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Swiddens in transition: shifted perceptions on shifting cultivators in Indonesia

Meine van Noordwijk, Elok Mulyoutami, Niken Sakuntaladewi, and Fahmuddin Agus

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Abbreviations

Al	aluminium
ASB	Alternatives to Slash and Burn
Ca	calcium
CEC	cation exchange capacity
cm	centimetre
CO2	carbon dioxide
Fe	iron
ha	hectare
K	potassium
kg	kilogramme
km	kilometre
N	nitrogen
m	metre
Mg	Depending on context: magnesium or Mega-gram (10^6 g)
mg	Milligram
No.	Number
P	Phosphorus
pers. comm.	personal communication
REDD	reducing emissions from deforestation and degradation in developing countries
S	Sulphur
t	tonne (1,000 kg)

Abstract

Swidden is the origin of all current agricultural systems across Asia. How it has evolved in different settings depends on which period and products in the cycle–the food cropping phase or the regenerating fallow phase–emerge as the most economically important. Carbon stocks decline as forest is converted into intensively managed plantation or cropland, whether by burning or not. Focusing on fire does not mitigate the loss of diversity in traditional crops and the wild component of agroforests. By refusing to accept the tradition of shifting cultivation of food crops in situations where it still is sustainable, and by restricting access to forest resources, existing forest policies in Indonesia have forced intensification on nearby unprotected land and fomented conflicts over land use. The Indonesian government's early focus on jumpstarting intensive permanent cropping shifted to supporting tree crop monocultures. It would be better support the gradual evolution of swiddens and the agroforestry systems derived from it in accordance with local expectations.

Acknowledgements

We would like to express our gratitude to all those who participated in the seminar and workshop 'Keberadaan perladangan berpindah di Indonesia' on 17-18 April 2008 in Bogor. We would like to thank in particular Abigail and Darif Abot, representing farmers in Malinau, East Kalimantan; Susilawati of the Forest Agency in Malinau; Marzuki Hasyim, a farmer representative from West Aceh; Hasri Mulizar of Flora and Fauna International, West Aceh; Syahril of Bappeda, West Aceh; Jarimi and Farida, farmer representatives from Muara Bungo, Jambi; Havizzudin of the Forestry and Plantation Agency of Muara Bungo; Rojak Nurhawan and Atim Khaetami, representing farmers in Nanggung, West Java; Nia Ramdhaniaty of Rimbauan Muda Indonesia in Bogor; Erminna Mabel, representing farmers in Jayapura, Papua; Yoseph Watopa of Conservation International Papua; Yafeth Watori of Bapedalda, Papua; Jim Sami of Riak Bumi, Pontianak; and Rahmat, a farmer representative from Semalah, Kapuas Hulu, West Kalimantan. We also thank Manuel Boissiere, Godwin Limberg, Linda Yuliani, Yayan Indriatmoko and Valentinus Herry of Riak Bumi; Iwan Ramses of the Centre for International Forestry Research in Malinau; and Gamma Galudra, Ratna Akiefnawati and Ery Nugraha for their advice on selecting participants. We thank Patrice Levang for his active role in the workshop and seminar. We thank the organizers and participants of the meeting in Hanoi for their active interest in and comments on the Bogor workshop, especially Christine Padoch. We acknowledge the generosity and thoughtfulness of our donor, Ujjwal Pradhan of the Ford Foundation. Last but not least, thanks to Carol Colfer, Martua Sirait, Brent Swallow, Laxman Joshi, Johan Kieft, Satyawan Sunito and Christine Padoch for their valuable input. Peter Fredenburg and Michael Hailu assisted with technical editing.

Table of contents

Preface

Fifteen years ago, Alternatives to Slash and Burn (ASB) started as a global program of the agricultural research centres supported by the Consultative Group on International Agricultural Research, together with national agricultural research systems, universities and nongovernmental organizations in the humid tropics. The primary driver of this applied research program was the international concern over the loss of tropical forests expressed in the Rio conventions on climate change and biodiversity conservation. Much was expected of agricultural intensification as a way to reduce the amount of land needed to meet local and global demand and thus create conditions for forest conservation.

The early characterization phase of ASB in Indonesia focused on Sumatra and made clear that slash and burn is used, not just in remnants of traditional swiddening, but also to clear land for resettled farmers in transmigration programs, start tree crop plantations both smallholder and large, and establish industrial timber estates (van Noordwijk et al., 1997). The association of slash and burn with traditional shifting cultivation proved to be false in Sumatra, and ASB transformed itself into a more comprehensive study of land-use change and its social, environmental and economic consequences. Its analysis of the tradeoffs and choices to reconcile environmental and development concerns then gave rise to early forms of rewarding upland poor for the environmental services they provide. In parallel, the improved fallow network documented the many innovations across Asia for intensifying land use in smallholder farming systems that have evolved from classical swidden in response to opportunities for market integration and to pressures on land. The monumental *Voices from the forest: integrating indigenous knowledge into sustainable upland farming*, edited by Malcolm Cairns, finally appeared in 2007.

In the meantime, swiddens are still an important way of life in some of the more remote parts of Indonesia. The chain of events that transformed much of Sumatra, for good and for bad, is repeating itself on other islands. The same perceptions of shifting cultivation as the main culprit of forest loss keep coming back in the public debate, often without much evidence. Lessons from one place must be shared elsewhere. This volume is a contribution to the broader debate and follows from a regional review meeting in Hanoi, Vietnam, followed by a review focused on Indonesia. We hope it will help to create a more realistic assessment of the challenges and opportunities faced by people living in the forest margins of Indonesia.

Bogor, September 2008

Ahmad Muzakir Fagi

Former Director of the Indonesian Food
Crop Research Institute and First Coordinator
of ASB-Indonesia

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Director General of the
World Agroforestry Centre
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Executive Summary

