24. BRINGING AGROFORESTRY TECHNOLOGY TO FARMERS IN THE PHILIPPINES: IDENTIFYING CONSTRAINTS TO THE SUCCESS OF EXTENSION ACTIVITIES USING SYSTEMS MODELLING

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We present a systems modelling approach to evaluating the success of an agroforestry extension program in Leyte the Philippines. During the program, variables which are intrinsic to farmers' socio-economic and farming systems were found to have influenced the uptake and acceptance of extension advice. Evaluation of the program therefore depended on identifying the variables and their interdependencies and assessing their relative influence on program outputs. For this purpose, a systems approach which encourages breaking systems into component variables, but also acknowledges the context of problems, assisted construction of models. Using both empirical data collected during program activities and input from stakeholders, Bayesian Belief Network (BBN) modelling was undertaken to predict critical success factors for the four main extension activities, namely recruitment, the effectiveness of written extension materials, development of farmers' self-efficacy in nursery and silvicultural management and attrition of participating farmers. A key predicted constraint to program recruitment is farmers' perception of harvest security and whereas this variable can be partly addressed through dissemination of information on harvesting legislation, title security cannot. Differing levels of farmers' education flow through to differences in predicted reading ability, comprehension of extension literature and possible misconstrual of information. The variable most critical to the development of farmers' self-efficacy is extended problem-solving support.

INTRODUCTION

This paper describes the use of systems modelling to evaluate an agroforestry extension program which was undertaken over three years as one of the activities of the Australian Centre for International Agricultural Research (ACIAR) project ASEM/2003/052, *Improving Financial Returns to Smallholder Tree Farmers in the Philippines.* Systems modelling was chosen because other approaches are less suitable for the evaluation of agroforestry extension. Statistical analysis is best suited to experimental research which is difficult to evaluate if interventions involve human interaction (Rossi *et al.* 2004). Economic approaches require long-term data collection and the usefulness of structured surveys suffers because the context of responses is often ignored (Pretty *et al.* 1996).

An evaluation process which includes the viewpoints of stakeholders may also be more appropriate than approaches in which assessments are conducted by external experts using predetermined indicators of success (Cramb and Purcell 2001; Owen 2006). Although the evaluation of development assistance in the past has often neglected the complex processes behind assistance uptake, it is no longer acceptable to disregard them (Henderson and Burn 2004; Henriksen and Barlebo 2007). Hence, systems modelling, which includes breaking problems down into component variables, considering interactions between them, recognising the dangers of narrow model boundaries and the importance of qualitative as well as quantitative data (Sterman 2002), matched the evaluation needs of this program. In particular, systems modelling permitted inclusion of the subjective human-behavioural variables which had been observed throughout the program to affect outputs.

Systems modelling also permits prediction of outputs for alternative input scenarios and for extension programs, this is useful to identify critical success factors or impediments. Identification of variables which are within the capacity of program managers to control, allows input-dependent prediction of upper and lower limits of program success. If qualitative variables are included and stakeholders are used to assess their influence, models may be populated with data which reflect stakeholders' 'real life' assessment of situations. This increases the validity and reliability of models when they are used to predict the success of extension programs in similar situations.

The extension program used as a case study in this paper was designed to provide answers to three research questions (RQs):

- RQA. What extension activities and information are appropriate to recruit smallholder farmers in Leyte and to develop their self-efficacy so that they are able to continue the establishment of trees without further extension assistance?
- RQB. Will an extension program which offers technical advice and assistance be effective in improving the uptake of timber tree establishment and the silvicultural management of tree farms?
- RQC. What are the constraints, opportunities and resource requirements involved in scaling up an extension program as described in RQB, from the local to a wider level?

The program had been conducted as case studies in four municipalities in which farmers were assisted to grow seedlings in home nurseries and establish plantations of *Swietenia macrophylla* (mahogany). Evidence collected throughout the program and during a final survey indicated that the effectiveness of extension activities was influenced by social, cultural, and biophysical issues. The program superimposed extension system variables on the farming system and where this occurs, feedback effects are often difficult to discern (Sterman 2002).

The first focus of this paper is the application of systems modelling to four aspects of the overall extension system: contacting and recruiting farmers, the effectiveness of written extension materials, development of farmers' self-efficacy and attrition of participating farmers over the course of an extension program. The second focus is an evaluation of the methods adopted for the elicitation of information from stakeholders. A final focus is the usefulness of the models to supply answers to the three RQs.

RESEARCH METHODS

The extension program is reported in Baynes *et al.* (2009 in press) and a précis is presented below. Between 2005 and early 2008, assistance was offered to farmers in Leyte to grow seedlings in home nurseries and establish trees. The program consisted of recruitment, initial training and extension assistance to farmers in the municipalities of Libagon, Dulag, Leyte Leyte and Bato, the Philippines (Figure 1). Recruitment was made through local government unit (LGU) officials after permission had been granted by the municipal mayor. The program was designed to provide assistance in two formats. For volunteer-farmers in the municipalities of Dulag and Libagon, assistance was provided via a field tour which included an overview of small-scale forestry. The tour was followed by extended assistance to grow seedlings and establish trees, mainly mahogany. For farmers in the municipalities of Leyte Leyte and Bato, extension assistance was restricted to the field tour, collecting seed and setting up a home nursery. Compared to farmers in Bato and Leyte Leyte, farmers in Libagon and Dulag therefore received three extra site visits, where in addition to assistance to set up a home nursery, they were advised how to prepare sites, plant and maintain trees. The rationale underpinning the delivery of two assistance regimes was that if farmers are capable of establishing trees once they are initially competent in growing seedlings, then a hypothetically scaled-up extension program would be more cost effective if extended assistance is not necessary.

Although extension activities were well received, overall recruitment was low, many farmers did not use the written extension materials and the number of farmers who initially participated, declined throughout the program (Table 1). Farmers initially displayed a very low level of nursery and tree-growing processes. Unexpected problems (e.g. persistent rain or predation of seedlings by chickens and rats) caused severe loss of farmers' confidence unless extended assistance was supplied. These problems prompted extension staff to identify and document variables which had influenced the success of the program.

