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

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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)



## 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:

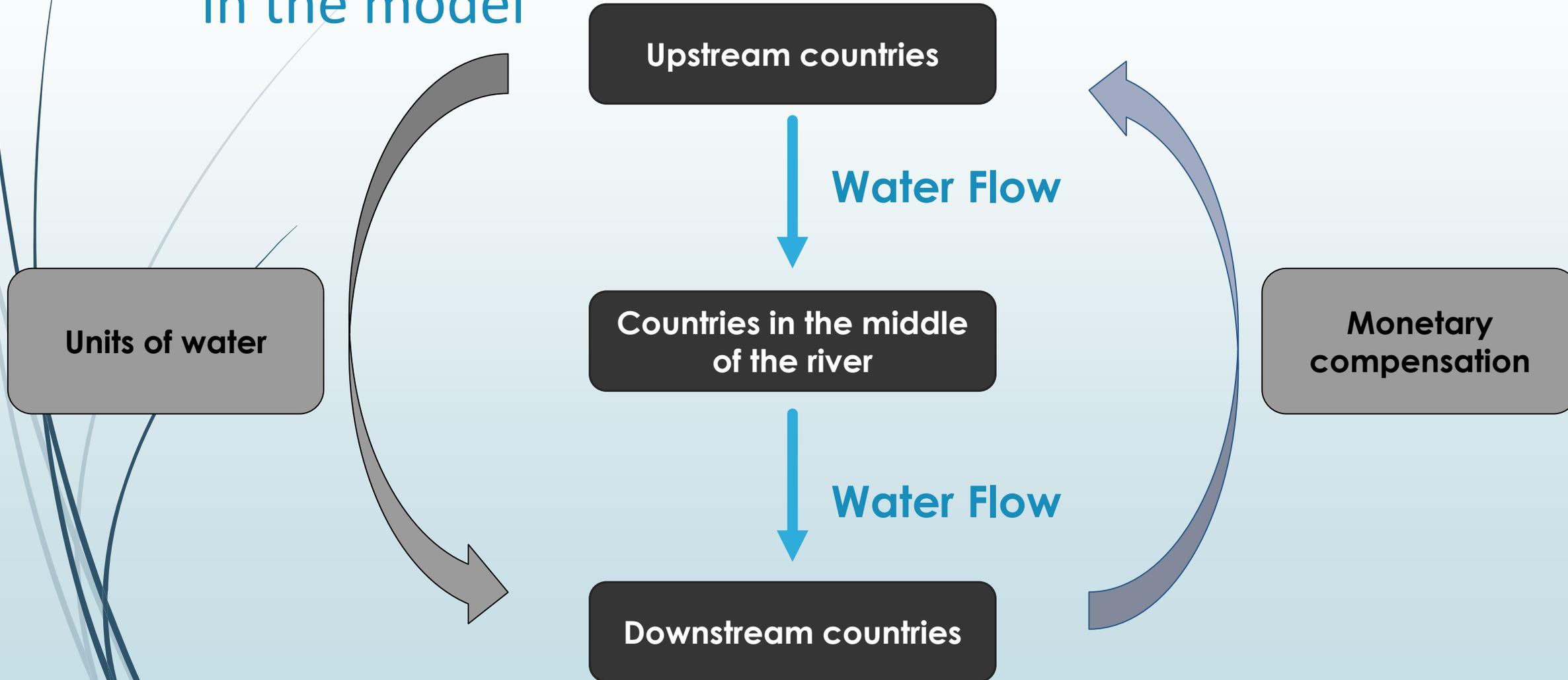
**Consume** all the water available to increase their own satisfaction

