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Article

Project Benefits, Land, and Land Tenure of Upland Community based Forest Management Program Implementers in Sicopong Watershed, Philippines

Apollo R. Abrigo[*1], Yasushi Furukawa[*2] and Isao Kawata[*2]

ABSTRACT

Considering the land, land tenure, and the project benefits received by the 116 respondents who are members of the People's Organization in relation to the objectives of Community Based Forest Management Program, i.e., sustainable forest management and upliftment of the socio-economic status of the beneficiaries, the study showed benefits provided by the project comes in environmental and economic forms. More than 2,000ha of forest tree and agroforestry plantations were established. For forest tree plantation however, the government has yet to allow the People's Organization to conduct at least thinning activity on their plantations. On the other hand, the economy of the community especially the members of the People's Organization improved at least during the project funded period. In the analysis of data, it was found that those with bigger land claims and security of tenure have more economic benefits during and after the project especially when harvesting commence. While many studies focus on the members, the study also showed the differences among the members and how each membership types allocate their lands. Based from the total respondents, the average land allocated for the project is 2.3ha, the average land for food and commercial production is 2.0ha, and that the average total land claim is 4.2ha. Around 27% of the total members (2003 membership data) have individual land tenure through Certificate of Stewardship Contracts issued during the Integrated Social Forestry Program period roughly 10% have Memorandum of Agreement with the PO because they allowed their area to be developed under the project. With the present PO situation, the remaining majority of the PO members comprising 63% based on 2003 membership data that could not have individual land tenure security because they do not have lands developed under the project is in the brink of moving away from the PO.

Keywords: people-oriented forestry, sustainable forest management, upland community, poverty

INTRODUCTION

Environmental degradation, particularly deforestation, and upland[1] poverty are some of the major problems facing the country as early as 1970's. The 1999 forest cover of the Philippines was only 19% of the total land area which is 51% lower almost a hundred years ago (ESSC, 1999) while the recent data on upland population stands at 24 million (PIA, 2005) out of the approximately 80 million total population. The people residing in the uplands are referred as "poorest among the poor" (CRUZ, 1988). To solve if not minimize the effect of these twin problems, the government adopted the Community Based Forest Management program (CBFM) in 1995 as the national strategy to combat said problems. Attainment of sustainable forest management and eradication of poverty are the two major objectives of CBFM program.

Philippines Agenda 21, 1987 Philippines Constitution, and

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the Master Plan for Forestry Development in 1990were some of the factors that attributed to the paradigm shift to sustainable forest management in the country through community based forest management (UMALI, 2000). CBFM as a strategy evolved from a number of people-oriented forestry programs implemented in the country as early as 1970's (PULHIN and PULHIN, 2003). In this approach, the government tapped the People's Organization (PO)[2], who are usually living within or adjacent to the project area to realize the objectives of CBFM program (DENR, 1996).

Adopting the findings of BACALLA (2006), 1.57 million ha were allocated to organized communities, i.e., PO, through the issuance of long-term land tenure security called Community Based Forest Management Agreements (CBFMA). CBFMA is an agreement into by and between the government and the local community, represented by the People's Organization, as forest managers, which has a term of twenty-five (25) years and renewable for another 25 years. The rest of the project sites are under land tenure agreements from different people-oriented forestry projects implemented in the past by the government (DENR-EcoGov, 2004).

However, after more than a decade of CBFM implementation in the country, it seems that its twin goals of sustainable forest management and upliftment of socio-economic condition of the beneficiaries have not yet provided a clearer view as pointed by HARRISON *et al.*, (2004), sustainability of CBFM program remains open to question.

There are several programs and projects under the umbrella of CBFM program, mostly with foreign funding assistance, one of which is the Forestry Sector Project (FSP)[3]. FSP is a watershed and mangrove rehabilitation project implemented nationwide with funding assistance through a loan from the Japan Bank for International Cooperation (JBIC). The tenured area (with CBFMA) under FSP is almost 52,500ha (DENR-SAPI, 2003) representing only 3.3% of the total 1.57million ha (BACALLA, 2006) awarded with CBFMA n the country. Among the 24 watershed rehabilitation sub-projects under FSP with CBFMA is the Sicopong Watershed Rehabilitation Sub-project[4] in Negros Oriental province.

Although several researches have been made regarding CBFM in the country, the objective of the study, in particular, is to know how the twin goals of sustainable forest management and upliftment of socio-economic condition of the affected community can be obtained in the site selected. The study will also describe the level or status of these twin goals by considering a socio-economic point of view. In particular, benefits, land size, and land tenure of the PO members in relation to improvement of living and sustainable forest management will be highlighted.

STUDY SITE AND RESEARCH METHOD

Sicopong Watershed Rehabilitation Subproject is located in Negros Oriental province (Fig. 1). It embraces about 2,000ha of the upper portion of Sicopong River that flows to the Visayas-Mindanao Sea on the Southwestern part of Negros Oriental. It lies between 9°29' 47" and 9° 33' 21" latitude; and 122° 59' 7" and 123° 00' 24" longitude. From the capital of the province, Dumaguete City, the entry point going to the site along the national highway is approximately 75km. From the entry point, the site could be reached by using the most common means of transportation by motorcycle in the area called "habal-habal"[5].

The Sicopong Watershed Rehabilitation Subproject covers Barangays[6] Pal-ew and Santo Niño of Tanjay City and Barangays Sab-ahan and Mansangaban of Bais City, all in the province of Negros Oriental. All these four barangays are situated inside the mountainous area of the cities. The location of these barangays is shown in Fig. 3 about the present land use later in Chapter 3. Considering the population for year 2000, Barangay Sab-ahan is the highest among the four with 6,234 followed by Barangay Santo Niño with 5,369. Barangays

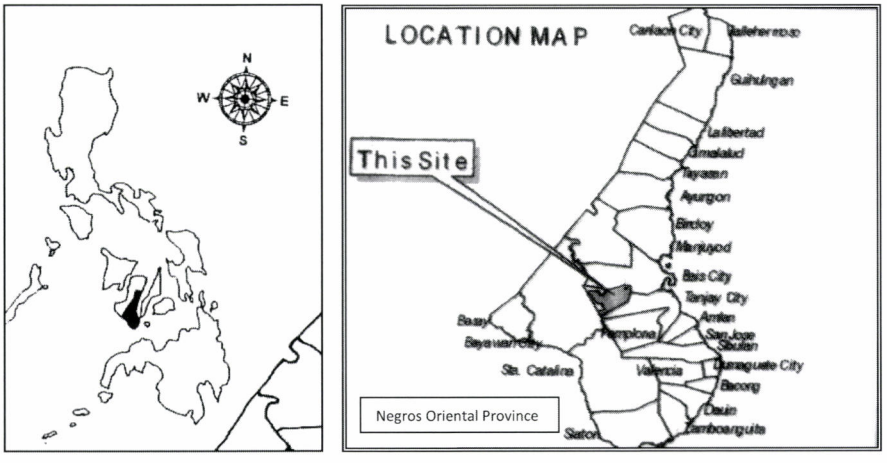

Fig. 1 Location of the Study Site

Pal-ew and Mansangaban both have a total of 1,331. Table 1 shows the population per barangay including the number of households inside the project area.

In terms of area, Barangay Pal-ew is the largest with 9,806ha followed by Barangay Sab-ahan with 7,825ha. Table 2 shows the forest area of the barangay and the area planted under the Sicopong Watershed Rehabilitation Project. It also shows the percentage (shown in parenthesis) of the project area based on the forest area of the barangay.

The site was selected for this study primarily because it is one of the first projects who implemented CBFM in the country after it was launched. It is also the first among the 36 sub-projects under the Forestry Sector Project where the PO was awarded with the Community Based Forest Management Agreement in 1998 covering the 2000-ha original project area. This is the original area where the 926-ha plantation (forest trees, agroforestry, and bamboo) out of the 2000-ha contracted area were established until year 2000. The remaining more than 1,000ha of plantations are found outside the boundary of this original project area.

The PO submitted a request to the DENR to increase their CBFM area to more than 7,000 ha to cover the plantations they established outside the boundary of the original project area.

The research was conducted in March 2006 and a follow up/supplemental research in November of the same year. Data collected were drawn from observations, documentary evidence, group discussions, and a survey using a semi-structured interview of 116 respondents (PO members and/or former members) selected based from the list of PO members through random sampling procedure. Table 1 shows the number of households inside the project and the number of respondents per barangay. Personal discussion with key informants including government personnel and other individuals who are or have been involved in the project was also conducted.

The questionnaire developed for the interview contains questions about the socio-economic status of the respondents and general information about their household (age, educational attainment, years residing in the area, economic activity, etc.); sources of income; about their tenure status (claimant or tenant); about their land being claimed (how they acquire the lands if they have claim lands); what benefits or incentives they get from joining the PO/project. These are some of the questions found in the questionnaire.

In the case of informal discussions, this usually took place during night time after dinner. Ordinary members who were left because it is too late for them to go back home and PO officers with some DENR personnel participate in the said informal discussions. Project-related topics were mostly discussed. In this kind of discussion, some of the issues they shared were not captured in the semi-structured interviews. Issues pertaining to tenant-landlord relationships were also opened up.

The original plan was to have a house to house interview, but because of accessibility and distance problems it was decided to conduct interviews in barangay centres[7]. Lack of available resources on the part of the first author also affected the original plan. The interview was conducted by the first author together with the enumerators hired to assist in the interview. Local dialect was used in the questionnaire and in the conduct of the interview.

Contextual experience of the first author was also used in this study being a former DENR employee assigned to monitor and evaluate the progress of the sub-project activities not only in the study site but in other sub-projects in Central Visayas as well.

Table 1 Population and Number of Households per Barangay

Barangay	City	Population	Total Number of Household (HH)	Number of HH inside the project	Number of Respondents
Sab-ahan	Bais	6,234	1,131	153	43
Pal-ew	Tanjay	1,331	907	242	22
Santo Niño	Tanjay	5,369	1,035	127	47
Mansangaban	Bais	1,331	230	73	4
TOTAL		14,265	3,303	595	116

Table 2 Total Area per Barangay Including the Forest Area and the Project Area

Barangay	Area (ha)	Forest Area (ha) A	Project Area (ha) B	Percentage (B/A)
Mansangaban	680	442	195	44
Pal-ew	9,806	4,106	289	7
Sab-ahan	7,825	5,699	303	5
Sto. Nino	7,438	4,742	1,222	26
TOTAL	25,749	14,989	2,009	13

RESULTS AND DISCUSSION

The People's Organization (PO)

History and role of the PO

The implementation of the Sicopong Watershed Subproject paved way for the birth of Sicopong United Environmental Rehabilitators for Sustainable Development Association, Incorporated (SUERSDAI). The residents covered by the subproject were organized as an association to accept and implement the Comprehensive Site Development (CSD) contract from Department of Environment and Natural Resources (DENR)[8]. CSD includes plantation activities from nursery operations to plantation establishment to maintenance and protection of plantations established under FSP Prior to the signing of the CSD contract, the association was organized by an Assisting Organization (AO)[9] Community organizing (CO) activities lasted for two years and conducted almost simultaneously with the CSD activities. Originally, members of the PO came from only three barangays. But because of the area expansion that happened after the project period was extended, another barangay (Santo Niño) was included. The lack of available area inside the original project boundary is one of the major reasons why the PO accomplished only 46% of the target until year 2000. There were many other residents inside the original project boundary who opted not to participate or join to become PO members. The two most common reasons for this include the belief that they will be ejected from the site as experienced in other areas and the other is having a small land area. To meet the target, one of the strategies used by the PO in convincing the other claimants to join is the benefit sharing that will come after harvesting of timber products.

Generally speaking, the communities were organized as part of the requirement under the Loan Agreement between DENR and JBIC[10]. At present, the PO has converted into a cooperative through another foreign funded project of the government. This is viewed as the POs way to sustain their organization by keeping them busy with other activities from the said project. In the present set-up of the PO, only those with land claims developed under the project are included. Fig. 2 highlights the milestones in the history of the organization.

Membership types of SUERSDAI

Based on the POs' original membership policy, only those residents with claim lands inside the original project boundary and are willing to have their area planted under the project are qualified to become PO members. As mentioned earlier, lack of area for planting inside the original project boundary and a shortage in manpower (labour) prior to project period extension and expansion in a way forced the PO to accept other residents to become members.

In their classification, there are three types of members. First, are the stakeholder members (SHM) who allowed their land to be planted under the project and may have participated in CSD activities. Second, are the honorary members (HM) better known as absentee claimants who just allowed their land to be planted under the project. Finally, are the non-stakeholder members (NSHM) who only provided labour during the height of project implementation (Abrigo *et al.*, 2006). Based on the 2003 membership data, the non-stakeholder members comprised the majority at 63% (603 members), the stakeholder members at 33% (316 members), while the honorary members at 4% (39 members).

In the analysis of data, membership types were re-classified based on land and labor provided. Adopting the PO definition of SHM who provided land, two types can be found. First are those who are residing in the area and the other one

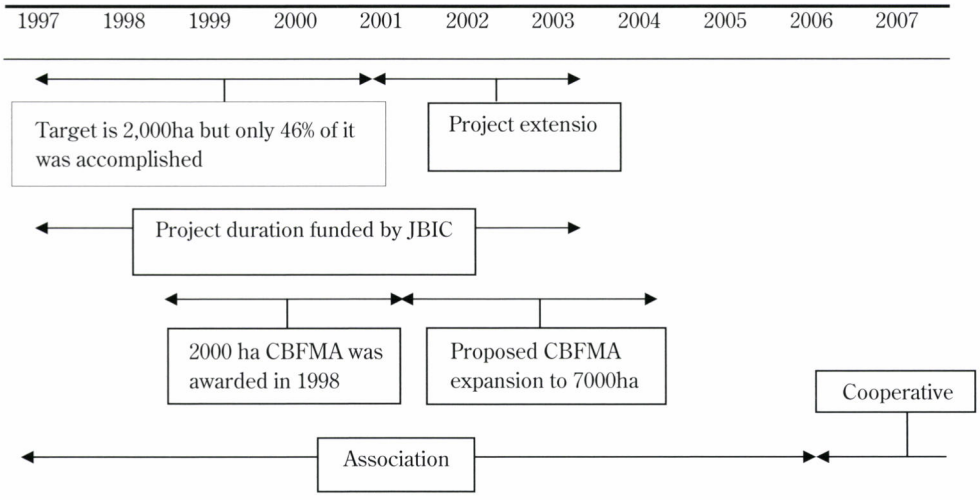

Fig. 2 PO and subproject milestones

Table 3 Number and type of members from selected years

Unit: year, number of members

Year	1997	2000	2003	2006	2007
Members	*298*	*793*	*958*	*485*	*351*
SHM			316	351	351
HM			39		
NSHM			603	134	

Sources: Survey data 2006
Note: SHM – stakeholder member; HM – honorary member; and NSHM – non-stakeholder member

are the absentee claimants whom they call honorary members. For the NSHM who only provided labour, two types can also be found called non-tenant NSHM and tenant NSHM. Tenant NSHM are generally those who do not have a claimed land and into an agreement with a landlord (although a number of those interviewed are claiming a piece of land). On the other hand, the non-tenant NSHM have a land being claimed, and for their own reason, did not allow their area to be developed under the project. In effect, there are four types of members present within the PO: 1) the present stakeholder members, 2) the absent stakeholder members, 3) the non-tenant non-stakeholder members, and tenant non-stakeholder members.

After converting to cooperative, again, only those with claim lands most especially holders of Certificate of Stewardship Contracts (CSCs)[11] awarded during the Integrated Social Forestry Program (ISFP)[12] and Memorandum of Agreement (MOA) with the PO are listed as members of the cooperative and the rest are not, based from the documents obtained. The role of NSHM who provided the labour requirement during plantation establishment is no longer seen in the current cooperative. The MOA between contains the benefit sharing between the PO and the land claimant who allowed their area to be developed under the project. Unlike CSC, it is not a legal document recognized by the government.

From Table 3 it can be observed that the numbers of members is increasing until year 2003. This is the period where there were still funds coming from the funding institution. After the funding assistance terminated, number of members decreased. For year 2006, it was assumed that the honorary members (HM) were included in the SHM. The reason why they were able to have a data for 2006 is because of the fact that they joined in another foreign funded project called Philippine Environmental Governance financed by the United States Aid for International Development (USAID).

Changes and accomplishment of the PO for plantation establishment

Based on the original project plan, the PO must accomplish 2,000ha of forest and agroforestry plantations until year 2000. However, due to reasons like lack of area for development inside the original project boundary because the other residents did not join, the PO only accomplished 46% of 2,000ha target. Fortunately, the project period was extended.

Another reason for the low accomplishment was the low survival rate of the original species. These species are proposed in the sub-project appraisal report. In the case of reforestation component there was really no change in species except for the size of area allocated for each. In the original design, same species should be used during re-planting (replacing dead planted seedlings). The PO noticed that mangium (*Acacia mangium*) thrives well in the area compared with mahogany (*Swietenia macrophylla*) because of this instead of replacing mahogany with the same species, they used mangium. Survival rate of the plantation is the basis in paying the accomplishment of the PO. On the other hand, there was a change in species under agroforestry component. The jackfruit (*Artocarpus heterophylus Lamk.*) was replaced with mango (*Mangifera indica*) and the combination of species jackfruit and gmelina (*Gmelina arborea*) was scrapped. One factor that has affected the low survival of mahogany is the quality of seedlings used. They were raised in a nursery by farmers who are more familiar with vegetable crops than forest tree species. The situation prompted the PO to request DENR through resolution for a change of species. For agroforestry species, higher market value and familiarity are the reasons why they chose mango over jackfruit. The lack of available area inside the original project boundary, as mentioned earlier, is one of the major reasons that led them to expand and plant outside the original project boundary. Through another resolution submitted to DENR, they were allowed to plant outside the original project boundary for as long as it is inside Sicopong Watershed. Fig. 3 shows the present major land use in Sicopong Watershed Subproject.

