Chapter 7

How do participants view the technologies used in companion modelling?

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The companion modelling approach mobilizes a number of tools to establish a representation of a given system. The most commonly used tools are simulation tools, principally agent-based computer simulation tools (virtual agent-based simulation model – VAM), role-playing games in their various forms (human agent-based simulation model – HAM and computer-assisted human agent-based simulation model – cHAM) and hybrid agent-based simulation model (HyAM) tools, which are hybrids of the two previous tools (Chapter 3 gives a detailed description of these four tools). However, other tools are also used to establish a view of the system and consider possible scenarios, such as spatial representations that may be based on various technologies (e.g. map, three-dimensional modelling, GIS, etc.) and knowledge representation diagrams (e.g. ARDI, systemic, UML diagrams, etc.). Some of these tools are based on computer technology and others only use paper and pencil, but all of them involve a set of standards and codes (known as the tool formalism) to represent a situation.

The participatory framework in which these technologies are used raises many questions. Is the tool formalism suited to the cognitive framework of users or participants? How do they interact with the tool? What are the effects of using the tool on the group of participants? Does the tool allow participants to deal with the question raised? Several chapters of this book provide answers on how to use these tools with stakeholders (Chapter 9) or explain the technical and methodological specificities of tools and combinations of tools (Chapters 3 and 10). This chapter discusses the use of tools as seen by the participants, that is, the perception they have of how easy it is to use the tool (ergonomic design) in a given experiment, its advantage for the group and its ability to stimulate thinking about the system represented.

To answer these questions, our analysis is based primarily on the assessments carried out in the ADD-ComMod project (Chapter 6) of 18 case studies involving the ComMod approach, each using different tools according to the phases of the approach. However, as these assessments only partly answered the questions posed, we made use of other assessments to support our analysis.

The second section of this chapter describes the various tools used in the companion modelling approaches and the technological diversity on which they are based. The following section defines the framework used (i.e. ergonomics, effect of the tool and ability to encourage thinking) for the analysis of participants' perception of the tools used in participatory workshops. The following three sections present the results of this analysis for the three primary types of tools used, that is, simulation tools, diagram construction tools and spatial representation production tools. In the last section, we assess the strengths and weaknesses of various technologies and draw conclusions about their complementarities and the possible combinations of tools in view of the perception that participants have of them. In this section, we also examine how participants view their ability to be autonomous in using those tools.

Tools used in the participatory mode

Before analysing how they are viewed by their users, we describe the type of tools involved and how frequently they are used in group situations in the ComMod approach.

Variety of tools representing technological diversity

Companion modelling approaches are based on a whole variety of tools to express and represent views of the system studied and its possible developments. The tools used with companion modelling stakeholders fall into three primary categories.

– The tools used to produce agent-based simulations, including HAMs, which do not use any computer technology, cHAMs, which use computer technology for any function other than for specifying agent decisions, HyAMs, in which some agent decisions are specified by computer technology and VAMs, which are fully computerized.

– Tools for producing diagrams. The diagrams produced are generally based on the UML formalism, or on an entity/relationship-type formalism, such as the diagrams of the ARDI method, or on an *ad hoc* formalism based on a systemic approach. All diagrams are used to represent a system's entities, processes and interactions. The tools used to produce them are either manual (paper and pencil, marker board) or computerized (graphics software).

– Tools for producing spatial representations. These tools are used to locate in space the system entities, processes and system changes. There again, the variety of tools is based among other things on a diversity of technology. Some tools are based on computer technologies such as GIS, while others only use paper and pencil or a marker board to configure manually a spatial representation, and another type, known as a participatory 3D-modelling, is based on three-dimensional scaled relief model of a territory.

A last category of tools sometimes used in participatory mode is pseudocode a kind of programming tool. Pseudocode is a language close to natural language, which can be translated directly into computer code, but which calls for a stabilized lexicon.

The analysis in this chapter is primarily based on the assessments of participatory workshops held with the ADD-ComMod project. However, the assessment framework and the available results do not always distinguish the simulation tool from its media. Therefore, we were obliged to analyse the simulation tools independently of the spatial medium used, even though we realize that this introduces a bias. The tool, defined here as an object allowing a certain activity to be accomplished more effectively than without it, should thus be distinguished from the medium that is an object designed to impart information. Simulation model media and, in particular, spatial media, are covered in Chapter 3 and will not be discussed any further in this chapter. Let us just remember that 95% of the time, simulation tools are based on spatial media that are also based on a technological diversity (e.g. game board, computerized cartographic interface, etc.), which affects the perception participants have of the use of the simulation tool.

Frequencies of use of tool

All companion modelling approaches with the stakeholders of the system represented take the form of a series of workshops each aiming to achieve a particular objective towards representation sharing. While some of these workshops do not involve any tools, most make use of one or more tools acting as intermediate objects for sharing representations between stakeholders. Here we focus on this second type of workshop.

For the purposes of analysis and because of the assessment system used in the ADD-ComMod project, two simplifications were made in dealing with these participatory workshops. First, in cases where several tools were used in one workshop, only the tool viewed as the primary tool by the assessor was considered. A workshop initially organized, for example, around the construction of diagrams and then on the basis of simulations carried out using a VAM, will be coded and analysed later in this chapter either as a diagram construction workshop or as a VAM simulation workshop, according to whether the assessor selected one or the other as a primary tool. The second simplification concerns the sample of workshops selected. The assessment system only included workshops considered by the assessor as collective key moments in the implementation of the approach. Some cases in which tools were used were not included in the analysis either because they were not regarded as collective key moments, or because they took place outside the group interaction.

