Agricultural Water Use and the 1980 Groundwater Management Act:
Institutional Change and Water Conservation in South-Central Arizona, USA

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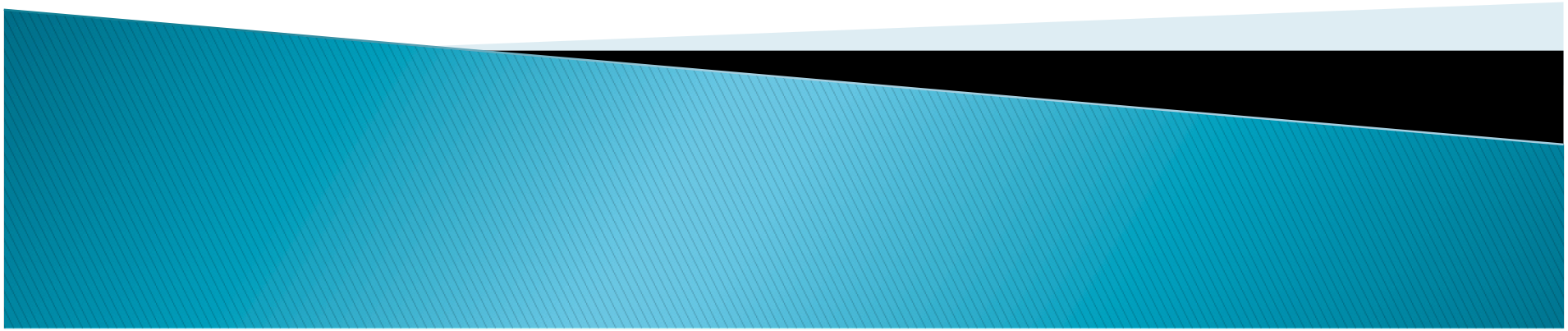


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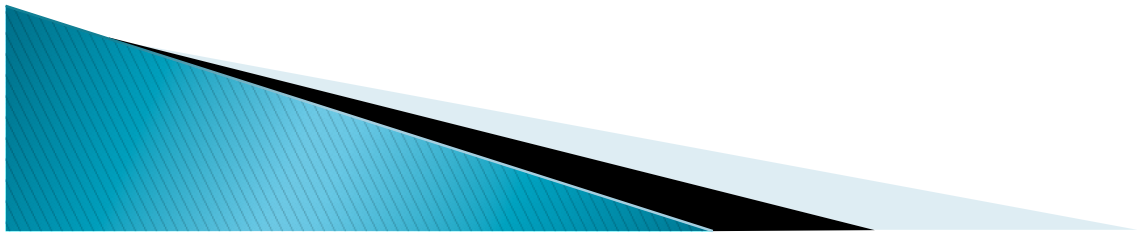
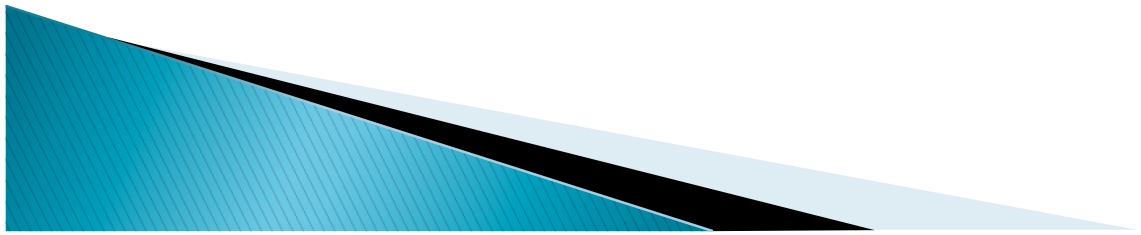
Background

- As Arizona's population boomed, groundwater overdraft a serious issue by the mid-1900s
  - Fissuring, subsidence, groundwater basin compaction
- Federal government threatened to withhold funding for Central Arizona Project (CAP)
- State hammered out comprehensive groundwater use reform in 1980
  - Called the **Groundwater Management Act (GMA)**

