. To a lesser extent, ability of streambeds to store water vs artificial recharge is contested knowledge.

Contested claims in many of the situations are or could be resolved by increased joint observations to build trust. People could resolve the issues more easily in all cases by collecting more information collaboratively. Good working relationships between individuals is also key in helping resolve the contested knowledge.

Groundwater issues are similar in the Yaqui and in San Pedro: both are challenging the models and the facts about water availability. If there is agreement on a method and there is a third party to generate the knowledge before hand, can reduce conflict.

Almost all the cases formed a technical assessment group. In the Ping Valley, there is a pricing problem and the upstream vs downstream issues are major and unresolved. In
Brazil, conflicts are being resolved by basin committees; rain prophets vs other sources of information have a role in forecasting.

In Brazil and Mexico, not just competing models (information) but differences in willingness to accept risk that affects decisions. It is critical to recognize that willingness to accept risk has a big effect on use of knowledge in decisionmaking. Generally, people don’t know how to deal with uncertainty in forecasts, they can’t describe probabilistic information very well, and would rather have deterministic information.

There is a lot of room for contesting knowledge about social and economic assumptions; does social science data get contested more than physical data? There are simple and complex factors in both arenas. Contested results or outcomes, are often based on a value judgement.

Science is viewed as being used as a weapon in the Thai case, in part because ordinary citizens can’t contest it.

We shouldn’t underestimate the role of leadership in incorporating multiple voices in the solution. This is true in the Thai case – the leadership is deferred to regardless of the discussion.

Are we objectifying knowledge, making it more concrete than it is in the real world? Perception is deeply rooted in cultural views, knowledge is sometimes contested because it is inconsistent with their world view. Contested relationship between government and the public, and a patronage approach to citizens change the way knowledge is perceived. The way they perceive government in Thailand is in a confrontational way. They don’t acknowledge what the government actually is doing, so the reality is not the same as what is perceived. For example, people on the basin committees dispute rates of discharge because it is government knowledge. The source of information is tied to the agenda of those who produce it.

When people have special interests, they will perceive knowledge differently, it is no longer objective. There is more contention of knowledge the more a system is regulated. This is consistent with the Thai situation. In Mexico, the main source of contention is amount of groundwater in storage.

“Facts” are disputed even in scientific arenas. Perception is a critical point in public policy. Agencies also ignore certain kinds of information that are not consistent with their world view. Building a base of facts is a common technique in consensus building.

Contested knowledge in the San Pedro has diminished as a result of trusted agents being in charge of data, peer review process for information has worked well. Design of study methods and data sources at the beginning avoids conflict at the end. This is one of the strategies for success.
Capacity of reservoir system is undisputed in the Brazil case, there is not much to argue about. But there are conflicts about current availability vs the likelihood of water availability in the future (floods and droughts). Other conflicts relate to which reservoir to release water from. They need projections of future precipitation in order to make decisions about allocations in the current year. There are arguments about how to deal with future uncertainty. With urban supply there is very high risk aversion, irrigation is low risk aversion by comparison, they can make seasonal decisions about planting. However, there are social impacts to these decisions, saving supply for the next year can affect users this year.

**Theme 3: Multi stakeholder deliberations**

In Brazil, there are two different councils. Local basin councils are concerned with reservoir operations, and meet two or three times during the year. These are actual water users. The basin committees include federal, state and private agencies. In the San Pedro case, the stakeholder group includes 21 agencies, interested more in scientific knowledge, planning and environmental protection. They have an advisory commission (the Policy Advisory Committee) for conflict resolution.

In the Yaqui Valley there are two committees, one is local, one is federal. The local supports regional decisionmaking, the national one focuses on all reservoirs. The local ones analyze water requirements for each year and proposes it to the national committee, which makes a decision. Most of the proposals that the local committees propose are accepted. They use a common methodology in both cases. Yaqui basin planning is annual. They don’t use climate forecasts because it is too risky to allocate water that way. CNA only allocates water that is in storage (not based on projections).

In Thailand there are national, river basin and local committees. Planning for the future includes many considerations – need power/authority to make decisions at the local level.

Inclusion of stakeholders helps to produce more knowledge, build the platforms for decisions. It is not just spatial (geographic) representation, it matters who is at the table. Having key players at the table makes a big difference in outcomes. Decision processes need accountability both upwards and downwards. This same thing was seen in Yaqui and Thailand.

Key individuals are really important, can do shuttle diplomacy even if not powerful themselves. Should participants be selected on negotiation skills rather than authority? Would manage conflict better that way. Differences between whether the committees generated information themselves, in Thai and Ceara, they did not generate information, in Yaqui different alliances were successful in generating new reports and information. SPP does fund studies, etc.
In Brazil, COGERH has constant field presence. Managers live in each basin, have a stream of dialogue with the user groups because they have local knowledge.

We misrepresent the concept of knowledge – it shouldn’t be called coproduction. It is colearning in Ceara. It is not a concrete piece of information, there is a disconnect between the state and the locals. State reps have privileged access to information. Learning together is the secret to success in the basin committees.

Time is a necessary ingredient, can’t be substituted for other resources. Participatory learning takes a long time.

In Thailand, river basin user groups vary dramatically based on what sectors they represent, also the types of learning are different. The irrigation system has a 700 year history, they learn from year to year. The multistakeholder group is much more complicated and recent, but learning is very important. How quickly is the data integrated and shared between groups?

Key lesson: Take the time to develop shared understanding so that the stakeholders will know the impacts of decisions.
IV. Key Knowledge System Insights in Water Management

1) There is a difference in perspective between single user groups (such as irrigation districts) and multistakeholder groups. Single user groups seek knowledge narrowly suited to their interests, supporting their perspective, while multi-user groups demand attention be paid to broader sources of knowledge. When people have special interests, they will perceive knowledge differently, less objectively. A multi-stakeholder approach may be a precondition to sustainable water management. However, coming to consensus in a big group with multiple interests is much more difficult than with a small number of players. Representation is more important than sheer numbers of people at the table.

Multistakeholder bodies or deliberative processes are more likely to bring in the diversity of interests, perspectives and kinds of knowledge needed to negotiate sustainable water management objectives than a single-use group although the later may be very effective at getting the system to work for its often purely economic goals.

2) The role of social science needs to be as carefully incorporated into decision-making as physical science. Perceptions of knowledge are critical, and are frequently more important than the “facts.” This is particularly important when the creators of information are separated from those who use it and/or there are trust issues. Knowledge is bounded with interests. Incorporating social and physical science is a different subject than perception of knowledge. Validation of knowledge is a social process.

