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Géraldine Abrami[1], Maja Schlueter[2,3]
[1] UMR G-EAU Cemagref 365 rue JF Breton BP 5095 34195 Montpellier, France
geraldine.abrami@cemagref.fr
[2] UFZ- Helmholtz Center for Environmental Research, Leipzig, Germany
[3] Department of Ecology and Evolutionary Biology, Princeton University, Princeton, USA
mschlute@princeton.edu

Abstract. In transition countries informal institutions play a major role and often interfere with new formal institutions leading to large discrepancies between rules on paper and rules in use. We develop an agent-based model to explore the interaction between formal and informal rules and its effect on the performance of the formal institutions, based on the example of water user associations (WUA) in Uzbekistan. The model is based on field experience such as community-based work and role playing games, complemented by available literature. In this paper we present the conceptualization of the model, its empirical foundation and a first baseline scenario. We model a water user association where rules based on formal and informal institutions can be used. The baseline scenario represents the results of a totally formal WUA. In a next step we will introduce informal rules and explore how they can coexist with formal ones. Further work will bring us to question rules' implementation and roles and relationships evolution through selective rules adoption. The model will allow exploring under which conditions the institution WUA can function well and what might be mechanisms for the selection and adoption of rules by individual members.

Keywords: institutional change, social simulation, water management, Water User Associations, Uzbekistan

1. Introduction : context and objectives

Following the third land reform in 2000 that eliminated large collective farms the Uzbek government introduced water user associations (WUA) in a top down manner to facilitate water allocation to the numerous new small-scale farms (Yalcin and Mollinga, 2007). In 2000 – 2003 thousands of WUA were formally established and empowered to distribute the water among their users, supposedly in a more efficient manner than the former collective farms. However, the goals of improvement of agricultural performance and introduction of democratic principles on the local level have only partially been achieved. As in other transition countries (e.g. Bulgaria, see Theesfeld 2004) the discrepancy between formal political intentions and informal effective institutional change on the local level is large. Moreover, the high incongruity between formal and effective rules provides conditions under which opportunistic behavior is able to grow and persist (Theesfeld 2004).

Instead of relying on the formal processes of water allocation in the WUA, for example, access to water is often ensured through informal practices such as patronage and unauthorized but tolerated water withdrawal (Sehring 2009). In a study of two other post Soviet Central Asian republics Sehring (2009) describes how the rules and organizations established formally by the state or international donor organizations are undermined by informal institutions. She uses the concept of "institutional bricolage" to describe how decision-makers and users selectively adopt some of these formal rules that compel to their socio-economic logic and neglect the others that are not compatible with functioning informal institutions. This "bricolage" also means that, on the one hand selected formal rules may be implemented through logics based on underlying informal institutions (e.g. fees get payed because traditional leaders are asking for it, not because of a market or economic efficiency logic), and on the other hand informal institutional roles may evolve with their inscription in new formal rules.

The relationship between formal institutional change and informal institutions has so far received only limited attention (Sehring 2009). This research aims at using this institutional bricolage framework within social simulation to investigate how formal and informal rules may coexist in a WUA and impact on its efficiency. The model presented in this paper is focusing on water allocation and distribution in a WUA (distribution is here taken in the sense of allocation implementation, not in the sense of scheduling). The main question this model aims at studying at the first stage of this research is: how does the system react when, starting from a situation where all actors use best practices of the formal institution WUA as described in manuals, we gradually introduce actors that behave according to informal rules ? We intend to use two dimensions of "good governance" as indicators of the performance of the WUA in simulations: social dimension (equity in water allocation) and economic dimension (water efficiency).

This research follows an empirically grounded and parsimonious design process (section 2). It is still in a very preliminary stage and this paper presents our conceptual model of a very simple WUA where rules based on formal or informal institutions may be used (section 3). A first implementation of an ABM of a totally formal WUA has been completed and has been used to calibrate a baseline scenario. Based on this scenario results, our next step will then be to implement informal rules and explore how they can coexist with formal ones. Further work will bring us to question rules' implementation and roles and relationships evolution through selective rules adoption. (section 4).

2. An empirically grounded design process

This social simulation work is part of a more global research process where it has been iteratively linked with community-based field work in Uzbekistan. In a first step an initial conceptual model of water management in Khorezm WUAs was set up from previous field work and expertise. A RPG was then built on the basis of this conceptual model. This RPG was implemented and played 4 times during a field trip in Uzbekistan in April 2008. The participants of these RPG sessions were farmers and managers from 2 communities, in Khorezm and South Karakalpakstan. Several types of management rules were observed during these sessions, from very formal centralised management to a completely informal case with no kind of central management though a “bricolage” one exhibiting interpersonal arrangement with a formal central institution. Even though we can suspect the participants have exhibited best practices during the game sessions, the spectrum covered by these management rules is completely coherent with our problematic and we will incorporate these observed rules in our model. This will allow us to reflect on past game sessions once back on field.