On the basis of this analysis method, we reviewed the frequency of tool use in the cases in which companion modelling was implemented (Figure 7.1). Role-playing games in its HAM or cHAM form alone represented half of the case studies. VAMs were used in one application out of five, while HyAM tools, which are hybrids between the two previous categories, were used in 5% of cases. The other tools used during collective key moments were mainly group diagram production tools (19%) and more rarely, spatial representation production tools (5%) or pseudocode (2%).

Due to the simplifications made by the assessment system outlined above, the statistics shown in Figure 7.1 do not reflect the importance attached to spatial representation production tools in companion modelling approaches. Indeed, in many cases assessors did not include participatory mapping, 3D-modelling or participatory GIS workshops in the analyses of collective key moments. The trivialization of such workshops since the 1990s and which, as stressed by Chambers (2006), are now among the most common type used in participatory rural appraisals, partly explains the lesser attention given by assessors to these workshops. In addition, spatial representations were sometimes constructed at the beginning of a workshop where the main tool was a simulation tool[1], or outside strictly group workshops. The frequency with which mapping is used in companion modelling approaches is thus actually much higher than that shown in Figure 7.1.

The relative use of the various tools is not independent of the modelling phase in which the group is located, that is, design, modelling, validation or scenario-building. As shown in Table 7.1, the construction of diagrams was primarily used in design workshops. In one case study, however, the construction of diagrams was used to coordinate scenario-building workshops. Pseudocode, for its part, was exclusively reserved for modelling workshops. HAMs and cHAMs were primarily intended for scenario-building. In rare cases (three identified), these tools were used for model validation or design. VAMs for their part were primarily intended for scenario-building workshops. However, their mobilization in a participatory framework often involved the joint construction of the tool, which accounts for their prior use in modelling or model-validation workshops. Although the use of HyAMs was fairly similar to that of VAMs, the few workshops based on this type of tool do not allow such accurate statistics to be compiled.

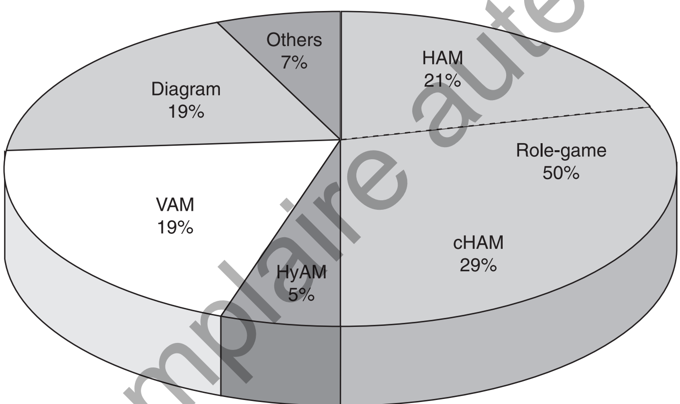


Figure 7.1. Main tools used during collective key moments in case studies in the ADD-ComMod project.

Table 7.1. Types of workshops during which tools were used (excluding spatial representation production tools).

	Diagram	Pseudocode	HAM	cHAM	VAM	HyAM
Design (%)	88		11			
Modelling (%)		100			25	50
Model validation (%)				17	38	
Scenario-building	12		89	83	38	50

[1] This is, for example, the case of role-playing game workshops where the game board is first jointly constructed with the participants.

For the reasons stated above, workshops involving spatial representation production tools could not be included in our statistics. However, the reports of individual cases of the ADD-ComMod project (i.e. outlines and logbooks) show that these tools were most often used in scenario-building or design workshops, particularly for building the spatial media on which the simulation tool was to be based.

Perception analysis framework and available data

This section mirrors the previous section on tools. It first describes the criteria for analysing how these tools are viewed by their users and then the information available for studying them.

Tool perception analysis criteria

Our framework for analysing how tools are viewed by participants is based on three sets of criteria relating, respectively, to their ergonomics, the effects of their use and their ability to encourage participant thinking.

The ergonomic design criteria for the tools measure how accessible the tools are to participants and thus the interfaces (computer or otherwise) allowing users to interact with the tool (e.g. to understand its functioning and its results, and how to change its content). Three aspects are assessed.

– Is the tool user friendly (is it fun to use, what is its response time)?
– Is it easy to understand (is its formalism within the intellectual grasp of the stakeholders)?
– Can the participant handle it (change its contents)?

The second set of criteria assesses the effects on the group of using the tool as perceived by participants. For this purpose, five potential effects of use have been identified: (i) creation of knowledge; (ii) change in perceptions; (iii) help in interacting with others; (iv) change in practices; (v) creation of a forum for discussions between participants.

The latter criterion assesses the tool's ability to encourage participant thinking about the functioning of the system represented and its future. In particular, it assesses the link between the model and reality as perceived by participants as well as the tool's effectiveness in exploring changing trends in the reality on the ground (exploratory simulation).

It should be noted that the analysis criteria used are not independent of each other. For example, the tool's ease of understanding influences the creation of knowledge. Help in interacting with others and changing perceptions partly depends on the creation of a forum for discussions between participants. The analysis results clearly show these interdependencies.

