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COMPARATIVE ANALYSIS OF FOUR PINE PLANTATION MANAGEMENT SITUATIONS IN WEST JAVA†

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SOPANDI, A. & RULE, L. C. 2000. Comparative analysis of four pine plantation management situations in West Java. Four systems of managing pine plantations in West Java, Indonesia, were compared using two types of criteria: technical efficiency using data envelopment analysis, and financial criteria (NPV, B/C ratio, annual equivalent value, and IRR). Both types of criteria were used to evaluate the systems for the first 15 y after establishment. Only the financial criteria were applied in a 30-y period evaluation. The four systems are plantation management for timber production, for timber and food crops (involving "tumpangsari" activities), for timber and resin, and for timber, resin and food crops. Perum Perhutani, a state-owned company, manages these plantations. The 15-y period evaluation showed that systems involving food crops were more efficient, technically and financially. The 30-y period financial evaluation showed that systems with resin harvesting activities were more efficient. Considering a 30-y rotation, combining resin harvesting and "tumpangsari" would be a very good strategy for Perhutani to facilitate the attainment of its economic goals and of its social objective of allowing the greatest participation by local people in the company's forest activities, in both the short and long run. Both arrangements reflect a very important implication: a win-win situation for the timber company and for the local population as situations in both sides are improved.

Key words: Agroforestry - tumpangsari - data employment analysis - financial criteria - pine plantations

SOPANDI, A. & RULE, L. C. 2000. Analisis perbandingan bagi empat situasi pengurusan ladang pine di Jawa Barat. Empat sistem pengurusan ladang pine di Jawa Barat, Indonesia, dibandingkan menggunakan dua kriteria: kecekapan teknikal menggunakan analisis pembangunan data, dan kriteria kewangan (NPV, Nisbah B/C, nilai persamaan tahunan dan IRR). Kedua-dua kriteria digunakan untuk menilai sistem-sistem tersebut bagi 15 tahun pertama selepas penubuhannya. Hanya kriteria kewangan digunakan dalam penilaian untuk tempoh 30 tahun. Empat sistem tersebut ialah pengurusan ladang untuk pengeluaran balak, tanaman makanan dan balak (melibatkan aktiviti "tumpangsari"), untuk balak dan damar, dan untuk balak, damar dan tanaman makanan. Perum Perhutani, syarikat milik negeri,

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menguruskan ladang-ladang ini. Penilaian untuk tempoh 15 tahun menunjukkan bahawa sistem yang melibatkan tanaman makanan adalah lebih cekap dari segi teknikal dan kewangan. Penilaian kewangan bagi tempoh 30 tahun menunjukkan bahawa sistem-sistem dengan aktiviti pengusahasilan damar adalah lebih cekap. Mengambil kira kitaran 30 tahun, gabungan pengusahasilan damar dan "tumpangsari" boleh menjadi strategi yang sangat baik bagi Perhutani untuk memudahkannya mencapai matlamat ekonomi serta objektif sosialnya yang membenarkan penyertaan paling besar oleh penduduk tempatan dalam aktiviti ekonomi syarikat dalam jangkamasa pendek dan jangkamasa panjang. Kedua-dua kaedah menunjukkan implikasi yang sangat penting: situasi kejayaan bagi kedua-dua pihak iaitu syarikat balak dan penduduk tempatan kerana situasi untuk kedua-dua pihak telah ditingkatkan.

Introduction

Perum Perhutani is a state-owned company that has authority to manage production forests in Java island in Indonesia. Forests for people and for profitability are the basic philosophies in Perhutani's framework (Perum Perhutani 1993). Pressure from communities living around the forests that need agricultural land has compelled Perhutani to involve local people in its forestry activities. Two social forestry approaches, agroforestry and resin tapping, implemented by Perhutani, are very important avenues through which these local communities become involved with forestry.

