Mathematical modelling for consensus building in the Lerma-Chapala basin

Álvaro A. Aldama, Javier Aparicio, Alberto Güitrón
Mexican Institute of Water Technology
Opening remarks

- All waters are shared. Catchments and aquifers do not match political boundaries.
- Water management, particularly in water scarcity regions, often generates conflicts.
- Consensus building is necessary to promote an effective governance of transboundary waters.
- Consensus building is complicated by the lack of scientific knowledge about the true state of catchments and aquifers and their probable response to different climatic, water use and technological scenarios.
The Lerma-Chapala basin

- **Area**: 50,000 km²
- **Water volume**: 5,000 hm³
- **Population**: 11 million people
- **Economic contribution**: 12% of national GDP
Challenges

- Very complex hydrological topology and social fabric
- Increased competition for water and conflicts among users and uses, especially during periods of low precipitation
- Water demand exceeded supply, leading to overexploitation
Challenges: Inefficient water use in agriculture

Traditional low efficiency irrigation
Challenges: Inefficient water use in cities

Water leak in a domestic intake
Challenges: Contamination

Untreated discharge to the Lerma river
Challenges: Deforestation
Challenges: Chapala lake survival

- Largest surface water body in Mexico
- Main water source for the city of Guadalajara
- Level decreased over 4 m from 1993 to 2003
- 70% loss of storage: danger of disappearing
Storage in July, 2002: 1,145 hm³

Record of Chapala lake stored volumes

Natural capacity of the lake: 4500 hm³
Comparison of satellite images of the lake

1986

2002
Main challenge

- Confrontational positions of Guanajuato (upstream) and Jalisco (downstream) states
- Discussions based on opinions and not on facts
- No agreements/consensus could be reached
**Actions undertaken**

- IMTA performed scientific studies under contract with the National Water Commission (CNA):
  - A hydrological study of the lake: evaporation and runoff in ungaged catchments
  - Water pollution in the basin and the lake
  - Water consumption, water economics and social conflict studies
- Models developed and validated: system dynamics simulation and genetic algorithm-based optimization
  - the river and its tributaries
  - existing reservoirs
  - irrigation units
  - cities, towns and industrial complexes
  - aquifers and, of course
  - the lake
MODELO DINÁMICO DE SIMULACIÓN PARA
EL ANÁLISIS DE LA PROBLEMÁTICA EN LA CUENCA
LERMA-CHAPALA
Schematization of solution options
The consensus building process

- Each of the states represented in the basin hired experts to form a high-level technical group reporting directly to the Basin Council.
- CNA coordinated and supervised the overall process.
- IMTA provided: 1) training in the use of the models and 2) scientific and technological support and advice.
- Once the simulation and optimization models were approved, the group performed, under IMTA´s guidance, the analysis of climatic, water use and technological scenarios, as well as of solution options.
- After around 30,000 person-hours, an agreement was reached to define a so-called Joint Optimal Operational Policy.
- The models proved to be essential in the consensus building process, since they created the proper climate for discussions based on facts, rather than on opinions, thus making it possible to overcome the existing impasse.
The high-level technical group in session
The training process
On the basis of the described scientific and technological actions, an agreement between the five state governments and the Guanajuato agricultural users was drafted. The agreement includes a reference to the models as decision-making tools and establishes water allocation rules, seeking to satisfy as much of the agricultural demand as is physically possible and to preserve the Chapala lake. The agreement was signed by the five state governors in December, 2004, with the presence of the President of Mexico as Honorary Witness. The agreement was signed by the agricultural users in January, 2005. On the basis of the agreement a basin-wide restoration effort has been undertaken by the Ministry of the Environment and Natural Resources and by CNA.
ACUERDO DE COORDINACIÓN PARA LA RECUPERACIÓN Y SUSTENTABILIDAD DE LA CUENCA LERMA CHAPALA QUE CELEBRAN POR UNA PARTE, EL EJECUTIVO FEDERAL A TRAVÉS DE LA SECRETARÍA DE MEDIO AMBIENTE Y RECURSOS NATURALES, REPRESENTADA EN ESTE ACTO POR SU TITULAR, ALBERTO CÁRDENAS JIMÉNEZ; Y A LA CUAL EN LO SUCESIVO SE LE DENOMINA COMO “LA SEMARNAT”; LA COMISIÓN NACIONAL FORESTAL, REPRESENTADA POR SU DIRECTOR GENERAL EL C. MANUEL AGUSTÍN REED SEGÓVIA, EN LO SUCESIVO “LA CONAFOR”; LA COMISIÓN NACIONAL DEL AGUA REPRESENTADA POR SU DIRECTOR GENERAL EL C. CRISTÓBAL JAIME JAQUES. EN LO SUCESIVO “LA CANA” LA SECRETARÍA DE AGRICULTURA, GANADERÍA, DESARROLLO RURAL, PESCA Y ALIMENTACIÓN, REPRESENTADA EN ESTE ACTO POR SU TITULAR EL C. JAVIER BERNARDO USABIAGA ARROYO A LA CUAL EN LO SUCESIVO SE LE DENOMINA COMO “LA SAGARPA” Y LOS TITULARES DEL PODER EJECUTIVO DE LOS ESTADOS DE GUANAJUATO, REPRESENTADO EN ESTE ACTO POR EL GOBERNADOR CONSTITUCIONAL, EL C. JUAN CARLOS ROMERO HICKS; DE JALISCO, REPRESENTADO EN ESTE ACTO POR EL GOBERNADOR CONSTITUCIONAL, EL C. FRANCISCO JAVIER RAMÍREZ ACUÑA; DE MÉXICO, REPRESENTADO EN ESTE ACTO POR EL GOBERNADOR CONSTITUCIONAL, EL C. LÁZARO CÁRDENAS BATLES, Y DE QUERÉTARO, REPRESENTADO EN ESTE ACTO POR EL GOBERNADOR CONSTITUCIONAL, EL C. FRANCISCO GARRIDO PATRÓN; CON LA PARTICIPACIÓN COMO TESTIGO DE HONOR DEL C. PRESIDENTE DE LOS ESTADOS UNIDOS MEXICANOS, EL C. VICENTE FOX QUESADA, AL TENOR DE LOS ANTECEDENTES, DECLARACIONES Y CLÁUSULAS SIGUIENTES:

ANTECEDENTES

I. El Plan Nacional de Desarrollo 2001-2006, expedido por el Ejecutivo Federal, establece que el desarrollo social y humano armónico con la naturaleza implica, entre otras cosas fortalecer la cultura al cuidado del medio ambiente para no comprometer el futuro de las nuevas generaciones; considerar los efectos no deseados de las políticas en el deterioro de la naturaleza y estimular la conciencia de la relación entre el bienestar y el desarrollo en equilibrio con la naturaleza.

II. El Programa Nacional de Medio Ambiente y Recursos Naturales 2001-2006, señala que deterir y revertir el deterioro ambiental acumulado es una tarea prioritaria para la seguridad nacional, además destaca la importancia de la participación del Gobierno Federal con los Estados en la formulación de propuestas para la atención de los distintos problemas ambientales y necesidades sociales, definido al mismo tiempo las estrategias a seguir, como son:
Closing remarks

- Scientific basin knowledge and proper technological tools proved to be essential in the analysis of scenarios and solution options for a complex set of water-related problems in the face of intense competition for the resource.

- Simulation and optimization models proved to be essential in building consensus among stakeholders with conflicting positions, in order to define sustainable transboundary water management schemes.

- Similar exercises are now in the process of being replicated at the Balsas and Valley of Mexico basins.