

# **Modeling Infrastructure Decisions for Urban Water Planning**

## **Applications for Mexico City**

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WWW-YES Conference Presentation  
5 June 2013

# Models

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- Used to understand systems and processes
- Decision models
  - Search through possible combinations to identify good solutions
  - Optimization models: search all available solutions
    - Linear, Non-linear
    - Mixed-integer
    - Dynamic
  - Heuristic models: focus search on favorable solutions
    - Genetic algorithms
    - Simulated Annealing

***Usefulness of models lies in the insights provided for system function and operation, not absolute numerical results***

# Optimization Modeling

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- Assess “best” solutions to complex problem sets
- Theory and procedures developed over decades
  - Growth of operations research
- Adopted as practice in many fields
  - Transportation planning
  - Water resources
  - Electricity and telecommunications
- Necessary Criteria
  - Define goal or objective
  - Define variable inputs and equations for relationships
  - Identify Constraints



# Two-Stage Linear Programming

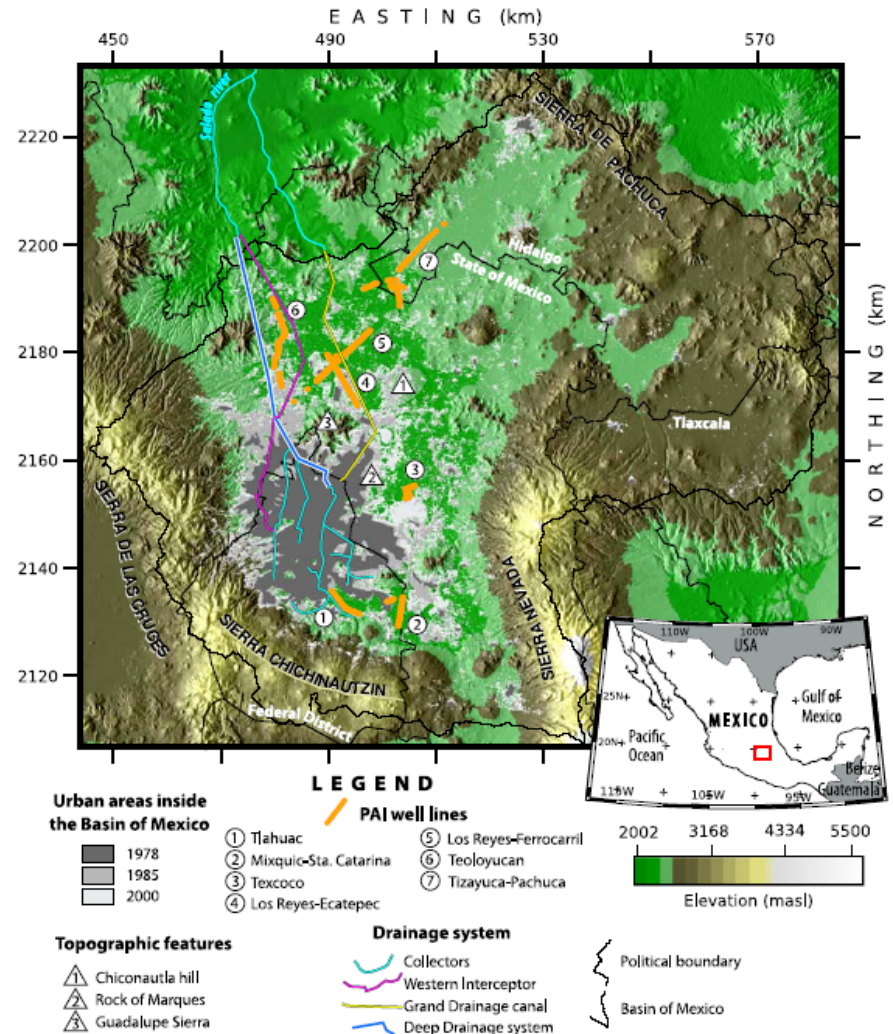
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- Probabilistic mathematical model useful in planning
- Two stages of decisions
  - Initial actions
  - Subsequent “recourse” actions
  - Balance costs and predicted damages
- Applications
  - Events where an initial decision must be made under uncertainty, and subsequent actions are possible
  - Water resources:
    - Flood planning
    - Water demand management

# Mexico City and Water

## Research Objective:

Use planning models to assess tradeoffs in cost and performance of water infrastructure options for the Metropolitan zone of Mexico City