"Tumpangsari", a type of agroforestry system where selected local people are allowed to cultivate agronomic crops between pine rows during the first two years, is commonly practised in pine and teak plantations in Java. In this system, with the opportunity to plant food crops for subsistence, the selected farmers also have the obligation to plant and take care of the trees until they are two years old. Each family is usually allowed to cultivate 0.1 to 0.2 ha (from a quarter to half an acre) of plantation. Known as "taungya" and introduced at the end of the 19th century (Becking 1928, Beekman 1949; cited in Simon & Wiersum 1992), this system was primarily a reforestation activity to ensure successful plantation establishment and, secondarily, was a means of improving local welfare (Hellinga 1952; cited in Simon & Wiersum 1992). Pressure from rapid population growth and increased demand for wood, fibre, food and fodder have caused changes in the system, such as intensified agronomic practices and smaller areas allotted to families (Sukartiko 1980, Simon & Wiersum 1992).

Another social forestry programme practised in pine plantations is pine resin harvesting. Resin, a non-timber product, is a source of additional income for both the tappers and Perhutani. The processed resin, called gum resin and turpentine, becomes an export commodity for the company that also sells both raw and processed resin to local processing industries in the subdistrict. In this programme, selected local communities are allowed to tap and to collect resin from 11-y-old and older pine stems (stands). A family is usually allowed, through a contract, to harvest the resin from about 0.4 ha (about an acre) of pine plantation. Perhutani pays the people based on the amount of resin collected.

Four management situations of pine plantation management

Based on the implementation of "tumpangsari" and resin harvesting activities within pine plantations in Java, four management situations can be identified and are referred to as types of "management system" in this paper. These are management of the plantation solely for timber production (TP), management to produce timber and food crops (TF), management for timber and resin purposes (TR), and management for production of timber, resin and food crops (TRF).

In the TP system, labour is contracted to do the planting and replanting for the first five years. The major purpose is purely for timber production. In the TF system, "tumpangsari" is allowed during the first two years. Selected farmers plant and replant trees only during the first two years as part of their duties. In the TR system, people are allowed to tap resin from pine stands 11-y-old and older through a contract system. Tree planting is done by contract labour. The last system, TRF, is the combination of TF and TR systems where "tumpangsari" is implemented during the first two years and resin harvesting is also allowed from 11-y-old and older pine stands.

Perhutani has implemented these systems and intended to involve as many local communities as possible. While a lot of reference has been made as to the benefits of "tumpangsari" to the local people (e.g. sources of income and food) and to Perhutani (e.g. reduced manpower costs), there is lack of information about the comparative benefits and efficiency levels of these programmes that can be used to determine which systems best facilitate the attainment of Perhutani's financial and social objectives.

A study completed in 1994 addressed this aspect by evaluating the four systems using two types of measure, technical efficiency and economic performance, for a period of 15 y after establishment. To see the economic performance of these stands for one rotation, an additional evaluation was made using economic criteria only for 30 y, the rotation of pine established for pulpwood and non-construction timber purposes in the area (Directorate General of Forestry 1976).

The pine plantations evaluated were planted in 1978 and located at the East Manglayang subdistrict of the Sumedang District in West Java where all four systems are practised. The area is located about 27 km northeast from Bandung, the capital city of West Java province. East Manglayang and its surrounding areas are primarily agricultural with a population of about 91 000. The majority (80%) of the population are farmers and the farm size is relatively very small, from 0.1 to 0.25 ha per individual. Some farmers have to rent land to cultivate agronomic crops while others only become farm workers. Others work in various capacities, including jobs in government and private sectors, in trade, and in other businesses. Very few have a college education (Pemda Sumedang 1992).

This paper presents the results of the two types of methods used in evaluating four situations or systems of managing pine plantations in West Java.

Data and data collection

Relevant economic data for the 15 y (1978 to 1993) about these plantations were obtained from secondary sources including Perhutani reports, government reports, research papers and articles, and other relevant references. Cost (input) items included expenses on materials and manpower related to administration, thinning, resin exploitation, nursery, planting, and replanting activities. These were grouped into three major categories: budget, labour and land. The benefit (output) items were categorised into four: crops and resin, fuelwood, timber and standing stock. To cross-check the accuracy of the secondary data, some informal and spontaneous interviews were made by Sopandi (1993) on various places with selected practitioners, including four foremen (one for each management system) and 15 farmers. Instead of structured interview, the contacts were more of the conversational type which seemed to be preferred by most Sundanese people.