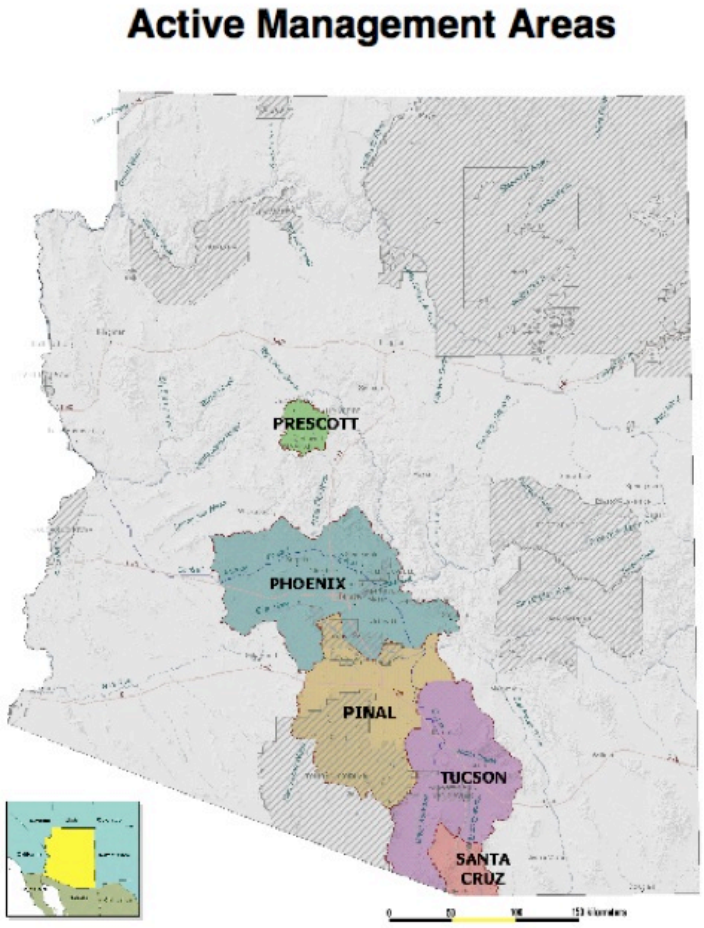


Background, cont.

- The GMA's intentions were to curb overdraft through a combination of:
  - Conservation strategies
  - Augmentation and supply development
  - Reduction in agricultural water use through strict prohibition of its expansion in designated areas

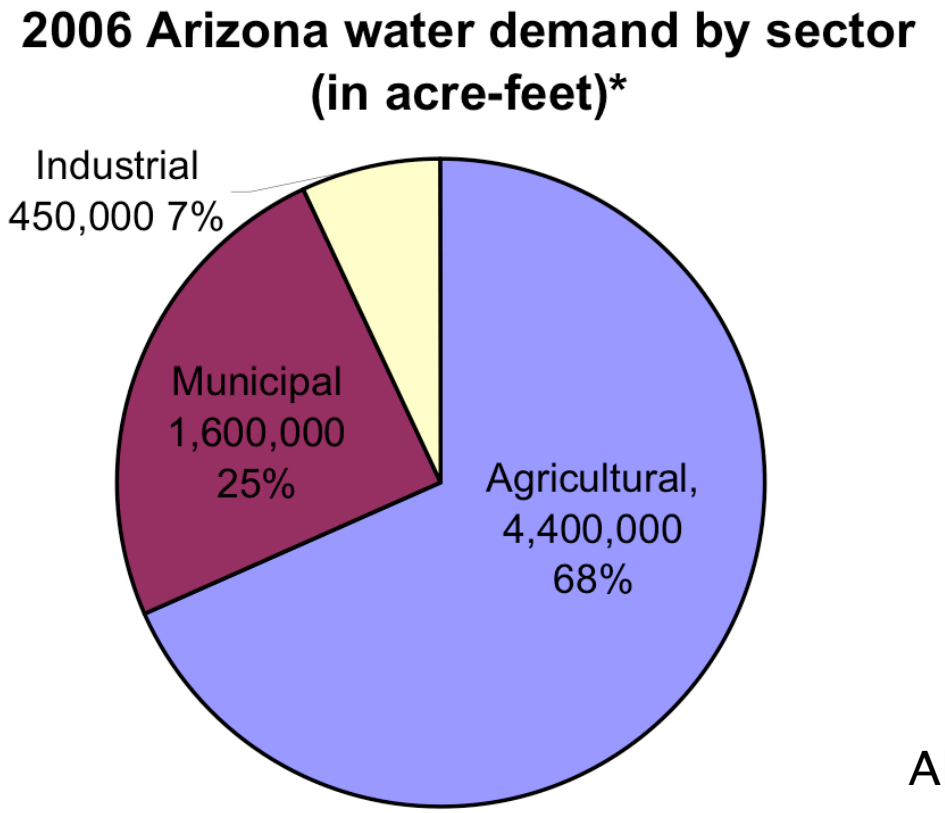


Regulated Groundwater Basins= AMAs



(ADWR, 2009a)

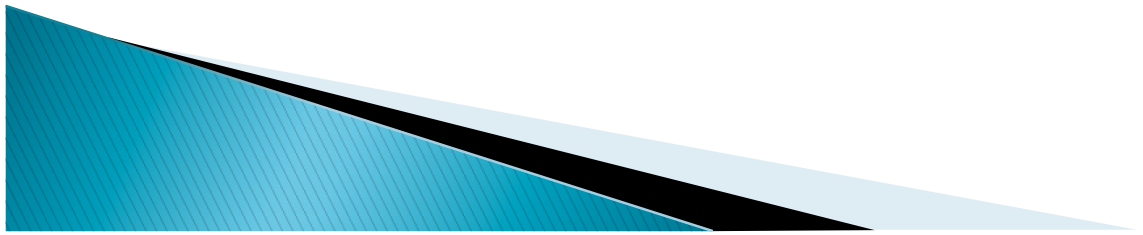
Why look at agriculture?



