INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 9, No. 4, p. 219-231, 2016
http://www.innspub.net

RESEARCH PAPER | OPEN ACCESS

Land suitability analysis of the most preferred tree species in production forest areas

Basir Achmad*

Faculty of Forestry, Lambung Mangkurat University, Banjarbaru, Indonesia

Article published on October 30, 2016

Key words: Community, Land-suitability analysis, Rubber tree plantation, Land characteristics

Abstract

In supporting the People's Plantations program of the Government of Indonesia, the species planted should be preferred by communities. In addition, the land characteristics where the species will be planted should match with growth requirements of the most preferred tree species. Based on the interview with the communities, the most preferred tree species was the rubber tree with some reasons: (1) the tree species provided cash income continuously for a long-term period (100%), (2) they were easy to sell (89%), (3) they were easy to plant and maintain (86%), and (4) the communities were familiar with the tree species (79%). But on the basis of land suitability analysis, the land system characteristics did not match with the growth requirements of the rubber tree species. The unsuitability of the land system unit characteristics to the rubber tree growth requirements were mostly caused by (1) temperature regime, (2) water availability, (3) rooting conditions, (4) nutrient availability, and (5) terrain. However, based on financial analysis, rubber tree species was viable to cultivate because with a community's own labor system, the Internal Rate of Return was 47%, and with a hired labor system, the Internal Rate of Return was 29%. The two IRRs were greater than the social discount rate (12%). Therefore, the rubber tree species was suitable to plant for the People's Plantations program. The land suitability analysis had successfully discovered and tried to solve the problems that hampered the rubber tree growth so that rubber tree plantations will be more productive and sustainable.

***Corresponding Author:** Basir Achmad ✉ basir.achmad@unlam.ac.id

Introduction

Tree plantation planning in Indonesia, especially in forest areas, applied a top-down approach. In this case, the local governments at district levels proposed tree plantation projects to higher-level institutions, and then the central government determined the species to be planted, while the local government determined tree-planting locations. In such processes, tree species planted were determined by the government. Consequently, most tree plantation projects failed because the tree species planted were not familiar to the communities. Therefore, in this study, the local communities were involved in selecting tree species for tree plantations.

In implementing tree plantations, the local communities should be given rights and responsibilities in the activities starting from seed procurement, nursery, planting, maintenance, harvesting, and timber selling. The government should only provide information, extension, and training regarding these activities. In addition, the government should give them incentives such as supporting administration, free fees, and safety in using forest areas for tree plantations.

The ideas above have been accommodated by the Government of Indonesia through the PP program in accordance with the Regulation of Minister of Forestry No. P.23/Menhut-II/2007 concerning the procedures for licensing the utilization of forest products (wood) at PP in forest plantations. Van Noordwijk (2007) contended that the objectives of this program were to increase forest development and economic growth, and reduce national unemployment and poverty (pro-growth, pro-job, and pro-poor). This program was implemented on government production forest lands, particularly in logged-over areas and damaged forests. Another factor that has to be considered in tree plantations is the familiarity of the local communities with the tree species. Warner (1994) explained that a key aspect of tree management was the selection of tree species to plant by the community or individual households. Furthermore, Warner (1994) explained that the selection of particular tree species was more related to social and economic issues than to technical considerations. Some species were familiar to farmers because they were useful to communities and suitable for local land use patterns, and required a management regime that was compatible with the labor and input requirements of the entire production system.

In addition, Sitorus (1985) affirmed that in land suitability and capability systems, socioeconomic criteria are also important, and in fact they are dominant criteria in determining values and optimal land uses. Djaenudin *et al.* (1993) stated that the result of land analysis is one of criteria in selecting commodities to be developed in a certain land. Actually, in selecting the commodities, not only based on land suitability classes but also the economic values of the commodities should be considered. So in the present study, besides land suitability of the most preferred tree species, the economic value of the most preferred tree species was also analyzed. The objective of the research was to analyze: (1) the most preferred tree species by communities, (2) the land suitability of the most preferred tree species, and (3) the financial aspect of the most preferred tree species.

Materials and methods

Study Areas

The research was conducted in the production forest areas of Banjar district, South Kalimantan province, Indonesia. The areas outside the production forest areas, or the areas owned by communities, were excluded because it was assumed that there were no problems regarding tree species selection. Banjar district is located at 2°49'55" - 3°43'38" SL and 114°30'20" - 115°35'37" EL.

Primary Data

In determining the most preferred tree species by the communities for the PP program in the production forests of Banjar district, the communities in the village samples were interviewed using questionnaires with open-ended questions regarding tree species for tree plantations. Open-ended questions meant that the communities were asked to answer the questions without being provided answer choices.

In this case, the communities were able to mention more than one tree species. The most preferred tree species was the species that had the highest percentage of preferences.

The communities were from seven villages situated in the production forest areas. The villages were selected based on a cluster method, whereas the communities were selected randomly after excluding the communities who did not engage in agriculture activities. The seven village samples were Alimukim, Sumber Baru, Kahelaan, Kupang Rejo, Belimbing Baru, Angkipih, and Peramasan Bawah. The numbers of respondents interviewed were 124 individuals (5%) of the total population from the seven villages.

