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# ARDI: a co-construction method for participatory modelling in natural resources management

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**Abstract:** The outcomes of a series of tests of the ARDI (Actors, Resources, Dynamics and Interactions) method in complex cases or conflict-ridden situations is presented. ARDI is part of a companion modelling approach that makes it possible to engage a broad spectrum of stakeholders in the design and development of land and water management plans. It is essentially based on participatory workshops that set out to collaboratively imagine a future open, dynamic management system, capable of adaptation and anticipation, by gathering the various affected stakeholders in a partnership dedicated to preserving the natural resources and promoting a sustainable development. Its originality lies in the co-construction of a “conceptual model” of the functioning of the territory, according to a main negotiated development question.

The approach is based on the collective articulation of the key elements of a territory and context by affected stakeholders such as managers, representatives, socio-professional technicians, NGOs, experts and scientists, and local policy makers. This sharing of representations is done by means of a series of collective workshops during which Actors, Resources, Dynamics and Interactions (ARDI), making up the stakes of the territory are identified and clarified. This work of co-construction is conducted within a precise methodological framework that we present in a step-by-step format. The method is also illustrated with concrete examples gleaned from the tests carried out by the authors during the last 5 years. Finally, the need for skills development and pitfalls to avoid when applying the method are discussed.

**Keywords:** Participatory modelling, co-construction, conceptual model, natural resources management, facilitation

## 1. INTRODUCTION

The application of simulation models in collaborative decision-making for the management of natural resources is one of the characteristics of adaptive management (Holling, 1978; Walters, 1986). But the use of these models to stimulate the participation of stakeholders in the development of management scenarios is much rarer (Costanza and Ruth, 1998; Bousquet et al., 2002). The progressive shift from management plans based on an authoritative or rationalist model towards tools for mediation based on a democratic approach (Van den Belt, 2004) calls for the emergence of new tools of co-construction and sharing of information and understanding.

Following a series of tests of a method, implemented in complex cases (natural areas with multiple use, Biosphere Reserves, Regional or National Parks) or in conflict situations (Heritage Sites, urban-forest interfaces), a companion modelling approach making it possible to involve stakeholders in the design of land and water management plans was developed (Etienne, 2006). It is based on participatory workshops set up to imagine a more open, dynamic management, capable of adaptation and anticipation, by gathering the various stakeholders together to preserve natural resources and promote sustainable

development. Its originality lies in the co-construction of a “conceptual model” of the functioning of a territory, according to the negotiated main development question.

The approach is based on the collective articulation of the key elements of a territory and context by affected stakeholders such as managers, representatives, socio-professional technicians, NGOs, experts and scientists, and local policy makers. This sharing of representations is done by means of a series of collective workshops during which Actors, Resources, Dynamics and Interactions (ARDI), are identified and clarified. This work of co-construction is conducted within a precise methodological framework that we present and illustrate by means of concrete examples resulting from the tests carried out by the authors during the last 5 years.

## **2. KEY QUESTION AND KEY PARTNERS**

The success of the participatory modelling process depends on three key points being directly addressed when initiating the process. These points have to be discussed during one or more preparatory meetings among the mandatory partners and the facilitators of the approach. The first point involves identifying the different types of stakeholders and clearly defining the territory under question. Secondly, one or several facilitator(s) must be identified and their aptitude and legitimacy to carry out the debates during the process of design-validation-use of ARDI tools will have to be appointed. Thirdly, it is necessary to pay special attention to the convocation of the working group: choice of the partners, place of the meetings, periodicity of the workshops, modality of invitation. This is mainly because the representativeness of the participants and thus the richness and relevance of the conceptual model depend on that point.

The ARDI method was tested under a varied set of conditions, questions and territories. It was mainly applied by French researchers working in the field of companion modeling (Collectif Commod, 2006) but several agents of regional natural reserves were trained to apply it in France, and mediators are currently being trained in Western Africa Biosphere Reserves. The success of this approach to natural resources management lies in the relative independence of an external scientific agent, and the familiarity and skill of such a person in the handling of the methodological aspects. However, there is a distinct advantage to engaging a researcher as facilitator who is skilled in both the ecological sciences and social sciences with basic experience in facilitating debates between researchers and managers. But a communication expert can also easily play this role.