Main Findings	Policy recommendations
1. Definitions used in the policy arena and the institutional construction of a separate forest domain do not match local perceptions of rights, the actual dynamics of land use or the way swidden systems tend to evolve by adding value to the fallow and/or crop phase. A coherent system of land use is artificially split by separate forest and agriculture institutional frameworks. Claims to land by forestry institutions and the transfer of rights to logging and/or plantation companies trigger change in swidden communities.	1. Disentangle the debates on the functional roles of woody vegetation for society (the forest function) and the institutions and rights to use and modify woody vegetation and land use (forest institutions and governance, the agrarian issue) to achieve more evidence-based public dialogue and improve the transparency of decision making. Create an integrated platform to deal with the forest-agriculture continuum and its policies
2. The contest for land in relations between the state and local communities, and between members of the community and spontaneous and state-sponsored migrants, plays a dominant role in the decisions about clearing woody vegetation and replacing it with annual and perennial crops.	2. Substantially increase capacity to resolve land conflicts based on analyses of historical claims within the existing legal framework, which delegates the management of forest function to the Forestry Law and regulates all issues of land rights in the Agrarian law
3. Remote communities' market integration in Indonesia has historically arisen mostly from the modification of the fallow into an agroforest and the further intensification of agroforests into specialized tree crop production systems. It has not been led by changes in the crop phase of the swidden cycle.	3. Recognize the double-edged sword of restricting the use of forest resources. Support the development of markets for forest commodities through basic certification that distinguishes domesticated and semi-domesticated resources from wild ones that require protection. Support the utilization of existing agrobiodiversity.
4. The current focus on reducing the use of fire does not mitigate the long-term ecological concerns over the conversion of natural forest into intensively managed plantations. The loss of diversity in crops and the wild component of agroforests is less visible than smoke.	4. Improve data collection and analysis to support the formulation of more evidence-based policies to maintain environmental services and turn the focus from symptoms like smoke to the underlying causes of the loss of natural capital.
5. The rural development paradigm has switched from jumpstarting intensive permanent cropping to supporting intensive monoculture tree crops, rather than supporting gradual change in accordance with local expectations.	5. Respect local ambitions and expectations in support of sustainable development and critically review current subsidies for monocultures and support for land grabs by external investors or state agencies.

1. Definitions and forest institutions

'Swiddens' are land that is cleared of woody vegetation for the temporary production of staple food crops mixed with other annuals and/or perennials useful for local use and/or markets. Sometimes swiddening is termed 'traditional shifting cultivation', to differentiate it from the way migrants and agribusinesses temporarily use land without committing to its long-term sustainable use. The term 'slash and burn' refers to a method of clearing land used by large plantations and migrant farmers (or 'shifted cultivators') as well as in swiddens, often with negative associations of forest destruction. Even if these terms are technically synonyms, they set the tone and colour the debate. Depending on perspective, the gradual or abrupt changes in the practice are seen as either a solution or a problem in the search for sustainable development.

Less than 5% of the rural population in Indonesia has direct links to swiddening, but swiddens are prominent in about half of Indonesia's land and forest area. This apparent discrepancy is caused by the low population density associated with swiddens. As part of a synthesis for Southeast Asia, we reviewed the perceptions and concerns of farmers practicing swiddens, and of local and national governments, and compared them with the results of social, economic and biophysical science.

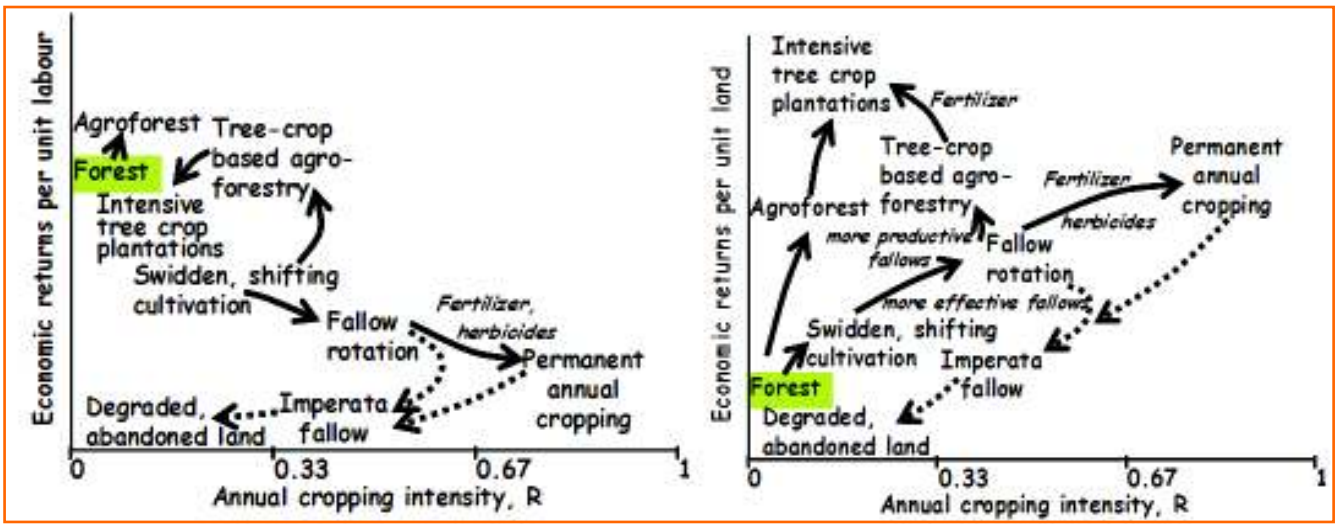

Figure a: Schematic relationship between the intensity of annual cropping (Ruthenberg R) and the total economic returns per unit of labour (left) and land (right). The positions of the land-use systems are approximate and depend on the relative value of forest or tree crop products and the annual food crop.

In response to market opportunities, such demographic changes as increases in population density and circular migration, restrictions on land use, and specific policies, the practice of swiddening constantly changes. Some of these changes occur within the existing definition while others cross over to other categories, but there is no uniform and consistent data collection that allows firm statements to be made on the extent of the practice or the number of people involved.

Forest definition: The internationally accepted definition of forest has two components: one specifies canopy cover and tree height, and that the other refers to the institutional framework of forestry, as it includes areas normally forming part of the forest area that are temporarily unstocked, as a result of human intervention such as harvesting or natural causes, but are expected to revert to forest.

Shifting cultivation is a forest-management practice within the internationally accepted definition of forest, as long as, in the woody regrowth phase, tree canopy cover meets the 30% minimum used in the definition and tree height meets the 5 meter (m) minimum. By definition, shifting cultivation cannot therefore be said to be a cause of deforestation, but it becomes a cause when the intensification of the system keeps the woody vegetation phase below the definitional limit. Existing forest policies, however, do not accept the shifting cultivation of food crops as a practice and, by restricting access to existing woody vegetation, have forced intensification on outside land and conflicts over the traditional use of land. Intensification and the increased market orientation of production systems are thus a consequence of and a challenge for policies aiming to protect the ecological functions of old-growth woody vegetation and the institutions that have developed around timber-based forest management.