Data used for analysing tools

The data used for this analysis are the results of assessments of the ADD-ComMod project concerning 18 applications of the companion modelling approach conducted in various countries on five continents and in diverse socio-cultural contexts (Chapter 6). For each of these case studies, several workshops representing collective key moments were selected and assessed with participants. Thirty-three participatory workshops based on the participatory tools analysed in the context of the chapter were selected, thus allowing the participants' opinions of the tool used to be gathered. As indicated above, very little data were gathered on spatial representation production tools and for this reason these tools were analysed separately using other data.

Thus the available data essentially concern simulation and diagram construction tools. For both categories, more than 380 comments were gathered, which allowed us to analyse the ergonomic design of the tools, the effect of their use and their ability to encourage thinking. Although these data are qualitative, a meta-analysis carried out in the assessments of the ADD-ComMod project made it possible, in the case of tool effect criteria, to extract quantitative data as presented in the next section.

Having defined the materials and methods involved, let us now look at the analysis results on the basis of three main types of tool: simulation tools, diagrams and charts, and spatial representation tools.

Participants' perception of simulation tools

Tool ergonomic design

Fun side and response time

Participants in workshops, taking part in HAM-type role-playing games, viewed these tools as user friendly and fun to use; waiting times were generally short and were not attributable to the tool but rather to the workflow in the role-playing game. Indeed, these tools were generally designed with this in mind and, in particular, to ensure that participants were kept busy and active all the time. This was also true, but to a lesser extent, in the case of cHAM and HyAM tools, where participants often had to wait while data were entered or the computer performed other operations. The case of VAM tools was somewhat different because the participants could passively watch the simulation running on the computer screen. The tool itself did not encourage participant action and it was often up to the coordinator to ask participants to give their reactions either during the simulation or between two scenario simulations.

Ease of understanding

Participants in workshops involving VAM tools were often held back by the tool's technicality, in that technical knowledge was required to interpret its results, and too much information had to be processed to understand its functioning and results.

In comparison, the HAM, cHAM and HyAM tools were easier to understand, as the participants were given a method for learning the rules and testing the model's operation, involving role-playing.

In addition, the computer interfaces used in all VAM tools, as well as in many cHAM and HyAM tools, could be difficult to read. In the case of the spatial representation interfaces that were most commonly used, the size of cells (in raster mode), the colour codes used as a caption and the changing states of cells after each simulation may be detrimental to some participants reading and accessing information. However, an *ex post* assessment of VAM workshops carried out with farmers in northern Thailand showed that three-quarters of the participants had a good understanding of the spatial interface and digital indicators, which could be read by nearly all participants after only two sessions (Becu *et al.*, 2008).

Ease of operation and handling

This criterion corresponds to the participants' ability to operate the tool, that is, to explore and change its contents as part of the analysis. The ability to operate the tool provides participants with a better understanding of its functioning and results. Participants are then actively involved in operating the tool, unlike a passive use that only involves reading and interpreting simulation results proposed by a third person. Being able to use the tool autonomously is of course linked to its user friendliness, which also facilitates its transfer. This aspect is discussed in the conclusion. In this section, user autonomy is seen in the context of a participatory workshop and not with regard to any new project coordinator.

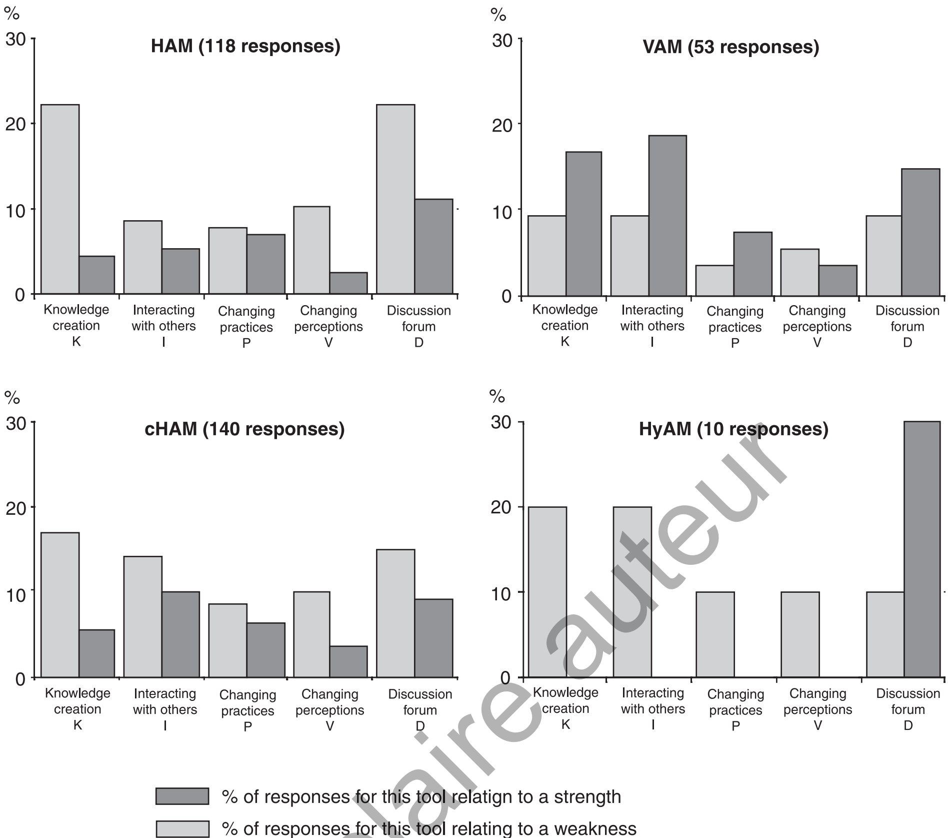
VAM tools were often seen by workshop participants as inflexible and only able to be operated and changed by the specialist. Some VAMs have user-friendly ergonomic interfaces, which allowed them to be operated by participants. Participants could, for example, start simulations by themselves, explore the various simulation results and even change the model's settings or rules if provided for; however, only the interfaced aspects of the model were accessible to the user. In other cases, changing the model required a programmer or a modeller to change the computer code.