ADWR 2010

Why look at groundwater?

- Buffer in times of drought
- As of 2006, the state of Arizona used roughly **2.7 million acre-feet of groundwater (43% of Arizona's water use)**
  - 2.8 million acre-feet of Colorado River water
  - 1.1 million acre-feet of other in-state river surface water (e.g. the Salt, Verde, and Gila Rivers)
  - 0.22 million acre-feet of effluent (ADWR 2010)



Research Questions

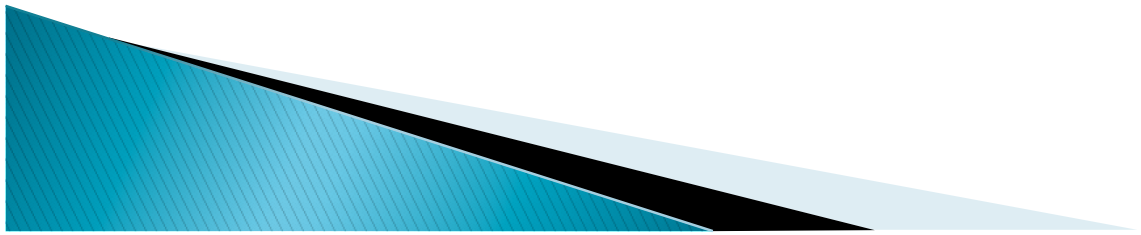
1. How is the 1980 GMA designed to address emerging concerns of groundwater resource scarcity in Arizona?

2. How has the institutional design of the GMA affected the perceived needs of agricultural groundwater users, and how have the agricultural groundwater users impacted the institutional design of the GMA?

Research Questions, cont.

3. What are the implications of this process of institutional change for achieving water conservation in the agricultural sector?

4. What do farmers and experts in water and agriculture view as potential means for enhancing water conservation on farms within Active Management Areas?