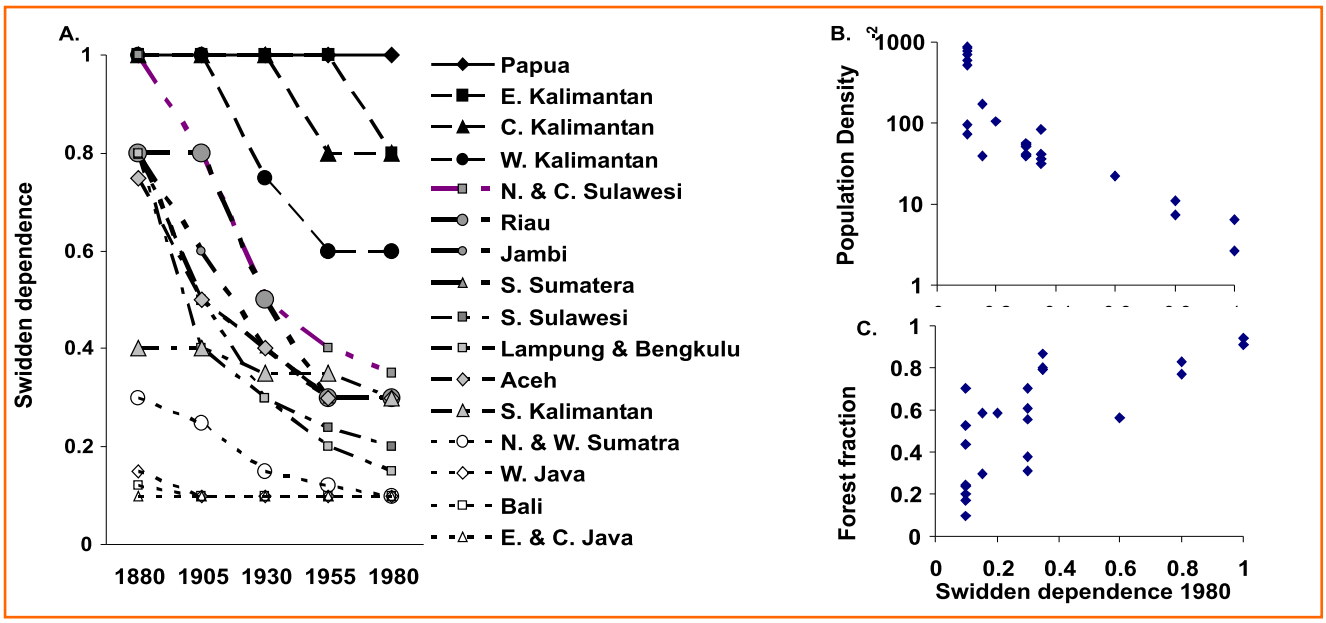

Figure b: The (A) historical shift in dependence on swiddens in provinces of Indonesia according to Richards and Flint (1994) in relation to (B) 1990 population density and (C) forest cover data.

According to the Richards and Flint index at provincial scale, the percentage of Indonesia's population outside of areas classified as urban that are fully dependent on swidden was 1.4% in 1980, but swidden involved 14.2% of the area of Indonesia and 18.9% of its forest. For 5.5% of the population, 48% of the area and 58% of the forest, the swidden index was at least 0.6, indicating a mixed livelihood strategy of swiddens with other forms of agriculture. For 24.9% of the population, 80.5% of the area and 87.9% of the forest, the swidden index was at least 0.3, indicating swiddens continued relevance in the overall livelihood pattern. For the remaining 75.1% of the population outside cities, 19.4% of the area and 12.1% of the forest, swidden played a minor or negligible role.

2. Access to land

Existing summaries suggest strong regional differentiation in Indonesia. At one end of the scale, major parts of Java moved out of shifting cultivation into permanent cropping before 1900, but with interesting local exceptions. At the other end, Papua still relies mostly on swiddens. Overall forest cover is positively associated with dependence on shifting cultivation, and population density has a negative association. The fraction of land used for irrigated rice is neutral with relation with forest cover once the effects of population density are accounted for. Most of the existing swidden systems occur in landscapes with fewer than 5 people per kilometre (km2), but the case study of sweet potato-based agriculture in Papua has 17 per km2. Land availability relative to local labour, the basing of local land rights on tree planting and the anticipation of future changes determine the transition of swiddens and their fallow into agroforests and tree plantations with initial food intercropping.

3. Market access and integration

An important transition in swidden systems occurs when the tree component of the fallow vegetation gains major economic importance, as happened in the development of rubber and mixed fruit-tree agroforests. Historically this change has occurred many times over. From examples in Sumatra, we can learn how local communities protected options for local food production in communal swiddens from the privatization of land that is linked to tree planting in the fallows.

Swidden transitions in Indonesia may have been primarily triggered by increased market integration for native non-timber forest products and the introduced tree crops of rubber and coffee that were initially compatible with woody fallow vegetation. Market integration starts with sources of income complementing local food production but, with attractive prices, can lead to reliance on the market for staple foods. As many forest and agroforest products have relatively high value per unit of weight, they provide options for fairly remote communities. Farmers who attempt to intensify food crop production may find it challenging to integrate into markets unless road access is good. The agroforest solution that combines high biodiversity at the landscape level with medium market integration is not an endpoint of the evolution, however, and may transform into more intensive tree crop monocultures, as is the current trend in rubber agroforests.

4. Loss of diversity and the focus on smoke and haze

The local dynamics of change in swidden practice include the maintenance of local food crop diversity and the opportunities and risks involved in specialization and the adoption of new cultivars and germplasm that may improve productivity in a limited sense but also entail an increased risk of failure. Our case studies document this for upland rice swiddens in Kalimantan and sweet potato-based swiddens in Papua.

Technical understanding of the benefits and risks of the use of fire in clearing land have distinguished between the heat and ash effects of biomass burning and its impacts toward increasing the availability of phosphorus (P), a limiting plant nutrient when unavailable. Substantial losses in nitrogen and cations occur, but crop growth benefits from the P released by heating soil. Erosion tends to be high after land is cleared, but existing landscape filters may prevent soil loss at the landscape scale as long as the fraction cleared in any year is small and vegetation is maintained in the riparian zone.

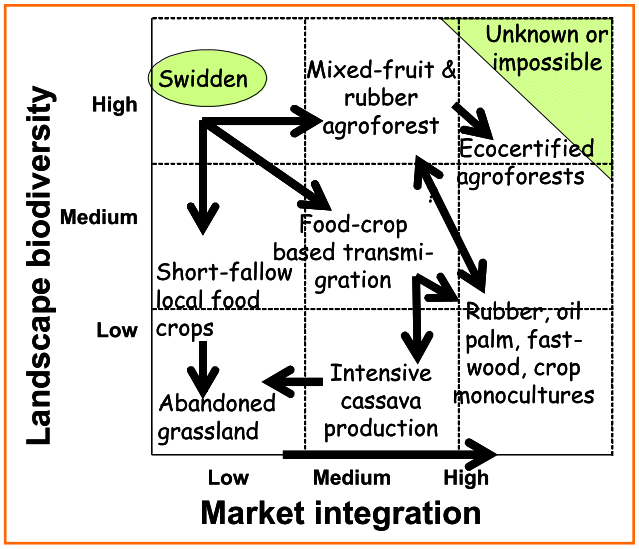

Figure c: Schematic relationship among the degree of market integration, landscape-scale biodiversity of swiddens and derivative land use systems.

