# Identifying barriers and opportunities for transitions towards more sustainable agriculture through system analysis. The case of Vereda La Hoya, Colombia

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**Abstract:** *The paper presents the results of studies which investigated farmers' reasoning and behaviour with regards to the mis-use of personal protective equipment and pesticide among smallholders in Colombia. First, the research approach is described. In particular, the structured mental models approach and the integrative agent-centred framework are presented. These approaches permit to understand the farmers' reasoning and behaviour in a system perspective. Second, the results are summarized. The methods adopted allowed not only for identifying the factors, but also the social dynamics influencing farmers. Finally, suggestions for interventions are provided, which are not limited to a technical fix, but address the underlying social causes of the problem.*

***Keywords:*** *pesticide use, personal protective equipment, sustainability transition, Structural Mental Model Approach, Integrative Agent-Centred framework, Colombia*

## Introduction

Potato is the crop with the highest demand for fungicides and insecticides in Colombia (MADR, 2006). The cultivation of potato is mainly located in the Andean regions of Boyacá, Cundinamarca and Nariño and carried out by smallholders (MADR, 2006). Smallholders in these regions often apply pesticide wearing insufficient or inappropriate personal protective equipment (PPE) (Cardenas et al., 2005; Feola and Binder, 2010). Moreover, they often tend to over- or mis-use pesticide, (MADR, 2006; Feola and Binder, in press).

Many studies suggest that, due to PPE and pesticide misuse, farmers in the region of Boyacá and their environment are likely to be exposed to a high level of risk (e.g. FMADR, 2004; Cardenas et al., 2005; Ospina et al., 2008). Therefore, while the use of crop protection products is considered unavoidable by farmers and experts in the region (Schoell and Binder, 2009a), a transition towards more sustainable agricultural practices, i.e. practices characterized by lower levels of health and environmental risk (FMADR, 2004). While previous studies have raised the issue of the risk related to pesticide use in the study region, a deeper understanding of farmers' behaviour is necessary to support the development of strategies to trigger such a transition.

The present paper reports the results of several studies conducted under the umbrella project „Reducing human health and environmental risks from pesticide use", carried out among smallholder potato producers in Vereda La Hoya, Boyacá Region, Colombia. The project aimed at assessing pesticide use-related risk and at identifying strategies for a transition towards more sustainable practices. The project was structured in three modules focussing on: i) farmers' reasoning and behaviour; ii) pesticide fate in the environment; iii) the integration of the first two modules into a simulation model for risk and sustainability assessment. The results presented here refer to the research conducted in the frame of the first module.

The goals of the paper are i) to present the methods and system approach applied to investigate farmers' reasoning and behaviour concerning pesticide use; and ii) to critically summarize the results of the different studies conducted, i.e. to describe specific conditions and social processes which

characterise the study area and their implications for a transition towards more sustainable agricultural practices.

## Study area

The study area consists of one *vereda* (community) called La Hoya located in the Department of Boyacá, on the eastern chain of the Colombian Andes. Vereda La Hoya ranges from 2,700 to 3,250 masl. over an area of 8.4 $km^2$ (840 ha), has an average temperature of 12°C, and a population of about 747 inhabitants. It is a rural region mainly dedicated to the cultivation of potato (MADR, 2006).

The production of potato in Vereda La Hoya relies mainly on smallholders, who cultivate an average of 3 hectares subdivided into different plots. The land is cultivated in two cycles a year (September to February and March to August). Average productivity rates are low and range between 15 and 17 Ton/ha (MADR, 2006).

Potato crops in this region are vulnerable to three major pests: the soil-dwelling larvae of the Andean weevil, the late blight fungus and the Guatemalan potato moth. To protect the crop from these pests, the use of chemical pesticides, in particular insecticides and fungicides, is widespread among smallholders (Feola and Binder, in press). The most common way of applying pesticide is by means of a lever-operated knapsack sprayer (20-25 litres), which is filled from a bigger tank, usually of about 200 litres, where the pesticide mix is prepared.