# Applying a Two-Stage Model

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- Probabilistic, two-stage decision model for infrastructure and planning decisions in Mexico City
  - Long-term decisions: Municipal and water supply infrastructure
    - Supply pipelines, treatment plants
    - Injection wells, infiltration basins
    - Demand management, rainwater harvesting, water reuse infrastructure, subsidies
  - Short-term actions: Municipal and user actions to mitigate shortages, subsidence, and water quality issues
    - Supply outages and damage costs
    - Water trucks
    - Household reuse

# Municipal Water Balance

- Water balance calculation

$$Outflows_{Canals} = (Imports + Extractions + HH\ Actions + Muni\ Reuse + Runoff) - (Demands + (Rchg_{Infiltration} + Rchg_{Leakage}) + Evaporation)$$

## Water Supply

### Imports

water supply pipes  
expansion costs

### Extraction

pumping costs

### Precipitation Runoff

### Municipal Reuse

direct potable reuse

### Household Actions

water trucks  
rainwater harvest  
reuse

## Use & Losses

### Demands

per capita use

### Recharge

leakage

WW treatment &  
injection

WW treatment &  
infiltration

### Evaporation

## Water Out

### System Outflows

Drainage Canals

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# Approach

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- Literature review and interviews
- Identify possible initial actions and costs (long-term)
  - Capital-intensive
- Identify possible subsequent actions to meet demands (short-term)
  - Municipal and household
- Parameterize likelihood of shortage events
  - Possible causes: rainfall, water demands, climate variability
- Seek to identify tradeoffs in:
  - Long-term vs. short-term
  - Distributed vs. centralized



# Framework for Potential Actions

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Long-term and Short-term Actions, categorized in relation to current approaches

<b>Long-Term Actions</b>	Landscape	Centralized control with some public education	Innovative policies, broad public engagement
	Import/Convey	Business as Usual	Water shortages lead to action, Information requirements
		Trucking	Capture and Reuse

**Short-Term Actions**

# Progress

- Literature review and existing data collection
- Fieldwork interviews
- Data collection
  - Hydrology
  - Groundwater data
  - Water balance calculations
  - Household water use
- Begin with broad system view
  - Apply known variables at appropriate scale to identify data gaps to collect or parameterize
- Consider case-study basins

**SAPASE** SERVICIO PÚBLICO DE AGUA POTABLE Y ALCANTARILLADO Y SANEAMIENTO DEL MUNICIPIO DE ECATEPEC

**FACTURA** B-064413

FECHA DE EMISIÓN: 16-Enero-2012 13:59:04

CÓDIGO: 98458

CLAVE EXTENSIÓN: 1711

SANDOVAL SANCHEZ JESUS JORGE

VALLE DE TEHUACAN S.M. de C.V. Mx 21, EL VALLE DE ARAGON 3A. SECCION ORIENTE.

CONCEPTO	CANTIDAD	UNIDAD	VALOR UNITARIO	VALOR TOTAL
13	1	0	No registrada	N/A
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Dom*12 Art. 130 Suministro de agua potable 3,729.55				
Dom*12 Bonificación consumo Art.10 LRMEM2012 38% -591.50				
Dom*12 Bonificación drenaje Art.10 LRMEM2012 38% -52.56				
Dom*12 Bonificación en consumo por pago anticipado 8% -124.53				
Dom*12 Bonificación en drenaje Pago Anticipado 8% -11.07				
Dom*12 Aportación mejoras Serv. ambientales 3.50% 54.48				
Dom*12 Art. 130 Bis Derecho de descargo de drenaje 8% 138.36				
Dom*12 Bonif. en consumo por serv. discontinuo 10% -172.95				

TOTAL A PAGAR: 969.76

FORMA DE PAGO: Efectivo

ESTABLECIMIENTO NO ACREDITA LA PROPIEDAD

Villanueva Barrios Yacuzzi

Calz.40 Ocho Cerros Plaza

ORIGINAL CLIENTE

# Outcomes and Limitations

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- Develop a hydro-economic model for water management in the Basin of Mexico considering environmental factors
- Explore tradeoffs in various strategies
  - Identify least-cost combinations of actions
- Data needs and applicability
  - Articulate relationships between variables
  - Quantify costs, potential damages, and challenges
  - Practitioner acceptance
- Consider parallel cases of urban water resources development

***Incorporating expertise of system managers and researchers is critical to understanding any system***

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