

CONFLICT RESOLUTION IN TRANSBOUNDARY WATERS: INCORPORATING WATER QUALITY IN NEGOTIATIONS

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THE TRANSBOUNDARY ISSUE

Global Situation

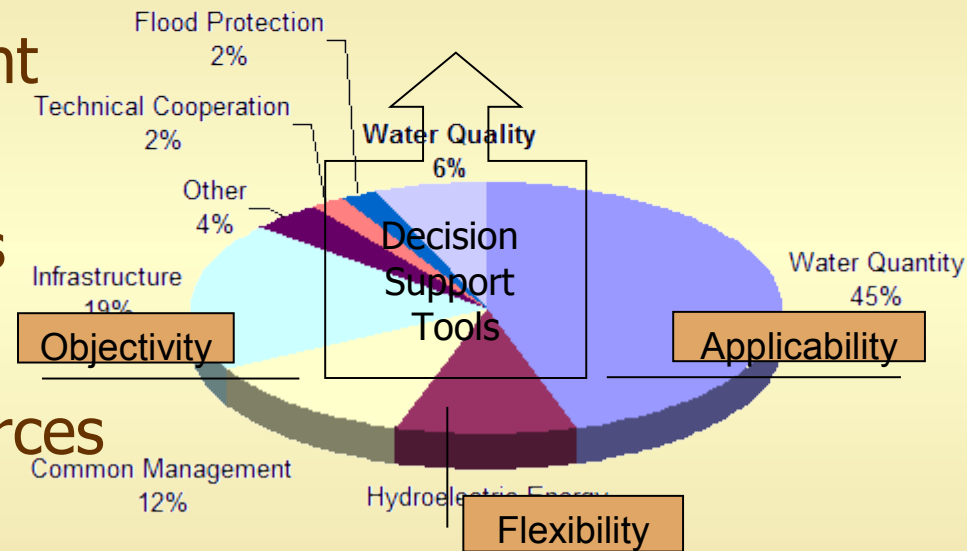
- Half of the earth's surface lies in transboundary basins
- 60% of the global river flow
- UN Conventions
- Means of co-operation or conflict?

Greek Situation

- 5 transboundary rivers in northern Greece
- ~25% "transboundary flow"
- Formal agreement only for Nestos

THE QUALITY ISSUE

- Water quality issues absent
- Need for appropriate tools
- Definition of pollution sources
- Estimation of impact