## Theoretical background

Pesticide use practices were studied according to the approach which proposes that agricultural systems have to be understood as complex social-ecological systems (e.g. Darnhofer et al., 2008). They are characterized by "non-equilibrium, dynamics, spatial, temporal and cultural variation, complexity and uncertainty" (Thompson et al., 2007). In such systems, sustainability itself should be regarded as a process in (temporary) equilibrium and not as a permanent system's state.

In order to guide agricultural systems towards sustainability, intervention strategies, i.e. on the issue of pesticide use, and appropriate (adaptive) governance have to be implemented at different institutional and spatial levels (Darnhofer et al., 2008). The effectiveness of such strategies depends not only on understanding the „hard", i.e. environmental and technical, components of the agricultural system, but also the „soft", i.e. social one (Woodhill and Röling, 1998; Binder, 2007).

Understanding the „soft" component of agricultural systems entails understanding, *verstehen* in Weber's terms (1978, see also Röling, 1997), the „why" of key agents' behaviour, i.e. pesticide use, in the agricultural system (Feola and Binder, 2009; unpublished), from which an unsustainable state of the system, i.e. loss of soil biodiversity and related ecosystem services, depends in last request. As showed by Feola and Binder (2009; unpublished) with reference to farmers' behaviour, such understanding has to be based on three pillars: i) an explicit and well-motivated behavioural theory; ii) an integrative approach; iii) feedback processes and dynamics. This permits to investigate on the one hand, the contribution of individual behaviour to the dynamics in the system and, on the other, the influences of the system on agents' behaviour. Most importantly, it permits to understand why a non sustainable practice, i.e. PPE misuse, might be the most sensible option for a farmer in a certain system. Thus, barriers and opportunities for transitions towards more sustainable practices can be identified and an effective governance of the agricultural system implemented.

## Projects' methods and procedures

The first module of the umbrella project „Reducing human health and environmental risks from pesticide use" was organized in two main research projects, addressing farmers' reasoning and behaviour respectively (Binder, 2005). In addition, three sub-projects were also carried out to

investigate selected aspects: farmers' risk perception (Baumberger, 2008), cooperatives of farmers (Oehler, 2008), and the potato market (Von Aesch, 2009) (Figure 1).

According to the theoretical background of the research, and despite specific research objectives and methodologies, the two main projects shared the same system approach. While the focus was on the farmers as key actors in the agricultural system and most exposed subjects to pesticide-related risks, both projects developed theoretical frameworks and methodologies which permitted to understand the farmers' reasoning and behaviour and their links to the context of their agricultural system. Thus, the two main projects complement and inform each other (Binder, 2005) (Figure 1).

