

MEGA-ADAPT: Simulating socio-hydrological and climatic risks in Mexico City through a self-organizing systems approach

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Vulnerability in Mexico City



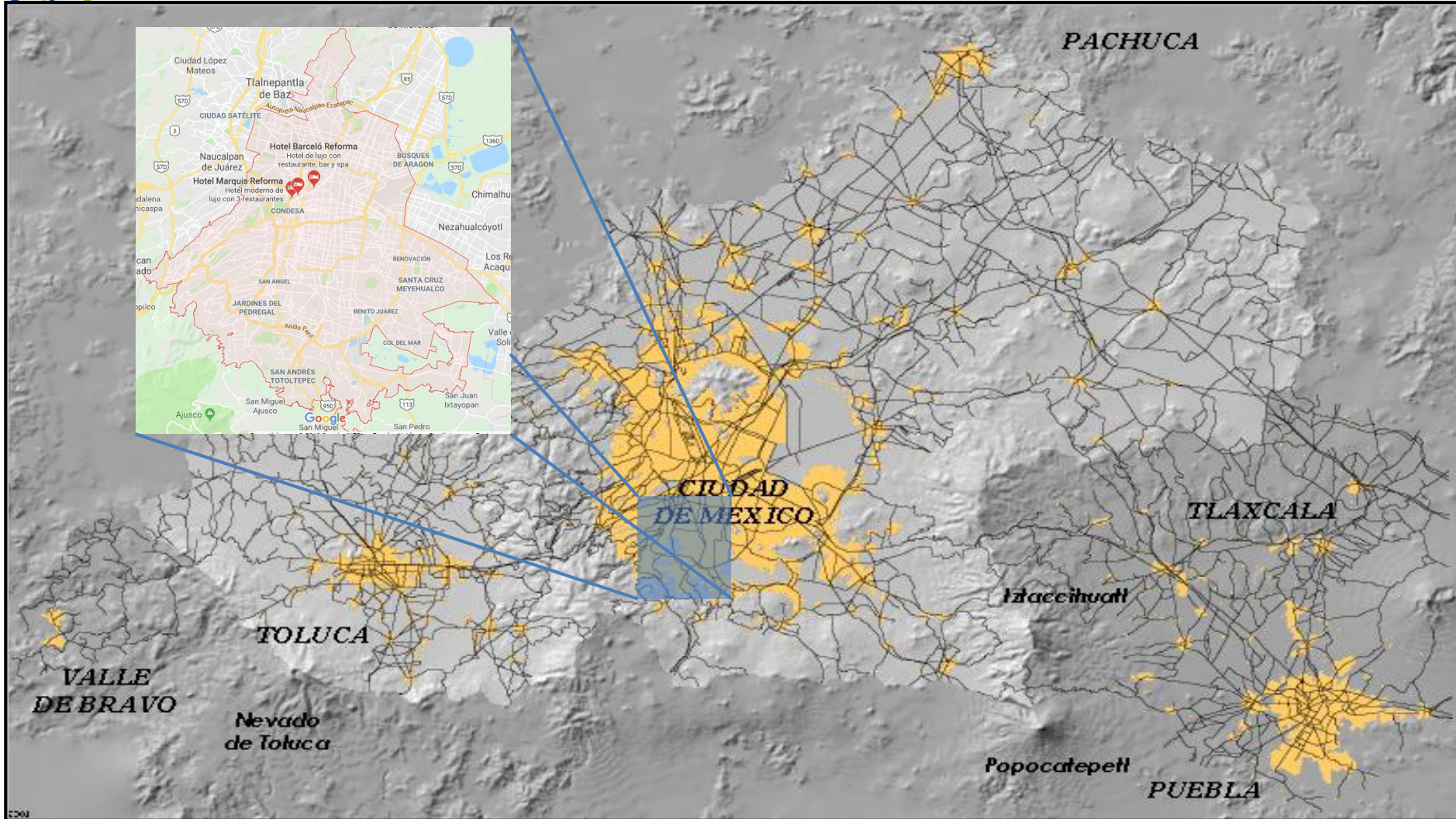
- What role does risk play in shaping a megalopolis?
- How current risk management generates vulnerability in the future?
- Can a megalopolis be resilient but unsustainable?
- What tools are needed to govern uncertainty?

Fuente: Marco Adrián Ortega Guerrero. Las inundaciones en Chalco, *La Jornada*, 12 de junio de 2000.

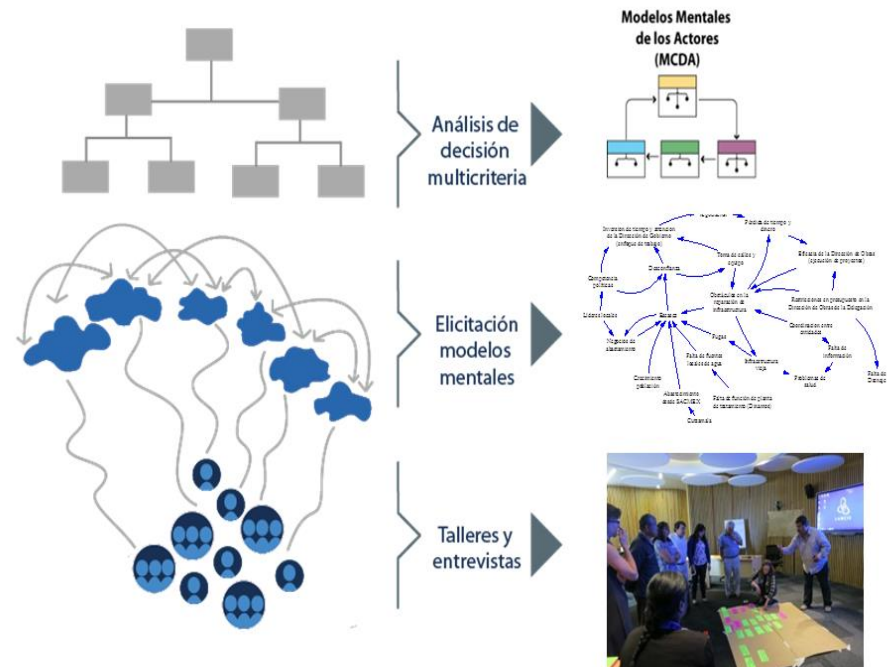
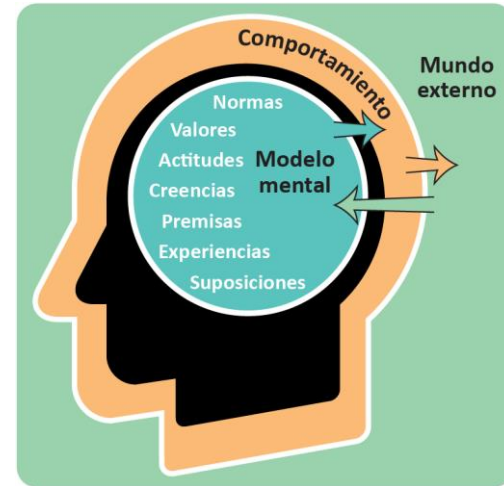