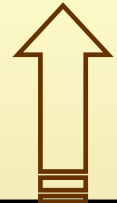


PURPOSE OF THE STUDY

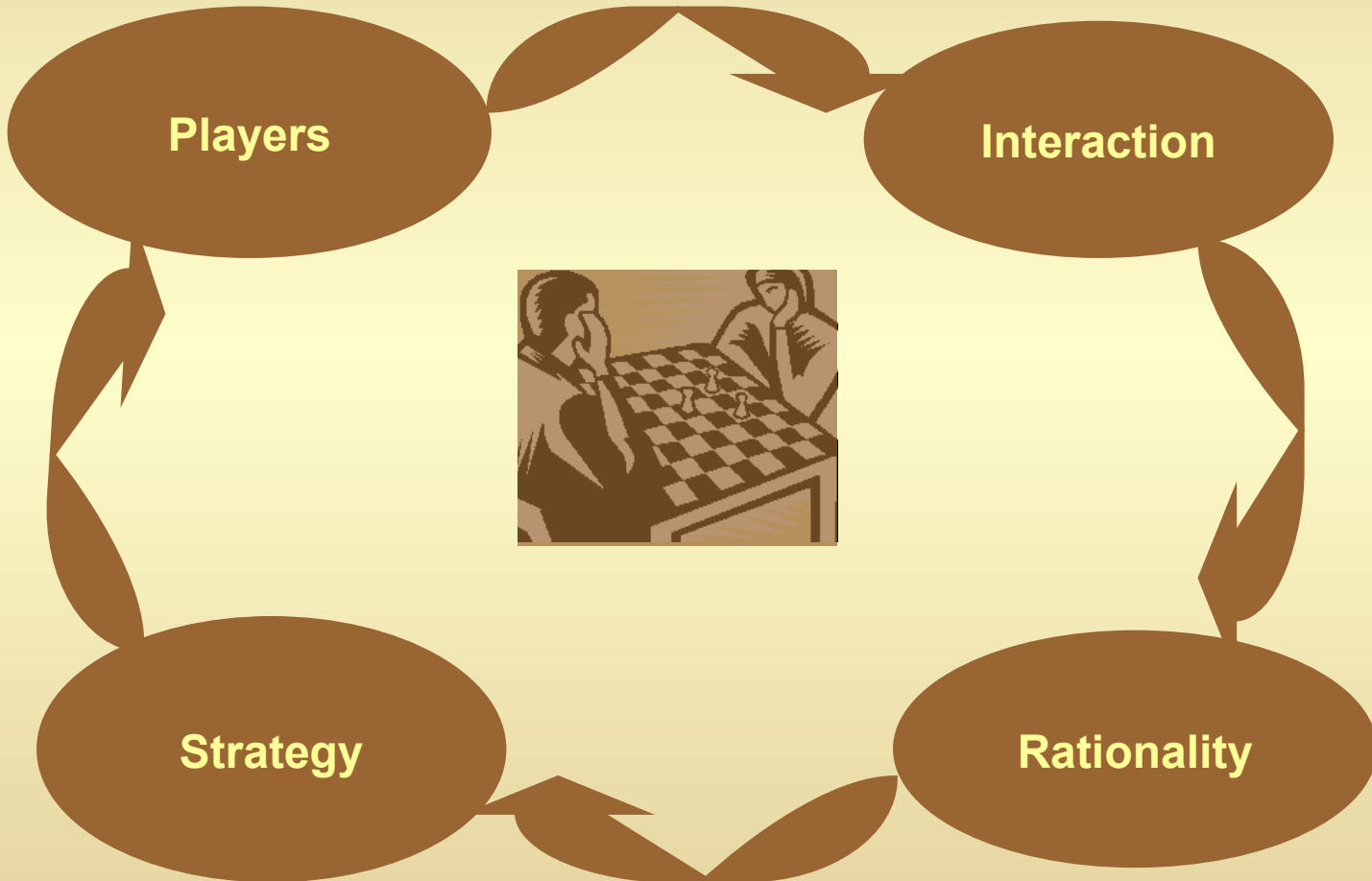
The development of a Negotiation Support System (NSS) for the management of transboundary water resources in compliance with the institutional and international legal framework contributing to conflict resolution in transboundary catchments