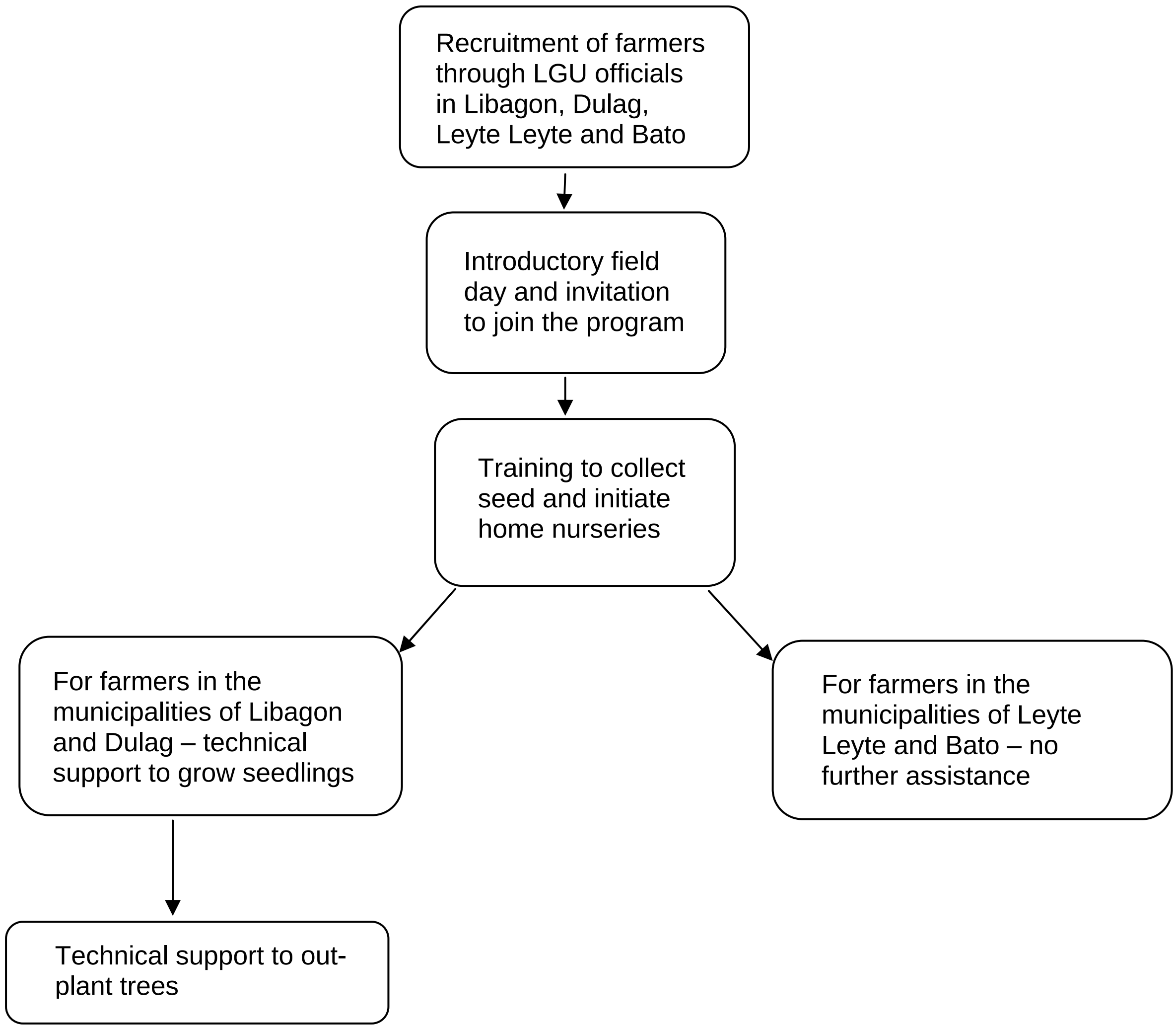

Figure 1. Stages in the conduct of the extension program, showing the delivery of extended extension assistance to farmers in the municipalities of Libagon and Dulang but not Leyte Leyte and Bato

Table 1. Participation in extension activities by smallholders in four municipalities in Leyte

Municipality	Number of farmers initially participating in the program	Number of farmers who established trees	Site survival after one year
Libagon	13	12	11
Dulag	9	7	3
Leyte Leyte	9	3	–
Bato	9	6	–
Total	40	28	

Identification of System Variables

To identify variables which had affected program outputs, data were collected as descriptive statistics, trip reports, visual observations, translated conversations with farmers, and opinions supplied by ACIAR extension staff. For each of the main extension activities, the variables were classified as either those which were addressed through program activities or those which were not (Table 2). It became apparent that even though the variables were imprecise and often best expressed as a probability, they could be arranged as a causal network in which parent variables influenced subordinate variables through to program outputs. This prompted the arrangement of the variables as a causal network and construction of preliminary models.

Table 2. System variables which were or were not addressed in the extension program

Main extension program activities	Variables which had been addressed	Variables which had not been addressed
Recruitment	Recruitment approach through LGU officials or advertisements Farmers' understanding of harvest legislation Farmers' perceptions of certainty of harvest	Land use Land availability Security of title Political favouritism Mayoral support LGU employee support
Written extension materials	Language in which materials are printed Text length Type of material (poster or pamphlet) Style of graphics	Farmers' reading ability Farmers comprehension of written materials Farmers' construal of the meaning of written materials
Development of self-efficacy	Competence in performing skills Understanding of underpinning theory Opportunity to ask questions and clarify issues Extended support to reinforce technical training	General education Social confidence
Attrition of participating farmers	Initial offer of assistance Extended support to reinforce technical training Destruction of sites through fire or grazing	Initial self-efficacy[1] Initial feasibility Unexpected problems

[1] Self-efficacy is defined in the appendix.

Construction of System Models

Choice of a systems modelling approach was complicated by the inclusion of both quantitative and qualitative variables, and the need to predict program outputs for varying levels of inputs. A clear visual display was also required to facilitate easy comprehension of models by stakeholders who were to be asked to validate model structure. Using these criteria, spreadsheets, mathematical models, multi criteria analysis and decision trees were not considered useful because they are difficult to explain to stakeholders (Cain 2001). In addition, causal loop diagrams do not represent the logical flow of extension activities. Neither is the concept of 'stock flow' diagrams (accumulation and changes to quantities in a system) easily aligned to modelling imprecise qualitative influences. However, Bayesian Belief Network (BBN) graphical models are suitable for probabilistic modelling through their ability to model cause and effect within systems.

BBNs consist of nodes (boxes) which represent system variables (each node having two or more classes), links which represent causal relationships and probabilities which quantify the chance that a node will be in a particular state given that its input (or parent) nodes are in particular classes. The graphical component of a BBN is called an *influence diagram* and consists of nodes and links. The mathematical component of a BBN uses Bayes formula to calculate the probability of the occurrence of an event (a conclusion) conditional on the occurrence of other events, (a premise). Variables which can be identified as causally influencing the outcome of other variables are linked into a network and variables further along the chain are modified by the influence of variables higher up. BBNs therefore show the logical consequences of linking the user's understanding of parts of a system into an integrated whole (Jensen 2001; Cain 2003). They are becoming an increasingly popular modelling tool in environmental management because they allow for the integration of biophysical, economic and social variables (McCann *et al.* 2006; Uusitalo 2007).

In Netica™ BBN modelling software, links encode the conditional dependencies between variables in probability tables. Probabilities inserted into the tables may be derived from empirical evidence or a personal belief and must be based on defensible evidence and reasoning (O'Hagen 2003). Alternatively, if the evidence is taken from a population which is being modelled, then the frequency distribution implicit in that data may be used as an approximation of the desired probabilities (Norsys 2007). The software also provides a sensitivity analysis capability which calculates *entropy reduction* to identify those parts of a model which most affect output variables.

