Effects of Interactions between Society and Environment on Policy in Water Resources Management: exploring Scenarios of Natural and Human-Induced Shocks

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Introduction to Case Study

ETNA MOUNTAIN
Active Volcano partially covered with snow during all the year
The Alcantara River Basin System

<table>
<thead>
<tr>
<th>Main Informations Table</th>
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</thead>
<tbody>
<tr>
<td><strong>Area (km²)</strong></td>
</tr>
<tr>
<td><strong>Mean elevation (m)</strong></td>
</tr>
<tr>
<td><strong>Max elevation (m)</strong></td>
</tr>
<tr>
<td><strong>Min elevation (m)</strong></td>
</tr>
</tbody>
</table>

**Groundwater Springs**

**Drinking Water Extraction**

**Power Plants**

**Alcantara Fluvial Park**
Socio-Hydrological Model Set-Up

Social Aspects (Parameters of the model):

- Government ($\mu$)
- People’s Personal Experiences ($\alpha$)
- Community’s Education and Culture ($\gamma$)

HOW DO SOCIAL ASPECTS IMPACT ON POLICY DURING (AND AFTER) NATURAL AND HUMAN-INDUCED SHOCKS?

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EFFECTS OF INTERACTIONS BETWEEN SOCIETY AND ENVIRONMENT ON POLICY IN WATER RESOURCES MANAGEMENT
EXPLORING SCENARIOS OF NATURAL AND HUMAN-INDUCED SHOCKS

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**Different Scenario Simulations**

**Natural Shock to the System**
*Progressive Shock*

- **SHORT TERM**
  - 1 Drought Event of 10 years in 25 years long time serie

- **LONG TERM**
  - Multiple Drought Events of Various length in longer time serie

**Human-Induced Shock**
*Immediate Shock*

- **SHORT TERM**
  - Water Demand from Groundwater extraction increases for a definite period

- **LONG TERM**
  - Multiple Events of Water Demand from groundwater Increasing in longer time serie

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Scenario A: «Natural Shock to the System» - Simulation Results

**Feedback Mechanism**

- The shocks produce a change in the regulation.
- The Minimum Groundwater Storage level increases (or decreases in Human-Induced Shock Scenario) to preserve the environment from future shocks (or to let people extract more groundwater for drinking water supply in future).

**EFFECTS OF INTERACTIONS BETWEEN SOCIETY AND ENVIRONMENT ON POLICY IN WATER RESOURCES MANAGEMENT**

**EXPLORING SCENARIOS OF NATURAL AND HUMAN-INDUCED SHOCKS**

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HOW DO SOCIAL ASPECTS IMPACT ON POLICY DURING (AND AFTER) NATURAL AND HUMAN-INDUCED SHOCKS?

Exploring Space of Socio-Hydrological Parameters

- Green Mind: \( \frac{\gamma_E}{\gamma_{DW}} \)
- Grey Mind: \( \frac{\gamma_E}{\gamma_{DW}} \)

The way of thinking of community
(Community’s Education and Culture)

- Environmental Awareness
  - More important than Drinking Water Awareness
- Environmental Awareness
  - Less important than Drinking Water Awareness

Memory: the capacity of community to remember water crisis
(People’s Personal Experiences)

Speed in Implementing Management Decisions
(Government)

- FAST ACTION
- SLOW ACTION
- SHORT MEMORY
- LONG MEMORY

Feedback Mechanism On Policy: \( S_{\text{min}}(t) \)

Time
The Role of the way of thinking on the Policy: «Green Mind» vs «Grey Mind»

Scenario A: Natural Shock to the System

<table>
<thead>
<tr>
<th>$\gamma_E$</th>
<th>$\gamma_{DW}$</th>
<th>$\alpha_E$</th>
<th>$\alpha_{DW}$</th>
<th>$\mu$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,2 - 0,71</td>
<td>0,8 - 0,285</td>
<td>0,5</td>
<td>0,5</td>
<td>0,05</td>
</tr>
</tbody>
</table>

$\frac{\gamma_E}{\gamma_{DW}} = 2,5$

$\frac{\gamma_E}{\gamma_{DW}} = 0,25$

Importance of Environmental Awareness
Vs
Importance of Drinking Water Awareness

DROUGHT PERIOD

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The Role of the Memory on the Policy

Scenario A: Natural Shock to the System

<table>
<thead>
<tr>
<th>$\gamma_E$</th>
<th>$\gamma_{DW}$</th>
<th>$\alpha_E$</th>
<th>$\alpha_{DW}$</th>
<th>$\mu$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.33</td>
<td>0.66</td>
<td>0.1 - 1</td>
<td>0.1 - 1</td>
<td>0.05</td>
</tr>
</tbody>
</table>

When $\alpha = 0.1$, the system has a **long memory**. When $\alpha = 1$, the system exhibits a **short memory**.

$\gamma_E / \gamma_{DW} = 0.5$

%Grey Mind %Green Mind

**Drought Period**
The Role of «Speed in Implementing Management Decisions (SIMD)» on the Policy

Scenario A: Natural Shock to the System

<table>
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<tr>
<th>$\gamma_E$</th>
<th>$\gamma_{DW}$</th>
<th>$\alpha_E$</th>
<th>$\alpha_{DW}$</th>
<th>$\mu$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.33</td>
<td>0.66</td>
<td>0.5</td>
<td>0.5</td>
<td>0.01 – 0.001</td>
</tr>
</tbody>
</table>

$\mu = 0.01$ - FAST REACTION

$\mu = 0.001$ - SLOW REACTION

$\gamma_E/\gamma_{DW} = 0.5$

GREY MIND

GREEN MIND

DROUGHT PERIOD
Investigating the Role of SIMD on the Policy

\[ \gamma_E \gamma_{DW} = 0.5 \]

\[ \gamma_E \gamma_{DW} = 1 \]

\[ \gamma_E \gamma_{DW} = 1.5 \]
The Need to Quantify: Sustainability Index Approach

Sustainability Index is calculated with Loucks (1997) definition:

\[ SI = \left[ REL \times RES \times (1 - VUL) \right]^{1/3} \]

\( SI = \) Sustainability Index

\( REL = \) Reliability

\( RES = \) Resilience

\( VUL = \) Vulnerability
Deductions and Conclusions

• For different **way of thinking** «grey» or «green», the policy on system regulation changes

• For different **memory** values, so for different **capacities of the community to remember water crisis**, the policy on system regulation changes

• For different **Speed in Reaction (SIMD)** the policy on system regulation changes and consequently the sustainability of the system:

• For faster reactions in the implementation of possible regulations we get to underestimate (or overestimate) the protection of groundwater resource to the detritment of environment (or to the detritment of the drinking water supply). This is a **paradoxical** effect.

• It follows that **extremely rapid decision-making strategies** (for example, programmed in conditions of water crisis) can be counter-productive in the long term if not updated over time and if elaborated by analyzing the problem on a short-term scale (immediately) without considering the long-term effects that a socio-hydrological model like this may suggest.

• **Not taking decisions** in water crisis also damages the environment
Thank you for the Attention