The Qualitative Stage of Building Bayesian Belief Networks in a Focus Group Setting: Decision-Making under Uncertainty among Vietnamese Rice Farmers

Abstract

An innovative mixed-methods approach to exploratory focus group design is presented using a case study conducted with smallholder rice farmers in Vietnam. Understanding human decision-making under the uncertainties of a complex and changing social and environmental context requires a flexible yet structured and theoretically grounded approach. Using Bayesian Belief Networks as the architecture of our model allows the study to incorporate both qualitative and quantitative data, the former gathered at this stage in a participatory focus group setting and the latter to be collected in a subsequent survey. This framework further lends itself well to incorporating systematic behavioural approaches to decision-making analysis using Ajzen's theory of planned behaviour framework, a symbiosis that remains underexplored in the literature. The visual nature of the networks makes them easily accessible to participants and the proposed technical solutions to field implementation are flexible, inexpensive, and shown in practice to mitigate issues of co-moderating discussion across language barriers. The tools and methods described are transparent, reproducible in comparative contexts and transferable to a range of research topics and questions.

[word count: 9,324]

1 Introduction

The methodological challenges of research into human decision-making embedded in a complex web of social, political, economic and environmental factors require a flexible and interdisciplinary approach. While bespoke solutions may suffice, they often fail to integrate into a wider body of methodological literature that would allow them to be applied in other research contexts, replicated and be more rigorously evaluated. Using a case study investigating food security and the pest-management related decision-making behaviours of Vietnamese rice farmers we describe a methodological approach that is theoretically grounded in a robust mathematical framework, and extends the traditional focus-group data collection in a creative way allowing their easy integration in a mixed-methods research design.

The focus groups described here were designed specifically to elicit a structured narrative that allows us to understand the farmers' decision-making as a contextual behaviour, within the changing physical and social environment in which they take place. A focus on behaviours and how they are formed is achieved by using a socio-psychological understanding of behavioural intentions. These are connected systematically with a wider set of additional external factors using a Bayesian belief network framework. This approach solves a perennial issue that plagues the generation and analysis of data in a mixed-methods setup. Namely it provides a way to systematically integrate both qualitative and quantitative data within one overarching framework. This framework additionally - by design - incorporates the uncertainty that is endemic in all human decision-making endeavours.

A brief outline of the research project among Vietnamese rice farmers provides the context for the methodological toolkit elaborated in this paper. The relevance of this paper is in establishing our proposed methodology within this interdisciplinary study of decision-making and describing its practical application. The next section elaborates on the main theoretical and methodological motivations that inform and are integrated into our research design: taking a behaviourally informed approach to decision-making and the mathematically logical representation of interrelated variables within *Bayesian belief networks*, which allows the integration of both qualitative and quantitative knowledge domains. The section concludes by looking at the role of focus group discussions in the context of using activity-oriented questions and visual communication tools.

All of this combines in a data collection research design that uses participant generated graphical representations within a focus group setting. We describe the practical implementation of the first—qualitative—stage of data collection needed in this two stage design. The fieldwork was carried out in Vietnam and we provide detailed instructions for the materials and facilitation guides. The suitability of this approach is discussed with a view of its application in other domains as well as some issues that arose in practice.

2 The Interdisciplinary Project

The interdisciplinary project *Implications for food production of adaptation to environmental change with an ageing agricultural sector: a case study of changing pest environments in Vietnam* combines the expertise of demographers, geographers, sociologists and population biologists to address two key elements of the food security debate: the role of environmental change, climate and insect, and the structure of the farming population, age and gender. It is interdisciplinary in combining the expertise from the different disciplines to create new instruments, models, and approaches that would not be developed if they were separately handled.

The defining research question addresses the growing need to move to modern adaptive methods of farming in order to address the changing climatic and pest environment at a time when the farming population is ageing. Of particular importance is the need to collect, assemble and model sound data on i) the consequences of climate and land use change on pests and diseases; ii) the contribution to global agriculture by small scale farmers vulnerable to such pest impact; iii) the age, gender and socio-economic profile of farmers and their ability to adapt. We hypothesise that the ageing of the rice farmer population and its concomitant feminisation will fundamentally affect food production by smallholders. Age, gender as well as educational attainment are assumed to be some of the important determinants of how people gauge risk, take account of their previous experience and react to new information.

The specific research focus for this paper is the farmers' decision-making process related to the use or non-use of pesticides and other pest management measures, and its determinants within a changing and uncertain environment. Our aim is to understand and then model farmer decision-making and the manner in which these might change in light of predicted future demographic developments. Stage one of the project comprised a full literature review which suggested that in addition to demographic, socio-economic and

environmental characteristics, key variables include farmers' past experience, social networks and knowledge; economic factors such as disposable income and access to lending and institutional factors such as government mandates, and access to pesticides. One rationale for selecting Vietnam as our case study was that the commune system reduced the variability in institutional factors. The first fieldwork stage comprised focus groups to collect a rich tapestry of qualitative data. These groups were also the tool for the development of the Bayesian belief networks which we describe here. The second period of field work comprises a quantitative survey, which both explores the various hypothesises generated through the focus groups, and enables the collection of quantitative data which will allow us to arrive at the conditional probability tables described by the BBN.

[Figure 1 about here]

Figure 1 was a first attempt at outlining the decision-making context we are interested in (not all possible connections are drawn on this schematic illustration). The complexity of the scheme mirrors the complexity within which farmers are making their decisions, and presents the researchers with the puzzle of disentangling the importance of different factors and their mutual interactions. In the context of interdisciplinarity the proposed research design is thus exploratory in nature. Its design involved fieldwork to establish the stakeholders' views, factors which influenced these, and importantly their feelings of control. The methodological solutions developed for this research question, and reported on in this paper, are transferable to analogous research questions dealing with human decision-making within a complex socio-environmental system.

3 Review of theoretical and methodological motivations

This project is not unique in requiring an interdisciplinary approach to studying a complex system of human and physical interactions. Our requirements are for an exploratory approach that is capable of integrating both the discursive complexity and contextual nature of behavioural data with an analytically robust and quantifiable framework.

In the exploratory stage, the data collection should be flexible in allowing the participants or stakeholders to establish the relevant parameters of their decision-making context, while minimising the researchers' preconceived notions of the relevance of specific

factors. Focus groups were thus chosen as the method of data collection. Insights were then formalised in a manner allowing the outcomes to be integrated into the second, quantitative stage of the project. *Bayesian Belief Networks* provide this framework, as explained below, and are crucial in integrating the multiple knowledge domains being investigated (for an excellent overview of other participatory modelling approaches see Voinov et al., 2010).

3.1 Behavioural approach to decision-making research

At the same time a systematic understanding of how human behaviours are shaped should underlie how this integration is accomplished. While the theory of planned behaviour does not frame the main study, it was felt that it was a key theoretical stance which would support our development of the BBN component of the project. We here outline these theoretical, conceptual and methodological approaches, before describing their integration through the focus group design used to analyse pest management decision-making by Vietnamese farmers.

The importance of taking a *behaviourally informed perspective* to human decision-making has been well understood across social disciplines including geography, economics and sociology, as well as specifically, if contentiously, in agricultural studies (Morris et al., 1995). This approach can be seen as a reaction to the utility-maximising *Homo economicus* model of the human decision-maker postulated by rational choice theory, and the contribution psychological theories as well as empirical research have made to discrediting the model as an explanation of observed human behaviour (Simon, 1956). Instead of treating farmers as optimising agents, we try to explore their motives, values and attitudes and how these interact within the specific structural and economic contexts that they inhabit.

[Figure 2 about here]

This behavioural approach relies on there being a demonstrable link between people's attitudes and their behaviours, where the *intention* to perform the behaviour can be seen as the proximal cause, while at the same time being open to other factors influencing intentions as well (See Figure 2). The *theory of reasoned action* (TRA) (Fishbein et al., 1975), later extended into, and superseded by, the *theory of planned behaviour* (TPB) (Ajzen, 1985) provides a parsimonious yet comprehensible model of human action. It stipulates that a person's behavioural intention is the result of their (i) beliefs about the consequences of the

behaviour and how desirable they are, (ii) the expected reactions of their significant others to their behaviour and how important their approval is and (iii) the extent to which they see themselves as having volitional control or expect to encounter obstacles in performing their behaviour.

