A systems approach to improving the quality of tree seedlings for agroforestry, tree farming and reforestation in the Philippines

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ABSTRACT

The limited supply of high quality planting materials for a wide species base is a major reason for the limited success of reforestation programmes or projects in many developing countries. This paper reports the research that was undertaken to improve the supply of high quality planting materials for agroforestry, tree farming and reforestation in the Philippines. A systems approach was used to identify mechanisms to improve the operational effectiveness of the forest nursery sector. A Bayesian Belief Network of the forest nursery sector was developed to examine the interactions between the key components of the forest nursery sector, identify key leverage points for intervention and explore potential impacts of possible policy interventions. Although improving the operational effectiveness of individual, communal and government nurseries will result in high operational effectiveness of the forest nursery sector, the operational effectiveness of government nurseries is likely to have a negative impact on the market for seedlings from smallholder nurseries i.e. individual and communal nurseries, thus impeding the sustainability of smallholder nurseries. Increasing the supply of high quality germplasm for a wide variety of species, improving the technical capabilities of smallholder nursery operators in seedling production and increasing the market demand of high quality seedlings from smallholder nurseries are the most important requirements for improving the operational effectiveness of the forest nursery sector. However, government nurseries can play a crucial role in improving the effectiveness of the forest nursery sector by diversifying their production to focus on species that are in demand by smallholder farmers and which cannot be supplied by individual or communal nurseries. Failing to do this will result in the current situation continuing in which government nursery sector competes with private and communal nurseries.

Introduction

The success of agroforestry, tree farming and reforestation initiatives in many developing countries is often constrained by the lack of planting materials and low quality of planting stock (Aalbaek, 2001; Noordwijk et al., 2003; Harrison et al., 2008a). The lack of planting materials and low quality of planting stock can be attributed to a plethora of factors including the lack of technical skills to produce high quality seedlings, the limited access of seedling producers to high quality germplasm, the absence of incentives to produce high quality planting stock, and the lack of appreciation of tree farmers on the importance of seedling quality

(Gregorio et al., 2010a; Nyoka et al., 2014). In addition, often the metrics to measure performance of reforestation are associated with government or NGO targets for number of trees planted rather than the long term performance of those trees (see Le et al., 2012, 2014) and this results in the limited concern of the agencies responsible for watershed rehabilitation to ensure the use of high quality seedlings in reforestation, agroforestry and tree farming programmes (Nyoka et al., 2014).

In the tropics, nursery-grown seedlings are the commonly used planting stock for plantation forestry (Evans and Turnbull, 2004), including trees for community-based forestry programmes and agroforestry. Accordingly, the quality and availability of planting stock is largely influenced by the operational effectiveness of the nursery sector (Degrande et al., 2013; Nyoka et al., 2014). In the Philippines, while seedlings for watershed rehabilitation programmes are supplied by nurseries from private and government sectors, low seedling quality and limited availability are still regarded as major impediments to the scaling up of smallholder forestry (Gregorio et al., 2008, 2010a,b; Harrison et al., 2008b) and

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improving the success of reforestation programmes in the country (Lapis et al., 2001; Combaliser et al., 2010; Israel and Lintag, 2013). In addition, poor silviculture of smallholder and community woodlots has resulted in poor timber yields relative to site potential (Herbohn et al., 2014) and use of higher quality seedlings is likely to lead to improved yields of timber from reforestation activities with a timber production component.

The paradigm shift of forest management to people-based forestry has transferred the bulk of seedling production to private seedling producers and community organisations. Training programmes have been provided to seedling producers but these initiatives failed to increase the supply of high quality seedlings for reforestation projects and private tree plantations in the Philippines (Lapis et al., 2001; Tolentino et al., 2002). A review of literature revealed that there is dearth of knowledge about the operational effectiveness of the forest nursery sector in the Philippines. While some limited research has been carried out regarding the technicalities of producing high quality seedlings, there has been no comprehensive investigation of the management practices and organisational systems of the forest nursery sector.

To investigate ways in which the supply of high quality planting materials to smallholder tree farmers can be increased, a study was conducted on the forest nursery sector of Leyte Province. The purpose of the study was to examine the interactions between the components of the forest nursery sector, develop a nursery sector model to identify key leverage points for interventions, and use the nursery sector model to explore potential impacts of possible policy interventions.