Secondary Data

Land Characteristics used for land suitability analysis (LSA) were obtained from the Center for Soil Research/Food and Agriculture Organization (CSR/ FAO) Staff (1983). In general, land units in land suitability analysis should contain 15 land characteristics grouped into seven land qualities, which were presented in Table 1. In matching the land characteristics with tree growth requirements based on CSR/FAO Staff (1983), there were three levels of suitability classifications: Land Suitability Order, Land Suitability Classes, and Land Suitability Subclasses.

Land Suitability Order consisted of two suitability orders: Suitable (S) and Not Suitable (N). Order S Suitability means land on which sustained use of the kind under consideration is expected to yield benefits which justify the inputs, without unacceptable risk of damage to land resources. Order N Not Suitable means land which has qualities that appears to preclude sustained use of the kind under consideration.

Table 1. Land quality and land characteristic components.

Land Quality		Land Characteristics	
Symbol	Item	Symbol	Item
T	Temperature regime	1	Annual average temp. (°C)
W	Water availability	1	Dry month (< 75 mm)
		2	Average annual rainfall (mm)
R	Rooting conditions	1	Soil drainage class
		2	Soil texture (surface)
		3	Rooting depth (cm)
F	Nutrient retention	1	Cation Exchange Capacity (CEC) me/100 g soil (subsoil)
		2	pH (surface soil)
N	Nutrient availability	1	Total Nitrogen
		2	Available P_2O_5
		3	Available K_2O
X	Toxicity	1	Salinity mmhos/cm (subsurface)
S	Terrain	1	Slope (%)
		2	Surface stoniness
		3	Rock outcrop

Source: (CSR/FAO Staff, 1983).

In addition, a land Suitability Class comprises three Suitability Classes: Highly Suitable (S1), Moderately Suitable (S2), Marginally Suitable (S3), and Not Suitable Class (N). Sitorus (1985) divided the Class not Suitable (N) into N1 (Currently not Suitable) and N2 (Permanently not Suitable). Land Suitability Subclasses reflect several kinds of limitations. Sub-classes are indicated by lower case letters following Class symbols S2 and S3 and Order symbol N. There are no subclasses in Class S1 as this by definition has no significant limitations.

Drissen and Konijn (1992) declared that description of the suitability classes was as described in Table 2. In addition, Land Suitability Subclasses were also applied because this classification reflects potential suitability after solving limitations of lands. The subclass of land units were matched with tree species requirements. In this case, a basic principle in the matching exercise was applied which is “the law of the minimum.” This means that the most limiting rating out of the land characteristics grouped in a single land quality is taken as the rating for that quality.

For example, if land characteristics grouped under land quality r- "Rooting Conditions" produce ratings for wet land rice: soil drainage class (S1), soil texture/surface (S2), and rooting depth (S3), then the suitability rating for land quality r- "Rooting Conditions" will be S3 with the symbol S3r.

Table 2. Land suitability classes.

Class	Description
Highly Suitable (S1)	Lands having no significant limitations to the sustained application of the given type of use, or only minor limitations that will not significantly reduce productivity or benefits and will not raise inputs requirement above an acceptable level.
Moderately Suitable (S2)	Land having limitations that in aggregate are moderately severe for sustained application of the defined use; the limitations reduce productivity or benefits, or increase required inputs to the extent that the general advantage to be gained from the use, although still attractive, will be appreciably inferior to that expected from class S1.
Marginally Suitable (S3)	Land having limitations that in aggregate are severe for sustained application of the defined use and will reduce productivity or benefits, or increase required inputs to the extent that the defined use will be only marginally justified.
Currently not Suitable (N1)	Land having limitations that may be surmountable in time but that cannot be corrected with existing knowledge at a currently acceptable cost; the limitations are so severe as to preclude the defined land-use at present.
Permanently not Suitable (N2)	Land having limitations that appear so severe as to preclude any possibility of successful sustained application of the defined land-use.

Source: Driessen and Konijn, 1992.

Mantel *et al.* (2007) explained that matching the land and soil information with the plant requirement information produces ratings that indicate the adequacy of land quality for tree cultivation under given conditions of management and inputs. In addition, Mantel *et al.* (2007) stated that the most limiting factor is assumed to determine the overall suitability rating in accordance with "Liebig's Law of the Minimum." This law states that crop growth is based not on the total of resources available, but crop performance is limited by the scarcest resource.

Land system unit characteristics were obtained from the RePPProT of Indonesia (1990). These land characteristics were matched with the requirement growth of the most preferred tree species. A land system map was a map containing detailed land characteristics produced by the RePPProT. Land systems were natural ecosystems in which rocks, climate, hydrology, topography, soil and organisms were correlated in a specific way (RePPProT, 1990 in Poniman *et al.*, 2004). The land systems provided useful information for regional planning, which enabled rapid identification of land suitability for specified types of land use.

The RePPProT land systems as the land resource data were one of the thematic geospatial data useful for supporting spatial land use planning (Poniman *et al.*, 2004). The land systems after being extracted to "Production Forest Areas" were presented in Fig. 1.