This model furthermore has the practical advantage of being easily operationalised, specifically there exist very clear and well tested guidelines on constructing quantitative questionnaires and their analysis (Ajzen, 2002). It has thus continued to be successfully used in a variety of fields from mobile learning behaviours in higher education (Cheon et al., 2012), recycling behaviours in the workplace (Greaves et al., 2013), HPV vaccination uptake (Gerend et al., 2012) or childbearing decision-making (Ajzen et al., 2013)[1]. In the context of agricultural studies it has however been argued, that the focus on *mechanistic methodologies* combined with the strong policy orientation of the field, and the high value it places on evaluation and numerical data, has meant that the behavioural approach has seen "limited theoretical development" (Morris et al., 2004; Burton, 2004). In practice this has meant researchers focusing only on the attitudinal component of behaviour, effectively ignoring the social and environmental context of people's actions. This socio-psychological critique argues for a reinvigoration of TPB with a greater integration of qualitative and quantitative approaches, with particular attention paid to the social influences and other external influences which farmers feel may interfere with their intentions (Burton, 2004).

3.2 Bayesian Belief Networks

Bayesian belief networks (BBNs) are probabilistic representations of the direct and indirect influences between a set of variables (Cooper, 1990)[2]. Developed in the 1980s (Pearl, 1985); they have found numerous applications in fields as diverse as artificial intelligence, medical diagnostics, forensic science, computational biology and environmental sciences. What these applications all have in common is that they deal with complex systems that incorporate at least some degree of uncertainty and BBNs are extremely well suited for this purpose (Pourret et al., 2008). That, and the fact that they neatly integrate qualitative and

[1] See Sniehotta et al. (2014) for recent critique of the theory, and Ajzen (2015) and Armitage (2015) for responses.

[2] They are variously also called Bayesian networks, belief networks, probabilistic causal networks, knowledge maps.

quantitative data, make them particularly suited for tackling complex multidisciplinary questions such as those attempted in the present case study.

A BBN is composed of two components: (i) the graph or the network of connected variables and (ii) a set conditional probability tables (CPTs), one for each node or variable, which describe the relationships between the variables. This maps neatly onto two distinct conceptual modes: (i) *qualitative*, representing the relevant factors and their causal connections and (ii) *quantitative*, describing the strength and direction of the relationships between the factors. Once both elements of a BBN have been established, the model provides a mathematically complete and parsimonious specification required for the inferential calculation of the probabilities of the outcome variable(s).

[Figure 3 about here]

While this paper is concerned primarily with the process of building the graphical structure of the model, it is useful to demonstrate the use of BBNs as an inference tool with a toy example. Figure 3 shows the BBN describing the relationship between a person's *sex*, their *height* and their *hair length*. With only three variables there are not many possible graphs, but this example corresponds to our *expert knowledge* that the length of a person's hair has no effect on their height (or vice versa), hence there is no connection between the two. Let the three probability tables that determine this model correspond to our intuition: men and women are equally likely; men are more likely to be taller than women and are more likely to have shorter hair than them. We now have a fully specified BBN, which allows us to make inferences. If, for example, the only information we have about a person is their height, we can nevertheless make an inference about their hair length: our prior belief that they are equally likely to be male or female has been *updated* now that we know their height, and based on the updated probability of their gender, we can also update our prior probability of their hair being short or long.

This *belief updating* or *evidence propagation* in spite of missing data is at the core of BBNs: we can observe how the probabilities of some variables change when the values of others are adjusted. Although this is really a minimal example, it nevertheless allows us to demonstrate some of the core principles involved in BBNs and ones that are particularly important for the methodology described here: (i) reduced data requirements, (ii) the

information value of the model structure itself and (iii) the BBN as a graphical knowledge representation.

Firstly the use of a BBN to describe the relationships between variables dramatically reduces the data requirements for analysing the system: even in our small example, a full probability distribution of the three variables would require a $2 \times 3 \times 3$ table of probabilities. Because these 18 probabilities have to sum up to 100 percent we actually need to estimate 17 parameters from our data to fully describe the relationship between the three variables. But using the BBN shown in Figure 3 we are acknowledging the *conditional independence structure* of the data, which means the same relationship can be described using only the three CPTs. These three tables are two 2 x 3 ones—*P(Hair|Sex)* and *P(Height|Sex)* —and one 1 x 2 one—*P(Sex)*—and each of them also has to sum up to 100 percent meaning we now need to estimate only 11 parameters.[1] While this might not seem like a big difference, it increases exponentially with greater numbers of variables, and can quickly reach reduction factors of thousands or more – a simplification that is done completely transparently as opposed to with a *black box* modelling approach (Pourret et al., 2008).

Secondly, the structure of the graph is distinct from the probabilities: we can develop the structure of the network as a separate step from the process of actually populating the conditional probability tables with numbers. In fact understanding the structure alone can provide tremendous insight into the system modelled before any quantification. In practice there are several avenues for determining the networks structure, depending on the application and available data. One can derive the structure with data-mining from the quantitative data itself, however this requires a well-defined parameter space and a great amount of data. On the other hand, especially in underspecified modelling conditions or when little data is available beforehand, a complete model structure can also be defined solely by experts. A third approach is to combine both information sources by having data mining supplemented by experts, who can add variables or connections that are not present in the data (Aguilera et al., 2011).

Finally, a BBN model is a *graphical knowledge representation*: the factors (or nodes) and the connections with arrows indicating the direction of causation fully describe our understanding of the relevant factors in a visual and intuitively understandable way. In dialogue with stakeholders, whether during model building or model validation, the visual nature of BBNs offers an easily comprehensible and flexible tool for their active involvement (Marcot et al., 2001; Cain et al., 2003; Voinov et al., 2010).

3.3 Focus Groups and the use of *Indirect Communication Devices*

Focus group methodology has since the 1980s become an established and well regarded approach in academic research, with a rich literature exploring its aims, scope and guidelines for implementation (see text books on methodology Krueger et al., 2000; Morgan, 1997a; Bloor, 2001). Although researchers are not always explicit about whether they are using the individuals, the group, or their interaction as the primary unit of research (Cyr, 2015), the focus group discussion demonstrably produces data on all three by providing a forum for informants to agree or disagree, negotiate their common understanding, confront or even directly criticise or commiserate with each other, providing a rich tapestry of information beyond what can be achieved with individual interviews (Kidd et al., 2000).

In researching human decision-making the focus group provides an invaluable setting for exploring how people's attitudes and understandings are negotiated in a social context (Wilkinson, 1998). They therefore provide an ideal elicitation method for finding out which factors influence people's behaviours going beyond their attitudes, including which factors participants feel interfere with their intentions and how reference groups influence their normative beliefs and their motivation to comply with them (Burton, 2004).

While often used as a self-contained method in their own right, linking them with other data collection tools--such as individual interviews and participant observation within the qualitative tradition, or more recently within the *mixed-methods* paradigm with surveys or experiments--is a well-established supplementary use of focus groups (Morgan, 1997b). As an adjunct to other research methods they can be used to add nuance and depth and increase our understanding of more quantitative findings or, as developed here, in the exploratory or hypothesis-generating stage of the research, feeding into the development of a more structured data gathering phase (Wilkinson, 1998). Such mixed-method approaches invariably face the issue of linking quantitative and qualitative data collected in a way that makes them compatible and their contributions well balanced (Fielding et al., 1986; Creswell, 2013). And it is here that Bayesian belief networks have a particular advantage of formally bridging the qualitative and quantitative divide, thereby providing a framework that can accommodate the two data collection paradigms.

