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Pierre Biommel
CIEDA, GREEN research unit, UCR Universidad de Costa Rica, bommel@cirad.fr

Marie-Paule Bonnet
IRD, UNB Universidade de Brasilia, Centro de Desenvolvimento Sustentável, marie-paule.bonnet@ird.fr

Emilie Coudel
CIRAD, GREEN research unit, UNB Universidade de Brasilia, Centro de Desenvolvimento Sustentável, coudel@cirad.fr

Eva Haentjens
CIRAD, GREEN research unit, haentjens@cirad.fr

Cleber Nunes Kraus
UNB Universidade de Brasilia, Centro de Desenvolvimento Sustentável, binhokraus@gmail.com

See next page for additional authors

Presenter/Author Information

Pierre Biommel, Marie-Paule Bonnet, Emilie Coudel, Eva Haentjens, Cleber Nunes Kraus, Gustavo Melo, Stephanie Nasuti, and Christophe Le Page

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Livelihoods of Local Communities in an Amazonian Floodplain Coping with Global Changes

From Role-Playing Games to Hybrid Simulations to Involve Local Stakeholders in Participatory Foresight Study at Territorial Level

Pierre BOMMEL[a,d]; Marie-Paule BONNET[b, c] ; Emilie COUDEL[a, c] ; Eva HAENTJENS[a]; Cleber Nunes KRAUS[c]; Gustavo MELO[a] ; Stephanie NASUTI[c]; Christophe Le Page[a, c]

[a] *CIRAD, GREEN research unit, Montpellier – France (bommel, coudel, haentjens, le_page@cirad.fr)*
[b] *IRD, UMR 234 GET Géosciences environnement Toulouse - France (marie-paule.bonnet@ird.fr)*
[c] *UNB Universidade de Brasilia, Centro de Desenvolvimento Sustentável, Brasília – Brazil (binhokraus, teph.nasuti@gmail.com)*
[d] *UCR Universidad de Costa Rica, CIEDA, San José – Costa Rica (bommel@cirad.fr)*

Abstract: In the Amazonian floodplains, the local populations living from agricultural activities and fishing, have always coped natural variations, between flood and dry seasons. However, the rhythm and the amplitude of these floods are disturbed nowadays, resulting in great uncertainty for these populations. Biophysics and social scientists have joined hands to help these populations better improve their resilience to such changes. Our initial goal aims to better understand and discuss the impacts of current practices in the long term. To address this, we first turned the perspective around the preoccupations and strategies of local populations and collectively discussed possible future scenarios. Using a role-playing game (RPG) as a dialogue interface, an agent-based model (ABM) was progressively built. This is a hybrid model allowing the users to interact with the simulation: they take seasonal decisions on agriculture, fishing and animal husbandry, which are virtually performed by the model that simulates the evolution of the territory and provides production outputs. Moving from RPG to hybrid simulation enables sophisticated calculations and scenarios on a broader timeframe. However this experiment revealed that external actors (ranchers, commercial fishing companies, mining companies…) might contribute to environmental degradation that impacts the living conditions of the local actors. Faced with these problems, we claim a non-neutral posture that promotes equity and sustainability. Beyond technology, we address the issue of power plays and of how to integrate external stakeholders while strengthening the capacities of the most vulnerable.

***Keywords**:* Participatory Modelling; Role-Playing Game; ABM; Hybrid Simulation; Amazonian floodplains.

1 INTRODUCTION

The main environmental issues related to the livelihoods of the populations settled in the Amazonian floodplains (called "*várzeas*" in Portuguese) are discussed in several studies (Lima, 2005), from the history of Amazon occupation by indigenous and Portuguese to the implementation of land use projects. Conflicts over land, estates, extensive cattle ranching, land grabbing and illegal logging are elements that coexist in the daily lives of the communities living in the Amazon. However, a question little debated is related to the process of empowerment of the communities in relation to the results generated by research. To what extent they have access to these results? Are these results discussed between researchers and communities? How the information is the basis for thinking about future scenarios?

To address these issues, a participatory modelling (PM) work was undertaken with smallholders of a lake of the Amazon River, and their involvement in the research process was a central issue. They were involved not only as information receivers but also as protagonists in the development of scenarios from

the project results. Researchers from various disciplines participated in this exploratory experiment for integrating knowledge from several data-gathering campaigns with the perceptions of local actors. The building of a role-playing game (RPG) and the design of an agent-based model (ABM) have fostered multiple learning and a kind of interdisciplinarity. A joint reflection between smallholders and researchers about the possible scenarios on regional environmental conflicts emerge by strengthening the development of a critical analysis of these issues by local social actors. This paper describes the context of this (still ongoing) study, the developed tools and methods, as well as questionings on the posture of researchers facing evolving social situations.