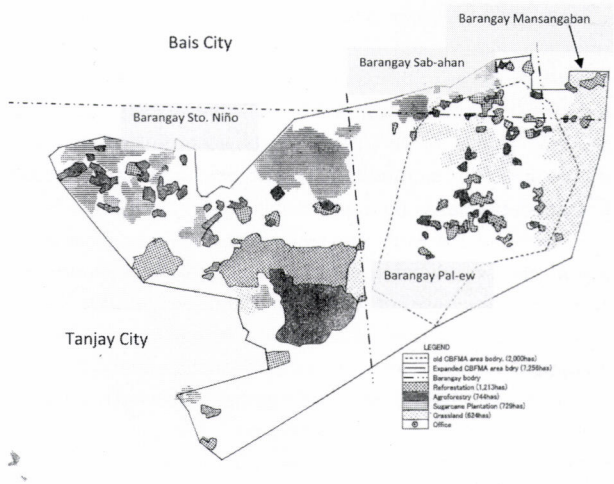

Fig. 3 Present major land use in the project site covering more than 7,000ha
Source: Re-traced from Sicopong Watershed Subproject Land Use Map from DENR Dumaguete City

Management of plantations and benefit sharing

Regarding plantation management during project period, activities like re-planting, weeding, fertilizer application and others, during this period are decided by the PO including the payment for its corresponding costs.

On the other hand, after the project period the role of the PO becomes facilitator. Management of the plantations especially the labour cost will now be shouldered by the SHM. The SHM needs to ask approval first from the PO before undertaking harvesting or any silvicultural activity like thinning in their area. The relationship between the PO and the individual SHM is bounded by a MOA.

Regarding benefit sharing, the income from the harvest of both forest and agroforestry products will be shared by the government and the PO. Based on the government policy, 25% of the gross sales that will be derived out of selling timber products go to the government while the remaining 75% to the PO (DENR, 1998). Regarding the 75% PO share, 33% will go to the organization while the remaining 67% will go to the stakeholder member claiming the piece of land. In the agroforestry plantations, however, there will be no government share which means that all income derived from it will be solely for the PO. Like the forest tree products a sharing between the PO itself and the SHM exist wherein 20% of the income (based on gross) will be for the former while the remaining 80% for the latter. This sharing agreement is also contained in their MOA between the PO and the stakeholder member. Unfortunately, there is no sharing agreement between the non-stakeholder members and the PO.

Household Head Characteristics based on 116 member respondents

Age, education, and main occupation/economic activity

Since nobody among the absentee claimants under SHM group was interviewed, the succeeding discussions will only focus on the three other types of members (present SHM, non-tenant NSHM, and the tenant NSHM. Table 4 shows the socio-economic profile of the respondents according to types of membership. The numbers in parenthesis shows the number of respondents based on membership types.

The highest average in terms of age at 47.9 belongs to the present SHM group while those under the NSHM group have almost the same average at 43. The total average age among the three groups is 44.7. Regarding education, the highest percentage of those who reached over elementary (at 18%) belongs to the SHM group while nobody among the tenant-NSHM group went beyond elementary.

The other respondents either did not have any formal education at all or no data was provided at 11.7% for present SHM, 10.7% for non-tenant NSHM, and 7.1% for the tenant NSHM group.

In Table 4, distribution of percentages from main economic activity shows that the non-tenant and the tenant NSHM are the same in terms of own farming while the present SHM is higher by four percent. It could also be noted that among the three membership types, the tenant NSHM has the highest percentage in terms of economic activity coming from labour at 29%. This is not surprising since most of the tenant NSHM are working as sugarcane labourers. The landlord-tenant relationship in this sugar producing area was confirmed through the report of CHERNIGUIN (1988) during the peak of sugar production. Among this three types, the biggest bulk of their income comes from own farming.

Table 4 Socio-economic profile of the respondents

Unit: %, age

	Present SHM (60)	NSHM		Average
		Non-tenant (28)	Tenant (28)	
Age	47.9	43.0	43.3	44.7
Education				
under elementary	70%	82%	93%	78%
over elementary	18%	7%	0%	6%
Main economic activity				
own farming	50%	46%	46%	48%
Labor	15%	14%	29%	18%
Others	30%	29%	14%	26%

Source: Survey data 2006

Income classes

Using the Mean Family Income, Table 5 shows the distribution of respondents based on income classes. This income class range was created by the government through the National Statistics Office. It is evident that majority of the members are very, very poor in all membership types, in fact, 71% belongs to the lowest income class. From the Table there are 11 families that fall in the income range 60,514 pesos to 75,036 pesos.

Considering the poverty threshold level per capita for year 2006 at 14,405 pesos and multiplying it to five as the average number of person per family set by the government through the National Statistics Office, the amount is equivalent to 72,025 pesos. Based on this, there are only 9 families living above the poverty threshold level and eight of them are from the present SHM group. In Table 5, there were three respondents from the income range ≤75,036 pesos which are above the poverty threshold level for year 2006. However, only one of the three has an annual income of more than 72,025 pesos, the two others have only 65,300 and 62,800 pesos of annual income which is still below the poverty threshold level.

Table 5 Mean Family Income Class by membership type by number

Unit: number

Income class*	Present SHM	Non-tenant NSHM	Tenant NSHM	Total	Percentage of Respondents
≤23,258	39	21	22	82	71
≤37,218	8	3	3	14	12
≤48,377	2	1	2	5	4
≤60,513	1	2	1	4	3
≤75,036	2	1		3	3
≤93,172	6			6	5
≤118,166	2			2	2
TOTAL	60	28	28	116	100

Note: * FIES 2006 http://www.ncsb.gov.ph
Source: Survey data 2006

Table 6 Means of "acquiring" lands by the members

Unit: number

Means of obtaining lands	Present SHM	Non-tenant NSHM	Tenant NSHM	TOTAL
Original kaingineros	7	0	1	8
Inherited from parents	21	3	3	27
Buying adjacent or others' land	29	2	1	32
Others (tenant, pledge, etc)	1	3	11	15
TOTAL	58	8	16	82

Source: Survey data 2006

Land, Land Tenure Situation and Its Relation to the Project

Lands in the uplands classified by the government as forest lands are technically owned by the government through the Regalian Doctrine (POFFENBERGER and MCGEAN 1993, PULHIN and DIZON, 2003). BORRAS (2006), although, argued that forest lands or public lands defined as 'public' in public policy practice no longer fits the basic criteria used in theory to define public lands in developing countries like the Philippines. The emergence of migrants residing in these forestlands led the government to award land tenure instruments to the communities and individuals through different programs. In this study, the instrument awarded to the community through the PO by DENR is the CBFMA.

How lands were 'acquired'in the uplands

The most common method of acquiring lands in the upland is by "kaingin". "Kaingin" as most commonly known in the country refers to slash-and-burn method of shifting cultivation although its definition evolved through time and places at least in the study sites of LAWRENCE (1997). Under the "kaingin" system, "First come, first serve" is the unwritten rule in the earlier times, especially after the logging company abandoned the area. In this aspect, the family with more members that are able to work can "acquire" larger piece of lands. After this, the second generation of family members normally "inherits" the land. Since this method is no longer practiced in the area, the term "kaingin" now refers to their farms. Not until an avoidable circumstance occurs within the family prompting them to sell it, the "ownership" of the land is just transferred from one generation to another. Another means of "acquiring" lands in the upland is through buying. This is also the most common method of increasing the area "acquired" by an individual. This scenario is exemplified in the present SHM group as shown in Table 6. In the questionnaire only 82 respondents provided an answer when asked how they 'acquire' their lands. An example of other means of acquiring land, especially in the study site, is through pledge or used as a collateral.

Allocated for the project (plantation) and land allocated for food and commercial production

Based on the data gathered, the average land allocated by a present SHM for the project is 4.1ha while the tenant NSHM is 0.6ha. Combining the land allocated for the project by all respondents, the average area is 2.3ha. The lands developed for the project for the tenant NSHM (who are supposed to have no land) are the lands from the honorary members who are absentee claimants. There are some cases wherein the tenant NSHM claims a piece of land aside from the land he/she tills being a tenant. The size of their own claim lands is almost always small limiting them to volunteer it to the project.

Regarding the land allocated for food and commercial production for the three (3) membership types, the averages are 2.9ha, 1.4ha, and 0.6ha for present SHM, non tenant NSHM, and tenant NSHM, respectively. Combining the three membership types, the average area allocated for food and commercial production is 2.0ha which is higher than the average total land claim for the non tenant and tenant NSHM.

For the total land claim, the present SHM registered the highest average at 7ha while the non-tenant NSHM is the same as the food production average which is 1.4ha, and 1.2ha for the tenant NSHM. As mentioned earlier, the area claimed by the tenant NSHM not only includes the area for which they are tenants (from absentee claimants) but also their own claims in some cases. The average total land claim of non-tenant NSHM is below the average land allocated for the project.

In here, we can say that for an individual to be able to allocate a land for the project without totally sacrificing their source of income of food for daily subsistence, he/she must have at least 4.2ha of land being claimed. The figure below shows the average land allocated for plantation and for food production including the average total land claim.

Table 7 shows the number and average land allocated for the project and for their own use by present SHM. The 5-ha area was used as the basis since it is the maximum area that can be awarded to individual members under CBFMA (HARRISON *et al*, 2004). In the table, it can be observed that those with lands 1-ha and below have allocated all their lands for the project. Except for class size 1.1-2ha, the average land allocated for the project is higher than that of their own use. It is assumed that even though their areas are small and below the average land allocated for the project, they still offered their land. They are those who opted for agroforestry plantations since they can still utilize the spaces in between agroforestry species for planting crops for their own consumption. It is not surprising to note that almost half of them with land above 5ha joined the project, one reason behind it is the fact that they cannot manage these big areas using their own resources. From Fig. 4 and Table 7, we can see how the land size plays an important role in the project.

Table 7 Number and average land allocated by present SHM

Unit: ha, number

Class size	Number	Project (ha)	Own use (ha)
1ha and below	5	0.7	0.0
1.1 - 2ha	7	0.8	1.0
2.1 - 3ha	9	1.6	1.1
3.1 - 5ha	12	3.0	1.4
above 5ha	27	6.9	5.2

Source: Survey data 2006

PO and its members' tenurial instrument

The tenurial instrument awarded in 1998 to the PO is the CBFMA covering the 2,000ha original project boundary. Since the remaining 54% of their plantation was established outside the area awarded with CBFMA, they must amend their CBFMA to cover said plantations. The PO already applied for the amendment to DENR, if approved, their CBFMA area will be more than 7,000ha. Regarding individual land tenure, the PO based on DENR policy must issue CSC to members (maximum of 5ha) whose land were planted under the project.

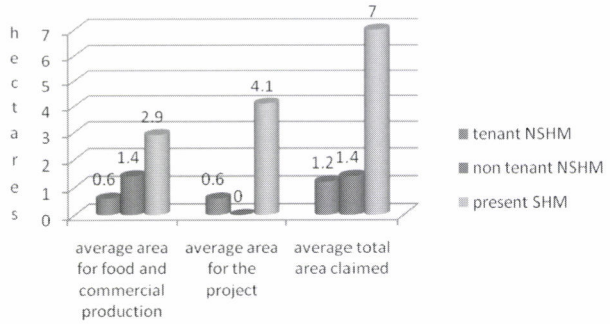

Fig. 4 Average land allocated by respondents per membership type
Source: Survey data 2006

Table 8 Number of present SHM with CSC and MOA per barangay

Unit: ha, number

		Number of Members			Tenure Document	
Barangay	project area (ha)	~5ha	5ha~	total	CSC	MOA
Mansangaban	195	9	33	42	42	-
Pal-ew	289	11	110	121	119	2
Sab-ahan	303	14	91	105	101	4
Santo Nino	1,222	26	57	83	-	83
TOTAL	2,009	60	291	351	262	89

Source: Survey data 2004 and 2006
Note: CSC – Certificate of Stewardship Contract; MOA – Memorandum of Agreement

Presently, no single CSC from CBFMA was issued by the PO.

On the other hand, almost 80% from the present SHM groups from the three other barangays are CSC holders awarded under ISFP prior to FSP except in Barangay Santo Niño. Having an idea on what security of tenure means and unsure whether their CSCs will be renewed for another 25 years, they also joined the project upon hearing that a similar security of tenure will be awarded to those who will participate. For these holders of CSCs, their definition of security of tenure is being sure that they will not be removed or ejected from the area as experienced in other parts of the country as reported by PULHIN *et al*, (2007). When asked about their priority of joining the project, it is not surprising to note that among the three, the tenant NSHM group gave the highest priority on land/security of tenure while the two other types prioritized the environment and as a source of income. Table 8 suggests that Barangay Santo. Niño, at least in the area covered by FSP, did not implement ISFP.

CONCLUSION

Based on the findings, it can be concluded that the project provided benefits in different forms. For the members, clearly they received wages during project implementation. This in a way lessened some burdens of living like sending their kids to school as mentioned by some of the respondents. On one hand, the SHM benefited more because aside from the wages, they will received income from selling of crops, and that their land were secured (especially those within the original boundary). Aside from these, the area was reforested as evident by the 2,000ha of forest and agroforestry plantations. The objective of the project to reforest the area, in this aspect, was achieved. In spite of these, the project still has several problems.

The benefits received by all members are only during the project implementation or while there is still funds from JBIC, in other words short-termed. After the project however, the benefits of the project specifically the economic benefits will only be received by those members who have lands. In this case, those with bigger land developed under the project will benefit more. In addition to this, the project even helped this present SHM group with bigger lands to use, develop, and manage their lands. The lands that were "given" by the present SHM group are usually barren lands, far from their residents, and in some cases sporadically located. The project solved the problem of the SHM of managing big lands since many of them are not financially capable. Both the non-tenant and tenant NSHM have no direct economic/financial benefits after the funded project. Considering the 2003 membership data, they comprise 63% of the total membership. The situation in a way resulted to a very low participation of members to PO activities and a lower number of memberships after the project as shown earlier. During planting activities, local people were hired as labourers by their own organization, which according to HAYAMA and SEKI (1999) is the government's perspective of a "participatory" forest management. Now that the PO has converted into a cooperative, the role of NSHM who contributed much to the accomplishment of the project targets is no longer seen. Because of the transformation of the PO from an association to a cooperative, these NSHM who think that they are still members of the PO are in a way "ejected" without their knowledge based on the present set-up of the PO. This was based on the data gathered and confirmed during the interview. The PO's sustainability, under the tenurial agreement, is very critical because the plantations (deemed as the major source of income) they established could only be harvested if they remain intact. The transformation of the PO to cooperative could be viewed positively and negatively. It is positive, in a sense that the organization was sustained. It is negative, since it deprived the majority (NSHM) from benefiting from the organization. Equality and social justice in this case are missing.

Regarding land tenure for the PO, so far only the original project boundary is covered with CBFMA. On the other hand, roughly 27% only from the total members for 2003 are assured of land tenure because of CSC awarded during ISFP while the rest have none.

About sustainable forest management (plantations established) that includes harvesting, the picture is not yet clear since the PO is facing problems on marketing and lack of capital. In addition to this, the government's policy on harvesting even issuance of resource use permits is not stable proving detrimental to the POs (PULHIN *et al*., 2007).

The upliftment of socio-economic status of the majority of the beneficiaries are short-termed making the subproject to be more environmental since the objective of rehabilitating the environment was obtained through the plantations established. On the other hand, the other objective of raising the standard of living of the affected communities has yet to be seen and based on the result of the study, it was only obtained during the funded period of the project. Unless PO policy (especially sharing agreement) and government policy (harvesting in CBFM areas) will be re-considered and be stable, respectively, and other alternatives will be identified only then sustainable forest management and upliftment of socio-economic condition can be achieved at least in the study site.

ACKNOWLEDGMENTS

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END NOTES

[1] In the Philippines, this is usually an area associated with mountains or high elevation

[2] A group of people, which may be an association, cooperative, federation, or other legal entity, established by the community to undertake collective action to address community concerns and needs and mutually share the benefits from the endeavour (DENR, 2000)

[3] Only two out of the 10 projects and programs under the CBFMP umbrella were implemented without foreign funding assistance, Integrated Social Forestry Program and Upland Development Project (PULHIN and PULHIN, 2003).

[4] In official reports, all the sites under the Forestry Sector Project are referred as a 'sub-project'. For this paper, the word sub-project is used interchangeably with the word project which will also refer to the study site.

[5] It is a regular motorcycle that could carry an average of up to five (5) passengers at the same time including the driver.

[6] Barangay is the smallest political unit in the country. This is similar to the Japanese political unit called "shi, cho, son"

[7] This is the place in the barangay where people gather to buy or sell their farm products during local market day called "tabo". Barangay hall, schools, and basketball court are commonly found here.

[8] DENR is the primary government agency responsible for the conservation, management, development, and proper use of the country's environment and natural resources.

[9] A local NGO contracted by DENR to conduct community organizing activities for two years

[10] Only 8 out of 47 POs nationwide under FSP were already existing prior to the implementation of the project

[11] Tenurial instrument awarded during ISFP and presently for awarding to individual PO members awarded with CBFMA

[12] Integration of earlier people-oriented forestry programs in the country that provided land tenure security for beneficiaries (individual/family and communities) through the Certificate of Stewardship Contracts (CSC) implemented in 1980's.