Specific terms and values of inputs and outputs were used. The budget refers to financial resources for managerial and materials expenses, and was measured in rupiahs per hectare (Rp ha^{-1}). Rupiah is the Indonesian unit of currency, equivalent to roughly 2000 Rp per US$1. Labour was measured in man-days per hectare (mds ha^{-1}) and the labour requirements for each system were determined. Land was measured in hectares. Timber harvest was a major output obtainable from both thinning (done twice) and the final cut and was measured in cubic meters per hectare (m^3 ha^{-1}). Fuelwood, another output from the first and second thinning, was measured in staple meter per hectare (sm ha^{-1}). A staple meter is a volume measurement 1 m long, 1 m wide, and 1 m thick. Forest byproduct was the category that included all other non-wood outputs, such as food crops from "tumpangsari" and pine resin from resin harvesting, and was measured in rupiahs per hectare (Rp ha^{-1}). The fourth output was the standing or remaining stock. In 15 y, the plantations have not yet reached the 30-y rotation. Thus, the standing or remaining stock was calculated as an output in the analysis, and was measured in cubic meters per hectare (m^3 ha^{-1}).

Four sets of data were obtained corresponding to these four systems of managing pine plantations. To illustrate the type of benefit and cost information collected, one example is given in Table 1 for the management system for timber, resin and food crop production for the first 15 y. (For further information on data used for other systems, please contact the authors.)

A 12% nominal interest rate and a 7.96% inflation rate were used to determine the real rate of interest used in this study. The 12% nominal rate was based on government policies that apply to credits for forestry investments (Government of Indonesia 1993). The 7.96% inflation rate was the average for Indonesia for the period 1978–1993 (International Monetary Fund 1992, McLeod 1993). The corresponding real rate was 3.74%, or almost 4%.

Table 1. Costs and benefits per hectare of 16-ha pine plantation for timber, resin and food crop production with "tumpangsari" (TRF)

Year	Activity	Costs ha^{-1} (thousand rupiahs)	Benefits ha^{-1}
0	Nursery	58.425	Agricultural crops: 798.0 kg
	Tumpangsari	26.426	
1	Administration	18.231	Agricultural crops: 2268.0 kg
	Tumpangsari	12.149	
2	Administration	21.256	
	2nd replanting	6.748	
3	Administration	27.280	
	3rd replanting	9.962	
4	Administration	30.302	
5	Administration	36.324	
6	Administration	39.349	
7	Administration	45.382	
8	Administration	48.419	
	1st thinning	61.508	Timber: 6.390 m^3
9	Administration	54.459	Fuelwood: 3.563 sm
10	Administration	57.567	
11	Administration	63.534	
	Resin exploitation	81.250	Pine resin: 545.530 kg
12	Administration	66.568	
	Resin exploitation	123.639	Pine resin: 759.840 kg
13	Administration	72.620	
	2nd thinning	90.062	Timber: 9.970 m^3
	Resin exploitation	130.095	Fuelwood: 4.125 sm
14	Administration	75.682	Pine resin: 551.500 kg
	Resin exploitation	163.039	Pine resin: 659.900 kg
15	Administration	81.739	Standing stock: 86.130 m^3

Evaluation approaches

Two approaches were employed in the evaluation and comparison of the four management systems. The first one was a measurement in physical magnitude using technical efficiency as a criterion. The second was a price or financial efficiency evaluation using various economic criteria. Two situations were considered, based on the inclusion of certain costs and benefits in the calculation. Situation 1 considered all costs and revenues generated by all activities, regardless of whether or not they flow back to Perhutani. Situation 2 considered only costs paid for and tangible benefits received by Perhutani.

