Netherlands Journal of Agricultural Science 48 (2000) 91-104

Agro-ecological strategies in North Lampung, Indonesia: social constraints to biological management of soil fertility

R. GAUTHIER

Environment Department, Wye College, University of London
Wye, Kent, TN25 5AH, UK
Fax: +44-1233-812855; e-mail: r.gauthier@wye.ac.uk

Received 18 December 1998; accepted 28 February 2000

Abstract

The article examines the socio-cultural and political factors which affect the adoption of biological management of soil fertility in Javanese and Lampungese farming communities of the Province of Lampung , Indonesia. The research was carried out using a hybrid methodological framework, thus blending quantitative and qualitative analysis to provide a holistic picture of the agro-environmental and social conditions of the area. Analysis was carried out to identify relations between ethnic group and agro-ecological strategy. These strategies were then analysed and contrasted to assess the acceptability and possible constraints to the adoption of biological soil management. Land tenure issues and inter-community social dynamics are analysed and their impacts on long-term adoption of biological means of soil fertility management are investigated. Implications for policies and programme are drawn.

Keywords: Biological management of soil fertility, livelihood, land tenure, policies and programmes, agro-ecology, Lampung, Indonesia.

Introduction

As shown in this special issue of the Netherlands Journal of Agricultural Science, biological management of soil fertility (BMSF) has a potentially important role to play in Southeast Asia's agriculture. The recent financial crisis in the region made it harder for farmers to access agro-chemical inputs. Specifically in Indonesia, the economic situation has affected millions of farmers in their attempts to sustain a livelihood. Given this, the adoption of alternative methods for maintaining soil fertility will be crucial to the livelihood activities of subsistence farmers.

BMSF has aimed at researching different biological methods for the maintenance of soil fertility by reducing the dependence on inorganic fertilisers. It also aims to improve policy and programme linkages from community to district and on to the national policy arena (Van Noordwijk *et al.*, 1996). Yet to be able to give realistic policy recommendations, detailed work must be done at the field and community levels, both on bio-physical and social aspects. The study presented in this paper is

based on research into the links between agricultural policies, farmers' livelihoods and environmental change at the forest margin in North Lampung, Indonesia (Gauthier, 1998). The study took a holistic view of the area, recognising the bio-physical, socio-economic and cultural constraints to agricultural livelihoods. In the current paper data from this study are examined with respect to the utilisation of BMSF techniques. From the above perspective, livelihood constraints and their interrelations which can affect the appropriateness and adoption of BMSF can be assessed.

The specific aims of the paper are to identify any socio-cultural constraints that may exist to farmers in the research area adopting biological management of soil fertility measures. In order to do this the paper will investigate cultivation practices in the area, identifying the predominant land-use patterns and their links with the socio-cultural and political situation in the area. Strategies regarding soil fertility for the groups identified will be investigated, factors influencing such choices ascertained, and implications drawn for soil management policies and programmes.

Research area and methods

Research area

The research was conducted in North Lampung, in one of the Alternatives to Slash and Burn (ASB, Van Noordwijk et al., 1995) sites (Figure 1), and comprised three settlements with a mix of ethnicity (one was mainly Javanese transmigrants (Tegal Mukti), one was an ethnic Lampungese hamlet (Belimbing Beku) and the third was comprised of a mix of Javanese spontaneous migrants and ethnic Lampungese (Panaragan Indah)). The ethnic composition of these villages allowed for comparison between indigenous and immigrant farmer livelihoods and farming systems.

The bio-physical features of the research area are described in detail in van Noordwijk et al. (1995) and Gauthier (1998), but can be summarised as follows: altitude of 30–60m. above sea level, peneplain, with relatively high population density (69 people per square km) (BPS, 1996; BPS Lampung Utara, 1996), with a mixture of food and perennial cropping systems. The area is characterised as having acid soils with poor fertility (van Noordwijk *et al.*, 1995). Two main seasons are evident, with approximate rainfall of more than 200 mm month^{-1} occurring between November and April, and less than 100 mm month^{-1} between May and October. Temperature ranges between 26–28 °C throughout the year (BPS Lampung Utara, 1996).

Research methodology

The study was conducted using a hybrid methodology (Batterbury *et al.*, 1997) which blended qualitative and quantitative methods. The aim of employing this array of methods was to obtain a structural overview of the research communities, supplemented by qualitative data, to provide a holistic picture of the socio-environmental conditions of the area. The rationale is discussed in detail in Gauthier (1998).