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Article

Monitoring Agricultural Expansion during the Economic Crisis in Indonesia: A Case Study of the Rawa Danau Nature Reserve

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ABSTRACT

Following the 1997 Indonesian economic crisis, faith in agriculture was justified and plantation farmers reacted by expanding their fields at the expense of forest cover. The objectives of this study were to examine the spatial pattern of land-cover changes that occurred in the Rawa Danau Nature Reserve, Indonesia, with the background of the economic crisis period and to characterize the situation of local people causing agricultural expansion in this area. A satellite-image analysis and a household-survey analysis were executed. The economic crisis has played a major role in changing land-use practices and has affected protected areas. The satellite-image analysis shows that a rapid change of vegetation-cover occurred after the economic crisis as compared with the period prior to the crisis. The household-survey and spatial analyses show that, initially, villagers located near protected areas are more likely to encroach on protected areas than villagers located further away from protected areas. However, after a period of several years, even distant villagers encroached upon the nature reserve. Aside from proximity of access, the smaller size of agricultural land holdings, the larger number of tenant farmers and the increase of unmonitored access to the nature reserve after the economic crisis were the characteristics of agricultural expansion villages within the study area.

Keywords: land-cover change, agricultural expansion, economic crisis, satellite-image analysis, household-survey analysis

INTRODUCTION

Land-use and land-cover change (LULCC) can be a major threat to biodiversity through the destruction of the natural vegetation and the fragmentation or isolation of nature areas (VERBURG *et al.*, 2006). Both regional and local-scale studies have demonstrated a number of critical events that give rise to land-cover change, such as tropical deforestation (GEIST and LAMBIN, 2002; KUMMER and TURNER, 1994; VERBURG *et al.*, 2006). In particular, agricultural expansion is the leading land-use change associated with nearly all global deforestation cases (GEIST and LAMBIN, 2002).

According to BOSERUP (1965), there are two general types of agricultural systems: extensive agriculture and intensive agriculture. Extensive agriculture tends to exist where there is relatively low population pressure, together with widely available land resources and simple technological systems (lower input). In contrast, intensive agriculture occurs in high densely populated regions with limited land resources, accompanied by evolution in agricultural technique (higher input) due to frequent cropping.

Limited land resource problems occur in two situations – either when the opportunity to obtain new land is severely limited or when available land is not legally accessible (e.g., PELUSO, 1992). In the first situation, BOOTH (1985) and BOSERUP

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(1965) reviewed the way agricultural production processes adjust over time to the increasing population pressure by looking at Javanese agricultural case studies. However, many cases of agricultural expansion in protected areas, notably those areas in high-density regions, are categorized under the latter situation (e.g., the cases of Sierra Madre Nature Park of the Philippines (VERBURG *et al.*, 2006) and Bangladesh (IFTEKHAR and HOQUE, 2005)). PELUSO (1992) notes that millions of Javanese subsistence farmers live alongside state-controlled forestlands in one of the world's most densely populated agricultural regions. Because their legal access and customary rights to the forest have been severely restricted and the legally available agricultural land is not sufficient, these subsistence farmers have been pushed toward illegal use of forest resources.

Indonesian Economic Crisis

Beginning in mid-1997, Indonesia experienced an economic crisis that collapsed almost all Indonesian economic sectors due to the extreme depreciation of its currency. Indonesian *rupiah* declined in value more than 70% from Rp. 2,450 to the US dollar in July 1997, to Rp. 11,000 to the US dollar in mid-September 1998 (SUNDERLIN, 1999). The prices of essential commodities skyrocketed, and the numbers of people below the poverty line increased from 11% in 1996 to between 14 and 20% in 1998 (POPPELE *et al.*, 1999). Socioeconomic problems arose as a result, such as increased unemployment, rampant inflation, loss of consumer purchasing power, and grave social instability (SUNDERLIN *et al.*, 2001; SUNDERLIN, 1999). Law enforcement degenerated due to changes in the political situation following the economic crisis.

During this time of uncertainty, manufacturing industries collapsed and people looked to rural economic sectors such as agriculture that were comparatively sheltered from the effects of the crisis (e.g. SUNDERLIN, 1999). Furthermore, since the early days of the crisis, experts and policy-makers focused on agriculture as a means to escape the crisis. Faith in agriculture was justified and plantation farmers reacted by expanding their fields at the expense of forest cover.

Objectives

The objectives of this article are to examine the spatial pattern of agricultural expansion in a nature reserve area of the Banten Province, Indonesia, during 1994 ~ 2000, and to characterize the situation of local people causing agricultural expansion in this area. The analysis was performed against the background of the economic crisis that occurred in 1997. These objectives were obtained by combining time-series of medium-spatial-resolution remote sensing analysis and information sourced from a socioeconomic household survey.

MATERIALS AND METHODS

Study Area

Our study was conducted in the Rawa Danau Nature Reserve. The area is located within the Cidanau Watershed, in the Serang District of the Banten Province, Indonesia, approximately 100km west of Jakarta. Geographically, it is located at 6° 10' South and 106° 00' East (Fig. 1). The reserve was established in 1921 to conserve the last fresh water and peat swamp forest ecosystems that remained on Java Island, and to preserve the area's biodiversity (UNEP, 1999; VAN DER KAARS *et al.*, 2001). It has a humid tropical climate with a dry season that lasts from April to October. According to the Ministry of Forestry, the area covers around 2,500ha. According to our calculations, based on the official boundary map, the reserve covers around 3,890ha. This relatively flat area lies between 80-200m of elevation and is surrounded by several hills. The Cidanau River flows through the center of the reserve. On the northern hill, adjacent to the nature reserve, there is an additional 1,700ha of protected forest called Gunung Tukung Gede. The water sourced from the Cidanau River supplies the Cilegon industrial complex and Cilegon City, both located in the northern coast (TSUYUKI and BABA, 2003).

The nature reserve and adjacent uplands are surrounded by densely settled agricultural and urban areas. There are six administrative sub-districts around the nature reserve: Cinangka, Padarincang, Ciomas, Anyar, Pabuaran and Mancak. At least eight villages (i.e. V1, V2, V3, V4, V5, V6, V7, and V8) are close to the nature reserve; the closest one (V1) forms a strip located on the border between the Rawa Danau Nature Reserve and the Gunung Tukung Gede Protected Forest. This village interacts directly with the nature reserve and is relatively isolated. Compared with V1, the other villages are quite distant from the Rawa Danau Nature Reserve boundary.

Materials

Our primary data sources were Geo-referenced Landsat Thematic Mapper (TM) images acquired on August 28, 1994, and July 19, 1997, and an Enhanced Thematic Mapper plus (ETM+) image acquired on April 14, 2000, of path 123/row 64. These datasets were chosen because they were taken during the dry season and contained less than 10% cloud cover. A Rawa Danau Nature Reserve boundary map issued by the Ministry of Forestry, a map of the Cidanau Watershed boundary, and six sub-district boundary maps were collected and digitized. A ground truth survey was performed in 2001 to confirm land-use and land-cover in the study area (using a handheld GPS receiver and accompanying photographs). An explicit landmark indicating the nature reserve's boundary

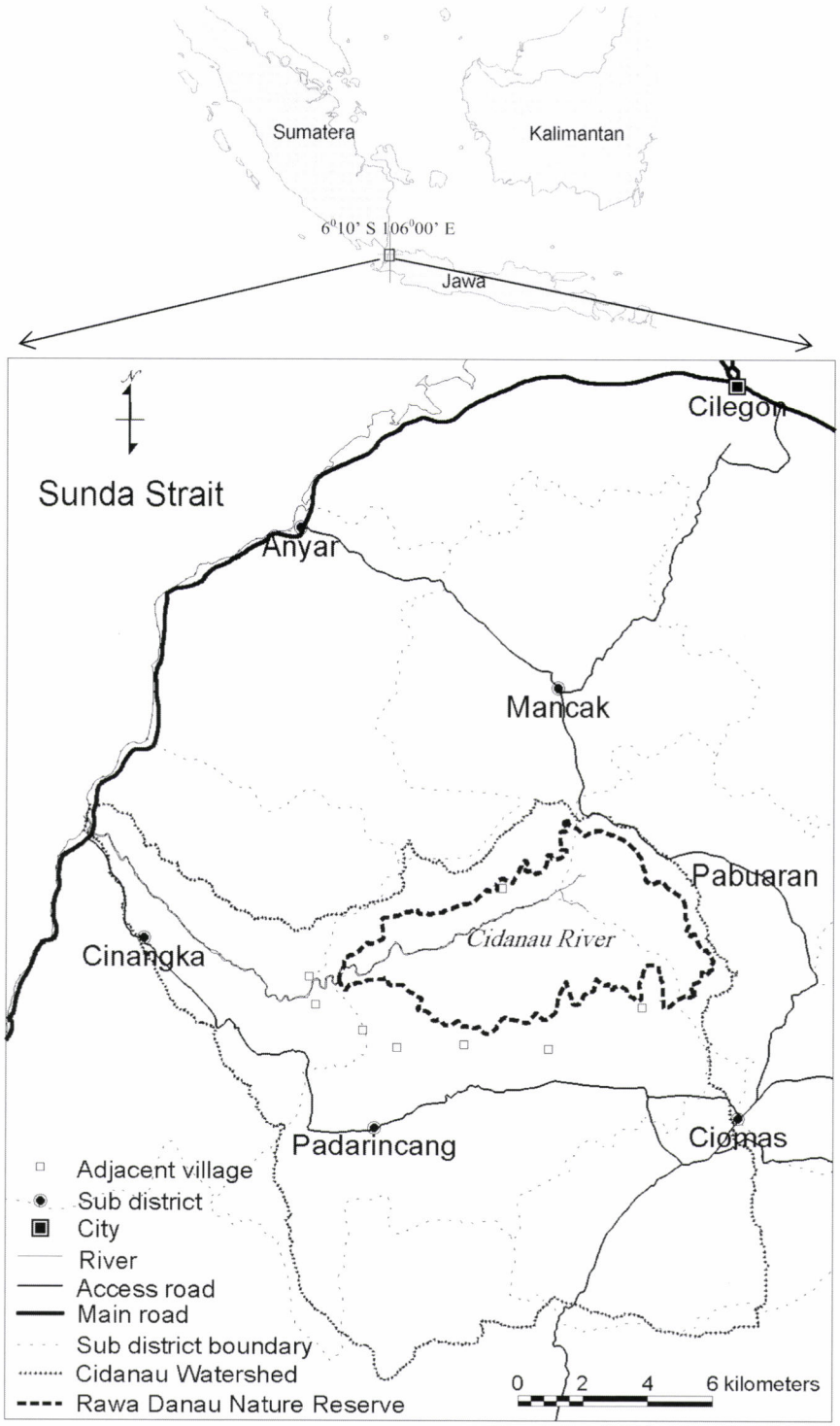

Fig. 1 Study area.

was noticed during this survey. We collected socioeconomic data while performing ground truth by interviewing household respondents living in the area surrounding the nature reserve.

Flow of the Study

This study consisted of two interrelated efforts: first, a satellite-image analysis to establish the agricultural expansion of land-cover changes, and second, a household-survey

analysis to understand the situation of local people that lies at the root of the agricultural expansion. First, to identify land-cover changes during the two periods of interest, before and after the 1997 economic crisis, the Normalized Difference Vegetation Index (NDVI) differencing algorithm was employed. This algorithm was selected because of the inclusion of a vegetation feature that could function as a change indicator for the nature reserve, thereby indicating where vegetation had decreased, increased, or remained unchanged over observation periods. PHUA and TSUYUKI (2004) described how to identify deforestation or agricultural expansion where a vegetation-decrease change has occurred. Thus to identify agricultural expansion as the major course of land-cover changes, time-series of agricultural land-cover derived from image classification were overlaid on the vegetation-decreased change. Second, a spatial analysis was then performed to recognize the spatial pattern of agricultural expansion with regard to the distance from the nearest villages and the nature reserve boundary. Finally, a descriptive qualitative analysis was performed on the socioeconomic household data obtained from the field survey.

Image Radiometric Correction

Relative radiometric normalization substantially reduces the inter-scene variability resulting from changes other than the land-cover changes (ELMORE *et al.*, 2000; MUNYATI, 2000). We adopted the relative radiometric normalization based on pseudo-invariant features (SCHOTT *et al.*, 1988). The ETM+2000 dataset was chosen as the appropriate reference image for the relative radiometric normalization procedure because it is the most up-to-date dataset and has a wider range of ground truth sources. The so-called pseudo-invariant features (i.e., bare surface and calm water), the reflection of which, in theory, does not change over time, were carefully selected. Normalization equations were then derived from the regression analyses to adjust the spectral values of the time-series image datasets to those of the ETM+2000.

Change Detection

The most widely used NDVI was employed in an image-differencing algorithm for detecting change. NDVI operates on a special characteristic of the reflectance of vegetation in the near-infrared band (*NIR*) and visible band (*R*) of remote sensing data (LILLESAND *et al.*, 2004). NDVI is defined as follows:

$$NDVI = \frac{NIR\text{-}R}{NIR+R}$$

The image differencing technique of NDVI was used to acquire information concerning changes in vegetation within the nature reserve over a period of time. The TM1997 dataset was used as the key point of observation in comparing changes before and after Indonesia's economic crisis of 1997. NDVI differencing is calculated as follows:

$$NDIFF = NDVI_2 - NDVI_1$$

where *NDIFF* is the NDVI difference, $NDVI_1$ is the NDVI at the beginning of the observation period, and $NDVI_2$ is the NDVI at the end of the observation period.

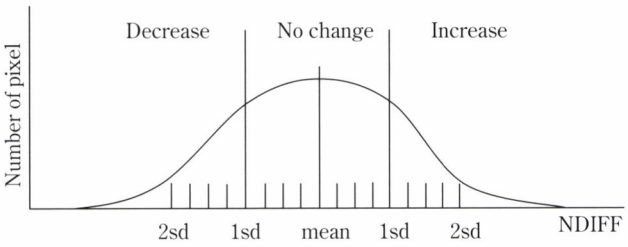

Fig. 2 Threshold determined using fractions of standard deviation from the mean to identify the vegetation decrease, vegetation increase, and vegetation unchanged in the NDVI differencing algorithm.

Thresholding was applied to identify changes in vegetation over time including increases, decreases, and unchanged areas. There is no theoretical basis on how a threshold of change or no change can be established (PHUA and TSUYUKI, 2004). A standard deviation (sd) from the mean is often employed to establish a threshold, and is usually found suitable (JENSEN, 1996). In the present study, thresholds at 0.25 sd intervals were tested iteratively from 0.5 sd to 2.0 sd to obtain the highest accuracy (Fig. 2). Three test sites covered by change reference points (i.e., decrease, unchanged, and increase) derived from a visual image-to-image interpretation (TM1997 and ETM+2000) based upon observations made during ground truth were then selected. One of the sites was located at the northwestern part of the study area in the V1 locale. The remaining sites were in the V6 and V8 areas, in the southern part of the study area. The accuracy was assessed using an error matrix. Overall accuracy and Khat statistics were used to determine the most accurate threshold.

Image Classification and Agricultural Land-cover Extraction

The fundamental objective of image classification is to automatically categorize all the pixels within an image into land-cover classes or themes (LILLESAND *et al.*, 2004). Supervised classification is the procedure most often used for quantitative analysis of remote sensing image data (RICHARDS and JIA, 1999). In the present study, a supervised classification using a maximum likelihood classifier was performed on time-series image datasets to obtain spatial information about the historical agricultural land-cover within the study area. Six bands were used, consisting of visible, near-infrared, and short-wave infrared bands (Bands 1, 2, 3, 4, 5 and 7) for each image dataset. From each image, two sets of sample regions were

selected. One set, containing fifty sample regions, was used to represent pixels from each desired set of classes (i.e. shrub and bush, orchard, forest, dry field, inundated field, and "other"). The other set, also containing fifty sample regions with similar attributes, was used to assess accuracy (e.g., HILL, 1999). Each of the sample regions was developed using the ground truth, image visual interpretation, and the use of prior unsupervised classification results as land-cover references.

The "shrub and bush" category mainly consists of wetland grasses (*Phragmytes karka*) as well as other wetland shrubs and bushes. Forests in the nature reserve were dominated by swamp forest formations. The orchards were covered by relatively more scattered vegetation compared with the forests. Dry fields were dry agricultural fields (usually dry paddy fields) and inundated fields were waterlogged agricultural fields (usually wet paddy fields). The "other" category included both bare land and built-up areas, because the two categories had such a low percentage compared with the other classes. Now that we were interested in obtaining time-series agricultural land-cover, we categorized dry field and inundated field as "agriculture" and categorized other land-cover classes as "non-agriculture".

Spatial Analysis of Agricultural Expansion

A spatial analysis was conducted by combining the time-series agricultural land-cover, the artificial buffer areas generated from the mid-point of the eight villages nearest to the nature reserve, and the artificial buffer areas directing inward generated from the nature reserve boundary. We assumed that every household living near the nature reserve was equally likely to engage in encroachment activities.

The buffer areas were set at 0.1km intervals, positioned 0.1 to 3km from the center of the villages. Similar buffer intervals were applied inside the nature reserve, positioned from 0.1km to 1.5km from the reserve boundary. Matrices were then produced by overlaying these two buffer areas. To indicate any trends and spatial patterns relating to agricultural expansion with regard to the distances from the nearest villages and the nature reserve boundary, the ratio and the area of agricultural land-cover were calculated and charted for each buffer and each matrix, respectively.

Household Data

Data sourced from census and household surveys has been the most prevalent type of social data used in studies identifying the driving forces of LULCC (CAMPBELL *et al.*, 2005). Individual household data allow for a better understanding of the land-use practices within each village, as most land-use decisions are made by individuals and households (CAMPBELL *et al.*, 2005). We collected time-series population census data of the six sub-districts close to the study area from the local statistic office. The socioeconomic household data were obtained via interviews with the heads of households located near the nature reserve. Fifty-two respondents were chosen randomly from two villages. The nearest village (V1) is located directly adjacent to the nature reserve, while the second (V2) is located some distance away.