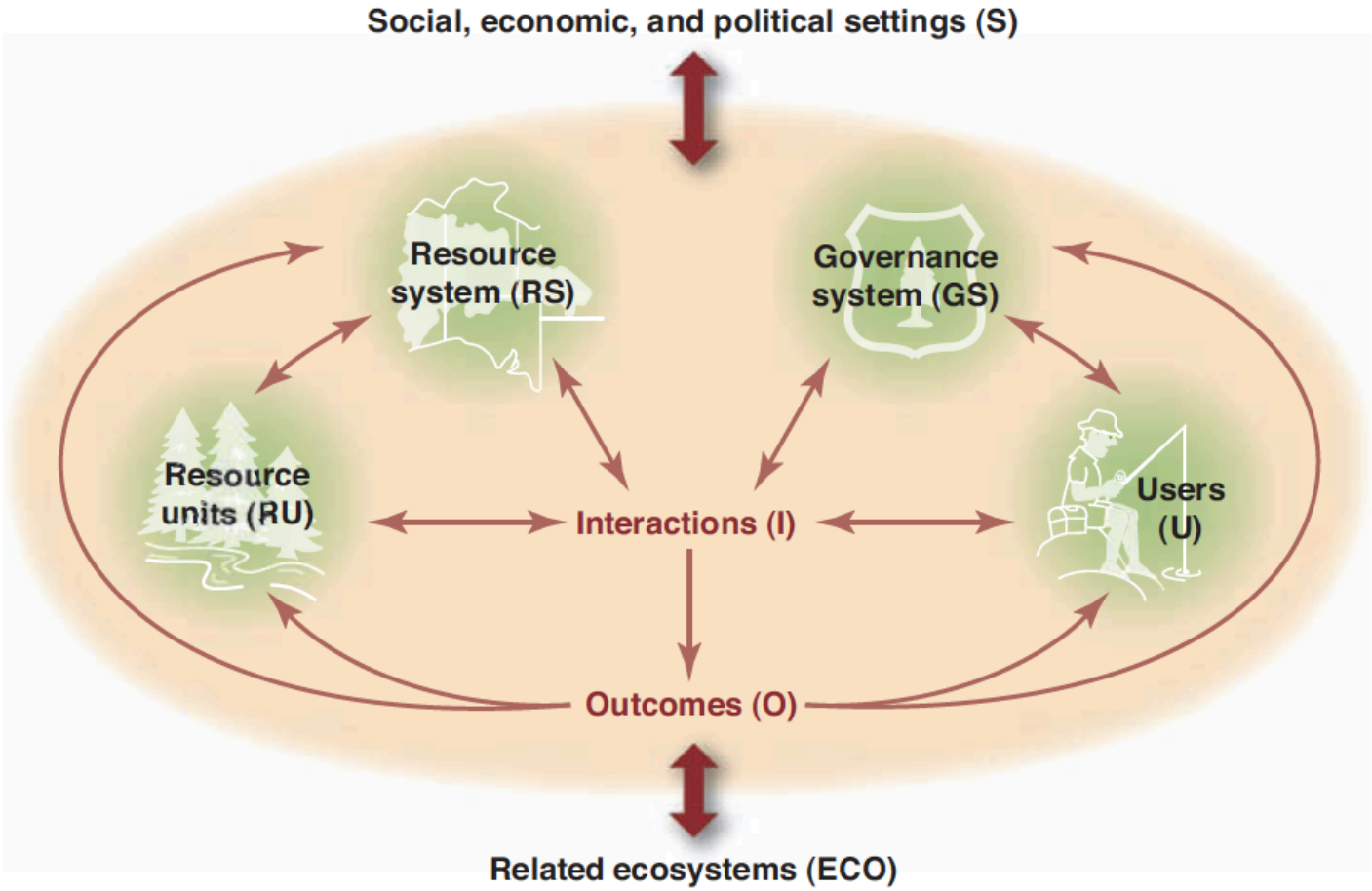


Institutional Analysis and Development (IAD) Framework

- **Institutions**
  - The formal and informal rules-in-use that guide and shape human action (Adger et al. 2003; Lam 1998)
- **Common-pool resources (CPRs)**
  - One person's use of a resource unit impacts another's use by making that resource unit unavailable to others (Ostrom 1990)
- **Social-Ecological Systems (SESs)**
  - Ecological systems that are closely linked to and impacted by a social system.

The Theoretical Framework

The core subsystems in a framework for analyzing social-ecological systems



Ostrom (2009, p. 420)

The Theoretical Framework, cont.

Examples of second-level variables under first-level core subsystems in a framework for analyzing social-ecological systems.

Social, economic, and political settings (S)

S1 Economic development. S2 Demographic trends. S3 Political stability. S4 Government resource policies. S5 Market incentives. S6 Media organization.

Resource systems (RS)

RS1 Sector (e.g., water, forests, pasture, fish)
RS2 Clarity of system boundaries
RS3 Size of resource system*
RS4 Human-constructed facilities
RS5 Productivity of system*
RS6 Equilibrium properties
RS7 Predictability of system dynamics*
RS8 Storage characteristics
RS9 Location

Resource units (RU)

RU1 Resource unit mobility*
RU2 Growth or replacement rate
RU3 Interaction among resource units
RU4 Economic value
RU5 Number of units
RU6 Distinctive markings
RU7 Spatial and temporal distribution

Governance systems (GS)

GS1 Government organizations
GS2 Nongovernment organizations
GS3 Network structure
GS4 Property-rights systems
GS5 Operational rules
GS6 Collective-choice rules*
GS7 Constitutional rules
GS8 Monitoring and sanctioning processes

Users (U)

U1 Number of users*
U2 Socioeconomic attributes of users
U3 History of use
U4 Location
U5 Leadership/entrepreneurship*
U6 Norms/social capital*
U7 Knowledge of SES/mental models*
U8 Importance of resource*
U9 Technology used

Ostrom (2009, p. 421)

Institutional Design of GMA

Ostrom (2009) variable	Groundwater Management Act
• RS1 Sector • RS2 Clarity of system boundaries • RS3 Size of resource system • GS6 Collective-choice rule	**Designation of Active Management Areas (AMAs) determines the boundaries of the regulated system as defined in the GMA. AMAs both an ecological and institutional boundary. Outside the AMAs, these rules do not apply.**
• RU5 Number of units • GS4 Property-rights systems • GS5 Operational rules • U3 History of use • U4 Location	**The establishment groundwater rights and permits. Right to irrigate with groundwater based on historic use between 1975 and 1980 (Needham & Wilson, 2005). One must continue to farm on original land for the water allocation to be supplied and utilized, because water and land stay tied together (Megdal et al., 2008).**
• RU4 Economic value	If the use of the land switches from agricultural to urban, for example, only three acre-feet of water per acre can be transferred to the new use, not the entire IGFR water allotment (Burton, 1990).

Institutional Design of GMA, cont.