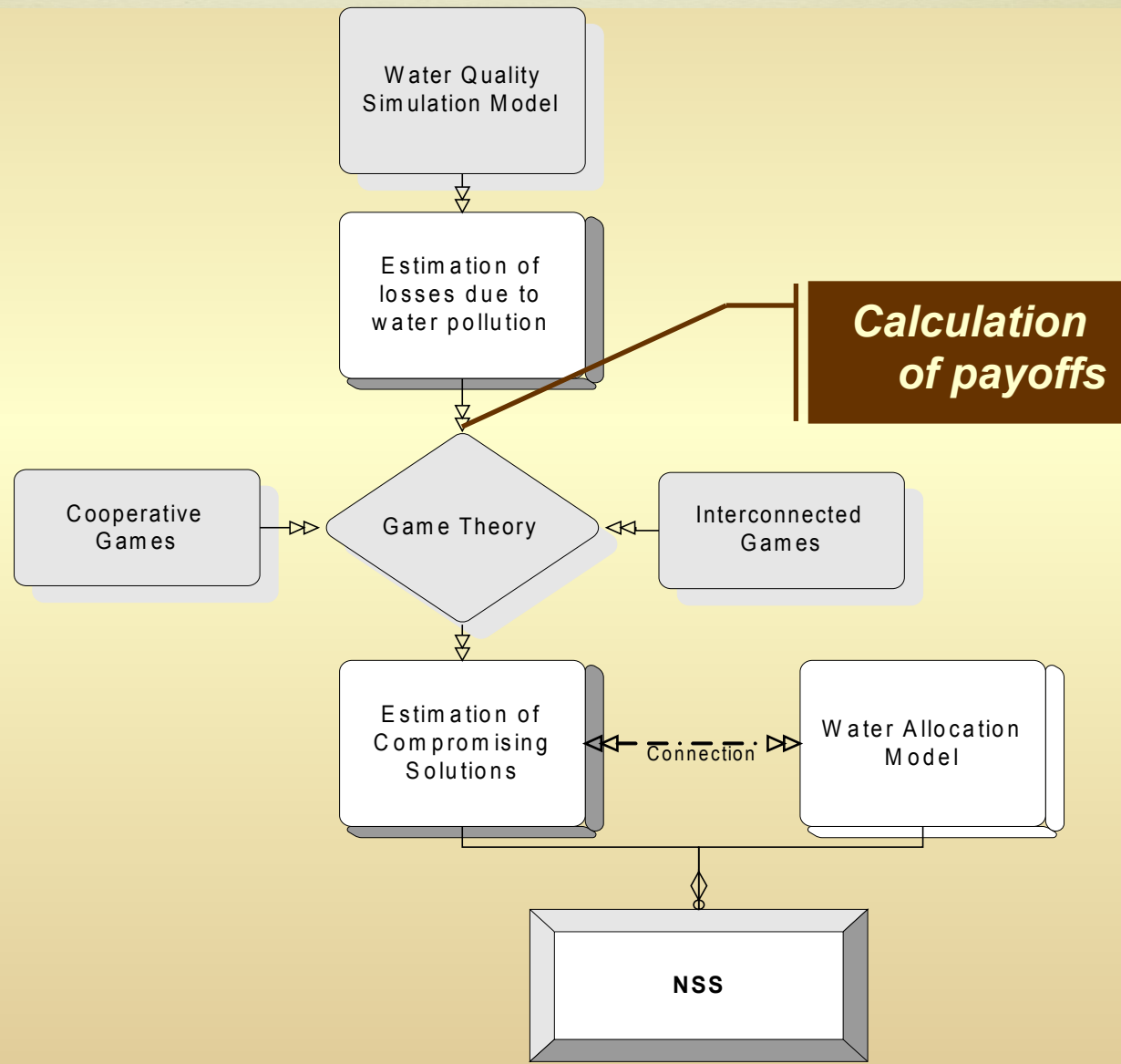
Nestos/Mesta River
GR - BG



GAME THEORY

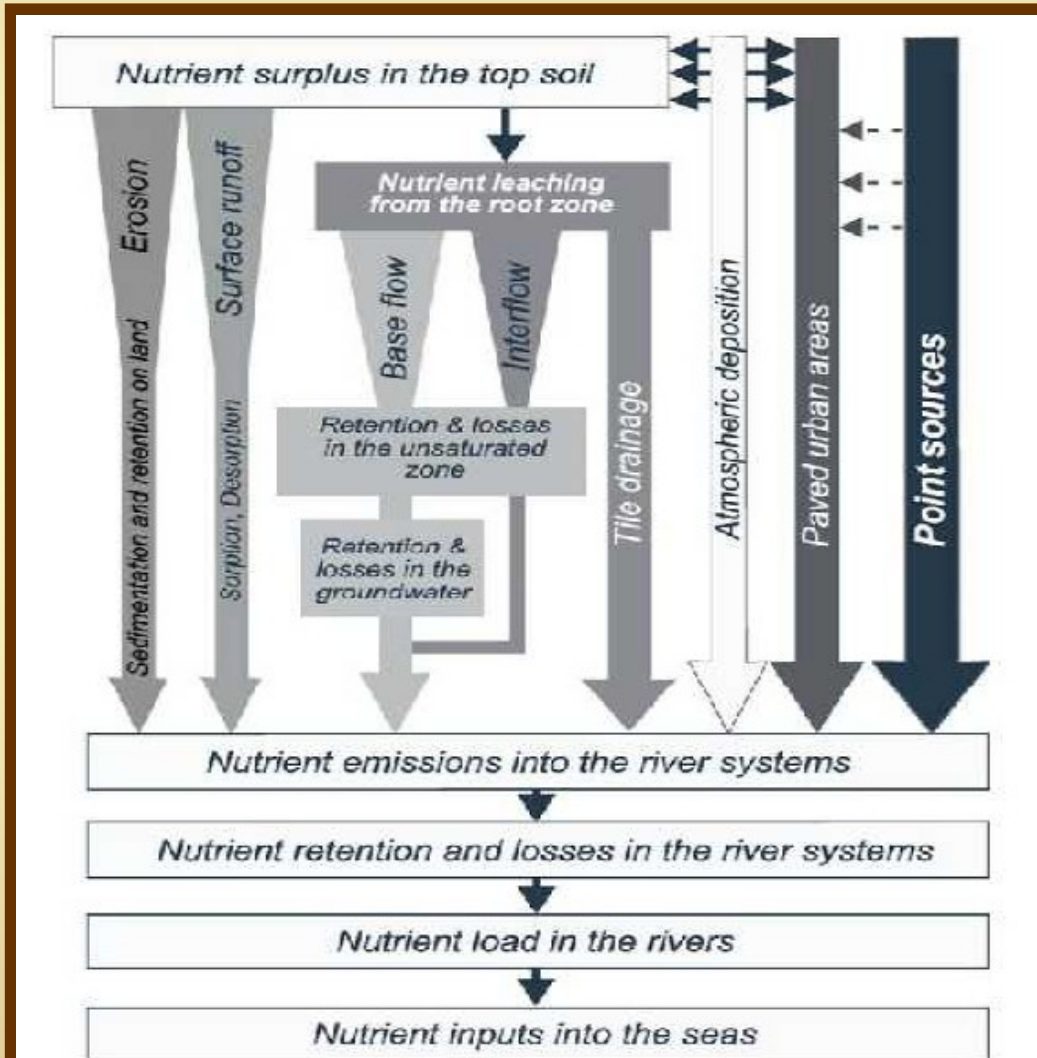


PURPOSE OF THE STUDY



SIMULATION MODEL

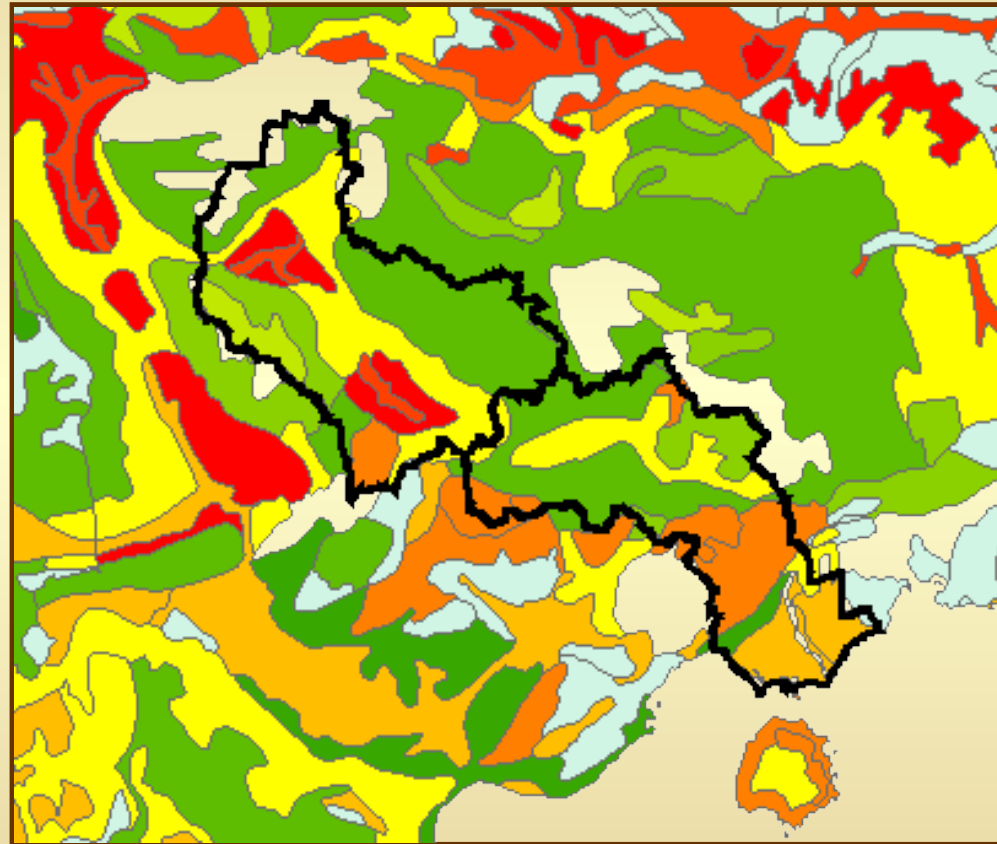