The research process comprised three strands, the first being exploratory, using

wealth ranking exercises were not undertaken as this would have been culturally inappropriate. The questionnaire data were analysed using SPSS version 6 for Windows, using an array of statistical methods such as Chi-square, t-test, cluster analysis and Pearson correlation.

The third strand of research ran simultaneously with the first two strands, and became the primary post-survey research method. This strand was based on detailed ethnography, obtained through participant observation and in-depth interviews. A number of detailed case studies were built up through repeated visits. The ethnography provided a 'thick description' (Geertz, 1983) of the communities. It further provided the means to triangulate (Chambers, 1997) the information between data sources, probing and cross-checking where discrepancies emerged, thus increasing the reliability of the data.

Data from all three strands of the research were combined to build up the following description of the agro-environment of the research area, providing the basis for analysis of local issues in relation to soil fertility management.

Agro-ecosystems evident in the research area

Until the late 1960s the area was covered by rain forest. Lampungese settlers then arrived and opened some land for cassava cultivation and the establishment of tree gardens. Major land clearance was carried out by the government in the 1980s as part of its transmigration programme. In this case, Javanese farmers were translocated (Translok) from another area of Lampung province to settle and cultivate the sparsely populated area of North Lampung. Currently a range of crops are grown by both communities.

Rice has a historical importance in the region (Marsden, 1811; Raffles, 1817; and Fox, 1991). and most farmers aspire to cultivate this crop. This is particularly true of the Javanese for whom rice cultivation has social status (Gauthier, 1998). Wet rice is the most widespread, though upland and swamp rice also feature. Yield for all types is low (wet rice – 1.2 tonnes ha^{-1} unmilled rice in an optimal year as compared to the national average of 4.5 tonnes ha^{-1} (FAO Production Yearbook, 1997); upland rice –725 kg ha^{-1} average yield, and only 200–300 kg ha^{-1} for swamp rice). Depredation by rats is significant on all types, and pigs also affect upland and swamp rice where plots are adjacent to the forest. Flooding and insect pests are further risks to swamp rice. Fertiliser and pesticide applications tend to be inadequate or unsystematic, further affecting yield. Yet despite poor yields, and heavy losses to rats in particular, farmers persist in sowing rice and opening up further paddy fields (*sawah*) where possible.

Cassava is also widely grown (by 87% of respondents), either to be eaten as a staple by those who cannot grow or afford rice, or sold as a cash crop. Again yield is low. Field observations indicate average yield to be near 8 tonnes ha^{-1}, compared to the national average of 12.39 tonnes ha^{-1} (Norman *et al.*, 1995). This is partially due to the widespread practice of early harvesting to avoid depredation by wild pigs. Other factors are low soil fertility and inadequate weeding.

The main perennial crops grown in the research area are sugar cane (*Saccharum officinarum*) and rubber (*Hevea brasiliensis*). Sugar cane is most extensive due to the existence of a commercial plantation (P.G. Bunga Mayang). In addition, many Javanese farmers in the research community of Tegal Mukti cultivate sugar cane as part of the plantations' smallholder programme. This government promoted scheme addresses the issue of local low soil fertility by supplying chemical fertiliser as part of the credit package.

Rubber has been established in the wider area for many years as part of the Lampungese traditional agro-forestry system, and was introduce into the research area by the shifting cultivators in the late 1960s. These systems are polyculture, and produce both cash and food crops (Purwanto, 1992). Examples of plantation practices for rubber exist just outside the research area where a World Bank project was established in 1976. This has had some influence on local practices as clonal stock is now replacing traditional rubber varieties.

Current soil fertility management practices

In the questionnaire survey, farmers were asked to describe the soil fertility and conservation methods they applied. The results are shown in Table 1.

Soil conservation measures reported in the formal survey focused mainly on erosion control, and of these, the use of raised beds (gulud) and water spillways (siring) were the most widespread. Some 11% of respondents did nothing to ensure soil quality. Of these, 9% mentioned waiting for flooding of their land, which brought new topsoil, while the other 2% took no measures at all. The soil conservation measures reported above are mainly used for food crops. Little soil conservation effort is made for tree crops, for example, no mulch is used around tree seedlings when they are first planted, though there were a few cases of contour cropping on sloping land. However, the actual planting of trees is in itself a long-term soil stabilising measure.

Table 1. Percentage of respondents using various soil conservation and fertility measures.