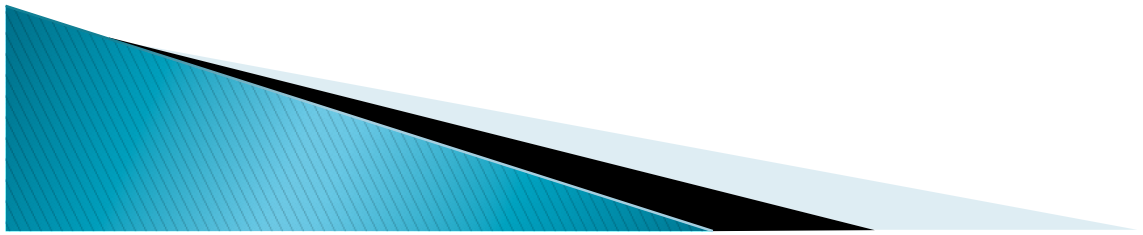
Ostrom (2009) variable	Groundwater Management Act
• RU2 Growth or replacement rate • RU7 Spatial and temporal distribution	Development of a program requiring urban developers to demonstrate a 100-year assured water supply for new growth (ADWR 2004).
• RU5 Number of units • GS5 Operational rules	**Farmers required to increase water efficiency every ten years, with the intention that farms would use less water in 2025 than in 1980 (ADWR 2003a).**
• RS2 Clarity of system boundaries • GS5 Operational rules	**A provision prohibiting irrigation of new agricultural lands within AMAs (ADWR 2004).**
• GS8 Monitoring and sanctioning processes	**A requirement to meter/measure water pumped from all large wells (ADWR 2004).**
• GS8 Monitoring and sanctioning processes	A program for annual water withdrawal and use reporting. These reports may be audited to ensure water-user compliance with the provisions of the Groundwater Code and management plans. Penalties may be assessed for non-compliance (ADWR 2004).
• GS1 Government organizations	**The establishment of the Arizona Department of Water Resources (ADWR) as the monitoring entity (Hirt et al. 2008)**

Institutional Design, variables *excluded* from GMA

Ostrom (2009) EXCLUDED variable	Groundwater Management Act
• U5 Leadership / entrepreneurship	**Assigned water allotments to farmers based on use from 1975-1980. Those who used more water were awarded a larger allotment than those who had been irrigating efficiently.**
• U7 Knowledge of SES	**Previous groundwater doctrine overturned quickly, making it difficult to incorporate the proper incentive structure to reward farmers for irrigating efficiently (as one way of coping with resource scarcity).**
• U7 Knowledge of SES	Assumed reaching 85% irrigation efficiency standard in Third Management Plan was economically feasible for farmers.
• U6 Norms / social capital • U8 Importance of resource	**Assumed agricultural acreage and water use would decline quickly. Significant amount remains.**
• U9 Technology used	Placed emphasis on reducing agricultural acreage (scale effect) as main way to conserve groundwater. Not as much emphasis on aiding farmers with water technology effects that could reduce per-acre consumption.

Results

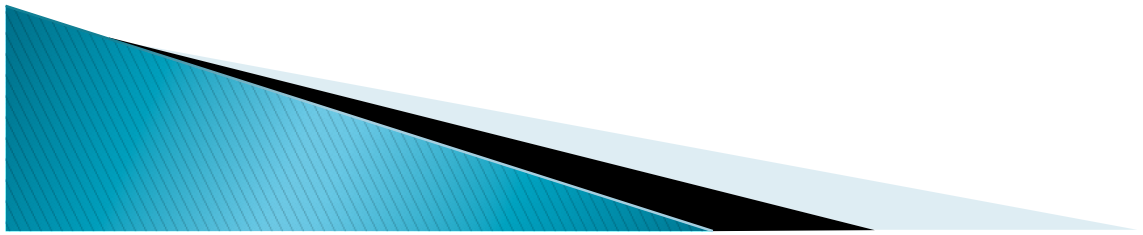
- “Users” has the fewest variables included or considered in the GMA.
  - Rush of GMA’s passage with the “carrot of the CAP”



A New Reality

- A water expert suggests the stark reality farmers suddenly faced:
  - *"I think it was shock at first for farmers that on **June 11, 1980** you could use as much water and irrigate any land that you wanted. Then **June 12, 1980** comes in and its like, 'I can only irrigate this much, and how much water do I have to use? Who is going to tell me what to do?'"*