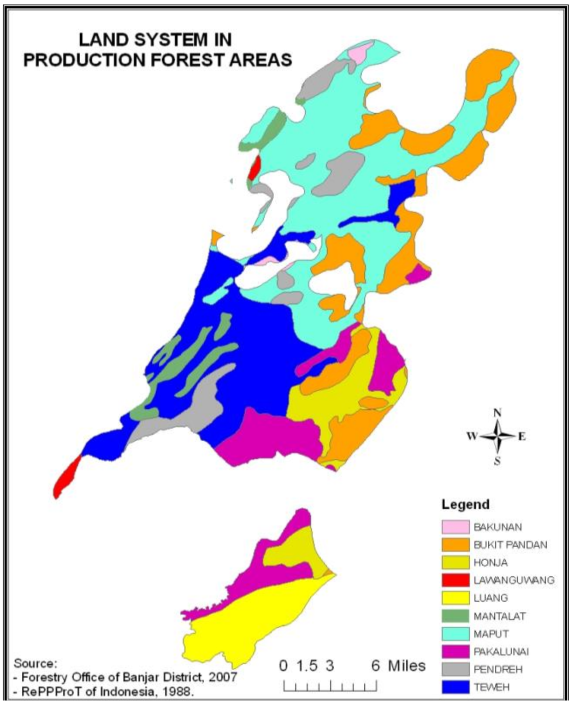

Fig. 1. Land system units in production forest areas.

Based on Fig. 1, production forest areas had 10 types of land system units, i.e. Maput, Teweh, Bukit Pandan, Pakalunai, Luang, Honja, Pendreh, Mantalat, Lawanguang, and Bakunan. Yet, the production forest areas were only dominated byfour types of land system units, which are Maput, Teweh, Bukit Pandan, and Pakalunai. The four types of the land system units occupied 74.46% of the production forest areas. In detail they were presented in Table 3.

Table 3. Land system units in production forest areas.

Land System Unit	Area (ha)	Percentage (%)
Maput	26,154.01	26.76
Teweh	20,268.92	20.74
Bukit Pandan	15,860.65	16.23
Pakalunai	10,489.24	10.73
Luang	6,969.87	7.13
Honja	6,893.13	7.05
Pendreh	6,276.61	6.42
Mantalat	3,606.70	3.69
Lawanguang	657.53	0.67
Bakunan	549.67	0.56
TOTAL	97,726.33	100.00

Analysis

In determining the most preferred tree species by the communities for the PP program in the production forests of Banjar district, the communities in the village samples were interviewed using questionnaires with open-ended questions regarding tree species for tree plantations. The most preferred tree species was the species that had the highest percentage of preferences.

In determining whether the most preferred tree species by the communities is suitable to plant in the production forest areas, the LSA was done. In this analysis, the characteristics of land system units in the production forest areas were matched with the growth requirements of the most preferred tree species.

In analyzing whether the most tree species is feasible to plant in the forest areas of Banjar district, it was analyzed financially. The role of the financial analysis was to evaluate private returns of a project or an activity in the present time (present worth). The present worth in general applies three criteria of investment: Net Present Value (NPV), Benefit Cost Ratio (BCR), and Internal Rate of Return (IRR).

Results and discussion

The number and percentage of respondents providing preferences on the preferred tree species were described in Table 4. According to Table 4, the tree species that had the highest percentage of preferences was the rubber tree (*Hevea brasiliensis*).

Table 4. Number and percentage of respondents providing preferences on the preferred tree species.

Tree Species	Botanical Name	Number of Respondents	Percentage (%)
Rubber	*Hevea brasiliensis*	124	100.0
Candlenut	*Aleurites moluccana*	79	63.7
Coffee	*Coffea* sp.	66	53.2
Durian	*Durio zibenthinus* Murr.	58	46.8
Teak	*Tectona grandis*	41	33.1
Langsat	*Lansium domesticum*	15	12.1
Sungkai	*Pronema canescens* Jack.	11	8.9
Cempedak	*Artocarpus cempeden*	4	3.2
Petai	*Parkia speciosa*	3	2.4
Cacao	*Theobroma cacao*	2	1.6
Jabon	*Antocephalus cadamba*	1	0.8

In general, the criteria used by the communities in selecting tree species were (1) the tree species provided cash income continuously for a long-term period (100%), (2) they were easy to sell (88.7%), (3) they were easy to plant and maintain (85.5%), and (4) the communities were familiar with the tree species (79.0%).

Familiarity factor on this point had the lowest percentage because a part of communities that were living in and around the forests and active in agricultural work were from Java and Madura Islands (outsiders). They came to the villages through either transmigration programs or self-transmigration. The indigenous people themselves tended to sell their land to outsiders because they believed that earning quick cash is more important than cultivating a land. After selling their land, they sought for a job to earn cash, such as panning for gold.

Based on the interviews, the intentions of the communities in planting trees were (1) earning cash (100%), (2) bequeathing the trees and farming lands to descendants (78.2%), marking land ownership (76.6%), for firewood (45.2%), land borders (43.5%), shelter (43.5%), construction materials (39.5%), and fence materials (25.8%). Based on data above, the communities emphasized three benefits in planting trees, i.e. earning cash, preparing trees and lands to descendants, and marking land ownership. These results showed that cash income was extremely important to the communities to supply their daily needs. In addition, bequeathing trees and lands to their children and grandchildren was also important. They assumed that it would be difficult to acquire a land in the future because of high competition with outsiders and high population growth.

Likewise, marking land ownership in the field was also very difficult. One way considered safe was planting trees on the borders of the lands, and this was the commonest way to mark land ownership in and around the forests.

