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Towards a cooperative water management : a repartition of the ressource between agents of a network through an agent-based model

Pauline Pedehour

University of Nantes (France)

DOCKSIDE Summer School

University of Battambang, Cambodia

1-5 October 2018

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Background

- UNESCO proclaimed 2013 as the « United Nations International Year or Water Cooperation »
- Lack of safe drinking water at home for 3 in 10 people worldwide according to a common report of UNICEF and World Health Organization (2017)

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The model

- Representation of a river by an **acyclic and oriented graph** with a water flow from the upstream segment of the river to the downstream one.

- Many agents located along the river with a node of water extraction and a tributary (+ or 0)

- **Trade-off** between two choices for the agents:

Consume all the water available to increase their own satisfaction

Let some water in the river for the others in exchange of a **monetary compensation** from the agents located downstream.

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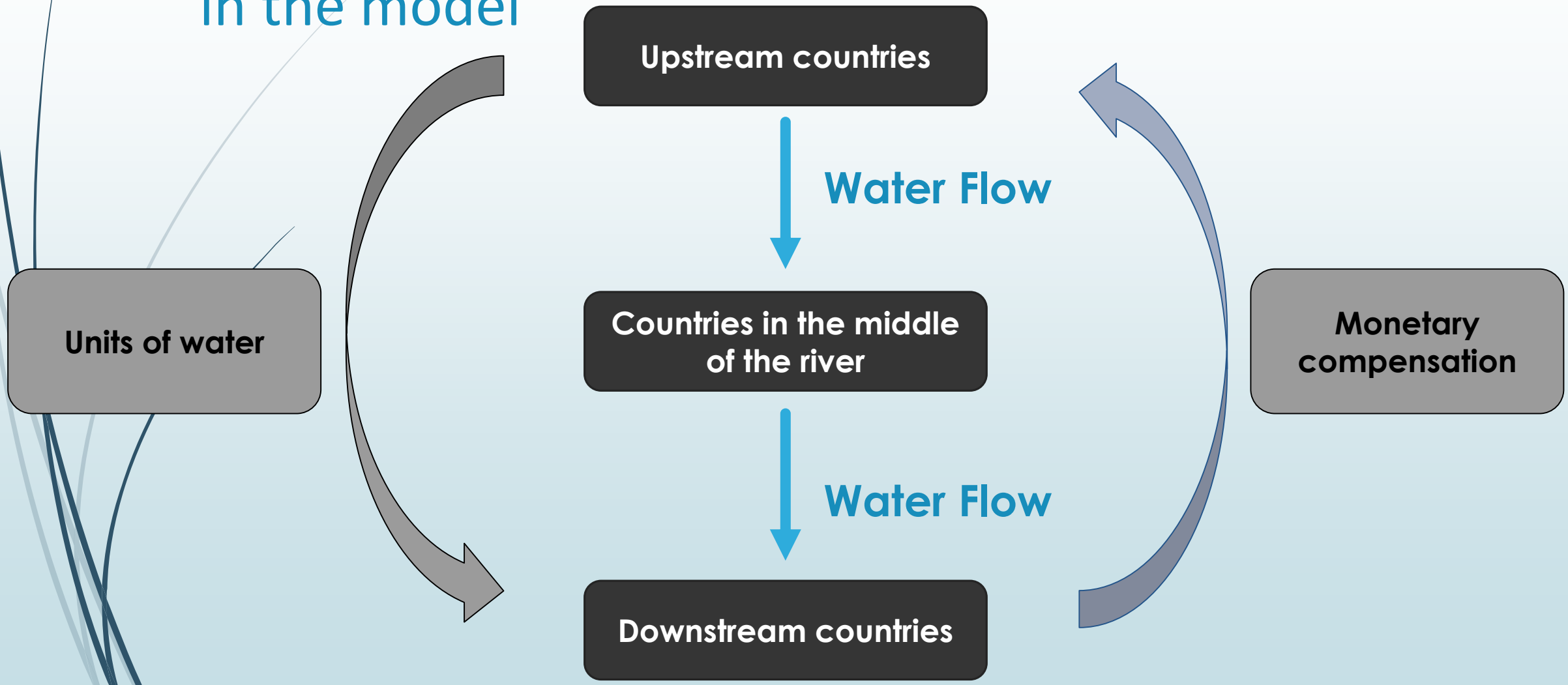
The principle of cooperation in the model