Finally, several criteria have to be considered when choosing participants for the exercise. Even if this choice is flexible (it is possible to invite a new participant in the course of the exercise), the process gains from having access to an initial “core group” that will be present throughout the process of co-construction. Three types of situations were confronted during the testing process:

1 - priority given to a global understanding of the system: the participants chosen from extension services of the territory whose local experience legitimizes their position to speak on behalf of the stakeholders that they frequently come into contact with. It is important not to forget any relevant activity according to the defined question, and to avoid over-representing an activity (for example inviting three foresters because there are three forest companies working in the territory).

2 - priority given to the involvement of local stakeholders but by maintaining a global view of the system: the participants are sorted from local stakeholders representatives chosen for their legitimacy (elected democratically, leader of a professional organization) and for the relevance of their activity in relation to the initial question.

3 - priority given to the involvement of local stakeholders whilst seeking to appreciate the diversity of the system: the participants are local stakeholders selected for originality of their practices compared to classical or formal stakeholder groups.

The position and status of researchers in the process is variable and is still being debated amongst the companion modeling community. The general rule is that researchers carrying knowledge of the context and major processes (social, technological, economic, ecological,

and political) be engaged. Some bring expertise to the initial stage whilst others will be integrated at a specific workshop, (frequently the discussion on system dynamics or the design of the interactions diagram), if the participants feel there is a need for an expertise on a particularly topic. As much this differentiation is relatively easy in the field of the ecological sciences, it is problematic in the field of social sciences where the researcher may play the role of the expert who holds a global vision of the social relationships or economic flows. The choice of the venue, the duration and the periodicity of the meetings depend on many factors external to the exercise itself (availability, schedules of obligation, levels of responsibility). But some principles should be negotiated and respected if the method is to be successfully applied. For example, the method is facilitated if the place is easily accessible to participants, and on neutral ground. If not, it must be clearly identified as the legitimate place of the partner who convenes to the exercise or raises the question. Each meeting must at least last 2 hours and the participants must remain centered on the collaborative exercise. The ideal is to conduct all the workshops over a period not exceeding 1 month and the meetings may take the form of: a) a 2-day and a half workshop, b) one half-day per week, c) three separate days.

### **3. THE ARDI METHOD**

#### **3.1 Co-constructing a common representation**

The first step of the companion modeling approach follows the ARDI method (or any similar one), in collectively identifying the principal stakeholders concerned with the key question, their management entities, the resources used and the main processes driving changes affecting these resources. With this intention, the group that takes part in the co-construction of the model must answer the three following questions (the formulation of which is adapted here to the establishment of a sustainable development project):

1. What are the principal resources of the territory and what is the key information to guarantee a sustainable use of these resources?
2. Who are the main stakeholders involved in the use or duty to decide the management practices of this territory?
3. What are the main processes that drive strong changes in resource dynamics?

Dependent on the extant and complexity of the territory concerned, the collective response to each of these three questions can take between 1 and 3 hours. Depending on the level of detail required, this can be between one half-day to one day and a half workshop. It is important that the order of questions be respected and the facilitator must take care that each one participant has the opportunity to deliver an opinion. In the sessions we facilitated, the following simple procedure was adopted: a) a drawing, on an interactive white board, easy-to-see by all the participants, b) for each element of ARDI, each participant has, in turn, the opportunity to respond, c) only one concept to be proposed at a time.

