

APPENDIX 1. IDENTIFICATION OF INTERACTION INDICATORS FROM THE CO-CONSTRUCTION PROCESS: EXAMPLE OF THE NIOKOLO-KOBA BIOSPHERE RESERVE

In order to make clear the identification of interaction indicators, I detailed the co-construction process carried out at the Niokolo-Koba Biosphere Reserve (Senegal) (Levrel and Kane, 2005).

An area situated within the triangular zone limited by the three towns of Wassadou, Medinacouta and Dialakoto was selected. This area was representative the main socio-ecological interactions taking place in the biosphere reserve.

The first step was to meet with the main local stakeholders concerned by the management of local natural resources (table A1.1): communitarian forest associations, Medinacouta and Dialakoto women groups, fishers, Wassadou and Medinacouta bananas growers, Senegal NGOs (Friends of the Nature and AGIR), Borassus palm tree growers, park managers as well as Serere farmers (who don't cultivate bananas). This phase lasted four days. It gave us the opportunity to discuss the MAB program and to come out with a diagnostic about the main socio-ecological problems (table A1.1).

Table A1.1: Socio-ecological dynamics in the biosphere reserve from the local stakeholders' point of view

Stakeholders	Main problem concerning the state of ecosystem services	Main origin of the dynamics	Social responses
Communitarian forest association	Erosion of forest resources	"Foreign" people go into the forest and make breeding and gathering	Need for local management with total control over the access and use of forest products
Medinacouta women groups	Damage due to wild animals, decrease of herbs and woods	Wart hog, overpopulation in the area, planting of banana	Need for water pumps for vegetable growing
Dialakoto women groups	No problems		Needs for water pumps for vegetable growing
Fishers	The degree of fish stocks is good because the level of water in the Gambia river is high for two years	Floods for two years	Need for professional materials for stocking and transporting fish
Wassadou bananas growers	Damage due to wild animals Damage due to floods The banana plantation's size is stable	Floods, wart-hog, baboons, hippopotamus Total control of access to lands by local economic interest groups	Hunting in order to limiting the damage due to wild animals
Friends of Nature	Poaching Livestock in the reserve Planting of banana	No game outside the reserve Most of the watering points are in the core area People live in the small transition area between a classified forest and the core zone of the biosphere reserve Absence of collaboration between the park managers and the Friends of Nature (who are well accepted by local stakeholders) Lack of alternative resources	Improving communication with local stakeholders Create some alternative sources of income Clarify the rights of access and giving more flexibility to the rights of use Defining watering points outside of the core zone

Medinacouta bananas growers	<p>Damage due to wild animals</p> <p>Problems because of cattle entering banana plantations</p> <p>Decrease of the abundance of herb and supports (branch, shrub and trees) for the planting of banana</p> <p>Small farmers have to go farther to collect these resources</p> <p>Because of floods, small farmers are in debt with the landowner</p> <p>Lack of time for alternative agriculture (groundnut, sorghum, corn, niebe)</p> <p>They are exclusively dependent on the planting of banana</p>	<p>Floods</p> <p>New migrants</p> <p>The landowner forces the farmers to carry out many maintenance tasks and to support the loss due to the floods</p> <p>Lack of control over the access</p> <p>Lack of control over the uses</p> <p>Institutional tension between the rules-in-uses and the rules of access: the landowner who controls the access should not put limits to it because small farmers pay the environmental cost (more time needed for collecting herb and supports)</p> <p>Conversion of natural habitats into cultivated areas</p> <p>High density of wild animals in a small area</p>	<p>Creation of a local economic interest grouping as in Wassadou, for a better control over the access</p>
AGIR	<p>Problems with the borassus palm tree growing</p> <p>Increase of forest exploitation</p>	<p>Lack of control over the forest access</p> <p>Lack of knowledge that would give more sustainable uses</p>	<p>Training</p> <p>Community management</p>
Borassus palm tree growers	<p>The exploitation of borassus palm trees is sustainable because the tree growers only collect leafs and petioles</p>	<p>Training for growers paid by Agir</p>	
Park managers	<p>Erosion of biodiversity</p> <p>Pollution of the Gambia river</p> <p>Natural habitats are disappearing</p> <p>Soil erosion</p>	<p>Planting of banana</p> <p>Poaching</p> <p>Gathering</p> <p>Livestock breeding</p> <p>Poverty</p>	<p>New materials to improve the monitoring and the access control to the biosphere reserve</p>
Serere farmers	<p>Decline of traditional agricultural activities (groundnut, sorghum, niebe...)</p> <p>Decrease of the abundance of wood</p> <p>Decrease of familial labour force for traditional agricultural activities</p> <p>Lack of material</p>	<p>Increase of the planting of banana</p> <p>Most part of young people wants to work in the planting of banana</p>	

The co-construction phase was carried out during four days at the Medinacouta village. The co-construction team was made up of ten representatives that were split into two working groups (table A1.2) and two mediators.