For model construction, data were sourced from descriptive statistics which had been collected throughout the program and qualitative data derived from interviews, written opinions, visual observations by ACIAR staff and feedback from local government unit (LGU) officials. Overall, 52 farmers initially expressed interest in the program, with sub-sets of farmers involved in various aspects. This provided estimates of some variables which were likely to be more reliable than stakeholders' subjective opinions. However, other variables were qualitative and subjective, (e.g. farmers' reading ability) and were not easily estimated. Where necessary, this prompted sourcing of data from stakeholders in order to populate models.

Preliminary models of the four main extension activities were constructed following general recommendations for model construction. These are that models should be made as parsimonious as possible – capturing the main factors that link a program to its outcomes – without making models so complex that the sensitivity of the output variable to input variables is swamped by intermediate variables and validation becomes confusing (Cain 2001; Donaldson and Gooler 2003; Marcot *et al*. 2006). It was not possible to involve stakeholders directly in the construction of preliminary models. Therefore, after initial development, the preliminary models were pre-validated by an expert group of three Filipino researchers, ready for formal validation by stakeholders at a workshop in Leyte. Definitions of key variables are described in Appendix 1.

Supply of Personal Assistance to Stakeholders at the Validation Workshop

Validation of the preliminary models was premised on the definition proposed by Cain *et al.* (2003) that the validity of data elicited from stakeholders is contingent on inducing them to offer their own perspectives and participate in discussion. Because the results of the workshop could be compromised if shyness, reading or writing difficulties inhibited participants from responding fully to questions, we decided to employ a one-to-one ratio of assistants to stakeholders. The task of the assistants was to translate if necessary, recapitulate information or instructions, elicit a comment and to record a verbatim reply to each question. Fourteen staff were available to assist with the workshop and the number of stakeholders was also consequently set at 14.

Validating Model Structure and Populating the Models

The workshop had two objectives, to validate the structure of the preliminary models and where necessary, to populate the models. Using a simple model, a Cebuano-speaking facilitator first demonstrated the calculation of conditional probability. Each of the four models was shown to the participants and the meaning and definition of the variables were explicitly described. Stakeholders were then asked to comment whether they thought that the models and their constituent variables were realistic, and an accurate representation of the influences which affect farmers' motivation and engagement in small-scale forestry. They were also asked whether variables should be added, deleted or re-ordered. Finally, they were asked to assess the probability of the occurrence of each variable.

To indicate the likelihood of variables taking a particular state, participants were asked to indicate their opinion on a Likert scale and to make a written comment. To ensure that responses were only used when participants had understood the question, whenever stakeholders did not record a comment which matched their response on the Likert scale, their response was treated as invalid. Valid Likert scale responses were averaged and the resulting mean probabilities entered into BBN probability tables. If two or more parent variables influenced a child variable, participants were asked to weight the influence of the variables in *elicited probability tables* using the procedures described by Cain (2001).

Stakeholders comprised seven participants who actively farmed their land (farmers) and seven participants who were not actively involved with the physical labour of farming (non-farmers). The non-farmer group comprised stakeholders who had outside employment or positions in local government. It was possible that socio/economic differences between the farmer and non-farmer groups may have caused them to respond to questions differently. Therefore, because the sample size was small, for four variables, a non-parametric Mann-Whitney rank-sum test was performed for data supplied by both groups to test whether the farmer and non-farmer group had responded differently. The variables were:

1. On non-intensively managed farms, the probability of farmers having land on which to plant trees
2. The likelihood of political favouritism affecting recruitment in municipalities
3. Farmers' ability to read paragraphs, written in their local dialect
4. The incidence of insecure title to land.

These variables were chosen because they were examples of variables which were wholly or partly beyond the capacity of the extension program to control and which may become critical impediments to the success of a hypothetically expanded program.

RESULTS OF THE WORKSHOP

Stakeholders validated the structure of three models, i.e. the recruitment of farmers to an agroforestry extension program, the usefulness of extension materials and the development of self-efficacy. They also supplied almost all of the data which was used to populate the models. For a fourth model which described the attrition of participating farmers throughout a program, stakeholders validated the structure of the model but empirical data which had been collected during the extension program were used to populate probability tables.

For most questions, the assistants were able to record a comment which indicated that stakeholders understood the nature of questions. Overall, only 6.5% of responses were rejected because farmers did not supply a valid comment.

For the four variables to which the Mann-Whitney rank-sum test was performed for data supplied by the farmer and non-farmer groups, a test of probability estimates assigned by both groups showed that for each variable, there was no significant difference between the responses obtained from each group ($P >= 0.05$, two-tailed test). Data from all 14 stakeholders were therefore processed as one dataset.

Model 1: Farmers Recruited to an Agroforestry Extension Program

In preliminary questions, stakeholders provided a demographic snapshot of 'typical' farmers in Leyte. The average age of farmers in Leyte was estimated as being over 50, with 35% of them having only elementary education or not having attended school. Approximately 30% of farmers were estimated as being poor tenant farmers with a consequent low level of involvement in community affairs.

Stakeholders suggested that Model 1 should be treated first as the level of contact achieved with farmers at the municipal level (Figure 2) and second as the recruitment of farmers at a personal level (Figure 3). Stakeholders accepted that contact with farmers at the municipal level is affected by land-use, mayoral support, employee support and political divisions (Figure 2). Once farmers have been contacted, however, they considered that recruitment is contingent on land availability and farmers' perceptions of harvest certainty, as described in Figure 3. Harvest certainty was seen as being influenced by farmers' security of title to their land and their understanding of harvest legislation.

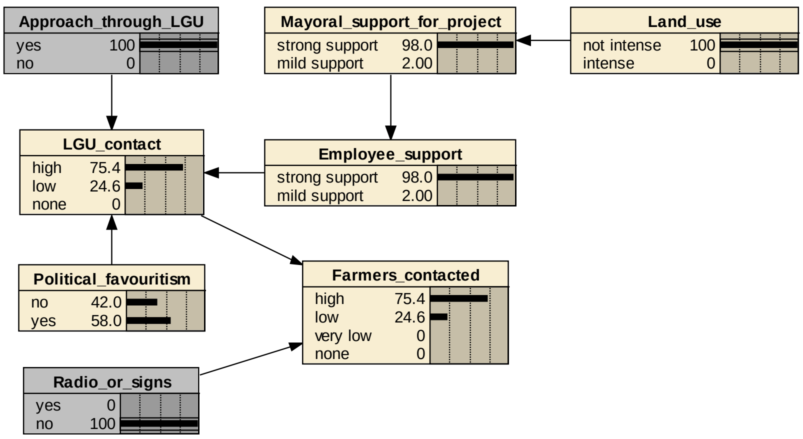

Figure 2. BBN model of the level of initial contact with farmers achieved through LGU staff or radio and signs