In practice the focus group is often extended with various activities that supplement verbal questions. This can be justified on the grounds of making the discussions more enjoyable and the participants less likely to succumb to boredom or fatigue (Colucci, 2007),

as well as functioning as ice-breakers and relaxing more reluctant participants and providing a *'focus'* to the focus group discussions (Bloor, 2001). These exercises can take various forms such as free listings, rating, pile sorting, picture sorting, role-play etc. and often a combination of several types is used. They also provide additional structure to the discussion, which also make comparisons across groups easier.

The instrumental use of visual methods in social research has been well established (see e.g. Van Leeuwen et al., 2001, Banks et al., 2015) and can in practice be be ascribed on the one hand to their role in enhancing data collection or presentation, and on the other in mediating the relationship between the researcher and participants (Pain, 2012). Combined with the strength of focus groups in eliciting a contextual understanding of human behaviour, both coincide in the proposed research design of using Bayesian Belief networks as the conceptual and structural framework of the data collection process. Their role of an *indirect communication device* between the researchers and the participants acquires additional salience in the case where the language barrier between the academic researcher and the participants must be mediated through an interpreter and/or co-moderator.

Despite subjectivity and reflexivity being a long-established concepts in social science epistemology, the acknowledgement of social background characteristics of the researcher rarely extends to consider the issue of unshared language competency (Edwards, 1998; Hennink, 2008). There is now growing acknowledgement that data collection conducted in a language different from the research analysis requires at a minimum greater transparency about the role of translators and interpreters in the knowledge-creation process (Liamputtong, 2008).

Nevertheless, the practicalities of conducting research in a cross-language setting, and the impact methodological choices have on the data collection process have received little attention in the literature (cf. Squires, 2009). This is particularly relevant in the case of more open-ended and fluid data collection methods of which exploratory focus groups are one - where the researcher conducting or facilitating the discussions has considerable influence over its flow and direction.

As opposed to interviews, in a focus group setting it is generally impractical to translate the group moderation, as it would severely impact the flow of the discussion. This situation requires a native speaker to moderate the discussion, which positions the academic researcher in a much more limited co-moderating role. And in addressing this challenge it is argued here that the use of a tool such as BBN building has the additional advantage of

greatly increasing the opportunities for direct participation and intervention of the researcher not conversant in the language of the discussion. This finding is in line with the findings of Colucci (2008) that activity oriented questions in general are a great tool for reducing language barriers inherent in cross-cultural settings.

4 Participant generated graphical representations in the field

The following section describes the practical implementation of a focus group discussion design which involves the conceptual and physical participatory building of Bayesian Belief Networks for elucidating the participants' main decision-making determinants. We first briefly outline how the theoretical and methodological frameworks discussed in the previous section are combined in an innovative research design, before describing its practical implementation within the case study.

4.1 Integrating BBNs into a fieldwork research method

The sophisticated knowledge engineering required to construct a Bayesian belief network in a well specified problem formulation, and the complexity of exploratory qualitative research into how people negotiate the complex web of social, political, economic and environmental factors and uncertainties they encounter daily are not incompatible. A practical operationalisation requires a mixed-method approach that adjusts the traditional considerations of both tools.

On the one hand, we use the BBN as the focusing tool for the qualitative data collection. In practice the collective building of such a network cannot be achieved using a pen and paper approach and requires a more flexible solution. This is solved using a simple setup using magnetic whiteboard cards connected with ribbon. This presents the physical centrepiece of these focus group discussions.

On the other hand, the networks built in this manner are not yet refined enough to qualify as BBNs in the strict mathematical sense. That requires the precise specification of each factor as a categorical variable with mutually exclusive and collectively exhaustive state values[3]. This task needs to be completed after the data collection in order to feed into the

[3] Although continuous variables can be used in so-called Gaussian Bayesian networks and can also be combined with categorical variables in Hybrid Bayesian Networks, they are in practice almost always discretised, which is why we limit ourselves here to categorical models only.

second stage of this sequential exploratory mixed-methods design (Creswell, 2013). Depending on the complexity of the research subject and the amount of time available to conduct the focus groups, a more complete BBN can also be built with the participants at this stage, including perhaps even estimates of the BBNs probability tables. However the intrinsic value of extracting a network structure should on its own not be underestimated. Based on the network structure a survey can then be designed to collect the information required to quantify the connections in the BBN. The outline of this second stage of the research design is described at the end of this section.

Although a BBN can theoretically have as many factors and connections as we like, in practice the numbers of connections in particular should be kept to a minimum, otherwise the data reduction properties of BBNs are limited. By focusing on individual behaviours and questioning what affects the attitudes, norms and perceptions of control people have about them, the BBN building is further streamlined in addition to the modelling being pushed closer to representing actual decision-making processes as the participants themselves enact them.

4.2 The fieldwork in Vietnam

With the goal of exploring the impact of the changing age and gender structure of Vietnamese smallholder rice farmers, specifically how it affects their decision-making process with regard to pest management, we conducted a series of focus group discussions. The fieldwork was conducted under the auspices of the Vietnamese Association of the Elderly (VAE) and the Vietnamese Farmer's Union (VFU) as a secondary partner. These two organizations are two of the largest *mass organizations* in the country and offer almost complete coverage: around 10 million farmers are members of the VFU and over 8 million older people in the VAE (eligibility is at age 60 for men and 55 for women). Both have chapters, facilities, and staff at all levels of Vietnam's administrative hierarchy, and their official sanctioning of our research significantly facilitated the fieldwork, while framing it in an institutional setup that gave less flexibility than might have been desired.

Two districts were selected for the focus group discussions—one in the rapidly urbanising district of Hoài Đức, an hour's drive from downtown Hà Nội and the other in the Hoằng Hoá district near Thanh Hóa the North Central Coastal region of the country—and within each of the districts two communes were selected by our host organizations. The focus group design was based on three key variables deemed relevant to the discussions: (i) age, (ii)

gender and (iii) socio-economic status. Age was used to split participants into two groups based on retirement age with the two organizations each recruiting for half the focus groups. Differentiation along the socio-economic dimension was based on official internal classifications of people as living in *poverty* or *near poverty,* which are income based, and more general designation of *difficult circumstances,* while the other half of the participants were classified as not living in these conditions. With gender being the third variable, this meant 8 focus groups were organized in each of the four communes.

[Figure 4 about here]

In each of the four sites the local chapters of VAE and VFU recruited 8 participants per group from their membership. The participants were selected by local organization staff using an internal procedure, and official invitation letters were issued, which seem to have contributed to a remarkably high attendance rate: most of the time all eight participants took part, and in 27 focus groups we had at most one person missing. The only exception was the very last scheduled discussion, which we had to cancel due to non-attendance related to it being high harvest time and the weather briefly clearing up, which the farmers were eager to take advantage of. Thus a total of 31 focus groups were conducted and Figure 4 shows the age distribution of the total of 228 participants, splitting them into the four age/gender categories.

For organisational and practical reasons the discussions were limited to about two hours, which in practice limited the depth and breadth of material covered. This was the main reasoning behind the decision to distinguish two distinct stages, *BBN-building* focus groups and *BBN-elaborating* focus groups, each of which is illustrated in turn in the case study example. We thus conducted 8 BBN-building discussions in the first commune and followed up with eight BBN-elaborating focus groups in the second commune (but same district). This was then repeated in the second district. Although considerable overlap exists, the first can nevertheless be thought of as mapping more generally onto the BBN framework and retaining considerable flexibility, while the second sharpens its focus by incorporating the behavioural approach more systematically. Had we had the opportunity to conduct longer, more in-depth discussions, we would have used a similar structure to break up the discussion within a single group.

4.3 Implementation of *BBN-building* focus groups

Aims

The aim of the first stage of focus group discussions is to gain insight into the system as a whole, its most important determinants, and how these different factors connect causally. The BBN is built with the active participation of the participants and represents their collectively negotiated understanding of their environment. This is accomplished using a combination of magnetic cards and ribbon connections described below.