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Simple utility function in the model

Utility function : $\boldsymbol{U_i = b_i(e_i) - c_i(e_i) - t_i \; with \; \sum_i t_i = 0}$

where U_i is the utility of the agent i

$b_i(e_i)$ is the **benefit** of i to extract and consume a level of water denoted by e_i

$c_i(e_i)$ is the **cost** of the extraction for the agent i

t_i is the **monetary compensation** in a cooperation (positive for the upstream agent and negative to the downstream one)

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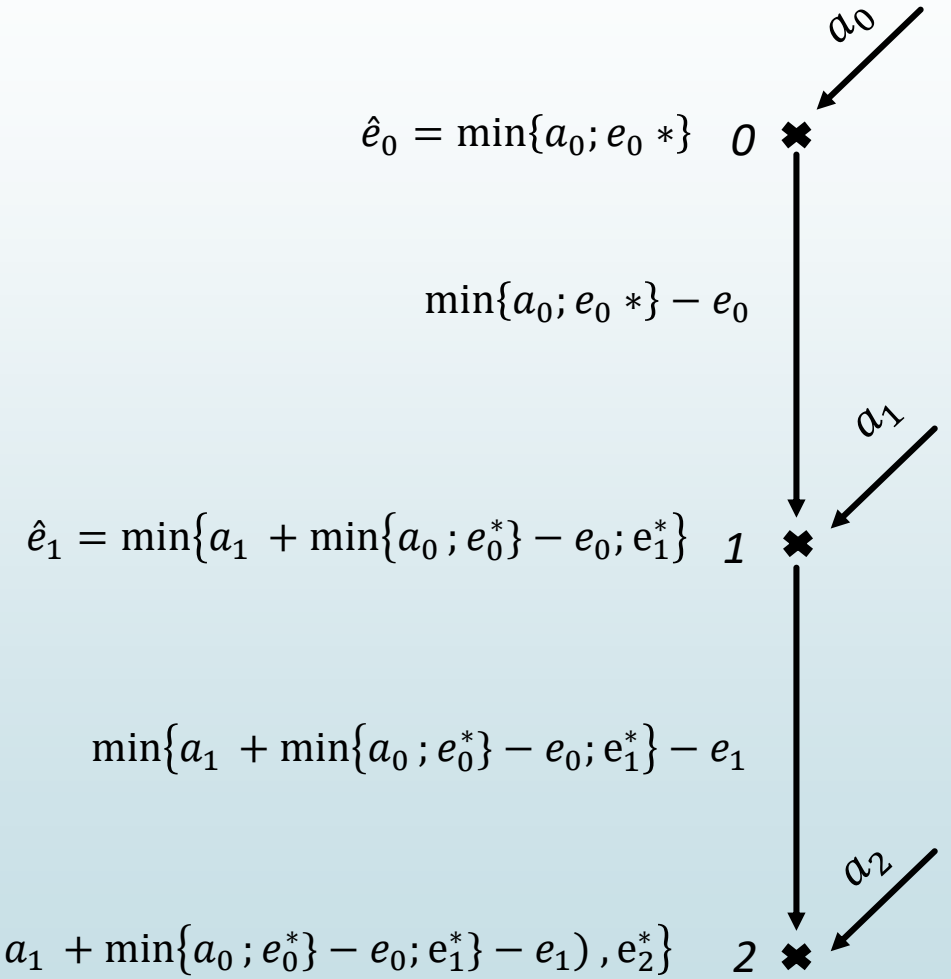
The model : example with 3 agents

- a_i the affluent/tributary of the agent i
- e_i personnal consumption of water of the agent i
- e_i* optimal level of water extraction of the agent i
- $\hat{e}_i$ level of water available for the agent i to do a trade-off between his own consumption and cooperation
- $a_i \leq e_i^*$ for $i = [\![0, 1, 2]\!]$