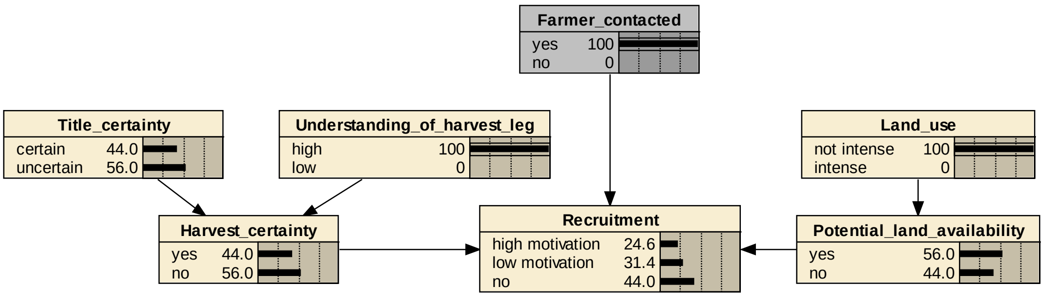

Figure 3. BBN model of influences which affect the motivation of farmers to be recruited to an agroforestry extension program

In Figure 2, the predicted level of support from municipal mayors is strongly influenced by the intensity of land use in the municipality. If typical farms are not intensively cultivated, strong mayoral support is highly probable (i.e. 98%), whereas if land in the municipality is typically intensively harvested, agroforestry or protective tree planting is not a political priority and the probability of strong mayoral support is predicted to be only 38%. This finding mirrors the results of the extension program and indicates that agroforestry programs are much more likely to be supported by elected officials and LGU staff in situations where land is not seen as being profitably used for annual crops.

For land which is not intensively farmed and where no political tensions exist in the community, the predicted probability of achieving a high level of contact with farmers is 96%, compared to 61% where divisions exist. Using empirical data collected during the program, the model was constructed so that the probability of contact with farmers is 'very low' if only radio announcements or signs are used to contact farmers. Despite detailed planning and execution, recruitment through these media in the municipalities of Libagon and Dulag (signs) and Baybay (radio) had been an almost complete failure. Stakeholders' commented that although political favouritism is a normal factor of rural Filipino life they envisaged that the culturally appropriate way to gain access to communities is via elected politicians.

For farms which are not intensively managed, stakeholders rated the probability of land being available to grow small numbers of trees[2] as being 56% compared to 38% for land which is intensively managed. On intensively managed land therefore, stakeholders still saw considerable scope for small-scale tree planting. Several stakeholders commented that farmers would always have a preference for growing annual crops, but that the security of these crops is difficult on plots of land some distance from the family home.

The probability of farmers having a high understanding of harvest legislation (25.6%) had been derived from interviews with 39 farmers during the extension program. In addition, at the workshop stakeholders considered that the probability of farmers having security of title was only 56%, this issue being a serious impediment to the development of farms in the Philippines. Using these data, only 11% of farmers are predicted to be certain of harvesting their trees ('harvest certainty', Figure 3). Alternatively, if an extension program provides information sessions so that all farmers have a high understanding of relevant legislation, the predicted probability of harvest certainty rises to 44%. An upper limit to the realistic likelihood of farmers being highly motivated to join an extension program is predicted to be 25% for a scenario in which harvest certainty is raised through an educational program and land use is not intense.

[2] The number of trees was nominally set as being at least 50 trees.

Model 2: Effectiveness of Written Extension Materials which are Used as an Extension Aid

The purpose of Model 2 is to supply answers to RQA by predicting the effectiveness of written extension materials as instructional aids or as 'stand-alone' documents. Using the design of extension materials which were developed for the program as a guide, the initial model was developed with 'language', 'text length', 'document length', 'graphics' and 'type of material' as parent variables. Key measures of effectiveness are farmers' comprehension of written material and the correct construal of meaning.

Stakeholders accepted the structure of Model 2 and provided data which predicts that farmers' reading ability is affected by both the language in which material is presented and the length of text, either phrases or paragraphs (Figure 4). Stakeholders' assessment of farmers' reading ability was that reading skills decline with increased text length and with departure from the local dialect to the national language or English. For extension material presented as phrases, the predicted probability of farmers having a high level of reading competency – in their local dialect (Cebuano or Waray Waray), Tagalog (the national language) and English – is 97, 84 and 58%, respectively (Table 3), whereas if material is presented as paragraphs, the predicted percentage of farmers having a high level of reading competency declines from 62 to 59 and 38%, respectively. These results preclude use of written material which is written in other than the local dialect.

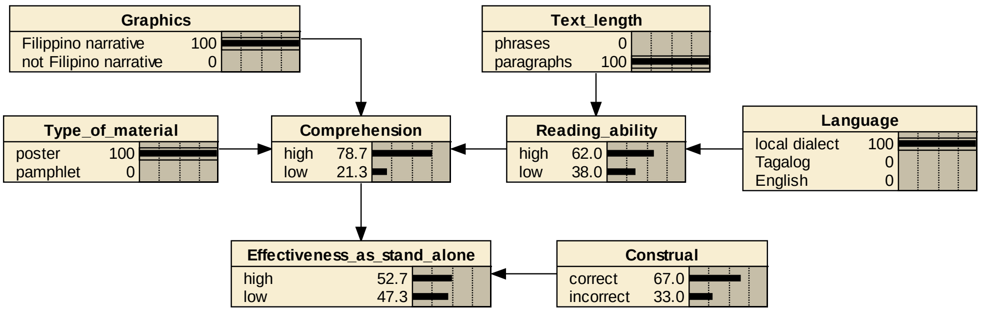

Figure 4. BBN model of the effectiveness of written extension materials as stand-alone extension aids

Table 3. Predicted probability of farmers being able to read either phrases or paragraphs in their local dialect, Tagalog or English

Language	Text presented as phrases	Text presented as paragraphs
Farmers having 'high' reading ability in their local dialect (%)	97	62
Farmers having 'high' reading ability in Tagalog (%)	84	59
Farmers having 'high' reading ability in English (%)	58	38

Stakeholders expressed a strong preference for 'Filipino style' narrative graphics rather than annotated diagrams. Using narrative graphics, and for extension material presented as pamphlets, the predicted probability of farmers having a high comprehension of extension material declines from 92% if farmers' reading ability is high, to 57%, if farmers' reading ability is low.

It would have been inappropriate to ask stakeholders about the extent to which farmers may misconstrue the meaning of extension information. However, previous interviews with farmers in which they had been asked to validate written extension materials, had indicated that their misconstrual of illustrations concerning pruning and thinning was 17% and 33%, respectively (Baynes *et al.* 2007). For scenarios where written material is presented as pamphlets, written in paragraphs in a local dialect and with narrative graphics, the predicted correct construal of extension material when used without verbal assistance declines from 62% (where the misconstrual rate is 17%) to 50% (where the misconstrual rate is 33%).

Model 3: Development of Farmers' Self-efficacy

Model 3 addresses the need for farmers to develop self-efficacy (RQA) and the resource requirements for a scaled-up program (RQC). Stakeholders accepted that farmers' social confidence during participation in extension activities is affected by their social status and their level of education. Hence, the principles of adult learning, as described by Knowles (1984), may not be applicable to some Filipino farmers because limited education and low social rank may inhibit them in extension situations. Consequently, Model 3 was modified so that farmers' social confidence is modelled as a surrogate of farmers' education (Figure 5).