Parameters and rules we use in the model relate to various kind of source : individual decision-making comes from field investigations and literature (e.g. Sehring, 2009); formal rules are issued from an IWMI Manual for establishment of WUAs (IWMI, 2005); the informal rules relevant in this context such as patronizing or corruption are taken from literature and personal experience; finally external constraints such as field configuration or water allocation and supply to WUAs figures can be taken from forma regulations, official documents or literature such as (Trevisani, 2007).

Following (Kronenfeld and Kaus 1993, Edmonds et al. 2005) for instance, we intend to start with models as simple as possible so that minimal sets of rules are defined.To keep the model as parsimonious as possible, it is built “from scratch” by starting a very simple formal WUA and then introducing step by step rules from informal institutions (patronizing, corruption), checking at each stage the minimal set of parameters needed. Social simulation examples and references to social theories will only be introduced later on for comparison and discussion purposes.

3. Model description

3.1. Baseline scenario hypotheses and rules

Our baseline scenario is based on the set of formal rules given by a WUA manual issued by IWMI (IWMI, 2004). However, the manual is only providing rules for the allocation and distribution of water, so it is also necessary to specify hypotheses and simplification on the model WUA configuration. Such hypotheses concern external constraints and WUA configuration and physical dynamics : hydrologic and agronomic dynamics are aggregated in a timestep of 1 year, farmers are next after

each other on a singe canal, and each of them has an identical field, they have same economic parameters and the only allowed crop is cotton. Finally, we consider an upstream-downstream effect which represents organizational and technical difficulties in delivering the water in a timely and sufficient manner to the users, which become more severe along the water flow gradient.
Future evolution will include notably differentiating farmers with soil types and number of fields, as well as considering a cash crop such as rice.

3.1.1. WUA formal rules and dynamics

Water allocation and distribution in our baseline model is straightly taken from (IWMI, 2004). It reproduces the steps, actions and exchanges of this “best practice” formal institution: 1. farmers decide cropping pattern – all cotton in baseline scenario; 2. The WUA Engineer assess water needs for each farm – actual water needs in baseline scenario; 3. Engineer aggregates water needs; 4. Engineer compares water needs to water limit given by external constraints; 5.WUA manager adjust cropping patterns to water limit and defines water scarcity rule – same reduction for all in baseline scenario; 6.Engineer defines water allocation – equal distribution in baseline scenario; 7. Manager and farmers sign contract on crop and water allocation plan; 8.Farmers sow – according to contract in baseline scenario; 9.water supply is given and Mirab (outlets operator) opens outlets according to water allocation plan and water scarcity rule. Water flow in the outlets considering upstream-downstream uncertainty effect; 10. farmers bring water to their field; 11. farmers harvest and calculate their budget

3.1.2. Informal institutions

We consider the following informal institutions in our model.
Patronage. Patronage is understood here as the preferential treatment of an actor because of his relationship with an influential higher level actor, such as a person from the administration or a wealthy farmer. We implement patronage by selecting individual farmers that will always first receive water according to their needs. This results in the definition of an informal rule for step 6 (Engineer designing water allocation)
Unauthorized water withdrawal. According to Sehring (2009) tolerated unauthorized water withdrawal can be considered as an informal institution in some places in Kyrgyzstan and Tajikistan. We implement unauthorized water withdrawal by randomly or according to power allowing farmers to withdraw more water than entitled to. This results in the definition of an informal rule for step 9 (Farmer get more water from outlet)
Corruption. The payment of bribes is wide spread in Central Asia (Uzbekistan is on place 166 out of 180; 2008 Corruption Perceptions Index, Transparency International, 2008). We implement corruption by allowing selected farmers to pay money to the mirab to achieve immediate access to water. The mirab decides whether he accepts

the offer or not according to the offers he receives. This results in the definition of an informal rule for step 9 (Mirab open outlets preferentially)

3.2. The conceptual model

In our model, we use an agent-role pattern to represent the relation between actors and rules (Abrami et al, 2005). Individual parameters and constraints are held by actors, while their actions are mainly described by rules. This means that actors are intended to follow a rules sequence among which they will be able to choose between rules coming from formal or informal institutions. We will set up this choice in our simulation scenarios by progressively tuning the set of informal rules. This agent-role pattern will ease the further process of exploring individual behaviours and constraints and rules implementation. The way we use this architecture can be seen on sthe UML class diagram on fig. 1.At step 9, Mirab has to open outlets. He can do so with the formal rules of following the water allocation plan; or he can accept being corrupted and go the informal way. The same applies for farmers.