HAM tools are just the opposite. The model's rules (at least the rules that relate to social entities and their processes) are oral rules given at the start of a role-playing game, but which can be changed at any time during the process. Moreover, workshop facilitators often want participants to change the rules as this indicates social adjustment. However, the possibility of changing the rules depends largely on the facilitator. The facilitator style will determine the extent to which the HAM tool can be operated by the participants.

Although these remarks are also true for the cHAM and HyAM tools, the increasing level of computerization of both these types of tools may, like their ease of understanding, make the tools less easy to handle and less user-friendly from the participants' standpoint. For instance, in a HyAM tool the participants cannot change by themselves the rules of the computerized social entities.

Effects of the tool as seen by participants

The meta-analysis carried out in the assessments of the ADD-ComMod project made it possible to extract quantitative data on the effects of using the tools as seen by the participants. For this purpose, the responses obtained from the assessments were listed according to whether they expressed a strength or weakness of the tool as judged against one of the following five criteria: creation of knowledge (K), changing of perceptions (V), help in interacting with others (I), incentive to change practices (P) and creation of a discussion forum between participants (D). For example, a lack of knowledge creation or a reformulation of existing knowledge (without creating new knowledge) was coded as a weakness in criterion (K). A better understanding of the views of others and a change in attitudes towards others was coded as a strength in criterion (V). A tool that allowed the involvement and participation of all participants was considered a strong point of (D). In contrast, it was coded as a weakness of (D) when it restricted discussions because there were too many scenarios to be analysed or response times were too long during simulation phases between two discussions.



The percentage of the responses for this tool relating to a strength are shown in the light columns and those relating to a weakness are shown in the dark columns.

Figure 7.2. The effects of simulation tools according to the workshop participants assessed by the ADD-ComMod project.

Figure 7.2 presents the results of this analysis and shows that the creation of knowledge and the creation of a forum for discussion between the participants were the two main effects of simulation tools according to participants (these criteria represent, respectively, 25% and 28% of responses, all simulation tools considered). Help in interacting with others was in third position of the effects perceived by participants (21%), while changing perceptions and changing practices represented, respectively, 12% and 14% of the responses. However, these simulation tools have different characteristics.

Knowledge creation

The HAM, cHAM and HyAM tools are well suited to the creation of knowledge. Participants saw them as tools, not necessarily for creating knowledge about a given system entity (although this is the case when the model illustrated a complex natural process, for example), but rather for highlighting knowledge, identifying constraints and changes, understanding interactions or behaviour and creating common knowledge.

While VAMs were also recognized as good tools for creating knowledge, they had as many weaknesses as strengths in this area. Participants thus recognized that they acquired knowledge about the complex system (that they shared between themselves), but the difficulty of understanding the model and its rigidity (i.e. difficulty in using and changing the tool) were detrimental to the creation of knowledge.

Discussion forum

The use of simulation tools in participatory workshops was always beneficial in creating a forum for discussion between participants. However, some tools were more beneficial than others. The results showed that the more tools are computerized (from HAMs to VAMs[2]), the more they had restrictions that were detrimental to the creation of a discussion forum. The HAM tool was clearly the tool best suited to discussing and following up cHAMs. The waiting time between two discussions (due to computer operations and the reading of interfaces) was the main restriction in workshops involving VAMs and more incidentally HyAMs and cHAMs. Similarly, the large number of parameters to be analysed was also a restriction in VAMs for this criterion.

Help in interacting with others

The simulations tools each promoted interactions between participants (and indirectly with stakeholders outside the workshop) in their own way. They helped to build relationships with others (sometimes by reducing tensions between actors or by giving the weakest players a voice in discussions) and increased the opportunities for interacting. In the case of role-playing games and HyAMs, this involved gaming. In the case of VAMs, an explanation of the interactions between agents helped in establishing relationships between individuals. As role-playing games distanced participants from reality, it also allowed them to interact on aspects of the system that are difficult to state in public, such as corruption, for example. According to participants, the contribution made by simulation tools was to create a cooperative spirit within the group; they were seen as catalysts for triggering group decisions.

However, the use of VAMs and, to a lesser extent, computerized role-playing games, resulted in some participants withdrawing in certain cases due to the inflexibility of these models. These cases were particularly apparent when players disagreed with the simulation results or found they did not reflect their opinions (sometimes resulting in frustration, exclusion and even guilt). This could be avoided if it was possible for participants to change the game rules in an HAM tool. The lack of discussion time in the case of computer models was also cited as an obstacle to interaction.