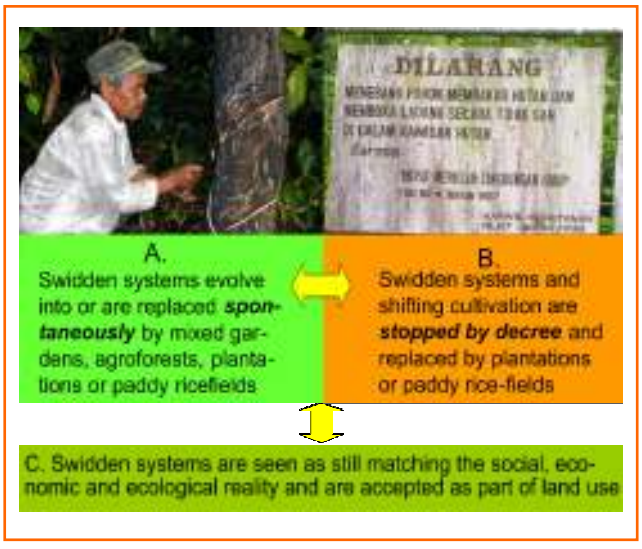

Figure d: Three policy domains with regard to swidden systems and their transformations.

5. Rural development paradigm

Government support for rural development has often focused on a rapid transition to either permanent food cropping or specialized, often monocultural tree crop systems, rather than supporting the gradual evolution of systems. Current experience with oil palm as an economic commodity shows different trajectories for Sumatra, where old palm production by independent smallholders is emerging, and Kalimantan, where contracts between companies and local communities over land access and transformation into oil palm monoculture continue to pose a challenge.

1. Introduction

1.1 Asia-wide review

'Swiddening' is a way of life associated with cultural traditions; 'shifting cultivation' is a technical description of a land-use system that alternates cropping and fallow; and 'slash and burn' is a method of clearing land used by large plantations, migrant farmers or shifting cultivators, often with negative associations of forest destruction.

The words we use to describe a system, even if technically synonyms, set the tone and colour the debate. Depending on perspective, gradual or abrupt changes in the practice are seen as either a solution or a problem.

In Indonesia, as elsewhere, the topic of shifting cultivation elicits strongly opposing views. The current debate on reducing emissions from deforestation and degradation adds a new layer of complexity to an already contentious issue, as the use of fire and other activities on the forest margin come to be seen primarily in the context of global emissions of greenhouse gasses and economic incentives to reduce them. The voice of local communities has yet to be heard in these debates. Swiddens are associated with subsistence and backwardness, rather than with sustainable development. But this view may reflect ignorance of the real dynamics.

We can distinguish three basic types of knowledge that need to come together: local knowledge of context, scientific perspectives on mechanisms and a public policy focus on desirable development outcomes (Figure 1).

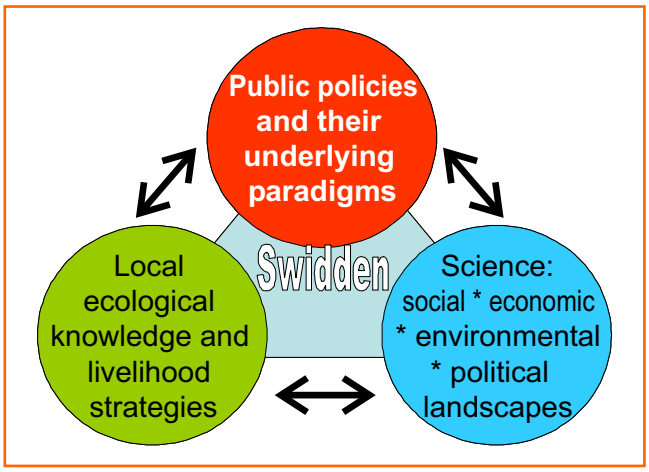

Figure 1: Triangle of knowledge systems involved in the analysis of swiddening.

An international group of scientists who have worked for several decades in Southeast Asia on land-use issues on the forest margin from social, economic and ecological perspectives recently reviewed the supposed demise of swiddening in Southeast Asia. That group included the authors of this volume. We aimed for a regional assessment of existing knowledge on change in swiddening throughout Southeast Asia, expecting to identify research gaps that need to be filled to address the concerns of swiddening communities. The objectives of the Asia-wide review were to

1. assess trends in the extent of swiddening and changes in land cover over past years using readily available remote sensing and map data;
2. assess the number of people engaged in swiddening using demographic and economic data from the various countries and inputs from case studies;
3. assess the impacts of swidden change on the social environment, notably livelihoods, economy and culture, using case studies and regional assessments;
4. assess the impacts of swidden change on the natural environment, notably the landscape, biodiversity, agrobiodiversity, water resources, and global climate, using case studies and regional assessments;
5. assess the importance of policy as a driver of change, including a review of commoditization, changes in scale of production, economic policy, land tenure, infrastructure, and national and subregional conservation policies;
6. provide a forum to compare research that has been done on swidden agriculture in Southeast Asia; and
7. bring new ideas and concepts regarding swidden agriculture management to policy makers in several Southeast Asian countries.

Scientists involved in the regional review held a 2-day workshop in Bogor with representatives of six landscapes in Indonesia, followed by a policy seminar. We had separate sessions with male and female farmer representatives of landscapes from Aceh to Papua and local governments and nongovernmental organizations from the same areas before comparing perspectives on issues and challenges. In the next step we compared these consolidated local knowledge perspectives with the trends seen by scientists of various disciplines and national policy makers. After covering the three corners of the triangle in Figure 1, we focused on the distinctions between spontaneous, voluntary change in land use and the situation in which outside agents try to impose change. This volume reflects the scientists' interpretation of the key findings, concepts and issues that emerged from this consultative process. We indicate the source of information where it refers to a specific case study. We address the issues specifically in Indonesian terms but also use the synthesis of broader patterns elsewhere in Asia.

1.2 Indonesia case studies

The current synthesis was informed by participants from six landscapes in Indonesia (Figure 2, Table 1) where swidden systems are in various stages of transformation.