➤ Mathematical Model MONERIS



SIMULATION MODEL



Basin Slopes



*Soil Map
(European Soil Database)*

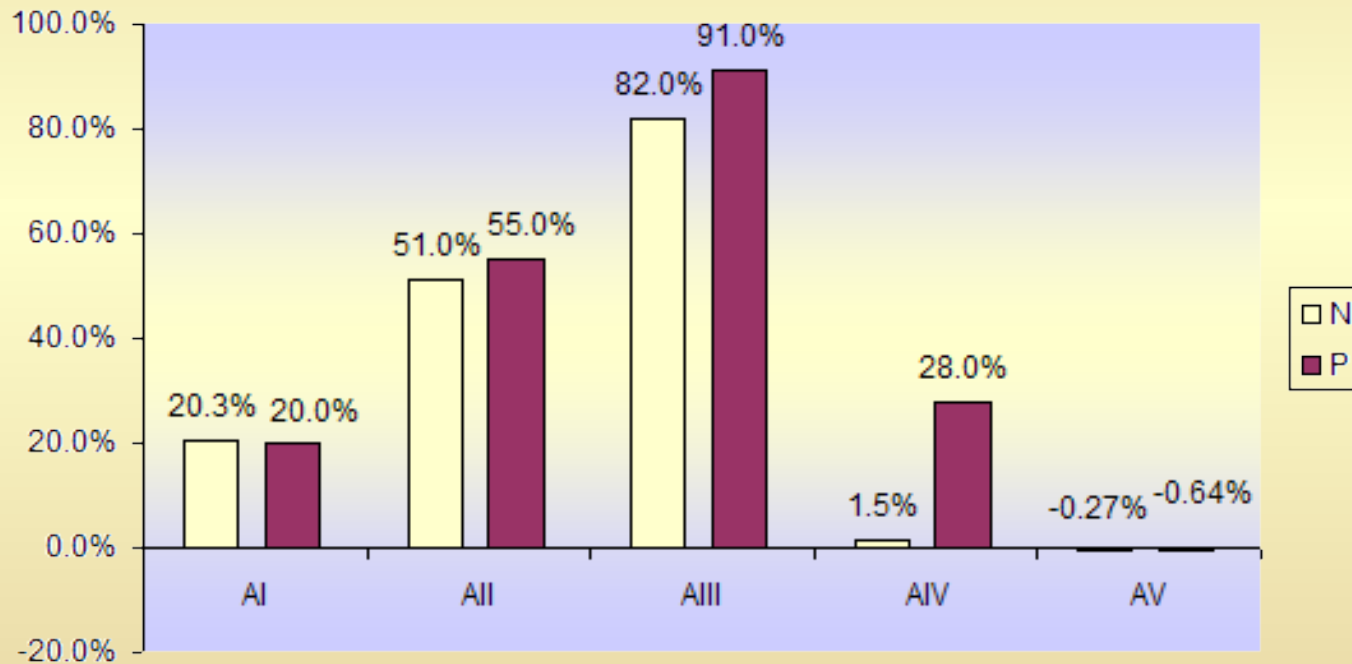
SIMULATION MODEL

Scenarios

- **AI:** all Greek settlements connected to WWT
- **AII:** half Bulgarian settlements connected to WWT
- **AIII:** all Bulgarian settlements connected to WWT
- **AIV:** Change Landuse (agriculture → forests)
- **AV:** Increase of population in both countries

