Bringing together diverging system perspectives: The utility of transdisciplinary scenario analysis

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Abstract: *This paper studies the issue of integration of expert and farmers knowledge. It adapts the method of scenario analysis to obtain a common system view between experts and farmers in Vereda la Hoya, Colombia. Within the transdisciplinary approach taken, we discuss the following theses regarding knowledge integration: (i) the formative scenario analysis allows for integrating knowledge of people with different educational backgrounds such as farmers and experts; (ii) knowledge integration can only be achieved if an atmosphere of "equality" can be created between the people; (iii) clear responsibilities and roles between researchers and non-researchers support the integration process.*

Keywords: *System analysis, stakeholders, farmers, experts, mental models, integration*

Introduction

In the past decades significant research efforts have been made in analyzing why smallholders respond to development interventions the way they do, that is why interventions are often not as successful as expected and often not sustainable (Abdulai and Binder, 2006; Hellin and Schrader, 2003; 1999). Within these efforts three major research fields can be identified. The first analyzes which farmers' characteristics or factors lead to a successful intervention. The second focuses on the interventions themselves and investigates how interventions have to be designed in order to be successful. The third research field studies the differences in the mental models between "experts" who design the intervention and farmers who are intervened upon.

In the research performed on farmers' characteristics, most of the studies agree that land tenure, access to credit, and technical assistance are critical factors for the adoption of more sustainable technologies or behaviors (see also Walters et al., 1999). In particular, studies of adoption or non-adoption of slash and burn technologies have shown that economic reasons (i.e. cheap technology and low necessity for use of pesticides (Abdulai and Binder, 2006; Ketterings et al., 2002), land tenure (Abdulai and Binder, 2006; Larson and Bromley, 1990; Schnuck et al., 2002), technical assistance (Abdulai and Binder, 2006; Schnuck et al., 2002); as well as access to credit and off-farm income (Abdulai and Binder, 2006)), play an important role for the adoption decision. Research on adoption of land improvement technologies (Walters et al., 1999), such as tree planting, has additionally stressed the impact of social organizations and institutions (Tendler, 1993; Ostrom, 1990; Uphoff, 1986). Research on pesticide use has shown that land ownership, access to credit, and wealth are positively correlated with increased pesticide use (Rahman, 2003; Swinton and Escobar, 2003). Technical assistance was found relevant for an increased use of protection equipment.

The second research field focuses on the interventions themselves aiming at deriving indicators for classifying successful interventions. Most of the research has analyzed the effectiveness of soil and water conservation technologies (SWC). Hellings and Schrader (2003) differentiate between direct and indirect incentives. The first include cash payments for labor, grants, subsidies, and loans, as well as in kind payments such as food aid, agricultural implements, and seeds. The indirect incentives include enabling incentives (land security, market development, etc.), sectoral incentives (prices, tariffs, etc.), and macro-economic incentives (exchange rates, interest rates, etc.). Concerning direct incentives, in Nicaragua from 1984 to 1991, farmers received cash to stimulate the construction of infiltration ditches. During that time the total length of maintained ditches increased from about 4,000 in 1984 to 19,000 in 1991. After the payments had stopped, the number decreased to about 5,000 in 1996 (Hellin and Schrader, 2003). Similar results are found for other developing countries (Pretty and Shah, 1997). Pretty and Shah (1997) suggest that one reason for the failures is the paternalistic attitude of the entities intervening. This attitude "undermines sustainability goals and produces impacts which rarely persist once the project ceases" (Pretty and Shah, 1997)[1]. They also observed that in some cases the environmental degradation was higher after the intervention, due to abandonment of the technology, e.g. destruction of terraces. In some communities even a process of social disruption process was encountered.

The third field of research investigates the differences in definition and perception between experts and farmers. Walker et al. (1999) found that words and farmers definitions of agriculturally specific terms differed even across villages located within the same region in the Philippines. They attributed these differences to the historical evolution of traditions and experiences. Similar results have also been obtained with respect to soil characterization systems and soil management (Blaikie et al., 1997; Ericksen and Ardón, 2003; Müller-Böker, 1991; Ryder, 2003; WinklerPrins, 1999). Müller-Böker (1991), for example, found that local farmers in Nepal characterized and evaluated soil quality according to its agricultural relevance, while scientists would primarily focus on morphogeneric criteria. Abdulai and Binder (2006) showed for the case of Nicaragua that farmers' decisions on the amount of pesticides to be applied significantly depended on earlier managerial decisions taken, such as burning or not burning the crop residues on the field. Thus, farmers do have a specific system knowledge from which they draw their conclusions and in which they embed their decision-making. In the case of pesticide application, Palis et al. (2006) stress that farmers believes on the relationship between action and effect lead to underestimation of risk and inadequate protection. Schoell and Binder (2009) showed that differing risk perceptions and priorities among the various capitals of farmers' livelihood between experts and farmers might lead to misunderstandings and failure of the intervention. Feola and Binder (2010), additionally showed that social norms are a key factor affecting farmers' decision whether to use or not use protective equipment when applying pesticides.