There is a necessary complementarity between “hard” and “soft” knowledge, technical information about infrastructure and hydrology vs. knowledge of public and private behavior, politics and institutions, politics and policy, funding. Both sources of knowledge are required for sustainability. Understanding of alternative institutional and physical infrastructure interventions to improve sustainability of water management is often not well integrated, because of problems both of “disciplinary” boundaries among researchers, and because of parallel “departmental” boundaries among bureaucrats. A successful example is the incorporation of social values in the dam building effort at the Castanhao reservoir in Ceara, engineers, local people and social scientists participated. Knowledge about multiple solutions needs to be incorporated into decisions. Integrators can help bridge between perspectives, force consideration of social issues explicitly.

In each watershed, the problems are different and management must be sensitive to these differences. The way in which knowledge is used is place-based and should involve the participation of the users of that place. Water management policy needs multiple actors, not only the hydrologists. Water is integral to culture, and values related to water can’t be legislated. To ensure appropriate representation, it is necessary to incorporate the knowledge of specialists in multiple fields, including social science and education. Cultural aspects should be acknowledged and incorporated in decisions and water management processes, while bearing in mind that some traditional practices are not sustainable and also must be adjusted to achieve sustainability.
3) Management scales and knowledge systems often don’t correspond to watershed scales. Timing of water management information is not always well matched to decision processes; cycles are daily, seasonal, annual and decadal. Scale of information should be matched to the size of the conflict/issue/decision. Three geographic issue types appear in Thailand: nested geographic issues, upstream and downstream issues and left vs. right bank issues. These are spatial challenges. In the Yaqui system, there is one scale that is the irrigation system and another is the source of water (the whole watershed). The Yaqui system works well because the nested single user groups match the physical system.

Knowledge systems need to reflect the geography and seasonality of water use and decisionmaking.

4) Groundwater-surface water interactions and inherent uncertainties make water management different from managing other resources. Hydrologic systems are inherently complex. People can directly observe land use change – they cannot directly observe subsurface flow pathways for groundwater. The reality that surface water and groundwater are linked, and that groundwater flow processes are a large, and “unseen” part of the hydrological system, is not apparent to many stakeholders. The relevant hydrological pathways are generally not always acknowledged in water management schemes and this gap in system understanding among water users has historically made water management ineffectual. As a result, many boundary organization or river basin organizations have made efforts to educate stakeholders on basic hydrological concepts of conjunctive use.

When particular knowledge is missing (e.g. hydrogeological connection of certain aquifer units)—controversy generally follows between stakeholders whose interests are affected by assumptions that are made to fill gaps. This controversy is especially evident as water resources decisions increasing overlap with land management and water for ecological purposes.

5) There is an inherent presumption of a right to water, particularly where it is naturally free-flowing or accessible as part of land ownership. A regulatory system that is imposed on this, especially a market based one, often introduces conflict. The role of privatization, water markets and pricing may have limitations in terms of a long-term strategy for sustainability. Managing water as a commodity brings its own agenda. One of the big changes in water management is using economics for managing water. Water is both an economic and a social good. Water rights establishment is important to ability to use economics in decisionmaking. There also needs to be an enforceable management system if you want to establish a market. News from the Ping basin: change that is too rapid can destroy a well adapted system.

6) There is a shift towards participatory management and decentralization of power in all four case studies. Does this support sustainability? The benefits include shared learning, more local knowledge being involved in decision-making, more buy in to the outcomes, trust in the source of knowledge and opportunities for peer review. Physical
familiarity and engagement within the local areas is important, but this does not guarantee two-way communication or improvements in management. There are major advantages such as decoupling of risk from a focus on individual decisionmakers when there is more participation.

Is there really a trend towards participation, or is it just a public relations campaign? Also the cost of public participation is very high, there are high transaction costs. True participation is a subjective thing. How do participatory processes actually relate to decisionmaking, especially big decisions? How is equity and legitimacy ensured? In Thailand, farmers and indigenous people have a strong role in the process, they need to protest to bring attention to their issues however.

Suggestions include:
- democratize the public space for decision-making (access to the process)
- create social (public interest-based) control over water resources
- encourage consideration of equity in the decision-making process
- enhance legitimacy in decision-making through constructing consensus
- combine the formal technical knowledge with the practical knowledge of the user groups creating co-production of knowledge
- reduce the information imbalance between the State and the private sector through greater transparency
- reduce the costs of enforcement incurred by the State by using shared governance to decentralize and spread out the costs

The complexity of hydrological systems requires a level of technical knowledge that is highly specialized, and in the name of effective participation, important technical issues may not receive due attention. The transaction costs of the process of public participation and consultation can be very large, and perhaps there are less expensive mechanisms to assure open access to information. The objectives under which the participatory process is defined as a priority must themselves be treated as the highest priority. Despite its problems, public participation is the best path to achieve the objectives. But the point is that this is the PATH and not the arriving point.

7) Land use planning and water supply are inextricably linked, and this should be formally acknowledged in decision processes. Decisions about water affect all other sectors, economic growth, forestry, agriculture, etc. Although integrated resource management is complex and challenging, failure to acknowledge these linkages will result in unsustainable management systems. It is difficult to monetize the tradeoffs in this area. Knowledge systems that service rainfed ag are different from knowledge systems for irrigated agriculture.

Typically, land use classifications more closely explain the economic productivity of water resources, as well as their scarcity value, than do simple sectoral classifications. Water management decision-making, and decision support systems, must integrate land resources. However, this requires simultaneous integration of sector-specific expertise and knowledge, activities that may not be rewarded within conventional institutional
arrangements. Water managers are typically trained within the technocratic confines of their field. However, land use management policies are a necessary component of a water decision-makers portfolio. Along with this broader “tool-box,” water managers must acquire the capacity to evaluate the full social, economic and environmental implications of their land-water management recommendations.

8) In the process of collaborative planning – what are the ingredients of success? a) Shared fact-finding leads to trust building, b) key players who have power to implement change within their sphere of influence need to be at the table, c) participants need to understand the basic rules of engagement in collaborative processes, d) leadership has to balance inclusion of all views with a clear path to a solution, e) there need to be ways to equalize the power base so under-represented groups can have a significant voice, f) adequate resources for accomplishing the stated mission, g) knowledge and participation of local governments and the private sector are required, h) credibility of leadership and information sources must be clear, i) a relationship between who pays and who benefits from solutions is also a component of sustainable planning, j) if there is agreement on an approach and a third party to generate knowledge before hand, this can reduce conflict …Also need to have a reason to work together, an agreement to agree, and a deadline.