SIMULATION MODEL

Nutrients decrease in the river system



ESTIMATION OF PAY-OFFS

- EPA recommends that total phosphorus concentrations should be less than 0.1 mg/l in rivers and nitrogen concentrations less than 2 mg/l
- Payoffs depend on the difference of the predicted value with the EPA recommendations

- Phosphorus payoff (P_p): $\frac{0.1 - C_P}{0.1} \%$

- Nitrogen payoff (N_p): $\frac{2 - C_N}{2} \%$

Total Payoff:
Average of P_p and N_p

GAME THEORY

Bulgaria

Present

Half Connected

All Connected

Present

-25.8

-111

-23.3

-101

-23.3

-93.3

Greece

All Connected

-22.1

-111

-19.9

-101

-19.9

-93.3

GAME THEORY

Interconnected Games

Bulgaria

Present Current Present +10% All Con. Current All Con. +10%

Present
Compensate

0.67 0.78 0 1.00 1.09 1.78 0.42 2.00

Greece

Present
No Compensate

1.00 0 0.33 0.22 1.42 1.00 0.76 1.22

All Con.
Compensate

1.29 0.78 0.63 1.00 1.67 1.78 1.00 2.00
Pareto Optimal

All Con.
No Compensate

1.63 0 0.96 0.22 2.00 1.00 1.33 1.22
Nash Equilibrium

GAME THEORY

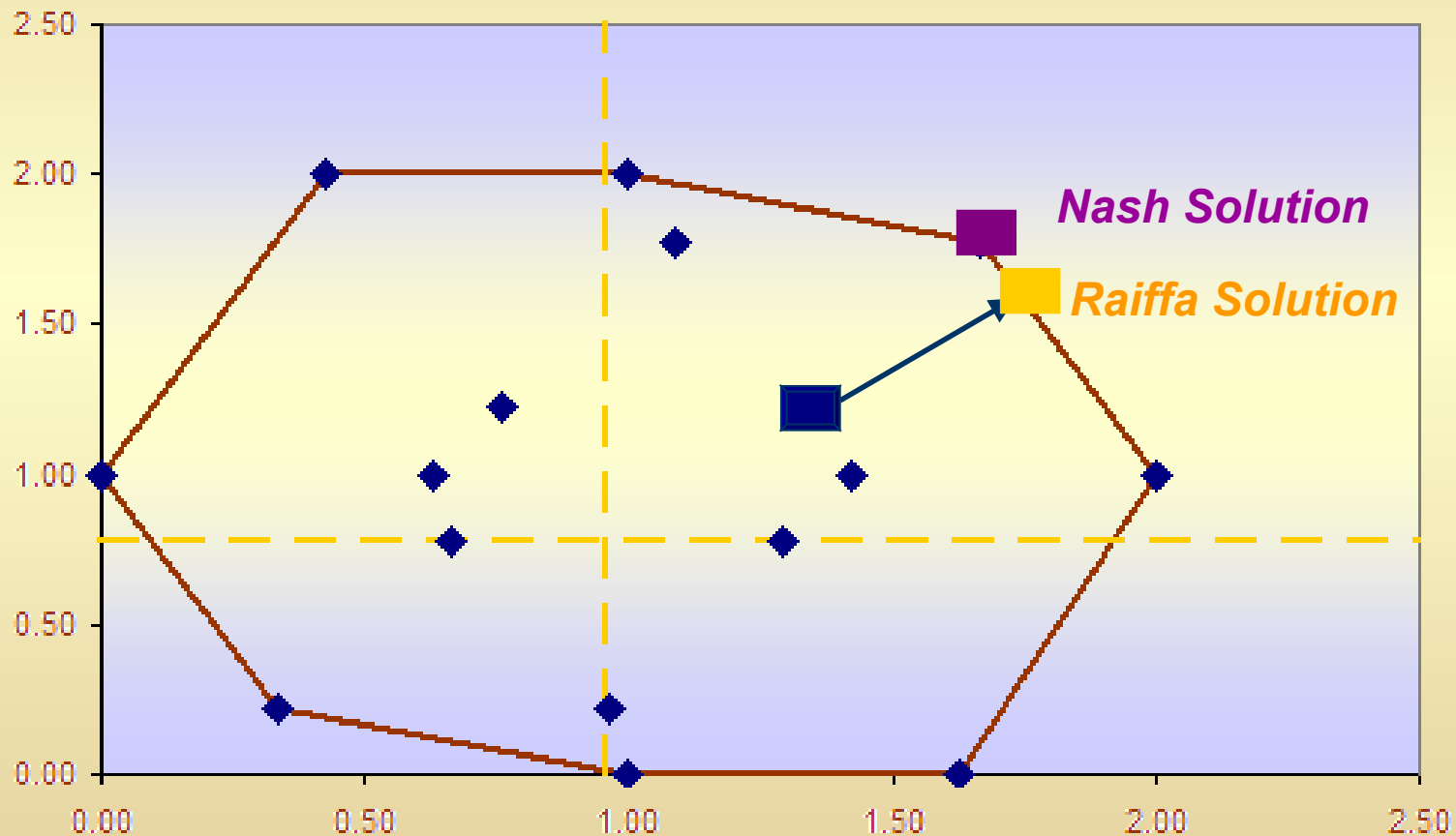
- A solution point (u, v) introduced by **Nash** as the bargaining solution of a game that is defined as the point where the function