SOIL CONSERVATION MEASURES	LAMPUNGESE	JAVANESE	TOTAL
Raised beds	18	49	33.3
Water spillway	28	26.5	27.2
Mulch	48	30.6	39.4
Contour cropping	14	8.2	11.1
Flooding	14	4.1	9
Other	10	12.2	11.1
Green manure	16	46.9	31.3
Animal manure	12	55.1	33.3
Chemical fertiliser	52	77.6	63.7
No measures	4	0	2
Number of respondents*	50	49	99

* One of the farmers surveyed is not included in this table because he had only a small number of trees and no other crops.

In response to the low soil fertility in the area, the use of chemical fertiliser is relatively widespread, with 64% of respondents applying such products to their crops. Included in the smallholder sugarcane credit package were urea, trisodium phosphate and potassium fertilisers, which farmers routinely divided out among their other crops or sold for cash, giving insufficient application rates generally. Otherwise fertiliser was purchased at the market, where urea cost Rp.50 kg^{-1}, KCl Rp. 650 kg^{-1}, and TSP Rp. 750 kg^{-1}. Application rates varied widely, between 50 kg and 300 kg ha^{-1}. While this practice may improve productivity, it also represents a drain on household finances. Perhaps surprisingly then, alternative, less costly, biological methods to manage soil fertility are much less frequently employed. While almost all respondents kept at least a small number of livestock, with 46% owning goats, and 29% at least one cow, only 33% reported using animal manure as fertiliser. As regards mulching and green manuring, these were reported to be employed by 39% and 31% respectively. However, on closer examination, it appeared that this is frequently only incidental as by-products of weeding rather than active decisions on soil management. Many farmers in the research area prefer to burn weed residue rather than feed it back into the soil in order to minimise work. They also believe this removes potential cover for rodent pests.

These soil fertility management techniques were learned from different sources: discussions with other farmers, official extension activities by the small holder sugar cane programme (chemical fertiliser use only) and, most importantly, farmer experimentation integrating indigenous with external scientific knowledge. The learning dynamics are complex and are not within the scope of this paper. A more thorough analysis of knowledge exchange dynamics is covered in Gauthier (1998).

The above description of agro-ecosystems and farming practices found in the research area can be further refined by comparing and contrasting between the Lampungese and the Javanese farming strategies. By clarifying the predominant land-use patterns, issues of soil management can be better ascertained, with the consequent implications for BMSF. This will be the focus of the next section.

Agro-ecological strategies: contrasts between Lampungese and Javanese

Through different means farmers develop strategies within a multitude of livelihood possibilities, which are adaptive in terms of the socio-economic and biophysical constraints which affect livelihood choices. Livelihood strategies and the different ways of deriving them are multiple but certain differentiating characteristics can be identified between the Lampungese and Javanese communities. This type of typological analysis was used by Ellis-Jones and Mason (1999) in Bolivia to evaluate soil management practices. Farming methods and crop choice are derived from both structural conditions and local attitudes. These will set farmers on agro-ecological trajectories which often differ between immigrant and indigenous farmers.

While there are clearly many factors which contribute to livelihood strategies, some, such as local and international prices and access to roads and markets, were the same for both communities. The government's extension service was universally

considered to have little impact on either community (c.f. Gauthier, 1998). Other factors showed clear cultural divergences. To understand the processes which operate within communities in selecting strategies to obtain a livelihood, it was considered appropriate to use as criteria the characteristics which farmers themselves believed to be necessary to achieve economic stability and which differentiated between the Lampungese and Javanese farmers. These criteria were arrived at through discussions with farmers from both communities, and emerged as attitude towards perennial crops and rice production, and land holding. These characteristics were then statistically tested to ascertain if they could be associated with specific ethnic groups.

To define agro-ecological strategies a cluster analysis was performed on four variables: land use (LANDUSE), which is the total number of hectares in cultivation; number of trees being cultivated (NUMTCUL), grouped in classes; number of tree species planted (NUMSPEC) as this is a measure of diversity; and, surface area of wet rice cultivated (SAWAHEC).

To perform the cluster analysis the variables were first normalised (Everitt, 1993). Table 2 provides the cluster association with the different normalised variables, and Table 3 describes the analysis of variance performed on these variables between clusters.

This analysis shows that there were highly significant differences between the two clusters in terms of land under cultivation, number of trees and number of species of trees cultivated, though the surface area of wet rice was not statistically significant. Case household cluster membership was then ascertained and the resulting means disaggregated by cluster (Table 4) to clarify what each cluster represents. A further t-test was performed on the means of these variables to clarify the differences between clusters (Table 5). The t-tests were used to cross-check the results of the analysis of variance and found to support them.