We required the respondents to answer questions concerning personal information, such as name, age, occupation, monthly income (i.e., farm income and off-farm income), education level, place of origin, the year the respondent came to live in their current home, and the number of people in their family. A figure of 500,000 Rp. was used as the baseline for a low-income household, based on the headcount-poverty line of Cilegon in 2001 (MUBYARTO, 2003). We also obtained information concerning the respondents' routines and their dealings with the nature reserve, as well as their knowledge and perceptions of the nature reserve. The last, data were collected on the respondents' land use, such as the extent of their land-holdings, type of land-use, land ownership, and land history.

Interviews with key informants who possessed particular knowledge concerning the various dimensions of land-use change issues in the study area were also conducted. The key informants provided additional information, particularly regarding the impact of external factors. The head of V1 and the authority of the Rawa Danau Nature Reserve were two of the key informants interviewed.

Most of the studies linking remote sensing observations and socioeconomic data have been performed using a direct relationship assessment by regression analysis at spatially selected units (e.g., at administrative units (SKOLE *et al.*, 1994; WOOD and SKOLE, 1998), or at the village level (MERTENS *et al.*, 2000)). However, ENTWISLE *et al.* (1998) emphasized the difficulty of relating remotely sensed patterns of land-cover change with the field observations of land-use change, as people live in nucleated villages away from their fields. CAMPBELL *et al.* (2005) also pointed out that where common property resources exist, identification of the spatial correspondence between household characteristics and land-use decisions may be problematic.

In this study, to combine the agricultural expansion pattern data and the local socioeconomic situation we descriptively analyzed the household survey results rather than directly relating the remote-sensing results and the household survey data via regression analysis (e.g. CAMPBELL *et al.*, 2005). Two classes of respondents were defined based on the distance between each village and the nature reserve. Frequency tables were constructed to descriptively analyze the dominant socioeconomic characteristics of each class of respondents. We then compared both classes to provide an insight into the differences between the respondents' socioeconomic characteristics and their roles in agricultural expansion.

RESULTS

Land-cover Change Detection

Fig. 3 shows how the accuracy measures changed with different thresholds. In assessing the accuracy of the NDVI differencing algorithm, an sd=1 threshold (e.g. −4.7 at the lowest and 7.8 at the highest thresholds of NDVI difference value in the 1994-1997 period) was determined to be the most suitable threshold for detecting changes of vegetation given 92.6% overall accuracy and 88.9% Khat statistic.

Based on the above result, the changes detected using the NDVI differencing algorithm for the period prior to the economic crisis (1994-1997) and that after the crisis (1997-2000) are shown in Fig. 4 and Table 1. The area under vegetation-decrease expanded nearly two times from 374ha (9.6%) during the 1994-1997 period to 638ha (16.4%) in the 1997-2000 period. These changes were detected in the southern and western parts of the nature reserve. The area under

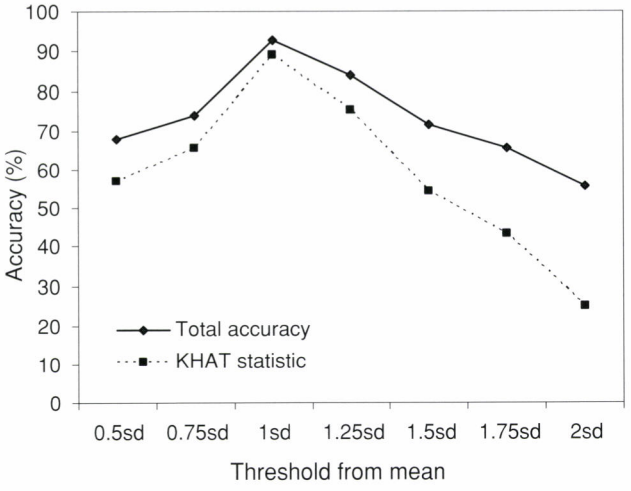

Fig. 3 Accuracy of the various threshold values. A threshold of one standard deviation from the mean gives the best change-detection accuracy.

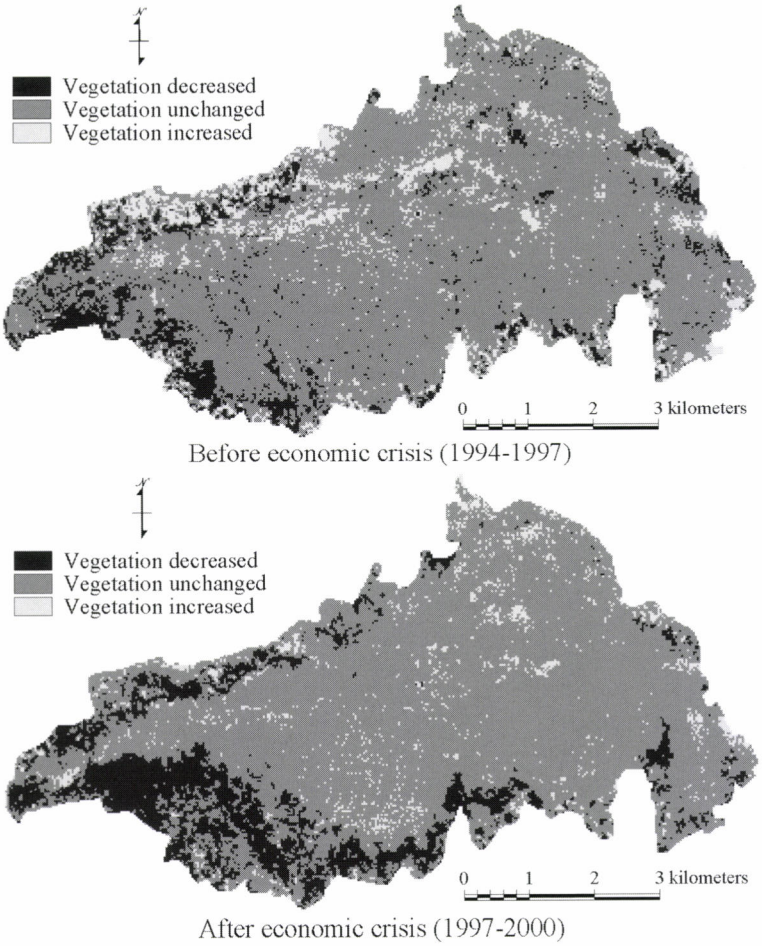

Fig. 4 Change detection results obtained using the NDVI differencing algorithm.

Table 1 Change detection results using an NDVI differencing algorithm at a threshold of one standard deviation.

Change category	Before the economic crisis (1994-1997)	After the economic crisis (1997-2000)
	Area in ha	Area in ha
Vegetation decrease	374 (9.6)	638 (16.4)
Vegetation unchanged	3,140 (80.7)	3,057 (78.6)
Vegetation increase	377 (9.7)	196 (5.0)
Total	3,891 (100.0)	3,891 (100.0)

Percentages are given in parentheses

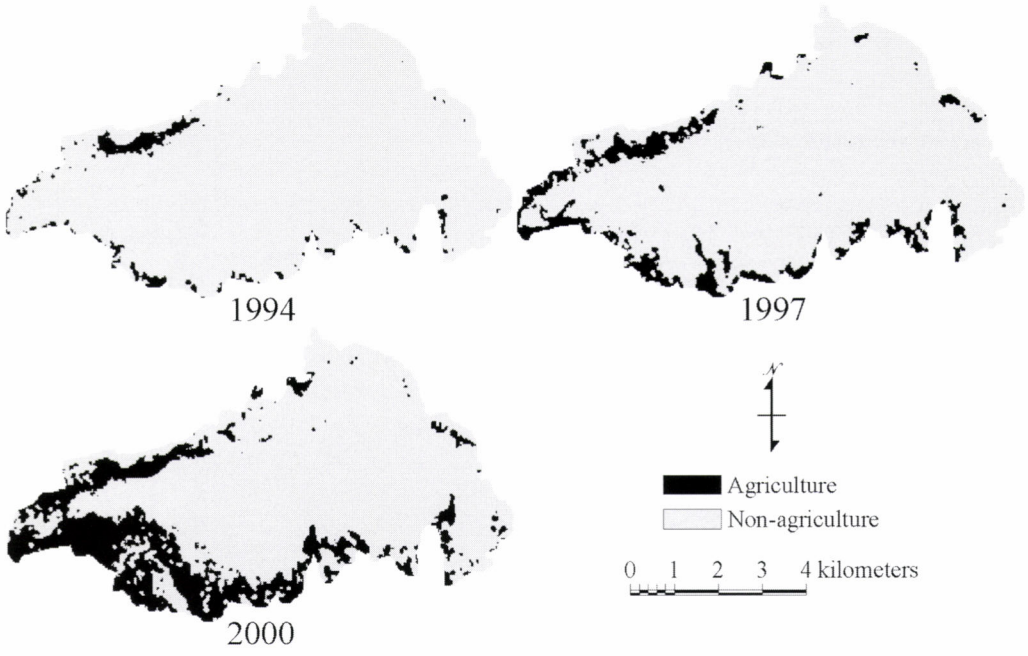

Fig. 5 Time-series spatial information of agricultural land-cover derived from supervised classification of satellite remote-sensing datasets.

unchanged-vegetation slightly decreased from 3,140ha (80.7%) in the 1994-1997 period to 3,057ha (78.6%) during the 1997-2000 period. The area under vegetation-increase decreased from 377ha (9.7%) in the 1994-1997 period to 196ha (5.0%) in the 1997-2000 period. Overall, the change-areas increased from 751ha (19.3%) in the 1994-1997 period to 834ha (21.4%) in the 1997-2000 period.

Table 2 Time-series area of land cover derived from supervised classification.

Year of observation	Non-agriculture (ha)	Agriculture (ha)	Total (ha)
1994	3,730 (95.9)	161 (4.1)	3,891 (100.0)
1997	3,488 (89.7)	403 (10.3)	3,891 (100.0)
2000	3,038 (78.1)	853 (21.9)	3,891 (100.0)

Percentages are given in parentheses

Agricultural Expansion as the Major Course of Land-cover Changes

Historical agricultural land-cover maps derived from the supervised classification of time-series satellite imagery and its statistical results are described in Fig. 5 and Table 2, respectively. The overall accuracies of classification were above 90%, with the exception of the 1997 data (89%). The area of agricultural land-cover had more than doubled from 276ha in the 1994-1997 period to 623ha in the 1997-2000 period. The results showed an obvious expansion of agricultural land-cover in the southern and western parts of the nature reserve, which were previously shrub and bush, or orchard. The expansion of

Table 3 Land-cover changes in the areas under vegetation decrease and vegetation increase from 1994 to 1997.

1997 \ 1994	Vegetation decrease (ha)			Vegetation increase (ha)		
	Non-agriculture	Agriculture	Total	Non-agriculture	Agriculture	Total
Non-agriculture	176 (50.8)	0 (1.6)	176	293 (96.7)	44 (59.3)	337
Agriculture	170 (49.2)	28 (98.4)	198	10 (3.2)	30 (40.5)	40
Total	346 (100.0)	28(100.0)	374	303 (100.0)	74 (100.0)	377

Percentages are given in parentheses

Table 4 Land-cover changes in the areas under vegetation decrease and vegetation increase from 1997 to 2000

2000 \ 1997	Vegetation decrease (ha)			Vegetation increase (ha)		
	Non-agriculture	Agriculture	Total	Non-agriculture	Agriculture	Total
Non-agriculture	49 (9.3)	1 (1.1)	50	148 (99.8)	40 (85.3)	337
Agriculture	479 (90.7)	109 (98.9)	588	0 (0.2)	7 (14.7)	40
Total	346 (100.0)	110 (100.0)	638	148 (100.0)	47 (100.0)	377

Percentages are given in parentheses

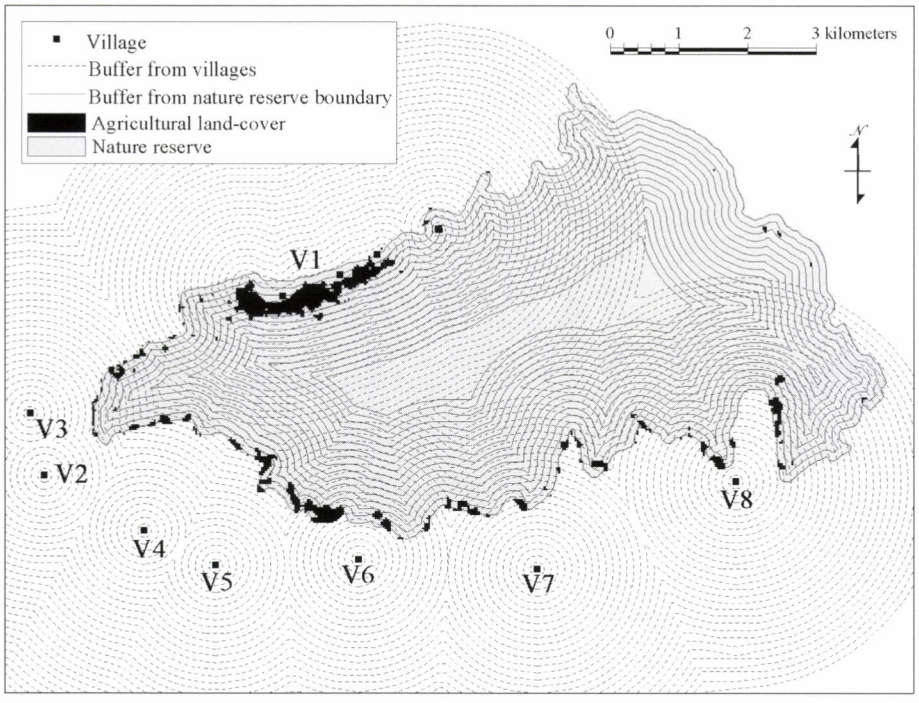

Fig. 6 Illustration of the procedures used for spatial analysis of agricultural expansion in 1994. The first buffer areas were established from the centers of the eight villages nearest to the nature reserve. The second buffer areas were directed inward, generated from the nature reserve boundary.

agricultural land-cover was also obvious on the northern edge of the nature reserve, where V1 lies adjacent to the nature reserve boundary.

Table 3 and Table 4 describe the results from the overlay analysis, which show the portion of agricultural expansion perceived as the major course of vegetation-decrease change. Our results for the 1994-1997 period show that 49.2% of the non-agricultural land-cover in 1994 had changed to agricultural land-cover by 1997. A rapid increase in agricultural land-cover was detected in the 1997-2000 period, with 90.7% of the non-agricultural land-cover changing to agricultural land-cover.

Spatial Analysis of Agricultural Expansion

Fig. 6 illustrates the procedures used for the spatial analysis of agricultural expansion in 1994. Agricultural land-

cover was observed to increase along the boundary of the nature reserve and then decreased moving away from the nature reserve boundary.

Over time, it was observed that agricultural expansion progressed across the boundary of the nature reserve (Fig. 7a). In the 1994-1997 period, agricultural land-cover grew by more than 10% only in the buffer areas located 0.1 to 0.3km from the boundary of the nature reserve. Then, during the 1997-2000 period, a similar expansion occurred in the buffer areas located 0.2 to 1.3km from the boundary of the nature reserve.

Agricultural land-cover was established in areas located further from the centers of villages (Fig. 7b). In the 1994-1997 period, agricultural land-cover grew more than 10% only in the buffer areas located between 0.4 and 1.3km from the villages. However, during the 1997-2000 period, similar growth occurred further in the buffer areas located between 1.2 and 2.0km from the villages.

Our time-series spatial pattern of agricultural expansion reveals that agricultural land-cover only slightly expanded at distances between 0.1 and 0.6km from the villages and between 0.1 and 0.7km from the nature reserve boundary (Fig. 8). This pattern indicates that the nearest villagers (V1) were unable to expand their agricultural land more than 0.7 km from the nature reserve's boundary due to the existence of swamp forest near to their village. This swamp forest remained undisturbed because of either the difficulty to convert or a prohibition to encroach enforced by the nature reserve authority.

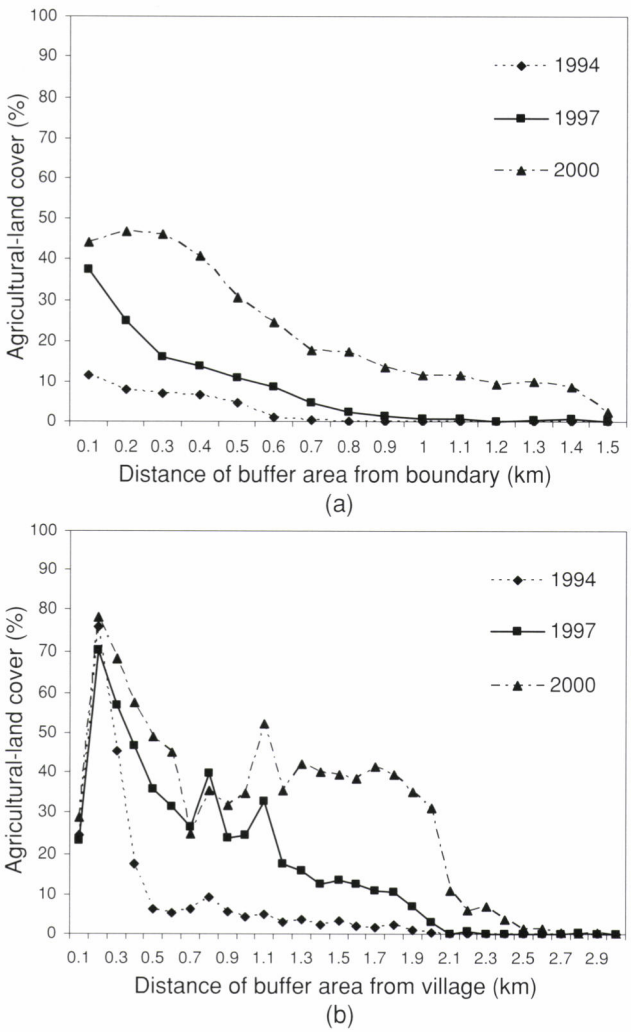

Fig. 7 Trend of agricultural expansion with regard to distance from the nature reserve boundary (a) and distance from the nearest villages (b).