Mexico City Metropolitan Zone

Simulated urban sprawl: 2000-40



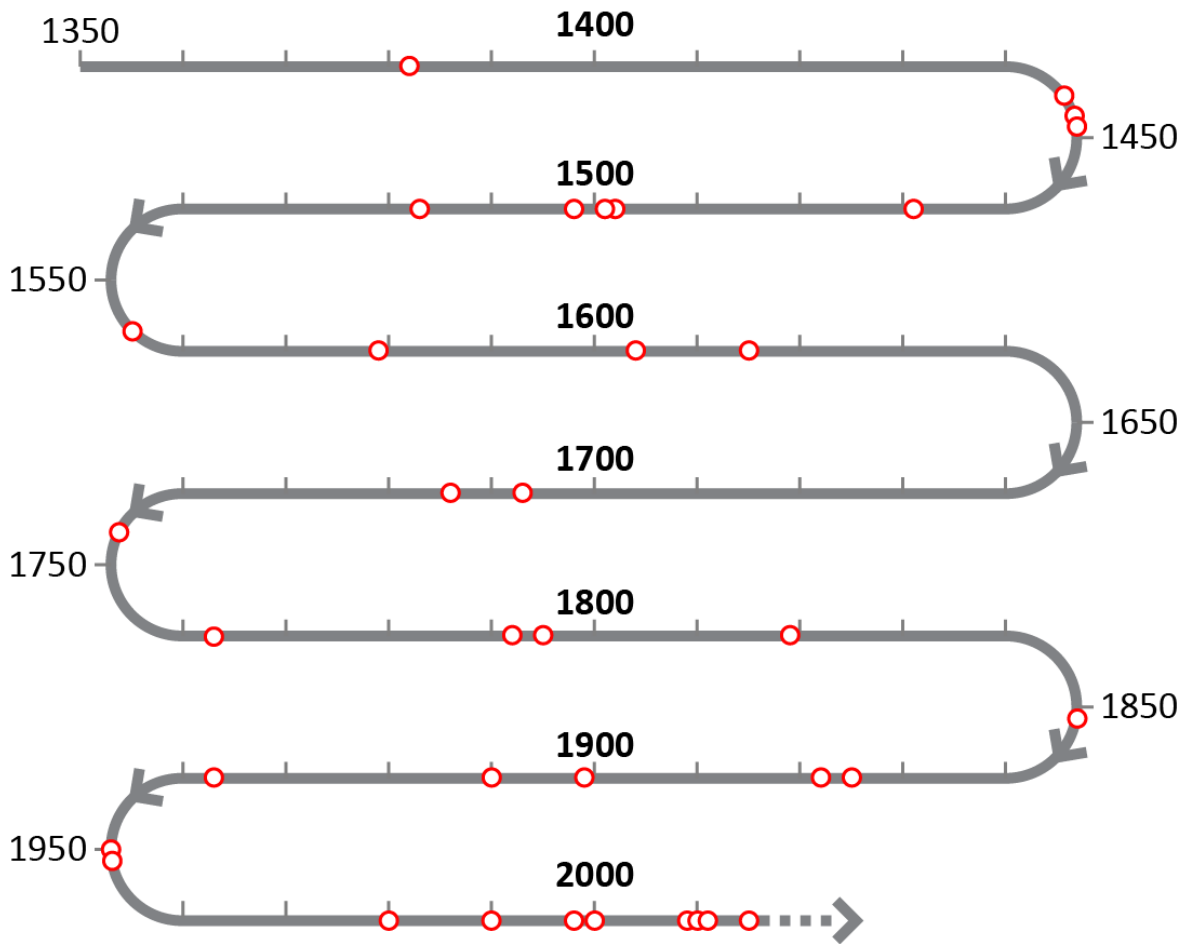
- **Vulnerability is an emergent property:** an outcome of a socio-political and biophysical processes
- The “**socio-political infrastructure**” (social and political norms, values, rules, and relationships) undergird and structure the myriad decisions made by public and private actors
- The socio-political infrastructure is likely to be as influential in urban vulnerability dynamics as “**hard infrastructure and environmental management**”



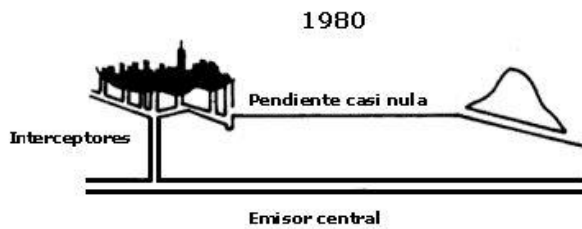


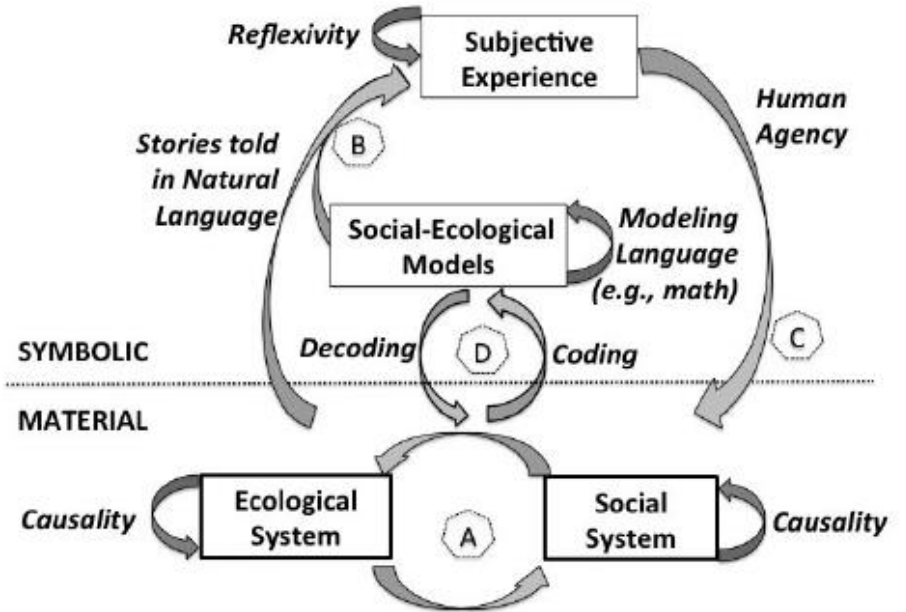
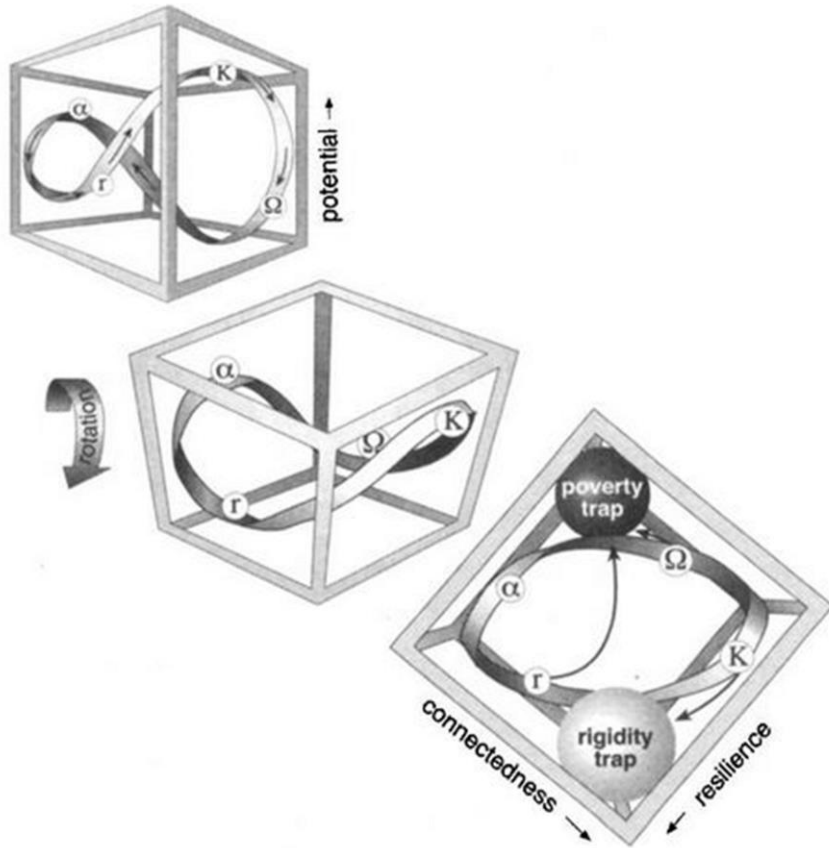
Socio-hydrological risk: Flooding