Other lessons learned from experience: Projects can be approached incrementally, starting off on a smaller scale with projects that are not as controversial. If smaller, easier decisions are made, trust can be built towards tackling the larger issues. Establishing the rules of engagement of the parties, the modes of communication, the decision-making framework, etc needs to be formalized and agreed to from the beginning. As difficult as this might be, getting the initial stages right is fundamental to the future success or failure of the project. However, in public processes, getting everything right the first time is unrealistic and adaptation of processes is to be expected.

Problems need to be well articulated, and related goals should be stated in a manner that is inclusive to all affected interests. Open discussion and sharing of scientific and other knowledge between interest groups is helpful and allows for collective learning. While there are certain to be differences in point of view, having all the issues on the table and discussing differences can foster a more open process which is likely more conducive to collaborative management.

Collaboration is time intensive and only individuals and organizations with the necessary time and resources are truly able to participate. This can lead to a more limited but generally highly informed collaborative body which may in fact be better for the decision making process, as extremely large participatory efforts can be hampered by lack of access to knowledge. However, this approach requires having people who truly represent the breadth of affected parties. All interests must be represented and the people doing the representing must have social, political, economic, or scientific influence. While this method of participatory management may be more proactive in moving things along, the concerns and interests of traditionally underrepresented interest (eg. minorities, environment) are potentially jeopardized.
Leadership is crucial throughout each step of the process. Having the right individual or group of individuals guiding the process can make or break success. Individual personalities and relationships are key, perhaps more so than institutional relationships.

Major questions exist as to whether or not the participatory process works at all, and under what conditions it is likely to be productive over the long term. Having the necessary resources, whether they be monetary or knowledge based, is crucial. The collaborative approach to management can actually help in securing these resources as a larger group is likely to be more effective in securing funding. The accomplishment of goals can frequently be tied to the availability of resources.

Government support and recognition is key as evidenced by the various case studies. If participatory resource management and local control is to be successful there must be a certain level of top down control and oversight; however it must be framed in a manner that is agreeable to local interests.

Contested claims to truth can be resolved by various parties agreeing to formation of technical assessment or review groups or through direct observations and monitoring. These parties should be perceived as accountable upwards to decision-making authorities and downwards to the stakeholders. In some cases joint observation or assessment is necessary, whereas in others a trusted third party may carry out work on behalf of other groups.

Water needs to be recognized as a finite resource. A key to sustainability is acceptance of the concept of limits, such as living with drought as the baseline, rather than planning based on an assumption of median or maximum conditions. Knowledge for sustainability includes understanding the nature and implications of climate variability and change on water supplies. This will enhance resilience of human systems.

Truly embracing limits results in a completely different relationship with the resource base that is more likely to include compromise and collaboration. This is a reframing of the human-environment interaction, and requires acknowledgement of limits in both demand and supply options and forces integration of social and physical knowledge sets. Hydrology and engineering options have limits. In our cases, the San Pedro exhibits limits to management on the demand side; the Yaqui system exhibits the limits of the supply side approach.

Sustainability is not an end-point but a trajectory that includes technological, social, economic and environmental components. Pushing too much on one part of the equilibrium will cause thresholds to be crossed in other areas. Because there is an absolute limit to resource availability, there is a time scale to resource use limitations that should be explicitly considered in planning decisions.

Practical experience is important in achieving long-term sustainability. Agencies with organizational history and a lot of institutional experience have far more perspective and may have more realistic views of what is achievable than newer entities.
that may not have gone through cycles of adaptation. Optimism is not a substitute for experience.

Practical experience is important in achieving long-term sustainability, because it takes time for system knowledge to mature and for institutions to adapt. Long-term agency experience results in an understanding of context, players, politics, and the development of important relationships, but this alone may not mean the agencies are more enlightened. Time is an essential ingredient of learning; relationships and institutions need to mature through cycles including cycles of natural variability. An approach to bringing experience to new arenas is partnering with experienced individuals and agencies.

However, the fact that institutions survive over the long term does not mean they are inherently successful, they need to be continually challenged; complacency is a serious problem for institutions.

Knowledge for sustainability in water management includes development of a culture of integrated learning and risk taking in agencies and institutions.

11) Crisis, opportunity and leadership are components of change that work in different proportions in specific applications. The language of crisis is often used to create a rationale for action (used for political purposes). Institutional change can result, but in many cases transformation of institutions takes time. An example is the way drought cycles are related to change in several of the cases. In some cases in Brazil and Mexico there was an immediate response to drought, in others there was little notable change in management or infrastructure. The incorporation of participatory decisionmaking is a fundamental change in decision structures, all the previous crises were in a different social context. Advancement in knowledge or collective awareness is another component of change, and there are “watershed” moments in this area, such as the Rio summit, which had huge influence on the Brazil and Thailand cases.

Major changes in goals and policies for long-term management of water resources, regardless of whether understanding from research or practice, benefits from having either individual leaders or institutionalized relationships that can bring expertise into decision-making bodies on a regular and long-term basis. Sustainability discussions have the effect of depoliticizing things, political analysis needs to be explicitly included. Availability of knowledge to actors is critical for a good decision making during water resources management reform processes.

12) Drivers for water reform can be either external or internal: External drivers, such as fiscal constraints or more general political economy transformations of the country or the state, include the cases of Ceara or Yaqui. In both cases strong leaders created the conditions for reform in all sectors. Formation of organizations and institutions to increase participation in water resources happened within these general trends. There were narrow windows of opportunity to introduce reforms with the change of the government administration. Sources of knowledge for
wide institutional reforms were international organizations like the World Bank and local knowledge provided by past experience and long term planning. The most important inputs were the good (or bad) practices examples in other places.

Internal drivers, such as droughts or floods exacerbate conflicts and help in bringing attention and interest in solving water problems. Implementing solutions including infrastructure, legislation, regulations, incentives and awareness campaigns need to be articulated in a short time. Information and knowledge about hydrology, projects and integrated solutions are essential to make the right decisions.

**Major changes in goals and policies for long-term management of water resources are accompanied by changes in what knowledge is sought and used. Although crisis may trigger or create windows of opportunity for such changes they are not necessary for shifts to develop. Both external and internal factors can contribute to change. Broad changes in socioeconomic development and culture underlie shifts in goals in all basins. Changes to research agendas both precede and follow goal changes.**

13) Reform needs a champion who can articulate the needs and the opportunities and formulate a coherent plan of action. How can we stimulate formation of champions and provide knowledge to the reform processes during relatively narrow windows of opportunity?