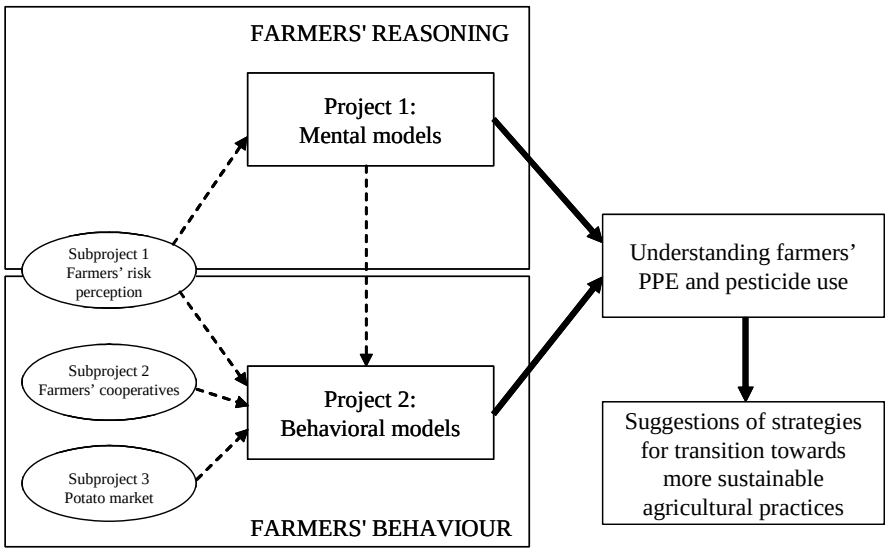


**Figure 1.** Project's complementarity.

## Project 1: mental models

The objective of this project was to derive and understand the reasoning behind the use of pesticides. As key part of this project the Structured Mental Model Approach (SMMA) (Binder and Schoell, 2010) was developed. The SMMA is a methodological approach aimed at understanding differences in mental models (MMs) between experts and farmers, regarding the risks farmers are confronted with. In the SMMA, the Sustainable Livelihood Framework (SLF) (DFID, 2001) is combined with the Mental Models Approach (MMA) (Morgan et al., 2002), and a theoretically grounded and structured approach obtained.

The SMMA combines concepts emerging from psychological cognition theories (Morgan et al., 2002) with socio-cultural theories (Giddens, 1984; Sen, 1989; DFID, 2001; Baumgartner et al., 2004). The SMMA provides thereby a systemic perspective for relating farmers' MMs to their livelihood, social structure, and decision-making. It depicts the factors influencing a farmer's mental model and consequently his/her decisions.

The SMMA's procedure consists of three steps: (i) definition and weighting of the different livelihood capitals; (ii) analysis of livelihood dynamics, and (iii) definition of the social capital by means of agent networks.

The SMMA was first used to derive and compare the perception of the present situation concerning risks of pesticide use of farmers and experts. The assumption was that farmers are constrained by economic, environmental and socio-cultural factors, which consequently influence farmers' MMs and makes farmers' MMs differ from the MMs of local experts (Schoell and Binder 2009a). Thirteen experts and ten farmers of Vereda La Hoya were interviewed with the SMMA in 2005 and their MMs of the extended pesticide system elicited.

To identify farmers' future visions concerning pesticide management, the future visions of farmers and experts were analysed by deriving MMs of the future (Schoell and Binder 2009b). To achieve this goal the SMMA was adapted to the future context (Future-SMMA). Ten farmers were interviewed in 2007 concerning their future perspectives and expectations which lead to farmers' future visions. Subsequently then experts were interviewed, also in 2007, about the feasibility and the consequences of farmers' future visions.

Farmers and experts were convened in two workshops to discuss present and future visions respectively. By combining experts' and farmers' perspectives an enlargement of common system understanding and a more holistic view of the problem resulted, which supports the development of policies concerning pesticide use on a clearer and more amply ground.

**Project 2: behavioural models**

This project aimed at understanding farmers' PPE misuse (Feola and Binder, 2010) and ineffective pesticide use (Feola and Binder, unpublished). The research was based on the Integrative Agent-Centred (IAC) framework (Feola and Binder, 2009; unpublished).

The IAC framework integrates and adapts Giddens' Structuration Theory (Giddens, 1984) and Triandis' Theory of Interpersonal Behaviour (Triandis, 1980). In the framework, an agent's (i.e. farmer) decision to enact a specific behaviour (e.g. PPE use) is influenced by external and internal drivers. The former consist of contextual factors (i.e. facilitating conditions or barriers), whereas the latter include habit (the frequency of past behaviour), physiological arousal (the physiological state of the individual) and intention. The latter is in determined by: i) expectations (the beliefs about the outcomes, their probability and their value), ii) subjective culture (social norms, roles and values) and iii) affect (the feelings associated with the act).

The behaviour can have intended or unintended and perceived or unperceived consequences, which can feed back to the farmers. Only the perceived consequences, which are reinterpreted by the agent, feed back directly to farmers by influencing intention, affect, habit and physiological arousal. The feedback processes can reinforce the current state or trigger change and can occur at different temporal levels. Agents' interactions happen either directly or indirectly. The former depend on the agents' social network. The latter happen through the consequences of behaviour, which can aggregate at the next higher hierarchical level, being perceived and reinterpreted by individual agents.