Increasing vulnerability

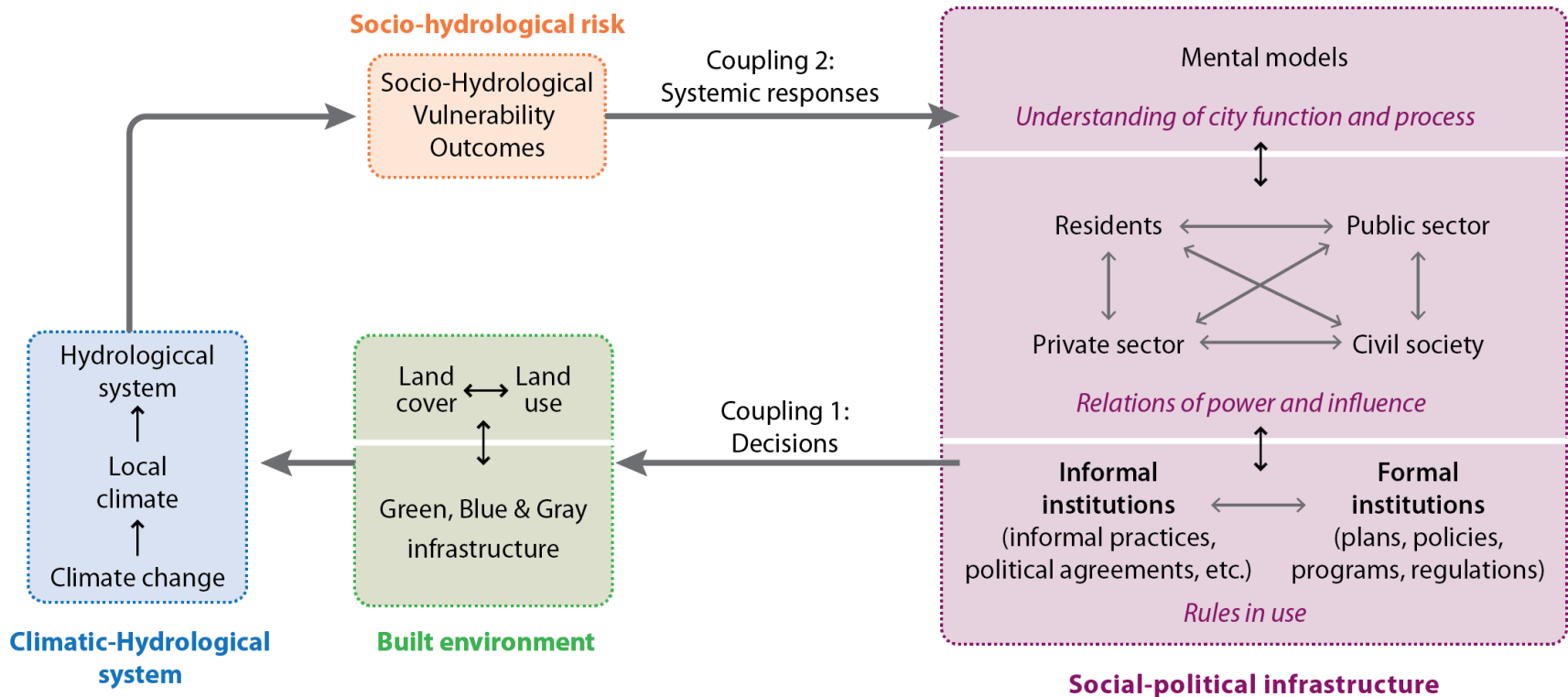








From the perspective of self-organizing systems, **MEGADAPT (MEGAcity-ADAPTation)** simulates urban vulnerability and adaptation as a process of reflection