Materials

Ferro(us) sheet is an inexpensive material that can be easily purchased from specialised online vendors and provides the perfect tool for implementing the participatory BBN building. The flat sheet material is attractive to magnets and is coated with white vinyl, which allows writing with dry erase whiteboard markers. The sheeting is commonly (and more economically) sold in larger formats, which can easily be cut to the required size.

Magnets used in this case study were rare earth neodymium magnets because of their exceptional strength and small size. However in practice these characteristics proved more cumbersome than helpful, and regular magnets would have been more appropriate, as well as cheaper.

Several types of *connectors* were considered in the preparation of the focus group materials with the prime objective of allowing the network to be flexible and easily adaptable. Both flat elastic bands and retractable lanyard links were trialled, but were deemed too unwieldy and unnecessary as regular flat fabric ribbon that can be cut to length provides enough versatility.

Facilitation

In traditional implementations of focus groups it is usually recommended to use a predetermined questioning route or script for the discussion facilitator to follow (Krueger et al., 2000). While there are certainly advantages to the consistency of results obtained with such an approach, the exploratory nature of BBN building demands the facilitation is not scripted sequentially in order to allow topics to emerge organically.

The focus group facilitation guide listed suggested topics for discussion, but made it clear that the list was not exhaustive and that the moderator should explore any new factors that emerged in the process (the guide we used in the field is provided as supplementary material). Instead a more abstract set of instructions was given, explaining how the discussion

should be structured and simultaneously mapped onto the network being built in front of us. This involved two components: new topics or *factors*, which are represented by the magnetic cards, and how they influence each other or *causal connections*, which are represented by the ribbons.

[Figure 4 about here]

Each new factor that came up would be written on a card, trying to ensure it was a simple concept, clearly described, which served as a discussion point to ensure a common understanding of the factor was reached. If other factors came up during this discussion, they could be written on another card and placed on the side, keeping the focus of the conversation while ensuring that no ideas would be forgotten. This happened with some regularity and both the facilitators and the participants appreciated this opportunity to break up the linearity of the discussion without repercussion. The instructions further stipulated that each factor should have clear categories or options as required by the mathematical BBN framework.

The card then needed to be placed in relation to the existing factors allowing us to explore and discuss the nature of the connections. These represent the mechanisms of influence as the participants understand them and by interrogating the *why* and the *how* of these connections the card would be situated within the network context. The connections were made using the magnets and ribbons and also indicated the direction of the connection (marked with red ribbon as can be seen in Figure 4). It would often emerge that the connection under discussion was not a direct one, but was mitigated through another factor, and the versatility of the magnetic card and ribbon setup meant that they could easily be moved around and reconnected in more accurate ways as these emerged. When a new factor was added the first connection was usually easy to establish and reach consensus on. Further connections were sometimes contentious, and were sometimes even removed after a while if it emerged the mechanism was mediated via an existing factor, or one that had not been added yet.

4.4 Implementation of *BBN-elaborating* focus groups

Aims

The aim of the second round of focus groups is to further elaborate the framework that was the consolidated outcome of the previous round. Having established a provisional network structure that is common to all of the different groups, the flexibility of the network is now secondary (although it is still amendable) and the moderator can focus more systematically on questioning how participants' behavioural intentions are formed.

Materials

A single BBN diagram was constructed from the outcomes of the BBN building focus groups, encompassing all the factors and structures that emerged as relevant. Specifically we now distinguish between behaviours (printed in red) and factors (printed in black), a distinction that was not made in the first set of BBNs (see right panel of Figure 5 for the English translation of the BBSs used in the Hoằng Hoá district). In this diagram the behaviours (e.g. fertiliser use) are connected to *influencing factors* (e.g. soil quality) and *outcomes* of that behaviour (e.g. plant quality/resistance).

[Figure 5 about here]

Due to the extremely low cost of printing in Vietnam, the BBN was printed on a large A0 poster for each group and markers were used to elaborate the network further directly on each poster during the focus groups. At the end of each session the posters were photographed (two examples are shown on the left pane of Figure 5). An alternative approach would have been to prepare the BBN before each group using the same cards and magnets as in the first set of focus groups, but this was deemed impractical and unnecessary.

Facilitation

The participants were presented with the printed diagram and told that this was the result of discussions with farmers in the previous commune, while at the same time making it clear that it was not a *correct* model, and that it was open to debate and amendments. To further prevent that the printed network would be treated with more esteem than it deserved, one crucial factor – *water* – was intentionally omitted, thereby ensuring each group felt they were in fact co-building this model, hopefully increasing their engagement.

The facilitator's guide for the second set of focus groups was grounded in the *theory of planned behaviour* i.e. trying to elicit the (i) attitudes towards a certain behaviour (knowledge and understanding of the behaviour and its impacts and utility of its outcome), (ii) controls over a certain behaviour (what restricts or limits a behaviour and how much

control does the person have over it) and (iii) subjective norms in the shape of perceived social norms to perform a certain behaviour. The BBN diagram served as a guide to discussing these three aspects of behavioural intention formation:

(i) a connection between a behaviour and its outcome was used to question the participants' strength of belief in the causal relationship and asses its relative importance (e.g. how do different modes of fertiliser use affect plant resistance, does this knowledge come from practice/experimentation, how certain are they in this connection, how easily would they adopt a different fertilisation regime);

(ii) a connection between an influencing factor and a behaviour was used to query how much the behaviour was determined - made possible or restricted - by the influencing factor, and how important this restriction is to them personally (e.g. to what extent does they type of soil limit their options of fertiliser use, is this limitation taken for granted or are there ways to reduce its importance, are there other factors that would make the soil type irrelevant e.g. lack of funds to buy any type of fertilizer in the first place);

(iii) finally the participants were asked about who is affected by each behaviour, and whether their opinion about them (not) performing it was important to them (e.g. would any particular fertilization regime invite approbation or condemnation from owners of neighbouring fields, and if so how important is this to them).

Within this framework the discussion inevitably led to new influencing factors being added to the diagram as well as new connections between the existing ones. Whenever there emerged to be several factors influencing a behaviour the facilitator was expected further to establish their relative importance by ranking them.

The photographs in Figure 5 show the example of two focus groups both adding the factors *water* and *co-operative* (nước means water and HTX stands for Hợp tác xã, meaning co-operative). Both discussions pointed to water (availability) being affected by both weather and the co-operative (via controlling the irrigation systems) and water in turn having an effect on tillage and plant quality/resistance. You can also see how the group shown on the top had changed their mind about water directly affecting the pest environment and settled on the

main effect of water on pest levels being directed through its effect on plant quality and therefore the plants' resistance, not by directly creating an environment conducive to pests.

4.5 Analysis of Focus Group Data

The analysis of the data from the two sets of focus groups allows the collection of quantitative data that will allow us to arrive at the conditional probability tables described by the BBN that emerged from the stakeholders' accounts of their decision-making. This is in striking opposition with developing a BBN model from an existing data source, which might produce equally plausible results, but such a model would invariably be removed from the actual practice and reality of the decision-makers themselves.

The quantitative survey implemented in the second fieldwork phase thus incorporates a set of BBN relevant questions. Ajzen's (2002) questionnaire construction guidelines can be applied using any standard scaling procedure (e.g. Likert scaling). Here we provide an illustration following the pest management measures example given before:

(i) Attitude towards behaviour:

– *Behavioural belief strength:* Using animal manure will make the rice plants less vulnerable to pests than using chemical fertilizer: [extremely likely — extremely unlikely];

– *Outcome evaluation*: Vulnerability of rice plants to pests is: [extremely important — extremely unimportant].

(ii) Perceived behavioural control

– *Control belief power:* Not having ready cash will make it [much more difficult — much easier] to apply animal manure;

– *Control belief strength:* Not having ready cash when fertilising is required is [extremely likely — extremely unlikely]

(iii) Subjective norms:

– *Normative belief strength:* My neighbours think I [should — should not] apply animal manure to my fields;

– *Motivation to comply:* Generally speaking, how much do you want to do what your neighbours want you to do: [not at all — very much].