Since the rubber tree was the most preferred tree species by the communities, the land system unit characteristics were matched with the growth requirements of the rubber tree species. The result showed that the land system units ranged from most suitable (S1), suitable (S2), marginal suitable (S3), to not suitable (N) based on the requirements of rubber tree species. However, based on the "Liebig's Law of the Minimum," the characteristics of the land system units did not match with the growth requirements of rubber tree species. Description of the unsuitability of each land system unit to be planted with rubber tree species was described in Table 5.

That all land units were not suitable for rubber tree plantations. The reason was, several land characteristics of the land units were not matched to the rubber tree requirements. Mantel *et al.* (2007) avowed that matching of land and soil information to the plant requirement information produces ratings that indicate the adequacy of land quality for tree cultivation under predefined conditions of management and inputs.

Table 5. Description of the unsuitability of each land system unit to be planted with rubber tree species.

Land System Unit	Land Suitability Rating	Description
Teweh	Nw,n	Not suitable because of water availability (dry months) and nutrient availability (P_2O_5).
Maput	Nt,w,n,s	Not suitable because of temperature regime (average annual temperature), water availability (dry months), nutrient availability (P_2O_5), and terrain (rock outcrops).
Pakalunai	Nt,r,n,s	Not suitable because of temperature regime (average annual temperature), rooting condition (rooting depth), nutrient availability (P_2O_5), and terrain (rock outcrops).
Mantalat	Nt,w,s	Not suitable because of temperature regime (average annual temperature), water availability (dry months), and terrain (rock outcrops).
Honja	Ns	Not suitable because of terrain (rock outcrops).
Pendreh	Nt,w,r,s	Not suitable because of temperature regime (average annual temperature), water availability (dry months), rooting condition (rooting depth), and terrain (rock outcrops).
Bukit Pandan	Nt,n,s	Not suitable because of temperature regime (average annual temperature), nutrient availability (P_2O_5), and terrain (rock outcrops).
Lawanguang	Nt,w,n	Not suitable because of temperature regime (average annual temperature), water availability (dry months), and nutrient availability (P_2O_5).

Land System Unit	Land Suitability Rating	Description
Bakunan	Nw,r,n	Not suitable because of water availability (dry months), rooting condition (soil drainage class), and nutrient availability (P_2O_5).
Luang	Nt,w,r,s	Not suitable because of temperature regime (average annual temperature), water availability (dry months), rooting condition (rooting depth), and terrain (rock outcrops).
Rangankau	Nn,r,s	Not suitable because of nutrient availability (P_2O_5), rooting condition (soil drainage class), and terrain (rock outcrops).

The unsuitability of the land system unit characteristics to the rubber tree growth requirements were mostly caused by (1) temperature regime (t) particularly annual average temperature; (2) water availability (w) especially the length of dry months; (3) rooting conditions (r) including soil drainage class and rooting depth; (4) nutrient availability (n), specifically availability of phosphate (P_2O_5); and (5) terrain (s), particularly the number of rock outcrops.

Teweh land units had dry months (0-3), whereas rubber trees only tolerated 2 months. According to the Central Bureau of Statistics of Banjar district (2010), dry months in the Banjar district mostly occur in June, July, August, and September. Furthermore, the Teweh land units also had a nutrient limitation, i.e. available phosphate (P_2O_5). Teweh land units just had available phosphate <10ppm, whereas rubber trees required phosphate at least 10 ppm. Like the Teweh land units, Maput land units were also not suitable for rubber tree plantations because of phosphate (P_2O_5) deficiency. Even the Maput land units had a terrain factor problem, i.e. rock outcrops. The Teweh land units had 10 rock outcrops while rubber trees tolerated only 2 rock outcrops. Further, the Maput land units had problems with annual average temperature, and the length of dry months. The Maput land units had annual average temperature 20-31^oC, while the rubber tree species required at least 23-22^oC (temperature 23^oC was better than 22^oC).

Furthermore, the Maput land units had dry months 0-4, while the rubber tree species tolerated 2 months. For the Pakalunai land units, besides they had problems with annual average temperature, available phosphate, and rock outcrops, the land units had a problem with rooting depth. In this case, rooting depth of the Pakalunai land units was 76-100 cm, whereas the need of the rubber tree species was at least 80-129 cm. Yet, according to the Central Bureau of Statistics of Banjar district (2010), the effectiveness of soil depth for roots to take water in the Banjar district, i.e. generally (66.45%) happens at more than 90 cm deep, 18.72% at 60-90 cm, and 14.8% at 30-60 cm deep. Like the Maput land units, Mantalat land units had also problems with annual average temperature, the length of dry months, and availability of phosphate, but they did not have a problem with the rock outcrops.

Honja land units just had the limitation of terrain factor (rock outcrops). The Honja land units had 5 rock outcrops, while the rubber trees tolerated only 2 rock outcrops. Pendreh land units had the same limitations with the Maput land units; except that the Pendreh land units had no data about availability of nutrients. Furthermore, Bukit Pandan land units were similar to the Pakalunai land units, but they did not have a problem with rooting depth. In addition, Lawanguang land units had limitations in annual average temperature, the length of dry months, and availability of phosphate. The land units had annual average temperature 21-33^oC, dry months 0-4, and very low available phosphate (<10ppm), while rubber trees required at least annual average temperature 23-22^oC, dry months 0-2, and low available phosphate (10-15ppm).