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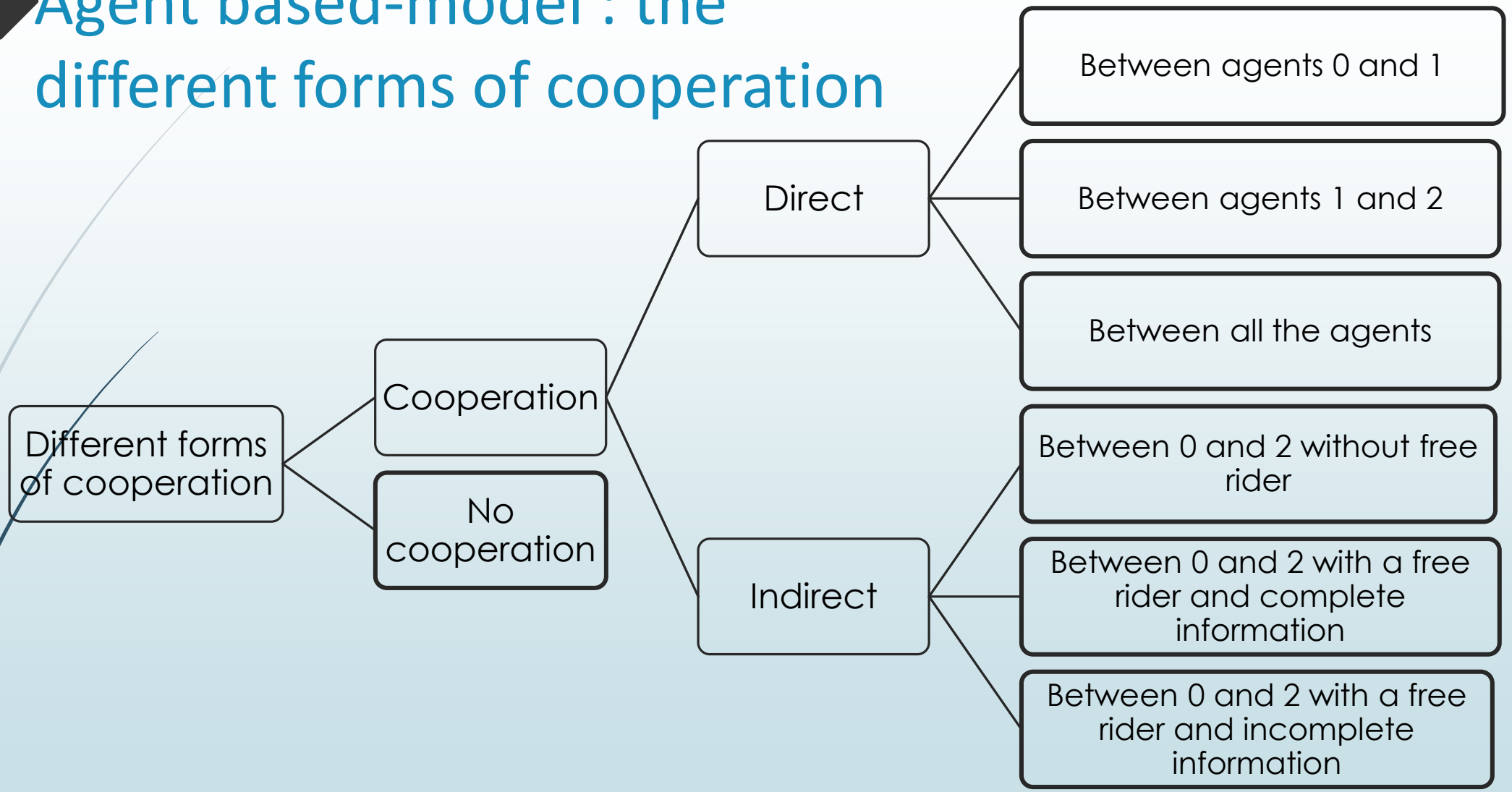
Agent based-model : the different forms of cooperation



Free rider is a market failure that happens when people take advantage of something (a collective good, a common resource) but contribute little or nothing to the efforts or costs