2 CASE STUDY: THE AMAZONIAN FLOODPLAINS FACING CLIMATE CHANGES

2.1 Context

Hotspots of biodiversity, the Amazonian floodplains are among the most diverse and productive ecosystems in the world. Always moving, the coastal transition between aquatic and terrestrial habitats prevents stagnation and favours rapid recycling of organic matter and nutrients, enabling high ecosystem productivity and exceptional biodiversity. The organisms live in rhythm with the annual flood cycles. During summer low-flow periods, the banks are covered with kilometres of wide natural pastures, where ponds and streams that concentrate nutrients are suitable for fish spawning. In periods of high water, the river took back his rights, covering all these areas of land, which causes the mixing of populations and the renewal of silt soil. Attracted by these favourable conditions, human populations have settled for centuries in these floodplains (initially, Amerindian and Métis settlers, called *ribeirinhos*). They have learned to live with the variations in their environment, alternating their activities according to the seasons. In low water periods, they planted their manioc fields in fertile silt and moved their herds on pastures. In high water periods, they gathered their livestock on rafts lashed to their stilt houses and gave them cut forage. Fishing was central during the intermediate seasons.

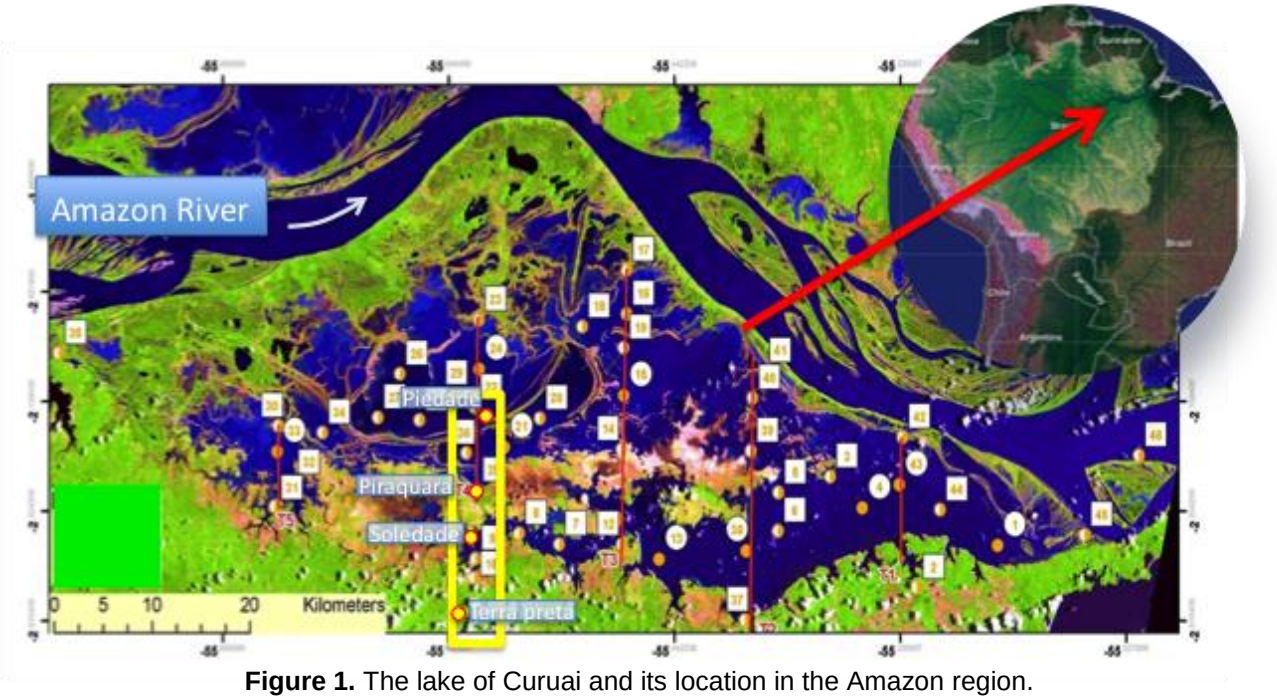

Figure 1. The lake of Curuai and its location in the Amazon region.
The white squares represent points samples collected for bio-physical analysis of the water. The yellow bar represents the transect containing the four communities that participated in PM