Bakunan land system units had limitations in the length of dry months, soil drainage, and availability of phosphate. These land system units had 0-5 dry months, poor drainage, and very low (<10ppm) available phosphate. Meanwhile, the rubber tree species tolerated 2 dry months, somewhat poor soil drainage, and require at least 10 ppm of phosphate. The Luang land system unit had limitations with temperature regime, especially annual average temperature. The Luang had annual average temperature ranging from 18 to 33°C, while the limit required by the rubber tree species was 22°C. Furthermore, the length of dry months in Luang was 0-5 months, whereas the rubber tree species tolerated only 2 months. Also, the Luang land system unit had rooting depth 76-100 cm, while the rubber tree species needed at least 80 cm. In addition, the Luang land system unit had 5 rock outcrops, whereas the rubber tree species tolerated only 2 rock outcrops. The last land system unit was Rangankau. This land system unit emerged because of Generalization analysis resulting in the increase or decrease of a land unit size. In the LSA, this land unit had bad soil drainage, limited available phosphate, and many rock outcrops.

Djaenudin *et al*. (1993) contended that through the results of LSA, land suitability classes in actual (A) and potential (P) condition can be obtained. In the assessment of land condition, it is necessary to pay attention to assumptions that will be used, including management and technology levels that will be applied. Land suitability class in actual conditions constitutes land suitability based on data from survey results or natural resources, where the input needed to solve the limit factors are not considered yet. The limit factors can be physical environmental factors, including land characteristics in relation to tree growth requirements that are analyzed. Furthermore, potential land suitability is the condition of land that will be achieved with treatment or improvement. Yet in the improvement of land conditions, economic factors must be considered. As long as the improvement is profitable, meaning that the production value is higher than investment value, the improvement is still feasible.

In addition, Djaenudin *et al*. (1993) simplified that the result of land analysis is one of the criteria for selecting agricultural commodities that will be developed in certain site. When selecting a commodity, not only the land suitability classes, but also the economic values of the commodity should be taken into account.

For instance, a land area is classified as marginally suitable (S3) for soybean (*Glycine max)* after LSA, but it is suitable (S2) for cassava (*Manihot utilissima*). In this case, the plant to be prioritized for development is the soybean because the soybean plant has a better market aspect and price. So, besides considering LSA, analysis of agricultural enterprises and marketing, and socioeconomic analysis should be done integrally.

Furthermore, Sitorus (1985) asserted that in land suitability and capability systems, socioeconomic criteria were important and in fact they were dominant criteria in determining values and optimal land uses. So the LSA was not the only one factor used to determine whether a tree species was viable to plant. Based on the statements above, the LSA paid more attention to socio-economic factors as long as the trees still survived in a certain site over a long-term period. Yet, with the LSA, at least it was able to provide information about limiting factors and proper treatments needed to solve the limiting factors.

Based on the LSA, rubber trees were not suitable to plant in the production forest areas. But in fact, communities in Kalimantan had been planting rubber trees in their land since a long time ago, so that from the historical point of view, the communities had been familiar with rubber tree plantations. Dove (1993) acknowledged that local communities in Kalimantan started planting rubber trees in the early 1930s, and they associated rubber trees with swidden cultivation of food crops. In addition, rubber trees became a main source of the local communities' income, although the price and production of rubber latex were very low.

The Government of Indonesia (1991) in Dove (1993) stated that rubber was one of Indonesia's major sources: a major source of house income for eight million people, and the country's largest agricultural generator of foreign exchange that made Indonesia the world's second-largest rubber producer. And 75% of the bulk of Indonesia's rubber was produced in tiny gardens of a hectare or so, with century-old-technology, by "smallholders."

Moreover, the Golliath Business News (2008) informed that the prices of natural rubber fell; hitting rock bottom toward the end of the 1990s and early 2000s. The price was only US$ 0.50 per kg in the year 2001. In October, 2006, the price had shot up to around US$ 1.5 per kg. Based on this reality, particularly from the perspective of history, culture, and desires, rubber tree plantations were still possible to be established for the communities. Based on the data above, although the price of rubber was very low, the communities were still interested in planting rubber trees. Since the price had risen, the local communities would be more motivated to plant rubber trees. The results of the LSA in this study discussed land suitability based on actual conditions, so the conditions can be evaluated based on the potential conditions of the land for further development. This can be done by identifying improvements needed for development on the basis of the land quality groupings of land characteristics below:

1. Temperature Regime

Land system unit groups (Maput, Pakalunai, Mantalat, Pendreh, Bukit Pandan, Luang, and Lawanguang) had a problem with annual average temperature, and according to CSR/FAO staff (1983), there was no improvement possible for this limitation.

2. Water Availability

Land system unit groups (Teweh, Maput, Mantalat, Pendreh, Luang, and Lawanguang) actually did not have a lack of water, but they had an uneven distribution of dry months. The dry months ranged from 0-5 months, while growth requirements of rubber trees just tolerated at least two dry months continually in one year. The problem with dry months can be improved with irrigation works, but this needs high input and requires government funds or long-term credit to the land owner (CSR/FAO Staff, 1983).