*Efforts to link knowledge with action in the long-term management of water resources, regardless of whether understanding from research or practice, benefits from having either individual leaders or institutionalized relationships that can bring expertise into decision-making bodies on a regular and long-term basis.*

14) Establishing successful pricing mechanisms requires specific types of social, economic and hydrologic knowledge. Steps in establishing water pricing mechanisms include having a clear goal for the pricing scheme, understanding the hydrologic system well over long time frames, establishing and enforcing water rights, understanding the price elasticity for water in different sectors, cost recovery and price structuring options, etc.

*Additional research is needed in knowledge to support pricing mechanisms that are focused on sustainability.*

15) Most research on water resources development and management has not considered how the organizational and institutional relationships shape how knowledge is produced, shared and used. As a result we actually don’t have much earlier “experience” upon which to draw and compare findings that fits the specificities and challenges of water as a resource.

Formal evaluations are needed of the roles of knowledge producers and the forces that shape how that knowledge is used in real world applications.
Understanding of alternative institutional and physical infrastructure interventions to improve sustainability of water management is often not well integrated, because of problems both of “disciplinary” boundaries among researchers, and because of parallel “departmental” boundaries among bureaucrats. Training science integrators and individuals within organizations to be integrators of science who also study the flow of information would be a useful function.

16) Ecological sustainability and social justice objectives will not necessarily be met by a knowledge system that is controlled by and serves primarily economic objectives, although water resource development itself may be key to achieving those objectives. Therefore, technical expertise, sources of adequate funding, or the regulatory mechanisms that are required to address ecological and social needs, are often generated externally to local watersheds or communities, typically from higher levels of regional or national government.

A key contributing factor in this issue is the relatively short timeframes over which economic objectives are typically defined, and most importantly, the widespread lack of recognition for the influence that ecological systems and/or social justice issues exert over local economies at longer timeframes.

The long-term viability of either ecological or economic resources cannot be adequately addressed solely through consideration of short-term processes. Sustainability of either of these systems clearly involves consideration of the linkages between these systems and incremental processes and/or feedback mechanisms occurring at longer timescales. Decision support systems and other modeling tools may be essential to better quantify and communicate these complex relationships and interactions.

Ecological sustainability and social justice objectives will not necessarily be met by a knowledge system that is controlled by and serves primarily economic objectives, although water resources development itself may be key to achieving those very objectives.
V. INSIGHTS RELATIVE TO CASE STUDIES (Input from individual team about lessons learned in the workshop)

YAQUI RIVER BASIN TEAM

A.-Insights gained from case study regarding:

1) How are goals for long-term management of water resources in the river basin changed?
   - Create in the various water users and authorities, an awareness of the need for change.
   - Formulate a vision of what the desirable characteristics should be, such as confidence (in the organization), opportunity, flexibility, equity and sustainability.
   - Achieve consensus on the vision
   - Calculate the costs and resources required
   - Seek out alliances/partnership and financing sources
   - Select organizations or other entities for implementation
   - Revise the regulations and legal authority (as needed to accomplish the goals)
   - Establish a method for evaluation and follow-up of the efforts
   - Create a mechanism for providing information (transparency of operations)

2) How do multi-stakeholder processes (participation) contribute to the sharing of existing knowledge and production of new knowledge?
   - Allow open access of the public to information using various communication means and the internet
   - Conferences and workshops
   - Training
   - Links and partnerships with secondary and basic educational institutions
   - Commission studies and projects to consultants and institutions of higher education
   - Participate in external events and publish results

B.- Special Insights from our case:

1) What would you recommend to others?
   - Revise the number of members of committees of the decision-making bodies
   - Pursue legislation that grants greater authority for actions
   - Prioritize the actions that require investment
2) Insight from other cases.

- Environmental values should be considered
- Implementation could be facilitated by a structural entity (company) at the state level.
- The need to integrate the visions of all the user groups throughout the entire basin
SAN PEDRO TEAM

Changes in long-term management goals

-Driven by a combination of external regulatory drivers (federal in our case), improved understanding of physical/hydrological processes and context, and dynamic social / economic / political regional influences. Leadership of key individuals is also important.

-As the technical understanding of complex hydrologic factors increases, the complexity of appropriate water management goals and objectives also increases. In our case, a shift from a simple water budget framework toward the spatial management of water resources has presented new challenges.

-Over time, pressure mounts to do less research, and implement more tangible projects. Projects become larger and more complex, funding needs are greater, and new organizational structures, and perhaps revised goals, are likely required in response.

-There is a need to consider the biases and influences that various funding sources have on long-term management goals when pursuing funding.

Contribution of multi-stakeholder processes to existing and new knowledge

-The ability to secure adequate funding for research and monitoring at a watershed scale is greatly enhanced through collaborative, multi-stakeholder lobbying and fundraising efforts. In general, the more diverse the representatives are that are generating funding requests, the more attractive their requests will be to both governmental and private funding entities. The very same stakeholders would likely not be able to secure similar resources by working independently.

-Buy-in and engagement of all affected stakeholders at the very beginning of projects and/or investigations is essential for the eventual results or outcomes to be useful and/or accepted by them. The design of projects or studies, including the initial definition of goals and objectives, should be an open process engaging scientists, decision-makers, and affected interests from the community.

-It is sometimes essential for local communities to put “new knowledge” into language or terms that is understood and/or most meaningful to them locally, for that knowledge to actually be accepted, integrated, or applied. That means that technical findings sometimes need to be “translated” into common speak (without modifying the intent, accuracy, or meaning of that information). This can be a key role for multi-stakeholder groups in linking science with bottom-up policy and decision-making.

Recommendations to other basins, based on our case

-Minimize water demand first to reduce, or at least delay, the need for securing additional supplies. As the competition for water resources increases globally, it is difficult to
imagine that conservation strategies that minimize demand for additional supplies are not merited in practically all applications.

-Minimizing demand, regardless of specific methods, is reliant upon a clear understanding of the need to do so by local/regional communities. This understanding can best be developed through “participatory learning” that links scientists, decision-makers and local residents on key water management issues.

- Policy makers and community leaders will be more likely to succeed with the understanding and cooperation of a majority of the electorate. In turn, the leadership must explain and educate, listen and adapt, cooperate and concede, and facilitate consensus.

Our lessons learned, based on other cases
- Adaptive management for water resource allocation can greatly benefit from annual climatic forecasting tools, as well as other hydrologic predictive models, especially in regions with great inter-annual climatic variability.