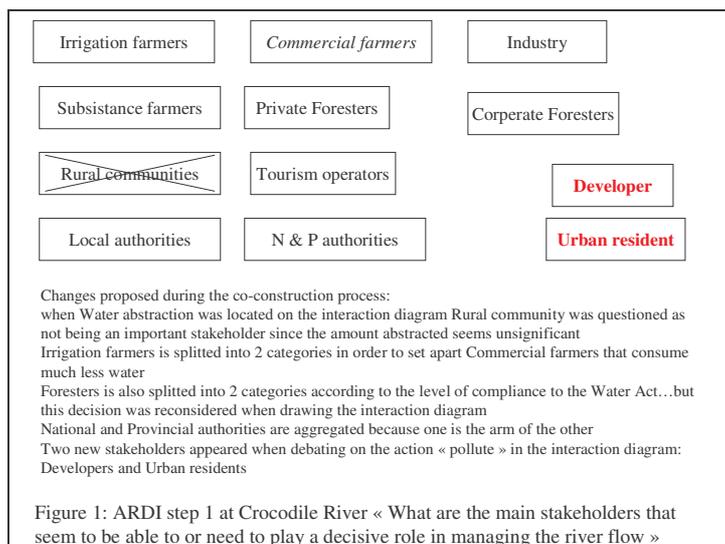
To facilitate sharing mental models and representations, the answers to the questions are formulated as lists of words, with a minimum of coding making it possible to easily classify the information. The workshop is generally led by two people: a facilitator and a secretary. The role of the facilitator is essentially the “hand” of the group and intervening only when the response is formulated either in a too generic form (i.e. to refuse systematically the term manager to define a stakeholder), or with a polysemous word or a term that can lead to confusion (i.e. wood can be the place where trees stand but also the material resulting from the exploitation of these trees). The role of the secretary is to keep track of the exchange between members of the group, or between one participant and the facilitator. Among the key aspects to monitor, three are particularly important: attitudes of the participants to each other as a way to reveal social links, arguments developed to support a proposal or to contradict it as a way to measure the strength of the assessment, and reasons advanced for changing a previously accepted proposal or terminology as a way to follow up the group dynamics. The first will permit to identify social networks, the second to better understand individual mental models, and the third to keep the track of the path followed to reach an agreement.

### 3. 2 Identifying key stakeholders (“A for actors” in ARDI)

The first stage of the ARDI process culminates in the “actors” diagram (“A” from ARDI) which is composed of the list of stakeholders and the corresponding management entities and the links between them (Figure 1). The exercise proceeds in 3 stages. Initially the participants simply list the stakeholders whom they consider associated with the question. As long as new suggestions for stakeholders are proposed, the facilitator goes on with the next participant or begins a new round from the table. Each “actor” proposed must be a direct stakeholder (people who use or whose practices have a direct impact on key resources of the territory), or an indirect stakeholder (people whose actions will encourage the direct stakeholders to change their practices). Each input is added to the interactive board by the facilitator as a new label, using colors to distinguish the category to which they belong (black case for the direct ones, blue for the indirect ones). The facilitator may suggest to precise certain types of actors (i.e. farmers be subdivided into stockbreeders and wine growers) or challenge the assignment to a category if there is not consensus in the room. A typical example of this type of intervention is the status given to the entity "herd". Certain participants will position it as a resource, others will regard it as an actor. When the grazing impact on grassland dynamics is a significant process, the facilitator may ask whether participants think that the herd is autonomous (it decides where, when and how much it will graze), or if it depends mainly on the decisions of the shepherd. In the first case, one will retain the herd as a stakeholder, in the second case, it will be listed as a resource managed by the shepherd.