3. Rooting Condition

a. Soil drainage

Land system groups (Bakunan and Rangankau) had a problem with soil drainage. According to CSR/FAO Staff (1983), this problem can be solved with artificial drainage, but this needs high input and requires government funds or long-term credit to the land owner.

b. Rooting depth

Land system units (Maput, Pakalunai, Pendreh, and Luang) had a problem with rooting depth. In solving this problem, CSR/FAO Staff (1983) stated that generally there is no improvement possible if the root restricting layer is thick. If the root restricting layer is thin, then the mechanical break-up of the layer may be possible to solve the problem.

4. Nutrient Availability

Available phosphate (P_2O_5) was one of the land characteristics from land quality of nutrient availability that cannot meet the rubber tree growth requirements. Most land system unit groups (Teweh, Maput, Pakalunai, Bukit Pandan, Lawanguang, and Rangankau) had a problem with available phosphate (P_2O_5). According to CSR/FAO Staff (1983), fertilizer applications for Not Suitable (N) rating needs moderate input that can be borne by the land owner with credit.

Brady (1990) stated that they were at least three phosphorus problems: first, soils had low level of total phosphorus; second, unavailability of the native phosphorus compounds for plant uptake; third, when fertilizers and manures were added to soils, they were fixed or changed to unavailable forms and in time react further, becoming highly insoluble forms. In addition, according to Foth (1990), fixation of fertilizer phosphorus resulted in low uptake of the fertilizer phosphorus during the year of application. Therefore, repeated use of phosphorus fertilizers result in an increase in soil phosphorus content.

In addition, Brady and Weil (2008) stated that most phosphate was fixed at very low and very high soil pH. If this condition was referred to soil pH (4.5-5.0) at the research location, the low soil pH was considered as one of the causes of phosphate deficiency. Furthermore, Brady and Weil (2008) explained that as pH increased from below 5.0 to 6.0, the phosphate became more soluble, and by applying proper liming and acidification, phosphorus availability can be optimized in most soils. Additionally, Charman and Murphy (2007) confirmed that the only economical way to reverse acidity in the soils was applying lime.
And Brady (1990) stated that acidity of soils could be reduced by adding agricultural lime in the soils.

5. Terrain

a. Rock outcrops

The most serious problem of all land system units for rubber tree plantations was rock outcrops. Of the 11 land system units, only 3 did not have a problem with the rock outcrops: Teweh, Lawanguang, and Bakunan. According to CSR/FAO Staff (1983), there was no improvement possible for solving this problem. In the case of rubber tree plantations, although the species were not suitable to be planted in the Banjar district based on the LSA, they were still preferred by the local communities because rubber tree plantations were still more profitable than other tree species. Djaenudin *et al.* (1993) asserted that the result of land analysis was just one of criteria in selecting agricultural commodity that would be developed in a certain site. In selecting a commodity not only based on land suitability class, but also based on the economic values of the commodity. In fact rubber trees still survive in Kalimantan and produce latex and wood as the main source of income for the local communities in and around the forests. In addition, although the price of rubber was very low, the local communities were still interested in planting rubber trees because the species are still more profitable than other tree species. With the higher price, now the local communities will be more motivated in planting rubber trees. Additionally, some limiting factors hampering the growth of rubber trees in Kalimantan can be reduced with fertilizing, liming, and maintenances. So the rubber trees are the favorite species of the local communities for tree plantations in the production forest areas of the Banjar district through the PP program.

In financial analysis, tree species analyzed was the most preferred tree species, i.e. rubber tree species with an age rotation from year zero (0) to year 25. The year 25 was assumed as the productive age limit for rubber trees to produce latex and wood. Nazaruddin and Paimin (1992) informed that the productive age of rubber trees can reach 25-30 years, but if they are tapped every day, the productive age will only be 16-18 years because the everyday tapping will result in decreasing the rubber tree bark earlier. Furthermore, Nazaruddin and Paimin (1992) stated that in the year 25-30, rubber trees can be cut for wood industries.

Also in the financial analysis, several calculation standards and assumptions were applied as shown in Table 6. These standards and assumptions were based on some references and the results of interviews with the local communities and experts.

Table 6. Some calculation standards and assumptions applied in financial analysis.

Item	Remark
Land area	1 hectare (ha)
Spacing	5 m x 4 m = 20 m^2
Number of trees per ha	10,000/20 = 500 trees
Latex production	Latex production is 0.009 kg/day/tree based on the research of Rafi'i (2004)
Seedling price	Rp3,606.25/seedling
Latex price/kg	Rp5000
Survival percentage of seedling	82.125%
Death percentage of seedlings	17.875% consisting of 10.73% (year 1), 5.36% (year 2), and 1.79% (year 3)
Replanting cost	Death percentage of seedlings x 500 x seedling price
Replanting percentage	Year 1 = 60%, Year 2 = 30%, and Year 3 = 10%
Cutting circle	25 years (productive maturity)
Labor systems	Hired labor and community's own labor
Land rent/land value	In infinite rotation, land rent/land value is included because it is assumed that the tree rubber growers will continuously plant rubber after the rubber trees in the first rotation, while in finite rotation, the land rent is excluded.
Tax	Tax is zero (0) because it is assumed as a subsidy from the Government.
Social Opportunity Cost of Capital/Social Discount Rate/Interest rate	12% is the current interest rate per year in the Bank
Exchange rate	US$1 = Rp13,000.