Changing perceptions

Although this was not the case most often quoted, the effect on changing perceptions was considered to be one of the strengths of all the simulation tools, whatever their implementation mode. It can be noted that what distinguished the HAM and cHAM tools was that participants mentioned fewer restrictions on change in perceptions than for the other two tools. In the case of VAMs, while spatial interfaces were generally welcomed, some

[2] Due consideration should be given to the low number of responses in assessing the quantitative results in the case of HyAMs.

participants did mention a certain mistrust with regard to the overly persuasive visual outputs, saying that they could arguably bias their judgement.

Changing practices

Changing practices was the effect least often cited as a strength in simulation tools. In view of the results, it appeared that changes in practices were more often initiated in the case of workshops involving role-playing games. However, the little information available on this criterion was not sufficient to confirm this assumption. In addition, participants often stated their intention to change practices during meetings subsequent to simulation workshops (or repeated simulation workshops).

Ability to encourage thinking about the system and its future

Chapter 3 provides a reminder that, in the context of companion modelling, the validity of a model, as conventionally defined, is of little interest and it is better to assess its ability to stimulate user thinking and encourage creative action in relation to the issue involved. For this purpose, the simulation tool must be able to connect with reality; not by conforming reality but rather by producing results that make sense in relation to this reality. For this reason, the perception the participants have of the link between the simulation tool and reality is also taken into account in this section.

The assessments of workshops involving HAM or cHAM tools clearly indicated that these tools make participants think about the system represented. Similarly, the exploratory scenarios proposed by participants showed that the tool helped to stimulate their imagination and creative action. In addition, as the participants were generally able to identify the differences between the model and reality, this increased the model's legitimacy. However, some participants found the model too simple or thought that it ignored certain processes or options they considered to be important. These criticisms were encouraging to some extent because they showed that the participants were able to identify the limitations of the model. However, they also pointed to a weakness in such tools, namely that they do not always provide a grasp of the full complexity of a situation. Sometimes role-playing games may also not be well accepted by groups of participants. This may happen, for example, when hierarchic relationships exist between the different groups of participants. This dichotomy was clearly expressed in case study 24 (see Chapter 6), where some representatives of government agencies considered it was not normal to 'play' with serious issues, while the representatives of local communities found this quite natural.

HyAM tools have the same characteristics as the previous two tools, but differ somewhat with regard to their link with reality. These tools are based on agents, part of whose behaviour is controlled by the computer. Participants may sometimes place blind trust in the decisions of computerized agents without questioning their validity. This difficulty in challenging the actions carried out by the computer on agents is a recurring problem of VAMs. In addition, the understanding of difficulties related to these tools and their inflexibility may limit the model's legitimacy in the eyes of participants. In many case studies, the legitimacy of the VAM was thus acquired either by jointly building the model with participants (e.g. during workshops involving the ARDI method) or through a third party, who was neither a designer nor a stakeholder in the system represented, and who provided expertise in assessing the VAM.

Meanwhile, VAM tools showed a clear advantage over other simulation tools, namely the ability to provide a large number of exploratory scenarios easily in a short time (compared with other tools). This specificity, made possible by computerization, means that when the restrictions connected with its use are overcome, the VAM proved to be a particularly effective tool in encouraging participants to think about the functioning of the represented system and its future. For this reason, VAMs were used in many case studies following a role-playing game based on the same conceptual model. A role-playing game facilitated understanding of the conceptual model and the VAM tool allowed participants to explore a whole range of scenarios.

The construction of diagrams as seen by participants

According to the data gathered, the technological diversity found in diagram construction methods does not seem to influence the perception that participants have of these tools. This section thus presents the results for these tools as a whole, while making a distinction in some parts between the types of formalisms used.

Ergonomic design

The construction of diagrams was not perceived as being much 'fun'. Its advantage, however, was that it did not keep participants waiting.

According to participants, the construction of diagrams did not really pose any problems of understanding, except that they had to learn the semantics involved. They may be of varying complexity depending on the formalism adopted. Participants in UML diagram construction workshops thus mentioned the high initial transaction cost due to the learning of the formalism. The graphic nature of the diagrams can facilitate understanding and there are many textbooks on learning formalisms aimed at audiences of different levels. In most applications, the workshop facilitators chose a diagram formalism whose complexity was appropriate for the audience.

The diagram construction tool was, in many cases, paper and pencil or a marker board on which participants draw by hand. Boxes, arrows or text then only had to be added or deleted to change the diagram contents. When the construction tool was a graphics software program, participants did not view it as being any less user friendly than the previous case.

Effects of the construction of diagrams as perceived by participants

Figure 7.3 shows in quantitative terms (using the same method as in Figure 7.2) the analysis results of the ADD-ComMod project assessment on the diagram construction effects.

The workshops that involved the construction of diagrams were primarily seen as discussion forums between the participants (and across disciplines when specialists from various disciplines attended). This generated a group impetus that promotes interaction among participants. The explanation of the interactions between agents provided by the construction of diagrams helped in establishing relationships between individuals. However, the long and sometimes tedious design of the diagrams was felt by some participants as restricting communication between them (e.g. lack of time for discussion, difficulty of seeing things with hindsight).