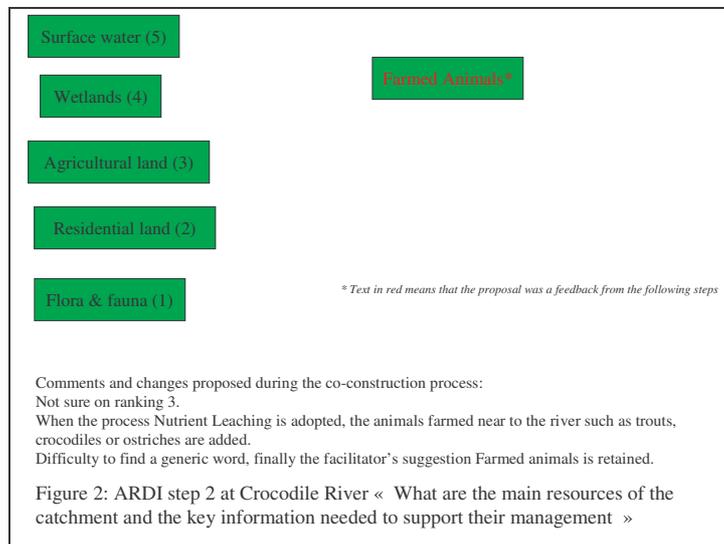
Next, the organizer will ask the participants to specify the links which exist between the identified stakeholders and to clarify in a simple way this relationship. Progressively, the facilitator adds arrows according to suggestions made by the participants. He also progressively shapes the diagram by bringing closer the stakeholders who have many relations and moving those away that do not have any. When the participants consider that the main interactions between actors are represented, the facilitator can put the finger on incongruities and gaps (i.e. no link between the stockbreeder and the shepherd) or point out stakeholders without any relation with any other. The facilitator then launches a discussion on the relevance to retain this “actor” in the diagram, while the secretary keeps record of the decisions taken by the group and the justification for the decision (the landowner is the typical example of a stakeholder who does not have a link with anybody but that is often retained in the diagram because he can easily block the development of the activities of another stakeholder).

Lastly, always according to the principle of the negotiatin, the participants must identify and clarify the management entities used by each direct stakeholder. Those can be spatial entities (forest plot, grazing unit, water catchment), or not (herd, cash).



### 3.3 Identifying key resources (“R” in ARDI)

The second stage consists of listing the relevant resources of the territory according to the key stakeholders previously identified, the word resource applying exclusively to goods or products used by any of the stakeholders (Figure 2). During the collaborative construction of the list, the principal types of resources are often gathered within five main categories (infrastructure, water, minerals, plants and animals). For each resource mentioned, the speaker is brought to justify his/her choice and is encouraged to specify which indicator seems to be the most relevant to make management decisions regarding that resource. Participants are encouraged to explain which characteristics of the resource they evaluate before taking a decision on that resource. This indicator can be quantitative or qualitative and if there is debate or non-agreement, several indicators may be applied to a particular resource. As certain resources are temporary, one may have to specify the period of existence (season, favorable year) and/or long-standing (lifespan of a building, time for filling of a dam). The resources functioning as exogenous variables but whose characteristics are critical in operating the system can also be mentioned (i.e. the rainfall in arid or dry zones). This set of indicators will be used afterwards, during the model implementation and the development scenarios steps, to visualize and compare the stakeholders’ points of view (Etienne et al., 2003).



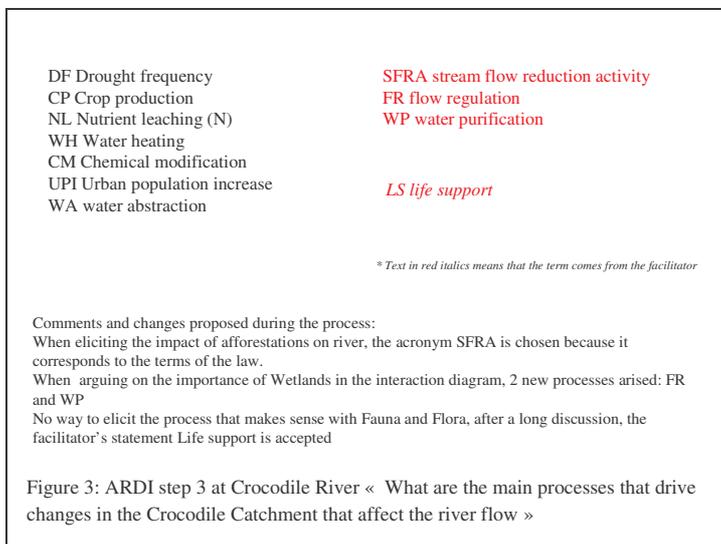
### 3.4 Identifying key processes (“D for dynamics” in ARDI)

The third stage consists of listing the main processes that drive change in the territory in relation to the question (Figure 3). These processes can deal with ecological dynamics (i.e. vegetation transitions or water flow), economic dynamics (i.e. market price-changes, subsidies amount) or social dynamics (i.e. social cohesion, knowledge transfer). If the list is large, the facilitator asks the participants to rank the 10 main processes giving 10 to the most important one and 1 to the least. Then he sums up the scores given by each participant and selects the 5 processes that get the highest score. For these processes, diagrams are drawn to explain what forces are driving changes, with respect to which resources.