The reasons for applying latex production based on the research result of Rafi'i (2004) were (1) Rafi'i conducted a real measurement of latex production based on the ages (planting years) of the rubber trees in the field, (2) latex production based on the results of interviews with the local communities tended to be overestimated. Based on the interviews with the local communities, the collected data showed that latex production was 0.18kg/tree/day on average. Likewise, Fahrizal (2011) found that latex production was 20kg/ha/day or 20kg/500trees/day = 0.04 kg/tree/day. Actually, normal production of estate plantations was 1,200kg/ha/year or 0.009 kg/tree/day, and (3) the respondents did not have rubber trees with ages reaching 25 years.

In the financial analysis, it was applied two kinds of labor systems: hired labor and community's own labor systems. In the hired labor system, some activities in establishing rubber tree plantations were assumed to be conducted by laborers, such as wood harvesting, cutting and burning scrubs and bushes, spraying herbicide, lining and making planting holes, planting, and tapping latex. In addition to labor costs, other costs were timber transport, seedlings for planting and replanting, herbicide, and fertilizer.

Based on financial analysis in the hired labor system, with an interest rate of 12% per year, Net Present Value (NPV)= Rp25,881,497, Benefit Cost Ratio (BCR)= 1.53, and when the NPV= 0, Internal Rate of Return (IRR)= 28.57%. Based on the three investment criteria, rubber tree plantations were feasible because they have NPV > 0, BCR > 1, and IRR > Social Opportunity Cost of Investment. Kadariah *et al.* (1978) asserted that in the project evaluation, "go" mark can be designated with NPV ≥ 0. If NPV= 0, the project exactly returns Social Opportunity Cost of Capital. If NPV <0, the project is rejected, meaning that there is another use of more profitable purpose for the resources used in the project. Furthermore, BCR is commonly used in government projects or projects with big scales so that their benefits and outputs vertically and horizontally can be considered further at primary, secondary, tertiary levels. Furthermore, Kadariah *et al.* (1978) contended that if IRR of a project/activity was equal to the current interest used in the Bank as Social Discount Rate; NPV of the project/activity was equal to zero (0). If the IRR was less than Social Discount Rate, NPV was also less than zero (NPV < 0). Therefore, if IRR of a project/activity is greater than Social Discount Rate, this designates that the project/activity "go." On the contrary, if IRR of a project/activity is less than the Social Discount Rate, the IRR designates that the project/activity "no-go."

In the community's own labor system, all activities that needed wages were removed in the financial analysis. This system mostly applied by the communities in the research area. Based on the interview with the communities, 95% of head of households maintained rubber tree plantations with their wives. The rests were done by laborers. The latter was applied by the communities that have rubber plantations of more than 2 ha because they were not able to handle their rubber plantation activities, especially in terms of tapping latex.

Based on the financial analysis in the community's own labor system, with the interest rate of 12% per year, NPV= Rp65,828,987, BCR= 8.59, and when the NPV= 0, IRR= 47.42. Based on the three investment criteria, rubber tree plantations were feasible to be cultivated because NPV >0, BCR >1 and IRR > Social Opportunity Cost of Investment (12%).

Conclusion

The most preferred tree species by communities was the rubber tree species. The rubber tree species was not suitable to plant in production forest areas of Banjar district. The matching results of the land system units to rubber tree growth requirements showed that all land system units were not suitable for rubber tree plantations. This was because some characteristics of the land units did not meet the rubber tree requirements. These characteristics were (1) temperature regime (t) particularly annual average temperature, (2) water availability (w) especially the length of dry months,

(3) rooting conditions (r) including soil drainage and rooting depth, (4) nutrient availability (n) specifically availability of phosphate (P_2O_5), and (5) terrain (s) particularly the number of rock outcrops.

Nevertheless, the local communities still considers the rubber trees as favorite species for a tree plantation. The reasons for this were the communities were familiar with cultivating the rubber trees, they received income (cash) every day from the rubber trees, they have a shorter time to harvest latex from rubber trees than from growing other tree crops, and they received cash from rubber wood at the end of rotation. In addition, based on the financial analysis, with a Social Discount Rate of 12% per year, rubber trees were economically viable to cultivate either with a hired labor or with a community's own labor system. With the hired labor system, NPV = Rp25,881,497, BCR = 1.53, and IRR = 28,57%. With the community's own labor system, NPV = Rp65,828,987, BCR = 8,59, and IRR = 47,42%. The three criteria meet the feasibility condition which states that a project or an activity should "go" when NPV > 0, BCR > 1, and IRR > current social discount rate.

Recommendation

Decision-makers in the PP program should be concerned about the most preferred tree species by the communities. The problems of site suitability of rubber tree species in tree plantations in the production forest areas can be alleviated by applying manure and/or compost on land system units that have nutrient deficiency. In case the land system units need high inputs to solve production problems, the communities should conduct proper maintenance for their rubber tree plantation. If the land system units have serious problems such that no improvement is possible, they should not grow rubber trees, especially, for example, where there are many rock outcrops.

Abbreviations

PP: People's plantations
LSA: Land suitability analysis
CSR/FAO: Center for Soil Research/Food and Agriculture Organization
RePPProT: Regional Physical Planning Program for Transmigration.