Efficiency means different things to different people, is defined differently at various levels of analysis, and becomes more complicated as one goes from individual systems to total systems. Technical efficiency and allocative efficiency are two concepts associated with production at the individual level (French 1977). Farrell (1957) says that a firm is technically efficient if it produces the maximum rate output for given quantities of variable inputs. Technical efficiency also implies that the firm adopts the best technology available and appropriate for that firm at a given set of input and output prices (Carlsson 1972). Allocative efficiency occurs when variable inputs are selected such that the value of the marginal product is equal to the marginal cost for each input (French 1977).

In this study, technical efficiency was measured in terms of the ratio of the total weighted outputs to the total weighted inputs using an approach called data envelopment analysis (DEA) that was proposed by Charnes *et al.* (1978) and simplified by Sexton (1986). The method is used to measure the efficiency of a decision-making unit which has multiple outputs and inputs with no objective way of aggregating inputs and outputs into productive efficiency (Sexton 1986). One advantage of DEA is that the factors can be measured in their natural physical units, and there is no need to convert them into a common unit of measure, such as dollars (Sherman 1986). The approach has been applied in several fields, including evaluation of forest management efficiency (Kao & Yang 1991), exploration of the efficiency among US National Parks (Rhodes 1986), and evaluation of the efficiency of health care organisations in hospitals (Sherman 1986).

To determine the financial performance of the system, a comparison based on economic criteria was done for the same 15-y period using four economic criteria: benefit to cost ratio (BCR), net present value (NPV), annual equivalent value (AEV), and internal rate of return (IRR).

To see the economic performance of these systems through one rotation, estimates of costs and benefits were made for the next 15 y and then an additional evaluation of the financial performance of the four systems was conducted using the same four criteria for the 30-y period.

A. Evaluation using technical efficiency as criterion, 15-y period

Actual data for the 15-y period since plantation establishment were used for this evaluation. Calculation of technical efficiency was a 2-step approach. First, the unit weight for each factor output and each factor input was determined using linear regression. This assumed that the relationship between each output (or input) factor to the total output is linear. Then technical efficiency was determined using Sexton's (1986) simplified formula.

Mathematically, the output-total output relationship is represented as:

$$Y = b_0 + b_1y_1 + b_2y_2 + b_3y_3 + b_4y_4$$

where Y = total output (in Rp ha^{-1}), b_0 = intercept for output model, y_1 = forest byproducts (Rp ha^{-1}), y_2 = fuelwood (sm ha^{-1}), y_3 = timber (m^3 ha^{-1}), y_4 = standing stock (m^3 ha^{-1}), and b_1, b_2, b_3 and b_4 = coefficients of related output factors.

The relationship of the input factors to total output is represented as

$$Y = a_0 + a_1x_1 + a_2x_2 + a_3x_3$$

where a_0 = intercept for the input model, x_1 = budget or expenditure (Rp ha^{-1}), x_2 = labour (mds ha^{-1}), x_3 = area (ha), and a_1, a_2 and a_3 = coefficients of related input factors.

The coefficients of each output factor and each input factor from these two models were determined. These coefficients were then used as weighted factors and then were applied into the formula for technical efficiency calculated as follows (Sexton 1986):

$$\text{Maximise } h_k = \frac{\sum_{r=1}^{4} u_{rk} Y_{rk}}{\sum_{r=1}^{3} v_{ik} X_{ik}}$$

$$\text{subject to } \frac{\sum_{r=1}^{4} u_{rk} Y_{rj}}{\sum_{r=1}^{3} v_{ik} X_{ij}} \leq 1 \text{ ; } j = 1 \text{ to } 4 \text{, the total number of management systems}$$

$$u_{rk} \geq 0 \text{ ; } r = 1 \text{ to } 4 \text{, the total number of outputs}$$

$$v_{ik} \geq 0 \text{ ; } i = 1 \text{ to } 3 \text{, the total number of inputs}$$

where Y_{rj} = the amount of output r produced by management system j, X_{ij} = the amount of input i used by management system j, v_{ik} = the unit weight placed on input i by management system k, and u_{rk} = the unit weight placed on output r by management system k. The decision rules are that a management system is efficient if and only if the technical efficiency (ratio) is equal to one, and that it is not efficient if this ratio is less than one. When several alternatives are being compared, the system with the highest technical efficiency is "most efficient", relatively.