For about thirty years, rainfall variability and land use change (especially due to deforestation) in the Amazon basin have caused changes in the hydrography of the river, with higher floods and increasingly frequent extreme floods. Several studies describe these hydrological changes on the scale of the Amazon, but little information is available on the adaptation of populations to these phenomena. By relying on an emblematic area - the big lake of Curuai (*Lago Grande de Curuai*) near Santarém - we

initiated the *ClimFabiam* project[1] to understand how local people were adapting to this changing environment and how in turn, changes in their practices may impact aquatic biodiversity.

To understand the strategies developed to address climate change, a diagnosis of agricultural and fishing activities revealed that the recurrence of severe floods in recent years has restricted the usage times and the area of várzea pastures. This pushed the farmers to the shore, for planting their manioc fields and opening new pastures at the expense of the forest. Like on other Amazonian pioneer fronts, soil fertility loss induces a continuous cycle of deforestation to compensate degraded pastures. This gradually leads to a reduction of primary vegetation and an increase in secondary forest. But here, this phenomenon is stronger: during severe floods, farmers are forced to concentrate their cattle on the few available pastures. These high stocking rates lead to degrade even faster the pastures. Analysis of satellite images shows that the opening of pastures is more rapid after extreme floods. Breeders confirm that the high mortality of their herds during the years of severe floods push them to open more pastures to consolidate their grassland reserves. According to local people, these new pastures, often located on river edge would have an impact on these rivers, draining and changing their quality.

2.2 Objective of the project

Initially, hydrologists and biologists of this project arose the question: Do the scientific results on the dynamics of these floodplains could allow the local actor to better anticipate future changes in river in order to adapt their activities and thus be less vulnerable to such changes? By mobilizing a multidisciplinary team, they have tried to link hydrology and biochemistry of the water, and identify plankton. They thought to compare these results with the perceptions of local actors and their strategies. Therefore, the social scientists have proposed to reverse the perspective to initiate dialogue with the actors: what were their issues and strategies, and what did they expect from the researchers? The challenge was then to develop a process that would initiate a real dialogue with local stakeholders, to confront the scientific models with the perceptions of the local actors. The main idea was to base our work on the Companion Modelling (ComMod, Bousquet et al. 2002, Barreteau et al. 2003; Etienne 2011) approach to gradually integrate the knowledge produced by both the researchers and the different actors of the territory, in order to encourage discussion on the evolution of the territory. This collective foresight work based on participatory modelling aims at examining alternative paths of development. From the construction of a shared vision of the current situation and what is most likely to happen (business as usual scenario), the purpose is to examine the likely consequences of several alternatives, in term of natural resources uses (agricultural, fishing, extractivism and livestock activities) as well as in term of local public policies. According to Börjeson's typology (Börjeson et al. 2006), these "exploratory scenarios" are compared to "normative scenarios" that describe the changes that should be applied to the system to reach desired situations. The purpose is, therefore, not to predict the best way to achieve a desired situation, but rather to explore the feasibility of various land use strategies and their implications for smallholders.

3 INVOLVING LOCAL STAKEHOLDERS IN A PARTICIPATORY FORESIGHT STUDY

3.1 Why participation? Why prospection?

In their survey on "Modelling with stakeholders", Voinov and Bousquet (2010) stressed that participatory modelling (PM) has become a buzzword, and in practice, people's participation is often just a catchy expression used by scientists to justify the process of extracting information (Pretty, 1995). In such cases, stakeholders are only contacted during the primary data-gathering phase and are frequently bypassed in the transfer of knowledge between researchers and policy makers (Becu et al, 2008).