The IAC framework was used as a basis for compiling a structured questionnaire for data collection. Data concerning PPE and pesticide use were collected together. Based on a literature review, the IAC framework's components were operationalized in one or more variables. The questionnaire was structured in sections, each section corresponding to a component and containing one or more questions for each variable. A survey was conducted in September and October 2007, involving a total of 197 smallholder potato growers in the study region and three comparative areas.

The IAC framework also drove the data analysis, which was carried out with SPSS 14.0. First, a characterization of the PPE use and pesticide use patterns was carried out. Second, the influence of the different behavioural drivers on i) PPE use and ii) adoption of pesticide application pattern was investigated by adopting a binomial and a multinomial logistic regression approach respectively. This permitted to quantify the influences and feedbacks which were initially hypothesized as being relevant for farmers in the study area, and test their significance.

## Results and discussion

The different projects and sub-projects produced convergent results, thus providing a consistent understanding of farmers' PPE and pesticide use, and for this reason are presented here together.

**PPE use**

*Static factors influencing PPE use*

Farmers tended to misuse PPE (e.g. gloves, boots, goggles) for different concomitant factors (Feola and Binder, 2010). Farmers who perceived PPE as being interfering with their work (e.g. because uncomfortable), were less likely to protect themselves. On the contrary, farmers who had a higher sense of compliance with safety labels which are present on pesticide packages, were more likely to protect themselves, as well as farmers who usually carried out the pesticide application alone, i.e. who did not hired workers to help them in this task. In addition, older farmers tended to use less pieces of PPE or to use them less frequently. Interestingly, not all factors were found to be significantly influencing the use of all pieces of PPE. For example, the cost of the equipment was relevantly influencing the use of waterproof clothes such as overall, trousers or jacket, but not the use of gloves and facial protection. In addition, the strength of the factors' influence differed for the use of different pieces of PPE. For example, thinking that PPE interferes with the pesticide application work was found to influence the use of gloves much stronger than the use of facial protection, probably due to the fact that the former hinders handling and movement more than the latter.

Other factors, which were hypothesized as influencing PPE use, in fact proved not to be relevant. Among these there are the level of education, the cost of gloves and facial protection and the expectations about pesticide-related health effects. Concerning the latter, farmers were generally aware that pesticides are risky substances and that not wearing PPE may increase their health risks (Feola and Binder, 2010), although the knowledge about the pathways of exposure might be incorrect (Baumberger, 2008). However, this did not significantly influence PPE use. That is, farmers with good knowledge of exposure pathways did not necessarily activate a risk reducing behaviour (Baumberger, 2008).

*Social dynamics influencing PPE use*

In addition to the above mentioned static factors, two dynamics were also proved to be significantly influencing PPE misuse in the study area (Feola and Binder, 2010). First, farmers tended to conform to the descriptive social norm, i.e. to what they perceived to be the most diffused behaviour among their peers (Feola and Binder, 2010). In other words, they tended to "fill the gap" between individual and collective behaviour. This process of conformity to the descriptive social norm configures a reinforcing feedback between the individual and the collective behaviour, which locks the system into an undesirable situation (PPE misuse) and makes it rigid to change. The process of conformity may be motivated by the goal of maintaining a positive self-concept. In effect, the cultural definition of the role of farmer in the study area did not comprise personal protection as a priority or defining trait (Feola and Binder, 2010).