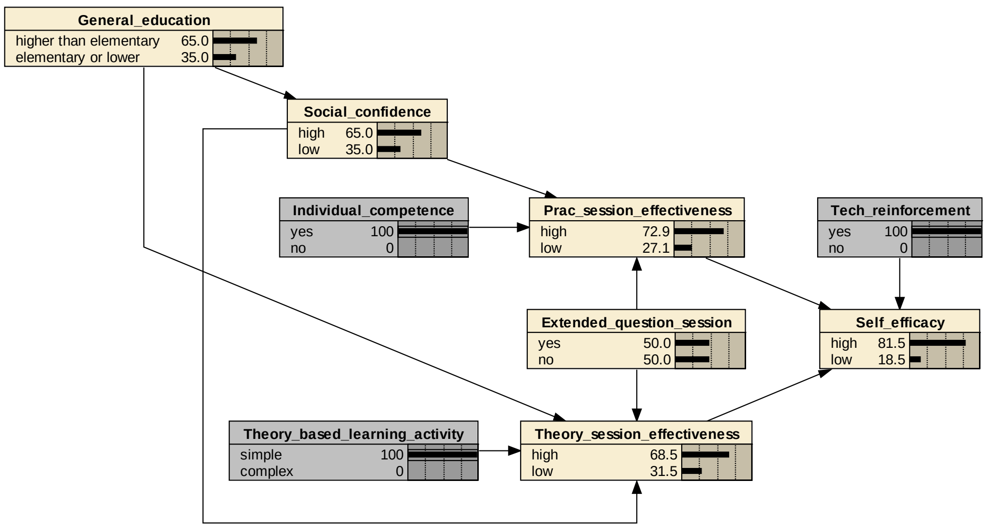

Figure 5. BBN model of the development of farmers' self-efficacy through training followed by technical reinforcement

In this model, if farmers' social confidence is high, predicted self-efficacy declines with the reduction of inputs from an optimal state, (i.e. individual competence, simple theory, extended questions and extended assistance) from 92 to 44% where inputs are in their most negative state (Table 4). Similarly, if farmers' confidence is low, self-efficacy declines from 77 to only 37% (Table 4).

A sensitivity analysis was undertaken of the sensitivity of 'self-efficacy' to variation in 'prac session effectiveness', 'theory session effectiveness' and 'technical reinforcement'. The entropy reduction – the uncertainty of the output variable which is expected to be eliminated if the true value of other variables is known – was 6.6% for 'technical reinforcement', 4.0% for 'practical session effectiveness' and 2.7% for 'theory session effectiveness'. These results indicate that extended assistance is the most critical success factor for the development of self-efficacy.

Table 4. Predicted probability of farmers achieving self-efficacy through the provision of practical and theory training and technical reinforcement

Technical reinforcement	Practical competence	Type of theory delivery	Questions encouraged	Farmers with high social confidence who achieve high self-efficacy	Farmers with low social confidence who achieve high self-efficacy
Yes	Yes	Simple	Yes	92	77
Yes	Yes	Simple	No	79	71
Yes	Yes	Complex	No	76	70
Yes	No	Complex	No	71	65
No	No	Complex	No	44	37

Model 4: Attrition of Participating Farmers throughout the Program

Using data which had been collected during the extension program, Model 4 describes the attrition of participating farmers throughout a program of this nature (Figure 6). The main variable within program managers' capacity to control is the provision of extended assistance. The model provides a response to both RQA and RQB by predicting the percentage of sites which are planted and survive, depending on the level of extension assistance. The model shows a decline in participation because: farmers already know how to establish trees; they decide that tree establishment is not feasible; unexpected problems occur; they lose interest over a period of time and planted trees are destroyed by grazing or fire (Figure 6).

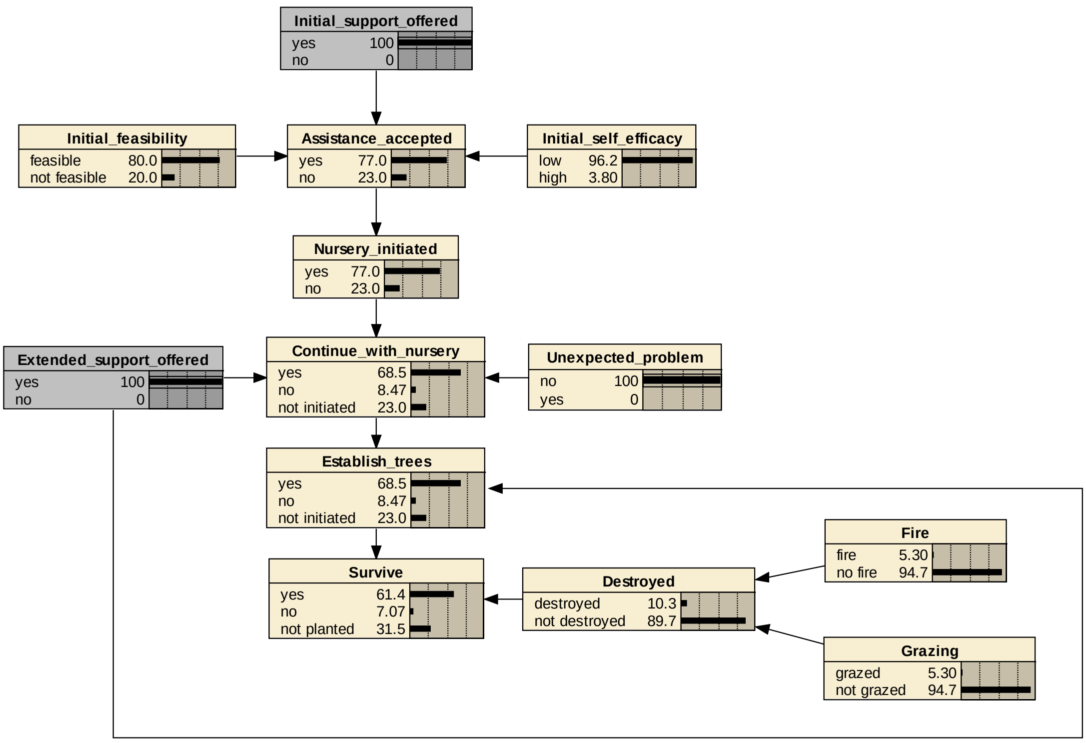

Figure 6. BBN model of attrition of farmers' participation in an agroforestry extension program

Only 77% of farmers who accept an invitation to an introductory field day are predicted to initially participate in a program and receive training to begin a home nursery. Some farmers are then predicted to lose interest and participation falls to 68% even if no severe problems occur (Table 5).