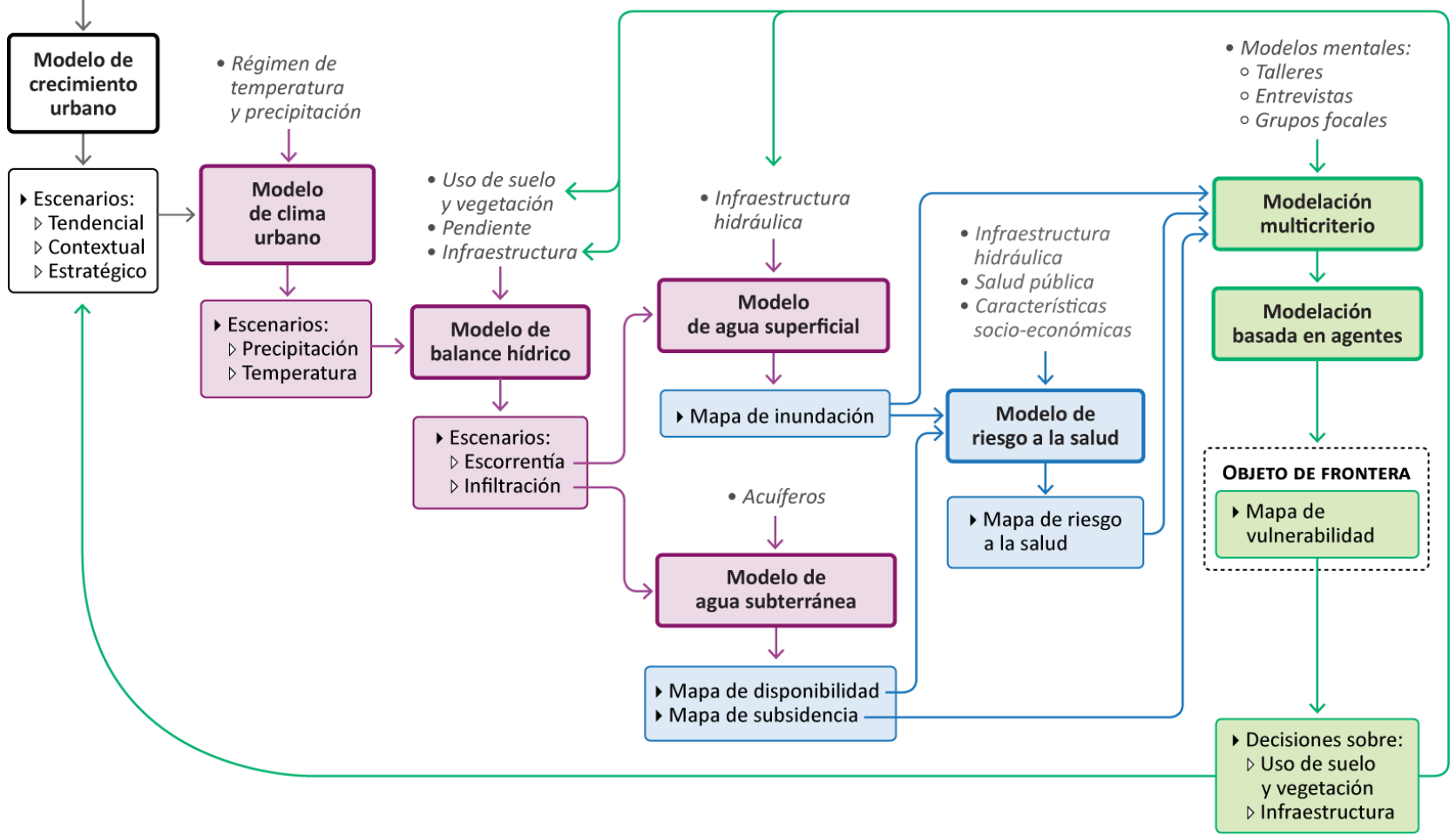
• Insumos

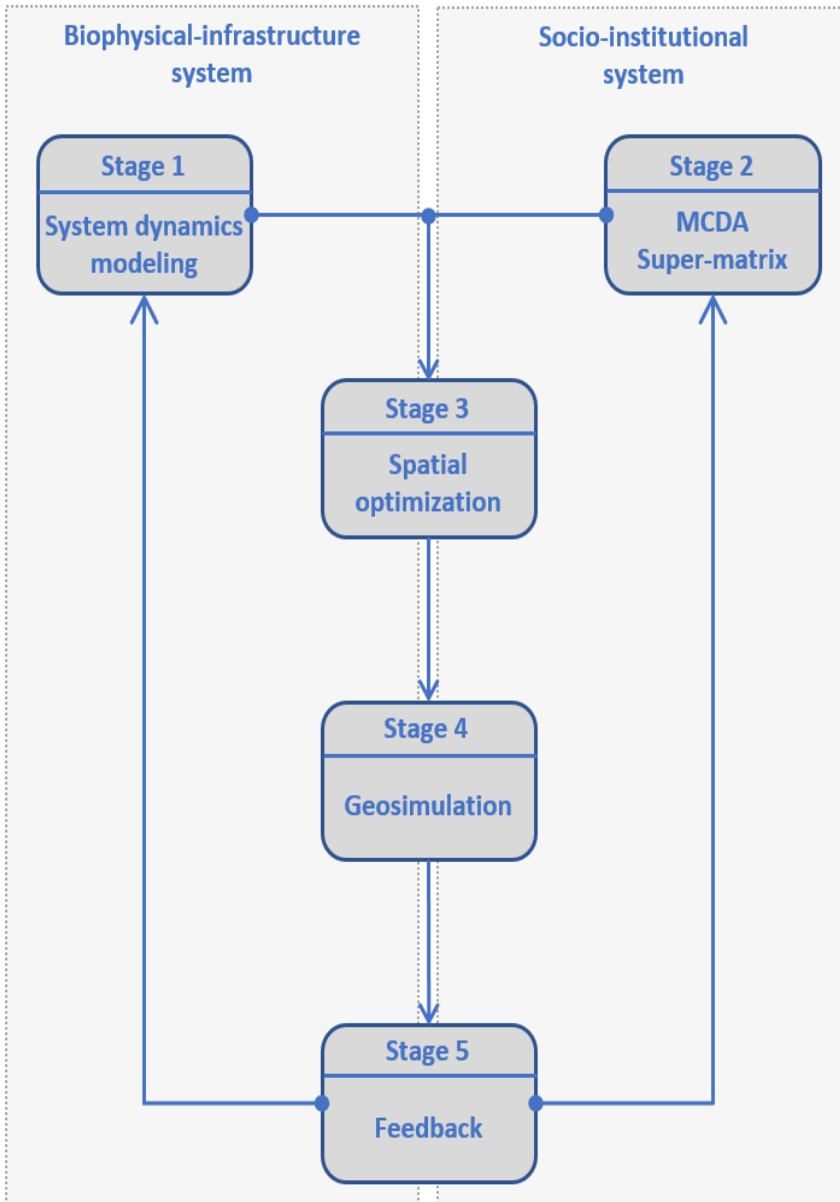
Modelos

► Resultados



• Zona urbana





Stage 1, *System dynamics modeling*: To simulate the behavior of biophysical-infrastructure determinants of risk

Stage 2, *Multicriteria decision analysis*: To elicit the stakeholders' priorities

Stage 3, *Spatial optimization*: To identify the decision space or set of alternatives

- Site selection: To rank the alternatives with their suitability for the two actions, based upon the known spatially explicit attributes of decision criteria.
 - Site search (multiobjective optimization): to identify the set of alternatives from the decision space that best meets the locational objectives and constraints
-

Stage 4, *Geosimulation*: To represent socio-hydrological risks as outcomes of the collective dynamic interactions of multiple urban entities.:

- Geographic automata
- CA & ABM



Water authority

City resident

Census block

Water
scarcity

- Build infrastructure
- Maintain infrastructure
- Extract groundwater
- Import water
- Supplement water

- Cope
- Store water
- Buy water
- Protest

- Increase subsidence
- Infrastructure failure
- Groundwater depletion

Flooding &
ponding

- Build infrastructure
- Maintain infrastructure

- Cope
- Modify household

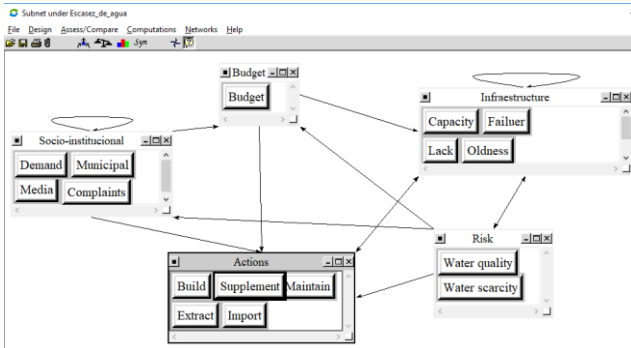
- Precipitation
- Runoff



MCDA: Analytic Network Process (ANP)

Combining tangible data (e.g., statistics) with intangible knowledge (e.g., judgments)

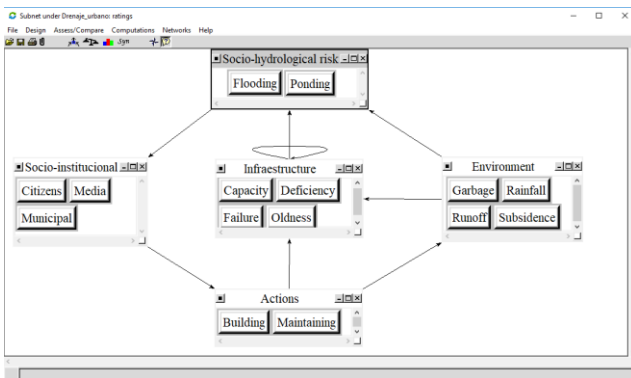
Water scarcity



Supermatrix

Cluster	Element	A		E				I				S			R	
		Ma	Bu	Ga	Ru	Su	Rf	OI	Ca	Fa	De	Mu	Ci	Me	Po	Fl
Actions (A)	Maintaining (Ma)															
	Building (Bu)															
Environment (E)	Garbage (Ga)															
	Runoff (Ru)															
	Subsidence (Su)															
Infrastructure (I)	Rainfall (Rf)															
	Oldness (OI)															
	Capacity (Ca)															
	Failure (Fa)															
Socio-institutional (S)	Deficiency (De)															
	Municipal (Mu)															
	Citizens (Ci)															
Socio-hydrological risk (R)	Media (Me)															
	Ponding (Po)															
	Flooding (Fl)															