The second dynamic concerned farmers' health. Farmers tended to react to the pesticide-related adverse health effects: those who experienced such effects were more likely to use PPE or use it more often (Feola and Binder, 2010). However, this did not configure learning or habit formation. This suggests that the reaction (i.e. use of PPE) may last only in the short-term and may tend to be disregarded as soon as the problem loses relevance with time. Clearly, this configures a balancing feedback loop, in which the use of PPE makes the occurrence of health problems, therefore the sensitivity to the negative health effects lower, and consequently reduces also the probability to use PPE in the future. This also suggests that farmers have to directly observe consequences to activate a behaviour (i.e. „feedback on knowledge", Schoell and Binder, 2009a). In addition, it is important to note that farmers tended to accept a certain level of sickness as a "normal" consequence of their activity (Baumberger, 2008; Schoell and Binder, 2009a). That is, the concept of pesticide-related "sickness" is culturally defined, tending farmers to consider themselves healthy as long as they can continue working. In addition, farmers' social status partly relies on their image of healthy and strong men, and a widespread belief that men become resistant to pesticide was observed (Baumberger, 2008). These cultural features imply that i) farmers may tolerate a rather high level of pesticide-

related adverse health effects before activating a protective behaviour (i.e. use of PPE) and ii) that they may tend to shift back to a non-use of PPE to fit their cultural environment.

**Pesticide use**

*Boundary conditions for an effective pesticide use*

Pesticide use in the study area was positively contributing to agricultural productivity. However, many farmers were not using pesticide effectively, i.e. they were using a quantity of pesticide per hectare per cycle which was higher than the one needed to control damage from pests (Feola and Binder, in press). This was mainly to be related to the boundary conditions within which farmers were taking their crop protection decisions (Feola and Binder, in press). First, technical factors were found to influence pesticide use. In particular, farmers in the study area usually cultivated small parcels which were scattered in the region, which hindered the possibility to use the leftover pesticide in other parcels (Feola and Binder, in press). Farmers were also found to cultivate in great part a variety of potato, i.e. Ica Húila, which is one of the most vulnerable to pests (Feola and Binder, unpublished). The farmers' frequent choice for this variety, which is highly productive and also the most used by the food processing industry in Colombia, might indicate an attempt to maximize production, but also a strong influence of the market on smallholders (Von Aesch, 2009).

Farmers who perceived an increase pest resistance to pesticide tended to adopt highly intensive (and low input-effective) pesticide application patterns (Feola and Binder, in press), which again confirmed that farmers tried to activate reactive behaviour to what they observe in the natural system (Schoell and Binder, 2009a). It is important to note that this may also configure a reinforcing feedback process, with pest resistance actually increasing even more because of the increased pesticide dosage (pesticide treadmill).

Farmers who were associated in cooperatives were more likely to adopt highly effective pesticide application patterns (Feola and Binder, in press). Cooperatives seemed to bring positive effects in terms of input-effectiveness in pesticide use, with the lower productivity being probably compensated by more stable contracts with buyers and a higher power on the market. The higher effectiveness of associated farmers in pesticide use might also be related, as noted by Oehler (2008), to the increased access of these farmers to highly qualified and targeted training, to which non-organized farmers seldom have access.

*The influence of training on pesticide use*

Training has been proved to be a strongly influencing factor in pesticide use (Baumberger, 2008; Oehler, 2008; Schoell and Binder, 2009a and 2009b; Feola and Binder, in press). Farmers usually received training from two different types of subjects: pesticide producers and sellers, and governmental agencies. Only a minor part of the farmers had access to training provided by NGOs, and these were mainly farmers associated in cooperatives.

Farmers trained by pesticide producers and sellers were found to achieve a higher productivity, but a low input-effectiveness in pesticide use (Feola and Binder, in press). The influence of this type of training was found to be strong, thus confirming that these agents in the agricultural system have a privileged role of information providers which is highly valued by farmers (Baumberger, 2008; Schoell and Binder, 2009b).

Training by governmental agencies reached few farmers (Schoell and Binder, 2009b). Moreover, different agencies were found to intervene uncoordinatedly and conveying contradictory information to farmers, with the effect of farmers reinforcing their image of pesticide producers as most reliable source of information (Schoell and Binder, 2009b).