If expected problems are encountered at the nursery stage, and extended assistance is not provided, the predicted attrition of participating farmers is very severe, only 7% of farmers growing seedlings to the planting-out stage. In addition, if encouragement and extended assistance to plant trees are not provided the predicted establishment rate of sites is reduced to only 4%. Finally, for this scenario, a predicted loss of approximately 10% of sites which are destroyed in the first year, reduces the percentage of surviving sites to only 3%. Even if farmers do not encounter unexpected problems, if encouragement and support are not offered, the predicted tree establishment rate is only 36%, a reduction of almost half of participating farmers because they gradually lose interest or are distracted by other activities.

Table 5. Decline in predicted percentage of farmers participating in an extension program

Scenario	Farmer participation with extended assistance (%)	Farmer participation with initial assistance (%)
Encounter severe nursery problems but persist	68	7
Establish trees	68	4
Site survival after one year	61	3

DISCUSSION

One of the principal advantages of a systems approach to extension evaluation is that identification of system variables and assessment of their importance provides a rich picture of the socio-economic context in which extension takes place. A complementary disadvantage is that there is also the potential for stakeholders to accept spurious influences out of a sense of politeness or indifference. It is a Filipino characteristic to try to accommodate other viewpoints and attitudes (Carson 1978; Goldoftas 2006) and culturally sensitive variables may be ignored or glossed over in a workshop situation.

The ability of BBNs to accommodate imprecise estimates of qualitative variables is also highly advantageous in extension, which by definition is concerned with subjective human values and attitudes. Unfamiliarity with the concept of probability can limit the extent to which stakeholders can provide probability estimates and a variety of methods have been used to elicit data, e.g. a consensus based approach followed by expert group review (Henderson and Burn 2004) or a semi-structured questionnaire (Cain *et al.* 2003). Henriksen and Balebo (2007) used stakeholder opinion to populate models of groundwater management, but found that explaining BBNs was demanding and time consuming. For this workshop, ACIAR staff commented that without the individual assistance supplied to every stakeholder, little response may have been elicited from less socially-secure stakeholders. Personal assistance permitted translation and repetition of questions to individual stakeholders. ACIAR staff commented that this elicited responses which were genuine and considered.

For program managers the ability to analyse the sensitivity of program outputs to inputs may assist planning and re-direction of resources away from activities which are likely to be less successful. In addition, prediction of limits to program outputs allows appraisal of the fundamental worth of programs. A difficulty with this type of evaluation is that it must be carried out *ex poste* once the variables have been identified and their importance at least tentatively assessed. An *ex ante* evaluation may invite model construction based on speculation. For this program, several variables (e.g. farmers attitude to fencing or fire control) emerged only late in the program and the importance of a key impediment (title security) only emerged at the final workshop.

Usefulness of the Models to Supply Answers to the Three Research Questions

In providing a response to RQA, i.e. 'What extension activities and information are appropriate to recruit smallholder farmers in Leyte and to develop their self-efficacy so that they are able to continue the establishment of trees without further extension assistance', modelling showed that nursery-based technical information in particular, was valued by farmers and that personal assistance was highly effective in achieving technology transfer. A comparison of the predicted levels of contact with farmers for different levels of land-use intensity and political favouritism indicated that these variables are not critical impediments to an extension program. Contact with farmers is reduced substantially where political cronyism exists. However, stakeholders' comments – that it is unrealistic to expect an extension program to work in a politics-free environment – indicated that the influence of this variable may be unavoidable. In a similar manner, stakeholders saw considerable scope for planting small numbers of trees adjacent to intensively managed land. Recruitment is predicted to be less where these variables are not in a favourable state, but not critically.

Stakeholders' insistence that a low level of recruitment will be achieved if title security and harvest legislation issues are not resolved, indicated that these issues are critical impediments for an extension program of this nature. Strengthening land tenure and harvest rights is often described as a prerequisite for increased agroforestry adoption, e.g. in Panama (Fischer and Vasseur 2002), in Haiti (Murray and Bannister 2004) and in Sumatra (Suyanto *et al.* 2005). Our results indicate that in the Philippines, unless land tenure and harvest rights are secure, the adoption of agroforestry is unlikely to rise above its low existing level. Whereas farmers' knowledge of harvesting legislation can be easily remedied, title security cannot. Unfortunately the complexities of Filipino law preclude a simple remedy for farmers with insecure title. Addressing farmers' awareness of harvesting legislation is therefore a critical success factor for program recruitment and an opportunity which may be exploited in a scaled-up program.

As a further response to RQA, for the predicted 38% of farmers who have difficulty reading paragraphs written in their local dialect, the usefulness of written extension material is marginal. This is in accord with the findings of Kiptot *et al.* (2006) in Kenya, that technical information must be simplified to help farmers' understanding of complex principles. In this case, even when graphics are included to bolster comprehension, approximately one farmer in four is predicted to fail to comprehend written materials. The consequences of misconstrual of the intended meaning of extension literature are potentially more serious. Farmers' mental model of the world may be likened to an invisible force which guides their actions (Eckert and Bell 2005). Hence, for agroforestry extension in Leyte, this modelling indicates that use of written extension materials, if not supported by verbal explanations, is questionable.

For RQB, i.e. 'Will an extension program which offers technical advice and assistance be effective in improving the uptake of timber tree establishment and the silvicultural management of tree farms', the effectiveness of extension assistance is provided in the high level of predicted self-efficacy achieved when learning conditions are optimised to accommodate farmers with limited education and self-confidence. Self-efficacy is a precursor to adaption and experimentation with technology. Hence, because farmers' innovations are entry points for technology development and adoption (Katanga *et al.* 2008), variables which affect the development of self-efficacy are key drivers of program success. In this program, the predicted 35% of farmers who may be apprehensive in learning situations is concerning. These farmers are less likely to develop initial self-efficacy and are more dependent on reinforcement of skills and knowledge. Even in situations where farmers achieve initial competence, only extended assistance may enable farmers to deal with contingencies. Consequently, if unexpected problems occur and extended assistance is not provided, the predicted loss of farmers' participation is predicted to be catastrophic.

It was initially expected that lack of a production to commercialisation (P-C) chain for timber trees may be a constraint. A well-identified P-C chain provides crops with a distinct adoption advantage (Kwesiga *et al.* 2003; Clement *et al*. 2004), but in this program farmers had previously identified domestic use (to build a house) as a main reason for growing trees. For the development of small-scale forestry in Leyte, the development of a P-C chain may be an opportunity, but farmers did not identify it as a constraint.

As a further response to RQB, the refusal of approximately a quarter of farmers who attend an introductory extension activity to then participate in a program may not be an important negative influence. ACIAR staff commented that some farmers may enquire about a program to see what material benefits it may bring and a proportion of farmers are likely to be unable to come to an arrangement with parents, siblings or landlords which will allow them to participate. An early loss of participation of farmers from a program may not imply that recruitment methods are at fault.

Unfortunately, a predicted loss of approximately 10% of sites planted in the first year is a serious impediment to the further adoption and diffusion of tree establishment. Negative publicity emanating from the destruction of trees is a serious impediment which is not fully apparent in the model. Fencing is a prerequisite if there is a risk of trees being grazed and any form of fire control (e.g. liaison with neighbours) is highly advisable.