NUMTCUL was not included in Table 4 because this variable is on an ordinal scale (i.e. classes: Siegel, 1956). NUMTCUL and cluster membership were plotted and showed a clear bimodal distribution between Clusters 1 and 2 (Figure 2). A Mann-Whitney U test (Daniel, 1978; Watt, 1993) was performed between cluster

Table 2. Cluster centres.

Cluster	ZLANDUSE	ZNUMTCUL	ZNUMSPEC	ZSAWAHEC
1	− 0.289	− 0.514	− 0.579	− 0.060
2	0.198	1.221	0.794	− 0.045

Table 3. Analysis of variance.

Variable	Cluster MS	DF	Error MS	DF	F	Prob.
ZLANDUSE	4.089	1	0.201	69	20.28	$p < 0.001$
ZNUMTCUL	51.667	1	0.205	69	251.50	$p < 0.001$
ZNUMSPEC	32.422	1	0.548	69	59.06	$p < 0.001$
ZSAWAHEC	0.004	1	0.551	69	0.007	0.933

Table 4. Cluster definition using the means of unstandardised variables.

Cluster	LANDUSE mean (ha)	NUMSPEC mean (number)	SAWAHEC mean (ha)	Sample Size
1	2.21	3.24	0.49	42
2	5.08	7.00	0.50	29

Table 5. t-Test between clusters, disaggregated by variable.

	LANDUSE	NUMSPEC	SAWAHEC
Cluster 1 Vs Cluster 2	$p < 0.001^{**}$	$p < 0.001^{**}$	$p = 0.932$ NS

** = significant at the 0.01 level, NS = not significant.

membership and classes of numbers of trees planted and was found to be significantly different ($U = 23.5$, $p < 0.0001$).

Therefore, the general characteristics of Clusters 1 and 2 are as follows: members of Cluster 1 have small plots of land, have fewer trees with fewer different species of trees represented, and some wet rice. The members of Cluster 2 have larger tracts of land, more trees planted with a greater diversity of tree species, and also have some wet rice.

Having identified two different patterns of farming, a chi-square test was performed between cluster membership and ethnic group membership, the results of which are represented in Table 6. Both clusters have members from both ethnic groups, but Cluster 1 has a higher membership of Javanese respondents (71% of total), with more than twice the number of Lampungese members. Cluster 2 is closely associated with the Lampungese (83%), with more than four times the members

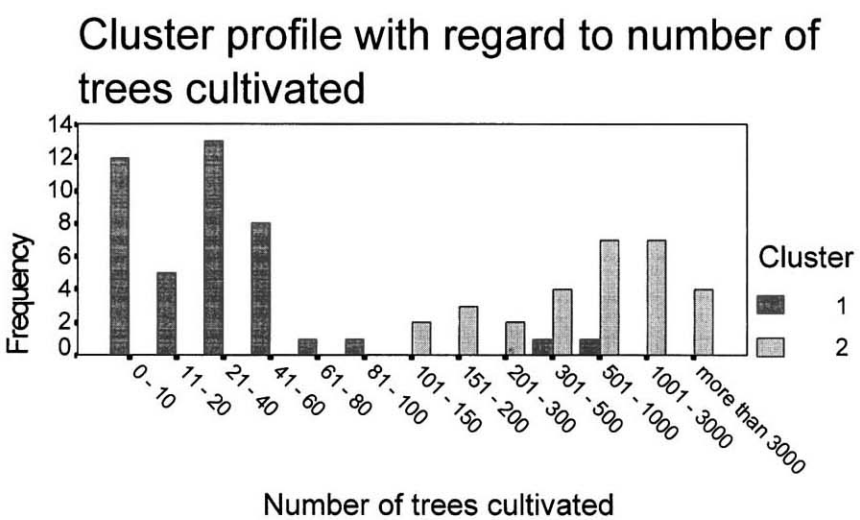

Figure 2.

Table 6. Chi-square test between cluster membership and ethnic group membership.

Cluster		Lampungese	Javanese	Row Total
1	Observed –	12	30	42
	Calculated –	21.3	20.7	
2	Observed –	24	5	29
	Calculated –	14.7	14.3	
Column Total		36	35	71

Chi-square Value = 20.15247, df = 1, p = 0.00001.

when compared with Javanese respondents. The chi-square was highly significant with $p = 0.00001$.