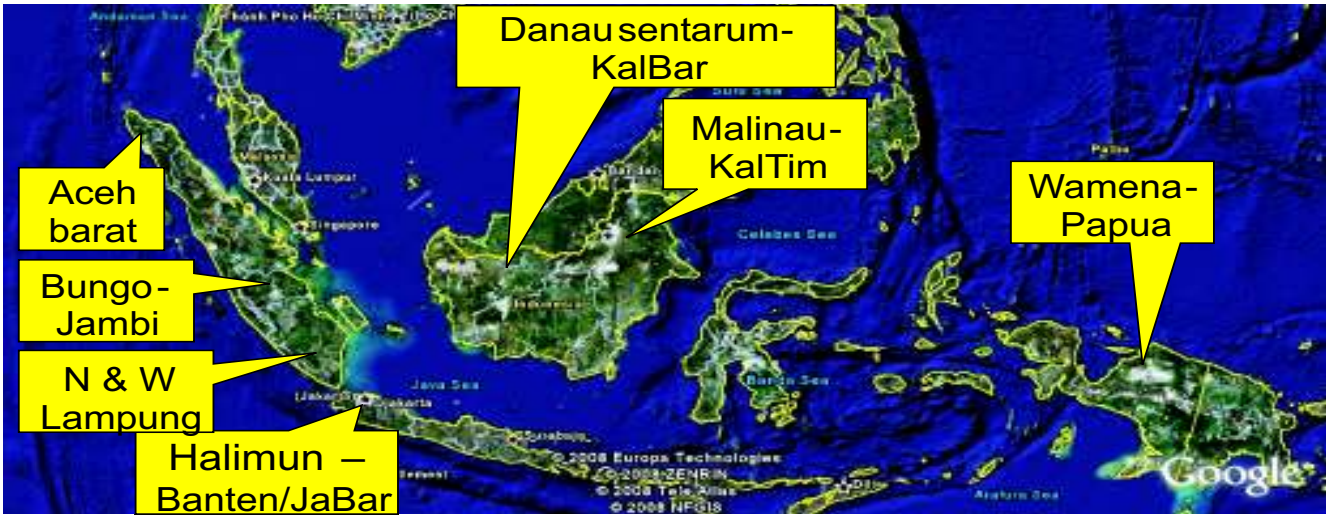

Figure 2: Locations discussed in the current synthesis.

Table 1: Benchmark areas in the current synthesis

Area	Physical characteristics	Population density relative to resource	Remarks
Halimun, West Java / Banten	Piedmont, peneplain	High, more than 1000 ps per km^2	Swidden areas are contested between local community and the national park authorities
North and West Lampung	Peneplain and moun-tain zone; degraded land rehabilitation as alternative to migration	High, 100 ps per km^2; immigration and (circular) emigration	Coffee based system and other cash crops replacing paddy under fallow rotation system
Bathin III Ulu, Muara Bungo District, Jambi	Piedmont; buffer zone of National Park (KSNP), rubber agroforests, traditional shifting cultivation	Intermediate (50 ps per km^2)	Swidden areas that were initially set aside for poorer community members under village regulation, are now transformed to rubber agroforest or tree crop plantations
Sungai Mas, Aceh Barat District, NAD	Mountainous with steep slope, upland area	Low (4 ps per km^2)	Land clearing for agriculture (intended for permanent or fallow systems) increased since the peace agreement
Danau Sentarum, Kapuas Hulu District, West Kalimantan	Piedmont, mountain Peat and freshwater swamp forest, hill forest	Low, 3 ps per km^2, with Dayak (Punan, Kayan, Taman, Iban, etc) on upland and Malay on lake-basin	Swiddens still exists, but part of the area was transformed to become rubber and oil palm
Malinau District, East Kalimantan	Heavily forested, mountainous terrain	Low (no more than 2 ps per km^2), land availability is high	Swiddens still exists; part of the area was transformed to become rubber and oil palm
Wamena District, Papua	Piedmont	Medium, 17 ps per km^2	Swidden and fallow rotation systems based on sweet potato production

Figure 3: Some of the faces of shifting cultivation in Indonesia: (top left) swidden plot in upland area of West Aceh (credit: Hasri Mulizar); (middle left) swiddeners in West Kalimantan (credit: Abi Ismarrahman); (top right) 'sesap nenek', or communal land used as swidden reserve in Bungo (credit: Elok Mulyoutami); (bottom left) workshop participant from Setulang village, East Kalimantan, performs a harvest dance (credit: Jose Arinto); and (bottom right) farmers on their swidden plot in Papua (credit: Fahmuddin Agus).

2. Main trends of intensifying agriculture in space and time

2.1 Swidden transitions

'Swiddens', 'shifting cultivation' and 'fallow rotations' are some of the many terms for systems that alternate annual food crops and perennial vegetation in a deliberate manipulation of natural vegetation succession. Swiddens are defined here as areas cleared of woody vegetation for the temporary production of staple food crops mixed with other annuals and/or perennials for local use and/or market. Food cropping alternates with the naturally regenerated vegetation. In the original forms of swiddening, the woody regrowth reaches the forest stage with the formation of a continuous litter layer, sparse understory vegetation and accumulation of nutrients in woody biomass. These nutrients can be released again in slash-and-burn land clearing.

Throughout Asia, swidden systems are the origins of current agricultural systems, but the transformations have been such that the underlying swidden pattern may be hard to recognize. The transformation of swiddens is reversible, depending on external conditions such as price fluctuations and policy (Colfer pers. comm.). Rather than aim for a sharp delineation of 'pure' forms of swidden, it may be more productive to emphasize the continuity of processes and patterns, bearing in mind that evolution, either natural or socioeconomic, is a process of gradual change in response to selection pressures, not the predictable emergence of 'higher' forms of life.

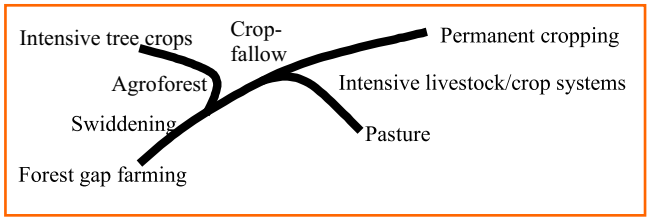

Figure 4: Simplified view of the gradual change in farming systems, with swiddening occupying a phase of the history of permanent cropping, tree cropping and livestock-based systems, with the latter two evolving from the fallow period.