*Differences between farmers' and experts' mental models*

A key aspect which was found to undermine training provided by governmental agencies' training are the differences between farmers' and experts' mental models (MM) (Schoell and Binder, 2009a). MMs of farmers and experts were found to differ significantly from each other with respect to definition of and interaction among the livelihood capitals. That is, farmers and experts tended to have diverging system understandings, which are often mirrored by the use of a different vocabulary (e.g. the above mentioned definition of "sickness"). For example, farmers use words like "cure" and "poison" for differentiating different pesticides. While both may be ranked to be equally toxic, farmers will tend to underestimate the toxicity of "cure"-pesticides in contrast to "poison"-pesticides.

Future visions of farmers and experts were also found to differ significantly. First, farmers consider social and environmental threats optimistically, whereas experts visions were pessimistic. Second, future visions of farmers and experts were inconsistent with respect to the future development of the region, due to differing opinions about who should take responsibility for the knowledge management of farmers, i.e. the extension service or the farmers themselves (Schoell and Binder 2009b).

**Policy implications**

The adoption of protective measures and of sustainable agricultural practices are often considered problems to be solved through a „technical fix" (e.g. Woodhill and Röling, 1998). That is, technical solutions are identified and proposed to farmers by experts in order to reduce pesticide-related environmental and health risks. Education is often called for to complement the technical fix (e.g. FAO, 1997; Kishi, 2005). Thus, knowledge about new technology, its advantages and mode of use is transferred top-down from experts to farmers.

However, there is growing evidence of the failure of this „expert culture" (Woodhill and Röling, 1998) and of educational programs addressing pesticide and PPE use (Murray and Taylor, 2000; Kishi, 2005) also in the study region (Ospina et al., 2009). The results presented in this paper show an example of why such technological or social fix programs may fail in triggering a transition towards more sustainable practices. Agricultural practices, were embedded in social and social-ecological dynamics which make the system rigid to change. Therefore, more articulated strategies are needed to address the social dynamics influencing PPE and pesticide use in Vereda La Hoya.

*Educational programs*

This does not imply that technical improvements or educational programs cannot contribute to tackle specific issues with regards to PPE and pesticide use. On the contrary, concerning the area of Vereda La Hoya, for instance, a technical development in the materials by which different pieces of PPE are made could contribute in reducing the perceived interference of PPE, with a likely increase in the number of users of PPE (Feola and Binder, 2010).

Moreover, the results presented here have practical implications for the improvement of educational programs in the study region. First, risk communication is more effective if it is related to the whole system influencing the subjects' lives. Experts' understanding of the embedding of pesticide risks in farmers' livelihood may allow for developing strategies and options for change which consider farmers' priorities and viewpoints. Second, the additional sources of information found, like religion and tradition, should be considered when designing new educational programs. Third, the credibility of the informer has to be ensured by directly linking the information provided to experience, since farmers' knowledge is experimental more than abstract (Schoell and Binder, 2009a).

*Coordination of interventions and activation of a learning process*

However, although an educational program might contribute in tackling selected issues in Vereda La Hoya, the results presented in this paper do imply that more articulated strategies are needed to address the social dynamics influencing PPE and pesticide use.

There is a need for a better coordination among agencies providing technical assistance to the farmers, in order to avoid the provision of contradictory information and consequently increase farmers' trust in the information (Schoell and Binder, 2009b). There is also a need for an alignment of future visions not only among farmers, but also among farmers and experts (Schoell and Binder, 2009b). This entails going beyond conventional extension and towards the activation of a social learning process (Woodhill and Röling, 1998). In such a process, farmers are not simply the target of "objective" optimal solutions brought about through top-down educational programs, but active and participant learners. Experts are not simply producing and conveying knowledge, but as well learn about the "human factor" (i.e. farmers' goals) (Schoell, 2010), interact with farmers, and facilitate farmers' realization of their own responsibility (Schoell, 2010) and agency (Giddens, 1984 p.16).