Let's detail the case of the banana farmer. The question launching the storytelling was : “how do banana farmers procure, collect and/or make use of these resources ?”. The team was split into two work groups to discuss the question.

After 15 minutes, all groups were brought together. The representative of the Wassadou banana farmers starts his storytelling. Throughout his discourse, the mediators ask, when necessary, “on the basis of what information, criteria and constraints does he make such a choice concerning his activities ?”.

The implicit “uses indicators” (in blue) and “decision criteria indicators” (in red) are identified during the storytelling.

First of all, one should **have a good muddy ground**, similar to the one at the **edge of the river**. One should then organize the exploitation of the banana plantation. In Wassadou a **Grouping of Economic Interest (GEI)** has been created in 1989. A **group of farmers** elected by their peers manages the banana plantation as a **common property**. This organisation's task is to **distribute the plots of land** of even size (2 500 m). Today, the **creation of new plots is strongly restricted**.

Having a plot, the farmer begins by **clearing it** but **leaves a strip of trees – that is at least 15 metres wide – in order to avoid soil erosion**. In a field, the **distance between two plants of banana needs to be of at least 2 m**. The **hole which shall welcome the plant should be 50 cm deep and its diameter 70 cm**. Farmers use **shovels, pickaxes and dabas** to make these holes.

Having planted banana trees, the **board of farmers gives the directives to bring the manure**. It is collected in the **enclosures of surrounding villages thanks to the use of carts**. They walk **8 km to find the manure** they need. But the distance is increasing. To obtain the manure, they proceed to a **barter with the breeders: salt against manure**. Besides, they use two other types of **artificial fertilizers: PNK and urea**. But **manure is imperative for the culture of the banana**.

After one month, **they mulch the fields in order to limit the loss of water** due to sunstroke and to maintain water in the ground during the dry season. They sometimes have to **walk several kilometres to collect herb for the mulching**.

For seven or eight months, the farmer shall **use a knife to select the best shoots**. Then the bloom takes place, after seven to nine months. With the bloom, **the plant begins to bow**. It is thus necessary to **install a support such as a branch or a shrub**. For the first bloom, supports may be small, but **with the growth of the banana tree it is necessary to get higher supports**. It is then necessary to **go farther**.

For the bloom, the **main tool of the farmer turns out to be the machete**. At the same time, **need in water increases because the warm season begins**. It is necessary to **irrigate more often – 80 litres per week per banana tree**. During the **wintering season**, the inhabitants **have time to grow groundnut, sorghum, corn or niébé**, which they keep for their **personal consumption**.

Their activity is drawn more difficult by the presence of **hippopotamuses and of wat hog which destroy young plans**. For two or three months, it is thus necessary to **keep an eye on the plantation night and day**. To **frighten hippopotamuses**, they use lamps wipe. They have tried to **enclose fields** but **hippopotamuses crushed the fences**. There are also the **baboons** who **steal bananas** as soon as the regimes are ripened. They also have problems with the **breeders** because **their cattle often wanders in their fields**.

The harvest is carried with machetes and carts that transport bananas up to the seesaw. It enables to harvest at least 6 to 7 tons by plot. The board of farmers bares the task to find the wholesale dealers to whom the production will be sold and to negotiate the price with them. The price is fixed according to the evolution of the costs and the **charges of the wholesale dealers - transport, packaging, taxes, etc**. The **farmers costs** depend mainly on the **purchase of**

the material as well as unpredictable problems such as the floods of these last two years. For this reason they would sell the kilo of bananas 150 FCFA today, while they sold it 140 FCFA one year ago - because of the floods of 2003 and 2004.

To obtain information on the charges of the wholesale dealers, an urban warehousemen's network is necessary, for this type of information would more likely be available in town.

They work with three wholesale dealers from Dakar or Touba. Once the price is settled, the store wholesale dealer comes to make the weighing and pays one month later."

This storytelling has been completed later on by the description of the representative of the Medinacouta banana farmers (we won't describe it here).

After this step, the mediators ask another question which allows to identify other uses and decision criteria indicators : "what do they do with these resources ?"

The banana farmer restarts his storytelling:

Incomes coming from the sale are shared between the common box and the farmers. Indeed, as regards expending – maintenance of pumps, petrol, inputs, etc. – the farmers decide on the needs to come and on a contribution per person corresponding to these expenditures. After the first harvest, the farmers give 50 % of the income coming from the harvest. They shall do so for every harvest until they settled their contributions. This would roughly go from 30 to 40 % of total income at the end of the year. If there is a good return, the contributions can be over from March.