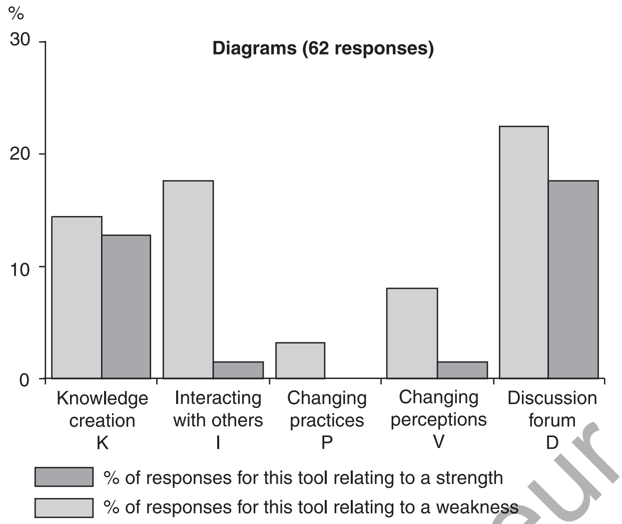


Figure 7.3. Diagram construction effects according to the workshop participants assessed by the ADD-ComMod project.

The creation of knowledge is one of the strengths of constructing diagrams. Compared with other tools, it works differently, since it is a joint conception process for sharing, reorganizing and consolidating knowledge. However, the participants in these workshops deplored the inability of the tool to be interpreted for prospective purposes. In addition, the construction of diagrams, when carried out with subject specialists from different backgrounds, tended to change disciplinary perceptions. It was less clear when carried out with local stakeholders of the systems represented. Moreover, it did not show any effects on practices.

Ability to encourage thinking

The question of the tool's ability is somewhat different in the case of the construction of diagrams as it is often a design exercise carried out before the development of a simulation tool. The assessment criterion is then more about the tool's capacity to clarify the modelling assumptions, and diagrams do this effectively. In addition, the construction of diagrams can also prompt participants to think about the reality and stimulate creative action. However, it is a presentation mode more suited to thinking about the way the system works rather than about its future.

Tools for producing spatial representations

Tools for producing spatial representations show a wide range of technological diversity and a wide variety of spatial representation formalisms. Those used in companion modelling are no exception to this rule. In this section, we take some of this diversity into account by adopting four main types of tools for the analysis (Figure 7.4).

– Manual mapping of land use and land cover. This was achieved by the participants using paper and pencil or a marker board. It generally described land use and located the various system entities in space. In almost half the cases, the maps produced in companion modelling used a space grid that imitates the raster mode, which can be then imported in an agent-based spatial simulation or a GIS.

– Mapping of waterflows. The diagrams produced generally represented the hydrographic or hydraulic network of the territory studied in the form of links (river sections) and nodes (network confluences or inlets/outlets). It goes without saying that this type of tool was only used in applications where water is one of the system's important resources.

– Participatory 3D-modelling (which produces terrain mockups). This technique was usually used in case studies where the relief of the terrain affects the actions taken by the players. The production of the model with participants could then explain the relationships between relief and practices. In all the case studies listed here, the model produced was also then used as a game board for a role-playing game.

– GISs are the only spatial representation production tools directly involving the use of computers. Spatial representations are produced in raster or vector mode and are generally used to describe land use and land cover and to locate entities as in the case of manual mapping. In contrast to the latter, however, a GIS can overlap various layers of spatial information and is provided with sophisticated spatial analysis tools. The maps produced by GIS are often used later for producing computerized space media for simulation tools. Figure 7.4 shows that in almost half the cases, GIS was used. Yet, while the three other types of tools systematically involved participants in the production of spatial representation, the use of GIS was not always participatory. The dataset used did not allow distinguishing between participatory GIS and non-participatory GIS.

As the assessments of the ADD-ComMod project did not produce a sufficient amount of data about these tools, their analysis was supplemented by information from the literature.

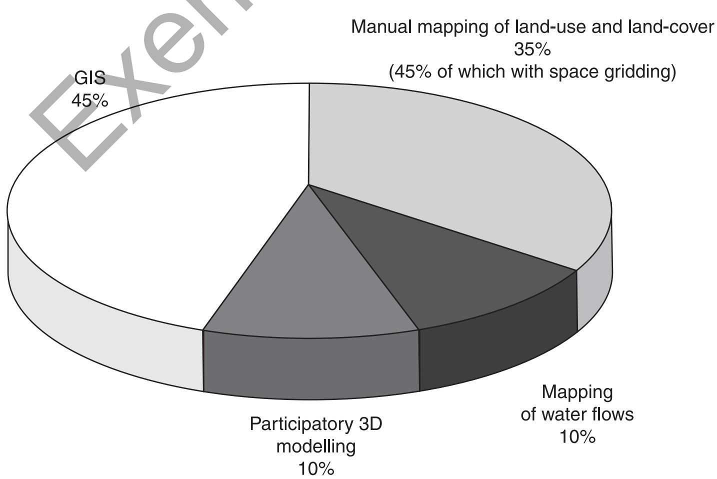


Figure 7.4. Spatial representation production tools used during case studies in the ADD-ComMod project.

Tool ergonomic design

Manual mapping is relatively easy to understand and very user friendly. In this regard, Chambers (2006) wrote: 'the versatility and power of participatory mapping, the relative ease with which it can be facilitated, the fun, fulfilment and pride which people derive from it, and its multiple uses by so many stakeholders, have helped it to spread more than the others [other participatory rural appraisal methods]'.

He also indicates that 'flow diagramming' is just as ergonomic but more restricted in its use. Participants in a workshop assessed in the ADD-ComMod project indicated that the map was often interpreted differently from one participant to another, according to their own knowledge and experience.