$[(u-u^*)(v-v^*)]$ attains its maximal value

- **Luce & Raiffa:** The cooperative point lies on the intersection of the 45-degree line, where the relative advantage remains constant

GAME THEORY

Cooperative Solutions



GAME THEORY

Other interconnected games:

➤ *Water quality game with social game (construction of new border point)*

↳ *Nash equilibrium \iff Pareto Optimal*

➤ *Water quality game with water diversion game*

↳ *Avoid diversion \iff Greece compensate*

GAME THEORY

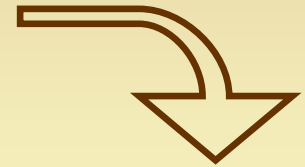
Mixed Strategies

- Inclusion of probabilities in the game
- Assign probabilities in pure strategies

	80%	10%	10%
	<i>Present</i>	<i>Half Connected</i>	<i>All Connected</i>
<i>Present</i>	-25.8 -111	-23.3 -101	-23.3 -93.3
<i>All Connected</i>	-22.1 -111	-19.9 -101	<u>-19.9</u> <u>-93.3</u>

GAME THEORY

Mixed Strategies



Present

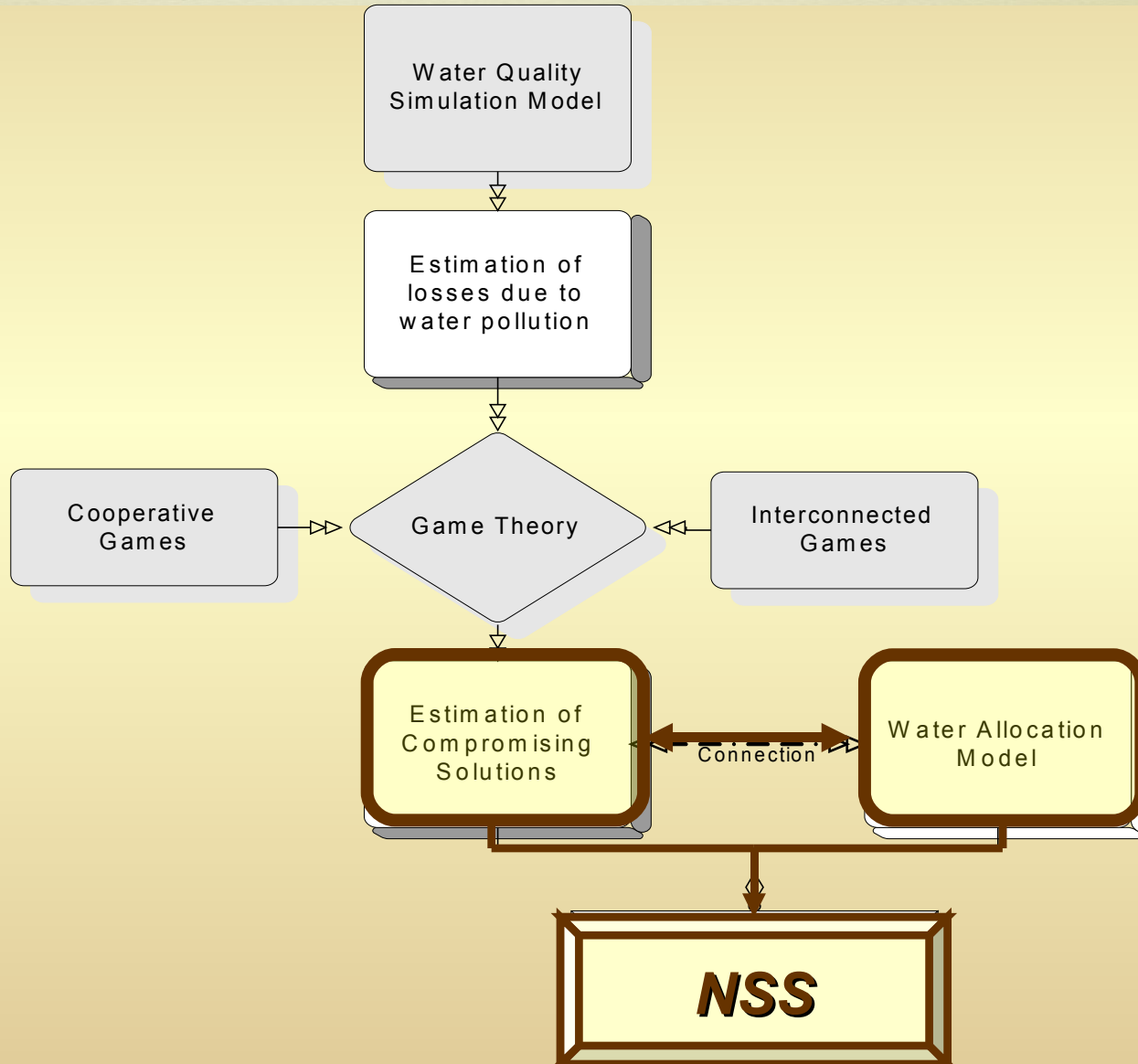
Half Connected

All Connected

0.8 - 0.1 - 0.1

<i>0</i>	<i>0</i>	<i>0.4</i>	<i>0.6</i>	<i>0.4</i>	<i>1</i>	<i>0.08</i>	<i>0.16</i>