While there is a strong association between cluster and ethnic group, there are also minority members from the other ethnic group in each cluster. In these cases the predominant factor appears to be relative wealth, and consequent land holding, compared with the majority of their ethnic group.

A diversity analysis was also carried out (c.f. Gauthier, 1998) which indicates that overall diversity between Lampungese and Javanese farming systems was not significantly different (t-test, $df = 69$, $p = 0.478$). However, this does not take into account the complexity level of the structure of the systems (Heywood & Watson, 1995) which, again, is strikingly different between the upland fields of the two groups. The Javanese in the area tend to grow cassava and/or sugar cane, most often as monocultures in the ladang, with trees mainly concentrated in their homegardens (pekerangan) (Jensen, 1993) or occasionally planted only at the borders of upland fields. In contrast the Lampungese have trees integrated throughout their upland fields as an essential part of their complex, income-generating agro-forestry systems (Michon & de Foresta, 1996; Gouyon *et al.*, 1993).

The preceding analysis has delineated archetypal agro-ecological strategies between Lampungese and Javanese, though ongoing dynamic changes are occurring within households and as trends throughout communities, which are generated from both within and outside these communities. This latter includes the socio-cultural and political conditions found in the area, which will have a strong influence on soil management practices, as illustrated in this research area.

Social constraints to farming livelihoods

The typical Javanese and Lampungese agricultural systems and livelihood strategies have evolved over time, and continue to evolve in response to many different factors, both enabling and constraining. Throughout the research period the main constraining issues in the area emerged as pest depredation, poor soil fertility and, perhaps less obviously, land tenure insecurity caused by improved access and increased population resulting in land being at a premium.

The implementation of the Translok programme has changed the land tenure situation of the area, whereby intangible assets such as claims and access to land, which are cornerstones of livelihood (Chambers & Conway, 1992), have been destabilised. As the negotiations for, and implementation of, land preparation for Translok were not consistent, land disputes have erupted. The actual distribution of land to the Translok participants was not carried out in accordance with the agreement that had been reached between the Department of Transmigration and the indigenous landowners, creating social space for litigation.

The most visually apparent impact of the on-going land disputes is the amount of land that has been left fallow and is reverting back to scrub. This is the outcome of farmers having opened up land and subsequently left it because of coercion and threats of violence.

The disputes have also worsened the Translok farmers' distrust of the government, for two reasons. The first is that, to date, only 18% of the land titles promised in their Translok package have ever been issued. The lack of title only furthers the claims of the land tenure plaintiffs as these certificates are the only land deeds recognised by the Government of Indonesia.

The second reason why Translok farmers distrust the government is its apparent lack of response to cases of 'land piracy'. Repeated representations have been made to the sub-district and district governments in efforts to settle issues, but they remain unresolved. The level of frustration at the inaction of the government's representatives led to inter-community violence in April 1996.

The following section will examine how this local socio-political situation, along with the cultural differences in agricultural practices and attitudes described earlier will constrain the adoption of BMSF practices and implications for policies and programmes.

Acceptability of biological management of soil fertility

Given the poor financial circumstances generally prevalent in the area, the low cost of biological methods and the high cost of chemical inputs, the question arises as to why the majority of farmers do not use biological methods of soil fertility management.

The characterisation of the two groups defined earlier shows that for the majority of the Lampungese, soil fertility is largely maintained through natural processes as they employ highly diverse agroforestry systems. The case can be made that the more diverse the agro-ecosystem above ground, the more diverse the habitat below ground for soil fauna (Giller *et al,* 1997). Also, above ground plant biodiversity performs a nutrient cycling function (Risser, 1995; Huston, 1993), and tree diversity minimises soil nutrient loss (Tilman *et al,* 1997). In the absence of this natural function, as in the Javanese food-crop monocultures, farmers will have to intervene, often choosing chemical means, even while BMSF options exist.

Deterrents to the adoption of BMSF

On first impression it would appear that there is a low level of awareness of the benefit of soil conservation measures in general, but informal discussions with farmers showed that this was not necessarily the case. As Pretty (1995) found, structural, labour and financial factors were also implicated. In particular farmers in the area reported BMSF measures as being too labour intensive. Compounding this was the issue of insecure land tenure. Where the farmers' right to their land was in question, they were reluctant to invest much time in soil conservation measures of which they may not see or feel the benefit.