*Diversification of intervention tools*

With reference to PPE use, diversification seems necessary in order to address the factors acting as barriers in the decision-making process. For example, the factors influencing the decision to use gloves differ from those influencing the decision to use facial protection. Thus, a set of diverse tools is more likely to yield good results (Feola and Binder, 2010).

*Addressing social dynamics*

Social structures, such as the descriptive social norm, should be addressed, this being essential in supporting a change at social level. Because structural factors are unlikely to change in the short-term, it seems essential to sustain the interventions in the medium- and long-term (Feola and Binder, 2010). This also implies that PPE misuse should be addressed collectively instead of individually. Individual farmers are unlikely to change their behaviour alone as the process of compliance with the descriptive social norm is so strongly related to farmers' personal protection choices (Feola and Binder, 2010). It has been demonstrated that the promotion of dialogue concerning pesticide issues may favor the process of social learning (Röling, 1997) and result in behavioural change (Yanggen et al., 2003). In addition, identifying active social networks and involving the "exceptional few", i.e. farmers who are particularly influential in the social community, might prove to be an effective strategy (Schoell and Binder, 2009a; Feola and Binder, 2010). These implications are not only valid for PPE, but also for pesticide use, since the analysis suggested that the dynamic of conformity with the descriptive social norm may also be active for this behaviour.

*The role of pesticide producers and sellers*

An additional implication for intervention on pesticide use is that pesticide producing companies and the pesticide sellers should be involved if changes in pesticide application types are to be achieved, since it seems clear that these actors play a crucial role in influencing farmers' crop protection choices (Feola and Binder, in press). Furthermore, cooperatives seem to bring positive effects in terms of input-effectiveness in pesticide use, with the lower productivity being probably compensated by more stable contracts with buyers and a higher power on the market (both for inputs and yield). In particular, cooperatives represent an institutional arrangement through which farmers can construct a shared social reality and activate learning processes. A support to local cooperatives could therefore result in a less intensive pesticide use (Feola and Binder, in press).

## Conclusions

The paper presented the results of several studies conducted under the umbrella project „Reducing human health and environmental risks from pesticide use“, carried out among smallholder potato producers in Vereda La Hoya, Colombia, and investigating farmers' reasoning and behaviour with regards to PPE and pesticide use. The different projects and sub-projects produced convergent results, thus providing a consistent understanding of farmers' PPE and pesticide use.

First, the research methods adopted were described. In particular it was shown that the Structured Mental Models approach and the Integrative Agent-Centred framework permit to understand the farmers' reasoning and behaviour and their links to the complex context represented by the agricultural system as they perceive it.

Second, the results of the studies were summarized. Concerning PPE use, it was shown how static factors, such as the workload or the sense of compliance with safety labels, strongly influence farmers' behaviour. Furthermore, it was shown that also two social dynamics, i.e. the conformity to the descriptive social norm and the reaction to pesticide-related adverse health effects, play a key role in determining the level of PPE use. Interestingly, farmers tended to accept a certain level of sickness as a "normal" consequence of their activity. That is, the concept of pesticide-related "sickness" was culturally defined.

Concerning pesticide use, it was shown that boundary conditions, such as the area cultivated or the membership in a cooperative, significantly influenced the level of pesticide use effectiveness. Furthermore the mostly negative influence of actual training programmes on pesticide use effectiveness and the existence of inconsistencies between farmers' and experts' mental models were underlined.

Third, policy implications were outlined. It was argued that educational programs, especially if improved so to conform to farmers' perception of the agricultural system, could play a role in fostering more sustainable PPE and pesticide use. However, it was also argued that there is a need in the study area to overcome the "technical fix" approach by devising more articulated strategies able i) to coordinate the work of different subjects operating in the field and, ii) to activate a true learning process among farmers and experts. Further, it was suggested that the diversification of the intervention tools, along with the targeting of the key social dynamics of conformity to social norm and social networking might facilitate a transition towards more sustainable practices. Finally, it was argued that the involvement of pesticide producers and sellers is essential to achieve such a transition.

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