- Some of the market pricing solutions beginning to be applied in Ceara, may have applications for San Pedro.

- The need for accountability and transparency of process(es) in a decentralized decision-making framework, is both universal between these sites, and very challenging! We are not alone in addressing his difficult challenge.

- One solution set will not fit all. The social, economic, and political environment of a community must be understood and accommodated. Each basin faces unique issues and therefore will develop solutions tailored to the fears, biases, and needs of the population.
A: Acronyms
The Challenge
The management of water resources for sustainable use, poverty alleviation and economic development is a technically and politically difficult challenge for societies. The knowledge systems that support decisions about water resource management and development link basic research to applications on a broad range of issues, from agricultural efficiency, to water quality implications of effluent use, to habitat implications of water supply and energy facilities. Decision support activities are also widely divergent, ranging from economic and social impact analyses and environmental assessments, to evaluations of alternative management options and institutional arrangements. Moreover, much of the knowledge in use day-to-day is experience-based and tacit, even where there are sophisticated systems of monitoring in place. Managers of dam and weirs, farmers, climate forecasters, local water managers, construction engineers and irrigation canal operators combine many forms of knowledge, consult through networks and negotiate in reaching their decisions and taking actions.

Some of the most critical decisions and technologies in sustainable development related to water are those with implications that may span decades, requiring the ability to respond to long-term climate, technological and consumption changes. For example, many decisions about major water infrastructure, like construction of dams, creation of irrigation schemes, and inter-basin transfers often have multiple, complex, and unanticipated longer-term impacts. Likewise, major water policies focused on demand management (rather than supply augmentation) may also have impacts that unfold over decades, for example, by encouraging certain styles of housing and gardens or investments in agricultural technologies. Some social innovations may even change the fundamental way water is perceived and “valued” from a virtually inalienable right to just another marketable commodity.

Our understanding of how best to bring knowledge and action together for the sustainable management of water resources is rudimentary.

Our Response

Purpose
This workshop aims to bring together a small group of practitioners, researchers and stakeholders from four different basins to help bring out the key issues involved in strategic planning and management of water resources. By strategic we mean a focus on long-term planning and management strategies, decisions over large-scale water-related infrastructure, and major changes to water use rules, regulations and institutions. The four
basins are in Yaqui Valley, Mexico, northeast Brazil, the Mae Nam Ping Basin, Thailand and San Pedro River, Arizona, USA.

The participants will probe, deliberate and write about their findings during the workshop. An effort will be made to provide assistance for meaningful conversations and exchange of written materials in local languages as appropriate, although we expect most common language at the meeting will be English. If you have any concerns about translation, please contact your group leader (Jim-Brazil, Louis-Thailand, Lee-Mexico, Kathy-San Pedro).

**Briefs**

While we would like you to arrive at the workshop prepared with your thoughts about your case and experience in light of the theme paper we will send, we do not want you to have a prepared power-point slide show. We see this more as a give-and-take discussion.

We are requesting each case study group to submit a brief (limited to 2 pages) articulating their responses to the set of questions in table 1 for their case study prior to the workshop. Development of the two page description will be coordinated by the project leader from your area.

All participants are also welcome to submit a short brief (2 pages maximum) expressing opinions or providing background information on any issue related to the workshop or their organization.

Each group should submit their brief to Catie Mohin (catherine.mohin@asu.edu) by 10 February 2006 for compilation and pre-circulation as a set to all other participants. The group lead will submit one document encompassing all the information gathered from the participants for each case area.

These briefs will form the starting point of discussions for all sessions removing the need for lengthy presentations and allowing us much more time for constructive discussion during the meeting.

**Questions for reflection**

**Table 1. Set of initial questions to guide the exploration and comparison of knowledge relations concerned with strategic planning and management of water resources in different basins around the world.**

1. **The Players** – What are the main organizations involved in strategic planning and management of water resources? Who works for them? What are the main activities and tasks they perform? What are the goals and mandates? What important resources do they control?

2. **The Issues** - What kinds of knowledge does each of the main players “have”, create or use? What are the most important knowledge-intensive decisions and actions that need to be taken? Whose knowledge is used, and whose is neglected?

3. **The Relations** - How is knowledge shared or contested by key organizations and individuals? Which actors and linkages help produce knowledge potentially useful
for sustainable management of water resources? Are there any players with important intermediary roles? What do they do?

4. **Performance.** Have the key organizations been able to respond effectively to challenges requiring application of current, or search for new, knowledge? How is performance of the players or their relationships monitored and evaluated? Are there transferable lessons from this experience?

---

**Workshop Agenda**

The workshop lasts for three days. Please make sure you make bookings that allow you to attend the full meeting. This is a draft agenda and will be revised depending on feedback of participants.

**Overview**

On **Day 1** (Monday) we will spend most of our time discussing each of the cases. We will start each discussion with a focus on the needs of the users of scientific information and try to get beginning answers to a set of questions we will send in advance.

On **Day 2** (Tuesday), we will take a cross-cut look at the different cases, focusing on three themes agreed to at the end of Day 1. We anticipate these will deal primarily with issues of “relationships and performance”. On the evening of Day 2, Steering Committee members and some participants will begin drafting a report based on lessons learned.

On **Day 3** (Wednesday), we will have a discussion of the draft reports - integrating information across cases, discussing interactions across themes, identifying lessons-learned, and noting future potential work. The activities of this day are critical in synthesizing the work of the prior two days.
## Schedule