B. Evaluation using economic criteria, first 15 y after establishment

The four economic criteria used in the economic evaluation of the four systems are the benefit-to-cost ratio (BCR), net present value (NPV), annual equivalent value (AEV), and internal rate of return (IRR). These are briefly discussed below.

The BCR is an evaluation technique that takes the ratio of the sum of present values of the expected stream of benefits to the sum of present values of the expected costs. Investments with a ratio > 1.0 are considered acceptable. The BCR is usually preferred for evaluating public projects (Sassone & Schaffer 1978, Gregory 1987). Maximising the NPV criterion is the empirical counterpart of the present value of net benefit criterion used to define dynamic efficiency (Tietenberg 1984). The NPV is a straightforward discounted cash flow measure of project worth (Gittinger 1982), and is best for capital budgeting decision (Gunter & Haney 1984) although it has a bias for big projects (Gregory 1987). Investments with positive NPVs are acceptable; the higher the NPV, the more attractive is an investment. Derived from the NPV, the AEV is the annualised uniform income from the investment and is useful when comparing projects, especially those which have unequal investment period (Gunter & Haney 1984). Higher AEVs signify better financial performance. The IRR indicates the rate of return earned by an investment and is commonly applied by international institutions because of its simplicity and ease of application (Gregory 1987, Kohli 1993). The higher the IRR compared to an alternative rate of return, the better is the investment.

C. Evaluation using economic criteria for one rotation (30-y period)

Using the same four economic criteria, projections were made for the physical outputs and inputs of the plantations for the next 15 y. The performance of the four systems was then investigated for the 30-y period considering the two situations of treating costs and benefits.

All linear regression models were developed using the Statistical Analysis System (SAS) package. Quicksilver, a computerised forestry investment analysis program developed by Vasievich *et al.* (1984), was used in determining the values of the economic criteria used.

Results

All analyses were done on a per hectare basis. Monetary values were converted to US dollars.

A. Comparison based on technical efficiency

The first linear model developed showing the relationship of output factors to total output is

$$Y = 72.947 + 1.112y_1 - 3.499y_2 + 5.999y_3 + 2.806y_4$$

where y_1 = forest byproducts (Rp ha^{-1}), y_2 = fuelwood (sm ha^{-1}), y_3 = timber (m^3 ha^{-1}), and y_4 = standing stock (m^3 ha^{-1}). This model had a good fit (coefficient of correlation of R^2 was 0.98 and the model was significant at the 0.0001 level).

The second model showing the relationship of input factors to total output is as follows:

$$Y = 514.443 + 6.072x_1 + 0.532x_2 + 1.372x_3$$

where x_1 = budget (Rp ha^{-1}), x_2 = labour (mds ha^{-1}), and x_3 = area (ha). This model had an R^2 of 0.84 and was significant at the 0.0038 level.

The regression coefficients of the output and input factors became the weighted factors used in the calculation of technical efficiency. From the linear models, the coefficients of the output factors are: 1.11 for forest byproducts, 0 for fuelwood (since $-3.499 \leq 0$ and DEA constraint is that all weighted factors ≥ 0), 6.0 for timber, and 2.81 for standing stock. That fuelwood contributes nothing is quite puzzling and the authors could not offer a possible explanation. For the input factors, the coefficients are: 6.07 for budget, 0.53 for labour, and 1.37 for land. Then for each system, each output (input) factor was multiplied by the related weighted factor. Technical efficiency was determined by taking the ratio of the sum of weighted outputs to the sum of weighted inputs for that system. Results are presented in Table 2.