In most cases (and unless prior training is given in such tools), the participatory use of GIS with local stakeholders calls for the presence of a facilitator who operates the computer software in response to requests from participants. As indicated by Chambers (2006), there is then a high risk of stakeholders being marginalized due to the attitude and behaviour of the facilitator who, through his skills in GIS technology, partially controls the production of the map. Participatory 3D-modelling is a relatively long exercise that can take several days. However, the elevation model, the high accuracy of these models and the ease in interpreting and understanding the mapping information they provide (Rambaldi and Callosa-Tarr, 2000), are sometimes worth the time and effort involved.

Effects of producing spatial representations

The primary effects of producing spatial representations are to allow the creation of a forum for discussions between participants and the creation of knowledge. The low-tech aspect of manual mapping and flow diagramming allows the greatest participation, as each participant can hold the pencil in turn. Producing 3D terrain models is more exclusive as it calls for proficiency in the process and the help of a facilitator. The omnipresence of the facilitator in participatory GISs means that these tools are the least suited to the creation of a discussion forum.

The creation of knowledge in the case of GIS is inherent in the process involved in the spatial representation joint construction and in reorganizing and consolidating the knowledge of participants. Although participatory GIS is the tool for gathering as much knowledge as possible, the quantity of information is sometimes detrimental to the creation of knowledge.

Link between spatial representation and reality

The ability of all these tools to provide a link between the spatial model produced and the actual space is undeniable. Spatial representations provide participants with outside world cues. The level of abstraction differs from one formalism to another, with chorems being the most abstract and 3D terrain models at the other end of the scale. Representing shapes in raster mode may seem more abstract than in vector mode and depends on the pixel size used. Yet, Barnaud and colleagues described three case studies involving the use of role-playing games where the game board had a different level of abstraction (Barnaud *et al.*, 2006b). In all three cases, players could easily establish the link with reality and the abstraction level did not seem to have affected this criterion.

Implications for the ComMod processes

The analysis, primarily focused on the results of the assessments of the ADD-ComMod project, enabled the participants' perception of the tools used in participatory workshops to be characterized. This section examines the implications of these results for companion modelling focusing in particular on the complementarity and the combination of tools and their possible transferability. We conclude by presenting analysis tools that are used more rarely in the companion modelling approach, such as the participatory video, 3D-visualization or pseudocode language.

Complementarity and combinations of tools based on their perception by participants

It is clear from our analysis that VAMs should be intended more for exploring scenarios (in particular, because of their simulation execution speed), while role-playing games (HAMs and cHAMs) were perceived as more appropriate for creating a discussion forum. The later also provided useful opportunities for help in interacting with others. While intermediate HyAMs allowed interaction with others through role-playing games, waiting times were sometimes detrimental to the creation of a discussion forum. Their use, which is still rare, did not make it possible to go any further in terms of recommendations. Participants in workshops involving HAMs, cHAMs or HyAMs said that they had a good understanding of the tool. This played a positive role in creating knowledge through the use of these tools and for changing perceptions, which are both key criteria in the ComMod approach.

The main drawback of VAMs lies in their difficulty in being understood by participants, either because of the technical knowledge required or because there is too much information to be processed. This restriction, and the relatively long waiting times due to computer operations and, to a lesser extent, the tool's flexibility, is detrimental to the creation of knowledge and to facilitating discussions and interaction between participants. However, the case studies involving VAMs analysed in the ADD-ComMod project mostly included only one (or two) simulation workshops with the same participants for a given model[3]. A parallel experiment involved the setting up of a different protocol, whereby computer simulation workshops were repeated with the same participants using the same model being made somewhat more complex in each workshop (Becu *et al.*, 2008). The results showed that after three sessions, most participants had acquired a sufficient understanding of the model to overcome any barriers to knowledge creation and the creation of a discussion forum.

It should also be noted that our analysis showed that computer interfaces (including spatial interfaces) seem to have a persuasive appeal to participants, which could be detrimental to the objectivity of their judgements.

The specific features of simulation tools with, on the one hand, fully computerized tools that are difficult to understand but which have a high potential for exploring scenarios and, on the other hand, highly ergonomic role-playing games promoting discussions between participants, demonstrate the complementary of these tools and that their combined use can be particularly useful. Researchers who make use of companion

[3] The workshops were repeated up to *n* times, but with different participants each time.

modelling have understood this well. In many applications, VAMs are used following on from a role-playing game based on the same conceptual model. Role-playing games facilitate understanding of the conceptual model, and the VAM allows participants to explore a whole range of scenarios. If the exploratory simulation is an important aspect in the approach, such a combination should be promoted. If the objective is to facilitate discussions and interactions between stakeholders, however, role-playing games may be sufficient.

The construction of diagrams is clearly a design tool promoting the creation and sharing of knowledge. It is also relevant for facilitating discussions and establishing relationships between individuals, as it clarifies the interactions between agents. The relative complexity of the formalism of some diagrams (in particular, the UML formalism) may be an obstacle to participants' understanding of the tool; a formalism appropriate to the specific audience should then be chosen. Diagram construction workshops are thus highly complementary to simulation tools and may be usefully combined with VAMs to explain their contents and thus correct their defects.