As illustrated in Figure 4, swiddens can evolve into

1. Agroforests, in which the value of the woody regrowth equals or exceeds the utility of the annual crop phase;
2. pasture systems, in which domestic animals' grazing of the fallows gains prominence; or
3. permanent cropping as the end point of the intensification of crop-fallow rotations, with legume cover crops or fertilizer trees, the transfer of manure from grazing systems, or the application of chemical fertilizer replacing the soil fertility functions of the fallow.

Box 1: Swiddens + fallow as a land-use system

'Land cover' may be simply defined as anything that is on the ground. Land cover may be observed using remote-sensing tools. It has specific spatial attributes such as vegetation and carbon and nutrient storage and forms a habitat for plants and animals. Thus, grasslands, trees, forests, deserts, cropped fields and buildings are, depending on the scale of observation, all recognizable elements of land cover. 'Land use' is an action humans perform on the land to meet one or more objectives. In some cases, the same words can describe both land cover and land use: pasturage, for example, is both a cover and a land use. However, land-use systems can entail a sequence of land covers. At different times, a patch of land that is part of a shifting cultivation system of land use can have as land cover a bare field, cropped field, bushy young fallow, secondary forest or even old-growth forest. Moreover, a specific example of land cover can be part of several land use systems: a cropped field can be part of a permanent cropping system, part of a long-cycle rotation or an example of any system in between these extremes (Figure 5).

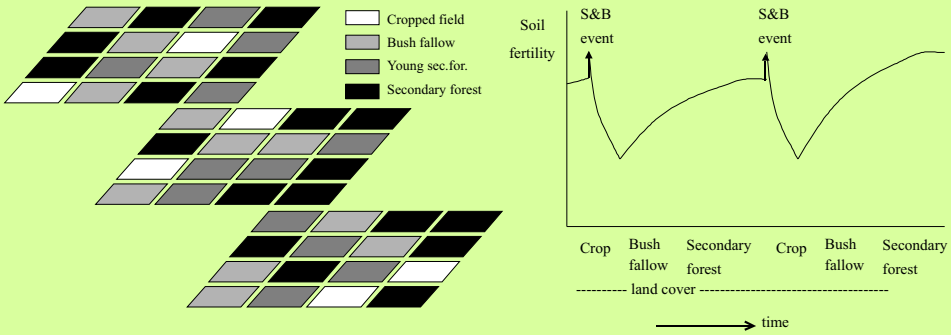

Figure 5: The diagram at left shows the spatial appearance of land cover in a shifting cultivation system at three subsequent times. The diagram at right shows soil fertility change under a sequence of land covers that together form the land-use system of shifting cultivation. Here the fallow length is sufficient to restore soil fertility and production potential over a complete cycle. Trenbath (1989) provided simple equations for the decline and recovery phase of soil fertility

Research on swiddens has often focused on the crop phase and soil fertility as dominating the cycle of use (= decline) and recovery. As emphasized by Trenbath (1989), however, the increase and decrease of crop production potential results from the interaction of soil physical, chemical and biological factors; weeds; and soil-borne pests and diseases that is not easily disentangled in its local configuration. Major differences among soil types, vegetation zones and climatic conditions complicate the interplay of factors, but the simple Trenbath (1989) model of decline and recovery is a useful starting point for understanding the dynamics.

After the cropping period, a succession of land-cover types occurs. Depending on the stage at which fallow vegetation is next cleared for a further round of cropping, we can classify the sequence of land-cover types as three land uses. If the land cover cleared is secondary forest, we can classify the land use as shifting cultivation. Likewise, if the land cover cleared is young secondary forest, we can classify the land use as long-fallow rotation. Finally, if the land cover cleared is bush fallow, we can classify the land use as short-fallow rotation. However, after clearing, the subsequent land cover, a cropped field, will be the same for all three of these land uses. This demonstrates that simply identifying a land-cover type on a plot at a particular time does not alone allow one to deduce the land use of that plot.

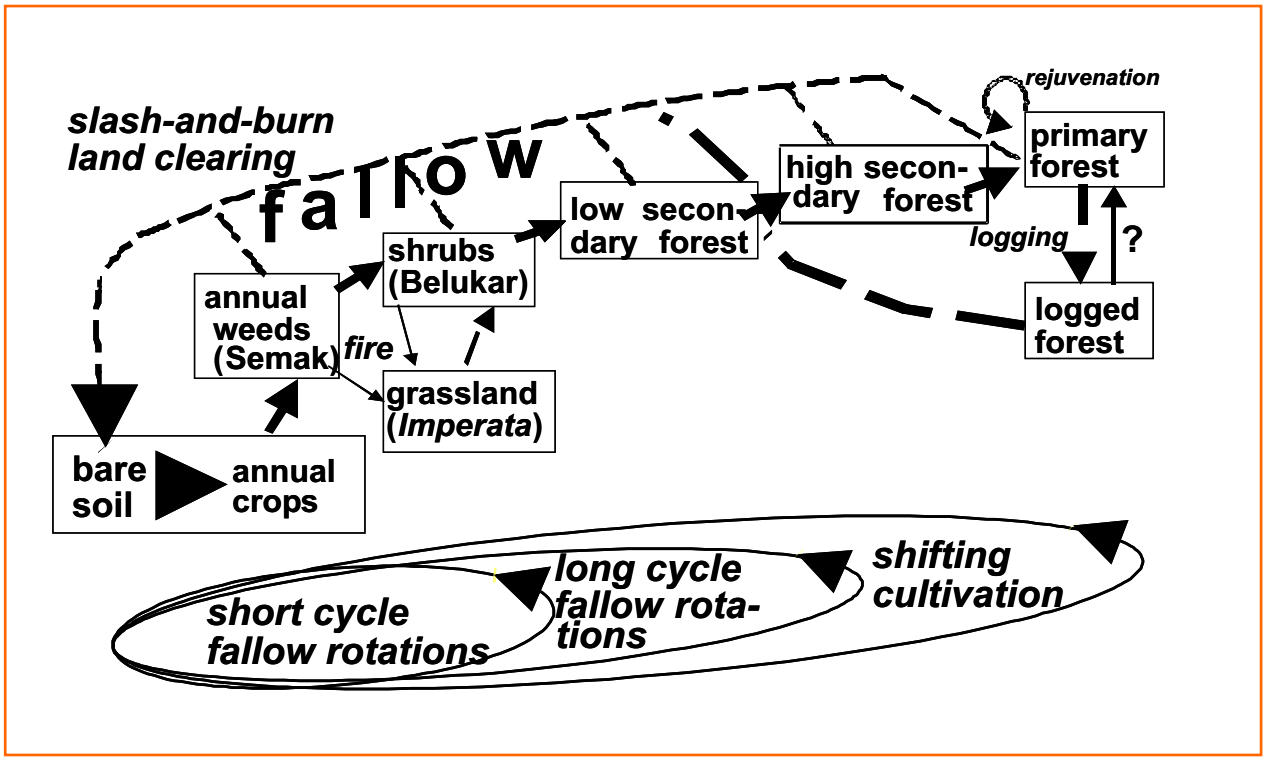

Figure 6: Transitions between land covers as part of fallow rotation systems (van Noordwijk et al. 1995).