Table 2. Technical efficiency of 15-y-old pine stands under different management systems

Management system	Situation 1[1]	Situation 2[2]
TP	0.88	0.88
TF	0.67	0.96
TR	0.70	0.70
TRF	0.64	0.91

[1]Considers all costs incurred and benefits received in each system.
[2]Considers only the costs paid for and benefits received by Perhutani.

Table 2 shows that all systems are not efficient because all ratios are less than one, suggesting that the time period (half the rotation time or 15 y) was not enough to attain efficiency in management. In short, the products – harvests from thinning , early resin harvesting, young growing stands, and the food crops produced – were not enough to attain the optimum level of output relative to the given inputs.

Under situation 1, management systems with "tumpangsari" (TF and TRF) were shown to be less efficient than those systems without it (TP and TR). This probably occurred because many villagers worked free in the plantation establishment phase in the TF and TRF systems so that including their labour as a cost in the establishment of the plantation caused inefficient labour allocation due to too many labourers in that activity.

The situation was reversed under situation 2. Management systems with "tumpangsari" (TF and TRF) are relatively more efficient than systems without it (TP and TR), suggesting that implementation of "tumpangsari" positively impacts management efficiency. Although all systems are technically inefficient, these results show that Perhutani would benefit more, in a relative sense by implementing systems with "tumpangsari" as a component.

Comparing the two situations for the first 15 y, accounting only for costs and benefits relevant to Perhutani showed systems that are more technically efficient, suggesting that the cost savings due to free labour in "tumpangsari" have outweighed the costs of implementing this type of agroforestry system in the pine plantations.

B. Comparison of financial performance, first 15 y after establishment

Table 3 shows the results of financial evaluation of the four systems for the first 15 y of existence. Under situation 1, the TF system ranks first and TR ranks last based on all four criteria. TRF ranks second while TP is third, based on NPV, AEV and IRR. These results suggest that, when all financial costs and benefits are accounted for, it would be good for the company to implement "tumpangsari" and to practise less of the system involving resin harvesting operations only.

Table 3. Values of economic criteria of pine stands under different management system at East Manglayang at 3.74% real discount rate, 15-y period

Management system	BCR ratio		NPV (U.S. $ ha^{-1})		AEV (U.S. $ ha^{-1})		IRR (%)	
	1[1]	2[2]	1	2	1	2	1	2
TP	1.63	1.63	8.77	877	77	77	20.43	20.43
TF	1.68	1.63	959	877	85	77	29.15	21.30
TR	1.47	1.47	719	719	64	64	18.73	18.73
TRF	1.59	1.55	900	819	79	72	28.62	20.70

[1]Situation 1 – considers all financial costs incurred and benefits received in each system.
[2]Situation 2 – considers only the financial costs paid for and benefits received by Perhutani.

Under situation 2, TF retains its top ranking although it ties with TP in at least three criteria. TRF is a close third while TR is the worst performer based on all criteria. These results imply that, from the company's point of view, the cost of implementing "tumpangsari" has little effect on the revenues received by the company. Also, systems with "tumpangsari" are only slightly better than managing the plantation for timber production only (TP) based on the IRR criterion (Table 3).

For both situations, the results suggest that TF would be the best performer of the four systems so that, from a purely financial point of view, it would be more beneficial for Perhutani to implement systems involving "tumpangsari" activities.

C. Comparison of financial performance for one (30-y) rotation

For the 30-y period and considering all costs and benefits (situation 1), the conditions were more complex (Table 4). TRF ranks first based on BCR and IRR criteria while TR is first based on NPV and AEV. Common to both systems, however, is the resin harvesting activity. TF is third and TP is a close fourth. These results suggest that, compared to the 15-y evaluation period, resin harvesting has improved the systems' economic performance in the longer term. This may be because mature pine stands have bigger stems, produce more resin, and thus generate more revenues.