When dealing with ecological dynamics, participants may agree to the successive states taken by the vegetation and specify the factors which cause the transition from one state to another including the time required to move from one state to the next. The diagram can either be designed “in situ”, or be a response to a proposal designed by an expert. In the two options, it must clearly distinguish the dynamics related to the human actions (effect of the techniques currently implemented), from natural dynamics (consequence of the abandonment of the uses). A similar diagram can be applied to the dynamics of water.

At the end of this phase, it is advised to review and revise the diagrams and to identify possible gaps. Three types of gaps may be identified. 1) An activity or a resource was identified but no participant carried enough knowledge about it. The group then agrees to

call upon an expert and nominates the person charged to identify and mobilize the expert. 2) An important actor was forgotten at the time of the preparatory phase and the group is concerned by this absence. The group then agrees to invite the person to the next phase. 3) An actor, a resource or a dynamic process are the subject of a total disagreement between two or several participants. The group then agrees on the choice of an expert and the type of information required from him in order to solve this dead-lock.



### 3.5 Eliciting interactions

The last phase of the ARDI method consists of synthesizing answers to the three preceding questions by stressing the interaction between users and resources. It is a pivotal of the exercise since it leads to the conceptual model representing all interactions related to the tackled question. It is advised to devote more time to this phase since it generally takes one half-day for a simple diagram (3-4 direct actors, 3-4 resources), and one day for a more complex diagram (5-8 direct actors, 5-10 resources). The group must then answer the following central question:

How does each stakeholder use the resources and modify the processes?

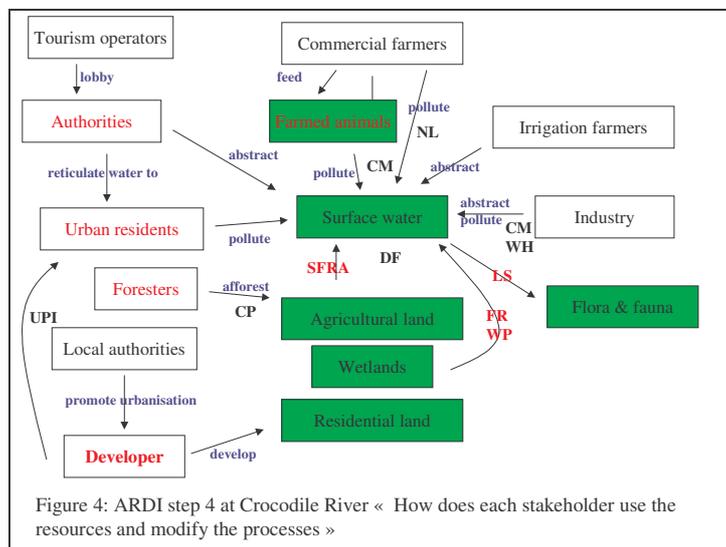
The facilitator will begin this stage by distributing and summarizing the diagrams carried out during the previous stages, by making a particular effort of clarification if new people were integrated to the group. When the diagrams are relatively simple, he directly invites the participants to collectively construct an interaction diagram. For that, the facilitator puts the main resource in the middle of the diagram and proposes to position the direct stakeholders related to this resource. Each participant chooses, in turn, to add an interaction between a stakeholder and a resource or between a stakeholder and another stakeholder. He can either add a link on the collective diagram, or ask to add one of the stakeholders of the list not yet included on the collective diagram. Each new interaction suggested must include a verb which specifies the type of action that generates the link. The proposer must justify his choice and indicate, when he knows them, the type of information used by the actors to make the corresponding decision (i.e. I authorize a new allotment because the request for residences exceeded 50; I withdraw my flock from this paddock because it remains less than 300 kg of fodder; I will look for an agreement with the Regional Park because more than 30% of the inhabitants complain about the area covered by fallow lands). Finally, when all the arrows are drawn, the participants locate on the diagram the key processes identified at the previous stage, by writing down their acronym besides the arrow representing an interaction that is supposed to strongly affect them.