Finally, research on soil sciences and pesticides suggests (Binder and Schoell, 2010; Blaikie et al., 1997; Ericksen and Ardón, 2003; Müller-Böker, 1991; Ryder, 2003; Schoell and Binder, 2009a; Schoell and Binder, 2009b; WinklerPrins, 1999), that an understanding of the differences between farmers and experts view, as well as the creating of a common system understanding and vision is needed for developing a communication strategy for improving the sustainability of interventions.

The goal of this paper is to show how different views of experts and farmers can be brought together. We suggest that a transdisciplinary process utilizing the scenario methodology is an appropriate way for doing so. In doing so we address the following question:

How can stakeholders with different system perspectives brought together to create a common system understanding?

The following theses will be discussed:

1. The formative scenario analysis allows for integrating knowledge of people with different educational backgrounds such as farmers and experts.
2. Knowledge integration can only be achieved if an atmosphere of "equality" can be created between the people
3. Create clear responsibilities and roles

We present results from a case study in Vereda la Hoya, Boyaca, Colombia.

The rest of the paper is organized as follows: First we present the study area and the sample selected. Second, we present the main steps of the approach used, show the key results and the

[1] For more information and a review please consult (Pretty and Shah, 1997)

contribution of the selected procedure to knowledge integration. We will focus only on the system analysis, the first part of the scenario analysis.

Study area

The study area Vereda la Hoya, is located in the rural part of Tunja, the capital of the Departamento de Boyacá (Colombia). The main source of income is farming in minifundios (i.e., average farm size of 6.6 ha (POT, 2000, Buitrago et al., 2000)). The land use in the region is the following: crop production (e.g. potato and carrots) 40%, animal husbandry 25%, fallow land 33%, and forest 2%. The local climate permits two harvesting seasons a year. The typical rotation consists of 2-3 cycles of potato, 1-2 cycles of carrots, and 2-4 cycles of fallow land (Schoell and Binder, 2009).

The Formative Scenario Analysis

We adapted the method of Formative Scenario Analysis (Scholz and Tietje, 2002) to our conceptual framework, the local conditions, and cognitive capacities of the farmers in Vereda la Hoya. The Formative Scenario Analysis (FSA) is a scientific technique to construct well-defined sets of assumptions to gain insight into a situation and its potential development. It provides a script describing steps a team must take in response to the current state and possible future states of a case. Because of the strict procedure and a complex mathematical analysis, FSA leads to scenarios, which include a system understanding, and are consistent within the selected parameters (Scholz and Tietje, 2002; Wiek, 2001; Binder, 2003). The quality of the developed scenarios depends on the stakeholders involved and their knowledge about the region/case and its boundary conditions.

The scenario analysis was performed in three steps: (i) system analysis; (ii) scenario development; and (iii) backward planning, corresponding to the above-mentioned questions. In this paper we will address only the first step: system analysis.

Table 1: Sample for the mental model research and two workshop sessions performed (Schoell, 2010).

Year	**Method** **[# of participating farmers] / [# of participating experts]** Mental Model (MM) Interview	 Formative Scenario Analysis Work Shops
[2005]	Structured Mental Model Approach (SMMA) [10] / [13]	System Analysis and Impact Analysis [9*+2] / [7]

* = participated also in the SMMA

System analysis

For developing the system analysis we departed from the elements defining the different capitals (human, health, natural, physical) of farmers' livelihood which were elicited with the Structured Mental Model approach (Schoell and Binder, 2009a).

Step1: definition and selection of the relevant elements

Method. In the first step, the group was divided into three mixed sub-groups, each composed of at least 3 farmers and 3 experts. Each group had to develop a consensus definition of the elements. The participants were presented the name of the element and a photograph of this element for the study area (Table 2). To achieve as much as possible "equality" between experts and farmers, each of the participants was asked to only name catchwords related to the definition of the element. After having collected all the catchwords a consistent definition was formulated (Figure 1a). The definitions of the groups were then discussed in the plenary session and consolidated.

Table 2: Example of an element and its photographic representation (after Schoell and Binder, 2009a).

Element		Regional reference		Photograph
Religion	→	Visualization of religion in Vereda la Hoya	→	Communal church farmers go to 

Consequently the most relevant elements with respect to farmers' livelihood were determined. For doing so a simultaneous voting procedure with cards between 0 and 2 was performed. At a given point in time every person had to raise their card stating how relevant the element was for farmers' livelihood (Figure 1b).