Flooding and ponding



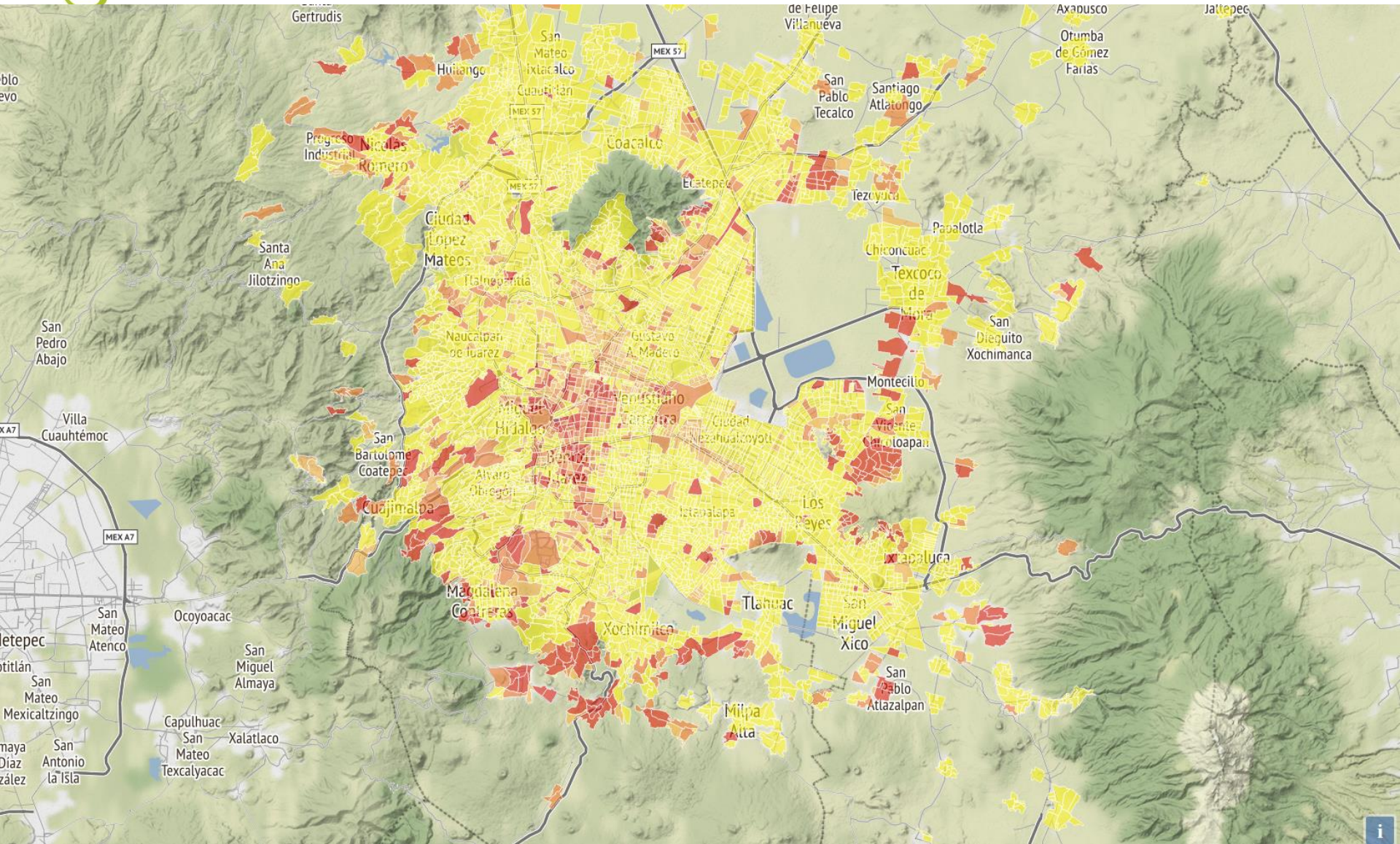
Aggregation

$$S_i = \left[\sum_{j=1}^J w^p (1 - x_{ij}^p) \right]^{1/p}$$



Pattern 1: Infrastructure efficiency

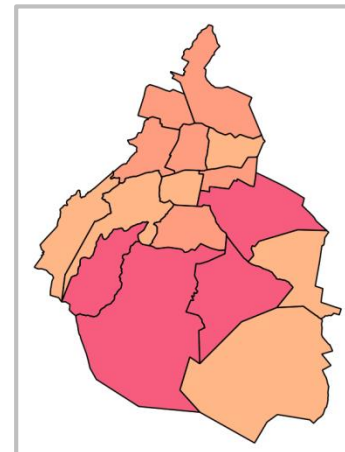
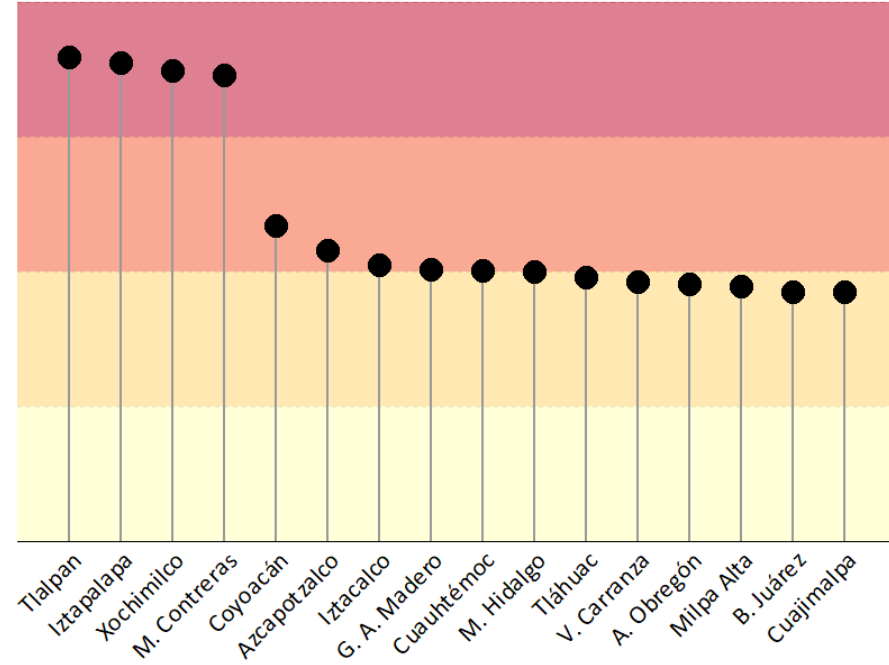
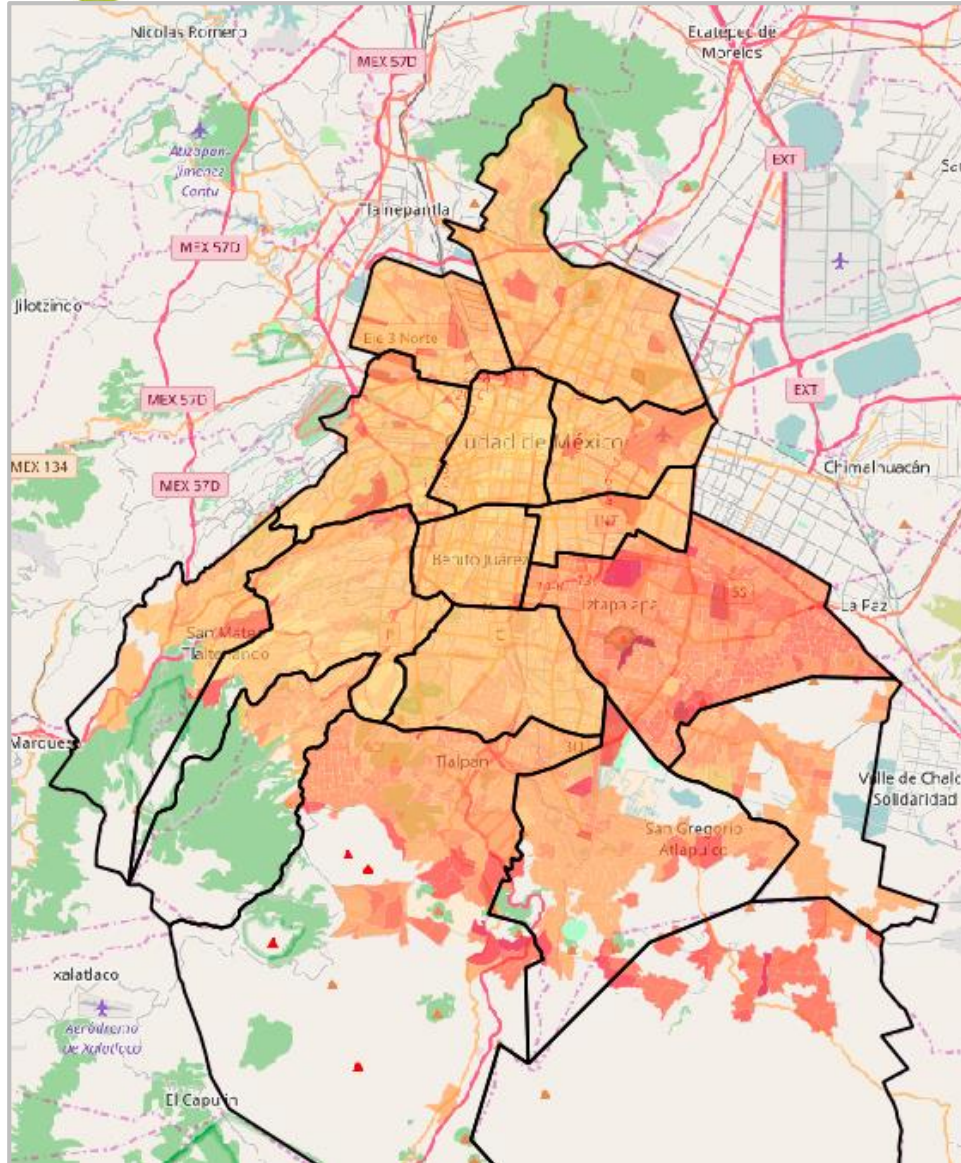
Homo economicus