**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





## Simple utility function in the model

**Utility function :  $U_i = b_i(e_i) - c_i(e_i) - t_i$  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  $e_i$

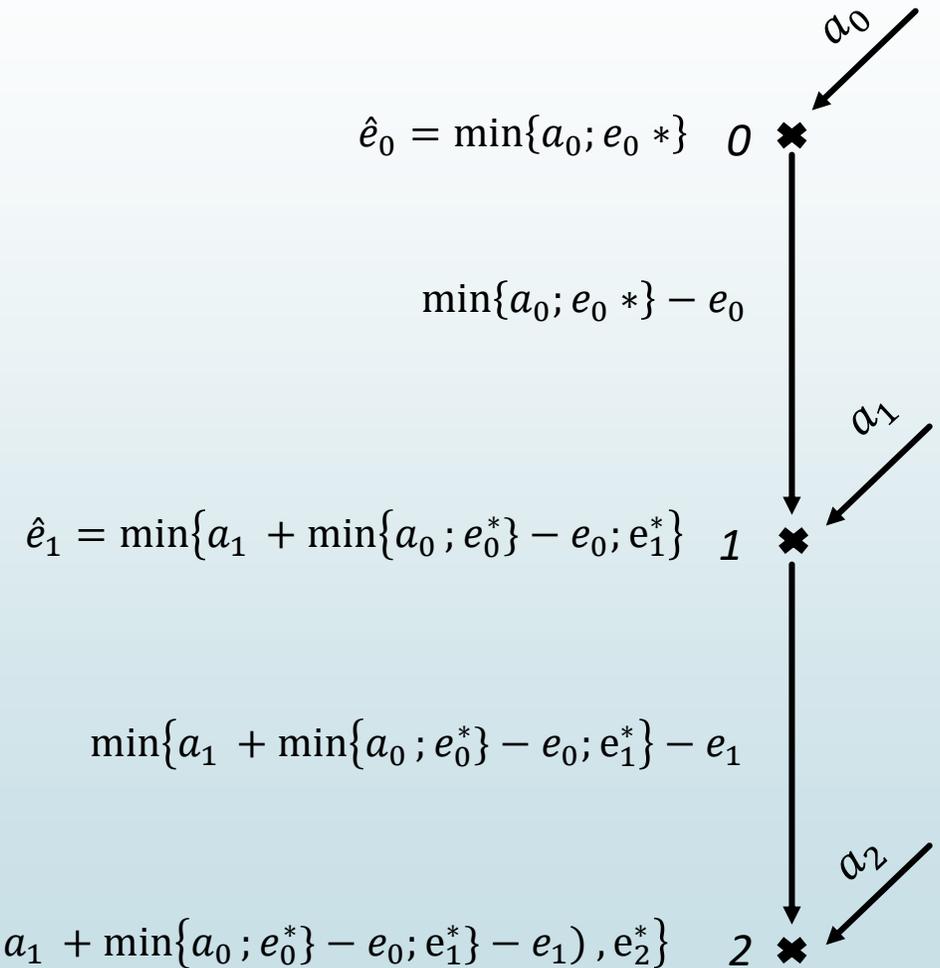
$c_i(e_i)$  is the **cost** of the extraction for the agent  $i$