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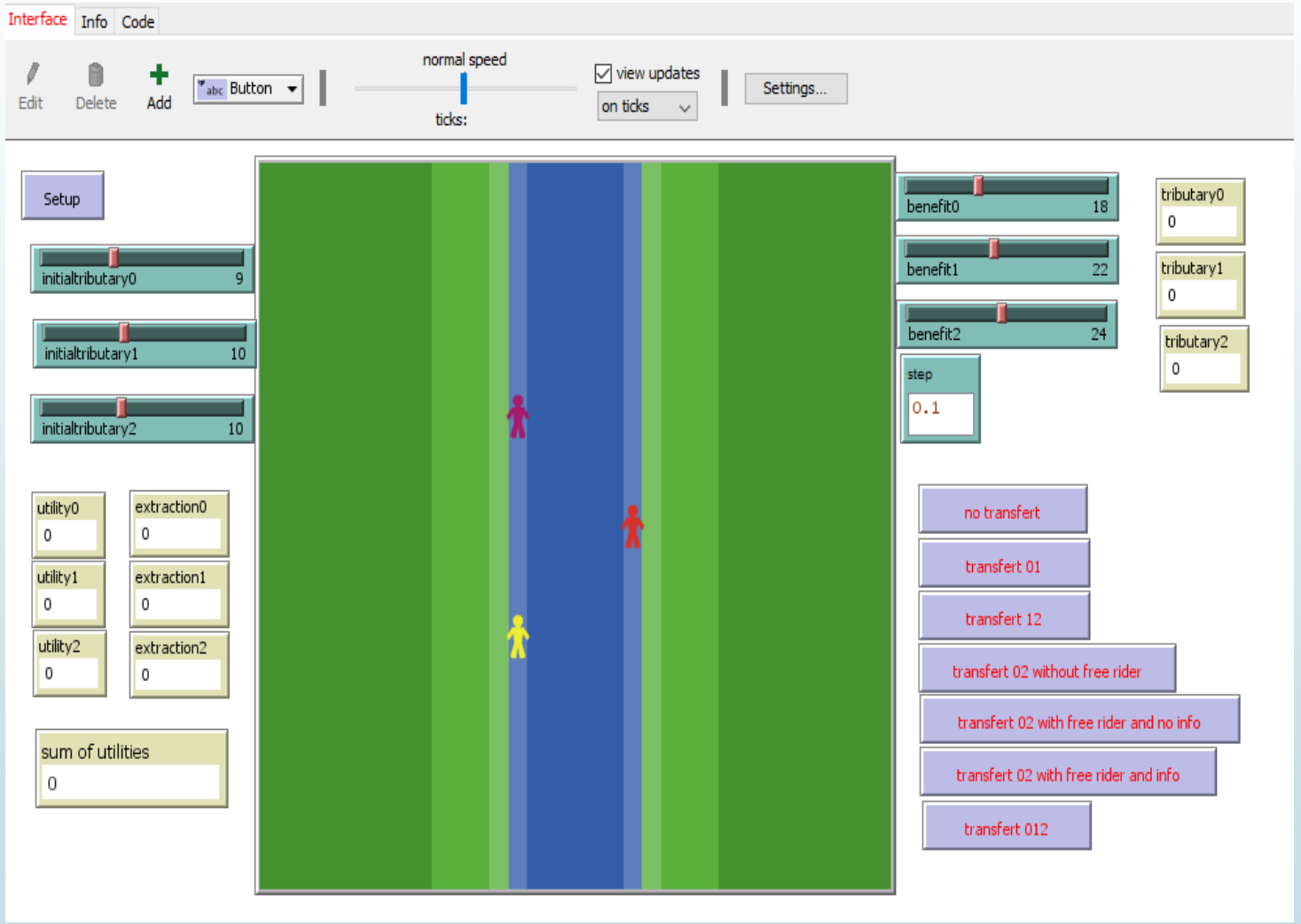
Agent-based model : Interface and process

- One period
- Many periods
- With a procedure to maximize the common level of utility
- Including a memory on past cooperations



Source : author, Master thesis model with Netlogo

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Utility maximization and memory : Results

Type of cooperation	Maximization without memory	Maximization with memory
Complete cooperation	47%	64%
All the other types of cooperation	48,4%	34,3%
Without cooperation	4,6%	1,7%

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The case of Mekong river

- Conflicts of use between upstream countries and downstream countries
- The dams on Mekong river underline this issue of cooperative management between countries
- The Mekong River Comission in 1995 : Laos, Thailand , Cambodia and Vietnam

Conclusion

- Results in favor of cooperation in a context of water scarcity excepted in special cases that are not usual in reality

  - Increasing tributaries and constant/decreasing needs of water

- The applied case of the Senegal river in favor of cooperation and optimization of water management

- Website to try the model :

http://perso.numericable.fr/tic-et-tac/