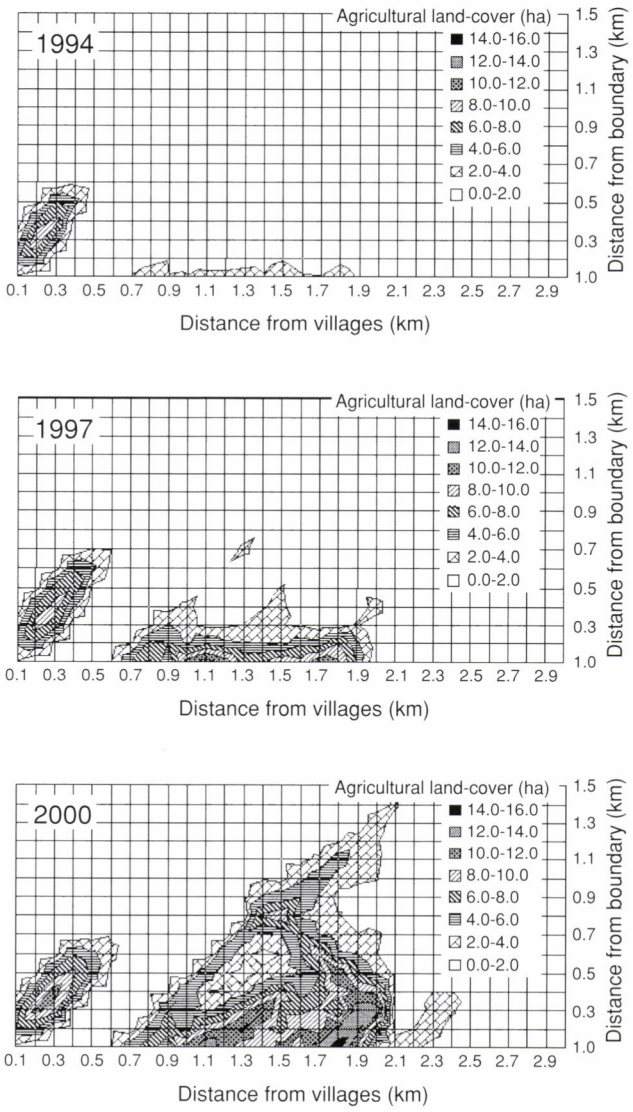

Fig. 8 Time-series spatial pattern of agricultural land-cover on matrices derived from overlying buffer areas from the nature reserve boundary and buffer areas from the centers of nearest villages.

In contrast, there was a rapid expansion at distances between 0.6 and 2.4km from the villages and between 0.1 and 1.3km from the nature reserve boundary. The largest agricultural land-cover on matrices shifted from distances between 0.2 and 0.3km from the villages in 1994 to 1.1km in 1997 and 1.8km in 2000. This result indicates that not only the nearest village (V1), but also the more distant villages participated in agricultural expansion in the wetland grasses ecosystem in the southern and eastern parts of the nature reserve.

Socioeconomic Characteristics of the Local People Residing near the Nature Reserve

While most case studies failed to confirm the simplification of the role of population or poverty in causing tropical deforestation (LAMBIN *et al*, 2001), population growth and its pressure on land use have been central to thinking about the human-environment condition. The population census data for the six sub-districts surrounding the study area showed an increase in population growth from 2.5%

Table 5 Socioeconomic characteristics of respondents

Characteristic	Criteria	Respondents from the near village (V1)	Respondents from the far village(V2)
		Count (%)	Count (%)
Occupation	Farmer	15 (88.2)	34 (97.1)
	Trader	1 (5.9)	0 (0.0)
	Other	1 (5.9)	1 (2.9)
	Total	17 (100.0)	35 (100.0)
Monthly income	Less than Rp.500,000	12 (70.6)	31 (88.6)
	Rp.500,000-Rp.1,000,000	5 (29.4)	3 (8.6)
	Greater than Rp.1,000,000	0 (0.0)	1 (2.9)
	Total	17 (100.0)	35 (100.0)
Year of residence	Before 1997	14 (82.4)	30 (85.7)
	After 1997	3 (17.6)	5 (14.3)
	Total	17 (100.0)	35 (100.0)
Place of origin	Same district (Serang District)	5 (29.4)	14 (40.0)
	Different district	12 (70.6)	21 (60.0)
	Total	17 (100.0)	35 (100.0)
Land holding[a]	Less than or equal to 0.5ha	8 (50.0)	28 (80.0)
	0.5-1ha	2 (12.5)	4 (11.4)
	Greater than or equal to 1ha	6 (37.5)	3 (8.6)
	Total	16 (100.0)	35 (100.0)
Education level	Less than or equal to elementary graduation	16 (94.1)	34 (97.1)
	Junior high graduation	0 (0.0)	0 (0.0)
	Senior high graduation	1 (5.9)	1 (2.9)
	Total	17 (100.0)	35 (100.0)
Land-use type[a]	Paddy field	12 (75.0)	33 (94.3)
	Orchard	0 (0.0)	1 (2.9)
	Paddy field and orchard	4 (25.0)	1 (2.9)
	Total	16 (100.0)	35 (100.0)
Land ownership[a]	State land (nature reserve)	10 (62.5)	17 (48.6)
	Private land	2 (12.5)	1 (2.9)
	Land worker/rental	0 (0.0)	17 (48.6)
	State land and private land	4 (25.0)	0 (0.0)
	Total	16 (100.0)	35 (100.0)
Land history[a]	Inherited from parent including nature reserve land	6 (37.5)	1 (2.9)
	Obtaining new land in the nature reserve	6 (37.5)	16 (45.7)
	Farm worker/rental	0 (0.0)	17 (48.6)
	Purchased land and obtained new land in the nature reserve	0 (0.0)	0 (0.0)
	Inherited from parent and purchased land	1 (6.2)	0 (0.0)
	Inherited from parents and obtained new land in the nature reserve	3 (18.8)	1 (2.9)
	Total	16 (100.0)	35 (100.0)

Percentages are given in parentheses

[a] One respondent (a trader) from the V1 did not hold any agricultural land

during the 1994-1997 period to 3.2% during the 1997-2000 period. The census data also revealed an increase in the household-population growth, from 2.5% during the 1994-1997 period to 4.9% during the 1997-2000 period.

The socioeconomic characteristics of the households in V1 and V2 are described in Table 5. Farming was the main source of income for the households (more than 85% in both villages). Most of the farmers (more than 95% in both villages) grew rice. The majority of the households (more than 70% in both villages) received a low income. Although many of them were migrants (70.6% from V1 and 60% from V2), most of the households arrived prior to the economic crisis (more than 82% in both villages). The level of education was low in both villages – only 5.9% and 2.9% of the households from V1 and V2 graduated beyond elementary school, respectively.

With regard to land ownership, 62.5% of the households in V1 cultivated in the nature reserve (state land), 12.5% of the households cultivated on private land, and another 25% cultivated in both state and private lands. In V2, 48.6% of the households cultivated in the nature reserve, 2.9% cultivated on their own land, and the remaining 48.6% of the households cultivated within a yield-sharing-based leased property.

Based on historical land status, 37.5% of the households in V1 held inherited land, compared with just 2.9% of those in V2. It appeared that the people residing in the village adjacent to the nature reserve had farmed in the nature reserve for a long time. In contrast, while the households in V2 holdings of agricultural land in the nature reserve was a more recent occurrence, those households held more new land than those from V1 (45.7% and 37.5% of the respondents from V2 and V1, respectively).

The households' perception of the nature reserve indicated that they generally understood that the nature reserve was a protected area. However, most of them knew little about the Government's aims in protecting this area. Households only recognized that the nature reserve was protected against cutting down the trees. For this reason, and possible because of the difficulty of converting swamp forest into paddy fields, the swamp forests remained undisturbed. Only a minority of households stated that they used the nature reserve as a natural source of un-cultivated food, such as fish and vegetables. Most of the households knew that the water from Rawa Danau is used by a steel factory in Cilegon City. With this knowledge, the households requested a rewards system as a compromise among the needs of the local people, the factory's downstream water usage, and protection of the water catchments that feed Rawa Danau.

Key Informants' Information

Key informants confirmed that the encroachment area of the nature reserve, as of 2001, had reached approximately 700 to 800ha. The southwestern parts of the nature reserve experienced the highest levels of encroachment following several years of abandonment. There were settled areas in this region prior to 1988, but the illegality of the settlements meant that in 1988 the Government moved the residents to an outer island via a transmigration project. However, the encroachment activity persisted after the completion of the project, and reached its peak after the 1997 economic crisis, when protection of the nature reserve was reduced as a result of political instability. Key informants stated that the majority of the encroachers were simply taking advantage of the uncertain political situation and resulting lack of forest policing, though the encroachers were aware that the area was a protected nature reserve. However, the key informants admitted that the increasing agricultural and livelihood costs derived from the economic crisis were the main reasons that encroachers were willing to take advantage of the lack of forest policing to encroach into the nature reserve.

DISCUSSION

Operational Detection of Land-cover Change

The NDVI differencing algorithm has been widely applied for monitoring land-cover change with varying degrees of success, for example tropical deforestation detection (PHUA and TSUYUKI, 2004), vegetation changes detection in semi-arid environment (ELMORE *et al.*, 2000), and wetland change detection (MUNYATI, 2000). For all change detection applications, the most critical part is the placement of the threshold level. It should be noted that when placing the threshold level the type of change occurring should be pre-determined to adequately place the threshold without excessive trial and error.

For agricultural expansion detection, it would be easier to determine the type of changes because agricultural expansion is related to a permanent conversion from natural landscape (e.g. forest, wetland grasses) to human induced landscape, which generally is represented by bare land or wet field. Although the analysis can be biased by the existence of green stage of paddy field, this bias could be reduced by selecting time-series data that fall within the minimum existence of green paddy field periods (e.g. at the middle of dry season (April) or the end of dry season (July and August)). Since the study area is a nature reserve that mostly consisted of green natural landscape, any vegetation changes, including those due to agricultural expansion activities, could easily be detected by the NDVI differencing algorithm. High level of accuracy achieved by the NDVI differencing algorithm indicated that the use of NDVI differencing algorithm to detect land-cover change that related to vegetation changes was appropriate.

During supervised classification, forests and orchards often misclassified each other, whereas the other classes were effectively separated. Forests and orchards contained significant biomass differences and these classes were

separable by visual analysis. However, training areas were unable to distinguish these two classes precisely by digital analysis (supervised classification). Since we were interested in obtaining time-series agricultural land-cover, this misclassification was not an important problem. Merging classes into agriculture and non-agriculture had significantly increased classification accuracy.

Our analysis was strengthened by combining NDVI differencing and supervised classification within a hybrid method framework. In this approach, NDVI differencing algorithm was used to define the areas where supervised classification can be applied. The NDVI differencing method was performed to define the "decreased vegetation" where the post-classification method exposed the type of changes that might cause the decrease of vegetation (i.e. agriculture or non-agriculture). This combined approach effectively eliminates the identification of land-cover change in areas where no significant spectral change has occurred between the two dates of the images. Using a similar approach, YUAN *et al.* (1999) and PILON *et al.* (1988) reported that the hybrid approach satisfactorily enhances the results obtained by post-classification analysis by reducing errors of commission in North America's and Northwestern Nigeria's semi-arid environment, respectively. MERTENS and LAMBIN (2000) also reported that the hybrid approach reduces the misclassifications on the final land-cover change map by reducing the area for which the results of the post-classification method were retained.

Land-cover Change and Agricultural Expansion

LAMBIN and GEIST (2001) reviewed that land-cover change has long been viewed as being continuous, but, in fact, it is a disjointed process, with periods of rapid change, often triggered by a shock effect. Parallel to this view, our results demonstrate that the 1997 Indonesian economic crisis has played a major role in the way that land-use practices affected the protected areas. Our analyses of land-cover change revealed a sharp increase in the proportion of agricultural land-cover during the period of the economic crisis. The combination of an NDVI differencing algorithm and supervised classification of time-series satellite remote-sensing data has effectively exposed the temporal pattern of land-cover changes and shown agricultural expansion to be the major course of such changes. The results showed that vegetation-cover changes increased after the economic crisis (1997-2000) when compared with the period prior to the crisis (1994-1997). In particular, the area of vegetation-decrease expanded nearly two times from the 1994-1997 period to the 1997-2000 period. The change accredited to agricultural expansion doubled from one period to the next. Comparable to this situation, Cameroon's 1986 economic crisis led to a significant increase in forest clearing by forest villagers (MERTENS *et al.*, 2000).

Driving Forces of Agricultural Expansion

The results of our spatial analysis indicate that nearby villagers are more likely to encroach on protected areas than more distant villagers. In addition, after a period of several years, even distant villagers will encroach on the nature reserve. This result is verified by the fact that the households of the village adjacent to the nature reserve tend to hold more agricultural land in the nature reserve than the ones from the more distant village. Aside from proximity of access, the household survey revealed that people in the more distant village possessed the other option for agricultural practices (e.g., holding agricultural land using a land-rent system) beyond encroaching on the nature reserve. Also, it should be noted that most of the households in more distant village held small agriculture lands. As a result, many of the households in the more distant village also encroached to the nature reserve for expanding their agricultural land especially after the economic crisis. Conversely, the people from the adjacent village had fewer options. Land tenure in the adjacent village was limited because the village was isolated, sandwiched between two neighboring protected areas. Because their legal access and customary rights to the forest have been severely restricted, these villagers have been pushed toward illegal use of forest resources (PELUSO, 1992).

Boserupian theory interprets the role of population growth in agricultural development in the context of broader conditions (LAMBIN *et al.*, 2001). Our findings that population growth and agricultural expansion within the nature reserve were increasing during the economic crisis, in a complex role, also correspond with this theory. As the study area was surrounded by highly populated areas with limited land resources, the agricultural system developed from an extensive system into an intensive system (e.g. BOOTH, 1985). However, the scarcity of land was combined with the existence of additional land that was not legally available for cultivation (i.e. the nature reserve). Considering this set of circumstances combined with the villagers' apathetic perception of the nature reserve, we conceive that the encroachments were inevitable. Our data shows that legal constraints would not be successful to inhibit agricultural expansion during a collapse of an economy combined with high population growth. IFTEKHAR and HOQUE (2005) also emphasized that limited land availability and unemployment because of poor governance and depressed national economy on the background of population pressure and poverty have been identified as the major causes of forest encroachment in Bangladesh.

The condition during Indonesia's 1997 economic crisis was exacerbated an already existing encroachment situation. The encroachment on nature reserves during the crisis were influenced not only by the changed economic conditions, but also by the dramatically altered political conditions (SUNDERLIN *et al*, 2001). With the downfall of President Suharto's rule, many of the repressive aspects of his regime receded. One

consequence of these events was that the restrictions on access to protected areas were relaxed. Agricultural expansion in the nature reserve was therefore motivated not just because of increased input costs, but also by un-monitored access to the land. Together with the increase in population growth and decline of the manufacturing industry during the economic crisis, such land-races became increasingly common.

CONCLUSION

In this study, we have demonstrated that agricultural expansion rapidly increased during the period after the economic crisis compared with the period prior to the crisis. By remote sensing analysis, the area under vegetation-decrease expanded nearly two times from the 1994-1997 period to the 1997-2000 period. Under the area of vegetation-decrease, the portion of change accredited to agricultural expansion increased twice over those periods. By household survey and spatial analyses, it appears that initially the nearby villagers are more likely to encroach on protected areas than more distant villagers. However, after a period of several years, even distant villagers encroached on the nature reserve. Aside from proximity of access, the smaller size of agricultural land holdings, the larger number of tenant farmers and the increase of un-monitored access to the nature reserve after the economic crisis were the characteristics of agricultural expansion villages within the study area.

Considering the high tangible and intangible values of the Rawa Danau Nature Reserve, stakeholders in the area surrounding Rawa Danau need to remedy this situation, as a solution will not be reached by the local residents alone. For this reason, a proper solution must be carefully planned: one that recognizes the industrial demands downstream for the fresh water of the Cidanau River and needs of the local people upstream for a well-maintained environment.

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Article

Local Residents' Perception, Attitude and Participation Regarding Nature Reserves of China — Case Study of Beijing Area

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ABSTRACT

In recent decades, China has seen a rapid increase in the number of nature reserves. This has led to many conflicts between nature reserve managerial boards and local residents. In other developing countries, the importance of enhancing understanding, perceptions, and attitudes of local residents has been shown to be of importance. However, top-down management in China still does not pay sufficient attention to the significant role of the participation of local residents. Here, we demonstrate the need to win support and encourage participation of local people in order to effectively manage nature reserves in China. The purpose of this paper was to understand local residents' perceptions, attitudes, and participation in nature reserves in the Beijing area by conducting a questionnaire survey. The results indicate that the majority of local residents hold favorable attitudes and intend to participate in the management of reserves. A structural equation model and analysis of variance revealed that the most positive attitudes and willingness to participate in management of nature reserves was mostly driven by a positive perception of the economy, i.e., increased employment through direct or indirect involvement of local residents. Positive participation has the potential to favorably shape local residents' perceptions and attitudes toward nature reserves. To win sustained local support, nature reserves should pay more attention to improving local income by creating new employment and environmental education opportunities.

Keywords: nature reserve, local residents, resident-reserve conflicts, perceptions-attitudes-participation, China.