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



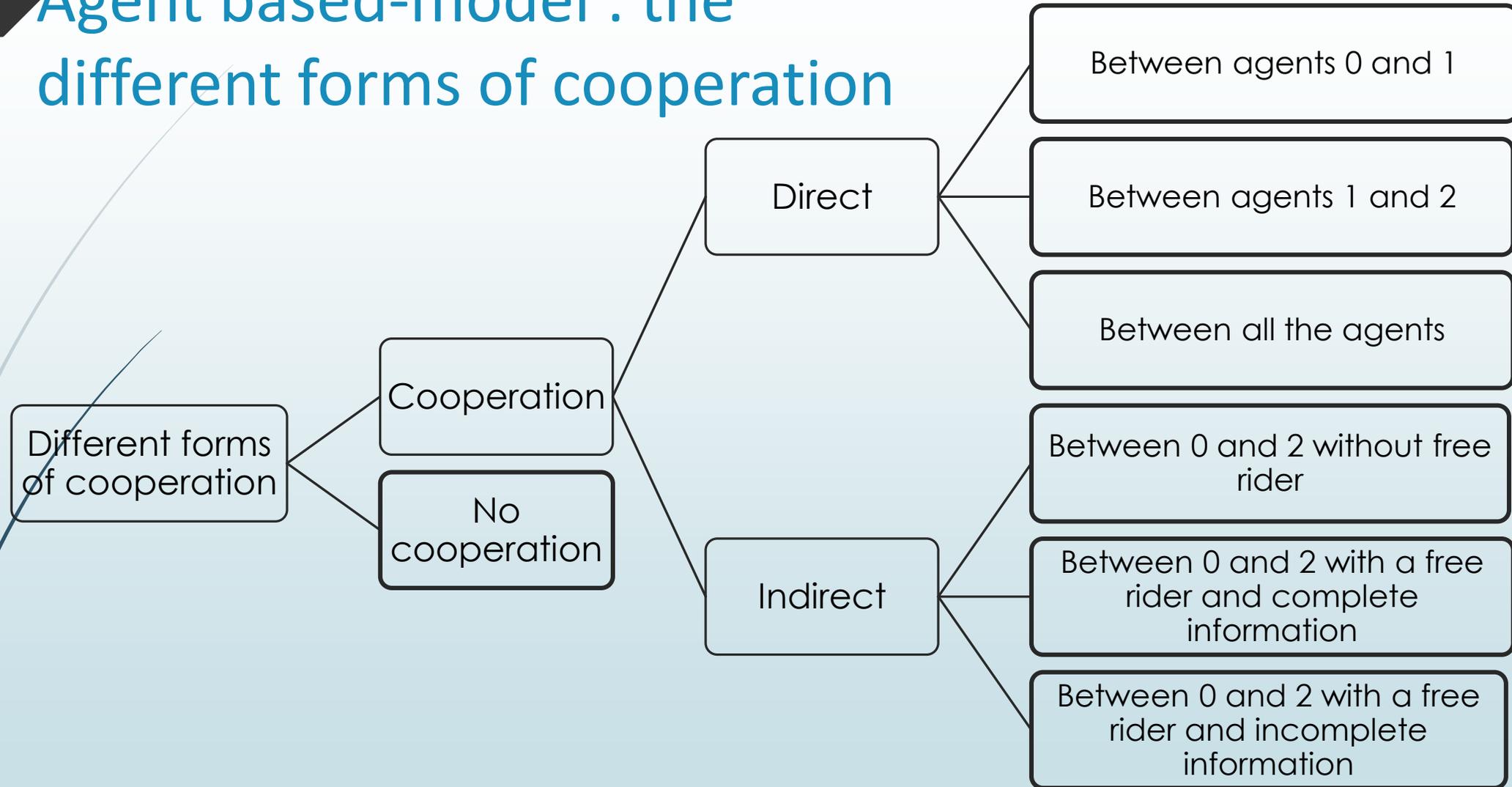
## The model : example with 3 agents

- ▶  $a_i$  the affluent/tributary of the agent  $i$
- ▶  $e_i$  personal 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  $i = [0, 1, 2]$





# 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



# 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

The screenshot shows the NetLogo interface for an agent-based model. The interface is organized into several sections:

- Top Panel:** Contains the menu bar (Interface, Info, Code), a toolbar (Edit, Delete, Add, Button), a speed slider (normal speed), a 'view updates' checkbox, and a 'Settings...' button.
- Left Panel:** Includes a 'Setup' button and three sliders for 'initialtributary0' (value 9), 'initialtributary1' (value 10), and 'initialtributary2' (value 10). Below these are utility and extraction sliders for three agents (0, 1, 2), all currently set to 0. A 'sum of utilities' display shows a value of 0.
- Center Panel:** A visualization area showing a blue vertical strip with three agents (two red, one yellow) positioned along it.
- Right Panel:** Features three sliders for 'benefit0' (value 18), 'benefit1' (value 22), and 'benefit2' (value 24). Below these is a 'step' display showing 0.1 and a list of transfer options: 'no transfert', 'transfert 01', 'transfert 12', 'transfert 02 without free rider', 'transfert 02 with free rider and no info', 'transfert 02 with free rider and info', and 'transfert 012'.

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
<b>Complete cooperation</b>	47%	64%
<b>All the other types of cooperation</b>	48,4%	34,3%
<b>Without cooperation</b>	4,6%	1,7%



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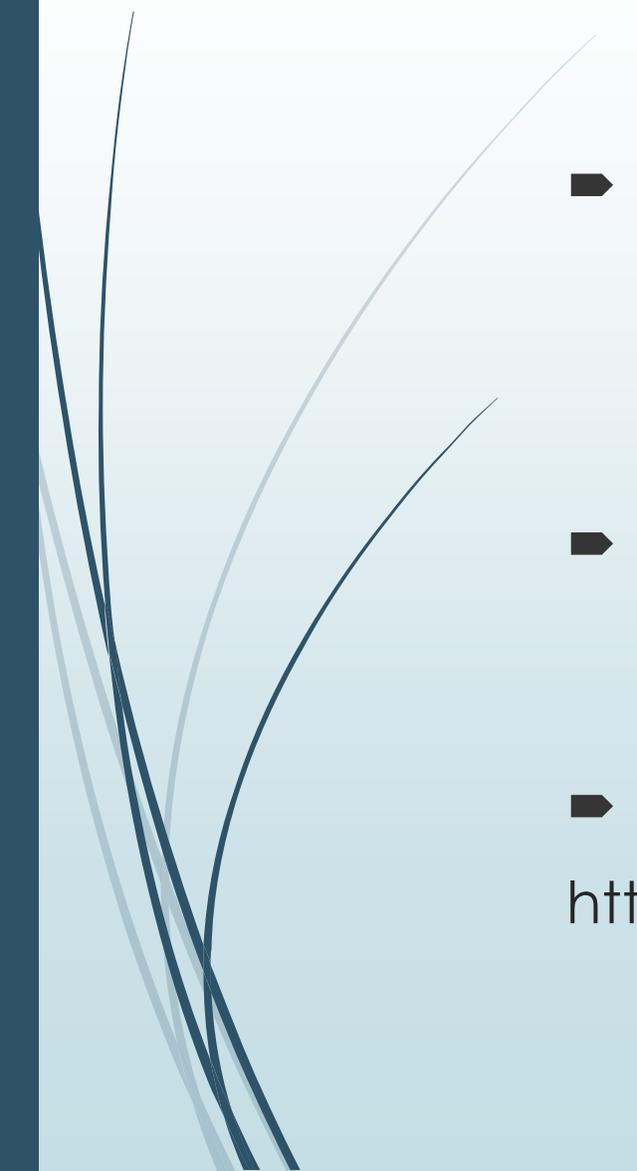
# The case of Mekong river



- 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 Commission 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/>