<i>0.6</i>	<i>0</i>	<i>1.0</i>	<i>0.6</i>	<i>1</i>	<i>1</i>	<i>0.70</i>	<i>0.16</i>

NEGOTIATION SUPPORT



CONCLUSIONS

Why Game Theory?

- *Simulates the “players” behavior*
- *Identifies Strategies and predict moves of the counter-player*
- *Predicts equilibrium states*
- *Connects different issues in the negotiations*
- *Incorporates socio-economic factors*
- *Estimates compromising solutions*

CONCLUSIONS

How to reach agreement?

1. Organize administrative issues



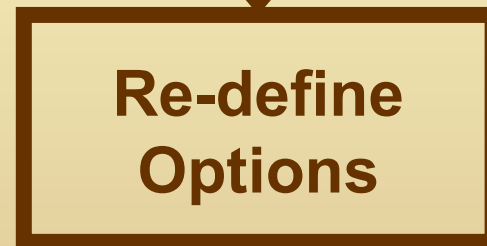
2. Data collection and homogenization



3. Define Options and Strategies



4. Start Negotiations



NSS

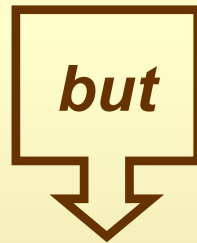
CONCLUSIONS

Agreements



CONCLUSIONS

- Antagonism is a social phenomenon observed in most of the social, economic and political issues
- Cooperation cannot be enforced through legal tools



can be promoted by creating cooperation motives that are acceptable to the opponent parties and in the same time
sustainable for the environment