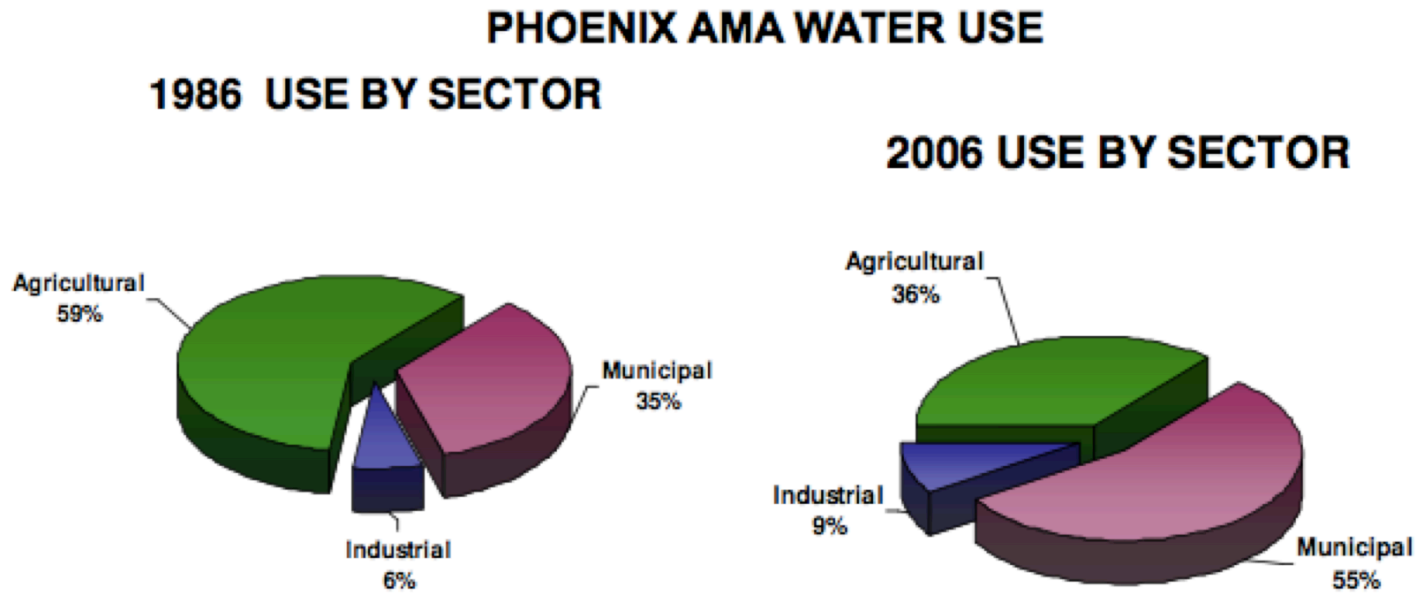
    (Water-agriculture expert #8, personal communication, March 10, 2010)



Results of GMA on water use

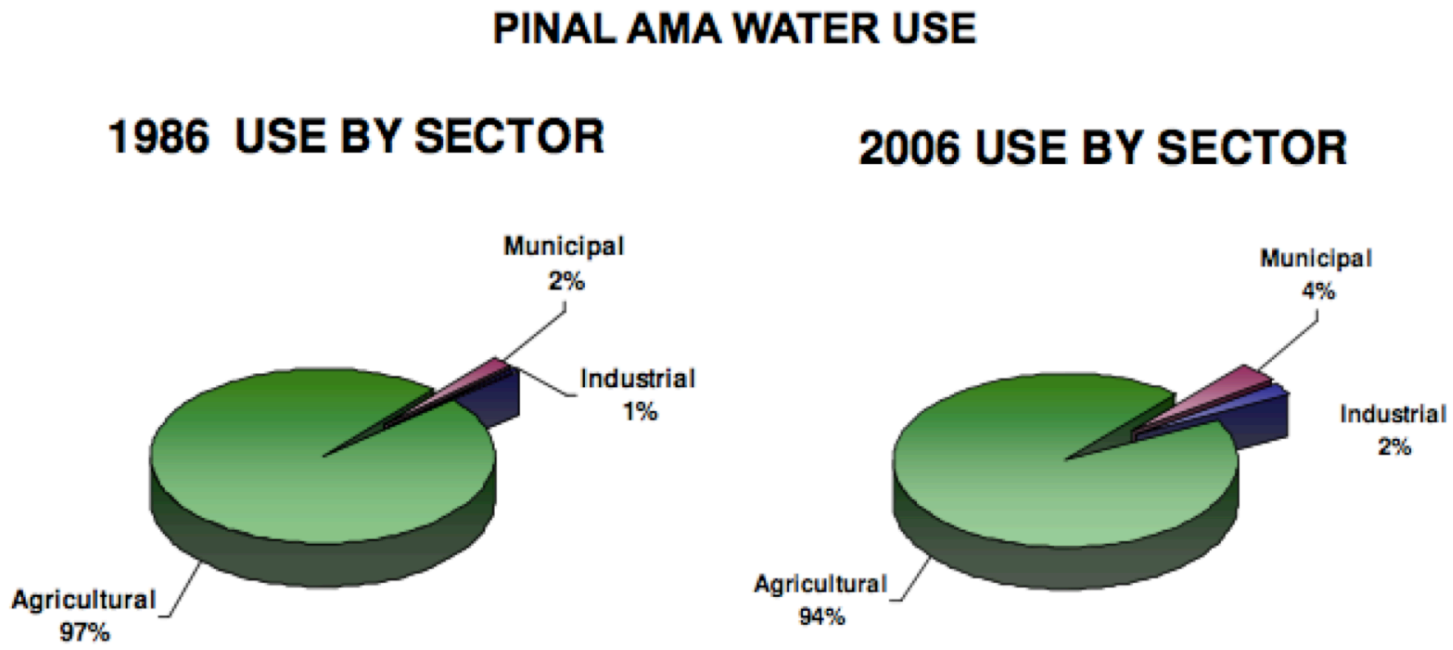
- Agricultural water use by the sector has decreased
  - *HOWEVER*, per-acre water use has remained stable since 1980 (Needham and Wilson 2005).