On the contrary, participatory modelling (PM) should encourage producing models that are able to promote mutual recognition of perceptions, knowledge appropriation and finally collective decision-making. As Voinov & Bousquet (2010) concluded, "adaptive modelling should clearly become a standard in the decision-making process under uncertainty, and stakeholder involvement is crucial to make it

[1] ClimFabiam: "Climate change and Floodplain lake biodiversity in the Amazon Basin: how to support adaptation and the ecological and economic sustainability" was funded by FRB (French Foundation for Research on Biodiversity)

happen". But few PM really integrate stakeholders at both the conception stage (identification of the problem, design and parameter setting) and the assessment stage (scenario building and collective exploration). If participative simulation is increasingly commonplace, the earlier phase during which the conceptual model is designed, remains more challenging and, so far, little work has been performed dedicated to the process of participatory modelling (Renger 2008). If we want to help resolve conflict and minimise environmental damage, "we need to work with stakeholders throughout the whole project, and to provide tools that they require, they choose, and they are willing to use" (Voinov & Bousquet, 2010). Thus, creating a sense of ownership of the process can only occur when the models developed are transparent and well understood by the stakeholder group (Korfmacher, 2001).

The objective of our work in Curuai is to help people reach collective decisions and to improve the actors' adaptive capabilities. The area where this work has been carried was a blank area of any sociological study. This experiment is thus a first scientific study in the region involving participatory modelling.

3.2 Who participated?

A partnership with the "Union of residents of Lago Grande de Curuai" called FEAGLE and another with the "Rural Family School"[2] (RFS) of Curuai allowed us to get closer to communities in the region. Throughout the project we have been working closely with these two partnerships around these issues. Contact with the rural school enabled to get closer to the students, around 30 future farmers, who are heavily involved in their communities. They have been trained in some scientific activities by attending various courses taught by researchers of the project. In turn, through them, we could understand in a more informal and spontaneous way the concerns of the region. Many researchers of the project also attended these courses, which have fostered a better understanding of everyone's stakes, and improved interdisciplinarity.

Among more than 100 communities of Curuai lake, we chose to focus our work on four communities representing the diversity of the rural activities in the area: a fishing community in the varzea; a community on the edge of the lake predominated by breeding; another one at 10 km from the lake on the "trans-lago" road that connects the entire region, where agriculture is the main activity; and a more distant in the forest, 20 km from the lake, where new lands are opened.

4 FIRST DIAGNOSTIC

Participatory activities and interviews conducted by anthropologists let local people to describe the changes they perceived. The increase in water level during floods is one of their biggest concerns, because it obliges them to redeploy their activities towards dry land and even to abandon their homes. Increasingly lower levels during low-water periods is less emphasized, but the farmers face difficulties related to drought and shifting rains coming increasingly later, making planting manioc riskier.

However, the most important changes in their lives come from major external pressures, such as industrial fishing, very large herds send from the neighbouring fazendeiros (large landowners) to graze in the varzea, a likely bauxite mining project nearby or the construction of a dam upstream.

This reveals different perspectives in terms of adaptation: even if local people can not do much to climate change, they seem to actively cope with it by changing their activities and practices; but they feel much more vulnerable to large-scale economic, political and demographic pressures. This is not so much the inevitability of change they find difficult, but rather the inability to determine their future at the expense of stronger forces far beyond their control.

5 FROM RPG TO HYBRID SIMULATIONS TO EXPLORE SCENARIOS ON THE LONG TERM

[2] The "Rural Family Schools" are specific ways to train and educate people living in rural areas. The training projects are based on two axes: the pedagogy alternating school and agricultural activities and the association of families.

Modelling in the broad sense has been central in the project. It has supported the coordination of research activities and synthesizing knowledge among researchers and actors. The modelling was initially implemented through a role-playing game (RPG) called "Varzea Viva", more easily understandable to all, researchers and local actors. It has been built with the students of the rural family school. It roughly displays the transect of the four communities we work with, each represented by four farms. Each of the 16 players manages his farm according to his wishes and to the constraints of the game: labour, money, land cover, livestock and so. Players act like they really would, allowing to better understanding their behaviours regarding situations close to reality. One of the collective stakes of the game relies on the movement of livestock herds, between varzea and dry land pastures, forcing players without grazing during floods to find another player to rent his pasture. Each game session is followed by a debriefing during which the elements of the game and the scenarios are discussed. The fun aspect of the game is fundamental to free speech. Each player is required to discuss his choices to manage his farm and to do an analysis of the general board in relation to the "real" situation.

Game sessions have been played in the targeted four communities, and then others by bringing together members of the four communities. They enabled rich exchanges with farmers and fishermen, especially about the various constraints in the region and about the long-term planning. During these sessions, the actors spontaneously addressed the impact of their activities on natural resources, even if they were not always capable of explaining causal relationships.