Spatial representation production tools allow the creation of a forum for discussions between participants and the creation of knowledge. In companion modelling, however, the main advantage of these tools lies in the construction of a space medium used as a game board or computerized spatial interface for a simulation tool. The ergonomic design of the tool is largely due to the technology used. Chambers (2006) moreover indicated that the more the technologies that are difficult to understand and use are involved, the greater the likelihood of some participants being marginalized and other participants, who have a better grasp of the tool, tending to monopolize it and regard it as a source of pride and empowerment. This is also true for tools other than spatial representation production tools. In some socio-political contexts, the type of technology used to represent space is an important parameter to be taken into account according to the type of stakeholders involved. So in an application in a catchment area in northern Thailand, Promburom and Bousquet (2008) used GIS with government institutions and policy-makers, since such actors were more receptive to this type of technology. On the other hand, when workshop participants were farmers from the catchment area, the use of two-dimensional game boards was preferred.

Transferability of tools according to participants

In the previous chapter, it was seen that in 14 cases, some participants expressed the desire to continue the ComMod approach in the same territory or in new situations. In most ComMod approaches, however, the tools are not transferred. In the approach cases carried out, this request could have had a wide range of objectives such as, for example:
– to broaden the participant audience by repeating the approach, which often calls for knowledge of how to tailor the tools accordingly
– to broaden the feedback audience in handling not only the results but also the tools; this is particularly the case when these tools are used for teaching purposes
– to continue the approach without the logistic support of the initial modeller(s).

Depending on the objective sought, the methodological and ethical issues raised by such a transfer, vary. What is transferred exactly, the tools, the ability to build them or the ability to use them in a given companion approach? Should tools be transferred without the approach? Who should they be transferred to and with what consequences? Which resources are provided for this transfer (these transfers)? These issues in part give rise to problems in learning (Chapter 9), involvement in local power games (Chapter 5) and participant 'outscaling' (discussed in Chapter 10).

Although few participants raised this issue in the assessments of the ADD-ComMod project, their remarks showed that they do not feel they have the ability to be autonomous in coordinating a workshop based on the same tools. The more complex the formalisms used, the more conclusive this was, as seen in the case of cHAMs and even more so for VAMs. However, specific coordination capabilities also were often mentioned in the case of VAMs. Past experiments also showed that if tools are transferred, such transfers should be considered as far upstream as possible of the project, firstly, to allow go-between individuals to be trained in the process[4], and secondly, to assess the potential impact of such go-betweens in better preparing for the transition with all the participants in the approach (this aspect comes under the general principle of transparency of project supervisors with regard to their approach). In addition, computer-based tools call for constant updating to ensure compatibility with operating systems and constantly changing modelling software (Meadows, 2001).

Other tools used in companion modelling

Computer programming tools are also sometimes used directly with the actors. The primary tool in this case is pseudocode. Although it is written in terms based on natural language, pseudocode often seems somewhat obscure to participants and a certain learning curve is involved. When compared with graphic diagrams, its written form does not facilitate its reading. Due to its lack of user friendliness, pseudocode is generally not intended to be handled directly by participants. Workshops using this tool generally include a modeller or computer specialist whose role is to translate natural language (participant proposals) into pseudocode.

It happens that in some applications, stakeholders ask for highly realistic spatial representation as a basis for discussion, without being either too technologically sophisticated or too costly in terms of development time. 3D-visualization can be a good compromise. This tool is complementary to simulation tools and comes after the definition of prospective scenarios on resources and landscape evolution. When a scenario is established with the participants, the future state of resources and landscape is imported in a GIS, which is then used to produce a 3D-cinematography. Endusers can then use the 3D-visualization tool to fly over the virtual landscape and zoom to specific areas that they need to analyse in detail for the consequences of the various scenarios. This tool is especially efficient in creating a discussion forum between participants about natural resources and landscape evolution issues in mountainous areas (Gibon *et al.*, 2004).

Other approaches using participatory video involve supporting local actors in the joint construction of audiovisual tools designed to model a problem affecting them. The making of videos, used as intermediate objects in the participant network, is a pretext for promoting discussion and moving forward as a group towards a shared representation of the situation. There is a wide range of participation procedures that involve the distribution of production functions (Colin and Petit, 2008; Shaw and Robertson, 1997).

[4] The training issue is, however, hampered because stakeholders usually do not have the time to learn a formalism (Meadows, 2001).

The descriptive strength of the images illustrating or complementing the audio content explains why videos are often considered by participants as providing objective proof. In addition, the oral nature of the message (accessibility) and the reproducibility of the medium (mass distribution) make it a powerful mouthpiece (Lunch and Lunch, 2006). Finally, the use of interviews can contribute to public legitimization of the views expressed (and thus alter the relative weights of the stakeholders in the local system), reinforce the value given to the video content and encourage the involvement of participants in its design.

While participatory videos do not provide for prospective simulation, their viewing does, however, promote the implementation of thought-provoking work (mirror video), or introspective work (Langlois, 1995). Within the network, it thus makes it easier to view with hindsight the rhetoric of individuals and the interactions of players. This seems essential for the group recognition of the coexistence of different action rationales.

The participatory video can also create new discussion forums, both real and virtual (Colin and Petit, 2008), giving rise to interactions between stakeholders when previously any communication seemed impossible for social reasons or geographical remoteness. It thus facilitates reconciliation and broadening of the network of participants (Snowden, 1984).

It should be finally noted that the fun side of this approach is not unrelated to the success of participatory video approaches on the ground. Indeed, in areas where there is an overabundance of research or development aid work, the implementation of these innovative solutions often provides new impetus for actions with local stakeholders (Colin and Petit, 2008; Dagron, 2001).