Agricultural Water Use
Phoenix AMA—1986-2006



ADWR 2009

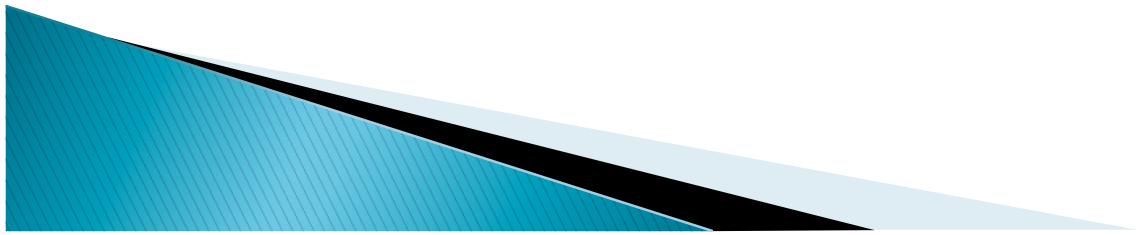
Agricultural Water Use
Pinal AMA—1986-2006



ADWR 2009

Why is per-acre water use stable?

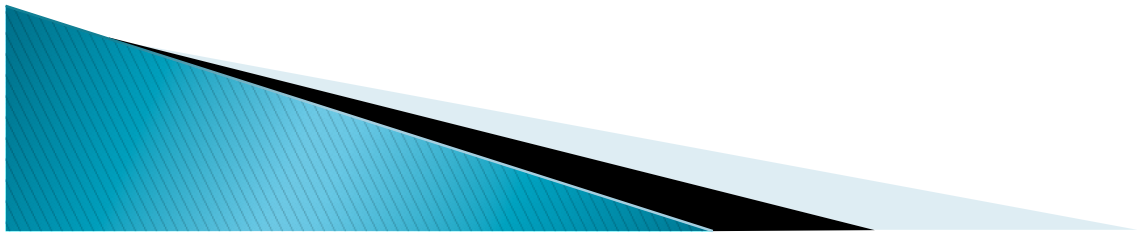
- Not long after its passage, farmers challenged the GMA to gain back some of the flexibility they felt they had lost (Megdal et al., 2008).
  - Need flexibility to respond to agricultural market fluctuations and climactic conditions



Adjusting the Institutions

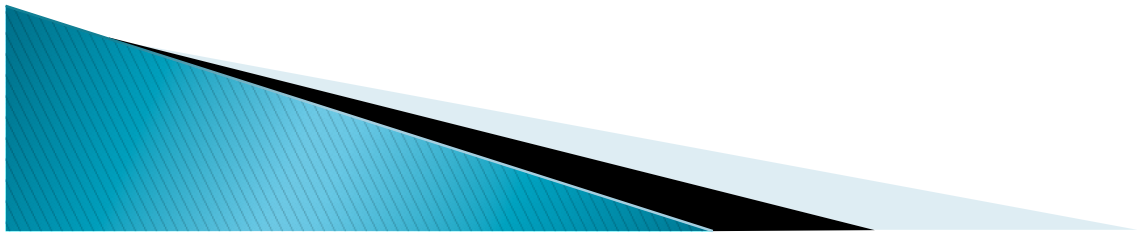
- Anderies et al. (2004) highlight that institutions associated with successful SESs often provide a "rough proportionality between the benefits a resource user obtains and his or her contributions to the public infrastructure" (p. 12).
  - An institution that does so is considered fair in most social systems (Issac et al. 1999).

- When institutions are constructed and considered fair, they reduce the chance that resource users will try **to challenge, avoid, or disrupt the policies of the public infrastructure providers** (Anderies et al. 2004).



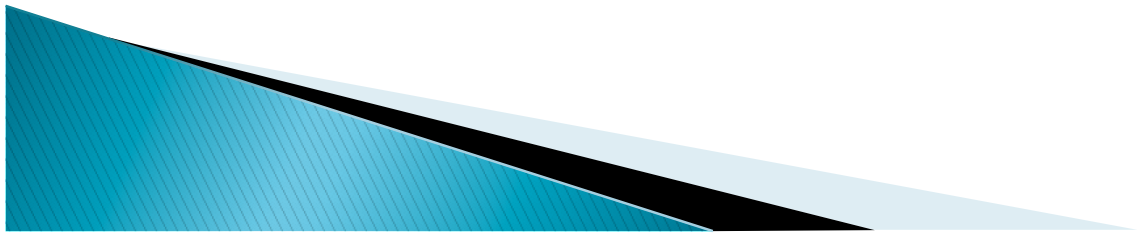
- To the agricultural sector of south-central Arizona, the GMA did not appear fair:
  - *[It was] an upheaval in the agriculture industry because we developed our water ourselves. The wells that we drilled we owned. We bought and paid for them, and took the risks when we drilled them. Sometimes you get dust, sometimes you get water. And here were some people … suggesting that we were going to lose control of those wells and the water that came from them, and that the water belonged to the state of Arizona instead of to me and my peers. It was brutal.*