By iterating through sets of outcomes, controls and significant others, and in combination with questions regarding the actual manifestation of the behaviour e.g. self-

reported use of animal manure in the previous season, this provides the dataset from which the conditional probability tables can be extracted (see Poppenborg et al., 2013 and Poppenborg et al., 2014 for technical details).

5 Suitability and Limitations

Overall the BBN framed focus groups proved to be a success as an exploratory data collection method for understanding the decision-making milieu in a structured fashion that feeds easily into a subsequent quantitative data collection stage. Within a relatively short time-frame we were able to begin to develop a picture of the participants' perspectives on the complex social and environmental system within which their rice farming is positioned.

Interestingly the symbiosis of BBNs and behavioural approaches has hardly been explored in the literature (*cf.* Poppenborg et al., 2014; Ticehurst et al., 2011). This is despite the fact that one common application of BBNs has been as a *decision support tool* or *aid*. The classic example can be found in the clinical setting, where a BBN is developed using available patient history (big) data and clinical experience. It can then be applied to help the user (i.e. doctor) make a decision, for example a diagnosis or choice of treatment, for a new patient, despite uncertain or incomplete information about this particular individual (Oni´sko, 2008; Nicholson et al., 2008). In this way these BBNs are effectively modelling the processes of reasoning, albeit an idealised one with a wealth of information. By analogy they can also be used to model the reasoning – or decision-making – of a Vietnamese rice farmer. In particular they can connect several behaviours or decisions with the social and environmental factors that encourage or restrict them, creating a representation of a realistically complex, interdependent and robust system. In this sense this methodological framework is therefore generalisable to the interrogation of any human decision-making complex.

It is important to note some practical considerations that arose with the field implementation of the method. One concern during the development of the method was its acceptability to both the research assistants moderating the discussions as well as how it would be received by the focus group participants. The physical representation of the BBNs as described and used here masks the probabilistic mathematical intricacy underlying them to such an extent, that they did not seem to appear intimidating to participants, but rather represented an intuitively understandable representation they could easily relate to. Their reaction was positive overall in both types of focus groups; there were no issues with

explaining the principles in the building stage and the diagrams presented in the elaborating stage were greeted with interest and approval.

The induction of the discussion moderators had to go into greater depth in explaining the underlying principles and eventual use of the BBNs. Used to following a more traditional focus group script, they were understandably anxious about this new tool and in particular the open-endedness it implied. This anxiety was partly relieved by the fact that the academic researcher was present throughout all of the focus groups and was able to intervene if necessary. As this was the first time this tool had been piloted in a focus group design, some adjustments were made during its implementation, although ideally we would have done a separate pilot beforehand. Namely it quickly transpired that we were overly optimistic in expecting the BBN building to be able to establish the factors as simple concepts with exclusive and clearly marked categories. This is not so much an indictment of the tool however, as of the broadness of the topic under consideration. In a project with a more narrowly specified remit, this could easily be done within the scenario envisaged. In our case however, we relaxed this expectation in order to be able to discuss as many factors and relevant connections, at the expense of precise definitions. This balance should be kept in mind when developing a similar design, in particular in relation to the amount of time available for conducting each discussion.

Similarly time constraints and broadness of the topic meant that in the second set of focus groups it proved difficult to establish a ranking of the importance of individual factors. Again this is deferred to the quantitative data collection, but could be accomplished at least partially at this stage if the network scope were more modest. Another case specific aspect of our design was that we were unable to revisit the same group a second time for the BBN elaboration phase. This should be considered if possible, however the setup presented is practical precisely because it allows us to continue developing our understanding in a similar second group, by maintaining the focus of the discussion, without the need for repetition that would be involved by having to build a new BBN every time.

We did not systematically evaluate the stakeholders' satisfaction, but our impression, confirmed by our local moderators and interpreter, is that it was genuinely positive. In line with similar participatory modelling approaches the farmers appeared to relish the opportunities to actively construct the the model physically and thereby direct the debate. This usually followed a introductory period of them expecting to be directed by the moderators, but they soon took to their more active roles. It was not unusual for a participant

to copy the final model using pen and paper, especially the models in the BBN-elaborating focus groups.

Finally the appropriateness of this method should be judged in relation to the required data outputs and appropriate modes of analysis. Between the two main approaches to analysing focus group data (Wilkinson, 1998), the *ethnographic*, strictly qualitative, analysis, and systematic coding approach of *content analysis*, this method is clearly more suited for the latter. Although this particular case study uses the BBN focus group design as a part of a mixed-method project, with the data feeding into the design of a quantitative data collection phase, the design itself is useful for conducting hypothesis generating focus groups in general, regardless of how they relate to the wider methodological toolbox of the study. The advantages of using a BBN design lie in structuring the discussion, while retaining a high level of flexibility; while using the *theory of planned behaviour* framework not only provides the theoretical framework for exploring human decision-making, it also links the qualitative analysis directly into the quantitative stage.

6 Conclusion

BBNs and the social-psychology approaches embodied in the TPB are a natural fit. They allow us to combine a theoretically informed model of human decision-making while taking into account a range of social and environmental influences. This research design establishes a robust common core bridging the qualitative and quantitative divide. The approach is however still useful even if not used as part of a mixed-methods design. A BBN structured focus group design is valuable in itself by providing structured narrative framework that corresponds to a causal understanding of the participants' reality, and allows the researchers to establish a comprehensive picture within a relatively short time frame. In this respect a BBN can resemble causal loop diagrams or cognitive maps and influence diagrams, and from the point of view of structuring a focus group discussion they are likely to perform in a similar manner. But while Nadkarni et al. (2007) describe the process of how to systematically convert one into the other, this is not a trivial problem, especially in highly dynamic systems. So even if quantitative data collection is not part of the original research design, the qualitative stage of BBN building is useful in its own right, and can furthermore always be augmented with the quantitative stage at a future time.

The instructional section of this study fills a gap in the literature on participatory BBN model building by detailing specific field techniques as they were used in their construction.

The case study circumstances, including organisational limitations and its cross-language setting, serve to demonstrate the flexibility of this approach, which can easily be replicated in a variety of settings and tweaked to their requirements. Whether the desired outcome is a representation of stakeholder knowledge, or the systematic groundwork for further quantitative or qualitative data collection, the use of BBNs as a physical and conceptual framework for conducting focus group discussions represents an easily accessible extension to traditional focus group design, and a valuable component of an interdisciplinary project.