Table 4. Values of economic criteria of pine stands under different management system at East Manglayang at a real discount rate of 3.74%, 30-y period

Management system	BCR ratio		NPV (U.S. $ ha^{-1})		AEV (U.S. $ ha^{-1})		IRR (%)	
	1[1]	2[2]	1	2	1	2	1	2
TP	1.30	1.30	1402	1402	79	79	10.24	10.24
TF	1.31	1.29	1429	1348	80	75	11.80	10.14
TR	1.33	1.33	2497	2497	140	140	15.02	15.02
TRF	1.34	1.33	2440	2359	137	132	17.87	14.59

[1]Situation 1 – considers all financial costs incurred and benefits received in each system.
[2]Situation 2 – considers only the financial costs paid for and benefits received by Perhutani.

Under situation 2, however, TR has clearly edged TRF to become the best performer of the four systems (Table 4). Similarly, TP outranks TF for third place. Again, these results indicate that resin harvesting could contribute more economically as time elapses. In addition, TF is less beneficial compared to TP in the long run. This implies that perhaps "tumpangsari" should be implemented by Perhutani only in shorter term forestry activities. The shorter turnover could help achieve Perhutani's goal of involving as many people as possible in its forestry activities.

In both situations, systems with resin harvesting were shown to bring in more benefits than any other system in this longer-term evaluation, as can be seen easily looking at the AEV or annualized uniform income. Compared to the 15-y evaluation results, the 30-y period has greater economic benefits primarily because of the final timber harvest.

Summary findings and implications

Considering all costs incurred and benefits received in each system, based on technical efficiency, the first 15-y evaluation period shows that TP ranks first and TR is second, suggesting that the allocation of labour in these systems is relatively more efficient than those with "tumpangsari" activities. Based on economic criteria, however, TF was shown to be the best, TRF was second, and TR was last. This implies that in the shorter term, with all financial costs and benefits being considered, "tumpangsari" activities promote the economic performance of pine plantations and support Perhutani's continued implementation of agroforestry in the area. Furthermore, in 30 y, systems involving resin harvesting and "tumpangsari" have better economic performance, suggesting that Perhutani should favour these two activities in their longer-term forestry plans. These two activities also help promote stronger, mutually-beneficial relationships with the communities living around Perhutani's pine plantations.

Considering only the costs paid for and tangible returns received by Perhutani and based on both technical efficiency and economic criteria, the first 15-y evaluation shows that TF has the best and TR the worst performance. These results imply that in the shorter term and if economics and meeting the social forestry goals are to be the guides, systems with "tumpangsari" would be most beneficial to Perhutani. However, the 30-y economic evaluation reversed the situation and showed resin harvesting to have the greatest positive influence on benefits, suggesting that systems involving this activity should be favoured by the company in the long term. Looking back to Table 3 would reveal that TRF (which has "tumpangsari" component) is a very close second.

As a word of caution, the models presented in this paper used coefficients that were not standardised. However, initial results (not presented in this paper) that came from using standardised coefficients indicated no significant difference when compared to the present set of results. An extension of the models used here may be developed by using standardised regression coefficients. Standardisation may be done by dividing each individual factor by the standard deviation for that factor. This then will remove the influence of differences in magnitudes among the various variables considered in the system.

Conclusion

In the shorter-term (or 15-y) evaluation, systems involving "tumpangsari" were shown to be more efficient, technically and financially, in meeting Perhutani's fiscal and social goals. In the long run (30-y rotation), the evaluation showed that systems involving resin harvesting were more financially efficient. Both activities involve people and should contribute to the improvement of the welfare of the villagers as sources of additional income. Comparing the two activities, however, "tumpangsari" allows greater participation by the people than resin harvesting because smaller areas are allowed for each family involved to practise the former within the forest.

Based on these results and considering Perhutani's fiscal and social objectives and the 30-y rotation for the plantations, the combination of the two activities — resin harvesting and "tumpangsari"— would be a very good strategy to increase the company's economic gains from the plantations and at the same time sustain the welfare of the communities surrounding the forests, thereby effectively reducing the number of people who, otherwise, are likely to encroach on the forest in search of land to till for food, and of wood and fodder.

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