(Farmer #1, personal communication, February 3, 2010)



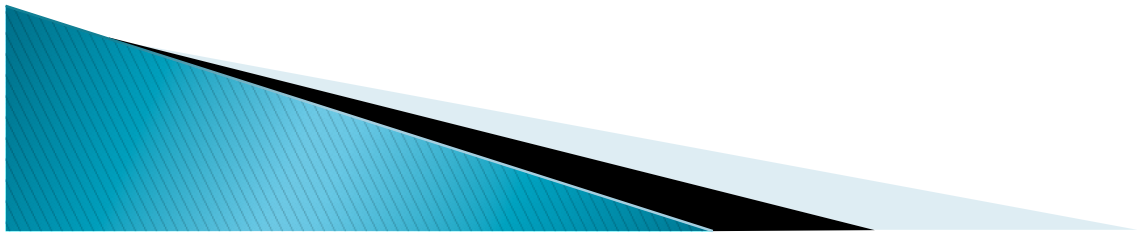
Institutional Change

- Resource users (farmers) impact governance system (GMA)
- Farmers won three main amendments:
  - **Flex credits**
  - Reduced irrigation efficiency standard
  - Best Management Practices



Flex credits

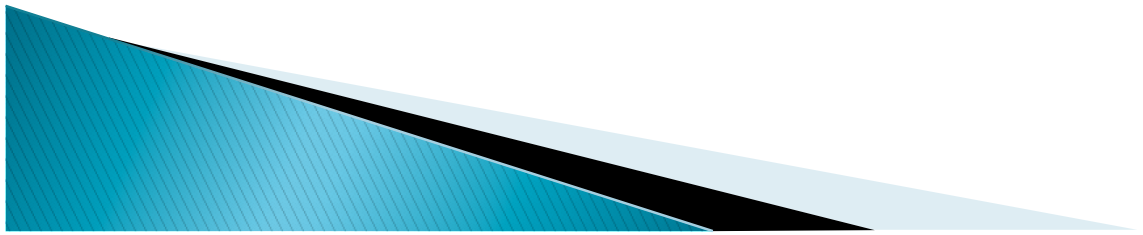
- Allowed farmers to bank water not used in one year and use it in another
  - By 2000, 6.6 million acre-feet of banked flex credits existed in the Phoenix AMA (Maguire, 2007).
- Potential threat to groundwater supplies in times of drought
  - Farmers legally entitled to draw as much groundwater as they banked



What can be done?

- Farmers suggestions on how to conserve water:
  1. Recognition by the Natural Resources Conservation Service (NRCS) of the temporary nature of farming in central Arizona.
     - This would allow more farmers who are leasing land the opportunity to participate in NRCS grants and other opportunities

     (Farmer #5, personal communication, February, 16, 2010)

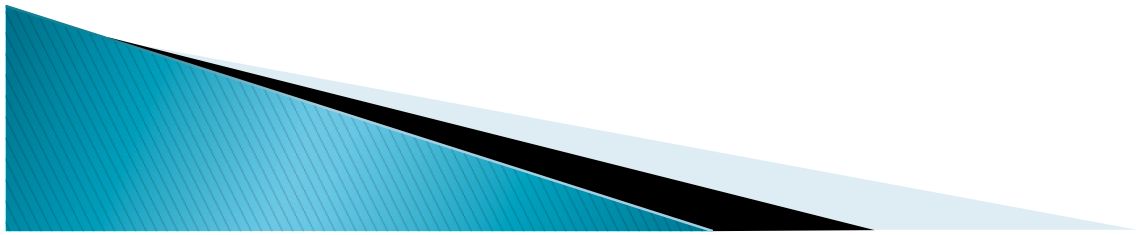


What can be done? (cont)

2. Promote the leasing (instead of the ownership) of portable irrigation systems, such as sprinklers and drip.
   - By leasing portable water-savings technologies, farmers who don't know how long they'll be farming can get funding for irrigation upgrades (Farmer #5, personal communication, February, 16, 2010).

What can be done? (cont)

3. Raise awareness of available funding opportunities to farmers to improve irrigation efficiency.
   - "[Some programs are] funded every year and only a handful of people take advantage of it"
     (Water-agriculture expert #8, personal communication, March 10, 2010).



Outreach and continued work

- University of Arizona Cooperative Extension publication (in progress)
- Social-ecological e-library: http://csid.asu.edu/socecolib/case/163
- National SARE reporting database: http://tiny.cc/r043b

Thank you!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