Box 2: Ruthenberg's R value

R value (Ruthenberg 1976) is the number of years of annual food crop cultivation expressed as a proportion of the length of the cycle of land utilization. The greater the R value, the more intense the land use.

R = (number of years of cultivation X 100)/length of cycle of land utilization

The length of the cycle of land utilization = the sum of the number of years of cultivation + number of fallow years. For 2 years of food crops followed by 10 years of fallow, the R value is 16.7.

(2 x 100)/(2 + 10) = 16.7

The following table shows the length of the average fallow period in years for different values of R, depending on the length of the cropping period for annuals.

	Length of a cropping period (years)			
R (%)	1	2	3	4
16.7	5	10	15	20
33.3	2	4	6	8
66.7	0.5	1	1.5	2

Terminology used in the integrated natural resource management lecture note series (van Noordwijk et al. 2001) is as follows:

R = 16.7 33.3 66.7

----------X----------X----------X----------

Shifting cultivation | Long fallow rotation | Short fallow rotation | Permanent cropping

Also, If the land-use system is in equilibrium and the number of plots opened for growing food crops in any year is constant, we can derive that the fraction of the total area under crops (the land cover classification) equals the R value as well.

Thus, R = the proportion of the area under annual crop cultivation as a percentage of the total area available for farming.

2.2 Trends

The distinction between 'shifting cultivation' and 'fallow rotation' may seem clear, but in practice there has not yet been any systematic data collection. While remote sensing can identify the open field stage for cropping, the various stages of fallow regrowth gradually merge into 'forest', and results strongly depend on the threshold used to define it.

A number of data sets can, however, help to provide a regionally differentiated picture. Richards and Flint (1994) provided an index of dependence on swiddening across Asia, based on reconstructions of historical data from various sources. Their data suggest that by 1880 swiddening had declined to minor importance on Java and Bali and was rapidly on the way out in West and North Sumatra. One hundred years later, Papua was still highly dependent on swiddens, and East and Central Kalimantan were only just starting the transition. For the rest of Indonesia, the transition to lower reliance on swidden took place in the period 1880-1980, with the most rapid change between 1905 and 1930. This happened to be the period that rubber gained prominence as a smallholder crop (Figure 7).

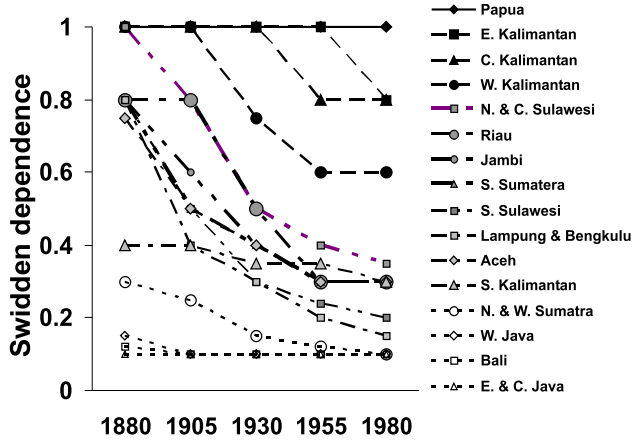

Figure 7: Historical change in land use in selected provinces of Indonesia, as reflected in the index of swidden dependence based on Richards and Flint (1994).

Although the Richards and Flint reconstruction involved a fair amount of 'guestimation', the broad pattern is reasonable. Their assessment of the 1980 situation can be compared with maps based on remote sensing.

Murdiyarso et al. (2008) presented data on the relationship between forest cover in 1990 and regency population density. In Figure 8 these data are aggregated to the provincial level. Compared to a reference line (forest fraction = -0.132 Ln(PopDens) + 1.114 [R^2 = 0.63]), a number of provinces stand out as having relatively high forest cover, especially Bali, North Sulawesi, Central Sulawesi and Maluku, while West Kalimantan, South Kalimantan, South Sumatra and Lampung stand out as having low forest cover compared with their population densities. (DI Yogyakarta is also in this category, but in other areas the cities were not included in the provincial data.) The example of Bali may be interpreted as evidence that an early shift from swidden to irrigated rice fields may have conserved its forest. Across the Indonesia data set, however, we found that the per capita area of rice fields has a neutral or negative association with relative forest cover.

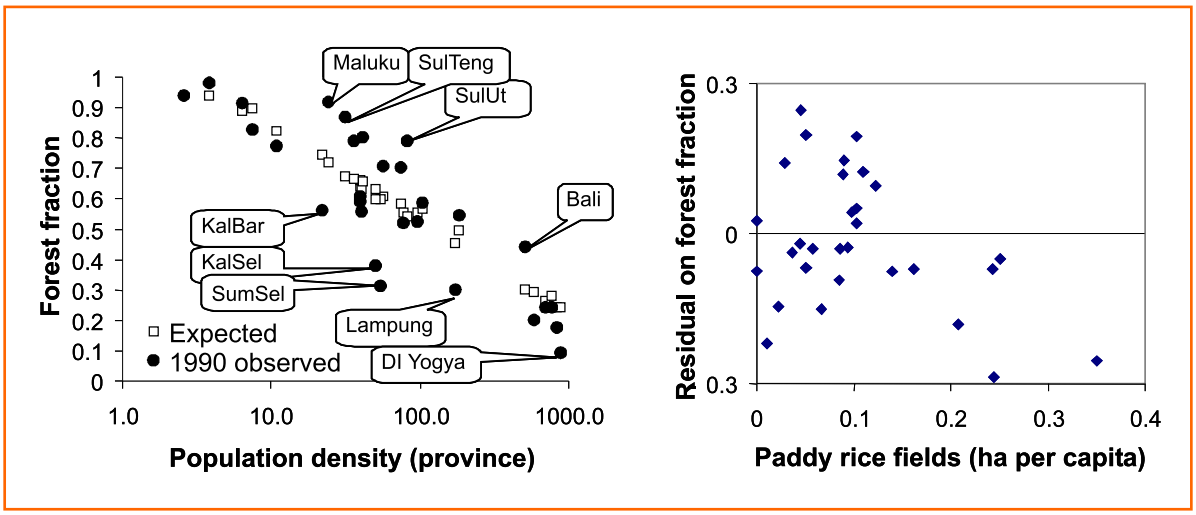

Figure 8: (left) Relationship between human population density per km^2 and forest cover for the provinces of Indonesia, with the main deviation between expected and observed data identified. (right) Test and refutation of the hypothesis that irrigated rice field area has a positive association with forest cover across Indonesia's provinces.