To better formalize the relationship between human activities and environment, and to increase the time horizons of the gaming sessions, an Agent-Based Model (ABM) has been implemented. This ABM is now a hybrid computer model (Le Page et al., 2011) allowing the users to interact with the simulation: they take seasonal decisions on agriculture, fishing and animal husbandry, which are virtually performed by their avatars into the model. Then, by integrating these inputs and the river level forcing variables, the simulation calculates the annual evolution of the territory and provides production outputs. In other words, the purpose is to simulate biophysical processes by the machine by integrating human activities decided by the players. This hybrid ABM was built as a continuation of the RPG: based on the structure of the game that had been validated by the actors, this model seeks to specify the impacts of the activities based on researchers data.

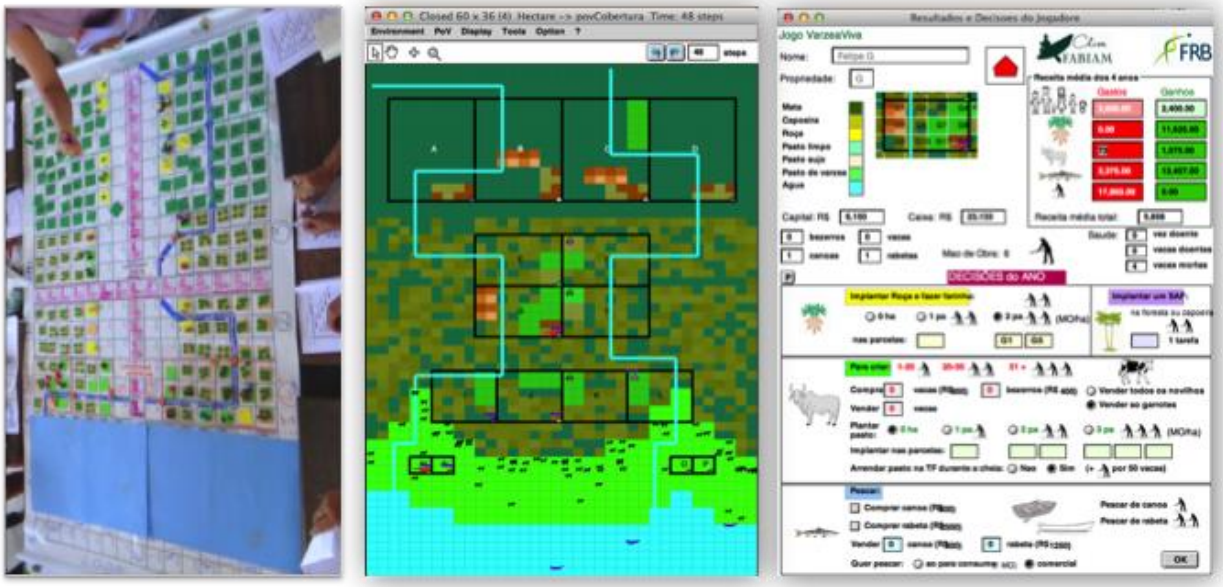

Figure 2. The board of the RPG (left); the spatial view of the simulator (centre) and the decision interface of a player (right).

Moving from RPG to hybrid simulation (fig. 2) enables sophisticated calculations and scenarios on a broader timeframe. It seeks to accelerate the evolution by simulating 4 years steps between each player's decisions. Pasture degradation and dwindling fish stocks are thus better highlighted. Every four years, an interface for each player is displayed that shows the current state of the farm (a zoom on his property) and the family (the costs and earnings of each type of activity, herd size and the number of

calves). The player is then invited to decide his strategy for the next four years. Depending on the family labour, he may choose to cultivate plots, buying or selling livestock or fishing boats.

For now, only few sessions were played. One with the 30 students of the rural family school allowed us to verify the understanding and usability of its interface. In April of 2016, some sessions have been organized in the communities with farmers and fishermen, to see what strategies they plan in the long run face to environmental changes and what alternative scenarios they would propose. Ultimately, this hybrid game will be available for standalone use by the actors. Thus, it would become an entertainment tool for NGOs or for education. Fuller descriptions of the RPG and the simulator, as well as photos of the study area are available online: http://cormas.cirad.fr/en/applica/varzeaViva.html

6 DISCUSSION AND FURTHER WORKS

Methodologically, three important elements contributed to the success of the project:

1) The role of modelling required organizing workshops to build mind maps and links between human activities and various ecological processes, which helped refine the project objectives and their appropriation by the researchers, regardless of their discipline. Then the design of the game helped guide and coordinate fieldwork and the sharing of collected information. The group of researchers tested the game to evaluate its game play and realism.