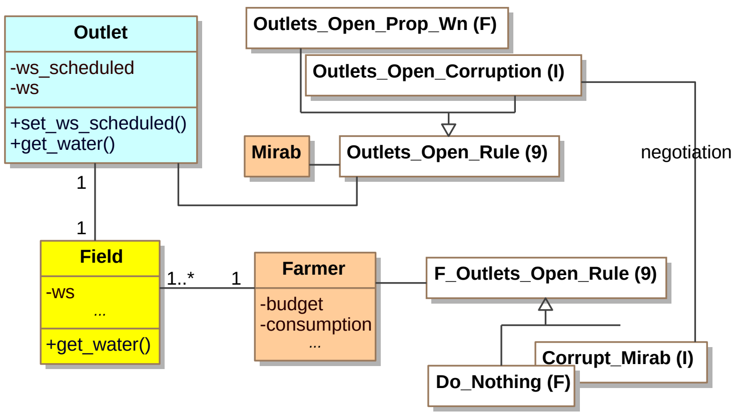

Figure 1. UML Class Diagram showing Farmer and Mirab rules and relations in the WUA model. The numbered figured in the rules correspond to the steps described in section 3.1.1. Formal rules are tagged with a (F) while informal rules are tagged with a (I).

Only the formal rules have been implemented right now. This implementation has been done using Netlogo 4.0.4. This model of a perfect WUA simulates water allocation among its members according to the formal rules as indicated in the WUA's manual. Water demand is assessed bottom up based on crop water demands, aggregated on the WUA level and compared with the water limits provided by the authorities. Based on this comparison cropping plans are adjusted. In case of water shortage during the irrigation season reductions are applied equally to all members. Performance of individual actors is measured in their net returns gained from agriculture. The upstream-downstream effect reduces the net returns of the downstream farmers.

4. Preliminary results and discussion

This first baseline version uses normalised values for simplicity. We will recalibrate the model to field values when necessary. Figure 3A shows the setup of the model and results of two calibration simulations. Farmers are located along the main canal and each have one outlet to their field. WUA manager and the engineer calculate water allocation that is distributed by the mirab (all agents located at the left). The different colors of the plants indicate the degree of water stress which increases along the resource gradient in a linear fashion. Figures 3B and C show the impact of the upstream-downstream effect on the net profits of the farmers from harvesting.

A)

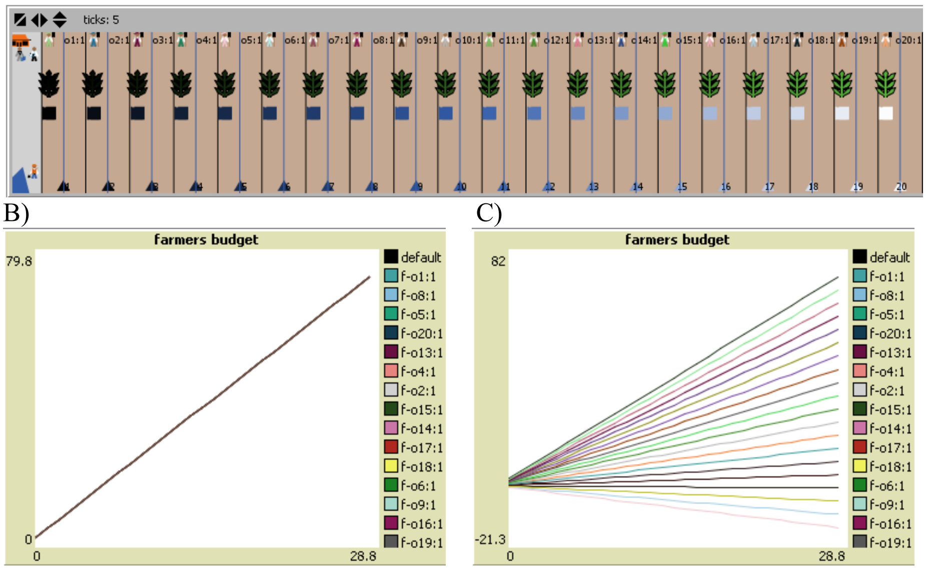

Figure 3: (A) Setup of the model (above); (B) farmer budgets after 30 years with no upstream-downstream effect, (C) farmer budgets after 30 years with an upstream-downstream effect of 0.3.

The model of a perfect WUA simulates water allocation among its members according to the formal rules as indicated in the WUA's manual. Water demand is assessed bottom up based on crop water demands, aggregated on the WUA level and compared with the water limits provided by the authorities. Based on this comparison cropping plans are adjusted. In case of water shortage during the irrigation season reductions are applied equally to all members which results in an equal loss of income to all of them. We also implemented an upstream-downstream effect which represents organizational and technical difficulties in delivering the water in a timely and sufficient manner to the users, and becomes more severe along the water flow gradient. The upstream-downstream effect reduces the net returns of the downstream farmers. This model constitutes the baseline for exploring the impact of informal institutions that will affect the allocation and distribution of water and disrupt the ideal delivery of water according to the formal rules. We are interested to investigate to which extent a WUA can cope with such disruptions and still produce the required crops and do so in an equitable manner.

4.1. Further work

Next to analysing the impact of the informal rules on the WUA we want to explore the social networks based on kinship or location in the irrigation network that facilitate the implementation of informal rules but also can support the adoption of new formal ones. Moreover we are interested in investigating the selection and implementation of rules which can easily be achieved through the agent-role pattern.
Finally, the model can also be used to model the evolution of agents' relationships and roles through institutional bricolage.

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