A response to RQC is collectively provided by responses to RQA and RQB. For a hypothetically expanded program, a constraint is that contact with farmers is only likely to be effected through elected officials. However, an opportunity to maximise recruitment is provided if farmers' fears of being unable to harvest trees in the future are addressed by providing information on harvesting legislation. Resource requirements for a hypothetically expanded program are predicated by the limited usefulness of written extension material and farmer's preference for personal contact with extension staff. Finally, the negative impact of farmers' reaction to the loss of trees through grazing or natural disasters represents a system variable over which program managers may have little control.

CONCLUSION

For the evaluation of this extension program, systems modelling provided insights into the values and socio-economic conditions of farmers which would have been difficult by other means. Use of the BBN modelling approach permitted construction of preliminary influence diagrams in which rearrangement of variables and causal links could be undertaken until a logical model emerged. Without the willing cooperation of stakeholders, validating and populating preliminary models would have been very difficult.

The system variable common to all four models is farmers' education and knowledge, either through their understanding of harvest legislation, comprehension and construal of written information, development of self-efficacy or their ability to cope with problems. Systems modelling highlighted the difficulty of targeting the cohort of farmers most in need of extension assistance – those with low education and social position. If these farmers are not explicitly targeted in program design, then the program may mainly benefit mainly richer or better educated farmers. Hence, to maximise the effectiveness of a hypothetically expanded program, extended assistance and support are necessary. Fortunately the high predicted success rate when extended assistance is provided indicates that programs of this nature may present an opportunity to help those farmers most in need.

REFERENCES

Bandura A (1994) Self-efficacy. In: VS Ramachaudran (ed.) *Encyclopedia of Human Behaviour*, vol. 4. Academic Press, New York, pp. 71–81

Baynes J, Monterola G and Pogosa A (2007) Development and validation of a pamphlet for small-scale forest extension. Paper presented to IUFRO 3.08 Conference. Ormoc City Leyte, the Philippines17-21 June 2007

Baynes J, Herbohn J and Russell I (2009) Bringing agroforestry technology to farmers in the Philippines: methodology and results of an extension program. *Small-Scale Forestry* (in press)

Bloom BS, Engelhart MD, Furst EJ, Hill WH and Krathwohl DR (1956) *Taxonomy of Educational Objectives; The Classification of Educational Goals*, Book 1, cognitive domain. David McKay, New York

Bloom BS, Hastings JT and Madaus GF (1971) *Handbook on Formative and Summative Evaluation of Student Learning*. McGraw-Hill, New York

Bloom BS, Madaus GF and Hastings JT (1971) *Evaluation to Improve Learning*. McGraw-Hill, New York

Cain J (2001) *Planning Improvements in Natural Resources Management*. Centre for Ecology and Hydrology, Wallingford, UK

Cain JD, Jinapala K, Makin IW, Somaratna PG, Ariyaratna BR and Perera LR (2003) Participatory decision support for agricultural management: a case study from Sri Lanka. *Agricultural Systems* 76(2): 457–482

Carson AL (1978) *The Story of Philippine Education*. New Day Publishers. Quezon City

Clement CR, Weber JC, Van Leeuwen J, Astorga Domian C, Cole DM, Arévalo Lopez LA and Aurgüello H (2004) Why extensive research and development did not promote use of peach palm fruit in Latin America. *Agroforestry Systems* 61(2): 195–206

Cramb RA and Purcell T (2001) Developing forage technologies with smallholder farmers: how to monitor and evaluate impacts. Impact assessment program, Working paper series No 41. Australian Centre for International Agricultural Research, Canberra

Donaldson SI and Gooler LE (2003) Theory-driven evaluation in action: lessons from a $20 million statewide work and health initiative. *Evaluation and Program Planning* 26(4): 355–366

Eckert E and Bell A (2005) Invisible force: farmers' mental models and how they influence learning and actions *Journal of Extension* 43(3): http://www.joe.org/joe/2005june/a2.shtml. Accessed 22 July 2008

Fischer A and Vasseur L (2002) Smallholder perceptions of agroforestry projects in Panama. *Agroforestry Systems* 54: 103–113

Goldoftas B (2006) *The Green Tiger: The Costs of Ecological Decline in the Philippines*. Oxford University Press, Oxford

Henderson JS and Burn RW (2004) Uptake pathways: the potential of Bayesian belief networks to assist the management, monitoring and evaluation of development-oriented research. *Agricultural Systems* 79: 3–15

Henriksen HJ and Barlebo HC (2007) Reflections on the use of Bayesian belief networks for adaptive management. *Journal of Environmental Management* 88(4): 1025–1036

Jensen F (2001) *Bayesian Networks and Decision Graphs*. Springer, New York

Katanga R, Kabwe G, Kuntashula E, Mafongoya PL and Phiri S (2007) Assessing farmer innovations in eastern Zambia. J*ournal of Agricultural Education and Extension* 13(2): 117–129

Kiptot E, Franzel S, Richards P and Hebinck P (2006) Sharing seed and knowledge: farmer to farmer dissemination of agroforestry technologies in western Kenya. *Agroforestry Systems* 68(3): 167–179

Knowles M (1984) *The Adult Learner: A Neglected Species*. Gulf Publishing Company, Houston

Kwesiga FK, Akinnifesi FK, Mafongoya PL, McDermott MH and Agumya A (2003) Agroforestry research and development in southern Africa during the 1990s: review and challenges ahead. *Agroforestry Systems* 59: 173–186

Marcot BG, Steventon DJ, Sutherland GD and McCann RK (2006) Guidelines for developing and updating Bayesian belief networks applied to ecological modelling and conservation. *Canadian Journal of Forest Research* 36: 3063–3074

McCann RK, Marcott BG and Ellis R (2006), Bayesian belief networks: application in ecology and natural resource management. *Canadian Journal of Forest Research* 36: 3053–3062

McGinty MM, Swisherr ME and Alavalapati J (2008) Agroforestry adoption and maintenance: self efficacy, attitudes and socio-economic factors. *Agroforestry Systems* 73: 99–108

Murray GF and Bannister ME (2004) Peasants, agroforesters and anthropologists: a 20 year venture in income-generating trees and hedgerows in Haiti. *Agroforestry Systems* 61: 383–397

Norsys (2007) Defining Node Relationships. http://www.norsys.com/tutorials/netica/secB/tut_B3.htm. Accessed 13 October 2008

O'Hagen A (2003) Bayesian statistics: principles and benefits. In: MAJS van Boekel, A Stein and AHC van Bruggen (eds) *Bayesian Statistics and Quality Modelling in the Agro-food Production Chain*. Proceedings of the Frontis workshop on Bayesian statistics and quality modelling in the agro-food production chain, Wageningen, Netherlands. Kluwer, Dordecht, pp 35–45

Owen JM (2006) *Program Evaluation: Forms and Approaches*. Allen and Unwin, Crows Nest NSW

Pretty JN, Simplice D and Vodouhê (1996) Using rapid or participatory rural appraisal. In: Swanson BE, Bentz RP, Sofranko AJ (eds) Improving agricultural extension; a reference manual. Food and Agricultural Organisation of the United Nations. http://www.fao.org/docrep/W5830E/w5830e02.htm#TopOfPage. Accessed 19 December 2008