INTRODUCTION

Before the 1980's, large forest and wetland areas in China were destroyed and the natural environment deteriorated, leading to the extinction of many wild species and frequent natural disasters. Since then, the Chinese government had made considerable efforts to protect natural environments and to mitigate destruction of forests and wetlands by establishing nature reserves that aim to strengthen the protection of forests and other ecological environments. By the end of 2005, China had established 2,349 nature reserves, covering 150 million ha, or 15.0% of the land area of China (Fig. 1). However, establishment of most nature reserves has focused on biological conservation and has completely ignored the opinions of local residents. In most cases, nature reserves have prohibited utilization of natural resources, causing conflicts between administrative bodies managing nature reserves and local residents (MIAO and OUYANG, 2000; ZHANG, 2002; WANG, 2002). Recently, the Department of Wildlife Conservation, State Forest Administration of the People's Republic of China (2003), decided that managers of nature reserves should change their attitudes, shift their role, and cooperate with local residents who should be seen as

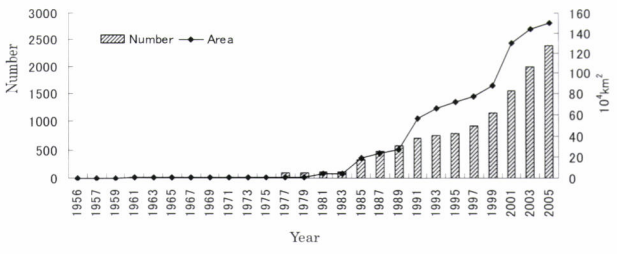

Fig. 1 Transformation of nature reserve area and quantity in China

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stakeholders in the cooperative development of nature reserves.

General public support is crucial to sustain nature reserves and successfully conserve ecosystems and biodiversity (BRANDON and WELLS, 1992; MÜLLER-BÖKER and KOLLMAIR, 2000; TRAKOLIS, 2001; MILLER and HOBBS, 2002; RAO *et al.*, 2003). The provision of goods and services for the subsistence needs of local residents was found to be an essential premise to resolve resident-reserve conflicts (MCNEELY, 1988; HEINEN and METHA, 1999; MAIKHURI *et al.*, 2000). Furthermore, many examples from around the world have shown that nature reserves are likely to succeed only if local people are directly involved in their selection, establishment, and management (MCNEELY, 1988; STRÆDE and HELLES, 2000; MEHTA and HEINEN, 2001; LACHAPELLE and MCCOOL, 2004; SHRESTHA and ALAVALAPATI, 2006). As stated by REDFORD *et al.* (2006), "protected areas of all types will not survive without people inside them using them in sensible ways, or those outside them respecting them and defending them."

Previous research on nature reserves in China tended to focus on wildlife and habitat, but only a few studies considered management issues, and these were based on the perspectives of government and reserve managers (YANG and XU, 2003; HAN, 2000). Studies on local residents and perceptions of nature reserves in China remain scarce (JIM and XU, 2002). It is necessary to investigate local residents' perceptions of nature reserves in China. Here, "local residents" refers to people living within or in the vicinity of nature reserves. It is especially important to understand their attitudes and participation in nature reserve management. Attitudes of local residents toward nature reserves can be considered supportive, opposing, or neutral. "Participation" implies behaviors of local residents toward involvement in nature reserve management, whether directly or indirectly.

The purpose of this study was to investigate perceptions of local residents in nature reserves in the Beijing area. In particular, emphasis was given to understand the relationship between attitudes and participation of local residents. Such information should help to elucidate the essential factors required to increase favorable impressions of local residents toward nature reserves. The paper also provides proposed approaches to reduce resident-reserve conflicts and to improve local residents' participation in nature reserve management.

STUDY SITE

Beijing

Beijing, a very large metropolis with a total population of 15.4 million (Beijing Statistical Bureau, 2005), is located between 115° 25' -117° 30' E and 39° 28' -41° 05' N in the temperate zone and has an annual average precipitation of 700mm. The total area of Beijing is 178,200km², of which 38% is plain and 62% is mountainous, stretching 160km from east to west and over 180 km from south to north. The city includes 18 districts and counties, with Dongcheng, Xicheng, Xuanwu, and Chongwen districts in the city proper, Chaoyang, Haidian, Fengtai, and Shijingshan districts in the near suburbs, Mentougou, Fangshan, Daxing, Tongzhou, Shunyi, Huairou, and Changping districts constituting the outer suburbs, and Miyun, Pinggu, and Yanqing counties in the countryside.

Beijing had established 20 nature reserves by the end of 2005; these covered 8% of the land area and were mainly located in Mentougou, Huairou, Miyun, Pinggu, and Yanqing districts of the north and west mountainous area. As the communities in and near these nature reserves have a relative more developed economy than other provinces and suffer high population pressure, most of the reserves face the same problems as the whole country, and all are typical of other reserves in developed areas of China.

Investigated Nature Reserves

The investigation was conducted in nature reserves in Baihuashan (the oldest reserve), Puwa (the newest), and Wulingshan, the only reserve in Beijing joined to a national nature reserve in Hebei Province in the west and northeast mountainous area of Beijing. The total area of Baihuashan nature reserve is 21,743ha, and it contains 242 families with 854 residents. The annual per capita income is about 3000 RMB yuan (1 US $ =6.8 RMB yuan), or only 22% of the average Beijing income (WANG, 2003). Puwa nature reserve covers 5,396.5ha and contains four villages with 320 residents. The annual per capita income here is about 4,000 RMB yuan, ca. 25% of the average Beijing income (CUI, 2005). Wulingshan nature reserve covers 4,150ha, with 1,177 residents and a per capita yearly income of only 2,200 RMB yuan, which is 19% of the average Beijing income (CUI, 2003). Fig. 2 shows the locations of the three nature reserves.

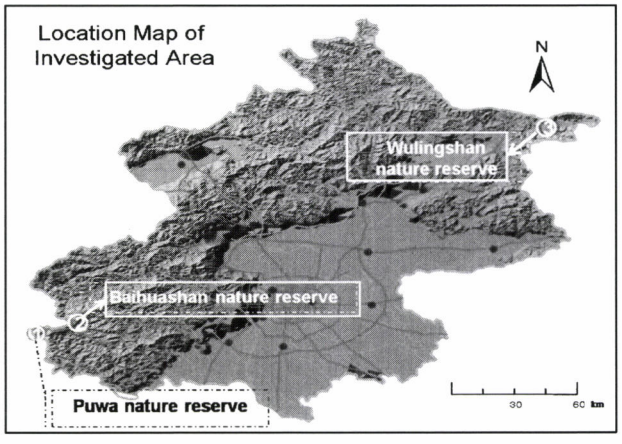

Fig. 2 Location map of investigated nature reserves

METHODOLOGY

A preliminary questionnaire survey of household opinions was first conducted in the three nature reserves. The questionnaire was then revised, and the final version consisted of 17 questions regarding local residents' perceptions, three questions on attitudes, and six questions on participation (Table 1). Further items on demographic characteristics, as well as free answers were also recorded. The answers to the first 26 items were ranked using a five-point Likert scale, where respondents assigned a score of 5 for strongly agree, 4 for agree, 3 for neutral, 2 for disagree, and 1 for strongly disagree.

Statistical analysis used the Statistical Package for the Social Sciences (SPSS) 12.0, for factor analysis to synthesize and process interrelationships between observations and to reveal obvious patterns (RYAN and MONTGOMERY, 1994). We aimed to concentrate the 26 variables into a small number of groups in order to summarize the representative information for all local residents' perceptions, e.g., grouping economic perceptions or environmental perceptions. According to the Kaiser standard (KAISER, 1970), common factors with an eigenvalue of more than 1.0 should be obtainable. From the eigenvalue and the correlation coefficient matrix of the variables, we obtained the factor loading (YANAI *et al.*, 1990). For example, the common Factor 1 (F1) included questions 1, 2, and 3 (P1, P2, P3), which concentrated on economic items, while common Factor 2 (F2) included questions 4, 5, and 6, which concentrated on environmental items (Fig. 3).

We constructed two hypotheses: 1) The attitude toward

Table 1 Content of the questionnaire

Code	Items
P1	Improve local economic development
P2	Increase chances of employment
P3	Raise incomes of local residents
P4	Increase opportunities for education
P5	Increase local public security
P6	Improve attractiveness of the community
P7	Protect local environments
P8	Improve roads
P9	Improve other public service facilities
N1	Increase crime rate
N2	Lead to traffic jams
N3	Increase environmental pollution
N4	Destroy local ecosystems and natural landscape
N5	Decrease income for local residents from forestry
N6	Decrease income for local residents from agriculture
N7	Increase crop damage by wildlife in the reserve
N8	Increase the need for maintenance activities
A1	Strongly support nature reserve development
A2	Satisfied with current development of the nature reserve
A3	The nature reserve has brought many benefits to the local community
S1	We have responsibility to protect the local natural environment
S2	Benefit from the nature reserve administration should be widely shared by local residents
S3	Participation in jobs provided by the nature reserve
S4	We have right to participate in decision-making on the development of the nature reserve
S5	If have opportunity, attend training courses
S6	If there is appropriate organization, would participate in volunteer work, such as planting trees, collecting litter, etc.

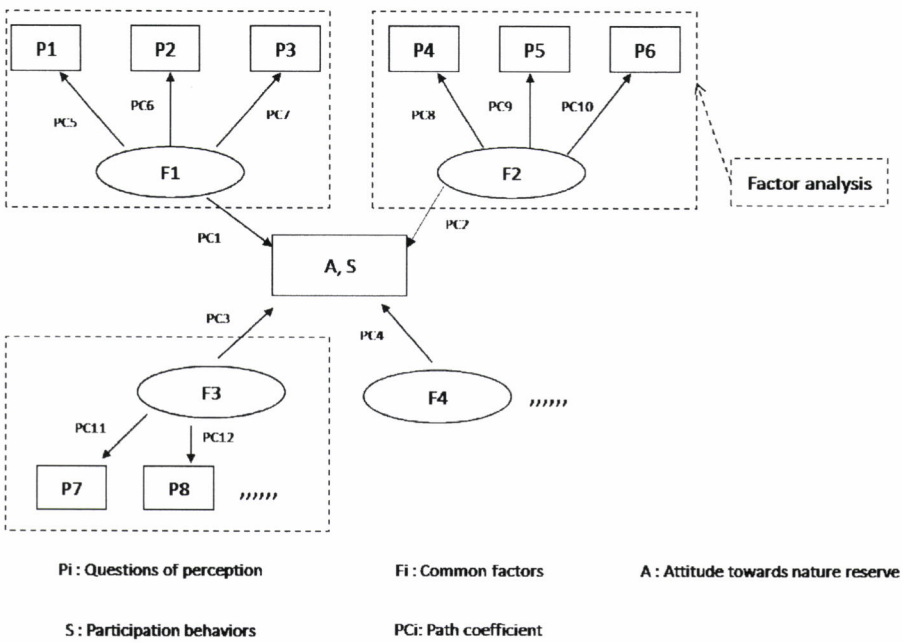

Fig. 3 Proposed structural equation model

nature reserves of local residents is impacted by their perception of the nature reserve; and 2) The positive participation of local residents is impacted by their perceptions and attitudes toward the nature reserve. Based on factor analysis, there will be some latent variables representing local residents' perceptions toward nature reserves; therefore, we selected a structural equation model (SEM) as the best statistical approach to explain the natural or social phenomena by introducing the latent variable that cannot be observed directly and by identifying causality between observations and latent variables (KARINO, 1997). This process can be considered as an expansion of factor analysis and multiple regression analysis (HAU, 2004). The structural equation model of local residents' perception was divided into attitudes (A) and participation (S) (Fig. 3). SEM analysis was used to verify which hypothesis is valid, and the path coefficient (standard partial regression coefficient) was used to show the intensity and direction of relationships among the perception factors, attitudes, and participation. Larger path coefficients indicate stronger influential factors. The goodness of fit of the structural model is indicated by the goodness-of-fit index (TOYOTA, 1998).

Analysis of variance (ANOVA) was used to test the ratio of variation within and between groups (YU, 2007). ANOVA tested whether the different demographic groups had different perceptions, attitudes, and participation intent. If a difference existed, we conducted a post hoc test to determine where the difference was among the groups (NAGATA, 1997).

RESULTS

Demographic Description of Respondents

In total, 484 questionnaires were distributed, and 444 valid responses were collected. Of the respondents, 57.2% were male. There was a slight skew toward older respondents: about 58.1% were over 45 years old, and only 9.5% of respondents were less than 30 years old. More than 86.7% of respondents had not finished senior high school; of these, 14.9% had no educational background, and 32.2% had only finished primary school. In total, only 9.9% of respondent families had an income of more than 15,000 RMB yuan per year, and 49.7% of the remaining families earned less than 5,000 RMB yuan, which is about 10% of the average annual family income in Beijing. Most (70.3%) of the respondents resided in the nature reserve more than 35 years, and 39.7% of families had family members doing some nature reserve-related work.

Residents' Perceptions

More than 50% of responses were positive (P1 to P9), with a value over 4 (Table 1 and Fig. 4), and P8 ("Improve road conditions") had the most positive response (nearly 90%). On the other hand, more than 30% of respondents assigned a score of 3 to P4 ("Increased opportunities for education"), many respondents showed a neutral response with this question. In terms of negative perceptions (Table 1 and Fig. 5), 80% of local residents disagreed with statements N1 to N4, giving these questions scores of 1 or 2. On the other hand, 60% of respondents gave a score of more than 3 to N7, and approximately 80% gave a score of more than 3 to N8.

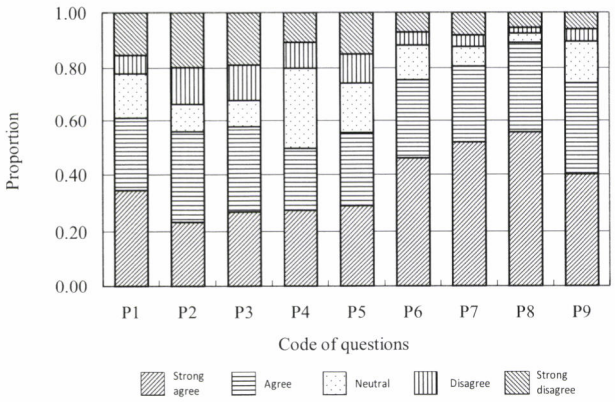

Fig. 4 Local residents' responses of positive perceptions
Note: For details of P1~P9 see table 1.

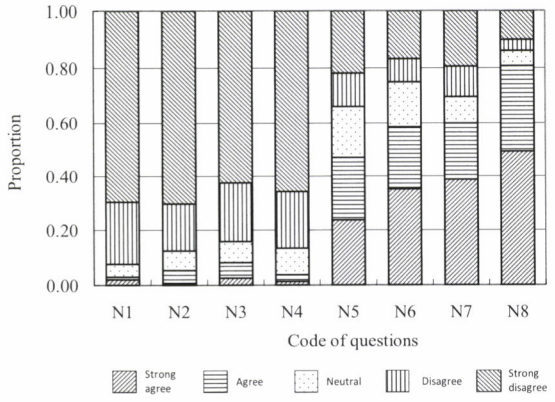

Fig. 5 Local residents' responses of negative perceptions
Note: For details of N1~N8 see table 1.

The majority (84.9%) of respondents supported the establishment of nature reserves, with scores of more than 3 to A1 ("Strongly support nature reserve development;" Table 1 and Fig. 6). However, for question A2, only 62.8% of respondents were satisfied about nature reserve development. In terms of participation (Table 1 and Fig. 7), S1 scored 88.2%, showing that residents perceive a responsibility to protect the local natural environment. Almost one-fourth (23.0%) of respondents gave a score of 3 to S4 because they did not have confidence that they would be allowed to participate in decision-making. Most (82.9%) respondents gave a score of more than 3 to S6, meaning that respondents intend to

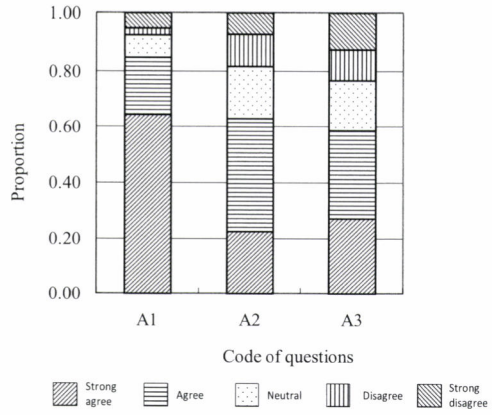

Fig. 6 Local residents' responses of attitudes
Note: For details of A1~A3 see table 1.

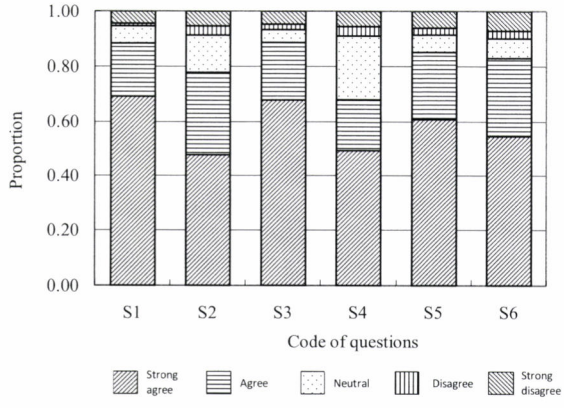

Fig. 7 Local residents' responses of participations
Note: For details of S1~S6 see table 1.

participate in the nature reserves as volunteers. In total, more than 60% of responses toward participation had scores above 3, and less than 10% of respondents disagreed with the statements about participation (S1 to S6).