Vulnerability by water scarcity

Current budget



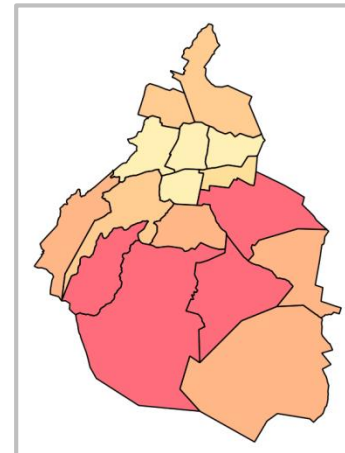
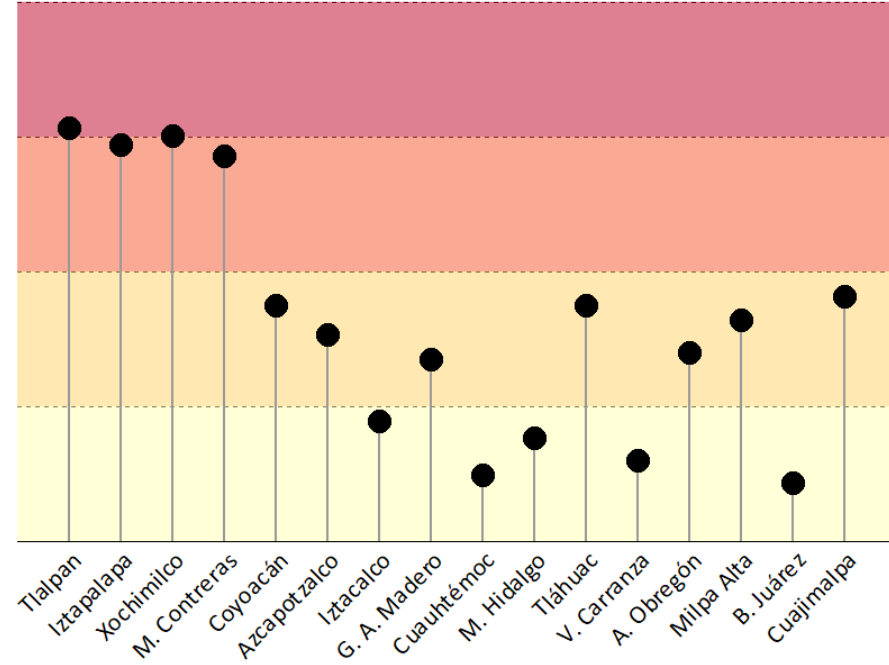
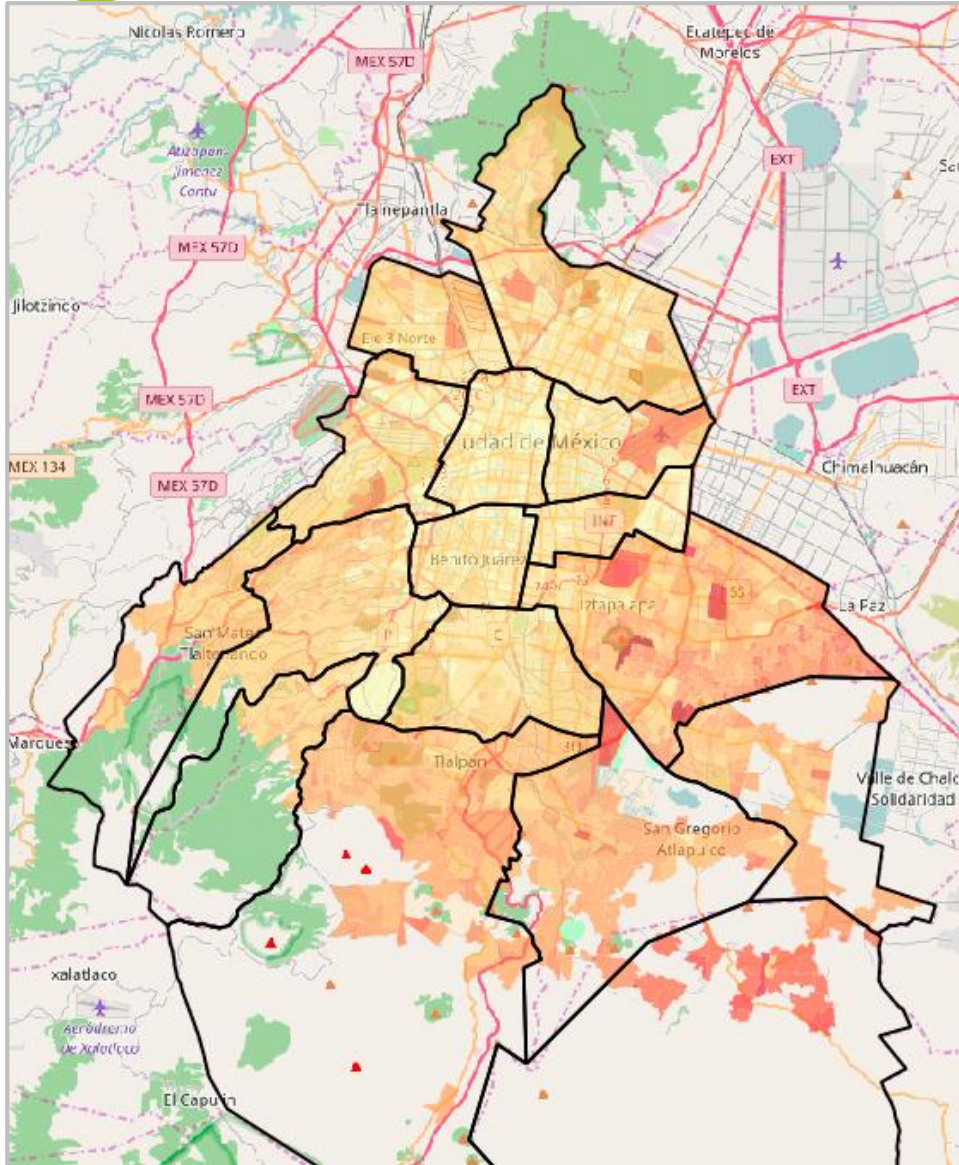
Grado de vulnerabilidad