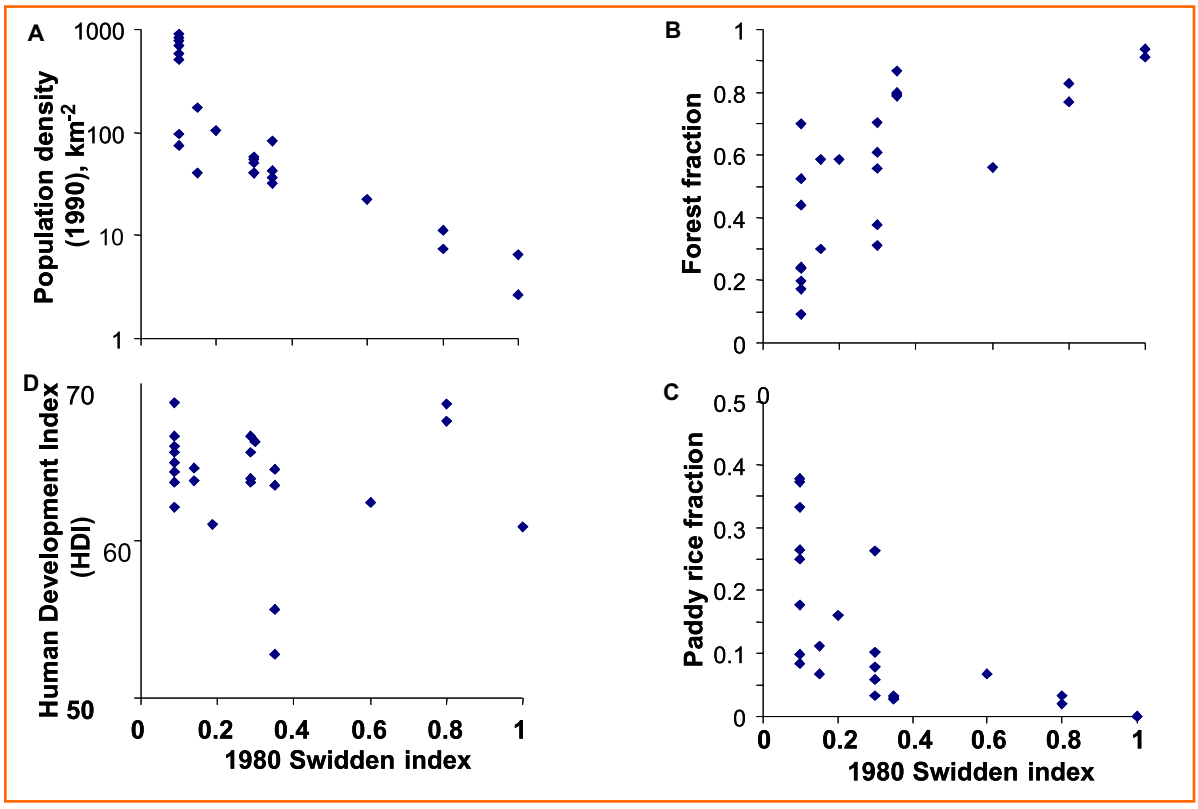

Figure 9: Relationship between the index of swidden dependence in 1980 (based on Richards and Flint, 1994; compare Figure 7) and (A) logarithm of population density, (B) actual forest fraction, (C) human development index, and (D) rice field area per capita.

The data show that swidden dependence at this scale is negatively associated with population density and paddy rice field availability and positively associated with forest cover, and that it is unrelated to the human development indices for health, education and disposable income.

The critical population density for shifting cultivation appears to be 10-30 people km^{-2}. Following Trenbath (1989), 15 people km^{-2} can be understood as 600 kilograms (kg) of rice per year per capita, a yield of 1 tonne per hectare (ha), R = 0.15 (7 years of fallow, 1 year of crop) and 2/3 or the area potentially arable.

According to the swidden index of Richards and Flint, the percentage of Indonesia's population outside of areas classified as urban that are fully dependent on swidden was 1.4% in 1980, but these swiddens involved 14.2% of the area of Indonesia and 18.9% of its forest. For 5.5% of the population, 48% of the area and 58% of the forest, the swidden index was at least 0.6, indicating a livelihood strategy of swiddens mixed with other forms of agriculture. For 24.9% of the population, 80.5% of the area and 87.9% of the forest, the swidden index was at least 0.3, indicating remaining relevance of swiddens in the overall livelihood pattern. For the remaining 75.1% of the population outside of cities, 19.4% of the area and 12.1% of the forest, swiddens played a minor or negligible role in 1980. We expect that the trend of reduced dependence on swiddens has continued, but recent data compatible with that of the Richards and Flint study do not exist.

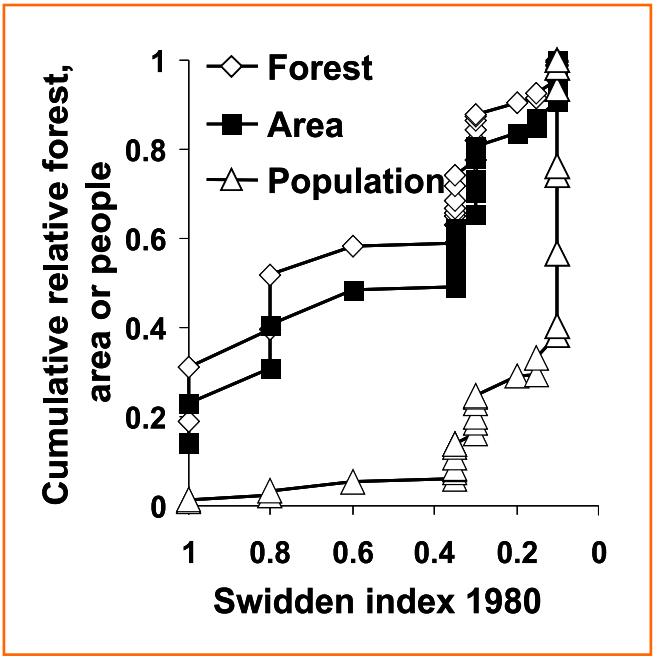

Figure 10: Relationship between the index of swidden dependence in 1980 and cumulative area, population and forest cover in 1990.