<table>
<thead>
<tr>
<th>Time</th>
<th>Session and Topic</th>
<th>Format</th>
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<tbody>
<tr>
<td>Sunday, 19 Feb 06</td>
<td></td>
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<tr>
<td>1830 - 2000</td>
<td><strong>Introductions and workshop goals</strong> <em>(Dinner)</em></td>
<td>Dinner</td>
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<td></td>
<td>Macayo’s Restaurant</td>
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<tr>
<td>2000-2100</td>
<td><strong>Orientation to Workshop and Overview of Arizona Water Issues</strong></td>
<td>Facilitator - Kathy</td>
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<tr>
<td>Monday, 20 Feb 06</td>
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<tr>
<td>0730-0830</td>
<td>Breakfast at the Marriott</td>
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<tr>
<td>0830 – 0930</td>
<td><strong>Outline of workshop</strong></td>
<td>Facilitator - Jim</td>
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<td></td>
<td><strong>Central themes and questions</strong></td>
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<td></td>
<td>Elaborate on and discuss key questions <em>(see Table 1).</em></td>
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<tr>
<td>0930 – 1030</td>
<td>In this and the next 3 case study sessions discussion should be centered around the main themes and questions. No presentations are needed, but people may draw on and refer to back-ground briefs or maps for illustrations.</td>
<td>Facilitator - Kathy</td>
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<tr>
<td></td>
<td><strong>Discussion of Arizona case study</strong></td>
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<tr>
<td>1030 – 1045</td>
<td>Break</td>
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<tr>
<td>1045 – 1145</td>
<td><strong>Discussion of Brazil case study</strong></td>
<td>Facilitator - Jim</td>
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<tr>
<td>1145 – 1245</td>
<td><strong>Discussion of Yaqui case study</strong></td>
<td>Facilitator – Lee</td>
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<tr>
<td>1245 – 1345</td>
<td>Lunch</td>
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<tr>
<td>1345 – 1445</td>
<td><strong>Discussion of Thai case study</strong></td>
<td>Facilitator – Louis</td>
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<tr>
<td>1445-1530</td>
<td><strong>Reflection time</strong> <em>(and break)</em></td>
<td>Individual writing, small group discussions.</td>
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<td></td>
<td>Identify the main themes emerging from the case studies so far. Summarize key points on cards and post these on walls.</td>
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<tr>
<td>Time</td>
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<tr>
<td>1530 – 1730</td>
<td><strong>Discussion of main emerging themes</strong>&lt;br&gt;Discuss and reach agreement on three main themes about linking knowledge with action for further exploration on day 2. Breakout groups for discussion on day 2 will be formed along the lines of these themes, including participants from each basin.</td>
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<tr>
<td>17:50-1800</td>
<td>Walk to the Brickyard (location of Decision Theater)</td>
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<tr>
<td>1800-1830</td>
<td>Invited Participants - Tour of Decision Theater&lt;br&gt;KSSD Members – meet in board room to discuss next day’s activities</td>
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<tr>
<td>1830-1900</td>
<td>Brief Reception, Decision Theater Lobby</td>
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<tr>
<td>1900</td>
<td>Walk to Monti’s for dinner</td>
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<tr>
<td>Time</td>
<td>Activity</td>
<td>Facilitator</td>
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<tr>
<td>0730-0830</td>
<td>Breakfast at Marriott</td>
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<tr>
<td>0830-0900</td>
<td>Discuss charge for the day and groups (participants will each be assigned to a group; the groups will simultaneously discuss the themes identified on Day 1.)</td>
<td>Facilitator - Louis/Jim</td>
</tr>
<tr>
<td>0900-1000</td>
<td><strong>Theme 1: Break-out groups</strong>&lt;br&gt;Break out groups will elaborate the similarities and differences observed between the case studies.</td>
<td>3 or 4 mixed break out groups. Post written summary at end of session.</td>
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<tr>
<td>1000-1015</td>
<td><strong>Break</strong></td>
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<tr>
<td>1015-1115</td>
<td><strong>Theme 2: Break-out groups</strong>&lt;br&gt;Break out groups will elaborate the similarities and differences observed between the case studies.</td>
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<tr>
<td>1115-1215</td>
<td><strong>Theme 3: Break-out groups</strong>&lt;br&gt;3 or 4 mixed break out groups. Post written summary at end of session.</td>
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<tr>
<td>1215-1315</td>
<td><strong>Lunch</strong></td>
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<tr>
<td>1315-1430</td>
<td>Groups share highlights from the morning’s discussion</td>
<td>Facilitator - Kathy</td>
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<tr>
<td>1430-1530</td>
<td>Break (Organizers develop proposed writing assignments for participants during break)</td>
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<tr>
<td>1530-1630</td>
<td>Discuss proposed assignments, Connections between themes and missing issues</td>
<td>Facilitator - Louis</td>
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<tr>
<td>1630-1800</td>
<td>Workshop report writing, working as groups and individuals</td>
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<tr>
<td>1830</td>
<td>Dinner – Bamboo Club at the Brickyard</td>
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**Day 3: Wednesday, 22 February 2006**

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<tr>
<th>Time</th>
<th>Activity</th>
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<tbody>
<tr>
<td>0730-0830</td>
<td>Breakfast at Marriott</td>
<td>Review yesterday’s write-ups and divide labor for revisions.</td>
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<tr>
<td>0830-0930</td>
<td><strong>Plenary discussion of draft products</strong></td>
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<td>Time</td>
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<tr>
<td>0930-</td>
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<tr>
<td>1030</td>
<td>Edit and review workshop report (cross-cutting themes)</td>
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<td>1030 –</td>
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<tr>
<td>1100</td>
<td>Break</td>
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<tr>
<td>1100 -</td>
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<tr>
<td>1230 -</td>
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<tr>
<td>1730</td>
<td>Field Trip: SRP Granite Reef Recharge Site &amp; Town of Gilbert Riparian Institute.</td>
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**Meeting Logistics**

<table>
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<tr>
<th>Host</th>
<th>Venue</th>
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</table>
| Arizona State University Office of Sustainability Initiatives  
Tempe, Arizona  
February 20-22, 2006  
(480)727-8596 office  
(480)965-2742 fax |  
Courtyard Marriott  
601 South Ash Avenue  
Tempe, AZ 85281  
PH: 480.966.2800  
[http://marriott.com/property/propertypage/PHXTE](http://marriott.com/property/propertypage/PHXTE) |

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<tr>
<th>Financial Support &amp; Reimbursements</th>
<th>Local Contact Information</th>
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<tbody>
<tr>
<td>Nora O’Neil</td>
<td>Catie Mohin</td>
</tr>
<tr>
<td>nora_o’<a href="mailto:neil@harvard.edu">neil@harvard.edu</a></td>
<td><a href="mailto:catherine.mohin@asu.edu">catherine.mohin@asu.edu</a></td>
</tr>
<tr>
<td>(617) 495-6013</td>
<td>(480) 965-4341 direct</td>
</tr>
<tr>
<td></td>
<td>(480) 727-8596 office</td>
</tr>
</tbody>
</table>

**Conveners**

Jim Buizer, Louis Lebel
Appendix C: Participants

Ceara Case Study
Dr. Francisco de Assis de Sousa
President, Fundação Cearense de Meteorologia e Recursos Hídricos – FUNCEME
Ceara, Brazil

Dr. Luiz Carlos Pontes
Economista
Ceara, Brazil

Dr. Hypérides Pereira de Macêdo
Secretario de Inferestructura Hídrica
Ministerio de Integração Nacional
Brasilia, Brazil