Common Factors in Local Residents' Perceptions

According to the Kaiser standard, we selected four factors for negative and positive perceptions that had an eigenvalue >1. The principle factor method and varimax rotation were used to obtain the factor patterns, where the factor pattern describes the factor loading value. A larger factor pattern shows a stronger influence of a common factor on the objective variable. In terms of positive perceptions, the first factor, "positive economic perception" (PE), was composed of P1, P2, and P3, with a contribution of 43.0%, and this was considered as an evaluation index for positive perceptions. The second factor, "positive living environment perception" (PLE), included six items and only contributed 15.2% (Table 2). The accumulated contribution of two factors of negative

Table 2 Factor analysis of positive perceptions

Code		Factor pattern	Factor pattern	Initial eigenvalues	Contributing rate (%)	Factor name
First factor	P1	0.773	0.251	3.873	43.0	Positive economic perception (PE)
	P2	0.890	0.082			
	P3	0.881	0.174			
Second factor	P4	0.413	0.476	1.364	15.2	Positive living environment perception (PLE)
	P5	0.381	0.431			
	P6	0.279	0.700			
	P7	0.056	0.586			
	P8	0.057	0.806			
	P9	0.256	0.781			

Note: According to the Kaiser standard, two eigenvalues >1.0 were selected for positive perceptions. The factor pattern reflects the factor loading value, with a larger factor pattern being a stronger objective variable.

Table 3 Factor analysis of negative perceptions

Code		Factor pattern	Factor pattern	Initial eigenvalue	Contributing rate (%)	Factor name
First factor	N1	0.763	-0.122	2.515	31.4	Negative living environment perception (NLE)
	N2	0.743	-0.065			
	N3	0.849	0.043			
	N4	0.811	0.172			
Second factor	N5	0.018	0.757	1.913	23.9	Negative economic perception (NE)
	N6	-0.041	0.777			
	N7	-0.006	0.688			
	N8	0.019	0.460			

Note: According to the Kaiser standard, two eigenvalues >1.0 were selected for negative perceptions. The factor pattern reflects the factor loading value, with a larger factor pattern being a stronger objective variable.

perceptions was 55.3%. N1, N2, N3, and N4 addressed the "negative living environment perception" (NLE), with a rate of 31.4%. N5, N6, N7, and N8 composed factors for "negative economic perceptions" (NE) and contributed 23.9% (Table 3). As a whole, the factors for improvement of individual and community economy were admitted positively, but the factors for living environment were negative.

SEM of Local Residents' Perceptions, Attitudes and Participation

We were able to evaluate whether and how the perceptions of local residents impacted their attitude and participation intent toward the nature reserves. From hypothesis 1, i.e., that the attitude toward nature reserves of local residents is impacted by their perception toward the nature reserve, and hypothesis 2, i.e., that the positive

participation of local residents is impacted by their perceptions and attitudes toward the nature reserve, we developed three models (Figs. 8, 9, 10). Fig. 8 shows the intensity of causal relation between local residents' perceptions and attitudes toward nature reserve. As the indication of path coefficients, driving factors will be found. Fig. 9 shows the intensity of the causal relation between local residents' perceptions and participation intents toward nature reserve. And Fig. 10 indicates the causal relation between attitudes and participations. The factors affecting the perceptions of local residents were regarded as latent variables in the ellipse, and the individual questions of the questionnaire were regarded as observational variables in the rectangle. With SEM analysis, we validated the relationship between perceptions, attitudes, and participation of local residents that could not otherwise be observed directly.

SEM analysis revealed that factor PE had the strongest causal relationships with A of local residents, with a path coefficient of 0.55, and the effect of PLE was also strong (0.24; Fig. 8). The correlation between NLE and A had a path coefficient of zero ($P > 0.05$), showing no impact of NLE on A. Moreover, the path coefficient between NE and A was also low (-0.09; $P > 0.05$), with no significant correlation. These data partially supported hypothesis 1: the attitude of local residents was impacted by their positive perception toward the nature reserve, and the most influential factor toward A was PE. In Fig. 9, the path coefficients from PE and PLE to S provided a strong indication that residents' feelings toward a growing

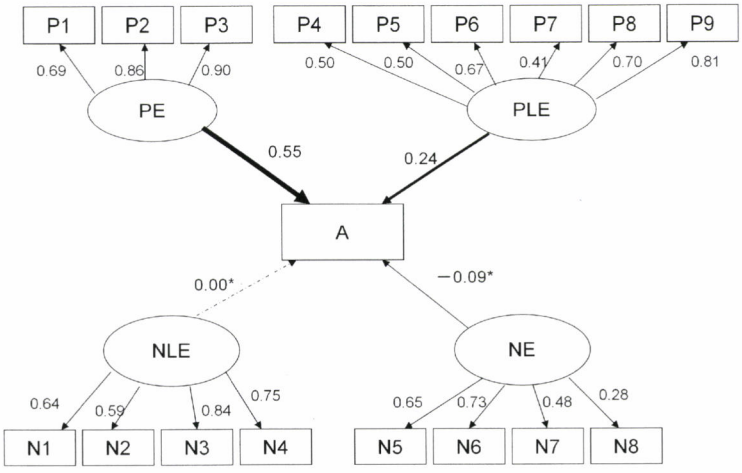

Fig. 8 Perception-attitude model by AMOS analysis

Note: A: attitude towards the nature reserve; PE: positive economic perception; PLE: positive living environment perception; NLE: negative living environment perception; NE: negative economic perception; P1~P9, N1~N8 see table 1; * non-significant. Path coefficient sees Fig. 3.

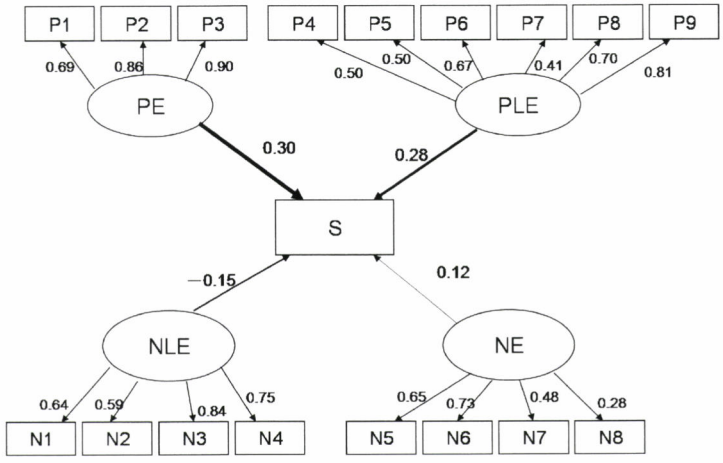

Fig. 9 Perception-participation model by AMOS analysis

Note: S: participation towards nature reserve; PE: positive economic perception; PLE: positive living environment perception; NLE: negative living environment perception; NE: negative economic perception; P1~P9, N1~N8 see table 1; Path coefficient sees Fig. 3.

economy and improving the living environment are likely to strongly increase their participation in the nature reserves. The path coefficient from NE to S was 0.12, while from NLE to S it was −0.15, showing that residents who had a stronger negative perception about the economy were likely to have a stronger participation intent, and residents who had a stronger negative perception about the living environment were likely to reject participation. These data supported hypothesis 2 that the participation intent of local residents is impacted by their perceptions of the nature reserve. All path coefficients of the model were significant in the predicted direction at $P = 0.05$. The largest path coefficient (0.71) was got, between A (attitude) and S (participation), which supported hypothesis 2, viz. that local residents' attitudes toward the nature reserve have the greatest influence on participation (Fig. 10).

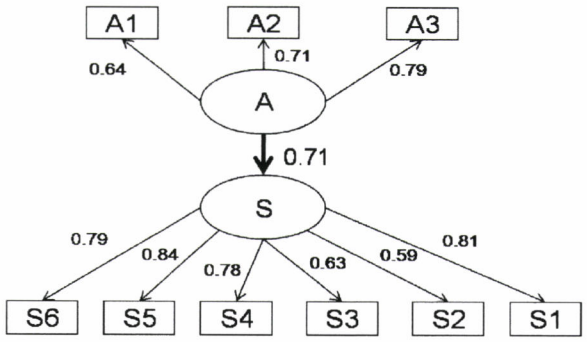

Fig. 10 Attitude-participation model by AMOS analysis
Note: A: attitude towards the nature reserve; S: participation towards nature reserve; A1~A3, S1~S6 see table 1; Path coefficient sees Fig.3.

Table 4 Goodness-of-fit index of SEM analysis

	GFI	AGFI	RMSEA
Perception>>Attitude	0.876	0.839	0.088
Perception>>Participation	0.870	0.832	0.089
Attitude>>Participation	0.905	0.842	0.126

Note: GFI = Goodness-of-fit index; AGFI = adjusted goodness of fit index; RMSEA = root mean square error of approximation.

Table 4 shows the goodness of fit (GFI) of the structure models, all of which were larger than 0.87, and adjusted GFI (AGFI) values, which were more than 0.83. Compared to the empirical value, both GFI and AGFI were not perfect but were acceptable (TOYOTA, 1998); therefore, the proposed structural models were considered acceptable.

Variations in Local Residents' Perceptions, Attitudes and Participation

The main purpose of this research was to elucidate the perception structure of local residents in the nature reserves. Perception was related to personal and locational characteristics such as length of residence, age, language, and sex (BROUGHAM and BUTLER, 1981; SHELDON and VAR, 1984). ANOVA and the post hoc test can show variations in perceptions to the same item for different groups of local residents. Table 5 provides the variables used in the analysis, with the dependent variable as ordinal and independent variable as nominal. Results are shown in Table 6, 7, 8, 9 and 10.

Age

A significant difference appeared in NLE ($P = 0.0038$, < 0.01) and S ($P = 0.0004$, <0.01). The post hoc test indicated a tendency of young people to have stronger negative perceptions than older people about the living environment. Residents younger than 30 or older than 60 years were likely to have a weak positive attitude toward participation in the nature reserves (Table 6, Table 10).

Table 5 Variables in the ANOVA

	Code	Composition
Dependent variable	PE (positive economic perception)	P1, P2, P3
	PLE (positive living environment perception)	P4, P5, P6, P7, P8, P9
	NE (negative economic perception)	N5, N6, N7, N8
	NLE (negative living environment perception)	N1, N2, N3, N4
	A (attitude)	A1, A2, A3
	S (participation behavior)	S1, S2, S3, S4, S5, S6
Explanatory (independent) variable	Sex	F, M
	Age	15-30; 31-45; 46-60; Over 60
	Education	None; Primary; Middle; Senior high school; College
	Income (Annual family income)	Under 5T; 5-10T; 10-15T; 15-20T; Over 20T (T = 1000 RMB Yuan)
	Period (Period of residence)	Under 5Y; 5-15Y; 16-25Y; 26-35Y; Over 35Y (Y = year)
	Relationships (Employment related to nature reserve)	Self; Family member; None

Note: For details of P1-P9, N1-N8, A1-A3, and S1-S6 see Table 1.

Table 6 ANOVA on local residents' age

Variables	Age	Number	Agree ratio (%)	d.f.	X^2	*p*-value
S	15-30	44	90.5	54	85.792	0.0038
	31-45	142	93.1			
	46-60	148	94.6			
	>60	110	86.4			
NLE	15-30	44	16.7	36	71.631	0.0004
	31-45	142	2.1			
	46-60	148	0.7			
	>60	110	0.9			

Note: For details of S and NLE see Table 5.

Table 7 ANOVA on local residents' education

Variable	Education	Number	Agree ratio (%)	d.f.	X^2	*p*-value
PE	None	66	60.6	48	68.337	0.0284
	Primary	143	60.1			
	Middle	176	63.1			
	High	57	73.7			
	College	2	100.0			

Note: For details of PE see Table 5.

Table 8 ANOVA on local residents' income

Variables	Income	Number	Agree ratio (%)	d.f.	X^2	*p*-value
S	<5T	199	91.0	72	97.399	0.0248
	5T~10T	141	90.1			
	10T~15T	60	95.0			
	15T~20T	19	89.5			
	>20T	25	100.0			
PE	<5T	199	57.8	48	69.142	0.0244
	5T~10T	141	58.9			
	10T~15T	60	81.7			
	15T~20T	19	82.4			
	>20T	25	84.0			

Note: For details of S and PE see Table 5.

Table 9 ANOVA on local residents' relation with nature reserve

Variables	Relation	Number	Agree ratio (%)	d.f.	X^2	*p*-value
A	Directly	98	86.7	24	41.253	0.0156
	Family	78	83.3			
	None	268	72.8			
PLE	Directly	98	93.9	48	71.188	0.0165
	Family	78	93.6			
	None	268	84.3			
PE	Directly	98	84.5	24	63.251	<.0001
	Family	78	83.3			
	None	268	53.4			

Note: For details of A, PLE and PE see Table 5.

Table 10 Post Hoc test by Games-Howell

Dependent Variable	Group (a)	Group (b)	Mean Difference(a-b)	Std. Error	*p*-value
S	Age1	Age3	-1.739(*)	0.876	0.048
	Age3	Age4	1.465(*)	0.631	0.021
S	income2	income5	-1.981(*)	0.696	0.045
NLE	Age1	Age2	2.76(*)	0.676	0.001
	Age1	Age3	2.89(*)	0.668	0.000
	Age1	Age4	2.85(*)	0.678	0.001
PE	Education1	Education5	-4.02(*)	0.471	0.000
	Education2	Education4	-1.67(*)	0.524	0.016
	Education2	Education5	-4.31(*)	0.311	0.000
	Education3	Education5	-3.78(*)	0.303	0.000
	Education4	Education5	-2.65(*)	0.421	0.000
PE	Income1	Income3	-1.87(*)	0.507	0.003
	Income1	Income5	-2.20(*)	0.677	0.021
	Income2	Income3	-1.87(*)	0.546	0.007
	Income2	Income5	-2.19(*)	0.707	0.028
PE	Relation1	Relation3	1.82(*)	0.418	0.000
	Relation2	Relation3	2.55(*)	0.428	0.000
A	Relation1	Relation3	1.50(*)	0.320	0.000
	Relation2	Relation3	1.17(*)	0.339	0.002
PLE	Relation1	Relation3	1.77(*)	0.559	0.005
	Relation2	Relation3	1.68(*)	0.524	0.005

Note: For details of dependent variables see Table 5. *. The mean difference is significant at the 0.05 level.
Games-Howell test treat one group as a control, and compare all other groups against it.

Education

The different educational levels produced significant variance in PE ($P = 0.0284$, < 0.05). The post hoc test indicated that local residents with higher educational levels were likely to have a stronger positive economic perception (Table 7, Table 10).

Income

A significant difference appeared in PE ($P = 0.0244$, < 0.05) and S ($P = 0.0248$, < 0.05) in relation to annual family income. The post hoc test indicated that residents with a higher income were likely to have stronger opinions than those with a lower income in terms of their perception of the economy. Residents with a higher family income were also likely to have a stronger positive response to participation (Table 8, Table 10).

Employment in relation to the nature reserve

The most significant differences were in PE ($P < 0.0001$), PLE ($P = 0.0165$, < 0.05), and A ($P = 0.0156$, < 0.05), with different relationships of local residents to nature reserves. The post hoc test indicated that residents who were employed in a nature reserve had stronger positive economic and positive living environment perceptions, and were also likely to be more supportive of the nature reserve (Table 9, Table 10).

DISCUSSION

Although faced with problems of land shortage, animal damage, and other difficulties directly associated with the existence of nature reserves, more than 80% of respondents said they had a responsibility to protect their local natural environment (Fig. 7), and wished to participate in some nature reserve management issues, even if there is no reward. Also, 80% of respondents had a supportive attitude toward the nature reserves (Fig. 6), and approximately 60% believed that the nature reserves brought them some benefits. Discontent of local residents toward nature reserves existed but was not very widespread in Beijing.

In total, 80% of respondents expressed willingness to participate in some job or training course if provided by the reserve (Fig. 7). Increasing employment and building capacity is a common expectation of most local residents. RIJSOORT and ZHANG (2005) found that staff of nature reserve management bodies were willing to invite indigenous experts to assist them in constructing a botanical garden, and villagers reported that participation among villagers generally improved by creating more occasions for interaction during 'interviews' and village meetings. Therefore, according to local residents, improving their education and participation opportunities is a valuable and significant way to diminish conflict with nature reserves.

The benefits of nature reserves were confirmed by most local residents (Fig. 4), especially with regard to improving their living environment (P4-P9), thus providing a direct impression of the potential for change. Improving the living environment of local residents is likely to be the most important factor for improving attitudes and participation. However, from the results of SEM analysis, we found that positive attitudes and willingness to participate in nature reserve management is mostly driven by PE (Figs. 8, 9). This confirmed that nature conservation should be linked to issues of local community development (ORMSBY and KAPLIN, 2005; LÜ *et al.*, 2003; FRAGA, 2006) and that biodiversity conservation can be successful only by alleviating local poverty (WILKIE *et al.*, 2006). In the surveyed nature reserves, approximately 50% of families are likely to have an annual income below 5,000 RMB yuan; thus they care most about economic benefits and believe that the nature reserve will benefit them.

On the other hand, most local people (80%) had negative attitudes toward questions on environmental impacts (N1-N4) on their lives (Fig. 5). It seems that nature reserve managing bodies place less emphasis on the negative impacts on local living conditions than on impacts on the economy. SEM analysis also revealed a weak influence of NLE on participation (Fig. 9), indicating that the nature reserve had not severely affected the local living environment. These results also mean that the majority of local residents is not aware of the impacts of tourism, economic growth, and infrastructure development. However, many studies have suggested that tourism may contain the seeds of its own destruction in that it may destroy the environment or landscape that initially attracted tourists (CEBALLOS-LASCURAIN, 1996; EAGLES *et al.*, 2002; BEUNEN *et al.*, 2007). Therefore, local authorities should place more importance on educating local residents regarding the relevant issues concerning the living environment.