Vulnerability by water scarcity

Improved budget



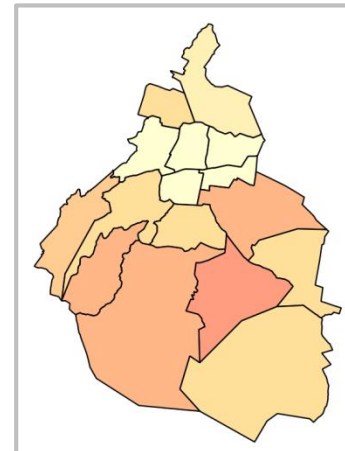
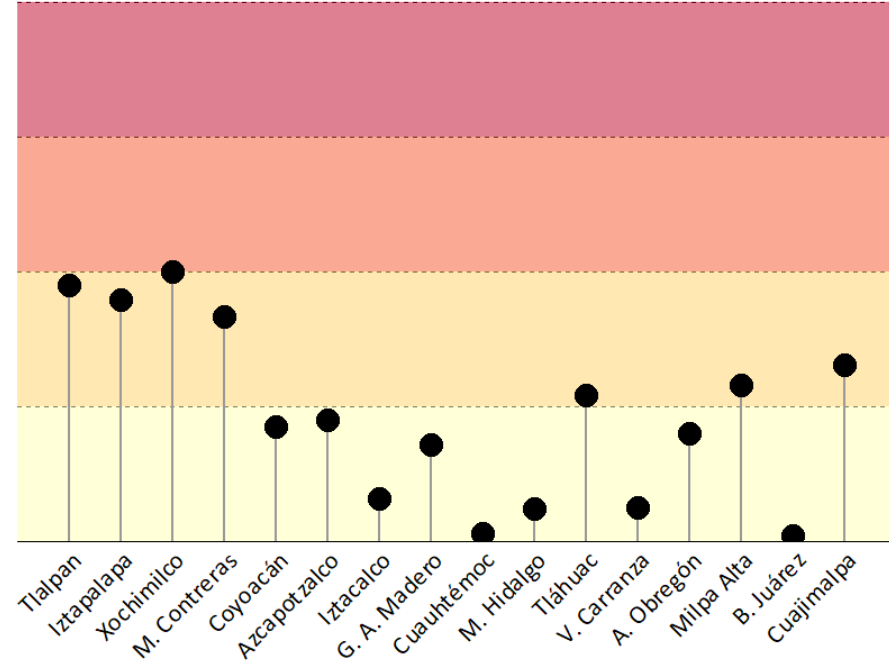
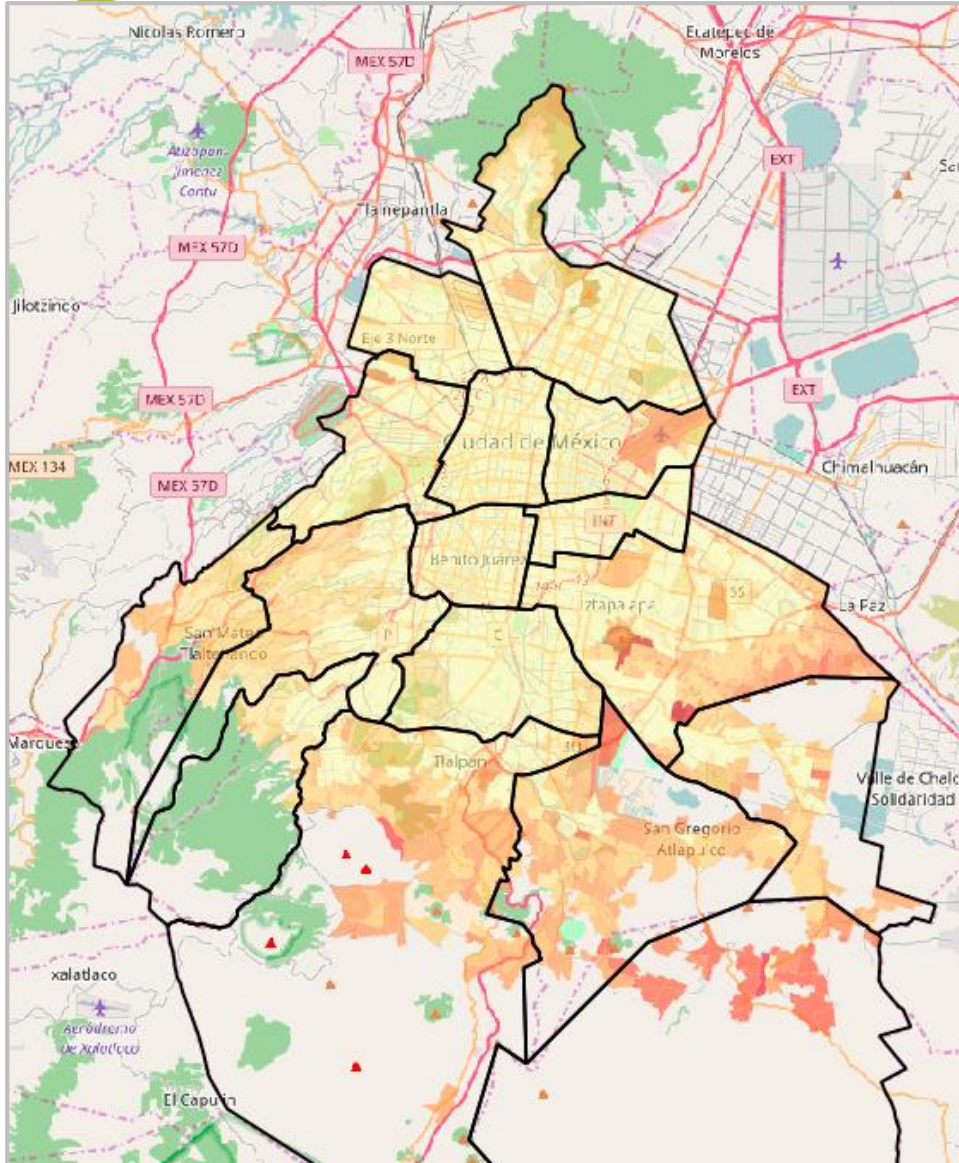
Grado de vulnerabilidad