Fernando Mayorga
Graduate Researcher, Arid Lands Resource Science
Bureau of Applied Research in Anthroplogy (BARA)
University of Arizona

Dr. Timothy Finan
Director, Bureau of Applied Research in Anthropology (BARA)
University of Arizona
Arizona USA

James Buizer
Executive Director, Office of the President for Sustainability Initiatives
& Special Advisor to the President of ASU
Arizona State University
Arizona USA

Yaqui Valley Case Study

Dr. Jose Luis Minjares
Senior Advisor
National Water Commission, Sonora Region
Sonora, Mexico

Dr. Fernando Gonzalez
Hermosillo, Mexico
Research Professor, Universidad Nacional Autónomo de México (UNAM), and former
Secretary of Agriculture and Water Resources
State Government of Sonora
Hermosillo, Mexico
Pedro Valenzuela  
Treasurer, Yaqui Valley Irrigation District  
Cuidad Obregón, México

Rodrigo Gracia  
Director of Administration, Yaqui Valley Irrigation District  
Cuidad Obregón, México

Lee Addams  
Earth Institute Research Fellow  
International Research Institute for Climate Prediction (IRI)  
Columbia University  
New York, USA

Ellen McCullough  
Agricultural and Development Economics Division (ESA)  
Stanford University & UN Food and Agricultural Organization(FAO)  
Rome, Italy

**San Pedro Case Study**

Bob Strain  
Mayor Pro Tem, City of Sierra Vista  
Chairman, Upper San Pedro Partnership  
Councilman, Sierra Vista City Council  
Arizona, USA

Dr. Holly Richter  
Upper San Pedro Program Manager  
The Nature Conservancy - Arizona  
Arizona, USA

Dr. Jim Leenhouts  
Hydrologist, US Geological Survey  
Arizona Water Science Center  
Arizona, USA

Kathy Jacobs  
Executive Director, Arizona Water Institute  
Professor, University of Arizona  
Arizona, USA
George Saliba
Department of Geography and Regional Development
University of Arizona
Arizona, USA

Mae Nam Ping – Thailand Case Study

Thada Sukhapunnaphan
Director, Hydrology & Water Management Center,
Upper Northern Region, Office of Hydrology and Water Management
Royal Irrigation Department
Ministry of Agriculture and Cooperatives
Thailand

Udom Jayyong
Policy Planning and Analysis Officer, Class 8 and Director,
Upper Ping River Basin Administrative and Management
Bureau of Water Resource, 1st Regional, Chiang Mai
Department of Water Resources, Ministry of Natural Resources and Environment
Thailand

Sawanee Sukhotu
Director, Bureau of Mass Promotion & Coordination
Department of Water Resources, Ministry of Natural Resources and Environment
Thailand

Po Garden
Researcher, Unit for Social and Environmental Research (USER)
Chiang Mai University, Thailand

Louis Lebel
Director, Unit for Social and Environmental Research (USER)
Changmai University, Thailand

Mrs. Phimphakan Lebel
Researcher, Ping Fisheries Project
Project Manager,
Unit for Social & Environmental Research (USER)
Changmai University, Thailand

Manoch Prompanyo
Researcher Assistant
Unit for Social & Environmental Research (USER)
Changmai University, Thailand
Appendix D: Initial Idea Summary from Case Studies

This list includes all of the ideas that were provided by the group on the first day of the workshop; the ideas were first categorized under headings and subsequently combined into the three main themes/questions. Many of these are rich for subsequent research and are therefore summarized here. The three themes that emerged from this discussion are:

1. **Changing Goals**
2. **Contested Knowledge**
3. **Multistakeholder Deliberations**

**Supply vs. Demand Side Solutions**
- Supply side vs demand side solutions—is there a trend in each case? Which are approaching from both perspectives?
- Demand vs. Supply Management-comparison of watersheds, what works best? Why? Under what conditions is supply management merited?

**Physical Context**
- Problem solving strategy should look at the entire river basin. We must preserve the upstream water sources, such as forest and mountain. The midstream utilizers must use the resources cautiously. The downstream deals with water pollution and should try to reduce it. Did everybody use this strategy to solve their problem? Does it work?
- Geological and climatic similarities between San Pedro Basin (USA) and Yaqui Basin (Mexico)
- The conflict between supply and irrigation ore similar in the Yaqui Basin (Mexico) and Ceara basins (Brazil).
- The quality of water in the stream of the basins is similar between Ceara basins (Brazil) and Ping basin in Thailand.
- Upstream vs. downstream conflicts mostly a problem in Thailand. Why is this not true in other cases?
- Drought plays a role in each area, although differently—intra-annual for Ping, inter-annual for others. Planning for drought is a key point of knowledge/manager interaction
- The hydrologist perspective: a key issue in each area appears to be the process of fairly and efficiently allocating available resources i.e. water supply

**Crisis as Driver for Management**
• Observation: crisis (floods, droughts) seem to be an important trigger for searching for solutions and innovation. Solution: Are there common responses?
• How does crisis stimulate innovation?
• Differences between the cases: 1)laws 2)humid vs dry regions 3)economy 4)water allocation
• Crisis! Can learning pro-active applications occur prior to crisis? What parts of water management assure “ideal” worded plan inside that?

Goal Setting-Financing of Research

• Yaqui and San Pedro - both have identified need for local decision-making with: 1)transparency 2)accountability. How is this ensured?
• Conflict Resolution measures methods for all 4 Watersheds - How are they different? The same? How is facilitation/mediation accomplished?
• Importance of bringing multiple stakeholder prospective into decision process - true for all for cases
• The roles of the water basin committee, councils. Public participation. How do they use knowledge?
• Role of international investment/knowledge/interference in developing water policy? How do international boundaries and interstate boundaries affect water management?
• Differences: Involvement of local government in solutions, environmental protection is a driver in USA
• Develop goal setting management philosophies at the basin level. How does research-based knowledge contribute to deliberate decisions?
• To what extent has funding drive whose knowledge and technologies are used?
• The actors who fund research influence the results. Eg: groundwater study in Yaqui Valley, San Pedro Partnership? Ping River? Ceara? Does research generally validate the objectives of funder?
• If research is funded through an intermediary, does it become more credible for stakeholders. (i.e. Irrigation District/Water Comission through a “National Science Foundation”)

Management

• Is integrated resource management a realistic goal? It is much broader than integrated water resource management.
• Interaction between “regulated” and under-regulated management occur in same river basin water system. “Co-production in uneven field?”
• Trend towards decentralization of water management – is this going to increase or decrease the role of politics? It definitely increases the complexity.
• Systems reliant on one source of water must make provisions to even out supply and demand.
• Theme of need for conjunctive management of surface water and groundwater in San Pedro and Yaqui. – not so much in Thailand or Brazil?
• Water Allocation. (Water right priorities). Human, Agriculture, Industries. How is knowledge transferred in each sector?
• Centralized vs decentralized management: Use of water management as a tool for achieving social objectives. Strongest in Mexico and Brazil.