Attitude had the largest influence on participation (Fig. 10), and strongly and positively supported hypothesis 2. A supportive attitude toward a nature reserve is essential for local residents' participation in reserve management. Factors that demonstrate a close causal relation with attitude will strongly influence participation of local residents. Measures to improve the support of local residents for nature reserves should include participation in nature reserve management.

ANOVA indicated that local residents who have higher annual incomes have a positive economic perception and are more willing to participate, probably because most of them have obtained economic benefit from the nature reserve and believe that further benefits will accrue. Therefore, a move toward increasing participant satisfaction and, in particular, improving participant income was the most important driving factor in promoting participation of local residents. ANOVA also revealed that increasing the employment of local residents in the nature reserve is most likely to influence perceptions and attitudes. Thus, local authorities and nature reserves can be a driving force to create new employment opportunities in their vicinity. The increased direct or indirect involvement of local residents in nature reserves and creation of sustained income sources is also likely to bring direct positive impacts

for the whole of society.

Middle-aged respondents were the most likely to participate in nature reserve issues. Some young residents did not care about nature reserves and considered that the reserves do not affect them, and some older residents did not understand the real purpose of a nature reserve.

The impact of education level influenced local perceptions. Respondents with higher levels of education were more likely to have stronger positive economic perceptions on nature reserves. Higher education levels equate to a high ability to create economic value in most cases, and these residents can realize more opportunities from nature reserves and increase their income.

CONCLUSION

Economic benefit is the most important driving factor for the participation of local residents in nature reserves in the Beijing area. Economic development is also the most important factor for sustainable development of nature reserves. Tourism can be developed by strengthening the local community infrastructure and social capacity to increase income from admission to reserves. Development of tourism will help local residents to improve individual economic development, such as family folk custom hotels, restaurants, and local products. Another approach is to create a new industry using the nature reserve as a brand, with the reserve managing body or local government providing start-up funding and technical training, or local residents using their own capital. Providing more employment opportunities can increase local residents' satisfaction with nature reserves. The reserve management can create employment for local residents, such as rangers, guides, and sanitation workers. Management can also attract more external capital and develop non-timber industries, such as local species nurseries, medicinal plant cultivation, and orchards.

The negative impacts of tourism must be considered by local residents and nature reserve authorities. Treatment of trash and sewage, entry of private cars, and similar issues must be addressed in nature reserve management. Although the majority of local residents thought that the establishment of a nature reserve improved their living environment, it is necessary to do more to strengthen infrastructure development, such as water supply, communication facilities, and sanitation, because these intangible benefits can increase positive perceptions toward nature reserves. At the same time, such infrastructure can improve tourism industry development.

Education is another significant factor strengthening the attitudes of local residents. Before providing jobs on the reserve, it is necessary to interest young people and build their capacity through training, such as forest ranger mobilization meetings and conferences on nature reserve information exchange. These can create many occasions for interactions and improve conservation awareness. Moreover, certification of training courses can be as appealing as economic benefits from participation.

In summary, local residents showed high levels of enthusiasm to participate in nature reserves in the Beijing area. Local participation in issues related to the reserve also improves positive perceptions and support. Therefore, the managing bodies of nature reserves should do their best to provide more and better employment opportunities through management reform, and local residents must maintain their enthusiasm and strengthen their abilities. If these criteria are met, the contradictions and conflicts should diminish, and improved reserve-resident relations will translate into long-term biodiversity conservation and sustainable utilization of natural resources.

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Article

Vertical Distribution of the Stem Cross-sectional Area Increment in Even-aged Stands of Hinoki Cypress

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ABSTRACT

This report presents the vertical distribution of the stem cross-sectional area increment of the hypothetical tree with average stem size and form in even-aged stands of Hinoki cypress (*Chamaecyparis obtusa*). Datasets from five long-term permanent sample plots established on the Kii Peninsula, central Japan, were used. In these plots, total height and diameter at breast height (DBH) of every living tree have been continuously measured several times at about 5- or 10-year intervals for over 40 years, but stem form has not been measured. The average relative stem curves determined for Hinoki cypress stands in Nara Prefecture were applied. The stem form of the hypothetical tree at each measurement was estimated by substituting the average total height and DBH into the average relative stem curve. The vertical distribution of the stem cross-sectional area increment was calculated as the difference between the stem forms at the beginning and end of the successive measurements. The vertical distributions in these plots were broadly divided into three types based on increasing trend downward in its lower portion: increase, constant, and decrease. Furthermore, variations in form of the vertical distribution were associated with intraspecific competition within the stands. In conclusion, the vertical distribution of the stem cross-sectional area increment presented here would be a useful indicator for planning stand density management.

Keywords: stem cross-sectional area increment, vertical distribution, Hinoki cypress, stand density management

INTRODUCTION

For Hinoki cypress (*Chamaecyparis obtusa* ENDL.), the geometrical distribution of the annual rings is of prime importance for timber quality, including characteristics such as width, uniformity, and straightness (*i.e.*, angle to the longitudinal axis of the stem). Since the distribution can be artificially regulated by thinning, prediction of the distribution as a result of thinning provides useful information for planning stand density management. The position of the annual rings at a given height depends on the stem cross-sectional area of the previous year and the stem cross-sectional area increment in the current year at the same height. Consequently, the ability to predict the vertical distribution of the stem cross-sectional area increment along the stem allows the prediction of the geometrical distribution of the annual rings.

In general, it is uncommon in planning stand density management to regulate the geometrical distribution of the annual rings of an individual tree. In other words, it is more practical for forest managers to predict the vertical distribution of the stem cross-sectional area increment at the stand level rather than at the level of the individual tree. The vertical distribution of the stem cross-sectional area increment of a tree in a simplified stand consisted of trees of same stem size and form that represents the stand may be helpful in assessing stand-level distributions. Although the tree is hypothetical, a periodic change in stem size and form would model those changes in actual trees in the stand. Therefore, the vertical distribution of the stem cross-sectional area increment of the hypothetical tree would be affected by various growing conditions in the stand.

Knowledge of the vertical distribution of the stem cross-sectional area increment in the hypothetical tree is useful for planning stand density management. However, no such information on the distribution is available. We therefore present vertical distributions of the stem cross-sectional area increment of even-aged Hinoki cypress stands.

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MATERIALS AND METHODS

We used datasets from five long-term permanent sample plots: Takatoriyama-I (HOSODA *et al.*, 2001), Takatoriyama-II (HOSODA *et al.*, 2001), Koyasan-I (HOSODA, 1996), Koyasan-II (IEHARA and HASEGAWA, 1986; UENO and HASEGAWA, 1976), and Myogabuchiyama (TANAKA *et al.*, 2003) in even-aged pure Hinoki cypress stands on the Kii Peninsula, central Japan, to determine the vertical distribution of the stem cross-sectional area increment. These plots were established by the Kansai Research Center of the Forestry and Forest Products Research Institute. In these plots, total height and diameter at breast height (DBH) of every living tree have been continuously measured several times at about 5- or 10-year intervals for over 40 years, but stem form has not been measured. Thinning was carried out several times in each plot. Changes in stand attribute by each thinning was certainly measured. General descriptions of these plots are given in Table 1.

The vertical distribution of the stem cross-sectional area increment was obtained as described below. In even-aged Hinoki cypress stands, relative stem form is similar from tree to tree, regardless of the stem size (KAJIHARA, 1985). Thus, the average relative stem curve (KAJIHARA, 1973) for each measurement was determined assuming that every tree in the stand had the same relative stem form. Previously, we determined the relative stem curves, which change with increasing total height, for even-aged Hinoki cypress stands in Nara Prefecture, Japan (WAGUCHI, 2005). Here we applied these curves to the average relative stem curves in the five experimental plots. The stem form for each measurement was estimated by substituting the published average total height and DBH as sizes that represent the stand into the average relative stem curve. At a measurement time with thinning, the stem forms just before and after the thinning were obtained. Using the stem form, periodic stem cross-sectional area increment at a given height was calculated as the difference between the stem cross-sectional areas at the same height at the beginning and end of the successive measurements. When a thinning was conducted at the beginning or end of the period, the stem form just after or before the thinning was used, respectively. The periodic increment was converted to the periodic annual stem cross-sectional area increment by dividing the periodic increment by the number of years in the period.

RESULTS AND DISCUSSION

In general, the vertical distribution of stem cross-sectional area increment in a tree can be schematically represented by a diagram of two simple geometric solids: a triangle for the upper portion and a quadrilateral for the lower portion, and is broadly divided into three types as shown in Fig. 1. The distribution type shifts from type 1 to type 3 as intraspecific competition becomes severe. The vertical distributions of stem cross-sectional area increments of the five permanent sample plots are shown in Fig. 2. All distributions can be represented by the diagrams in Fig. 1.

Every vertical distribution except for that of the period from 41 to 46 years in the Myogabuchi plot can be classified as type 1 or type 2 (Fig. 2). Changes in the yield index (Ry) of the four permanent sample plots except the Koyasan-II plot for

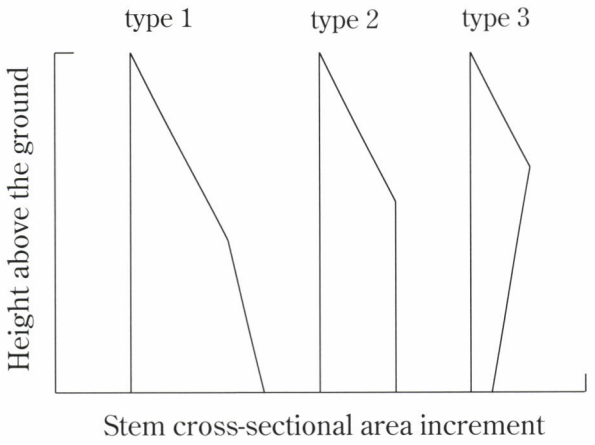

Fig. 1 Schematic diagram of the vertical distribution of the stem cross-sectional area increment

Table 1 General descriptions of permanent sample plots used in this study

Plot	Area	First measurement (after thinning)				Last measurement (before thinning)				Thinning age during measurement period
		Age	Density	Average total height	Average DBH	Age	Density	Average total height	Average DBH	
	(ha)	(year)	(trees/ha)	(m)	(cm)	(year)	(trees/ha)	(m)	(cm)	(year)
Takatoriyama-I	0.200	38	1,100	12.5	16.3	103	560	22.2	35.0	38, 49, 53, 58, 68, 83, 93
Takatoriyama-II	0.200	38	1,305	11.6	14.4	103	560	21.5	33.1	38, 49, 58, 63, 68, 93
Koyasan-I	0.248	22	2,444	8.1	10.7	82	903	18.7	27.0	22, 28, 37, 42, 47, 52, 57, 62, 72
Koyasan-II	0.200	43	1,255	12.9	16.5	93	860	18.6	30.5	43, 49, 63, 73, 93
Myogabuchiyama	0.200	10	2,850	3.3	4.0	51	1170	19.1	24.5	21, 26, 36, 46, 51

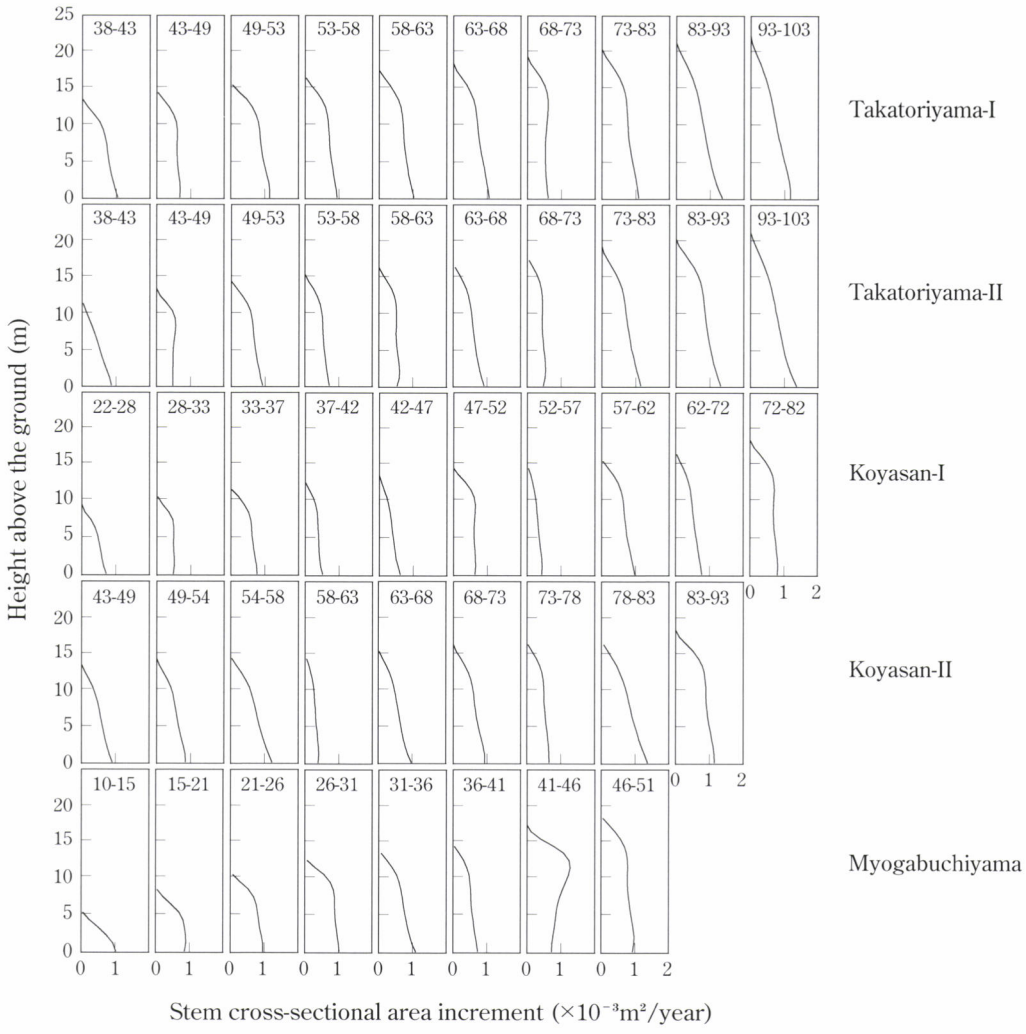

Fig. 2 Vertical distributions of the stem cross-sectional area increment in the permanent sample plots
Numbers in each figure indicate stand ages at the beginning and end of the period.

which Ry has not been published are as shown in Fig. 3. The amount of leaves per unit stand area in even-aged pure stands increases with increasing Ry, but the amount is nearly constant in stands with Ry greater than 0.8 or 0.85 (ANDO, 1968). In other words, trees in an even-aged stand with an Ry value >0.85 have become restricted in the growing space available for expansion of the tree crowns. Since the Ry values of the four permanent sample plots except for the period from 41 to 46 years in the Myogabuchi plot were 0.85 or less, the intraspesific competition in these plots has not been so severe. Therefore, the vertical distributions of stem cross-sectional area increment classified as type 1 or type 2 would be a result of the lower stand density management.

Only the vertical distribution of stem cross-sectional area increment in the period from 41 to 46 years in the Myogabuchi plot can be classified as type 3 (Fig. 2). The Ry in this period was greater than 0.85 (Fig. 3), indicating the severity of

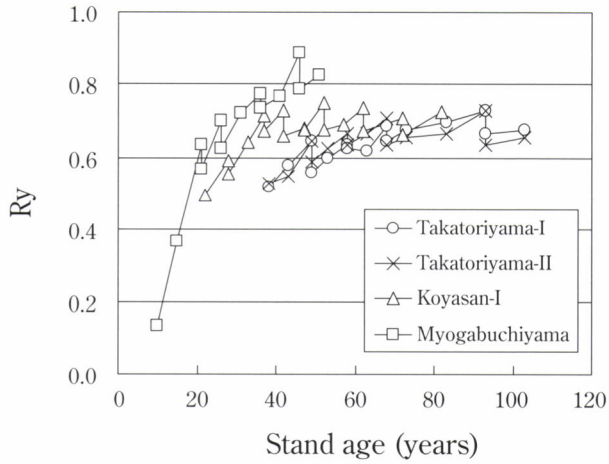

Fig. 3 Changes in the yield index (Ry) of the permanent sample plots

intraspecific competition. Therefore, this vertical distribution classified as type 3 resulted from a higher stand density management.

A broadening trend in the stem cross-sectional area increment of the lower portion from the 73-year-old Takatori-I and Takatori-II stands has become increasingly apparent (Fig. 2). In even-aged closed stands, the vertical distribution of stem cross-sectional area increment in dominant trees with an extremely large crown ratio takes on a type 1 pattern, the distribution in co-dominant trees takes on a type 2 pattern, and the distribution in suppressed trees takes on a type 3 pattern (ONAKA, 1950). Since sufficient growing space for crown expansion generally maintained for each tree in the older stands with long histories of appropriate stand density management operations, the distributions in most of these trees may be classified into type 1. Thus, vertical distributions in appropriately managed older stands will become a more exaggerated type 1.

CONCLUSIONS

This report presented the vertical distribution of the stem cross-sectional area increment in even-aged Hinoki cypress stands using appropriate average relative stem curves. The distributions could be represented by the same diagrams as for individual trees. Furthermore, the difference in form between the distributions was associated with intraspecific competition within the stands. In conclusion, the vertical distribution of the stem cross-sectional area increment presented here would be a useful indicator for planning stand density management.

The vertical distribution of the stem cross-sectional area increment is influenced not only by thinning but also by pruning. This study could not be represented the distribution as being related to pruning because of either of the reasons that pruning was not conducted or that its regime was unpublished over the period from the first to the last measurements in the permanent sample plots used here. In the future work, we intend to examine the effect of frequency, interval, or intensity of pruning on the vertical distribution of the stem cross-sectional area increment in even-aged Hinoki cypress stands.

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