This paper describes the participatory development of a Bayesian Belief Network (BBN) to model the forest nursery sector in Leyte, the Philippines and the subsequent application of this model to identify potential interventions or leverage points to improve the operational effectiveness of the forest nursery sector. The paper commences with an overview of BBNs as a tool for policy analysis. This is followed with a description of the study site and the nursery sector in Leyte. The development and structure of the BBN model for nursery effectiveness is then outlined. The results of the application of the model to identify important leverage points are presented and the key policy implications are discussed.

Research method

An overview of Bayesian Belief Network

Bayesian Belief Networks (BBNs) are conditional probability models in graphical form that show the cause and effect relationships between variables within systems (Jensen, 2001). They consist of nodes that represent system variables, links that represent causal relationships between nodes, and probability tables that quantify these relationships using conditional probabilities. BBNs can be used for predictive, diagnostic and sensitivity analyses, and because they use probabilities to relate variables, they explicitly allow uncertainty to be accommodated in predictions. These BBN attributes have made them attractive to a number of disciplines (including medicine, engineering, information technology, ecology and environmental management) that use a systems approach in decision-making, whilst accommodating uncertainty of evidence. In natural resource management, BBNs have been particularly useful for capturing, integrating and presenting knowledge about ecological and socio-economic systems (see McNay et al., 2006; Pollino et al., 2007; Smith et al., 2007). BBNs have been used to engage stakeholders and natural resource managers in systems analysis and decision-support utilising both expert opinion and empirical data in modelling systems (see Cain et al., 2003; Smith et al., 2005, 2007; McCann et al., 2006; Bosch et al., 2007;

Baynes et al., 2011). BBNs have also been applied to the adaptive management of natural resources (Nyberg et al., 2006; Henriksen and Barlebo, 2007). Although regarded as a user-friendly and versatile decision support tool, the BBN has a limitation of increasing dilution effect of impacts of interventions with increasing distance between the intervention and objective nodes within the model structure. This shortcoming can be offset through careful design of the model in such a way that it closely represents the real world.

The diversity and complexity of factors that influence the operational effectiveness of the forest nursery sector in Leyte Province, and the limited experience of stakeholders in using models in decision-making, make BBNs a highly suitable systems analysis tool for identifying interventions to improve the operational effectiveness of the forest nursery sector. In this study, a BBN was used to piece together the network of influences among key biophysical and socio-economic factors believed by the researchers to affect the supply of high quality planting stock within the Leyte nursery sector. Then, through scenario and sensitivity analysis capabilities, the BBN has been used to identify policy interventions that are potentially useful to solve the problem of limited availability of planting stock and low access of smallholders to high quality planting material.

Description of the forest nursery sector and the study site

Leyte Province has a total land area of 626,826 ha of which 35% is classified as timberland[2]. As of 2010, the province of Leyte had a population of 1.73 M (NSCB, 2010). Agriculture plays an important role in the economy of the province. The majority of the farmers in Leyte province have landholdings of not more than 5 ha (Groetschel et al., 2001). The main source of income for most of the population is the production of agricultural crops (mainly rice, abaca and copra), raising livestock and harvesting marine products.

As in most parts of the Philippines, forests were the major natural resource on Leyte Island in the early 1900s. Large-scale logging operations and conversion of forestland to agriculture, however, have largely resulted in a massive decline of forest cover on the island (Groetschel et al., 2001). Many attempts have been made by the Philippine government and international support agencies to rehabilitate the denuded uplands and halt destruction of the remaining forest. The most recent initiative is the promotion of community forestry, which recognises people as a vital component of the entire forest protection and rehabilitation process.

The bulk of seedlings used in smallholder forestry come from the three nursery groups – private, communal and government-owned. Private nurseries are usually established by individual farmers and are operated with the help of family members to produce planting stock, mainly for use on their own farm. A number of private nurseries also sell seedlings to other farmers and sometimes to government agencies. Most of these nurseries were established in response to the difficulty in obtaining planting stock from government nurseries, which are usually far from villages and hence inaccessible to most smallholders. The nursery is usually temporary in nature and is generally established next to the house of the operator for ease of maintenance and security against pilfering and stray animals. This type of nursery usually continues to operate for more than one planting season. Although most of the nurseries are established primarily to produce planting stock for personal use, the nursery operation is usually flexible to shift to commercial production whenever an opportunity to sell seedlings arises.

Communal nurseries are established by a group of people in the community for the purpose of producing planting stock for

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[2] In the Philippines, the DENR classifies all rural land in the public domain with a slope of 18% and above as *timberland*.