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FIGURES

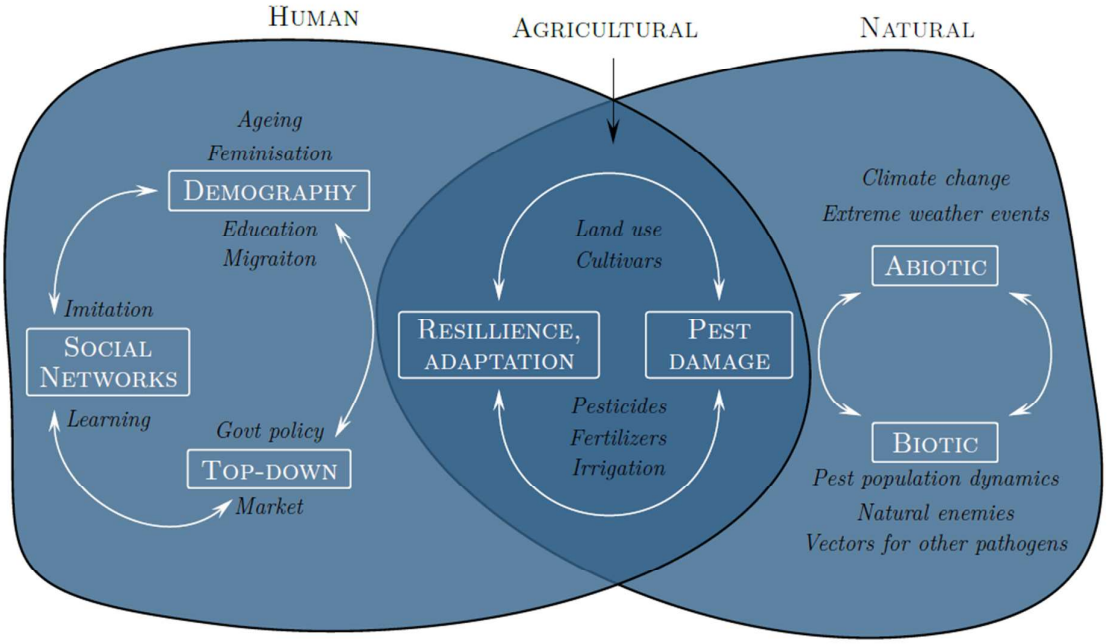


Figure 1: Preliminary scheme of the case study model structure

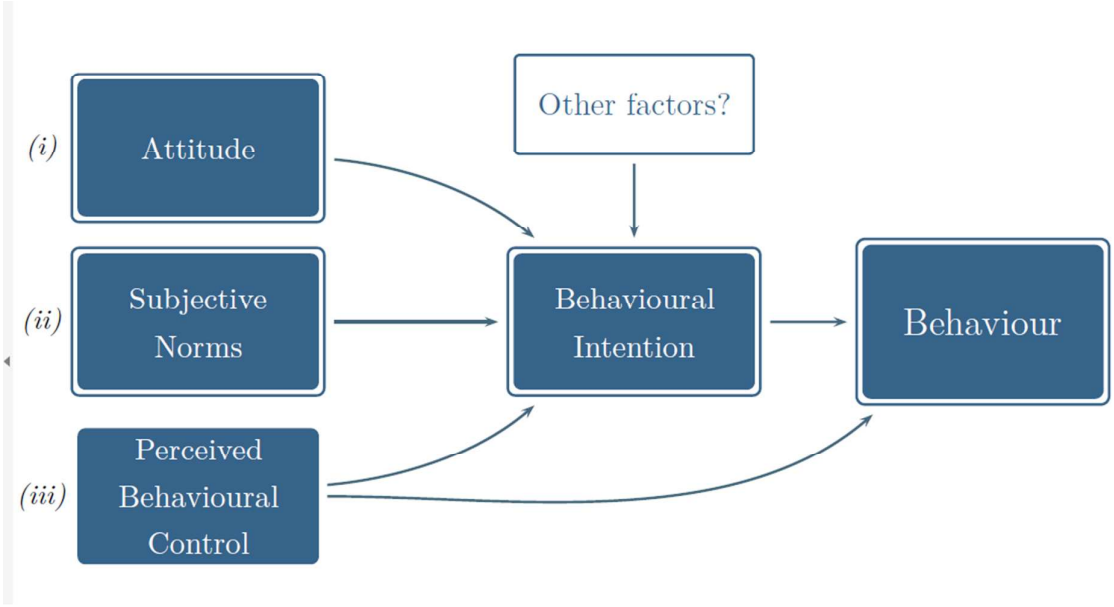


Figure 2: Schema of *theory of planned behaviour* model, the original *theory of reasoned action* factors are framed (adapted from Eagly et al. (1993) and Burton (2004))

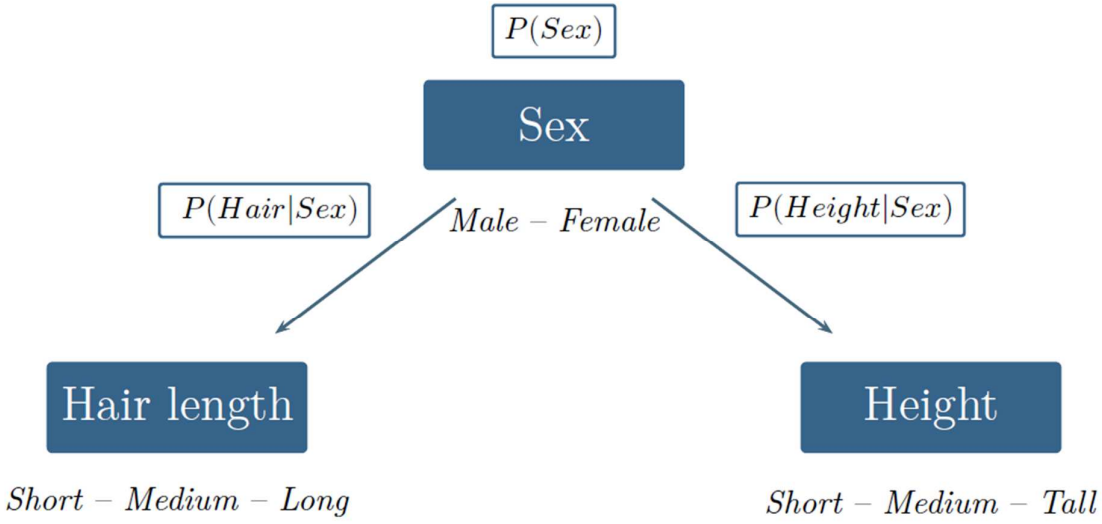


Figure 3: Toy example of BBN, adapted from Jensen et al. (1997)

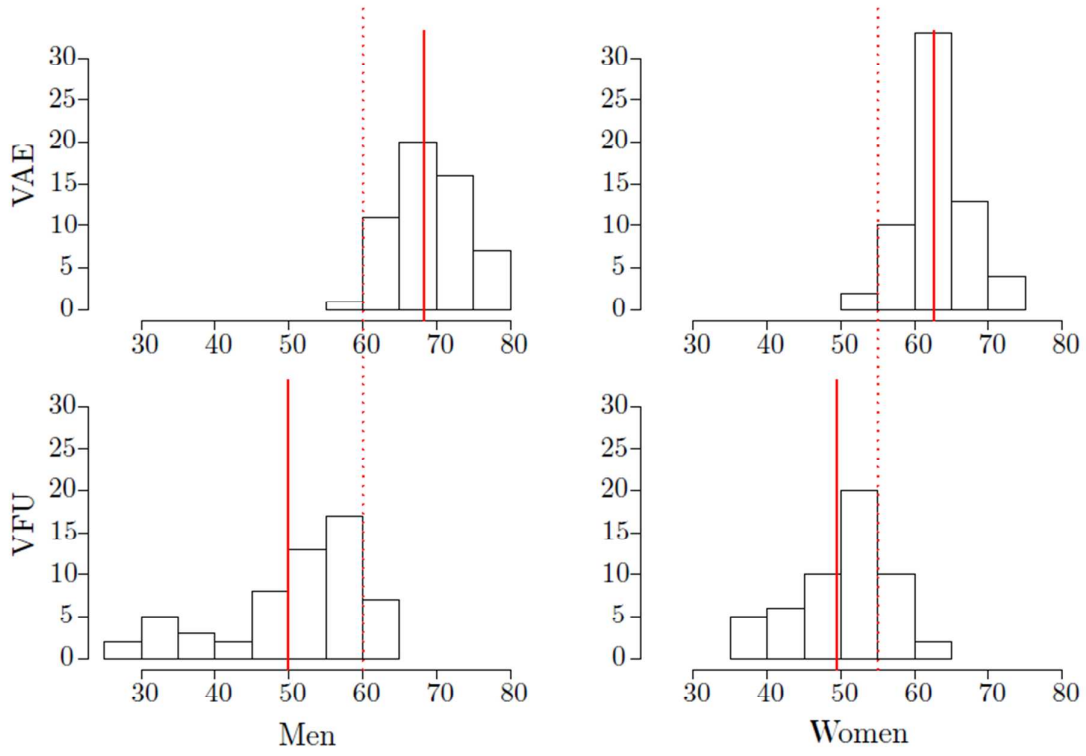


Figure 4: Age distributions with means in groups from Vietnam association of the Elderly (top row) and Vietnamese Farmers' Union (bottom row) for both men (left) and women (right). The cut-off age is shown in dotted line and the mean for each group in solid red.