In any case, it doesn't go beyond 50 % of total income. One may ask to pay less at first and more after if one happens to lack money. If the harvests' income is not enough for a farmer to pay the totality of the contribution, the other farmers would manage to pay and the overdue shall returned back the next year. On the other hand, if such a difficulty is bound to a lack of work, the group can decide to exclude the person or to ask him to pay off the year after 75 % height from the first harvest. Besides, if an unpredictable event occurs, the president calls in the council to adjust the budget and contributions.

The following question concerns the signs of changing ecosystem services that have been named during the storytelling : « what signs reveal that herb, muddy ground, trees and river water turned more abundant or more scarce ? ». This lead to identify the indicators of changing ecosystem services (in green).

The first basic sign of changing is the increase of the time necessary for collecting herbs, supports for banana trees and manure. This shows the increasing length of time taken to collect these natural resources (provisioning service). On the other hand, this leads to a decrease in the time dedicated to cultivate food crops (niebe, corn, groundnut, sorghum...).

Regarding the fertility of the ground (regulating service), there is a whole list of the different sorts of herb showing an impoverishment of the ground: djambul, bamid, n'dogom, n'dorac, ségo, cutumbo notouda. On the other hand, some trees show the fertility of the ground : Dugura (*Cordyla Pinnata*), Kohi (*Prosopis Africana*), Guru (*Guiera senegalensis*), Kéké (*Dicrostachys cinerea*), Woro (*Terminalia macroptera*).

Regarding the presence of water in the ground (provisioning service), the obvious sign that water is lacking of water would be the simple absence of trees. The presence of Borassus palm tree is a sign that water is present deep in the ground (the roots of this tree go deep). The more flood occurs, the less trees will regenerate trees, as well as herbs at the edge of the river (regulating services). Bushfires are very harmful for the abundance of tree and herbs. Large tree cut is also very bad both for trees and herbs. However the rising abundance of bamboo is perceived as a positive sign (provisioning services). Other signs may be found, such as the turbidity of the river (regulating services), its level (provisioning services), and rainfall.

After making this description, the two mediators highlight that two other potential indicators have been mentioned in the storytelling: the **productivity of the plots** and the **presence of strip of trees near the river**. This proposition received the participants' approval.

This process enabled to build up a table of simple sense-making indicators from which one could select the most interesting for various practices (table A1.3).

Table A1.3: Ecosystem services indicators, uses and decision criteria indicators identified from local knowledge in the Niokolo Koba Biosphere Reserves.

Indicators of changing ecosystem services	Use indicators	Decisions criteria indicators
<ul style="list-style-type: none"> -Distance for collecting supports (branch, shrub and trees) -Distance to collect herbs -Distance to collect manure -Abundance of species that are used the most frequently for the supports -Abundance of the most used species for the mulching -Abundance of tree (for the presence of water in the ground) -Presence of Borassus palm tree -Abundance of large tree cut -Abundance of bamboo -Presence of indicator species concerning the soil fertility -Surface of muddy ground -Rainfall -Flood frequency -Bushfire frequency -Water river level -Turbidity of the water river -Productivity of the plots -Presence of strip of trees near the river 	<ul style="list-style-type: none"> -Number of plot -Number of litres of water pumped per plot per week -Rate of clearing in the buffer zone -Rate of clearing at the edge of the river -Materials (daba, machete, pumps...) -Volume of manure used -Volume of artificial fertilizers used -Number of banana trees supports in the fields (branch, shrub and trees) -Number of bundles of straw -Volume of banana production -Size of the concessions -Rate of increase of the area dedicated to the banana culture -Number of conflicts with breeders -Number of damages due to wildlife -Number of baboons, hippopotamus and wat hog killed by farmers -Distribution of the income generated by the banana plantation -Level of returns coming from banana plantation 	<ul style="list-style-type: none"> -Access to plot -Access to hedge of the river -Available materials -Season -Characteristics of the banana plant (the plant begins to bow with the bloom and requires a support) -Dependence on the support and the manure -Risk of soil erosion -Availability of alternative resources (depending on the time available after banana culture activities) -Number of working hours to cultivate bananas -Number of working hours to protect the plantation against hippopotamus, wat hog and baboon -Number of working hours to collect supports, manure and herbs -Rate of dependence to bananas exploitation (having alternative resources such as groundnut, sorghum, corn... for personal consumption) -Rules of access enforced by the Grouping of Economic Interest (common property with control of the access) -Collective rules of use enforced by the Grouping of Economic Interest (directives to bring the manure, adjustments of the contributions, ...) sanctions, maximum of the contribution...) -Price of the banana -Unpredictable event -Relationships with wholesale dealers (not monopolistic) -Information on the charges of the wholesale dealers