Roles of Different Actors
• Roles of universities and academics in the water knowledge system.
• Role of indigenous people’s water rights in the system?

Institutional Arrangements
• How is water quality management taken into account in the water management scheme?
• Flooding is handled by different agencies and processes than shortages. Is this related to the knowledge system or what?
• Quantity and quality management – integrated knowledge and integrated institution works better?

Social/Economic Context
• Did your country use river basin-based system to solve their water issue? If so, how, and how efficient was it?
• Theme: Culture. While access to accepted technological and organization solutions to water management is nearly universal, the resulting policies and systems reflect unique cultural patterns of each country/society.

Access to Knowledge
• Large infrastructure and major policy.

Leadership and Knowledge Roles
• Role of key people with new solutions and pushing the ideas. Are key players “translators” or “facilitators” or “marketers”? Depends?
• Scales/ Levels: How do ideas of efficiency, benefits, and development change with scale? What information is brought to bear?

Transferability Between Cases
• How does your country solve the flood problem?
• What are the current solutions that benefit the countries and are being utilized right now? Share some information that could benefit others.
• Issue of priority: Municipal water rights ‘trumping’ lower-priority rights during shortage is causing conflict.
• Theme: Scarcity. All systems have adopted policies and procedures that seek market-based solutions to water and allocation, i.e. pricing, water rights, etc.

Solutions

• Ceara and San Pedro: Both manage in context of high precipitation variability. Municipal needs are relatively constant (though increasing). Forecasting and allocation issues are connected to uncertainty.
• Water scarcity similarities. Drought makes things worse.
• Managing drought is a key challenge for water managers in all

Motivations to Acquire Knowledge

• Knowledge should be demand-driven: What is the driving force for an organization to look for knowledge?
• How are information gaps identified?
• Gap between knowledge and decision makers. Change the thinking of decision makers?
• The institutional system in Thailand and Brazil is the issue: Federal, State, and local institutions.
• Knowledge Systems. Knowledge that affects and influences the supply of water includes information on locally stored water, economic feasibility studies, etc. however knowledge regarding the allocation and negotiation of water is not so prominent.
• Knowledge to manage “Rights” is translated as: Define water rights, distribute water rights, in context of private-sector involvement.
• Theme: Integration. There is clearly awareness of the need to look at water use in terms of the alternative uses. That is water for agriculture, drinking water, environment are not zero-sum, because societal needs are complex and interrelated.

Differences

• Geological and climatic similarities/differences among the different case studies.
• Water use technologies and practices: How do shortages and crisis [crises?] “stimulate” innovation systems? Were they in place already with “ready-to-go” solutions and shelf, or was crisis needed? Domestic vs international solutions. Look for solutions overseas.
• Learning: How are shortages of understanding or failure to update knowledge in place identified? Has government been able to fill/bridge gaps?
• Government is more willing to regulate and people are more willing to accept regulation when livelihoods are directly tied to water resources.
In the USP the scientists collaborate directly with local stakeholders and decision makers, to what extent does this occur in the other locations and how important is this?

Every group except USP makes water allocations on an annual basis through use of science and practical negotiation. This has many important ramifications.

You must be able to act and adapt quickly using scientific data to make yearly allocations and there must be a certain institutional capacity…. How well does this work and what gaps need filling?

Environmental concerns are significantly more prevalent in the USP where class and equity issues are more prevalent in the other cases… yet all cases involve intense politics.

Contested Knowledge (Uncertainty)

“Contested” knowledge: What are the key negotiation processes that can drive past impasse of “contested models” (Key individuals, $ for more data collection).

Procedures to overcome contested knowledge claims (models, impacts, resources).

How does a system incorporate new knowledge? Learn?

Plans/process and inputs/scope: “Plans” whose knowledge goes into them, are they consensus only? How does negotiation take place? What do they address? Water and agricultural integrity?

Soft-Hard Knowledge: Integration | Institution | Technology | Infrastructure

How does your country establish water pricing? Does it work? If doesn’t, how do you deal with the impediments?

To what extent is water management a political rather than a technical problem?

Use of climate forecasting for allocation only in Brazil? Others all want to see how full the reservoirs are.


Integration (interaction) between hard infrastructure and soft institutional measures: how both are affected by knowledge inputs of advisors and in-system practitioner decisions?

Markets/Pricing

What is the role of markets pricing/economics water markets in each case?

Water pricing. Conflicts and constraints of pricing policy among case studies.

How do decisions support tools vary among these watersheds?

Theme: Technology. All case studies have put a certain level of confidence in technological change either on the role of demand management (more efficiency of use) or on the supply side (water availability); less so in San Pedro case.
Science

- Science must inform decision-making.
- Uncertainty in the natural system is a key source of conflict – modeling and communicating uncertainty is key to decision making.
- To some degrees, local participation in decision making yields more effective results.

Engagement and Participation

- Water issues require the early participation of as many views as possible.
- Efficiency of management and decision making is affected by number of people “at the table.”
- Dialogues versus committees: Multi-stakeholders – committees, councils are common structures. But what about 1) Dialogue process? 2) Participation? Councils to reduce politics or collect knowledge?

Role of Government

- Every level of government has a role to play. Upper watershed management is crucial to overall river basin management and is neglected.
- Boundary organizations (with dual accountability) and individuals facilitate key linkages in the knowledge system (e.g. Yaqui Valley and risk-based diversion rules, irrigation district linking users with federal government land combining the knowledge systems).
- Role of science and role of stakeholders is evolving in all systems. These objectives may be in conflict.
- Where solutions are found, central government often plays a major role.

Conflict Resolution

- What is role of leadership/key individuals?
- Effective systems must embody both environment, social considerations.
- Role of environmental considerations varies dramatically across the cases.
- Difference of San Pedro versus others: environmental drivers of little importance in other watersheds?
- What will water quality problems be like in future (e.g. in Yaqui valley)?
- Multi-stakeholder councils are common mechanism, but what about dialogue processes?