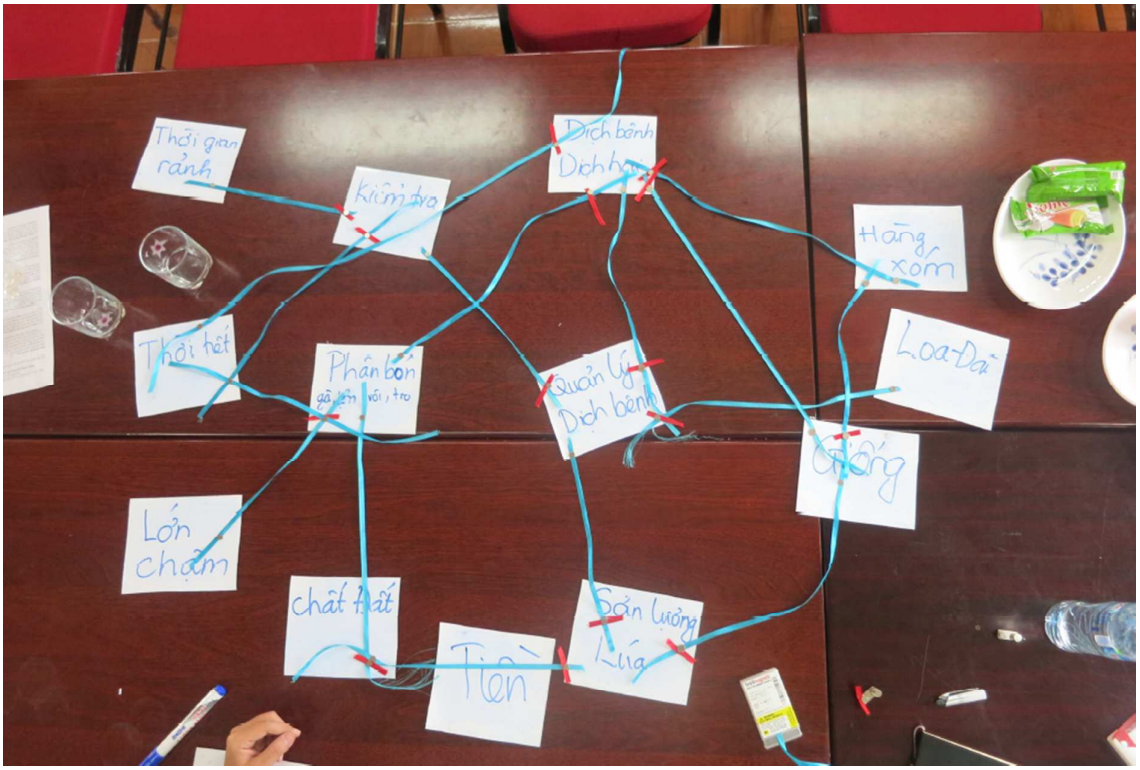
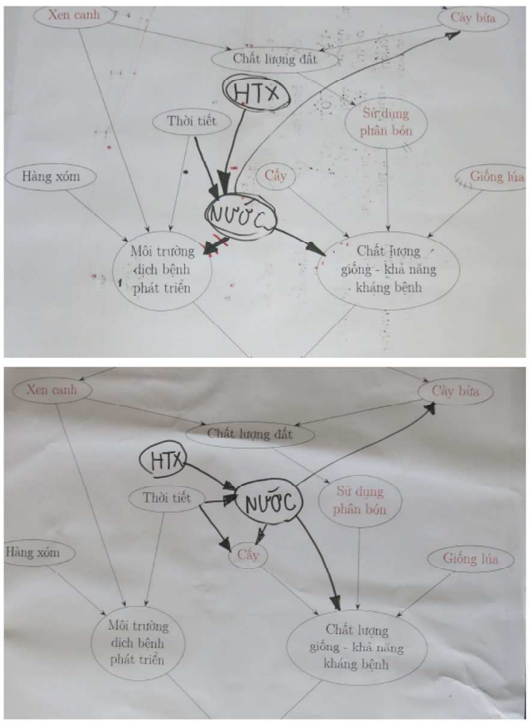


Figure 5: Example of network built with participants in Yên Sở commune,Vietnam



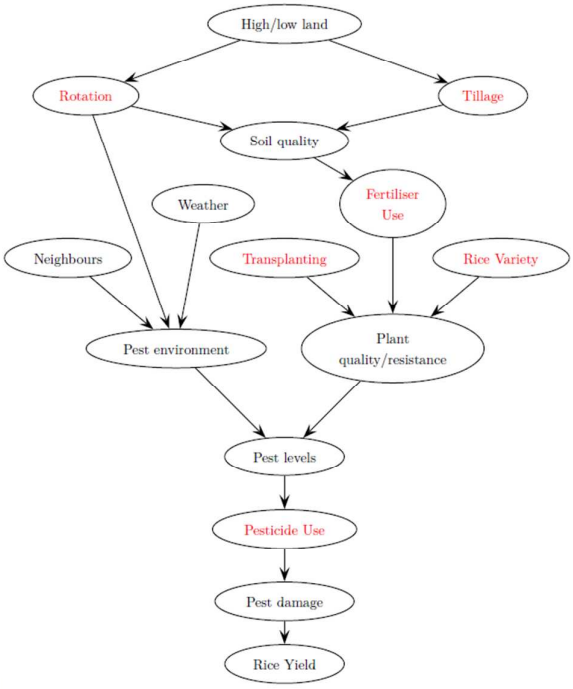


Figure 6: Translated elaborated BBN scheme as used in the Hoằng Trung commune, Vietnam (left) and two photos of the BBN after the FGD (right). [HTX stands for Hợp tác xã meaning co-operative and nước means water]

1

1 Focus Group Facilitator's Guide

Instructions are in italic font.

Script text is in normal font.

1.1 Before the start

- *Make sure you have all the materials ready:*

    1. *1 sign up sheet for participants - with details filled in.*

    2. *8 Information sheets for FGD and 8 Consent forms for FGD.*

    3. *The magnetic cards, magnets, ribbons and marker pens and scissors for cutting the ribbon.*

- *Greet the participants when they arrive.*

- *Ask them to take a seat and make themselves comfortable.*

- *If there are refreshments? Encourage them to help themselves.*

- *Ask them to fill out their name, age and education on the sign up sheet - BUT NOT the signature, tell them that is at the end of the discussion.*

- *Explain their names will not be used in the research, that this is just for our records.*

- *Give everyone the Information Sheet and Consent form and tell them they can read through the Information sheet while they wait.*

1.2 Introduction

1.2.1 Introduction of the team

Welcome and thank you all for coming today. My name is _____ and this are _____ and _____. I am from the _____ and I will be running the discussion with you today. This is part of a research project run by _____ and _____ here is the main researcher on the project. _____ will be translating for her during the discussion.

I will be leading today's discussion. First I will explain the whole process to you. Then my role will be to make sure we go through all the important points during the discussion and keep it within the time frame. I also want to make sure all of you have the opportunity to talk.

_____ and _____ will assist me with these things. They will also be taking notes. We are also recording this session, to make sure we record the discussion accurately.

The discussion session today will take about 1.5 to 2 hours. There are refreshments available and you can help yourselves to them at any time.

Are there any questions so far? If there are no questions we will start the recording now.

Make sure the audio recorder is running from now on.

1.2.2 Introduction of participants

Before we begin it would be good if everyone here could also introduce themselves. So let's start here and go around the room and everyone can tell us their first name and anything else you want to share with the rest of us. It would be nice if you could say a little bit about your farming, for example how much rice land do you have, and how long you have been growing it.

1.2.3 Information Sheet and Consent Form

Before we begin, we need to go through the information sheet. Some of you have already had a chance to look at it, so I will go through it with you now to make sure everything is clear.