2) The involvement of the rural school in the development of the game not only helped refine it with field knowledge, but also facilitates its adoption by the communities.

3) The gradual restitution of research results as well as the information sessions in communities and schools enabled the convergence of the different disciplines.

If the initial proposal of the project was to understand the impacts of climate change on biodiversity and the living conditions of the local people, the participatory approach forced us to revise these objectives to better address the concerns of the stakeholders. Indeed, it appears from the debriefings of the RPGs and hybrid simulations that difficulties are not only related to climate change. Socio-economic and demographic changes have often been put forward. To these land use and climate changes (cf. 1st diagnostics) is added a demographic increase in the villages. The urbanized area has increased eightfold between 1985 and 2014, due to (among other) the abandonment of villages in varzea that become hardly liveable because of the high floods. Domestic-source effluents are higher, which significantly impact the quality of the water and the populations of aquatic microorganisms. In particular, our analysis shows an increased presence of cyanobacteria. This constitutes a threat to both human and animal health and also to the fish populations. Cyanobacteria especially occupy the transition areas between land and water, where fish breed best. Their presence can thus further weakening the fish stocks, already threatened by commercial fishing and non-compliance with Community fisheries rules. On all these matters, the participants often expressed the general feeling of not being heard by the authorities and local institutions.

From a methodological point of view regarding the PM, we would like to raise the issue of how to include (or not) external actors whose actions nonetheless have strong effects on resource degradation: they include fishing companies and fazenderos. These questions are methodological but also ethical. The idea is not to put the responsibility for environmental degradation solely on these external stakeholders absent from the debates, nor blaming the local ones for their practices. Moreover, we implicitly aim to protect the most fragile actors who are also the first impacted by these changes. In the Amazonian context, far from administrative centres, social violence is part of everyday life. Pressures on the weakest are often radical. Thus, by inviting some external actors in participatory workshops and debates (if they do not refuse to engage in any form of dialog), we would take the risk of causing more violence and greater inequality. Which would be the opposite of what we're hoping to happen.

These doubts about the positioning of the researchers are discussed within the ComMod group (D'aquino, 2007). "Without attention to power asymmetries, there is a risk that the most powerful stakeholders will have greater influence on the outcomes of the participatory process than marginalized stakeholders" (Barnaud & Van Paassen, 2013). In this particular context, we chose for now to invite only the local actors for both, understanding the current process and anticipating possible futures. Agreeing on a set of community rules established by the local stakeholders to ensure their living conditions is already a inspiring ambition and a tremendous challenge. By providing local institutions with scientific

documents on the state of natural resources and by contributing to social cohesion, we hope that this early work can strengthen the negotiating capacities of the local actors.

7 CONCLUSIONS

To promote effective participation of smallholders settled along the Amazon for building scenarios, we are conducting an "exploratory" approach. It is characterized by the need to adapt to the context and the expectations of the actors. This adaptive approach evolves based on what happens during the participatory process. In contrast to an office work, where one or several scientists lead the development of a model, this experience has forced all the project members to coordinate themselves to develop the RPG and to design the hybrid ABM. The original idea of our approach is to start with a deliberately incomplete game to involve the stakeholders more heavily in the process and encourage them to propose changes and improvements. Starting with a rustic version of a “martyr” game seems a methodological strategy that ensures real involvement of the stakeholders in the design of the conceptual model and in the foresight work for collective decision.

In the Amazonian context described in this study, the question of external actors is a major issue to be addressed. Until now they didn’t participate in the workshops. But their activities contribute to environmental degradation and impact the living conditions of the local actors. Faced with these questionings, we do not claim a neutral posture, which automatically would strengthen the most powerful actors. Our “critical companion” posture that tries to avoid increasing power asymmetries, seeks to be legitimated in the eyes of those with whom we work, to make them more proactive and to provide them with elements to better protect their natural resources against climate, socio-economical and political changes. As stated by Barnaud & Van Paassen (2013), “there is no “right” posture to adopt”; we need to be more reflexive about our own postures to promote equity and sustainability. This ongoing work now enters a new phase in which the support of computer simulation enables to collectively explore longer-term scenarios. However beyond technology, will undoubtedly raise the question of power plays and how to integrate external stakeholders while strengthening the capacities of the most vulnerable.

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