Vulnerability by water scarcity

High budget



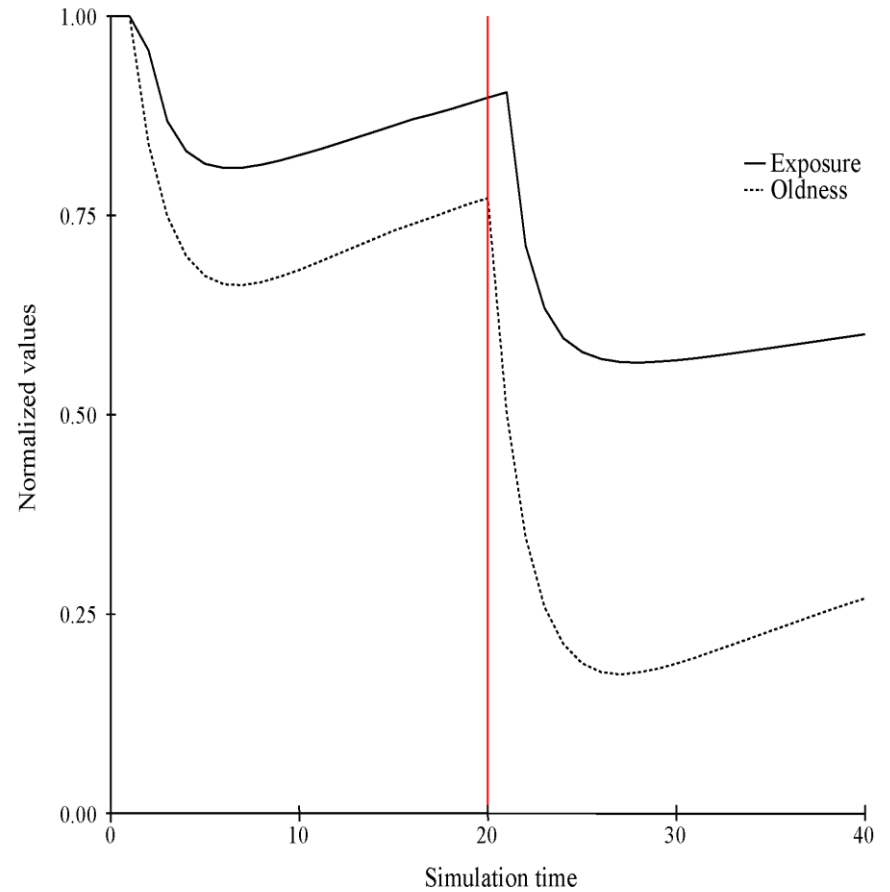
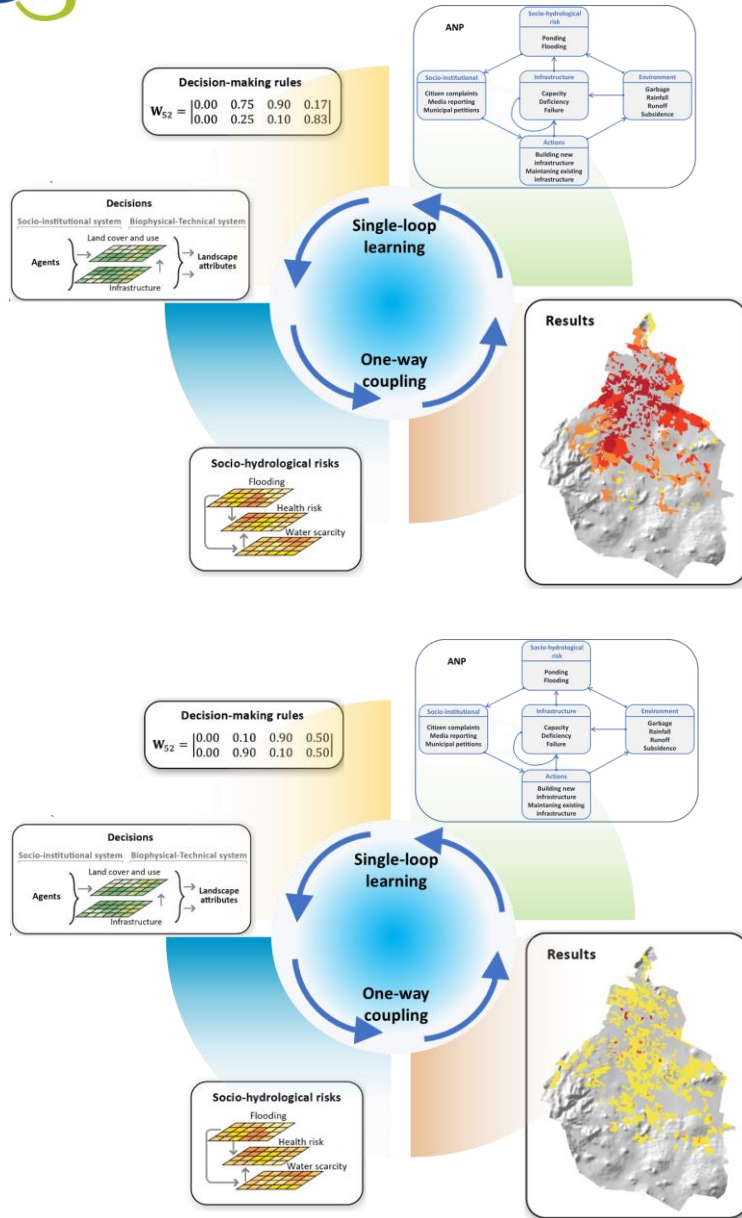
Grado de vulnerabilidad





Coupling/ double loop learning

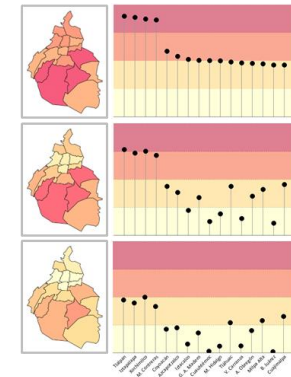
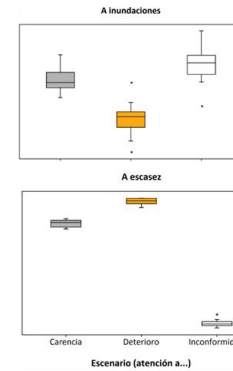
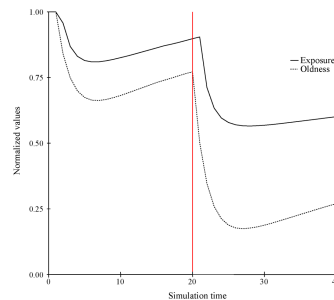
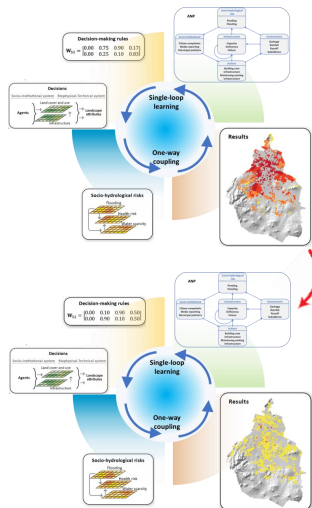
Evolution of risk



Final thoughts: Dynamic ANP, complexity and policy in building urban resilience

Transdisciplinary engagement issues

- Making the social and political processes that undergird urban risk dynamics tractable and transparent is a political act as much as a research challenge
- Results show the increasing burden of managing socio-hidrological risk
- Communication of meaningful information: Patterns, trade-offs and thresholds
- Opportunities for more transparent and democratic decision making



Methodological issues

- Behaviorally realistic agents
 - Shift from simple behavioral rules to more complex decision making processes
 - Respond to empirical information & data resulting from dynamic modeling
 - Integrate qualitative (judgments) and quantitative (statistical) data
- Simulation vulnerability from the perspective of complexity
 - Massively parallel system of concurrent behavior
 - Producing events that trigger other events
 - Behavior highly dependent on context
 - Elements react to both system's inner state and the emerging patterns

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