Figure 1a: Definition of the elements.

Figure 1b: Voting procedure.

Results. A selection of the elements relevant for the study are presented in Table 3. The include **structural elements** such as tradition, market and education, **environmental elements** such as water, soil and forest and **action related elements** such as pesticide management, alimentation and harvest.

Table 1: Definition of the elements (selection).

Variable	**Definition**
Education	Education is a form of living; Includes obtaining knowledge for personal growth, and influencing the community by transmission of specific knowledge.
Tradition	Customs, myths, cultural values and crafts inherited and learned from our ancestors.
Pesticide management	Process or activity of applying the pesticides to control and prevent plagues and sicknesses. It is performed through recommendations and/or customs or traditions.
Soil	Environmental resource. Basis for agricultural production and animal husbandry.
Water	Necessary resource for all activities of life. Its economic value has not been recognized.
Market	Space where producers, middleman and consumers trade products, achieving an economic benefit (agricultural market)
Harvest	Productive system established to obtain a benefit.
Forest	Natural space and symbol of life, fundamental to maintain a equilibrium of the natural resources.
Housing	Place of shelter to share all types of relations. Basis for personal and family growth.

Discussion. When defining the elements, farmers tended to provide more holistic definitions then experts did. For example education was defined by farmers as a form of living, whereas experts originally just mentioned the years of education. At the end when the group presented the first definition in the plenary session it became evident that farmers' definition of education was regarded as being relevant and experts reflected on it. Finally, it was unanimously accepted. For most of the elements a coupled definition consolidating the view of farmers and experts was obtained.

Step 2: Impact matrix

Method. In the second step the participants were divided again into the same three mixed group and had to fill in each 2/3 of the impact matrix (Figure 2a). Thereby the participants had to rate the interaction between two elements as being non-existent (0), weak (1) or strong (2). Each interaction was questioned and voted on as described above. If consensus was obtained a short sentence explaining the relationship among the variables was asked from one participant and recorded. If no consensus was obtained, two participants with different opinions were asked to explain their vote. The explanation thereby always started with the farmer. After the discussion, the vote was repeated. If no consensus was obtained, the votes and arguments were recorded and compared afterwards with the results from the other groups.

Figure 2a: Explanation of the how to fill the matrix.

Figure 2b: Filled impact matrix.

Result. An example of a filled impact matrix is shown in Figure 2b.

Discussion. At the beginning it was difficult for farmers to accept that they were supposed to have their own opinion and that it was valid as much as the one of experts. They had to dare to raise their cards and be able to explain their vote. They had more difficulties than the experts, as farmers tend to have a more holistic view of the system and are not accustomed to dealing with disaggregated knowledge. Experts in contrast have fewer problems in analysing each of the relationships at a one by one basis. In the beginning, when having to explain their statements, farmers arguments showed that they had not yet completely understood the procedure. However, within the first 10 votes they got accustomed to the way of thinking and could argue at the same level as the experts. Furthermore, it has to be noted, that when we used the same methodology two years later, farmers were able to remember and relate to it.

Step 3: Analysis of the impact matrix

Method. In the third step the impact matrix was analyzed utilizing the software systaim (Tietje, 2002). The results gained usually include strength of each element as well as subsystems and feedback loops. Nine subsystems were selected which departed from different active variables within the system. These subsystems were selected by the scientists. The next day, again in mixed groups, farmers and experts had to describe and validate three subsystems and present the systemic explanation in front of the whole group.

Results. The *strongest elements* were tradition, education, and pesticide management. Tradition influenced the activities of the farmers as it consists of experienced knowledge that had been proven to be successful and therefore was repeatedly used by farmers. Additional insights were: (i) Structure and action are deeply interlinked, also in agents' perception. That is tradition, education and markets significantly influence farmers' behaviour but are also influenced by their behaviour. For example, farmers are influenced in their production decisions by market prices and at the same time, they influence the local markets prices (e.g. regional overproduction leads to decreasing prices in the local markets). (ii) Environmental conditions might constrain changes. For example, seasonal variations dictate the planting and harvesting periods, which could be slightly shifted if e.g. irrigation were available. Deforestation leads to changes in the microclimate which in turn affects the availability of water. Finally, overuse of pesticides might lead to a decrease of earthworms in the soil, lowering so the soil quality and affecting its productivity.

The *system graph* depicts the relationships between the system elements which were rated as large. It can be observed that the selected system elements are strongly interrelated. The subsystem analysis allows for a deeper understanding of selected parts of the system.