Acknowledgements

I would like to thank Dr. Guillermo A. Mendoza, Dr. Richard J. Brazee, Prof. Jeffrey O. Dawson, Prof. Ann E. Reisner, and Mr. Sulaiman Bakri for their assistance in writing scientific knowledge.

References

Brady NC, Weil RR. 2008. The nature and properties of soils. Fourteenth Edition. Pearson Education, Inc. New Jersey.

Brady NC. 1990. The nature of soils. Tenth edition. Cornell University and United States Agency for International Development. Prentice-Hall, Inc. New Jersey.

Center for Soil Research/Food and Agriculture Organization (CSR/FAO) Staff. 1983. Reconnaissance land resources surveys 1:250.000 Scale. Atlas format procedures. Center for Soil Research, Indonesia Bogor.

Central Bureau of Statistics of Banjar District. 2010. Statistical yearbook of Banjar district. Banjar District Government Martapura.

Charman PEV, Murphy BW. 2007. Soils, their properties and management, Third edition. New South Wales State Government, Department of Natural Resources. Oxford University Express Victoria.

Department of Forestry of Republic of Indonesia. 1990. Forestry dictionary. Edition I (part II). Jakarta.

Djaenudin, Basuni, Nugroho K, Anda M, Sutrisno U. 1993. Technical guidance of land evaluation. Collaboration between Soil and Agro climate Research Center and National Agriculture Research Development Project. Research and Development Board of Agriculture, Agriculture Department of Indonesia. Jakarta.

Dove MR. 1993. Smallholder rubber and swidden agriculture in Borneo. A sustainable adaptation to the ecology and economy of the tropical forest. Economic Botany **47,** 136-147. The New York Botanical Garden, Bronx. New York.

Driessen PM, Konijn NT. 1992. Land-use system analysis. Interdisciplinary research (INRES). Cooperation between Brawijaya University, Wageningen Agricultural University, and State University Leyden. Malang, Indonesia.

Fahrizal Y. 2011. Cost and income analysis of rubber tree (*Hevea brasiliensis*) farmers in Mantimin village, Batumandi subdistrict, Balangan district, South Kalimantan province. Thesis, Faculty of Forestry, Lambung Mangkurat University. Banjarbaru.

Foth HD. 1990. Fundamentals of soil science. Eighth edition. Michigan State University. John Wiley & Sons. New York.

Goliath Business News. 2008. Profile of rubber plantations in Indonesia. Indonesian Commercial News. The Gale Group.

Kadariah, Karlina L, Gray C. 1978. Introduction to project evaluation. National Planning Program, Economic and Community Research Institute of Indonesia University, Faculty of Economics of Indonesia University. Jakarta.

Mantel S, Wosten H, Verhagen J. 2007. Biophysical land suitability for oil palm in Kalimantan, Indonesia. Report 2007/0. ISRIC-m World Soil Information, Alterra, Plant Research International, Wageningen UR. Wageningen.

McKinley CR. 1997. Growing christmas trees in North Carolina. North Carolina Extension Service, North Carolina State University. Raleigh, North Carolina.

Ministry of Forestry of Indonesia. 2010. Collection of regulations regarding people's plantations. Direct-orate of Forest Plantation Development, Direct-orate General of Production Forest. Jakarta.

Nawir AA, Murniati, Lukas R. 2007. Forest rehabilitation in Indonesia. Center for Forestry Rese-arch (CIFOR). Jakarta.

Nazaruddin, Paimin FB. 1992. Rubber, cultivation and processing, market strategy. Penebar Swadaya. Jakarta.

Poniman A, Nurwadjedi, Tobing L. 2004. Developing the national land resource database for supporting spatial land use planning. The third FIG conference, Bakosurtanal. Jakarta.

RafiI A. 2004. The effect of the difference of rubber tree (*Hevea brasiliensis* Muell. Arg) ages on latex production in PTPN XIII Tambarangan, Tapin subdistrict, South Kalimantan. Thesis, Faculty of Forestry, Lambung Mangkurat University. Banjarbaru.

Regional Physical Planning Programme for Transmigration (RePPProT). 1990. The land resources of Indonesia: a national overview: based on regional reviews of the land resources of East with South Kalimantan (1987 [main report]. National Coordination Agency for surveys and mapping (Bakosurtanal), Directorate of Development Program, Directorate General of Settlement Preparation, Transmigration Department. Jakarta.

Siswomartono D. 1989. Encyclopedia of natural resources conservation. Erlangga. Jakarta.

Sitorus SRP. 1985. Land resource evaluation. Tarsito Bandung. Bandung.

Suyanto, Nor H, Nugroho Y. 2007. The inventory of multi-purposed superior local tree species based on ecological condition for rehabilitating critical lands in Banjar district. Faculty of Forestry/Forest Management, Lambung Mangkurat University. Banjarbaru.

Van Noordwijk M, Suyanto S, Budidarsono S, Sakuntaladewi N, Roshetko JM, Tata HL, Galudra G, Fay C. 2007. Is hutan tanaman rakyat a new paradigm in community based tree planting in Indonesia? ICRAF working paper number 45. ICRAF Southeast Asia Bogor.

Warner K. 1994. Selecting tree species on the basis of community needs. Community forestry field manual 5. Food and Agriculture Organization of the United Nations (FAO). Rome.