Among other reasons that emerged as significant in the research area specifically was a link with the problem of pest depredation. While cross tabulation of soil conservation measures currently employed with depredation on specific crops shows no clear or direct link between soil conservation methods and pest depredation, there are, however, clear cases of pests affecting cropping system decisions and some of these decisions in response to pests have implications for soil fertility and conservation (Gauthier, 1996). For example, general agronomic and soil fertility management recommendations (Altieri, 1995; Ahn, 1993), as well as the soil conservation efforts of the Indonesian government's agricultural agencies, promote mulching and green manuring as prime methods of soil fertility management through biological means. The farmers in the research area were reluctant to use these methods, and when questioned why, the farmers responded that mulch or weed residue left on the soil increased rat depredation, as it provided habitat for the rats. This belief, and the consequent practice of soil clearing as a method of rat control has been reported by Fiedler (1994) to occur in eastern Africa also.

Land tenure insecurity also has impacts on the rodent pest situation. Abandoned plots, the majority of which were initially cleared using fire, are highly susceptible to *Imperata cylindrica* infestation (van Noordwijk *et al.*, 1995), further degrading the land. This fallow land also makes excellent reservoir habitat for vertebrate pests, especially paddy rats, which affect all the remaining cultivating farmers.

A link between land tenure insecurity and the rodent pest problem is also evident in the reluctance of the community to work together to reduce rat depredation. Communities in South and Central Lampung, as well as other parts of Indonesia, have successfully organised themselves to hunt paddy rats before planting the rice crop (gerobiokan). This community-led control method requires co-ordination and widespread adherence, yet under uncertain land tenure the community is reluctant to invest time and energy clearing rats and smoking out rat holes, only to have their 'rat-free' land taken by someone from outside the community.

The same is true for soil conservation measures. Longer-term soil improvement strategies such as agroforestry or mulching with nitrogen-fixing ground vegetation are seldom employed as the farmers cannot plan for the long-term due to the widespread insecurity (Blakie, 1985). As such, the farmers cannot invest in what Blakie & Brookfield (1987) term 'landesque capital', which is purposive land management designed to secure future production beyond the present crop cycle.

For farmers to be willing to make the necessary investments required by BMSF

practices they require stable land tenure, without which there is little incentive for investment in the land.

Implications for BMSF

From the purely bio-physical perspective, agroforestry would appear to be the agro-ecosystem best suited to the research area in terms of soil fertility management. In addition, it would also appear to address another major local agricultural constraint, as tree garden systems are relatively resilient to vertebrate pest depredation. However, when the perspective is broadened to include social factors, the aspect of land tenure emerges as key to the adoption of this or other long-term soil fertility management strategies.

Subsistence farmers who are trying to cope with adverse environmental and economic conditions have to balance their short-term needs with their long-term goals. The optimisation process is never perfect, and often long-term goals of financial and personal security have to be foregone in an attempt to meet daily and short-term survival requirements. The best illustration of this is the adoption of perennial crops. The long-term livelihood which would be facilitated by this type of cropping system cannot be envisaged as the majority of the transmigrant farmers in particular are caught in the subsistence trap, where available resources, be they human, financial or land, are focused on acquiring daily requirements for survival. Where assets are insecure, as in the case of land tenure, the shift from short-term food crops to a long-term perennial crop such as rubber will only be possible for the wealthiest and most powerful social actors in the community.

For the majority, before such long-term soil management strategies as agroforestry, or the use of more labour intensive BMSF practices are likely to be adopted, not only in North Lampung, but in any area where land tenure security is an issue, policies and mechanisms must be put into place for resolution of land tenure conflicts.

In more general terms, it is important to couple soil management research with more holistic socio-environmental research, which can reveal both the specific bio-physical and socio-economic constraints to adoption of BMSF or any other exogenous techniques and assist in identifying appropriate strategies and programmes that are better tailored to local conditions. In most cases this will result in hybrid traditional-improved agricultural systems, building on the local agricultural and environmental conditions, and, to be fully effective, be accompanied by policies based on socio-cultural reality which are supportive of long-term farmer investment in soil fertility management through biological means.

Acknowledgements

The research on which this paper is based was supported by an International Centre for Research in Agroforestry (ICRAF) studentship and made possible by a research

permit from the Indonesian Science Research Foundation (LIPI). I would like to thank Drs. Andrew Whitmore, Georg Cadish and Graham Woodgate, as well as anonymous reviewers, for their comments on this paper.

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