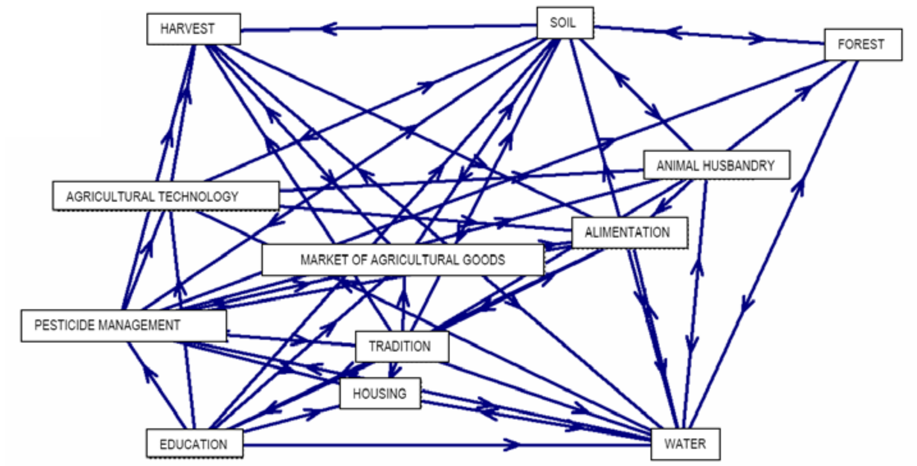

Figure 3: System graph.

Subsystem analysis

The scientists selected system loops departing from the active elements education, tradition and pesticide management. Figure 4 presents one subsystem composed of 5 elements departing from the element education. The explanation of one young farmer with respect to this feedback loop was the following: Young farmers are taught in school that they should treat water in a sound way. This includes having separate water containers for human consumption, animal consumption and pesticide mixing (Education→Water). Furthermore water should not be wasted. The water for pesticide mixing is in a different compartment and allows a variety of mixing and application procedures (Water→Pesticide management). If these activities are useful and successful and repeated several times they become tradition (pesticide management→Tradition). This tradition affects education in that the young farmers teach their parents with their success the new techniques and the parents themselves teach it to the next generation (Tradition→Education).

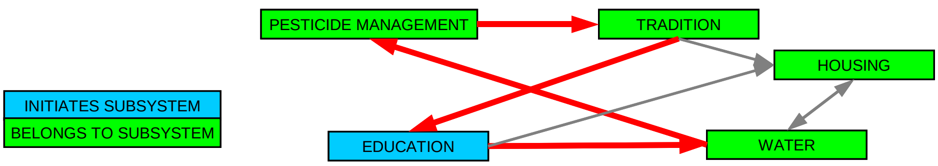

Figure 4: Subsystem graph.

Discussion. Experts were partly surprised of the outcome of the strength rating, where as farmer felt understood. The latter confirmed that the most important elements for their livelihood were tradition and education to grow and further develop on the one hand and pesticide management to obtain a save harvest on the other. The interconnectedness of all the system elements as depicted in figure 3, impressed all participants and left the conviction that only an integrative view would support the development in the area. When we analyzed the subsystems a new dynamic emerged. The farmers, who seemed to be less eloquent, explained experts how the system worked and how the different subsystem loops could be interpreted in relation to the study area. Experts on contrary stayed at the level of dual interactions and had more difficulties in seeing a story behind the sum of the interactions.

Feedback of the participants

After the workshop we asked participants to evaluate it. They reflect the learning process and mutual understanding process initiated during the workshop. Some opinions are cited below:

- …I have learned how our environment works and that most of the elements are related with each other (farmer)
- Working in groups…this approaches show that the system is rather complex… and it shows that there are possibilities for improvement… we learned that not only things are interrelated but that we can change them (expert)
- Group work led to knowledge integration – very important (expert/farmer)
- The ability and the will for change exist…this should be repeated in other communities (expert)
- We learned a lot… you are welcome for the next workshop- we want to continue improving ourselves (farmer)

Conclusions

1. The formative scenario analysis allows for integrating knowledge of people with different educational backgrounds such as farmers and experts. It allows for creating a common system understanding including the consideration of feedback loops and driving elements in the region.
2. Knowledge integration can only be achieved if an atmosphere of "equality" can be created between the people. The key difficulty is to balance the eloquence of experts having mostly university education with the limited ability to express ideas of farmers having maximal 3-5 years of education. The following approaches can support the creation of this "equality".
   - Use voting procedures rather than open discussions, so that the eloquence and the knowledge of experts can not dominate over farmers.
   - Have farmers and experts talk first with catchwords, rather then allowing long statements. This supports that farmers dare to talk and give short statements and utter their opinion.
   - Have always talk farmers first and then allow experts to comment on farmers' views.
3. Create clear responsibilities and roles
   - Measures for improving the livelihood in the region should aim at changes in structural factors in order to achieve a long-term change. As such also the need for clear roles and responsibilities is needed so that change can occur.

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