When the diagrams become too complex, it is preferable to proceed in a segmented fashion by cutting up the exercise into several phases. Two options are possible. If several stakes were clearly identified during the co-construction process, the facilitator proposes to carry out a diagram of interactions for each of these stakes and leads the procedure described in the preceding paragraph as many times as is necessary to complete the diagram. In this

case, he must take care that the resources and the stakeholders mentioned by the participants continue to relate well to the chosen stake, and in case of doubt, to clarify the considered link. If stakes are not clearly identified, the facilitator proposes to gather the resources into categories, and then constitutes working groups on the 3 or 4 categories which appear most important to the participants. In this case, it is necessary to add a phase of pooling and comparison between the 3 or 4 built diagrams.

The role of the facilitator during the “interaction step” is particularly important and delicate since he constructs an easily accessible and recognizable diagram at the same time as facilitating the interactions and inputs (taking care to avoid confusing representations or crossed arrows, etc). He needs also to ensure clarity of inputs from participants (whilst avoiding putting them in delicate or uncomfortable positions) and regularly revisit those inputs that are not integrated into the diagram (i.e. boxes without arrows), without forcing the participants too much). The facilitator simultaneously assumes three objectives: a) to gradually prepare a common diagram comprehensible to all, b) to identify clear and indisputable interactions, and c) to leave the possibility of repairing lapses of memory. Additionally, the facilitators role are to oblige each participant to reformulate their input so as to avoid uninformative verbs (i.e. the herd grazes, the farmer farms his field, the manager manages his budget) or to retain only the interactions which make sense according to the question (i.e. in an exercise on fire prevention and urbanization, the interaction between the cereal farmer and his crop field was restricted to ploughing the stubble after harvest, because it is the only one that impacts land sensitivity to fire).

This phase is generally the richest and most interesting of the co-modeling process, but to benefit maximally from this richness, it is essential to keep a record of the process of the construction of the four diagrams. There is specific value to knowing why and how a particular actor, or particular resource, or particular interaction, was mentioned, retained, eliminated or transformed. It is possible to use many means to reach this goal: audio recording (very comprehensive but very time consuming to analyze), a secretary dedicated to this task (very effective because they can quickly give an account of the sequence followed and how decisions were justified but it demands an additional person), the use of an interactive table or a digital camera allowing progressively to take a series of instantaneous diagrams with their construction (very demonstrative but requires either particular equipment, or a person partially dedicated to the exercise).



#### 4. TAKING THE PERSPECTIVES FURTHER

The completion of these four stages leads to the establishment of a conceptual model. This model is a critical output of the ARDI process as it is a graphical representation of how the stakeholders perceive the system to function. This has fundamental implications for the next stages: designing and implementing a management plan for the territory based on the

collaborative established understanding captured in the diagrams. Two options arise for the working group: a) to work out a proposal for a management plan based on the conceptual diagram (concerted research plan, charter of sustainable development), or b) to develop a computer simulation model that will assist in decision making and dialog. In the first case, the thinking will be focused on the territory and its priorities of development, education and research. In the second case, the thinking will focus on the implementation of a computer model or a role-playing game to help stakeholders to transport themselves to the future and imagine and vision collectively adaptive co-management scenarios. In both cases, the ARDI method is valuable and useful as it works with a collectively established conceptualization of the territory and provides a concrete tool for applying the concepts of adaptive management.

ARDI method has many similarities with Problem Structuring Methods such as the use of a model as a transitional object, the emphasis put on the group process and the importance of facilitation skills (Eden & Ackermann, 2006). But it is concentrated on the preliminary issue conceptualization stage of modeling and on the visualization of a shared mental model as other methods developed for systems thinking (Hodgson, 1992; Richardson & Andersen, 1995).

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