Rossi PH, Lipsey MW and Freeman HE (2004) *Evaluation: A Systematic Approach*, Seventh edition. Sage Publications, Thousand Oaks, California

Sanna LJ (1992) Self-efficacy theory: implications for social facilitation and social loafing. *Journal of Personality and Social Psychology* 62(5): 774–786

Sterman JD (2002) All models are wrong: reflections on becoming a systems scientist. *System Dynamics Review* 18(4): 501–531

Suyanto S, Permana RP, Khususiyah N and Joshi L (2005) Land Tenure, agroforestry adoption and reduction of fire hazard in a forest zone: a case study from Lampung Sumatra, Indonesia. *Agroforestry Systems* 65: 1–11

Uusitalo L (2007) Advantages and challenges of Bayesian networks in environmental modelling. *Ecological Modelling* 203: 312–318

Appendix 1. Definitions of Models and Key Model Variables

Figure 2. 'Farmers Contacted by an Agroforestry Extension Program'

The model predicts the likelihood of farmers (who are potentially predisposed to growing trees) being contacted and responding to an invitation to join an extension program which offers assistance to grow trees.

Variable	Definition of each state
LGU contact	'LGU contact' is defined as 'high' in situations where more than 15 farmers (who may potentially be interested in growing trees) per municipality are contacted, invited to be included in program activities and respond to the invitation. 'Low' contact is defined as being contact with less than 15 farmers per municipality.
Farmers contacted	For the definition of this variable, it is assumed that farmers may be interested in information about growing and managing trees for a variety of reasons, e.g. planting, valuing, application of silviculture, curiosity or the material benefits which the program may bring. 'Farmers contacted' is defined as 'high' in situations where more than 15 farmers per municipality are contacted, invited to be included in program activities and respond positively to the invitation. 'Low' contact is defined as being contact with less than 15 farmers and 'very low' contact is defined as being contact with only one or two farmers per municipality.

Figure 3. 'Farmers Recruited to an Agroforestry Extension Program'

The model predicts farmers' motivation to join an agroforestry extension program. It is assumed that for farmers to join the program in a fully participative manner, they must have unused land for which there is no alternative use and they must have security of harvest.

Variable	Definition
Potential land availability	'Potential land availability' is defined as being 'yes' or 'no' depending on whether there is sufficient space to grow 50 or more trees, or not, either as a block, rows or as inter-plantings.
Recruitment	'Recruitment' is defined as 'high motivation' in situations where farmers, after being introduced to the program, are motivated to join the program and supply necessary inputs to establish trees. 'Low motivation' is defined as occurring in situations where farmers join the program (often to see what material benefits it will bring) but soon lose enthusiasm and abandon their efforts or establish a minimal number of trees. 'No' recruitment is defined as a decision to not join the program.

Figure 4. 'Effectiveness of Written Extension Materials as an Extension Aid'

This model predicts the probability of farmers being able to comprehend (as a personal belief) written extension materials. The model also predicts the probability of farmers being able of construe the correct interpretation of written material which is available in information booths.

Variable	Definition
Graphics	'Graphics' are defined as being the pictorial accompaniment to text.
Language	'Language is defined as being either the local dialect (Cebuano or Waray Waray), The Philippines national language (Tagalog) or English.
Reading ability	'Reading ability' is defined as being 'high' in situations where farmers can read (i.e. understand words and sentence structure) texts of phrases or paragraphs. 'Low' reading ability is defined as the ability to only read simple well-known instructions and signs only. In this situation, farmers are heavily dependent on accompanying graphics.
Comprehension	'Comprehension' is defined as the meaning which farmers place on text or graphics and is defined as being 'high' when farmers are able to decipher meaning from texts and graphics and 'low' when farmers are unable or only partly able to decipher a partial meaning from texts and graphics.
Construal	'Construal' is defined as being an interpretation or mental construction which is put on text and graphics. Construal is defined as being 'correct' or 'incorrect' depending on farmers' ability to construe the correct extension message or not.
Effectiveness as a stand-alone extension aid	'Effectiveness of a stand-alone extension aid' is defined as the percentage of farmers who both comprehend written extension materials and correctly interpret the extension message

Figure 5. 'Development of Farmers' Self-efficacy'

This model predicts the development of farmers' self-efficacy – their development of self-confidence to the stage where they are confident of growing seedlings and establishing trees in the future.

Variable	Definition
General education	'General education' is defined as being either 'higher than elementary' or 'elementary of lower'. In the first category, farmers can read (i.e. understand words and sentence structure) of texts of phrases or paragraphs and can undertake simple mathematical computations, (e.g. calculate area from measurements of length and breadth). 'Elementary or lower" is characterised by an inability to perform these functions.
Individual competence	'Individual competence' is aligned to level 3 of Bloom's taxonomy for psychomotor skills, the 'yes' state being achieved when farmers are able to repeat (after practice) skills which are shown to them. The 'no' state is defined as a lack of competence at level 3. The premise underpinning this use of the taxonomy is that it was developed by Bloom *et al.* (1956) and Bloom *et al.* (1971) as a hierarchy of levels of learning behaviour to assist the design and assessment of learning activities. For psychomotor skills, level 3 of Bloom's taxonomy is the ability to repeat simple skills with precision, higher levels requiring integration of multiple skills. Therefore we used level 3 as being a minimum proficiency level which may lead to the development of self-efficacy.
Theory-based learning activity	'Theory-based learning activity is defined as being the supply of underpinning theoretical information in an extension program. The 'simple' state of this variable is achieved at level 2 of Bloom's taxonomy for cognitive functions in which information is understood. The 'complex' state of this variable is achieved when the delivery of theory exceeds level 2 and requires learners to apply, analyse, synthesise or evaluate information.
Self-efficacy	In general, 'self-efficacy' is defined as a personal belief about a capability to perform certain actions and exercise influence over life-affecting events (Sanna 1992; Bandura 1994). It is an important factor in determining subsequent adoption of technology (McGinty *et al.* 2008). In model 3, self-efficacy is defined as 'high' when farmers are sufficiently confident about undertaking the activity and lack of knowledge or skills is not an impediment. It is defined as 'low' when farmers are not confident about undertaking the activity.

Figure 6. 'Attrition of Participating Farmers throughout a Program'

This model predicts the attrition of farmers throughout a program, either because establishing trees is not feasible for them, they already have the required knowledge, they meet unexpected problems, lose interest or their trees are destroyed by natural disasters or grazing.

Variable	Definition
Initial feasibility	'Initial feasibility' is defined as being the initial practicality or possibility for farmers to establish and grow trees. It is defined as being 'feasible' or 'not feasible depending whether farmers have the land, title security, finance and time to undertake agroforestry.
Unexpected problem	'Unexpected problem' is defined as being the occurrence, either 'yes' or 'no', of an event which causes severe unexpected problems which are beyond the capacity of farmers to manage.