The goal of this research is to explore the understand how farmers make decisions about pest management on their rice fields. In particular we want to understand which factors are the most important and how they impact farmers from different backgrounds.

We are conducting focus groups like this one in 4 communes, with groups of farmers of different age groups, genders and different socio-economic backgrounds, ages and genders, to better understand how you make your farming decisions. You have been asked to participate because we believe your experience is important and will contribute to a better understanding of how rice pests can be managed better in the future.

- Your participation is completely voluntary.
- Your contribution to this study is anonymous and your name will not be used in any way.
- The discussion will be audio recorded to make sure we record all the information correctly.
- We will also take some photographs, but it is no problem if you do not want to be in the photos, just let us know and we will make sure your face does not appear.
- You may be asked to participate in an in-depth interview later, but this is optional.
- To cover your costs for attending the discussion you will be reimbursed for your travel expenses at the end of the discussion.
- If you have any concerns of questions pleas feel free to ask them.

So if you are happy with that we would like you to sign the consent form you got at the beginning. This is for our record, so we know that you agreed to take part in this FDG.

1.3 Instructions

1.3.1 General Instructions for the FGD

I want to first set some general rules for the focus group. This will ensure that the discussion runs smoothly.

The researchers have some topics that they think are particularly interesting. And we would like to hear what all of your views are on these topics. If someone says something that you do not agree with, please speak up and tell us your view as well.

Occasionally I may interrupt the discussion to focus us back on a particular topic or to move on to the next one, to make sure we cover all the topics we want to discuss today.

- We want all of you to express your opinions about the discussion topics. We are interested in multiple points of view about them. There are no right or wrong answers!

- We are not here to resolve any issues you may bring up, but to make sure we understand what they are.

- Please do not hold side conversations. We want to be able to hear from everyone, and side conversations will disrupt the discussion. We want to make sure that we hear what everyone says.

- Because we are also recording the session, it would really help us if you could speak up so that everyone can hear you.

1.3.2 Specific Instructions for the Network Building Exercise

Have the props at hand when giving these instructions to demonstrate - a few cards, one piece of ribbon and two magnets.

The main topics of our conversation today will be around pest management and what are the important factors that affect how you make decisions about it.

In order to facilitate the discussion and to keep the focus, we will use these magnetic cards to write on them and connect them using this ribbon. Don't worry, I will explain how it works and you will soon see how useful it is for the discussion.

Our main topic is pest management. So we will start with that and write it on the first card. *[place one (empty) card on the table]*Then we can discus about it, about what the different options are.

The next step will be to think about something that affects how you make your decisions about the pest management.*[place second card down a short distance away.]* We will write it on a new card and connect them together. Then we can talk about the connection, how do you think it works. *[take out a ribbon and start attaching it with the magnets]*What happens if something changes on one side , how it affects what we discussed on the other side.

By the end of the discussion we should have a nice network connecting all the important factors and we will have talked about how all of the connections work.

This is a practical method also because it is easy to move things around, and we can change connections at any time if you think there is a better way of showing what is happening.

1.4 Discussion

The main structure of the network building has two components, ***topics =factors = cards*** *and* ***influences=connections=ribbons****. The discussion is therefore structured generally:*

1. Discuss a new factor, and define it clearly and what it's main categories/options are

2. Discuss its connection(s) with the other factors already on the table, **one by one**

It is important that you stick with this and do not allow the discussion to get out of hand with too many factors being discussed at the same time. If this happens, politely say something like "We will discuss that in a moment, for now let's focus on only this factor/connection."

*In the main discussion you will move through the main topics = **factors** mentioned below. These are for guidance and are flexible. The order is not important! If something new comes up, that is not mentioned here, but seems relevant, you should (look for my confirmation and) proceed to explore it. But make sure you cover all of the factors mentioned below, even if it only means making sure everyone agrees they are not important.*

*Generally you want each new **card = factor**:*

- *To be a simple concept, clearly and simply marked - with a single word or phrase, so that it can be written on the card clearly and that everyone agrees what it refers to.*

- *Discuss what the different* options *are for that card - what different categories are possible.*

- *Try to keep the number of possibilities low, ideally 2-3. But make sure everyone agrees that this are the important ones.*

- *If there are too many options, try to group some of them together, so that you have a few main ones and the the rest together as* other*.*

- *the categories should be clear and* measurable*! Think about the second phase, where we will try to quantify them. This means you should not just use e.g. "good" and "bad", but you have to be clear about what the line between them is.*

- *If possible mark the different options on the cards using abbreviations or symbols.*

- *Use different coloured markers to make it clearer for the participants.*

When discussing each new factor try to stick to that factor alone. If participants start talking about all the different influences, you can politely say something like "We will discuss what affects it in more detail a little bit later, now let's first make sure we know what this card means."

But if the new factor looks like it is an intervening *factor - that means it comes between two other factors, then you can add it in between and discuss it that way.*

*Once you are happy with the **card** definition, move on to the connection. The connection is always between two cards. Because both cards have been properly defined already and their possible categories, you can think of this discussion as describing the cells in a table.*

Pest Management ⟵ Available Money

		Pest Management		
		Pesticides	IPM	other
Available Money	Yes			
	No			

Use this idea to guide the conversation exploring the possibilities in the table. In this example you could e.g. ask "If someone has money available, would they be more likely to use pesticides or IPM? Why?" Try to elicit probabilities - not specific numbers, but a general impression of likelihood.

And ask about "Why?", what are the mechanisms. If the answers to Why are another factor you can again say " We will talk about that as well, let's focus on only this connection now." You can even write down the suggested factor on a new card and leave it on the side for later, so participants know we will get back to it.

*In addition to "Why?" it is also important to ask what happens if there is **uncertainty**. How does that affect the connection, if people do not know the value of a particular factor. Is there something else that helps make the decision? That can be another card!*

*Generally when adding each new **connection = ribbon:***

- *The connection should have a **direction**. You can indicate it with the marker on the card*
- *When adding a new connection to the existing network make sure you do not create a circle! A circle means you can move through the connections in their direction and end up at the beginning.*
- *It is very important that we do not end up with a network that looks like a "star" - with one card in the middle and all others around it. Instead always try to push factors out and find simple connections through other factors.*

1.5 Suggested factors for discussion

Below is a list of possible topics to initiate the discussion. Other ones may come up in the conversation, or these ones may be defined differently. That is OK. The topics are sometimes wide to start the discussion, but you have to then narrow it down to a factor card as described above, depending on what the participants are saying is the most salient aspect of the topic.

1.5.1 Pest management methods

This is probably the easiest one to start with, or maybe the second one as well. It is the final outcome we are interested in. Don't place it in the middle, it should be more at the bottom, so there is room above it for all its "parents".

When you you have insects in the field, what are your options? What can you do about it?

1.5.2 Situation in the field

If have a pest problem in your rice, how can you tell? What different levels of pest infestation have you experienced? Are the different situations in the field important for how you decide to act?

1.5.3 Official information

Do you get information about pest management from official agencies? E.g. the plant protection department? How does that information affect your decision?

1.5.4 Training

What sort of training about pest management have you had? How long ago was it, who got it? Has the training changed how you deal with pests?

1.5.5 Pesticed brand/dose - *can be split into more cards*

How do you decide what pesticides to buy? What brands? How much to use?

1.5.6 Access to pesticide shop

How difficult is buying the right pesticides? If the shop is close or far, does that affect what you do about the insects?

1.5.7 Financial situation

How much of a financial burden is pest management? How do you normally pay for it? What happens if you do not have available money?

1.5.8 Access to lending

Is borrowing money for pesticides sometimes necessary? If yes, how easy is access to lending? Are you reluctant to borrow money?

1.5.9 Size of rice fields

Are decisions about pest management different depending on how much rice fields you have? Or if you have other crops as a fall-back?

1.5.10 Labour availability/Size of household

Does labour availability change the decision about how to deal with pests?

1.5.11 Education

Do you feel your education has an impact on how you make these decisions? Do you feel you have sufficient knowledge to deal with pests?